

OUR LAND  
AND WATER

Toitū te Whenua,  
Toiora te Wai

# Monitoring Freshwater Improvements

Monitoring the effectiveness of interventions and mitigation actions

Digital Toolshed Webinar, 4<sup>th</sup> December 2023

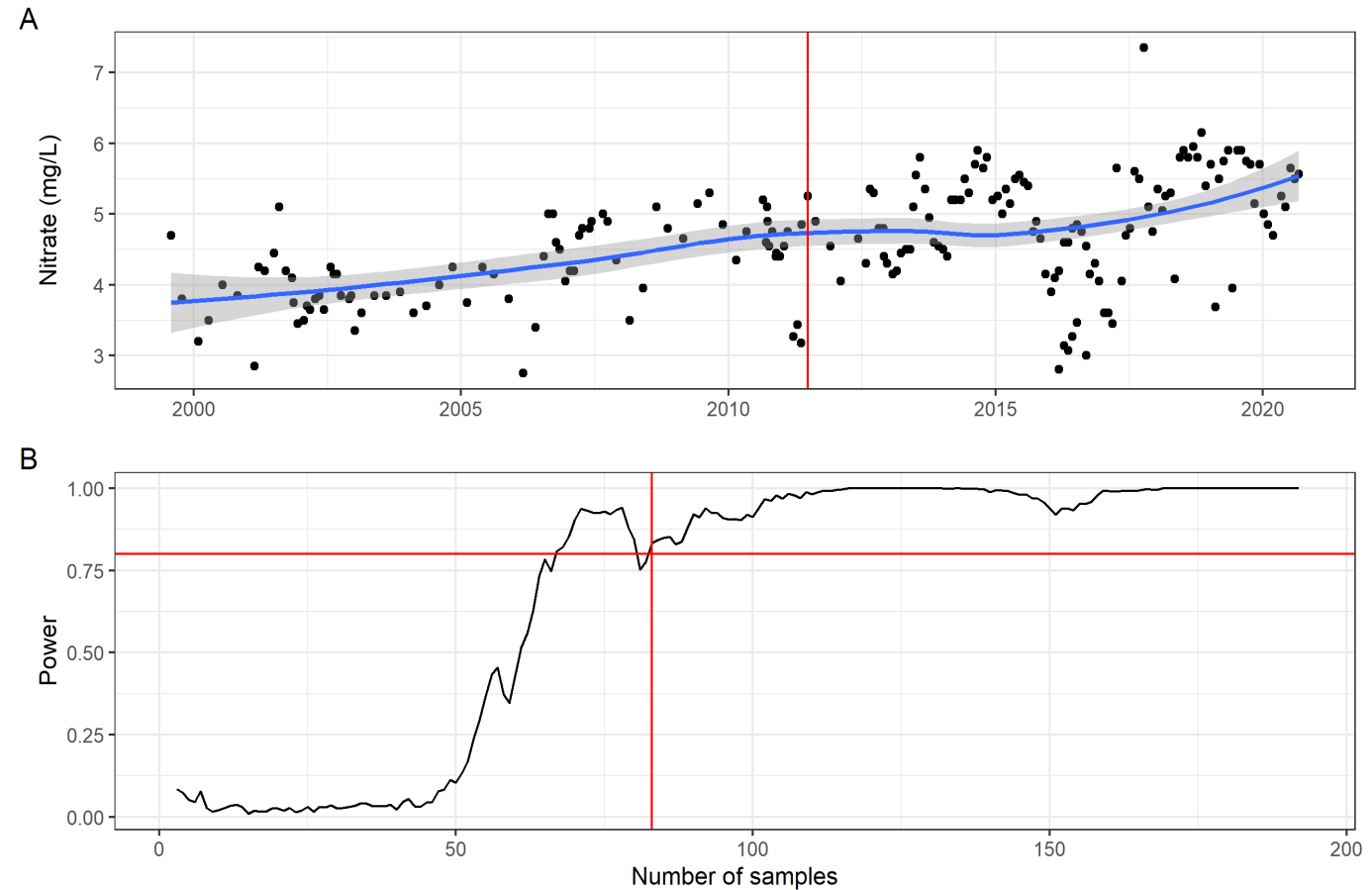
Olivier Ausseil, Joanne Clapcott, Maree Patterson, Matt Highway

Traverse Environmental, Cawthron Institute, Horizons Regional Council, Element Environmental

# Key principles

## Detecting water quality changes is tricky

- Water quality varies all the time
- Samples only provide a snapshot
- “Noisy” data
- More samples  $\approx$  more certainty



# Key principles

**Power analysis** at monitored and unmonitored sites to link:

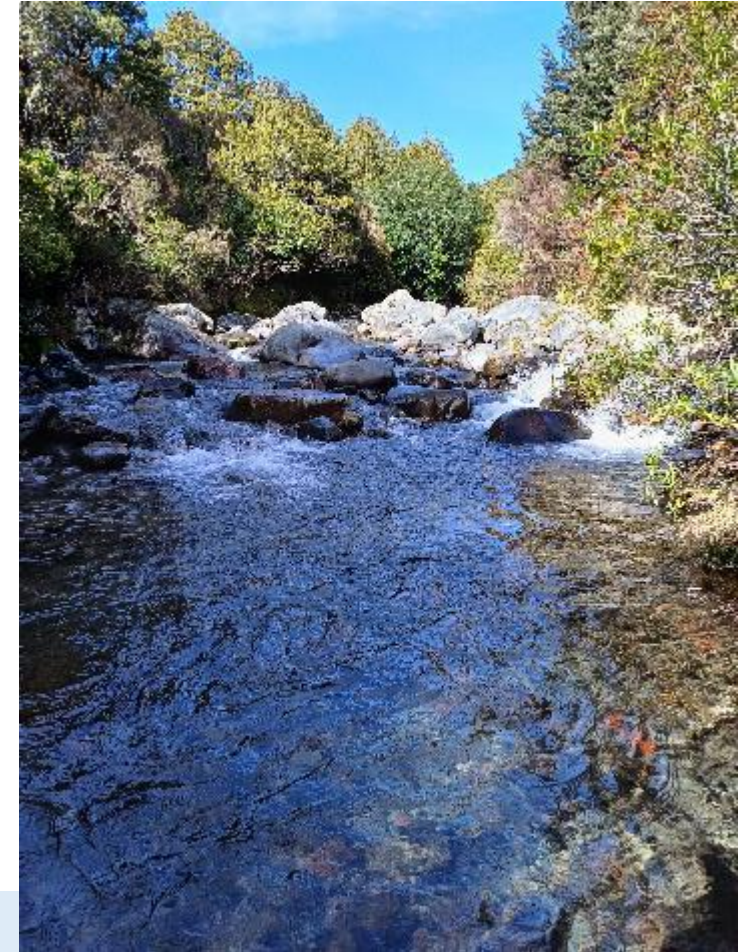
- Likelihood (power) of detecting a change
- % change
- Monitoring duration and frequency

As we increase data:

- Increase the likelihood of detecting a change or
- Reduce the time required to detect a change

Aim:

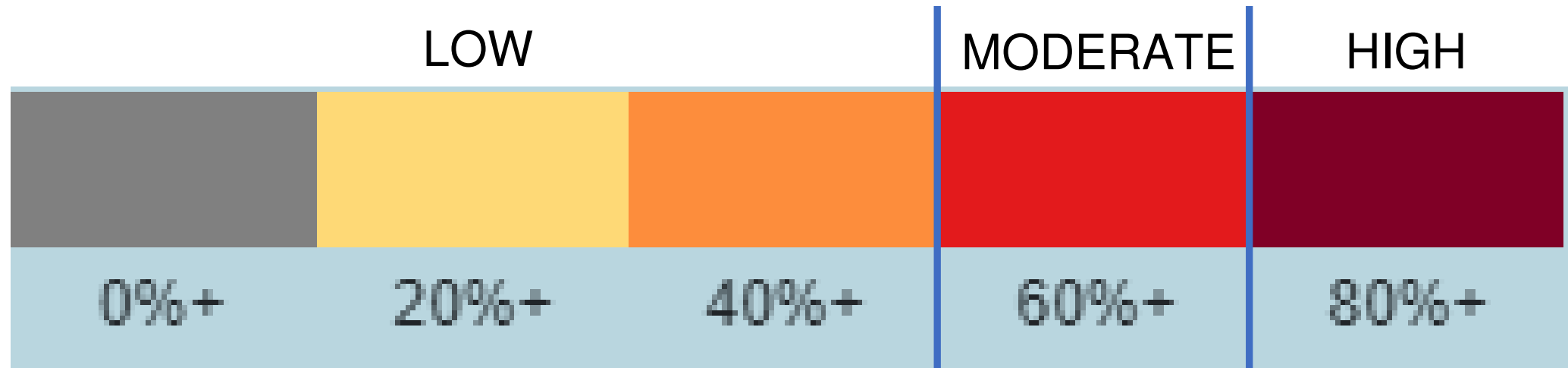
- Ensure that sufficient data is available in the future to assess restoration success



# Key principles

## Interpretation – power categories:

- Colour-coded in the WebApp
- >80% is “gold standard”
- 60-80%: Moderate
- <60% : Low



# Monitoring Freshwater Improvement

Monitoring the effectiveness of interventions and mitigation actions on freshwater improvement.

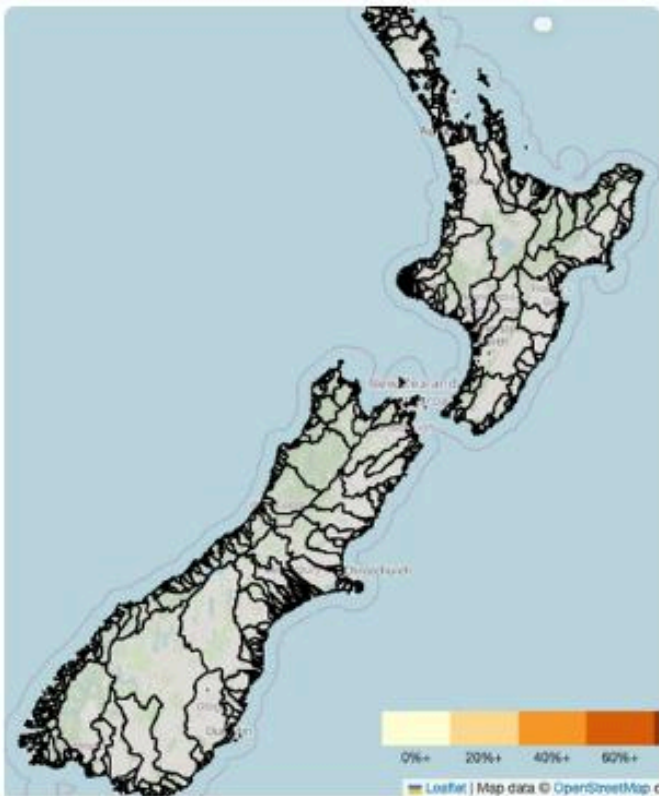
WebApp

Feedback welcome via form in 'Contact' tab

# WebApp Dashboards

The WebApp contains three dashboards relating to different freshwater environments.  
Within each dashboard there are modules to help design or review of monitoring programmes for detecting improvements.

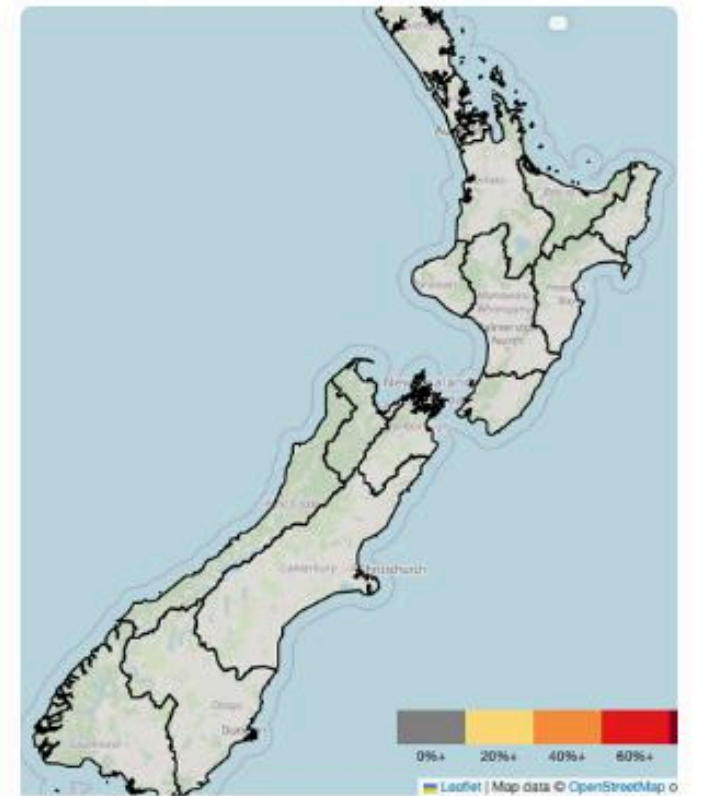
## Rivers



## Lakes



## Groundwater



# The Rivers Dashboard contains 6 modules Let's start with "Water Quality – Monitoring sites"

Water Quality - Catchment | **Water Quality - Monitoring Sites** | Ecology - Site Prioritisation | Ecology - Monitoring Sites | Land Mitigation | High Flow Load Contributions

Likelihood of detecting user-specified improvement in water quality indicators at existing monitoring sites

^ (1) Catchment Selection

(1a) Select a catchment on the map:

v (2) Define Indicator and improvements by site

v (3) Query Options



This module allows users to nominate the level of improvement in water quality indicators they are predicting or hoping to achieve. These improvements could be targets in a regional plan, or restoration objectives of a catchment group.

# Step 1: Catchment Selection

^ (1) Catchment Selection

(1a) Select a catchment on the map:

**7248225 - Waikawa Stream**

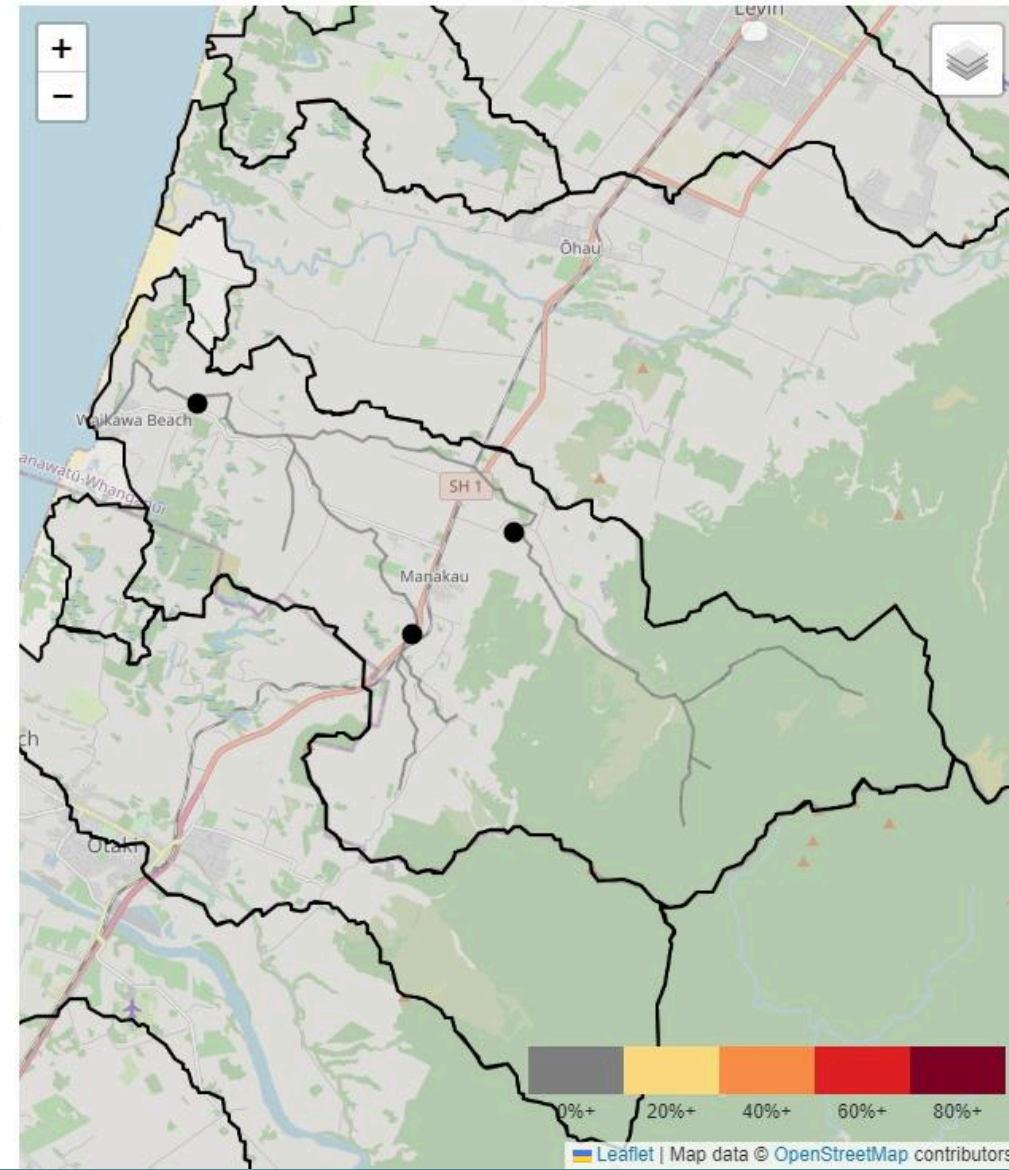
∨ (2) Define Indicator and improvements by site

∨ (3) Query Options

∨ (4) Download Results

The Waikawa catchment is located on the west coast of the North Island and flows out to the Tasman Sea just north of Otaki. It is a small catchment with high native fishery and recreational values.

Existing monitoring sites are shown as black dots on the map. There are three monitoring sites: one just out of the forest park, one on the mainstem near the coast and one on the Manakau Stream, a tributary.





## Step 2: Define Indicator and improvement by site

▼ (1) Catchment Selection

▲ (2) Define Indicator and improvements by site

(2a) Select Indicator:

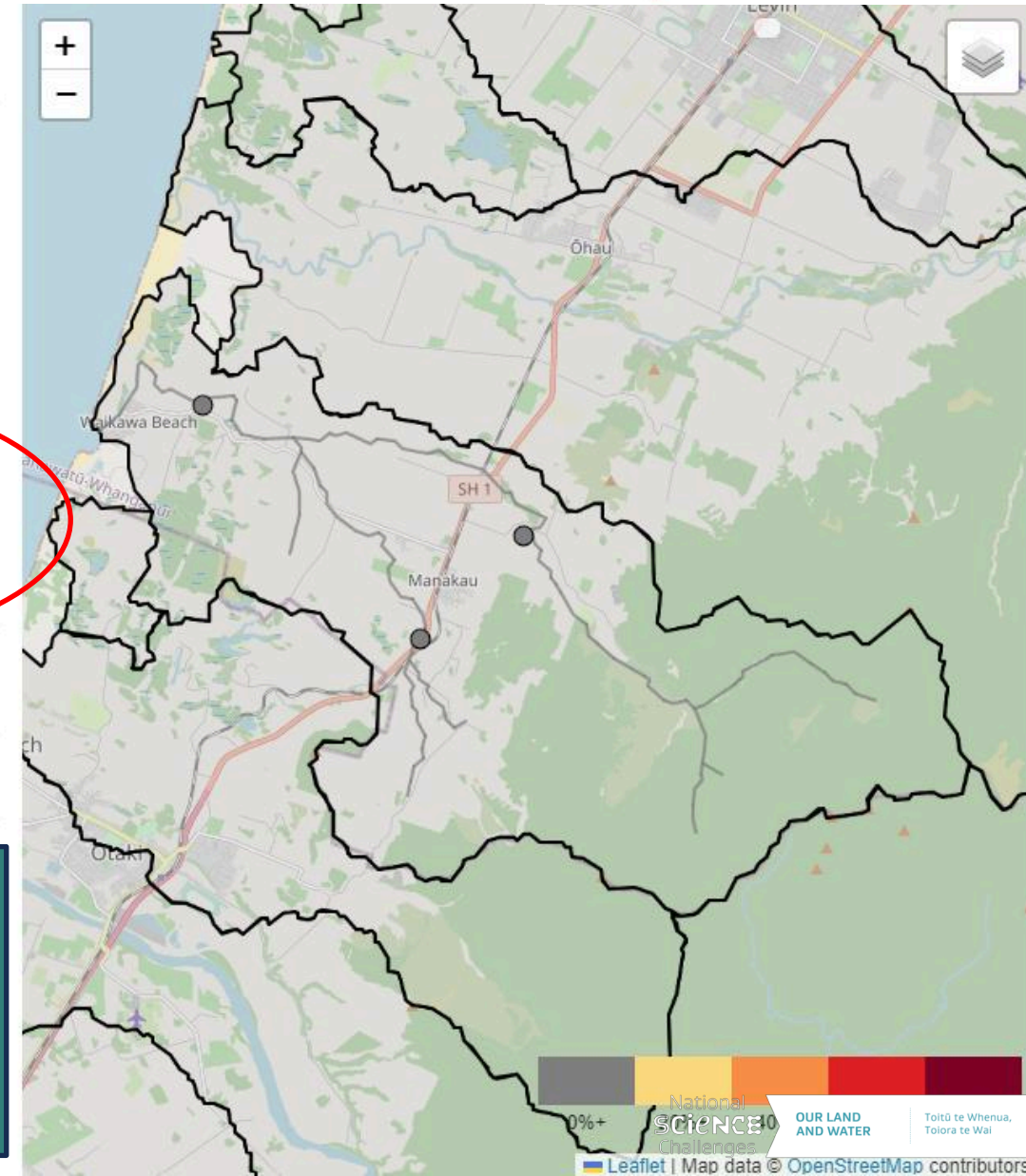
Visual Clarity

(2b) Assign a percent improvement by site under the  
"improvement %" column then press enter to confirm:

site name	improvement %
Waikawa Stream at Huritini	20
Waikawa at North Manakau Road	20
Manakau at S.H.1 Bridge	20

▼ (3) Query Options

▼ (4) Download Results



Step 2a: select one of 7 water quality indicators (Visual clarity, E. coli, DRP, TP, ammoniacal-N, nitrate-N and TN).

