



**Drinking Water
Protection
Conference 2023**

From the source to the last flowing tap

~~Practical~~ examples of source water risk identification in Aotearoa New Zealand

Presented by
Dr Jeremy Bennett



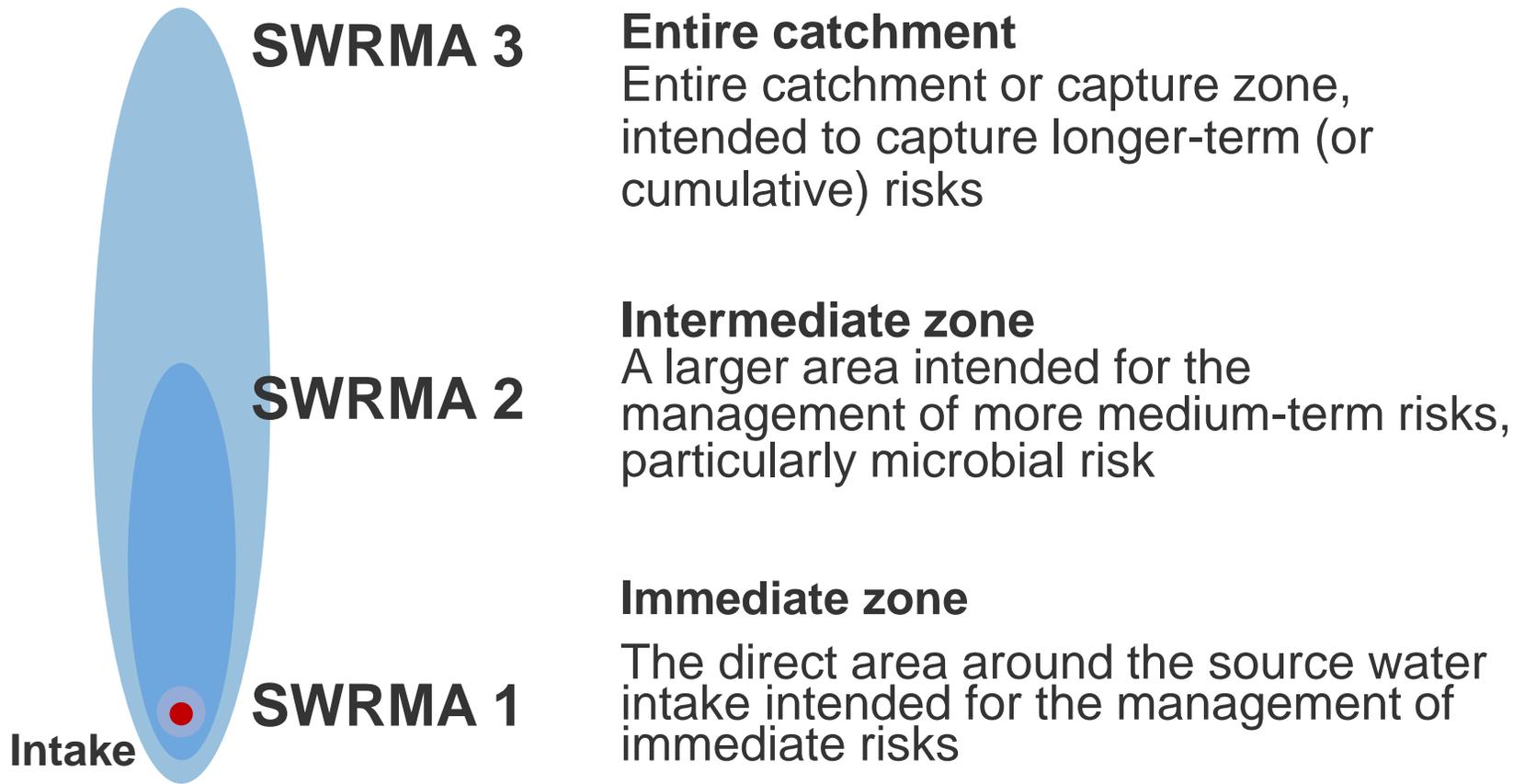
Water suppliers must prepare and implement a source water risk management plan to:



An aerial photograph of a vast, snow-covered mountain range. The terrain is characterized by long, sweeping ridges and deep, shadowed valleys, all blanketed in white snow. The lighting creates a gradient of blues and whites, highlighting the textures of the snow and the contours of the land. The overall scene is serene and majestic.