Step 2b: nominate a level of improvement in the water quality indicator. Here we select 20% to demonstrate as an example of interim improvement

## Step 3: Explore sampling duration and frequency

∨ (1) Catchment Selection

∨ (2) Define Indicator and improvements by site

∧ (3) Query Options

(3a) Select sampling duration (years):

5

10

20

30

(3b) Select sampling frequency:

quarterly

monthly

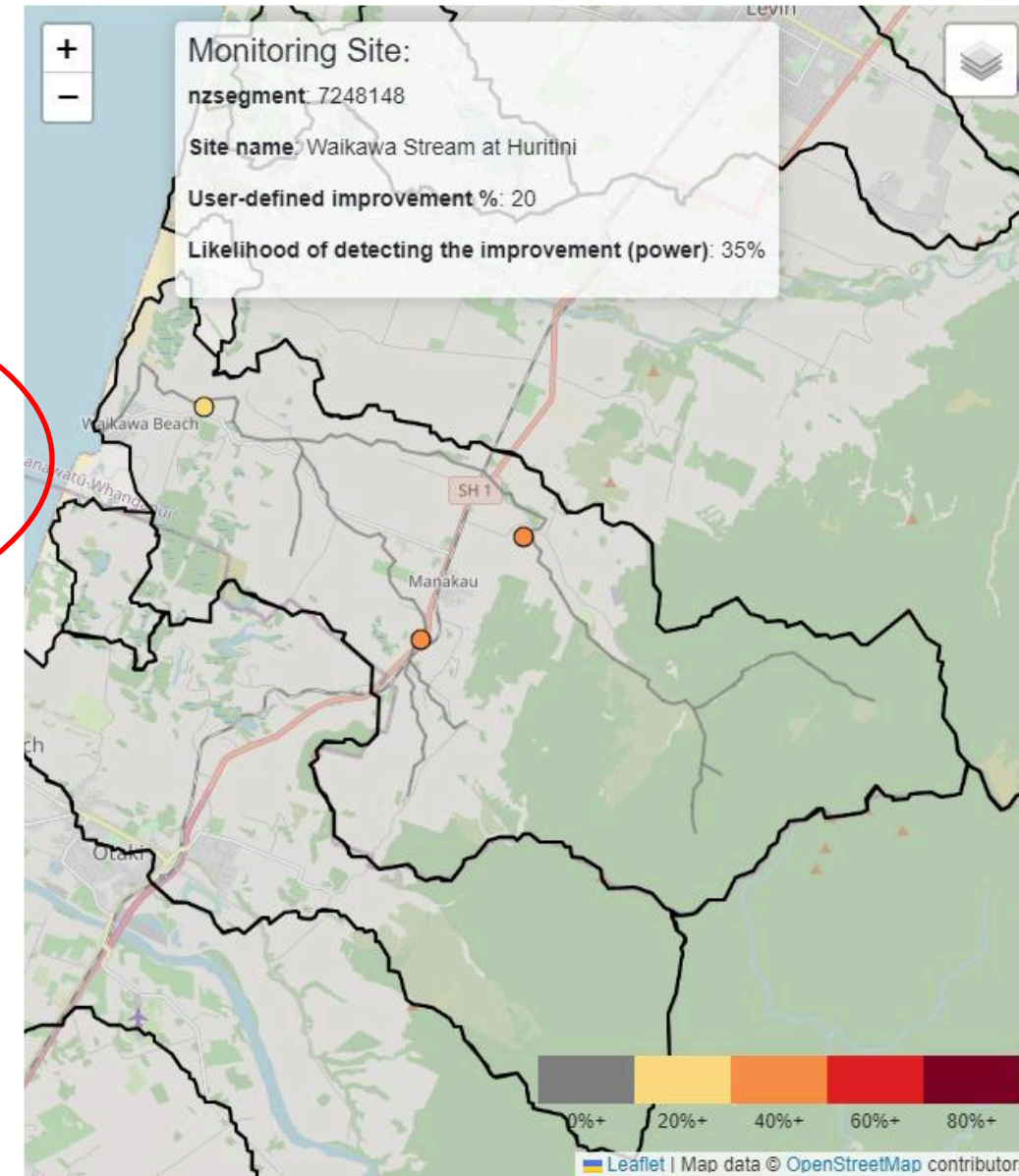
fortnightly

weekly

biweekly

daily

∨ (4) Download Results



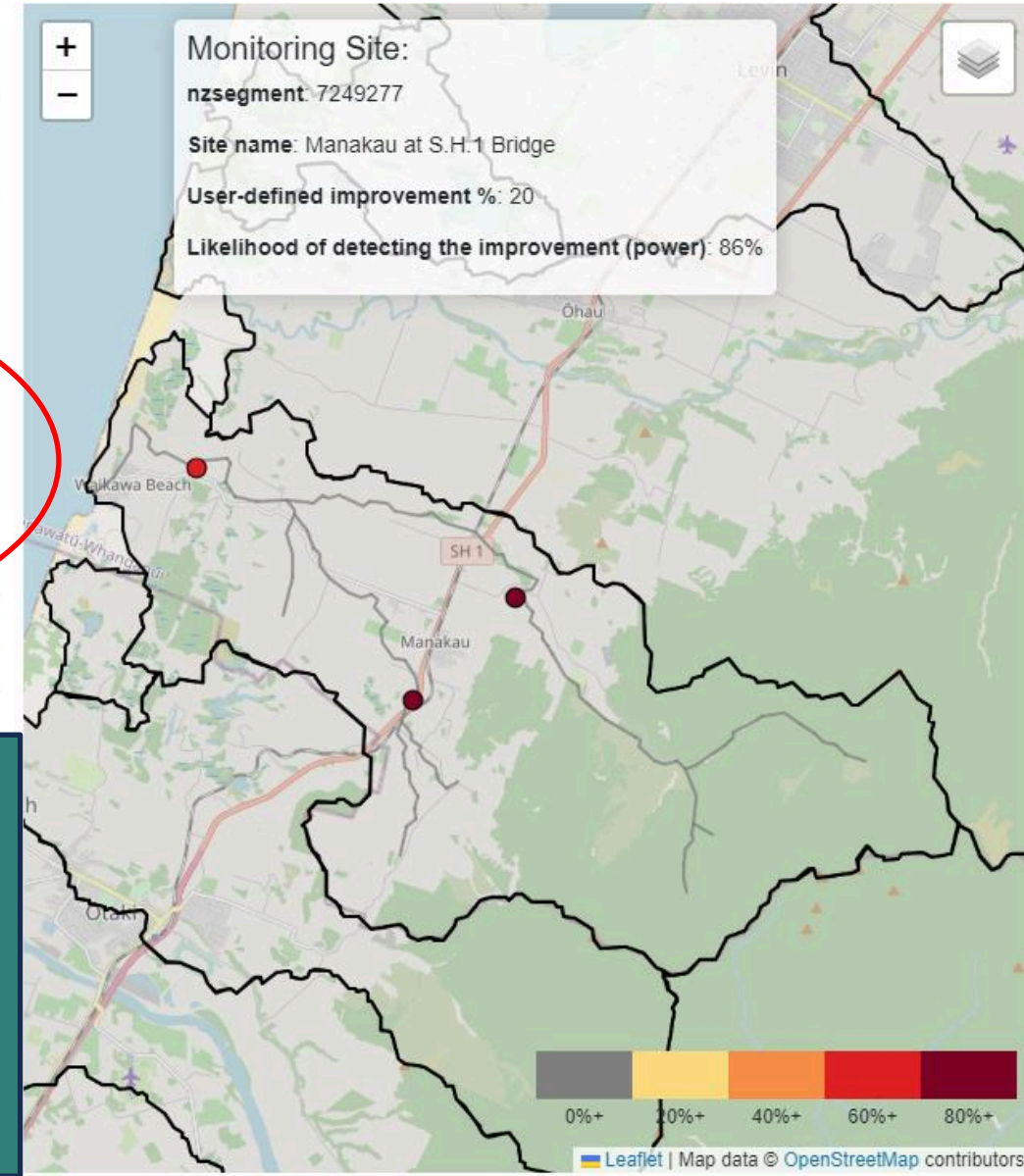
Step 3: Select Sampling duration and frequency to visualise likelihood of detecting nominated change.

Here, we keep the sampling frequency at monthly (current practice) and increase frequency to 10, 20 and 30 years. Power remains <60% at all sites.

► It will take a long time to detect a 20% change in water clarity with monthly observations

## Step 3: Explore sampling duration and frequency

- ✓ (1) Catchment Selection
- ✓ (2) Define Indicator and improvements by site
- ^ (3) Query Options
  - (3a) Select sampling duration (years):  
 5  10  20  30
  - (3b) Select sampling frequency:  
 quarterly  monthly  fortnightly  weekly  biweekly  daily
- ✓ (4) Download Results



Second example, we keep the sampling duration at 10 years to align with the regional planning timeframes and increase frequency to fortnightly, weekly and bi-weekly before obtaining power near or above 80% at all 3 sites.

- ▶ Higher frequency sampling will be required to detect a 20% change within 10 years
- ▶ Significant cost challenges for councils
- ▶ Consider alternatives to standard monitoring approach, such as high frequency monitoring sensors and / or community-based monitoring
- ▶ Prioritise sites for high frequency monitoring

# “Ecology – Monitoring sites” module

Water Quality - Catchment

Water Quality - Monitoring Sites

Ecology - Site Prioritisation

**Ecology - Monitoring Sites**

Land Mitigation

High Flow Load Contributions

Likelihood of detecting user-specified improvement in ecological indicators at existing monitoring sites

^ (1) Catchment Selection

(1a) Select a catchment on the map:


---

^ (2) Select indicator and specify improvements by site

---

^ (3) Query Options

---



This module allows users to nominate the level of improvement in ecological indicators they are predicting or hoping to achieve. These improvements could be targets in a regional plan, or restoration objectives of a catchment group.

## Step 2: Define Indicator and improvement by site

∨ (1) Catchment Selection

∧ (2) Select indicator and specify improvements by site

(2a) Select Indicator:

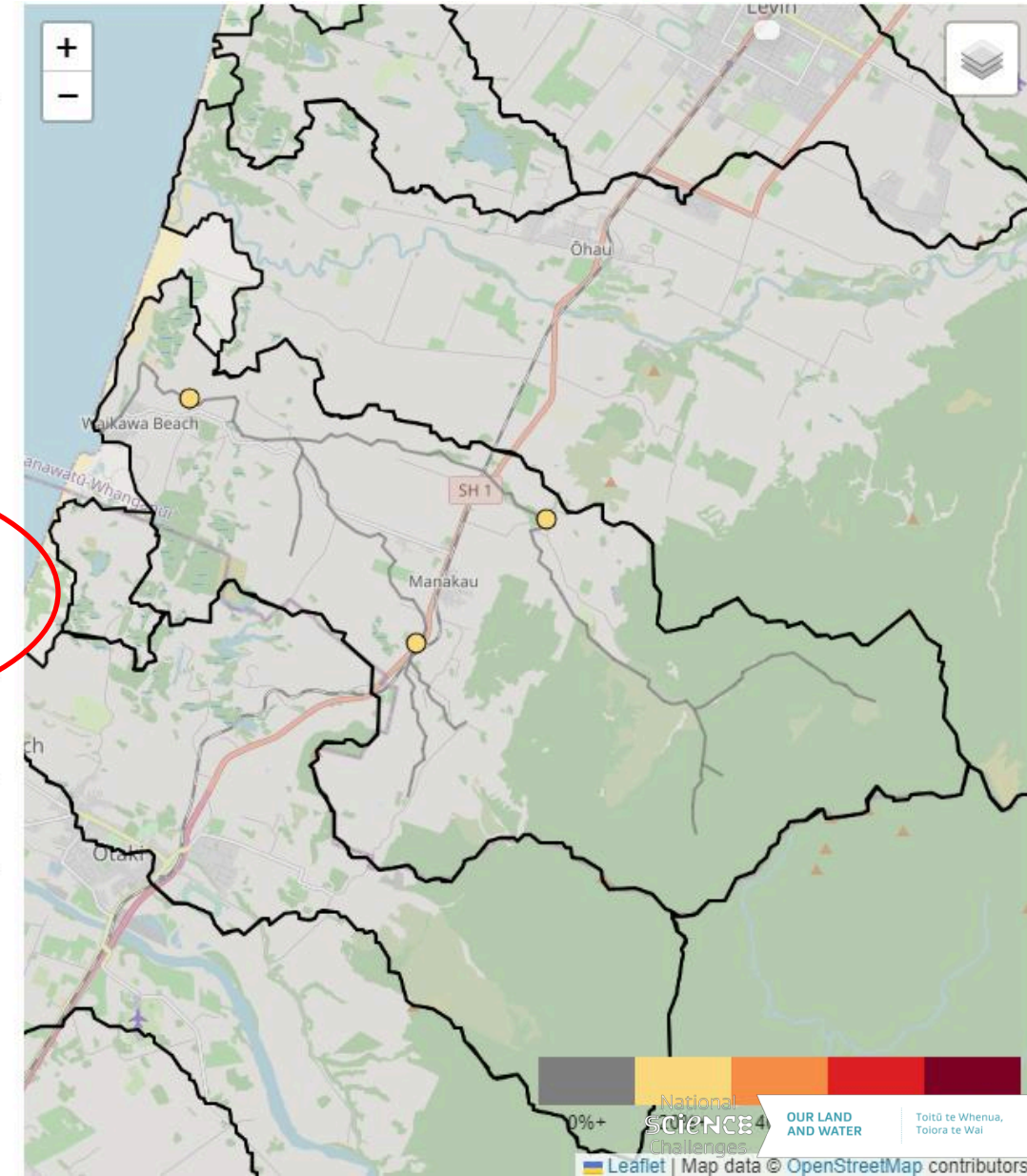
MCI

(2b) Type in a percent improvement by site under the "improvement %" column then press enter to confirm:

site name	improvement %
Manakau at S.H.1 Bridge	20
Waikawa Stream at Huritini	20
Waikawa at North Manakau Road	20

∨ (3) Query Options

∨ (4) Download Results

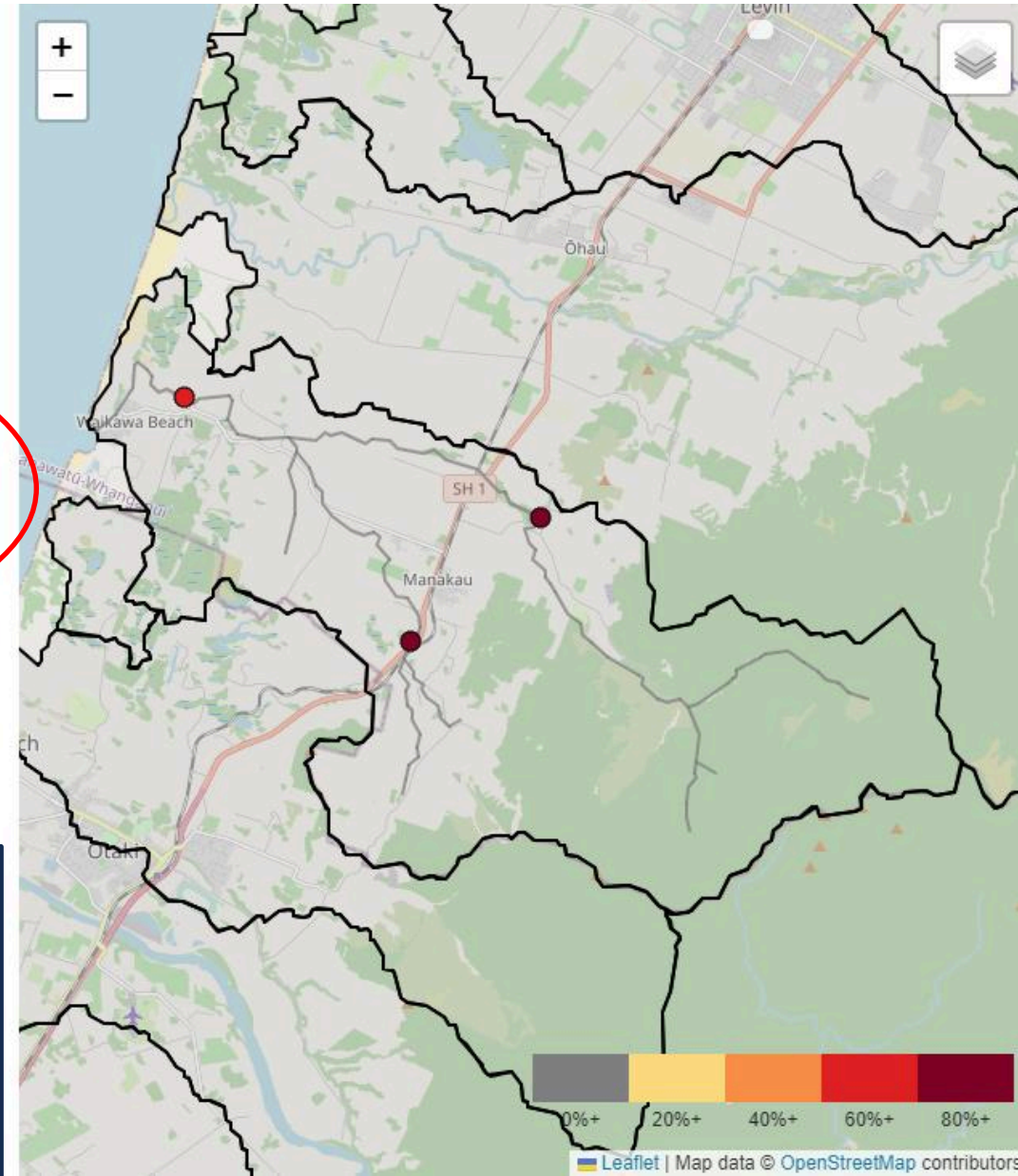


Step 2a: select one of 3 ecological indicators (MCI, periphyton biomass, deposited sediment)

Step 2b: nominate a level of improvement in the indicator. Here we select 20% again

## Step 3: Explore sampling duration and frequency

- ∨ (1) Catchment Selection
- ∨ (2) Select indicator and specify improvements by site
- ∧ (3) Query Options
  - (3a) Select sampling duration (years):  
 5  10  20  30
  - (3b) Select sampling frequency:  
 yearly
- ∨ (4) Download Results



Step 3: Select sampling duration and frequency to visualise likelihood of detecting user-defined change.  
For MCI, frequency is fixed at annually, so we can explore sampling duration only. By increasing duration to 10 then 20 years, power increases to near or above 80% at all 3 sites.  
► It will likely take between 10 and 20 years to detect a 20% improvement in MCI in this catchment

## Step 3: Explore sampling duration and frequency

∨ (1) Catchment Selection

∧ (2) Select indicator and specify improvements by site

(2a) Select Indicator:

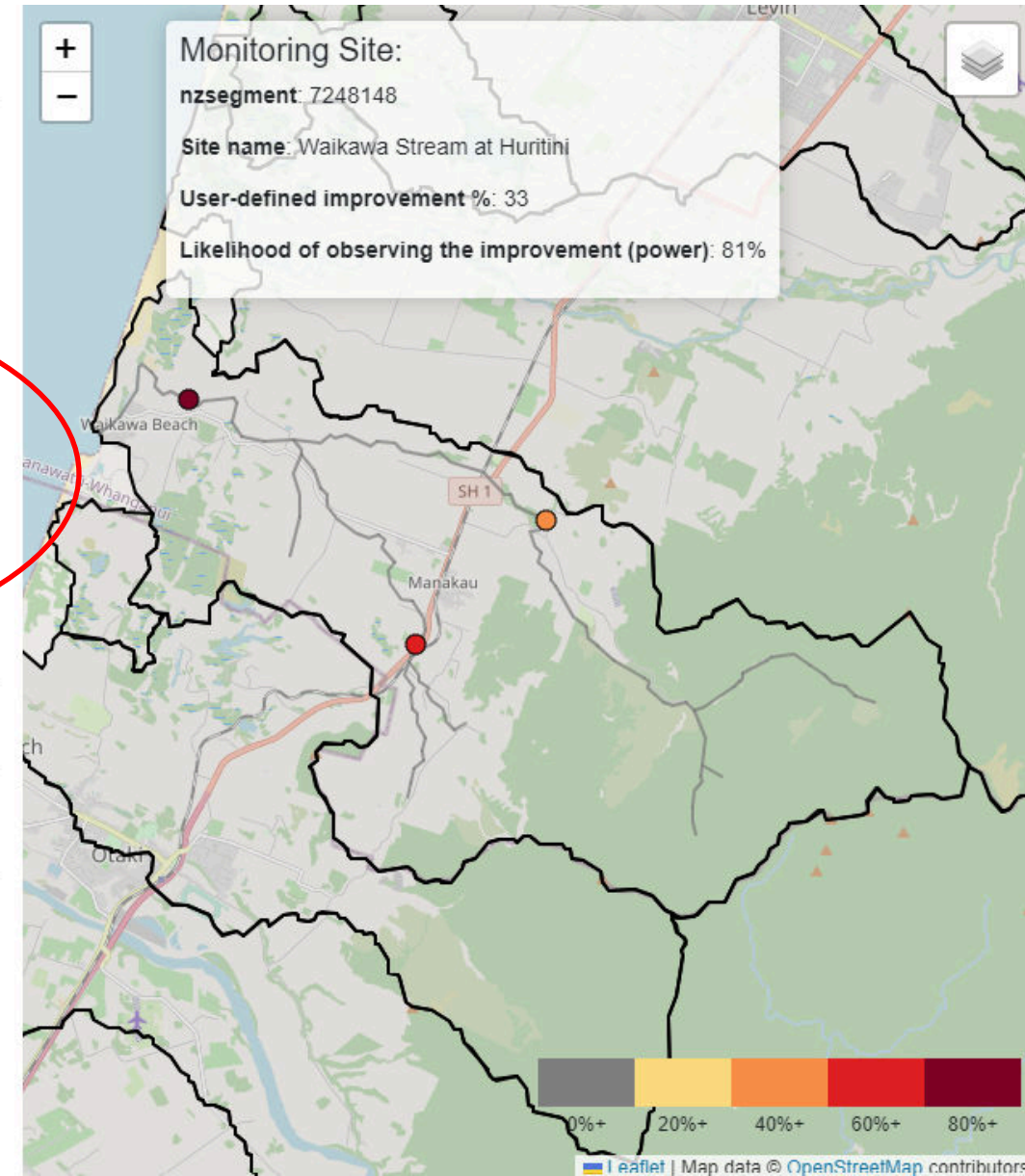
MCI

(2b) Type in a percent improvement by site under the "improvement %" column then press enter to confirm:

site name	improvement %
Manakau at S.H.1 Bridge	20
Waikawa Stream at Huritini	33
Waikawa at North Manakau Road	20

∨ (3) Query Options

∨ (4) Download Results



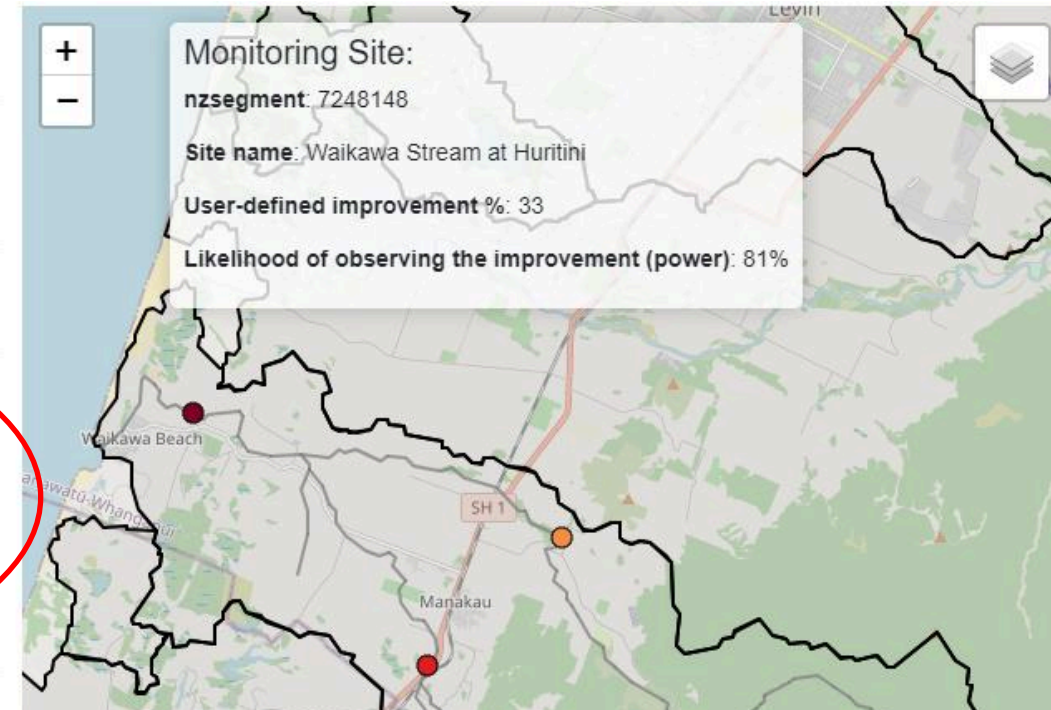
Step 3 (Alternative use): Estimate “minimum detectable change”  
Keep the sampling duration at 10 years to align with the regional planning timeframes and increase the improvement in step (2) until reaching a power near or above 80%.

► At the Waikawa at Huritini site, the App indicates that the change would need to be at least around 33% to be detectable in 10 years

# Step 4: Download results

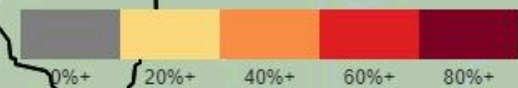
- ∨ (1) Catchment Selection
- ∨ (2) Select indicator and specify improvements by site
- ∨ (3) Query Options
- ∧ (4) Download Results
  - (4a) Download power results given the prior query options (csv):

[Download power results](#)



	A	B	C	D	E	F	G	H
1	nzsegment	improvement	indicator	n_years	n_sample	site name	power	
2	7248148	33	MCI	10	1	Waikawa	81	
3	7248627	20	MCI	10	1	Waikawa	55	
4	7249277	20	MCI	10	1	Manakau	71	

Step 4 download results as a csv file





Water Quality -  
Catchment

Water Quality -  
Monitoring Sites

Ecology - Site  
Prioritisation

Ecology -  
Monitoring Sites

Land Mitigation

High Flow Load  
Contributions

Mitigatable reductions in contaminant losses from land and predicted in-river contaminant load reductions

^ (1) Catchment Selection

(1a) Select a catchment on the map:

---

∨ (2) Select Contaminant

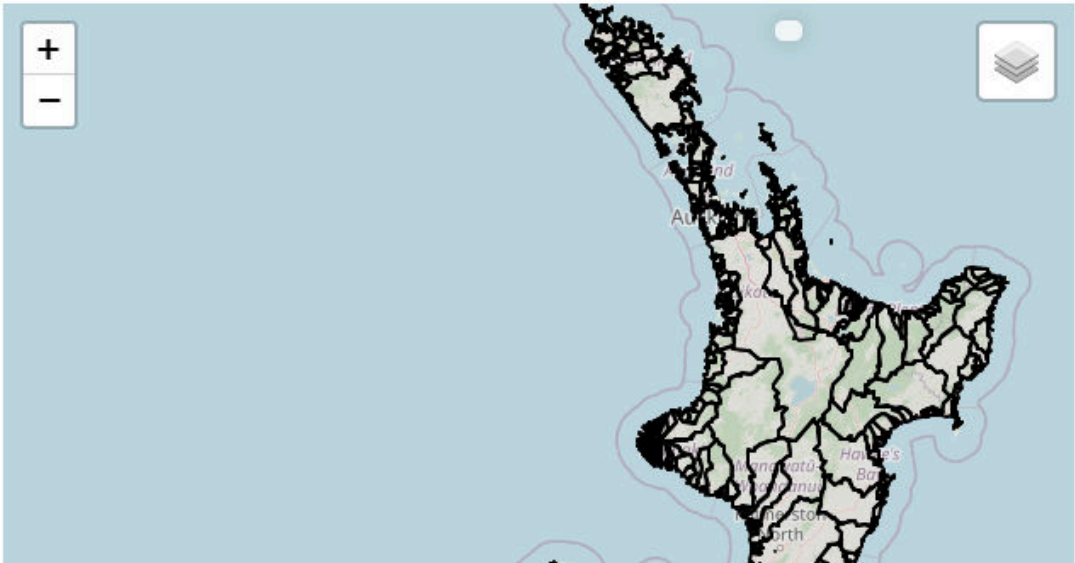
---

∨ (3) In-stream Improvements

---

∨ (4) Download Results

---



This module allows users to visualise default land mitigation information and predicted changes in contaminant loads in rivers

# Step 1: Catchment Selection

^ (1) Catchment Selection

(1a) Select a catchment on the map:

**3076139 - Pokaiwhenua Stream**

v (2) Select Contaminant

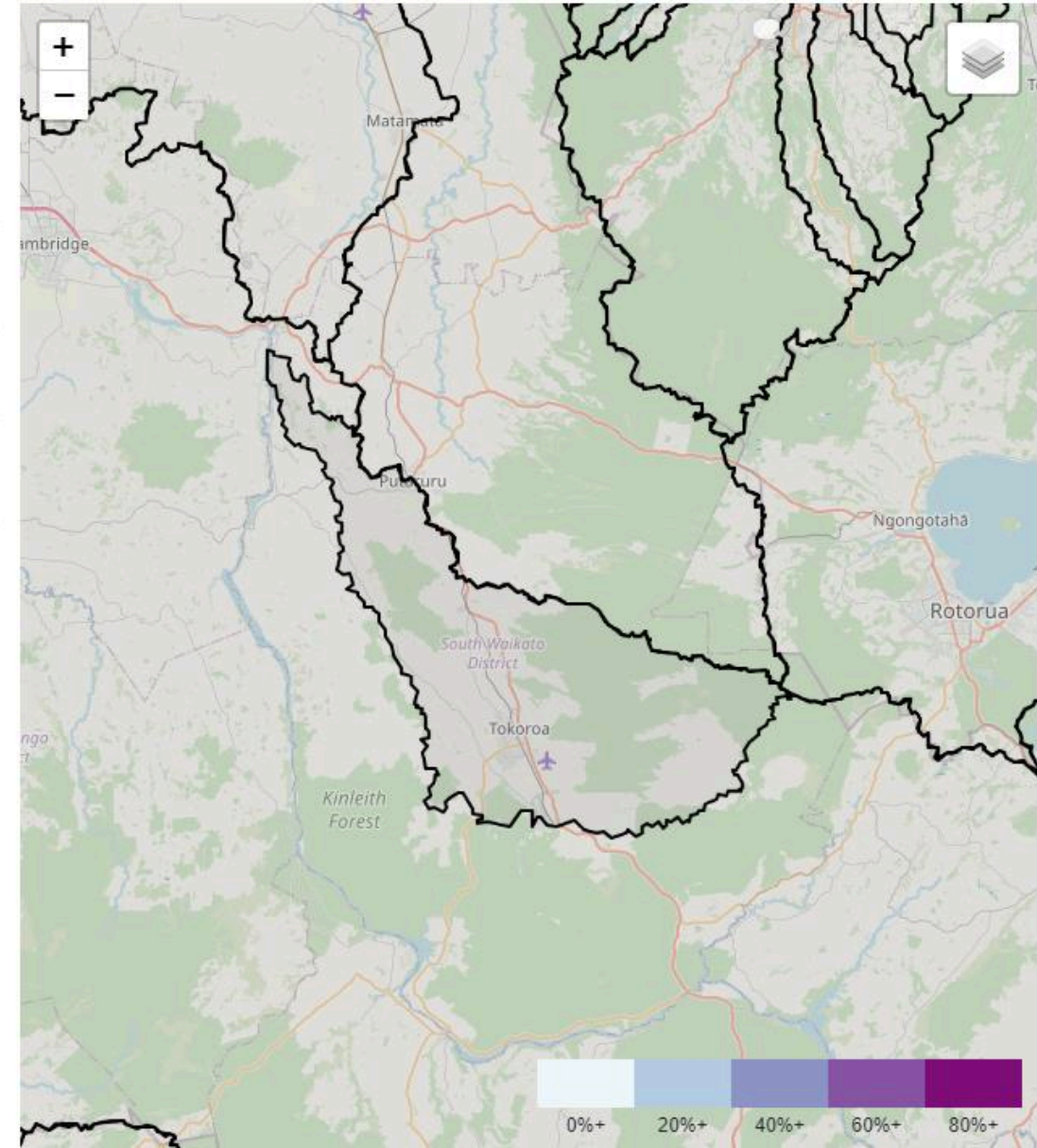
v (3) In-stream Improvements

v (4) Download Results

The Pokaiwhenua Stream is a tributary of the Waikato River. It is one of our case study catchments, in partnership with Ngāti Raukawa and the Pokaiwhenua Catchment Group.

The regional Plan (PPC1) requires water quality improvement in the short term (10 years) and long term (80 years).

For example, c. 10% reduction in nitrate-N in 10 years



## Step 2: Select a contaminant

▼ (1) Catchment Selection

▲ (2) Select Contaminant

(2a) Select Contaminant:

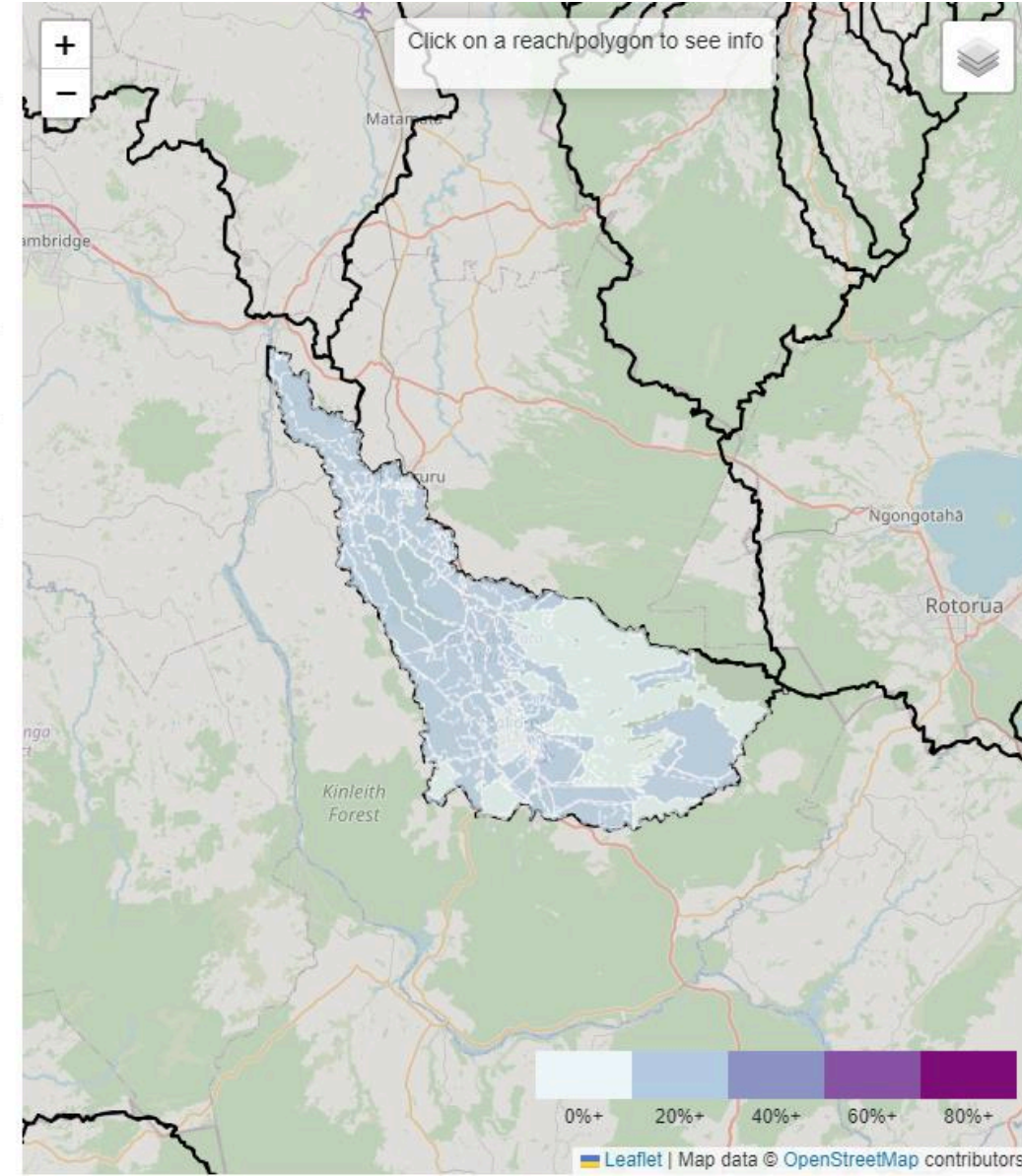
Total nitrogen

▼ (3) In-stream Improvements

▼ (4) Download Results

Step 2: Select one of the “big four” contaminants: TN, TP, Sediment or E.coli

Here we select TN, and the map presents a view of the “default” reductions in contaminant losses at source for each land cover of farm typology



## Step 2: Select a contaminant

∨ (1) Catchment Selection

∧ (2) Select Contaminant

(2a) Select Contaminant:

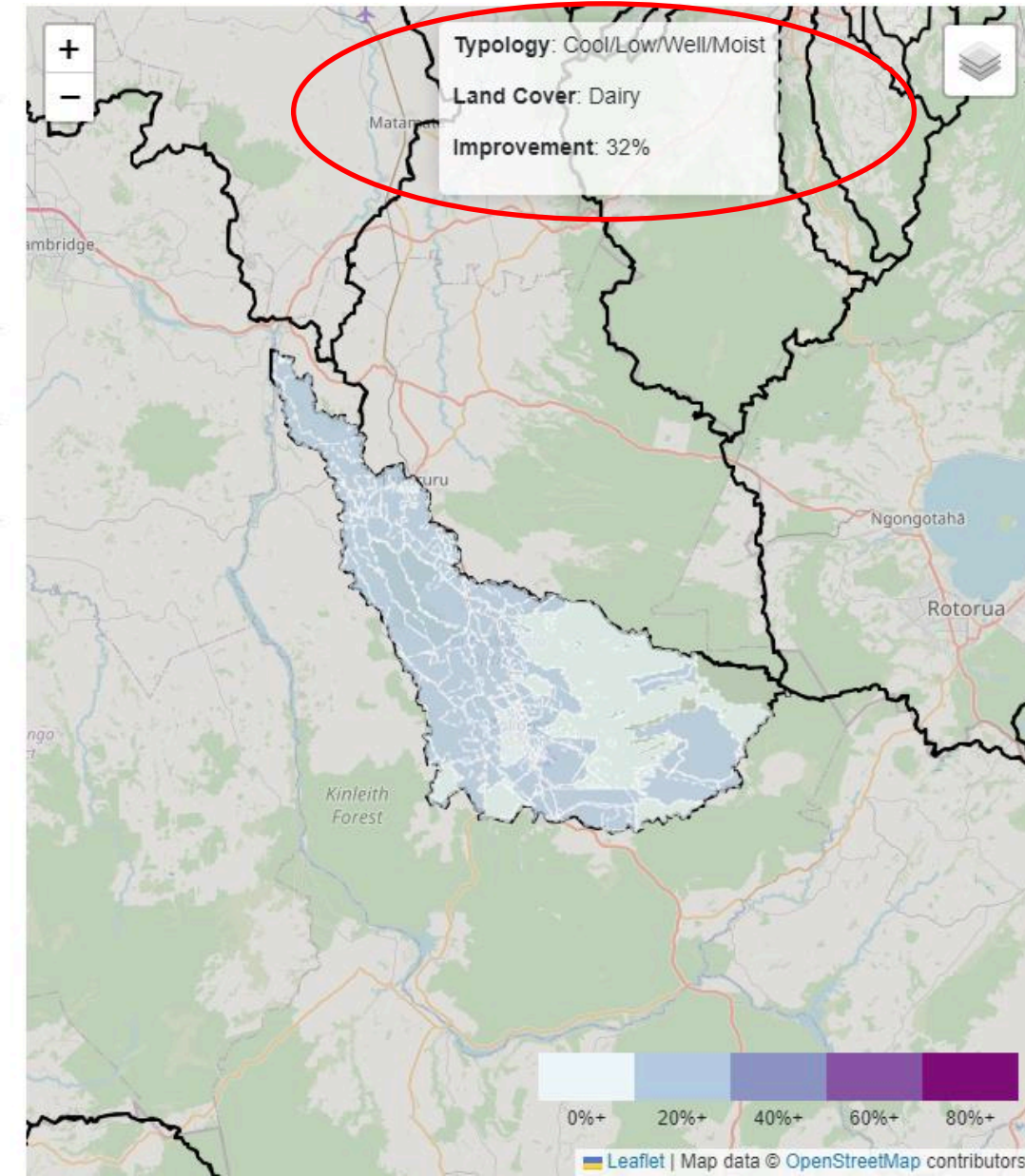
Total nitrogen

∨ (3) In-stream Improvements

∨ (4) Download Results

Example:

For this dairy typology, the “mitigatable” reduction in N losses from land is 32%. This is an estimated “maximum mitigatable” reduction assuming the implementation of all known mitigations



# Step 3: Visualise in-stream reductions in contaminant loads

∨ (1) Catchment Selection


∨ (2) Select Contaminant

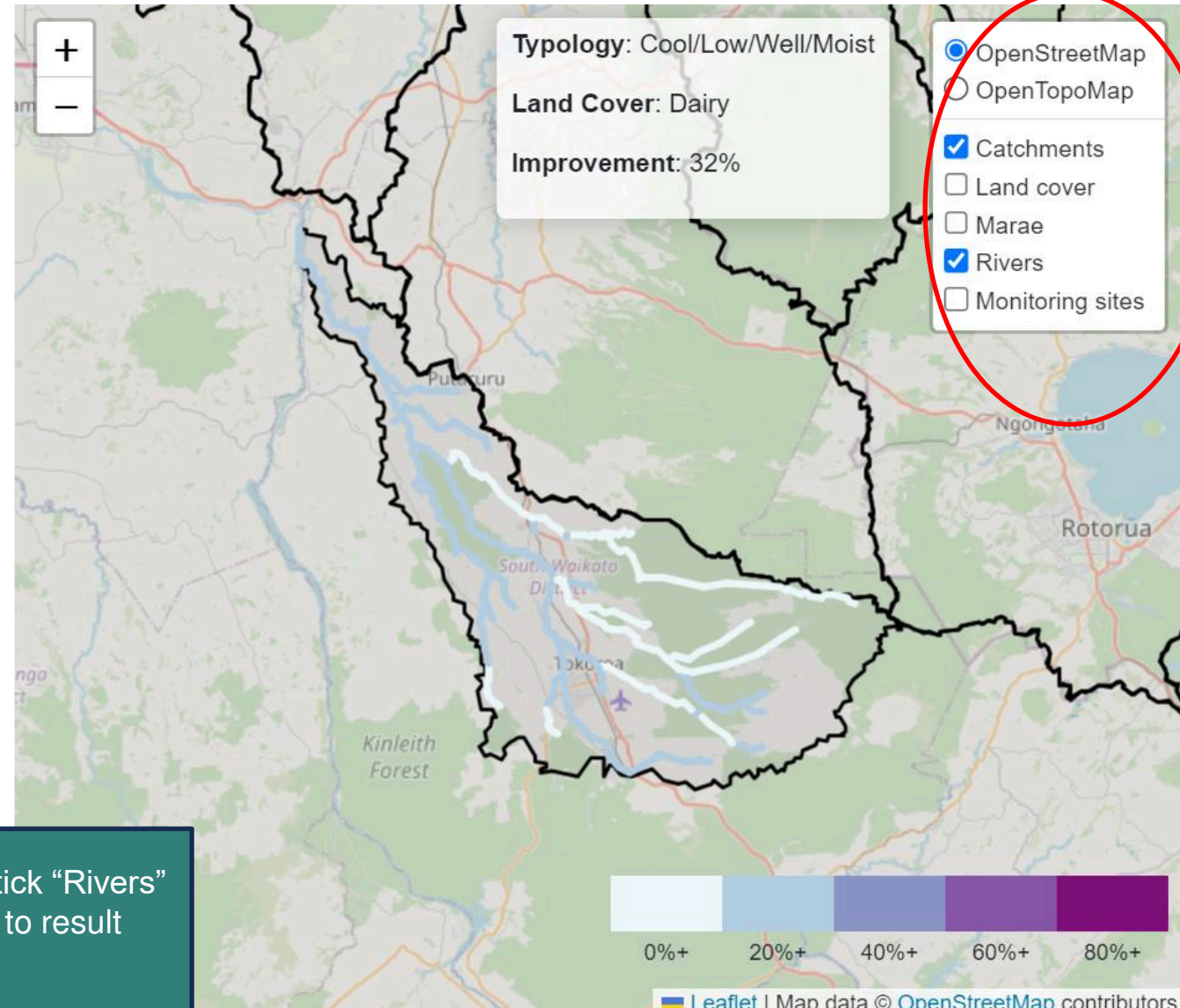
∧ (3) In-stream Improvements

(3a) Add the river reaches to the map via the layer button on the top right corner of the map, and the land cover can also be removed to more easily see the reaches.

(3b) Change the percent of the improvements applied. 100% is the max realistic improvement (**This option only applies to the river reaches**):



Click on  in the map's top right corner, untick "Land cover" and tick "Rivers" to visualise the reductions in in-stream contaminant loads predicted to result from land mitigation layer



## Step 3: Visualise in-stream reductions in contaminant loads

∨ (1) Catchment Selection

∨ (2) Select Contaminant

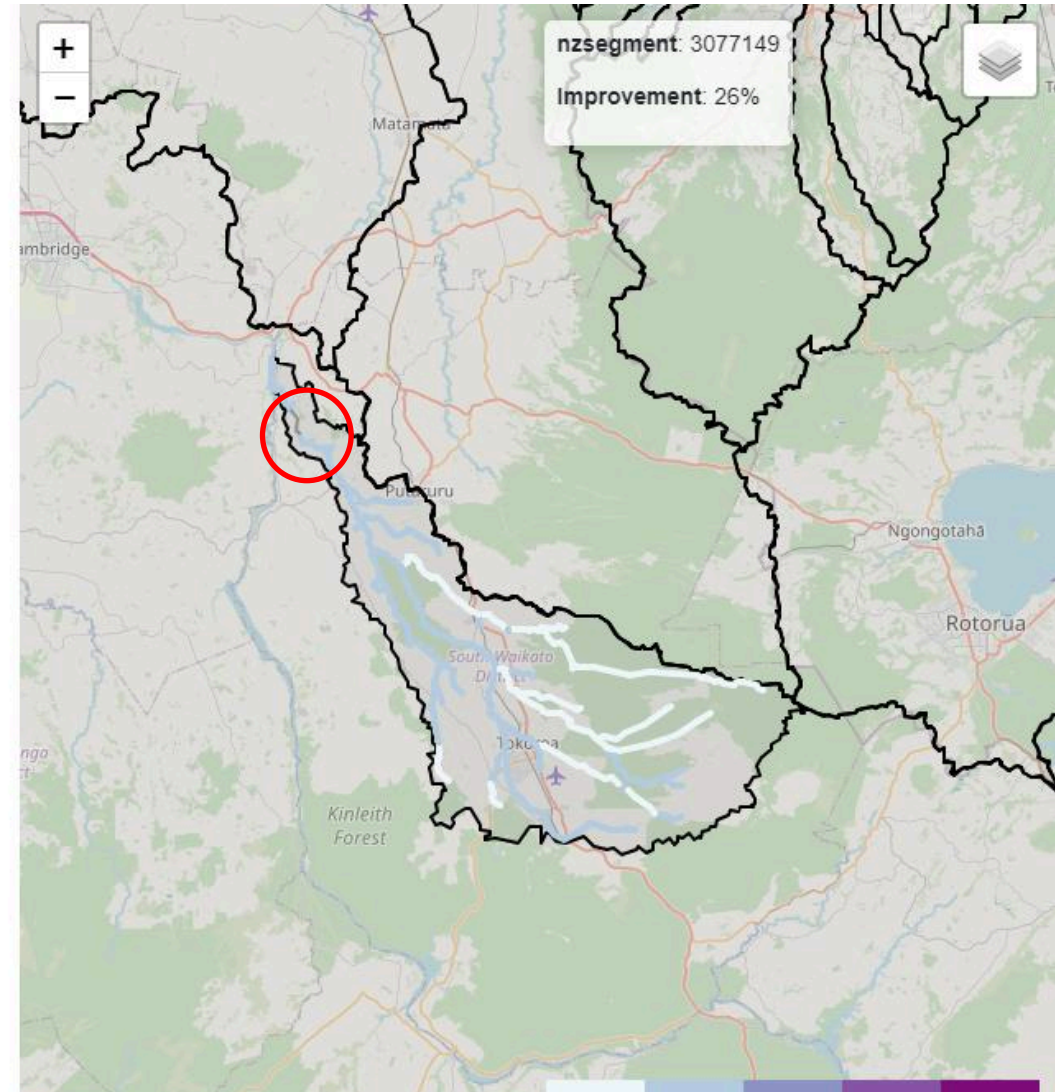
∧ (3) In-stream Improvements

(3a) Add the river reaches to the map via the layer button on the top right corner of the map, and the land cover can also be removed to more easily see the reaches.

(3b) Change the percent of the improvements applied. 100% is the max realistic improvement (**This option only applies to the river reaches**):



∨ (4) Download Results



Click on any stream reach to visualise the predicted reduction in contaminant load

▶ Lower Pokaiwhenua: a 26% reduction in TN annual load is predicted as a result of maximum mitigations

# Step 3: Visualise in-stream reductions in contaminant loads

∨ (1) Catchment Selection

∨ (2) Select Contaminant

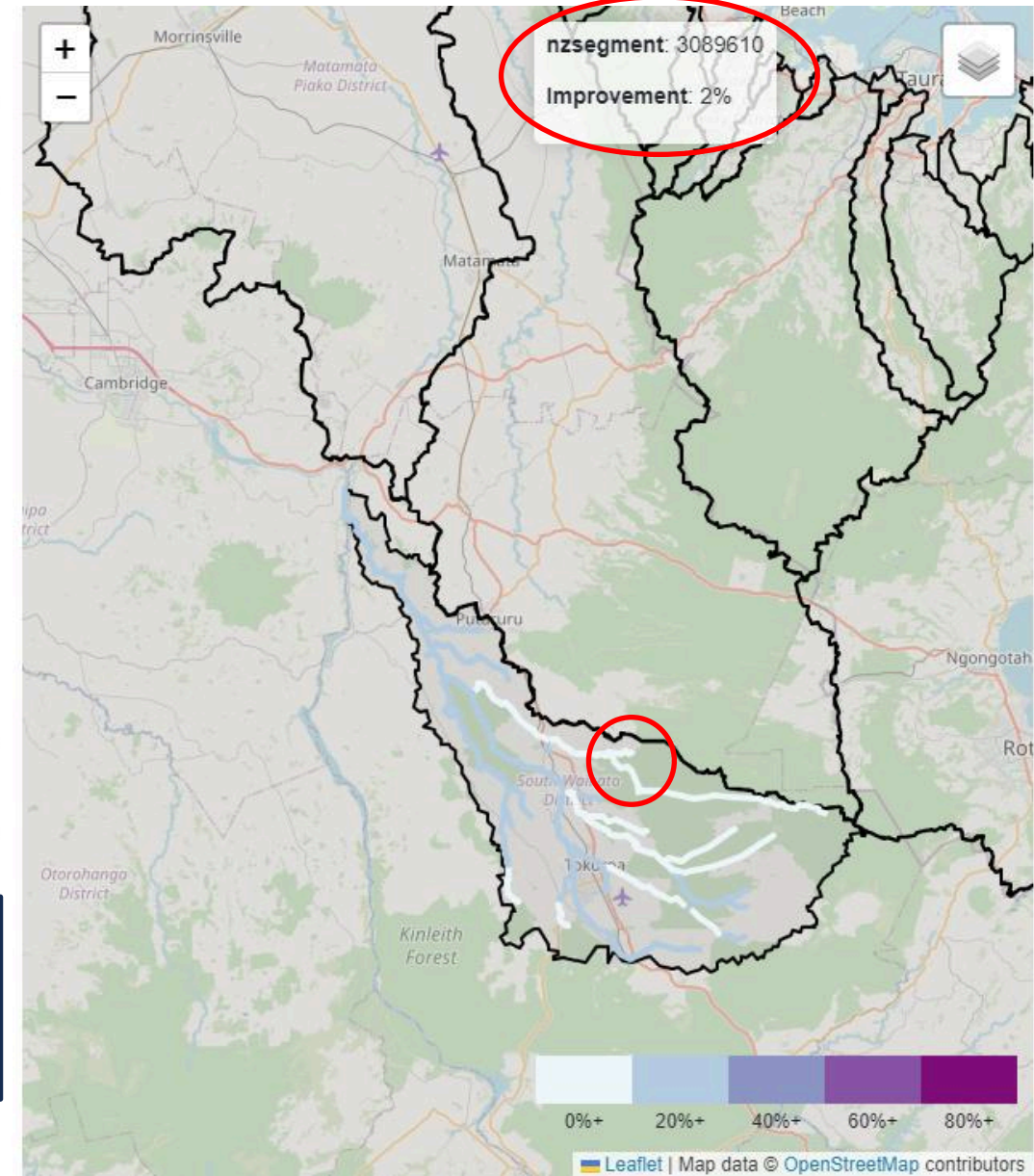
∧ (3) In-stream Improvements

(3a) Add the river reaches to the map via the layer button on the top right corner of the map, and the land cover can also be removed to more easily see the reaches.

(3b) Change the percent of the improvements applied. 100% is the max realistic improvement (**This option only applies to the river reaches**):



∨ (4) Download Results



Dependent on assumptions made for each land use /cover

▶ Forestry catchment: only 2% improvement (no N mitigations assumed in forestry)

## Step 3: Visualise in-stream reductions in contaminant loads

▼ (1) Catchment Selection

▼ (2) Select Contaminant

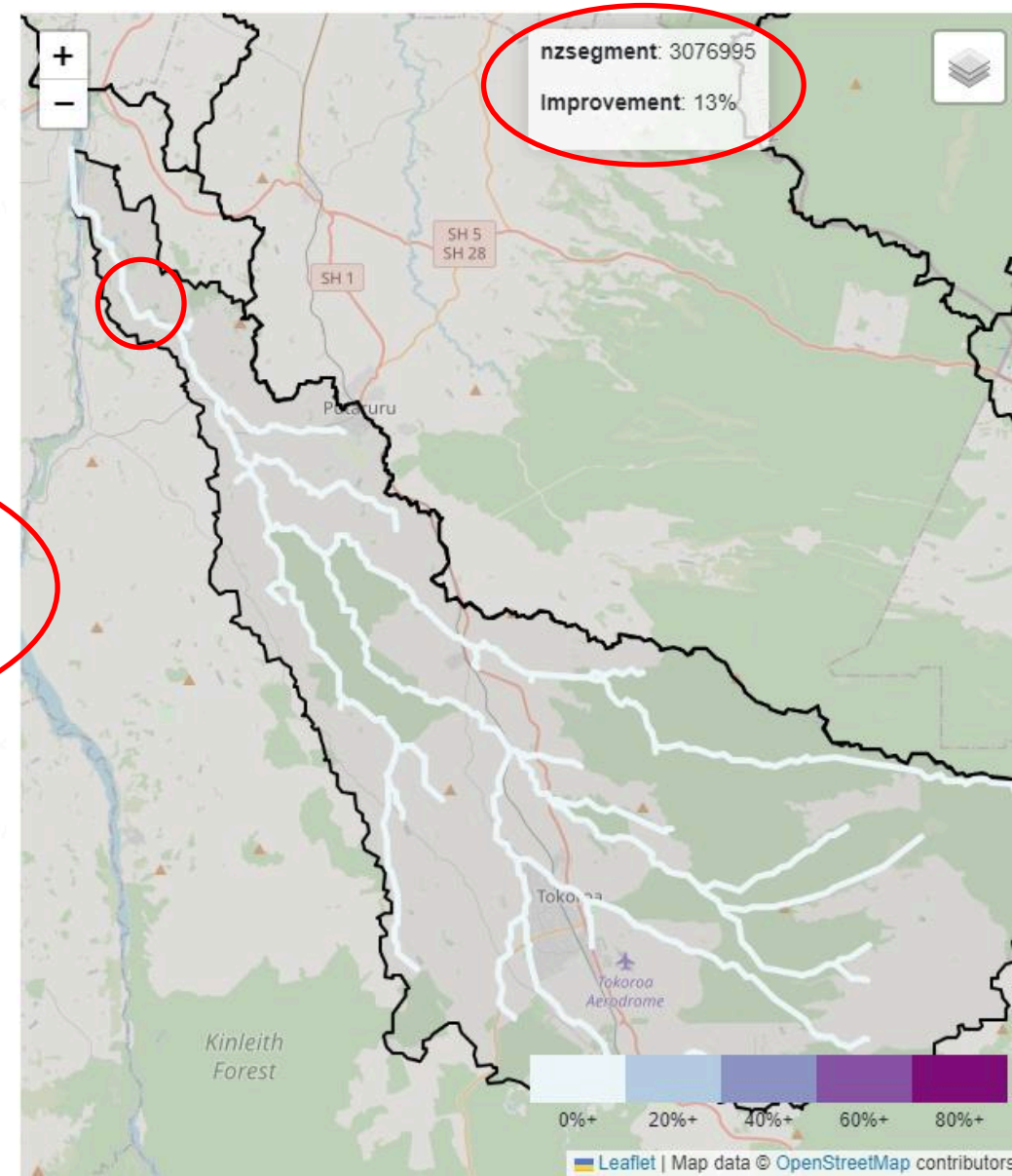
▲ (3) In-stream Improvements

(3a) Add the river reaches to the map via the layer button on the top right corner of the map, and the land cover can also be removed to more easily see the reaches.

(3b) Change the percent of the improvements applied. 100% is the max realistic improvement (**This option only applies to the river reaches**):



▼ (4) Download Results



Step 3b: adjust overall level of mitigation in the catchment as a proportion of the “mitigatable” reductions – 50% is half of the mitigatable reductions

► Lower Pokaiwhenua: 13% reduction in TN annual load is predicted



# “Water Quality – Catchment” Module

Water Quality -  
Catchment

Water Quality -  
Monitoring Sites

Ecology - Site  
Prioritisation

Ecology -  
Monitoring Sites

Land Mitigation

High Flow Load  
Contributions

Likelihood of detecting modelled water quality improvement in all river reaches of a catchment as a result of land mitigation

^ (1) Catchment Selection

(1a) Select a catchment on the map:

▾ (2 - Optional) Customise the Land Mitigation Layer

▾ (3) Query Options

▾ (4) Download Results

This module allows users to visualise the likelihood of detecting modelled water quality improvement in all river reaches of a catchment as a result of land mitigation

## Step 1: select catchment

## Step 2: customise the land mitigation layer

∨ (1) Catchment Selection

∧ (2 - Optional) Customise the Land Mitigation Layer

(2a) Download default Land Mitigation Layer as GPKG:

Download default layer

NOTE: Only modify existing values. Do not add additional columns; they will be ignored.