Delineating Pathways

Source Water Risk Management Areas Some definitions



Ministry for the Environment
Making Aotearoa New Zealand the most beautiful place in the world

BRF-2156: Final policy options for amending the National Environmental Standards for Sources of Human Drinking Water (NES-DW)

Date Submitted:	20 October 2022	Tracking #:	BRF-2156
Security Level	In-confidence	MfE Priority:	Non-Urgent

To Hon Kiritapu Allan, Associate Minister for the Environment	Action sought: Note that, in response to your feedback and submissions from stakeholders, the proposed amendments to the NES-DW have been refined. Agree to the preferred option for amendments to the NES-DW.	Response by: N/A
CC Hon David Parker, Minister for the Environment	N/A	N/A

Actions for Minister's Office Staff	Return the signed report to MfE
Number of appendices and attachments	Appendix One: Draft RIS for your information Appendix Two: Refining of three proposals into amendment packages Appendix Three: Packages of amendments to the NES-DW Appendix Four: Analysis of different packages Appendix Five: Interactions with other legislation

Ministry for the Environment contacts

Position	Name	Cell phone	1 st contact
Principal author	Morag McDonald	§ 82(2)(a)	
Responsible manager	Vania Llewellyn	§ 82(2)(a)	
Director	Jo Gascoigne	§ 82(2)(a)	✓

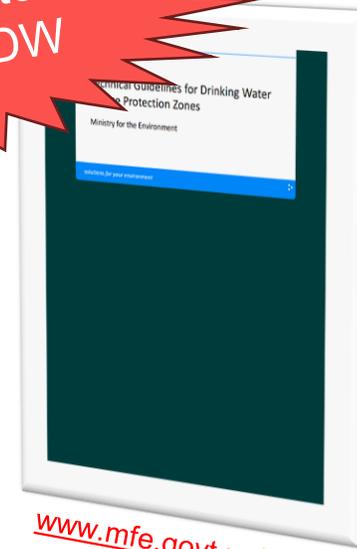
[brf-2156-final-policy-options-for-amending-the-national-environmental-standards-for-sources-of-human-drinking-water-nes-dw.pdf](#)

Guidelines

Ministry for the Environment
*Technical Guidelines for Drinking Water
Protection Zones* (June 2018)

Rutter, H and Moore, C. *Guidelines for
Modelling Source Water Risk Management
Areas*. Ministry for the Environment (2021)

GNS
*Envirolink Tools Project – Capture Zone
Delineation – Technical Report* (2013)



www.mfe.govt.nz/



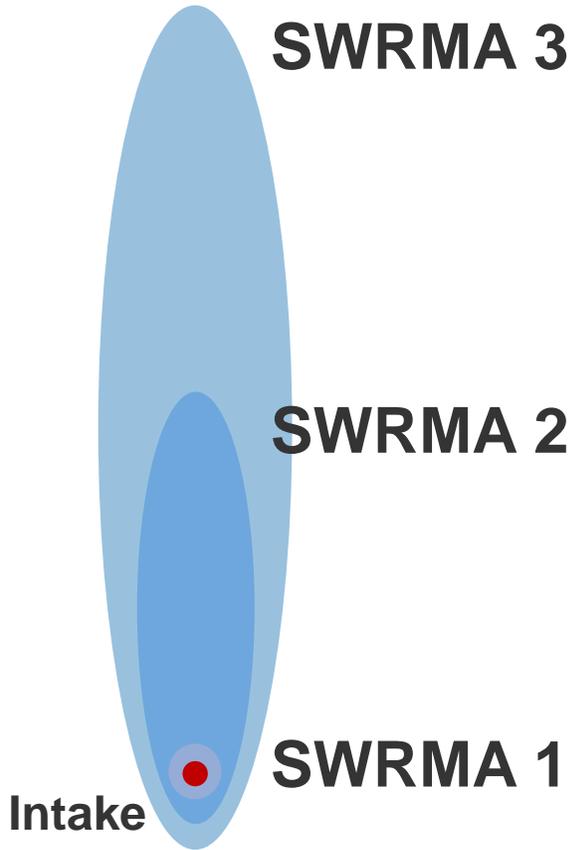
environment.govt.nz



envirolink.govt.nz/

Source Water Risk Management Areas

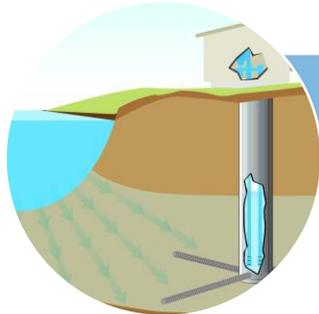
Water source categories



Groundwater



Surface water

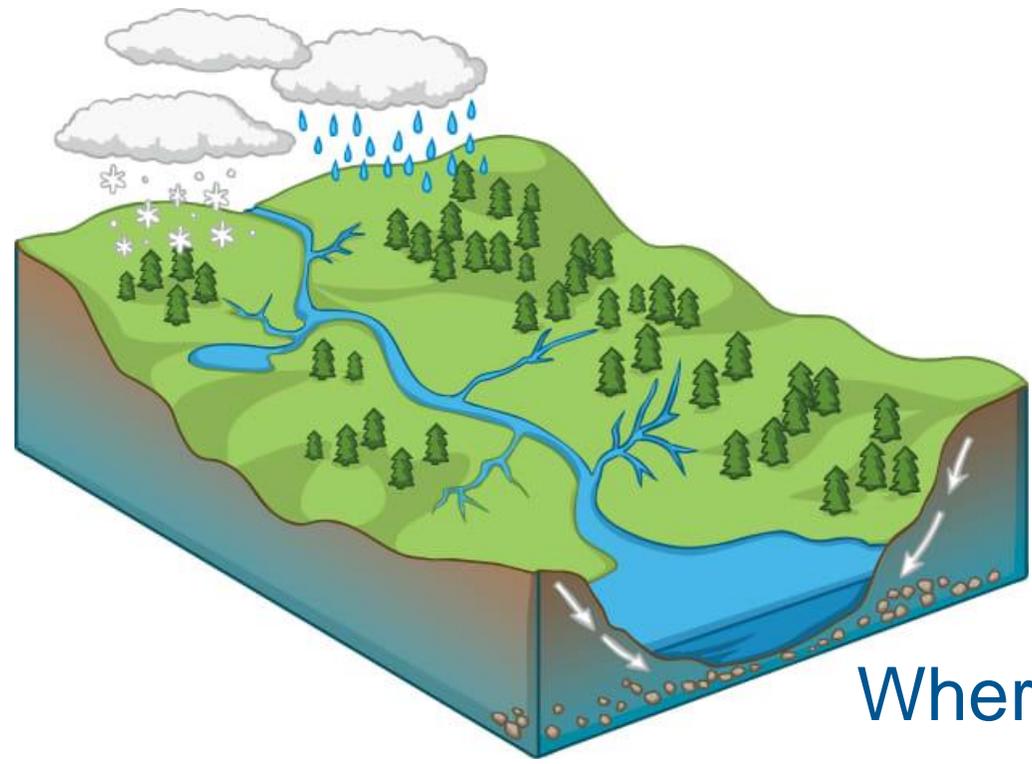
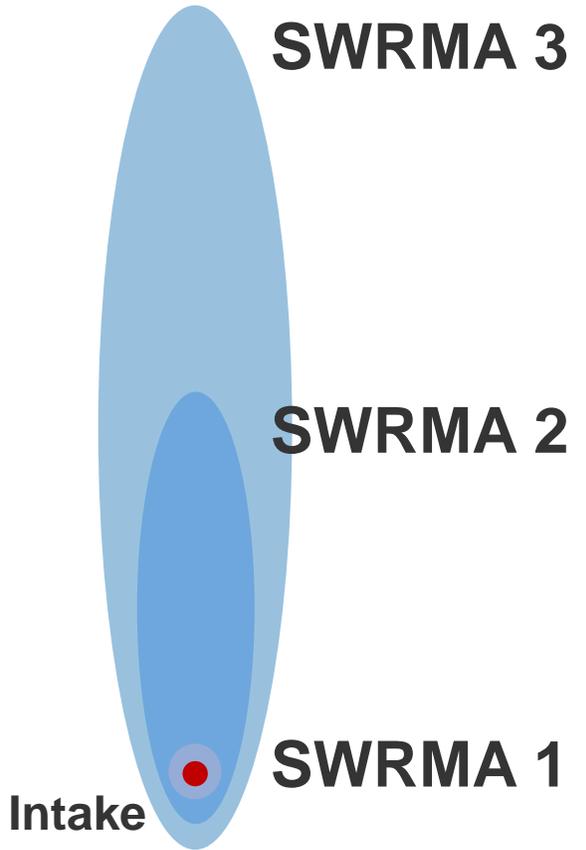