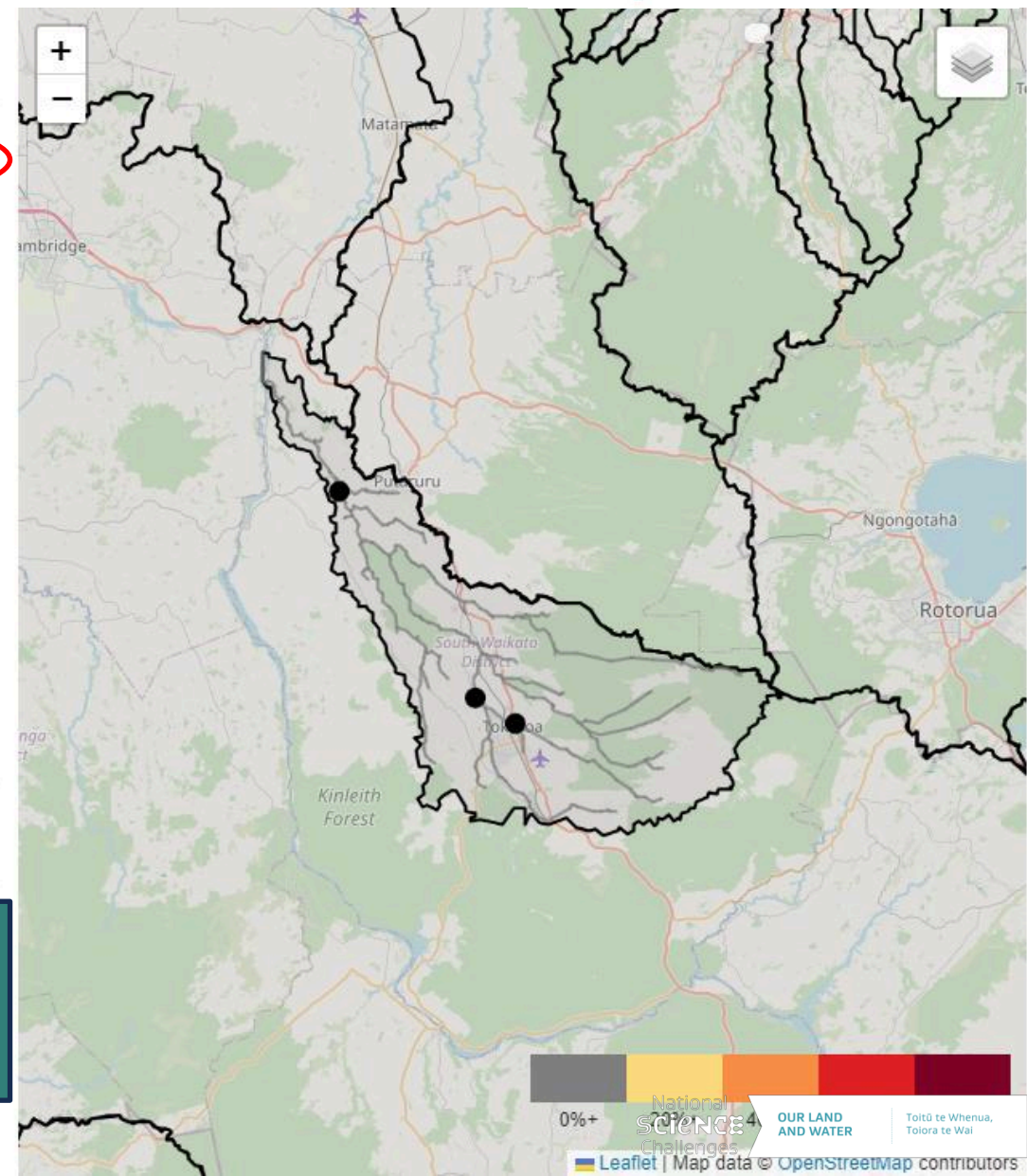
(2b) Upload modified Land Mitigation Layer as GPKG:

Upload modified layer

(2c) Process the modified Land Mitigation Layer and route the improvements downstream:

Process improvements

∨ (3) Query Options



It is important that the mitigations (nature, location and effectiveness) are user-defined

► Modified land mitigation layer for Pokaiwhenua based on likely mitigations within the next 10 years

# Step 1: select catchment

# Step 2: customise the land mitigation layer

∨ (1) Catchment Selection

∧ (2 - Optional) Customise the Land Mitigation Layer

(2a) Download default Land Mitigation Layer as GPKG:

[Download default layer](#)

NOTE: Only modify existing values. Do not add additional columns; they will be ignored.

(2b) Upload modified Land Mitigation Layer as GPKG:

[Upload modified layer](#)

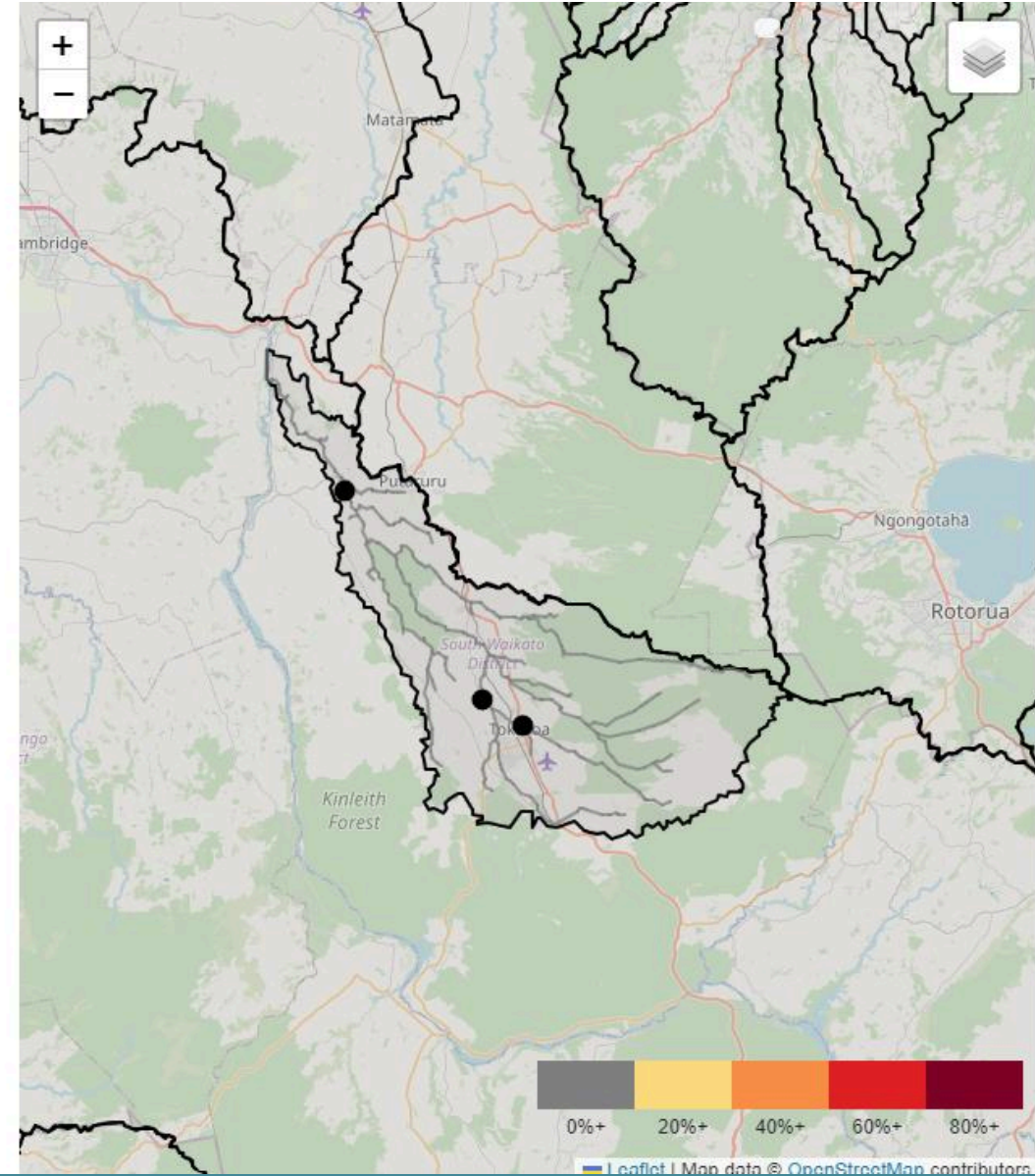
Upload successful

(2c) Process the modified Land Mitigation Layer and route the improvements downstream:

[Process improvements](#)

∨ (3) Query Options

∨ (4) Download Results



## Step 3: Select indicator and sampling duration and frequency

∨ (1) Catchment Selection

∨ (2 - Optional) Customise the Land Mitigation Layer

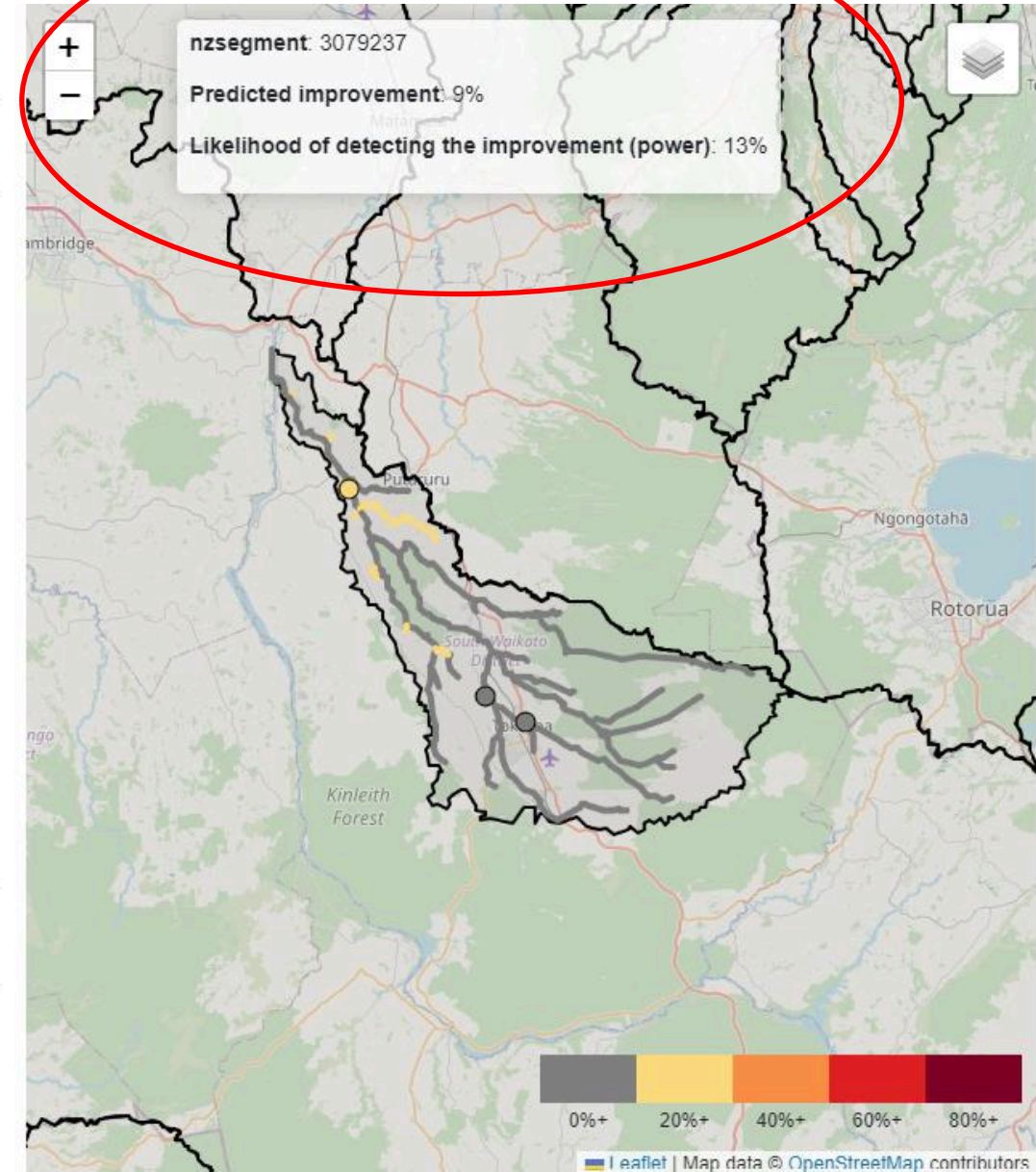
∧ (3) Query Options

(3a) Select Indicator:  
Nitrate nitrogen

(3b) Select sampling duration (years):  
5 10 20 30

(3c) Select sampling frequency:  
quarterly monthly fortnightly weekly biweekly daily

(3d) Select the percentage of the maximum contaminant loss reductions applied: ?  
0% 20% 40% 60% 80% 100%



Step 3a: Select one of the water quality indicators – here we select nitrate-N  
Click on any stream reach to visualise predicted improvement

► Lower Pokaiwhenua: a 9% improvement in nitrate-N concentrations annual load is predicted, which is consistent with PC1 10 year improvement targets

## Step 3: Select indicator and sampling duration and frequency

▼ (1) Catchment Selection

▼ (2 - Optional) Customise the Land Mitigation Layer

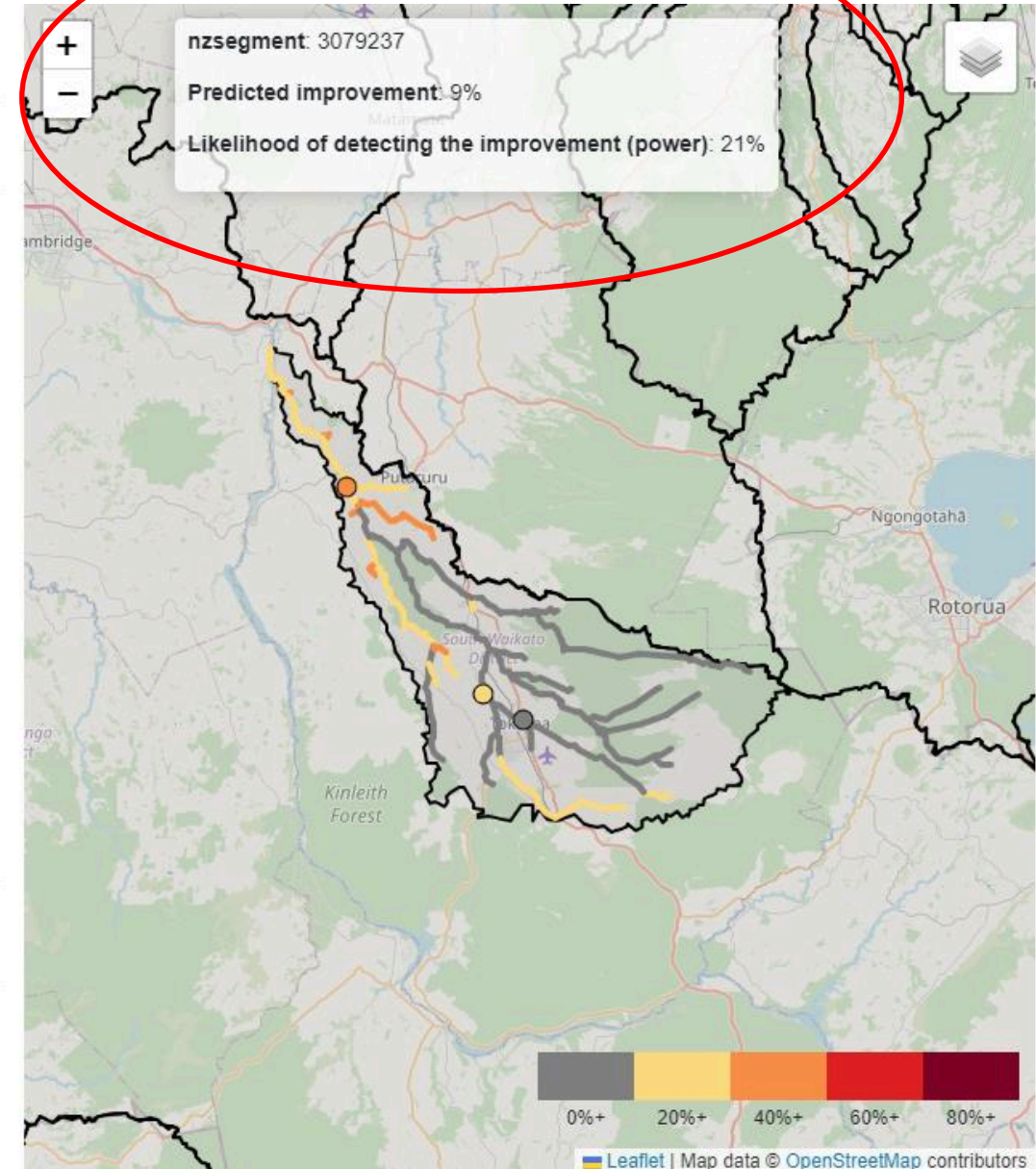
^ (3) Query Options

(3a) Select Indicator:  
Nitrate nitrogen

(3b) Select sampling duration (years):  
5 10 20 30

(3c) Select sampling frequency:  
quarterly monthly fortnightly weekly biweekly daily

(3d) Select the percentage of the maximum contaminant loss reductions applied: ?  
0% 20% 40% 60% 80% 100%



Step 3b: Select Sampling duration and frequency  
The map is colour coded according to predicted power  
Click on any stream reach to visualise likelihood of detecting change

► Lower Pokaiwhenua: monthly data over 10 years will be insufficient to detect the predicted 9% improvement (21% power)

# Step 3: Select indicator and sampling duration and frequency

▼ (1) Catchment Selection

---

▼ (2 - Optional) Customise the Land Mitigation Layer

---

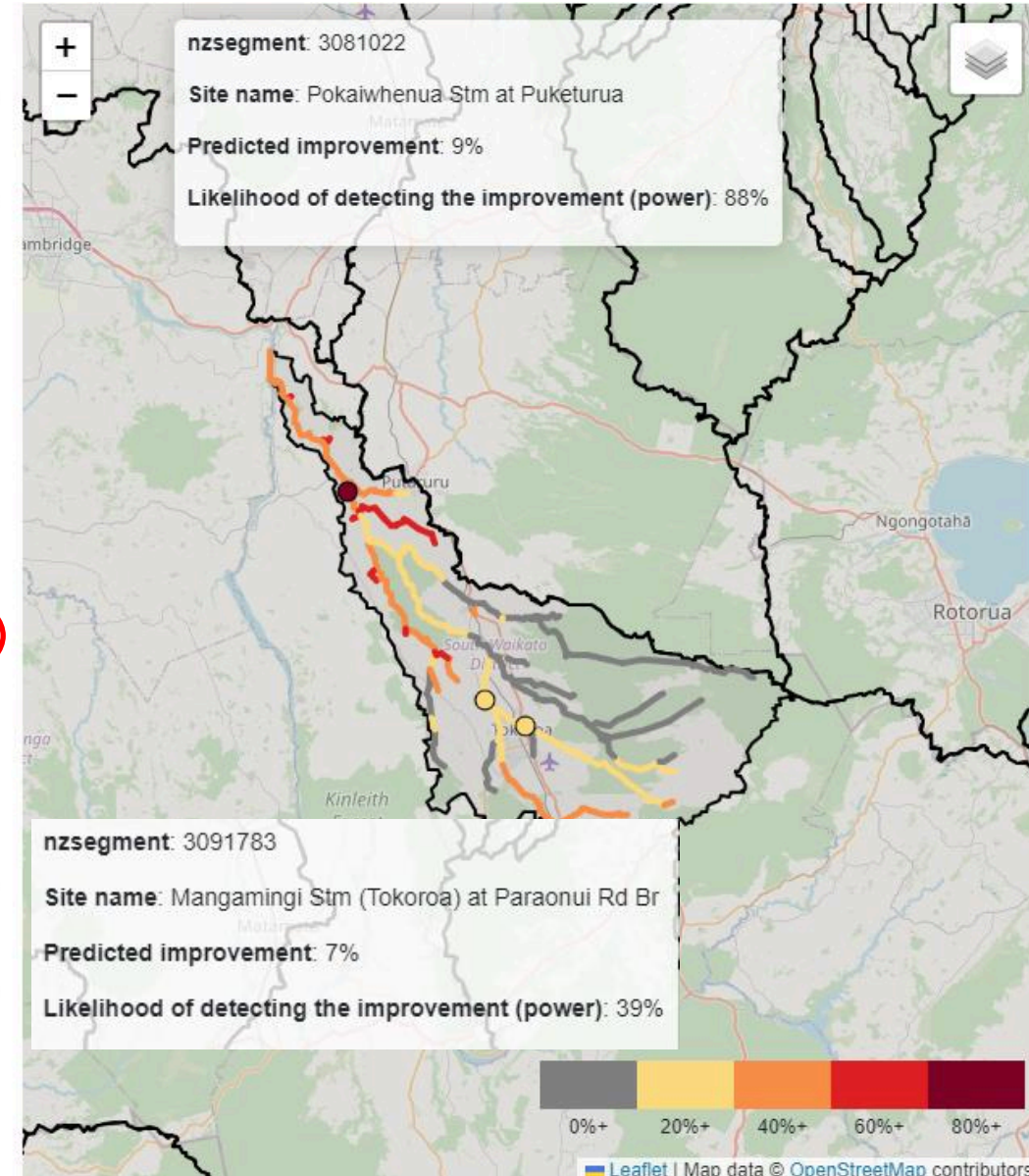
^ (3) Query Options

(3a) Select Indicator:  
Nitrate nitrogen

(3b) Select sampling duration (years):  
5 10 20 30

(3c) Select sampling frequency:  
quarterly monthly **fortnightly** weekly biweekly daily

(3d) Select the percentage of the maximum contaminant loss reductions applied: ?  
0% 20% 40% 60% 80% 100%