Conjunctive

Source Water Risk Management Areas

Conceptual model

Where is the water coming from?



Where does it go?

Source Water Risk Management Areas



Groundwater

Capture zone

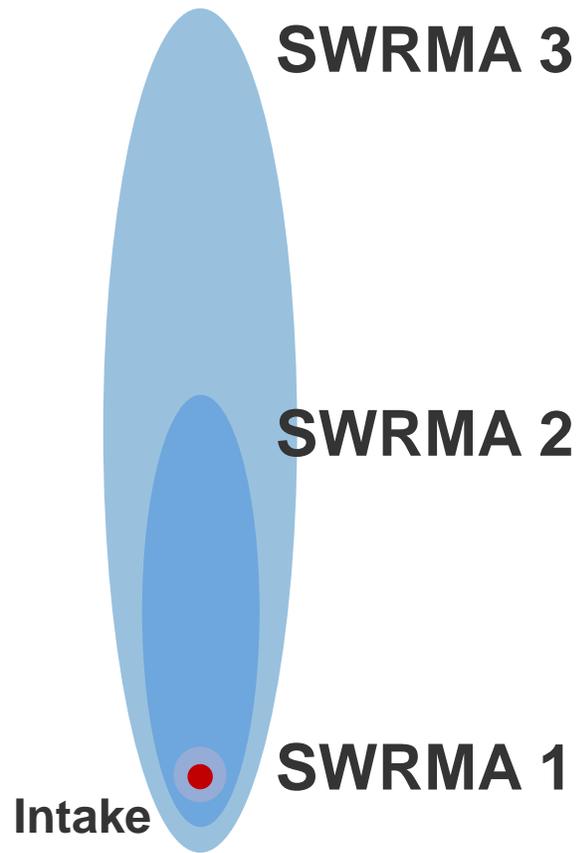
Entire catchment, accounting for hydrogeological boundaries