Step 3b: Increase frequency to fortnightly, click on existing monitoring sites

► Fortnightly sampling sufficient at lower Pokaiwhenua site, but not at upper catchment sites (Mangamingi and Whakauru)

## Step 3: Select indicator and sampling duration and frequency

∨ (1) Catchment Selection

---

∨ (2 - Optional) Customise the Land Mitigation Layer

---

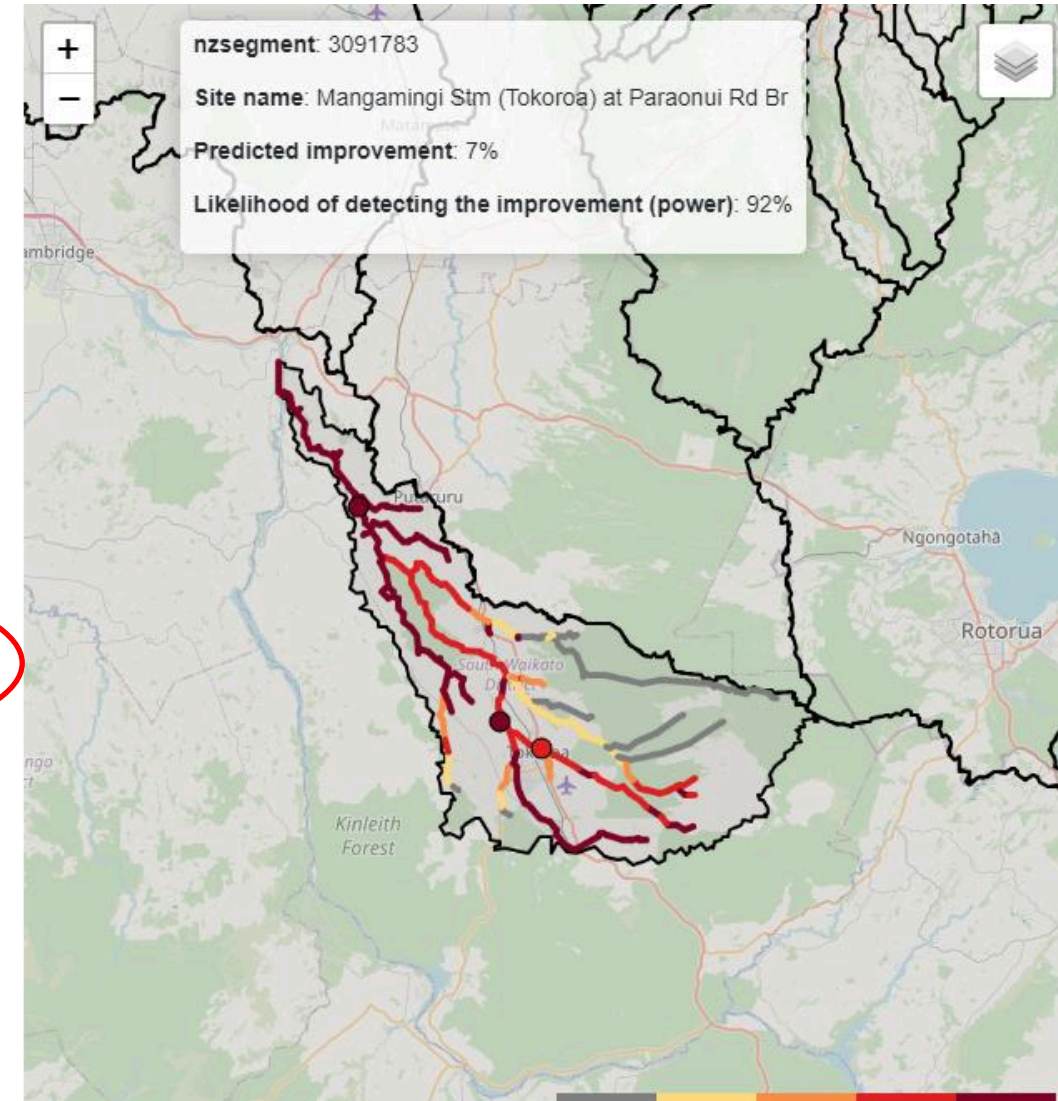
∧ (3) Query Options

(3a) Select Indicator:  
Nitrate nitrogen

(3b) Select sampling duration (years):  
5 10 20 30

(3c) Select sampling frequency:  
quarterly monthly fortnightly weekly **biweekly** daily

(3d) Select the percentage of the maximum contaminant loss reductions applied: ?  
0% 20% 40% 60% 80% 100%



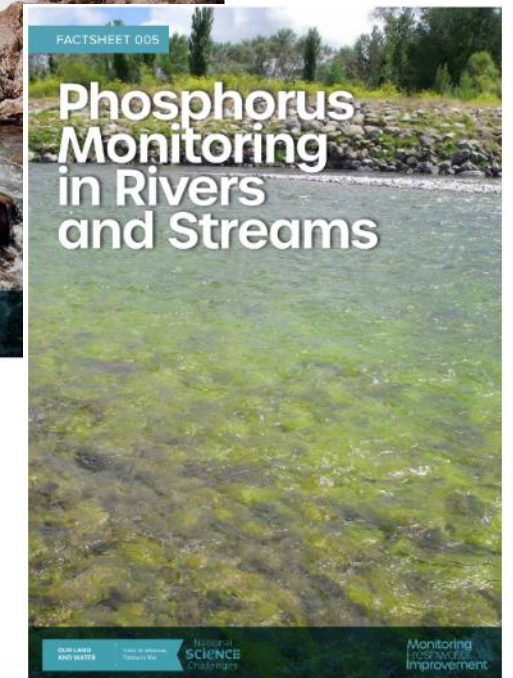
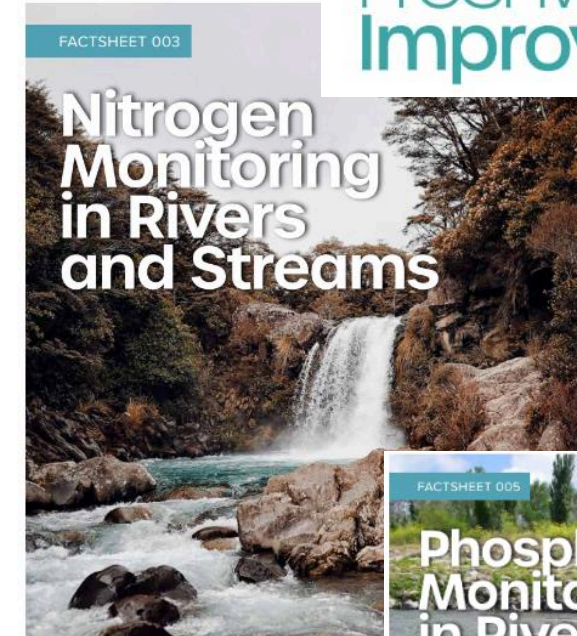
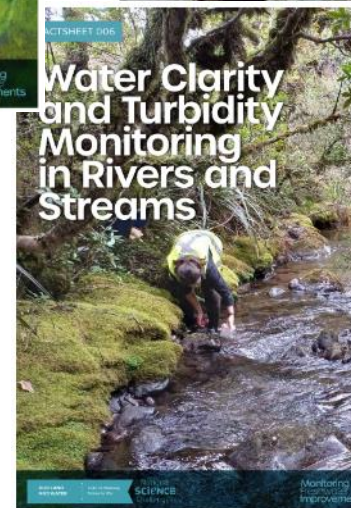
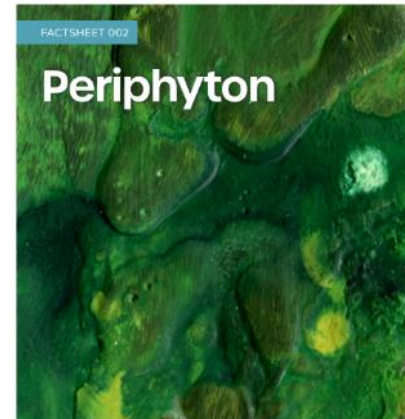
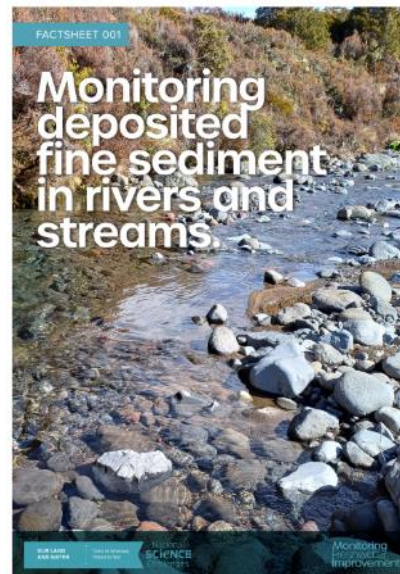
Step 3b: Increase frequency to weekly then bi-weekly, click on existing monitoring sites

- ▶ Biweekly sampling required at Mangamingi site
- ▶ Consider high frequency sampling

## Monitoring factsheets developed

13 Monitoring factsheets

- Description
- Links to values
- Links to NEMS
- Technologies available
- Monitoring costs



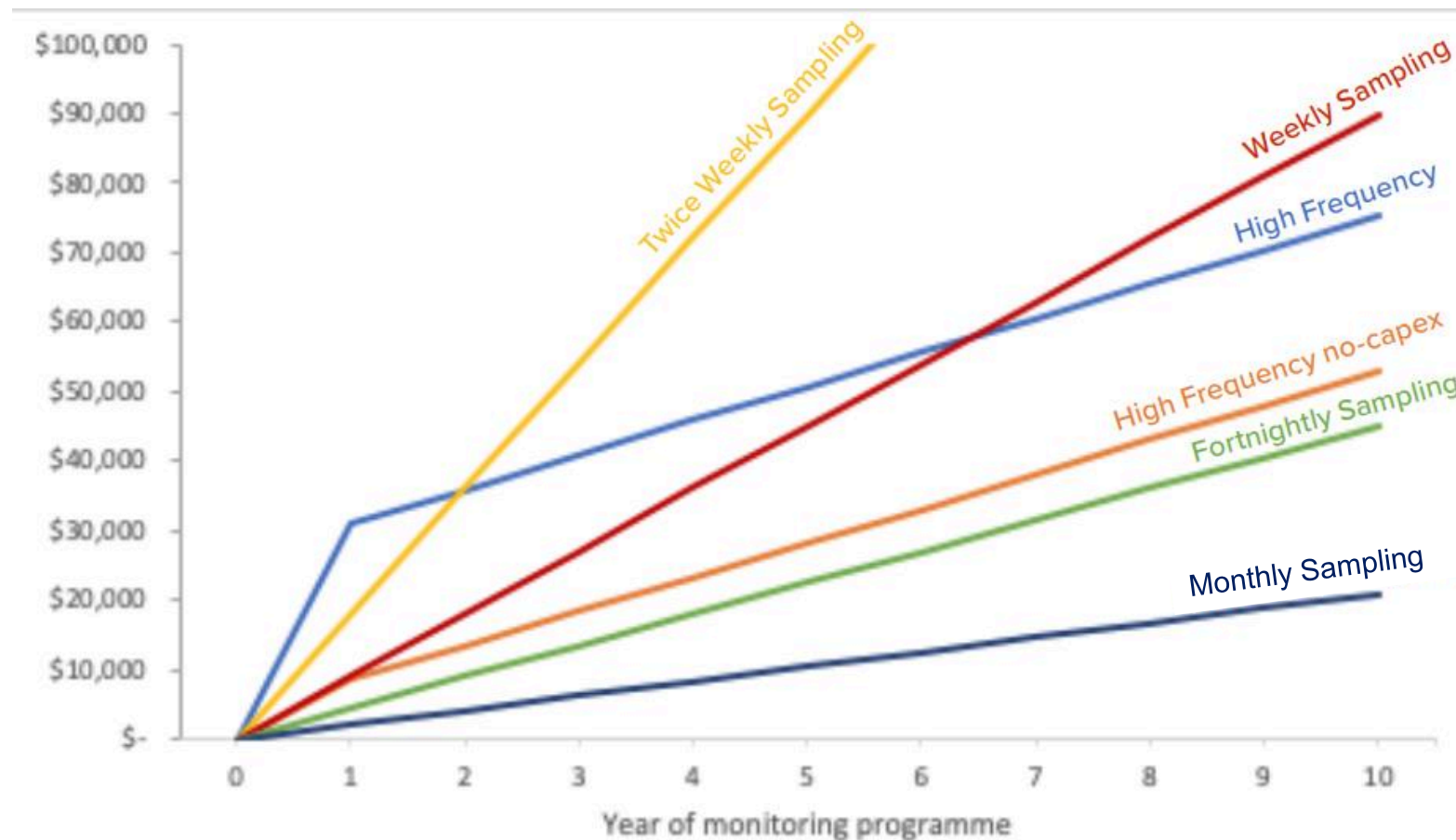


# Monitoring costs

## Nitrate monitoring costs

### Monitoring costs:

- Capex
- Lab costs
- Sampling
- Data QA/QC
- NEMS compliance



Average monitoring costs obtained from 4 large regional councils, include all costs associated with a standard State of the Environment monitoring programme, including data QA/QC.

- ▶ High frequency monitoring (including capex) is more expensive than monthly or fortnightly monitoring but becomes cheaper than weekly sampling from about 6 years
- ▶ When capex are excluded, high frequency monitoring costs are similar to fortnightly sampling

# “High Flow Load Contributions” Module

Water Quality - Catchment

Water Quality - Monitoring Sites

Ecology - Site Prioritisation

Ecology - Monitoring Sites

Land Mitigation

High Flow Load Contributions

Proportion of annual contaminant loads during high river flows



This provides the estimated proportion of annual contaminant loads during high river flows, at c. 350 monitored sites and modelled across the stream network

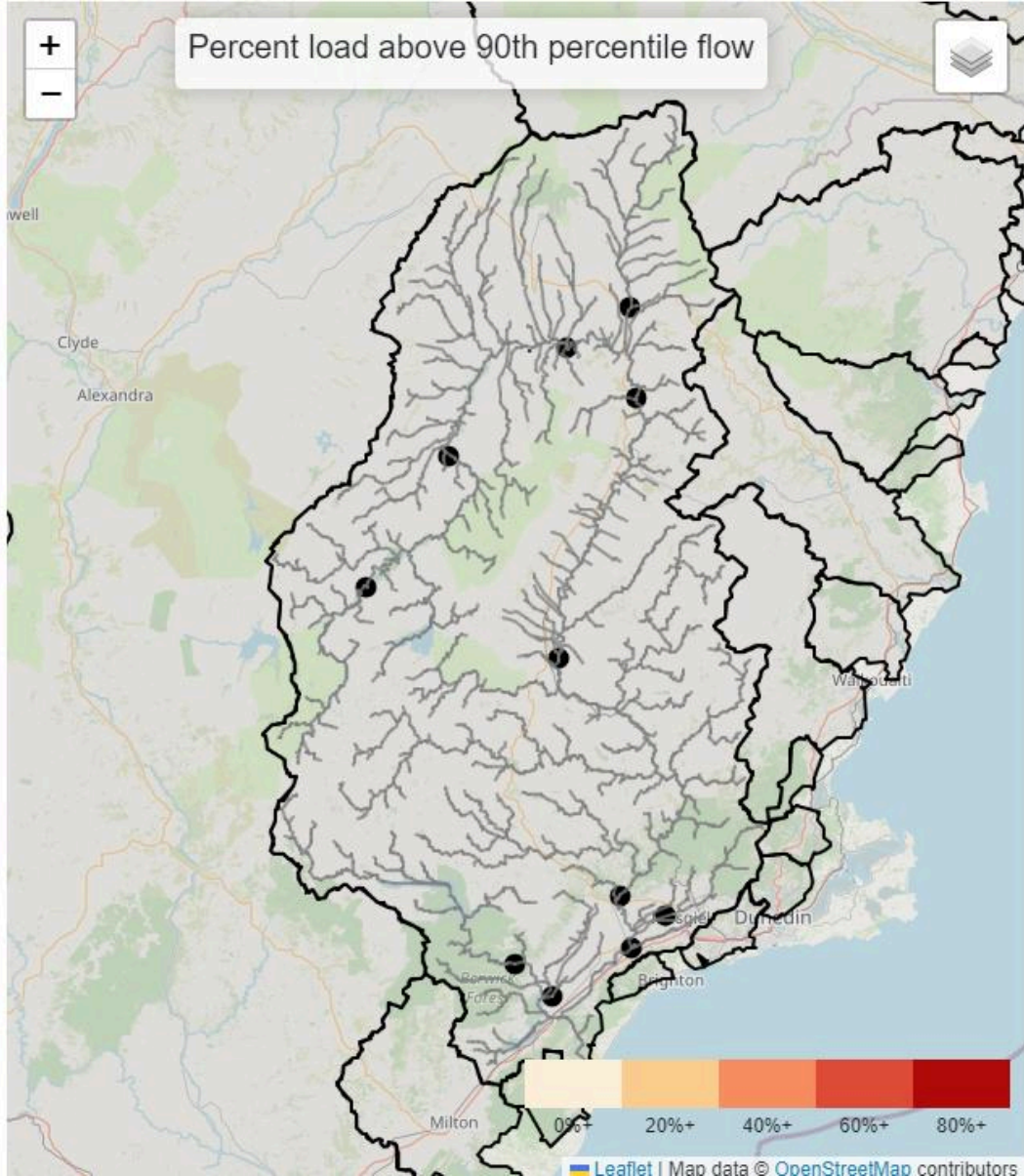
# Step 1: Catchment Selection

^ (1) Catchment Selection

(1a) Select a catchment on the map:

**14295077 - Taieri River**

∨ (2) Select Indicator



## Step 2: Select Indicator

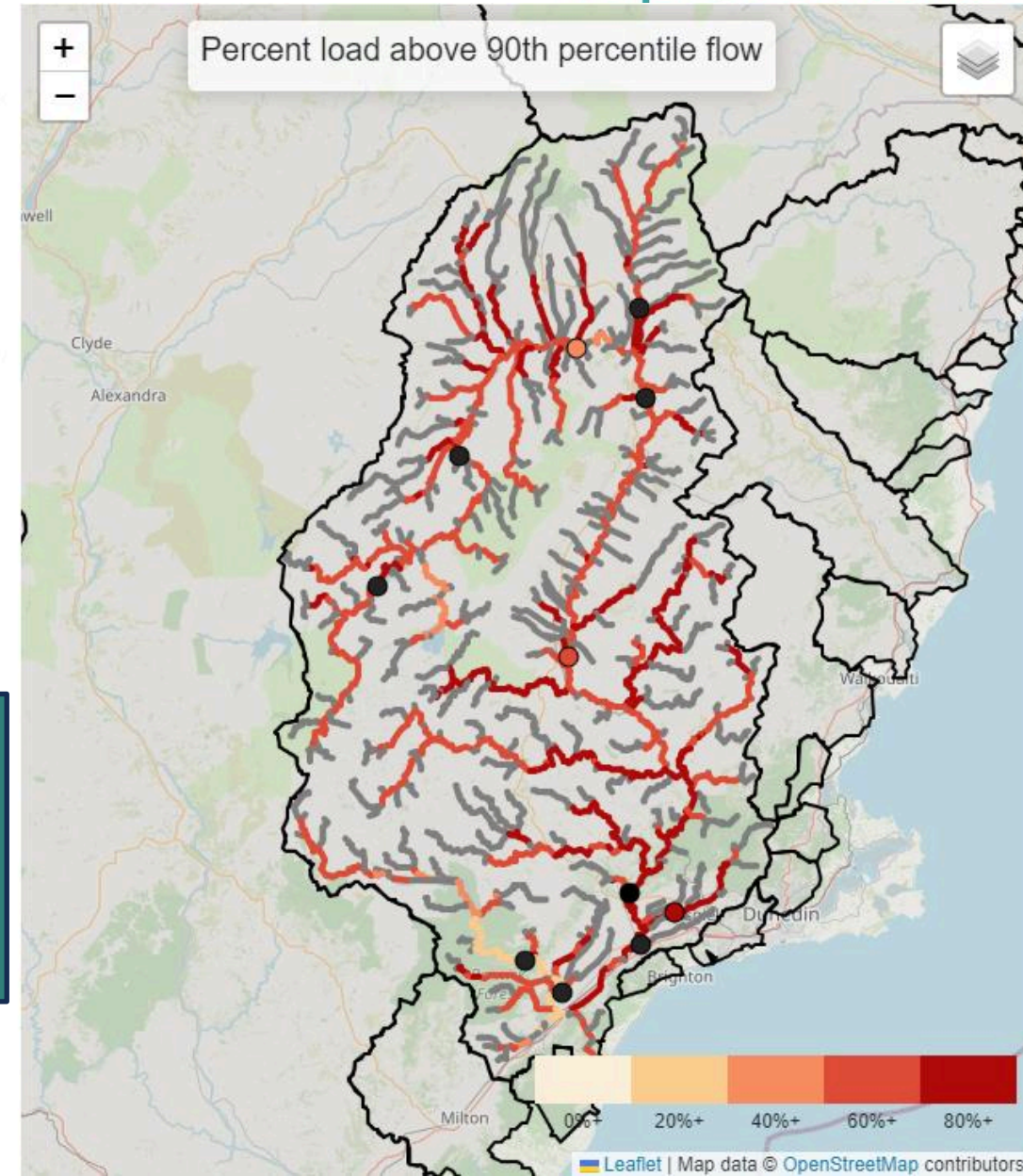
▼ (1) Catchment Selection

^ (2) Select Indicator

(2a) Select Indicator:

Total phosphorus

Taiari River catchment  
Coloured dots show monitoring sites with sufficient water quality and flow (discharge) data for WRTDS load estimates (black dots: site with no flow data)



## Step 2: Select Indicator

∨ (1) Catchment Selection

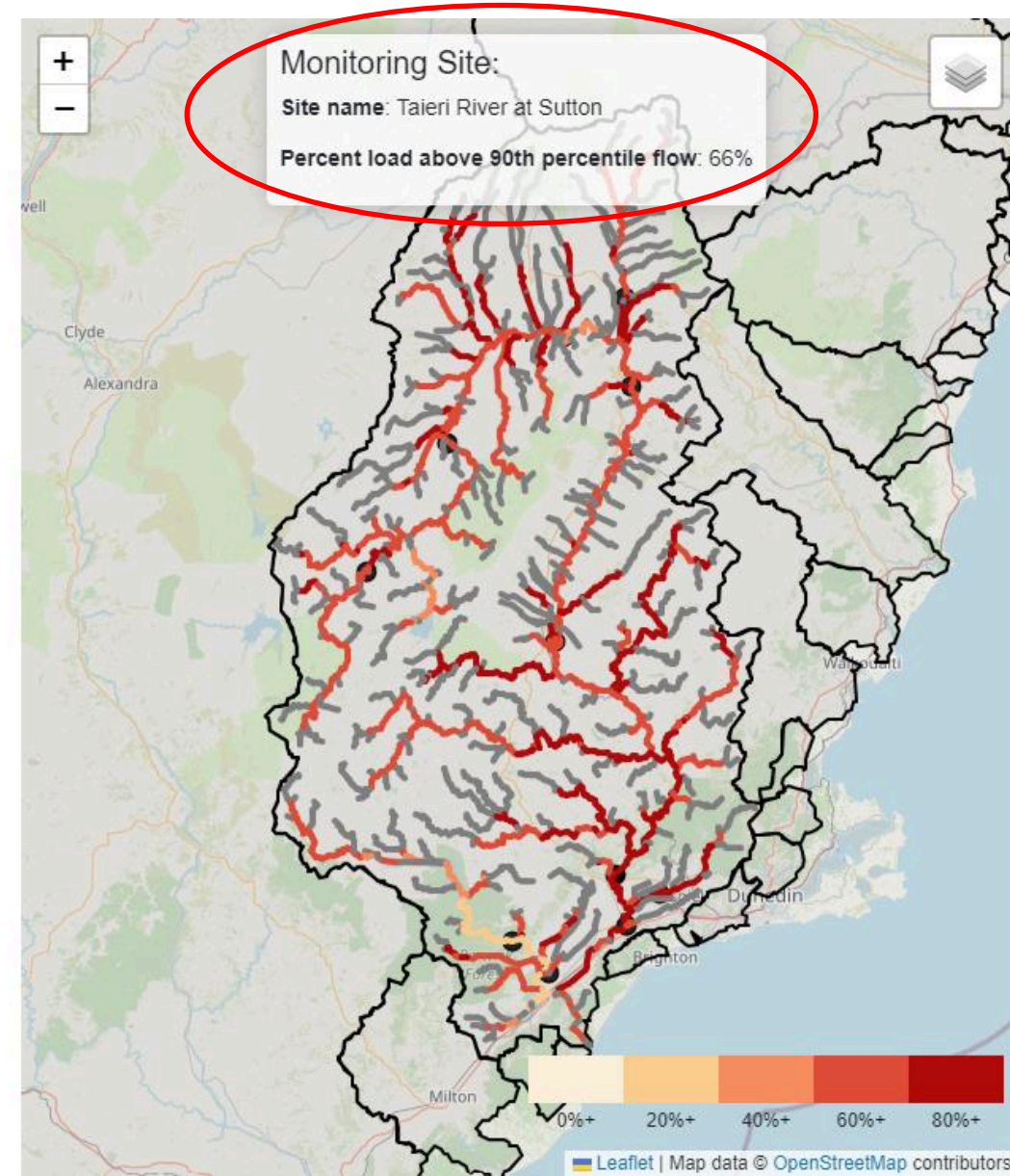
∧ (2) Select Indicator

(2a) Select Indicator:

Total phosphorus

Click on a site or any stream reach to visualise estimated proportion of annual load transported at river flows above the 90<sup>th</sup> percentile flow (10% highest flows)

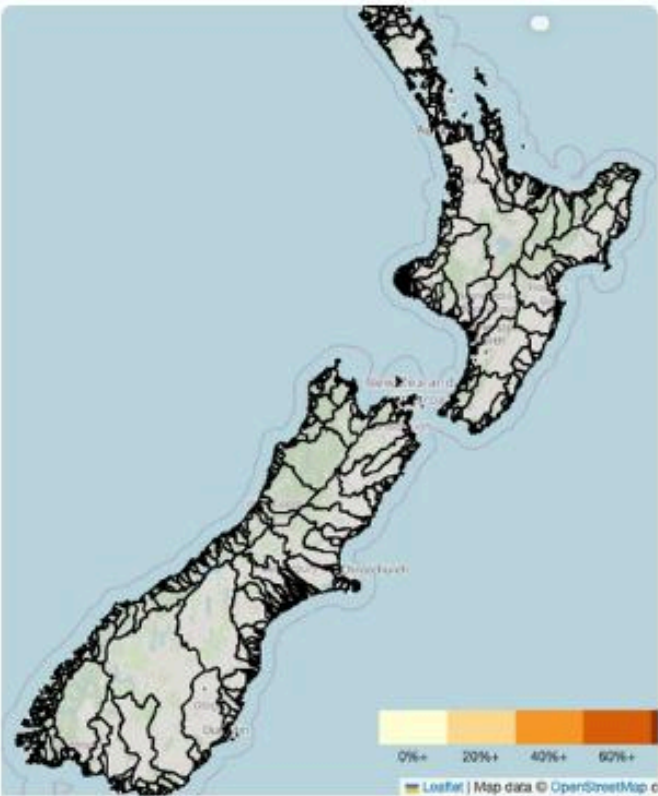
- ▶ Taieri at Sutton: 66% of TP load estimated to be transported at high river flows
- ▶ Provides an estimation of the “risk” of inaccurate load estimates if high river flow events are not well represented in sampling



# WebApp Dashboards

The WebApp contains three dashboards relating to different freshwater environments.  
Within each dashboard there are modules to help design or review of monitoring programmes for detecting improvements.

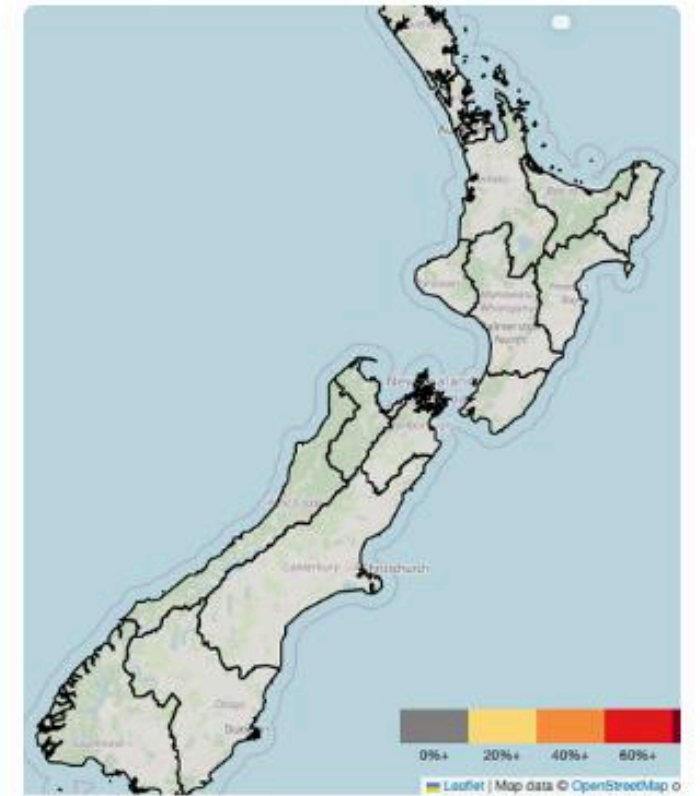
## Rivers



## Lakes



## Groundwater



# Lakes Dashboard

The Lakes and Lagoons dashboard can be used to assess the likelihood of a monitoring programme to detect improvements in the four indicators. The improvements can be specified as target improvements at existing monitoring sites or as expected improvements resulting from land-based mitigations.

The indicators of lake water quality available in the dashboard are: chlorophyll *a*, secchi depth, total nitrogen and total phosphorus.

*WebApp User Guide in development (available Dec 2023)*

Lake Catchments

Lake Sites

Likelihood of detecting user-specified water quality improvements in monitored and unmonitored lakes

^ (1) Lake Selection

(1a) Select a lake/lagoon on the map:

∨ (2) Define Indicator and improvements by site/lake

∨ (3) Query Options

∨ (4) Download Results

# “Lake Sites” module

∨ (1) Lake Selection

∧ (2) Define Indicator and improvements by site/lake

(2a) Select Indicator:

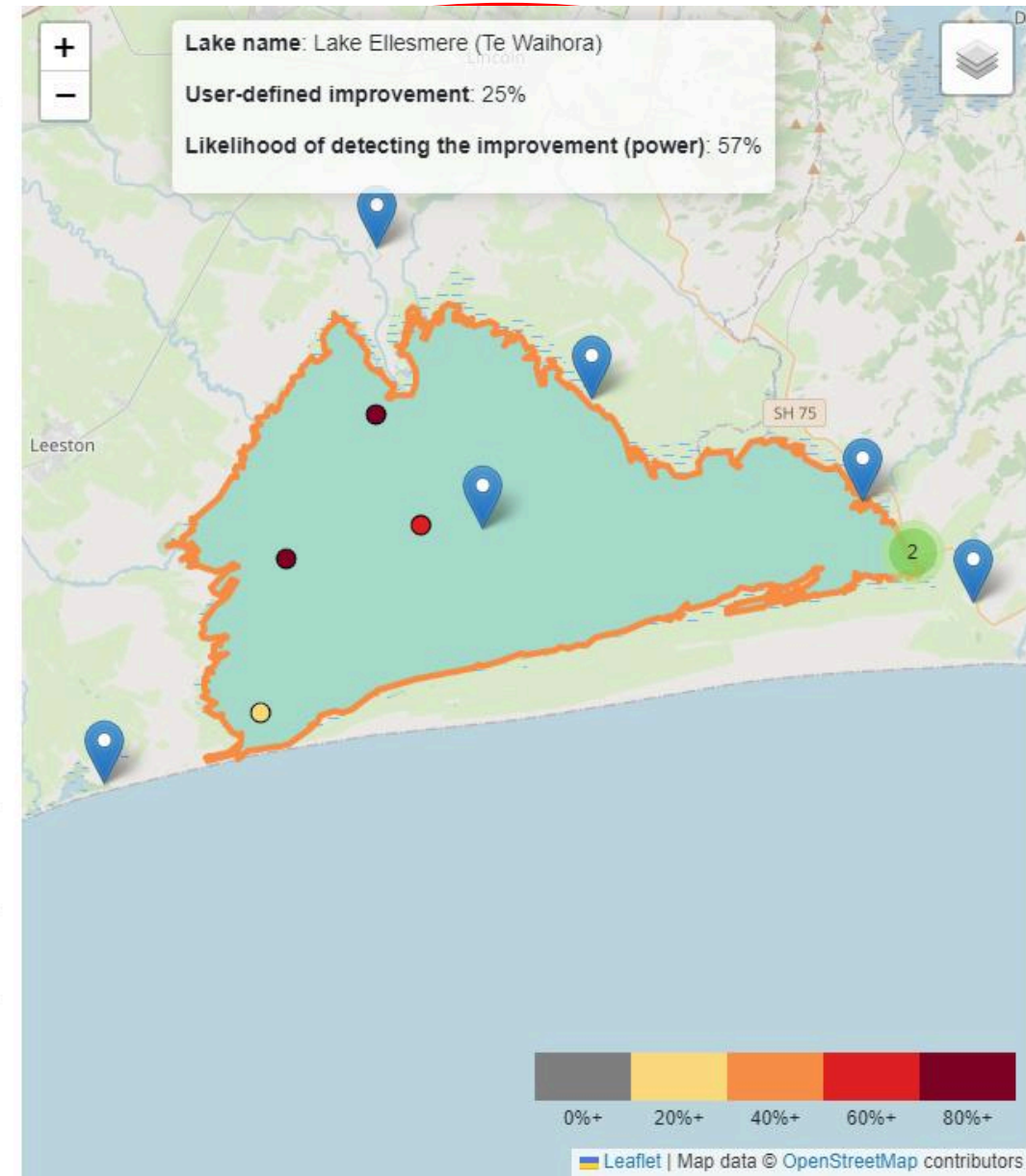
Total nitrogen

(2b) Assign a percent improvement for the overall lake:

25

(2c) Assign a percent improvement by site under the “improvement %” column then press enter to confirm:

site name	improvement %
Lake Ellesmere mid-lake	25
Lake Ellesmere off Taumutu	25
Lake Ellesmere off Selwyn River mouth	25
Lake Ellesmere off Timber Yard Point	25



Very similar to the “River Sites” site module  
The user nominates an improvement in one of four (TN, TP, Secchi depth or Chlorophyll a)  
Then select monitoring duration and frequency  
Likelihood of detecting changes provided at individual monitoring sites, for the whole lake where several monitoring sites per lake and at un-monitored lakes



# “Lake catchment” module

∨ (1) Lake Selection

∨ (2 - Optional) Customise the Land Mitigation Layer

∧ (3) Query Options

(3a) Select Indicator:

Total nitrogen

(3b) Select sampling duration (years):

5

10

20

30

(3c) Select sampling frequency:

quarterly

monthly

fortnightly

weekly

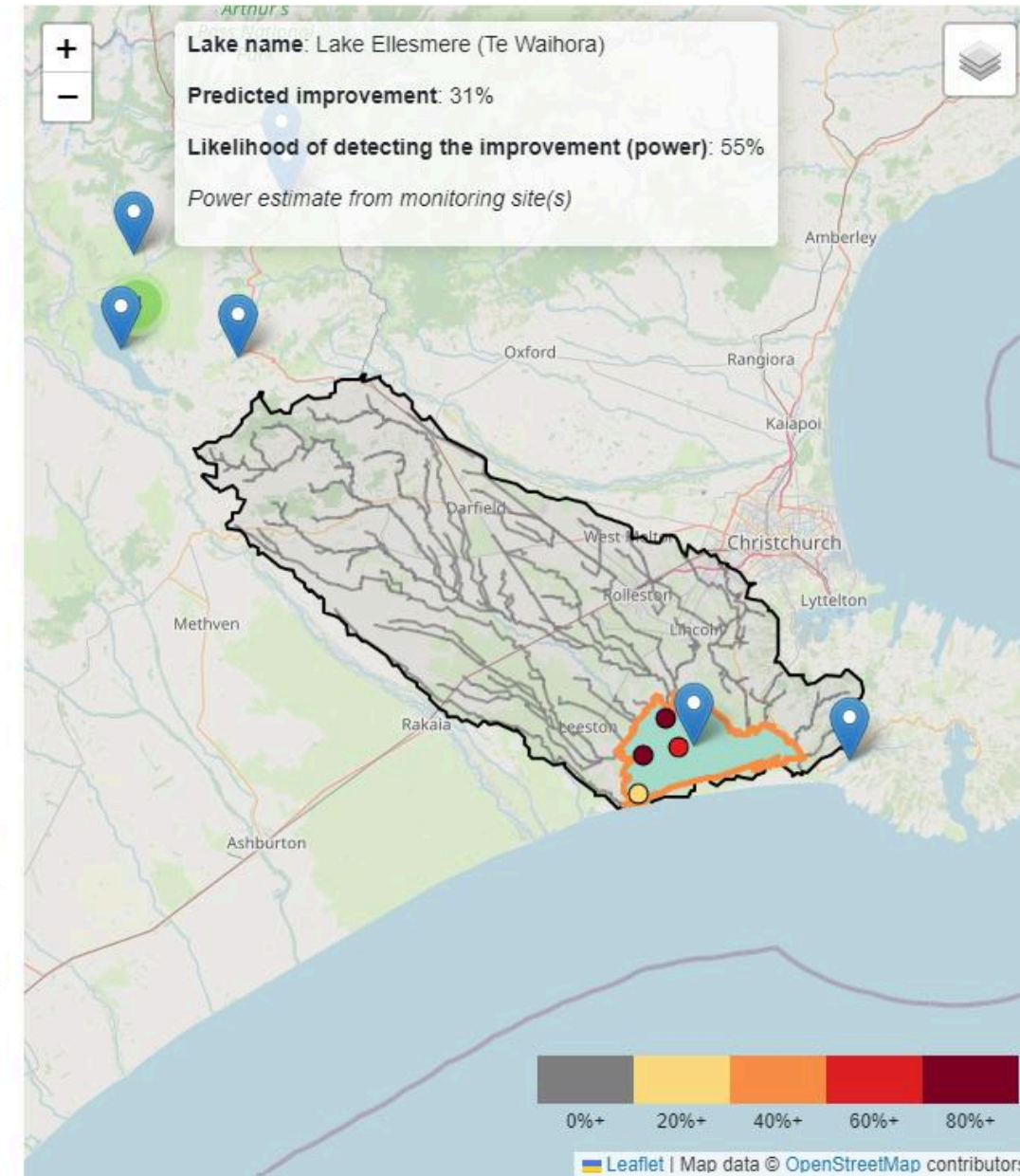
biweekly

daily

(3d) Select the percentage of the maximum contaminant loss reductions applied: ?



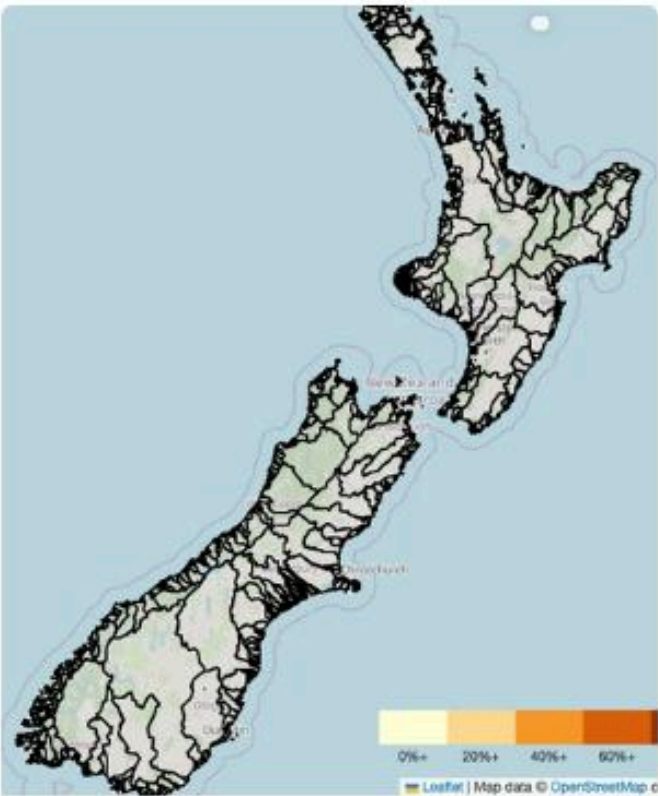
Very similar to the “River Catchment” module  
The user can use default land mitigation, customise it or replace it.  
The model “routes” the reductions in contaminant losses in the lake’s surface catchment and predicts in-lake Likelihood of detecting changes provided at individual monitoring sites, for the whole lake where several monitoring sites per lake and at un-monitored lakes



# WebApp Dashboards

The WebApp contains three dashboards relating to different freshwater environments.  
Within each dashboard there are modules to help design or review of monitoring programmes for detecting improvements.

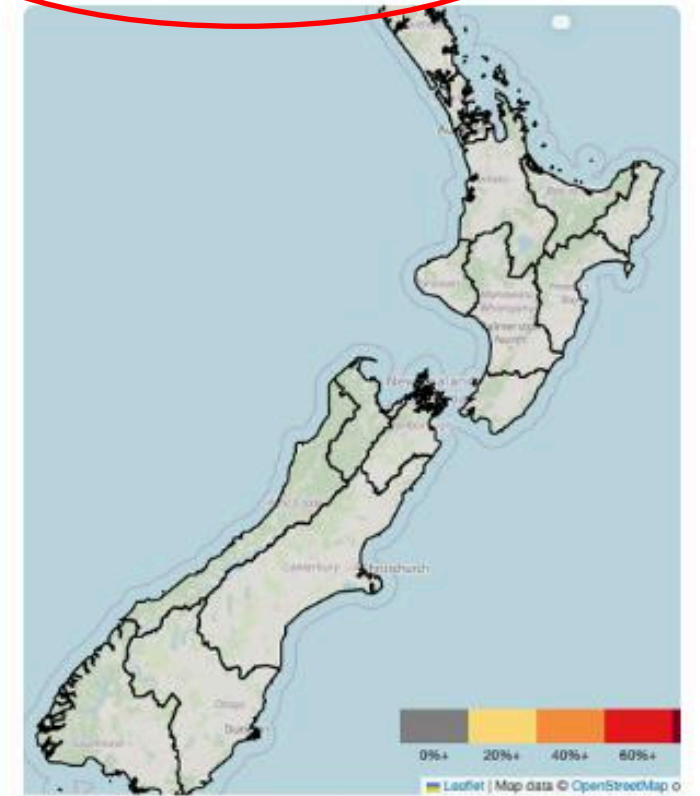
## Rivers



## Lakes



## Groundwater



# “Groundwater quality” module

^ (1) Select a Regional Council

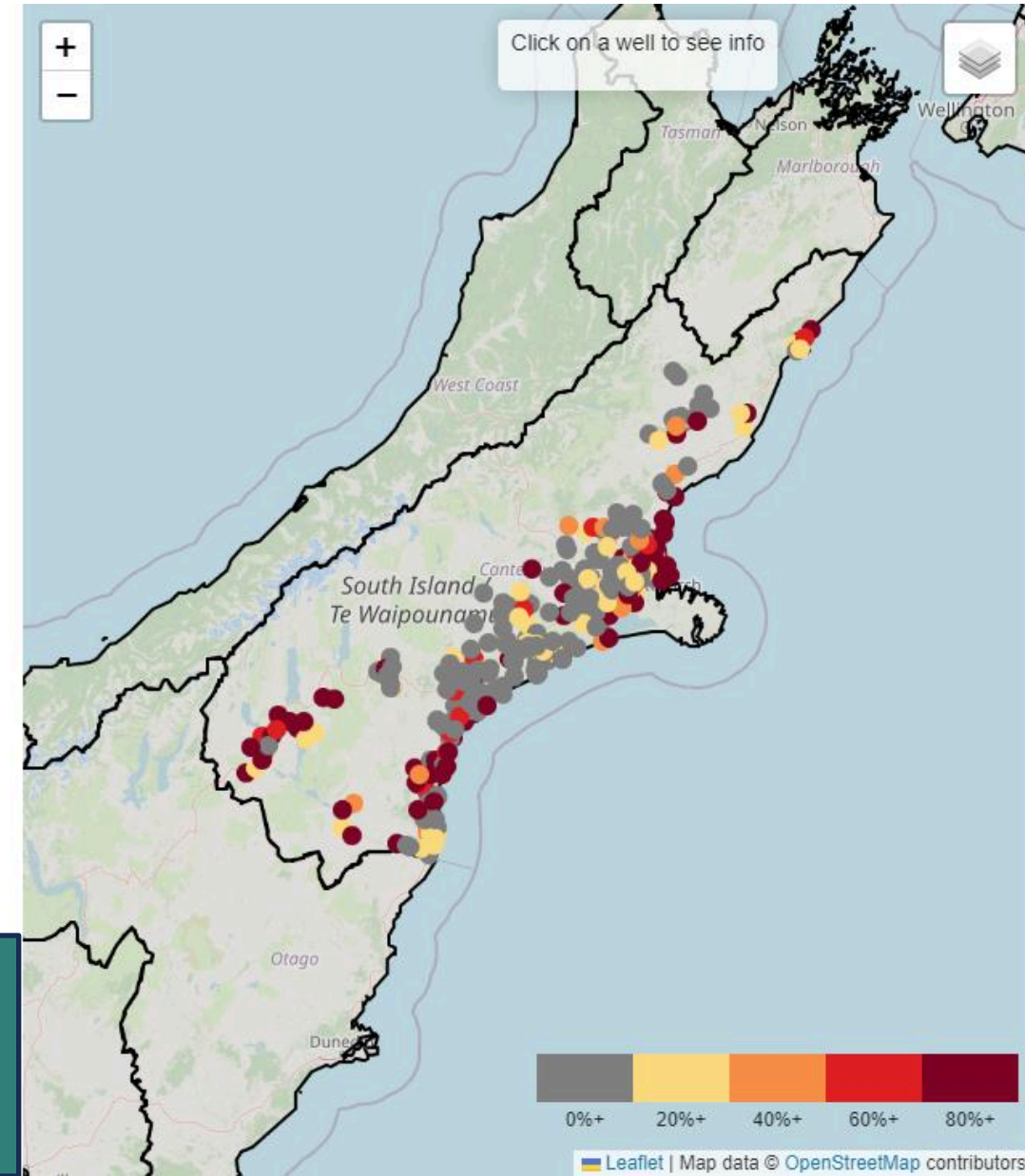
(1a) Select a Regional Council on the map:

Canterbury

∨ (2) Select Indicator and an improvement

∨ (3) Query Options

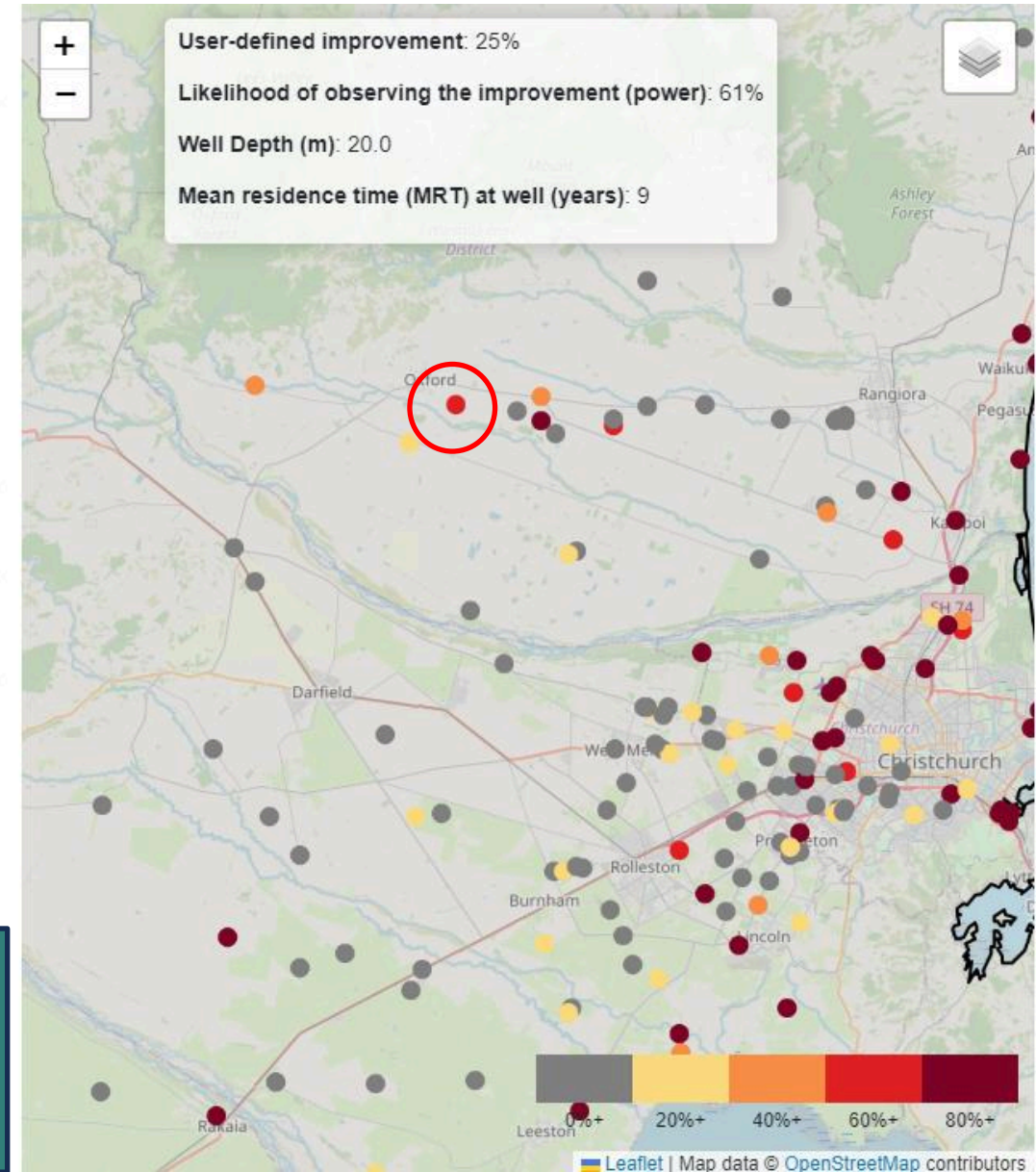
∨ (4) Download Results



Very similar to the “river sites” module  
Select a region, an indicator (nitrate only), a relative improvement and interrogate the map by clicking on existing wells.

# “Groundwater quality” module

- ∨ (1) Select a Regional Council
- ∧ (2) Select Indicator and an improvement
  - (2a) Select Indicator:  
Nitrate nitrogen
  - (2b) Select an improvement:  
5% 10% 15% 20% 25% 30% 35% 40% 45% 50%
- ∨ (3) Query Options
- ∨ (4) Download Results



Select a region, an indicator (nitrate only), a relative improvement, a combination of monitoring frequency and duration and interrogate the map by clicking on existing wells. The map display the user-defined improvement, the likelihood of detecting the improvement with the combination of monitoring frequency and duration, the well depth and, where available, the Mean Residence Time (MRT)

# “Groundwater quality” module

^ (1) Select a Regional Council

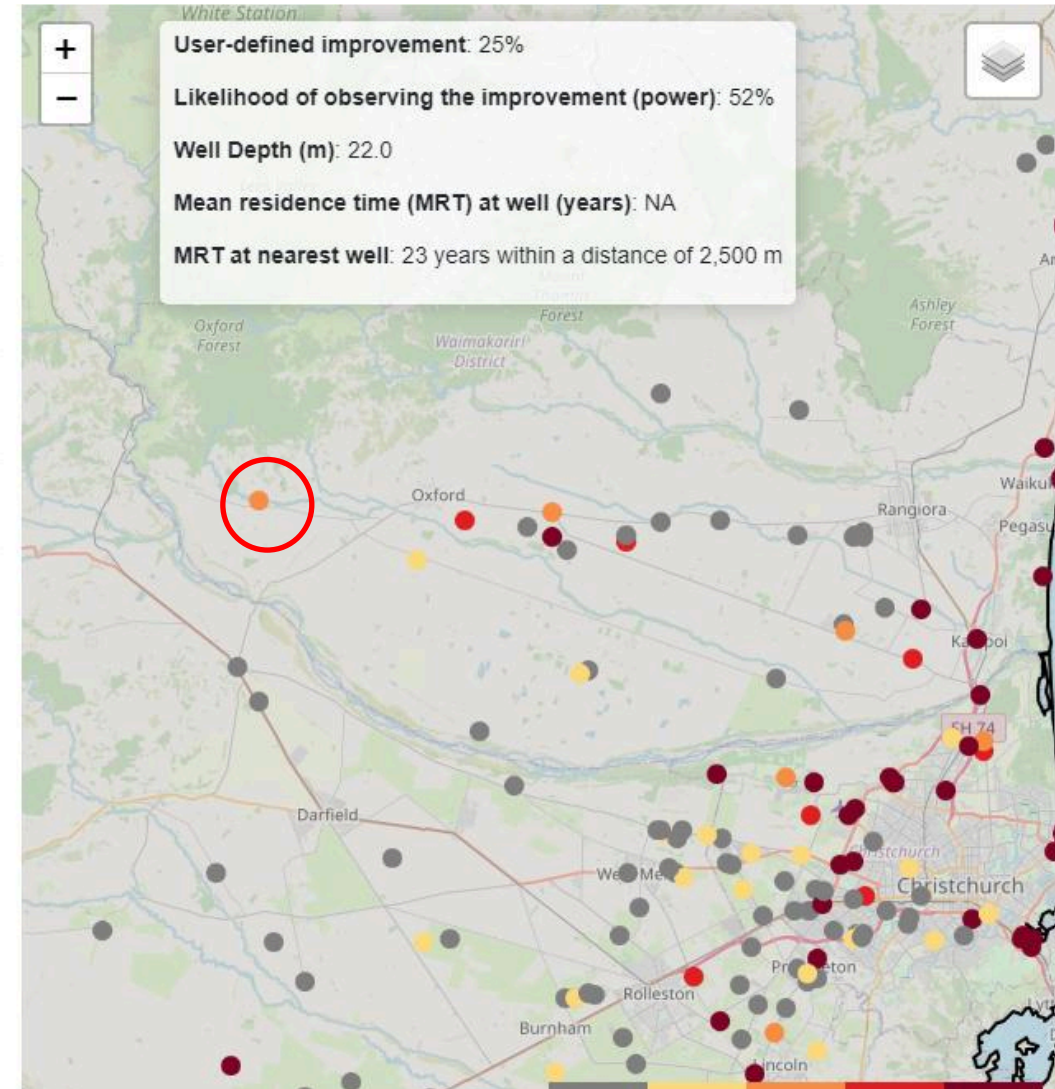
(1a) Select a Regional Council on the map:

Canterbury

∨ (2) Select Indicator and an improvement

∨ (3) Query Options

∨ (4) Download Results



Where no MRT data are available at the well, the WebApp displays the MRT at the nearest well within the same depth band.

# “Groundwater quality” module

^ (1) Select a Regional Council

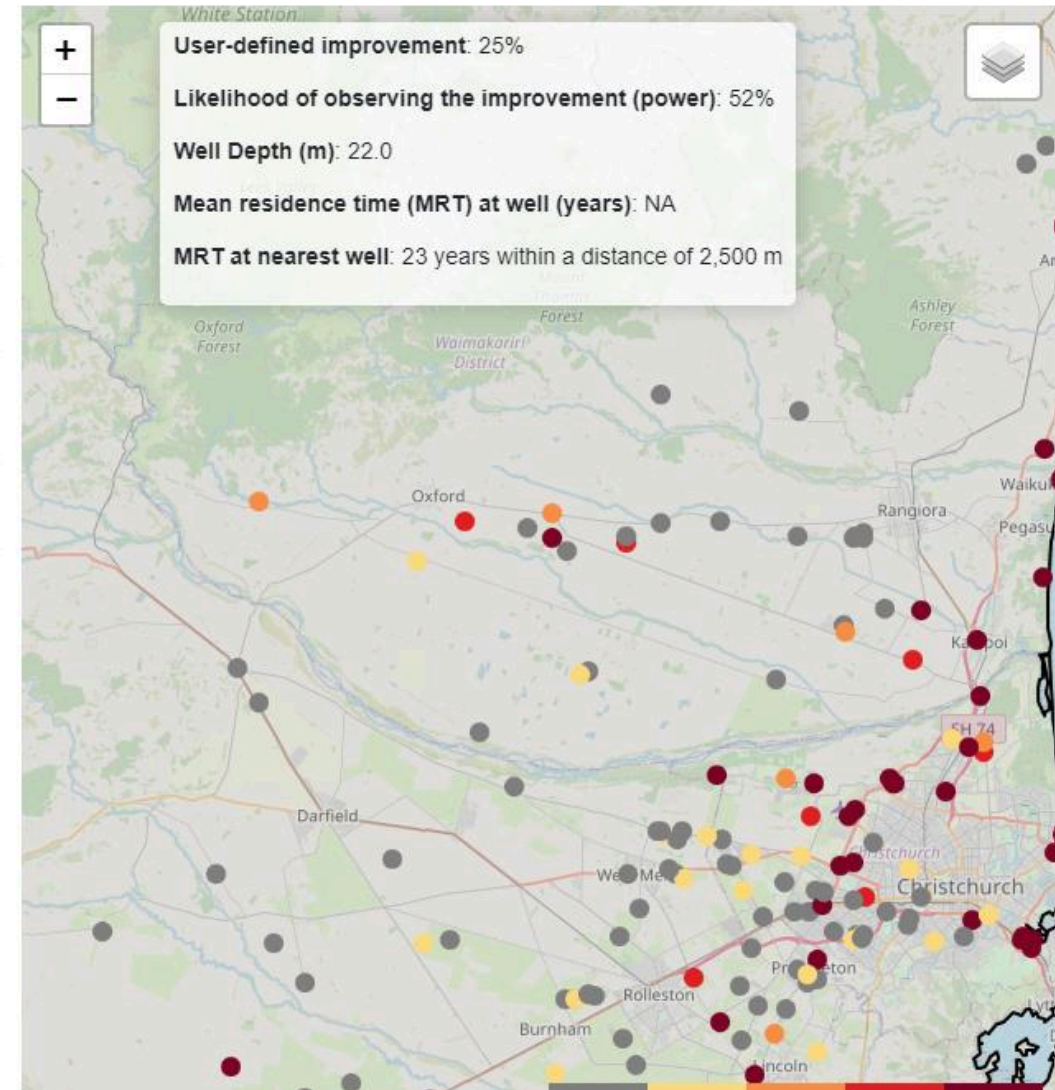
(1a) Select a Regional Council on the map:

Canterbury

∨ (2) Select Indicator and an improvement

∨ (3) Query Options

∨ (4) Download Results



Use Groundwater WebApp as screening tool:

- if power is low, do not consider further.
- if power is high, good candidate for further analysis to include lag time

Other resources (guidance document, Python packages for further analysis) available through the Website

# The Monitoring Design Team

Monitoring  
Freshwater  
Improvements



- Olivier Ausseil – Traverse Environmental (Programme Lead)
- David Hamilton – Griffith University (Science Lead)
- Joanne Clapcott – Cawthron (Te Ao Māori Lead)
- Alasdair Noble – AgResearch (Statistics)
- Mike Kittridge – HeadWaters Hydrology (GIS Tools)
- Zeb Etheridge – Komanawa Solutions (Groundwater)
- Rich McDowell – OLW Chief Scientist



**Headwaters  
Hydrology**



# Extended team



### Komanawa Solutions

- Matt Hanson Dumont – Groundwater
- Evelyn Charlesworth – Groundwater

### Cawthron Institute

- Laura Kelly – Ecological Indicators
- Roland Eveleens – Cultural Indicators

### Te Hoiere case study

- Ruihana Smith, Ngāti Kuia
- Kristie Pakipaki, Ngāti Kuia
- Aneika Young – Cawthron Institute
- Heli Wade
- Rachel Russell
- Peter Hamill



### Pokaiwhenua case study

- K'Lee Begbie – Ngāti Raukawa
- Anaru Begbie – Ngāti Raukawa
- Matt Highway – Element Environmental
- Haldleigh Putt
- Andrew Lennox



### Traverse Environmental

- Dimitrios Rados – Literature review, Data
- Lovisa Ekelund – Case Studies
- Laura Keenan – Science Editor



### Griffith University

- Felipe Castro-Suarez – Catchment modelling
- Rupesh Patil – Lakes





Olivier Ausseil (Traverse Environmental) – Programme and Implementation Lead

✉ [olivier@traverse.co.nz](mailto:olivier@traverse.co.nz) / +64 27 22 77 400

Joanne Clapcott (Cawthron Institute) – Te Ao Māori Lead

✉ [joanne.clapcott@cawthron.org.nz](mailto:joanne.clapcott@cawthron.org.nz) +64 272 460 517

David Hamilton (Australian Rivers Institute) – Science Lead

✉ [david.p.hamilton@griffith.edu.au](mailto:david.p.hamilton@griffith.edu.au) / ☎ +61 7 3735 3544

Rich McDowell (AgResearch) – OLW Chief Scientist

✉ [richard.mcdowell@agresearch.co.nz](mailto:richard.mcdowell@agresearch.co.nz) / ☎ +64 21 569 680

Zeb Etheridge (Komanawa Solutions) – Groundwater Lead

✉ [mgkittridge@gmail.com](mailto:mgkittridge@gmail.com) / +64 27 807 9847

Mike Kittridge (Headwaters Hydrology) – Webmap Lead Developer

✉ [mgkittridge@gmail.com](mailto:mgkittridge@gmail.com)

monitoringfreshwater.co.nz