Intermediate zone

1-year time of travel to well

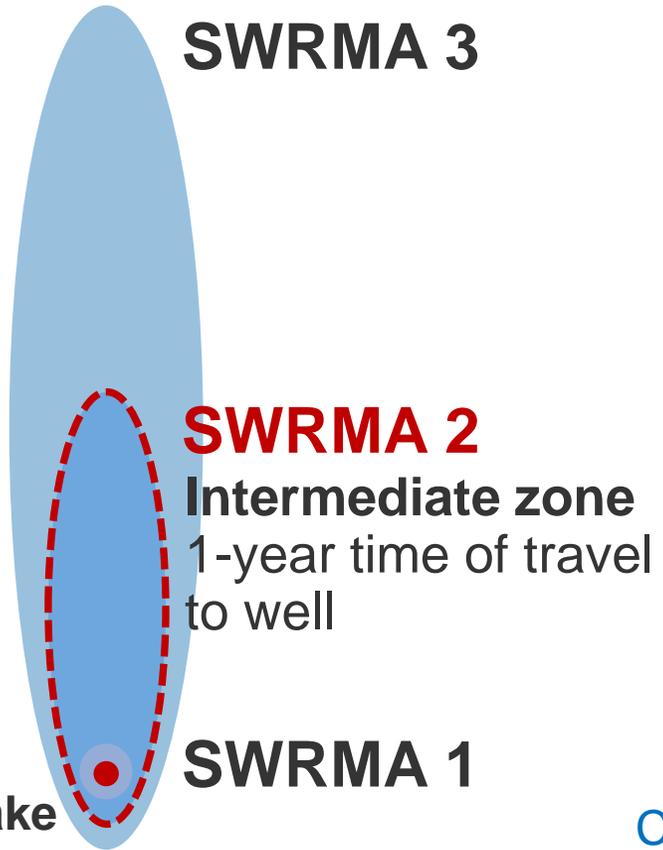
Immediate zone

5-30 m buffer of wellhead



Source Water Risk Management Areas

Groundwater



SWRMA 3

SWRMA 2

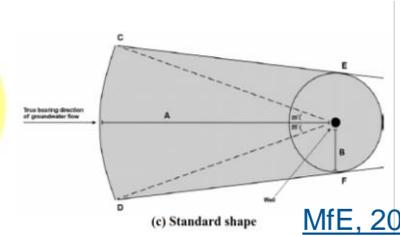
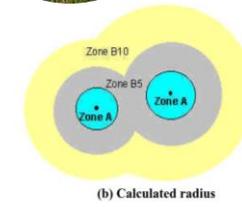
Intermediate zone

1-year time of travel to well

SWRMA 1

- Calculated radius solutions (simple GIS)
- Analytical solutions using few parameters (GNS GIS tools)
- Numerical modelling (particle tracking)

Complexity

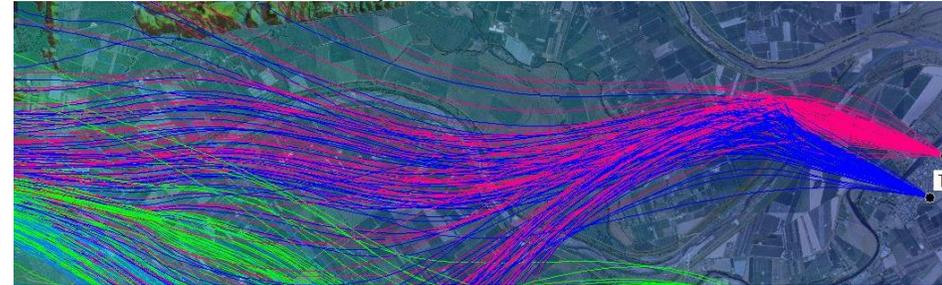
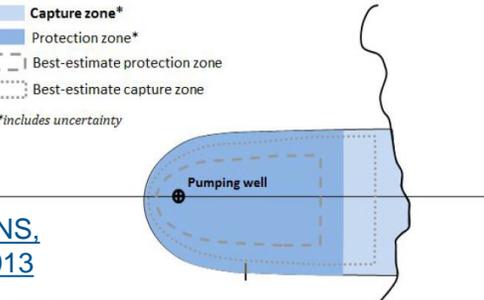


MfE, 2018

- Capture zone*
- Protection zone*
- Best-estimate protection zone
- Best-estimate capture zone

*includes uncertainty

GNS, 2013



Source Water Risk Management Areas



Surface water

Capture zone

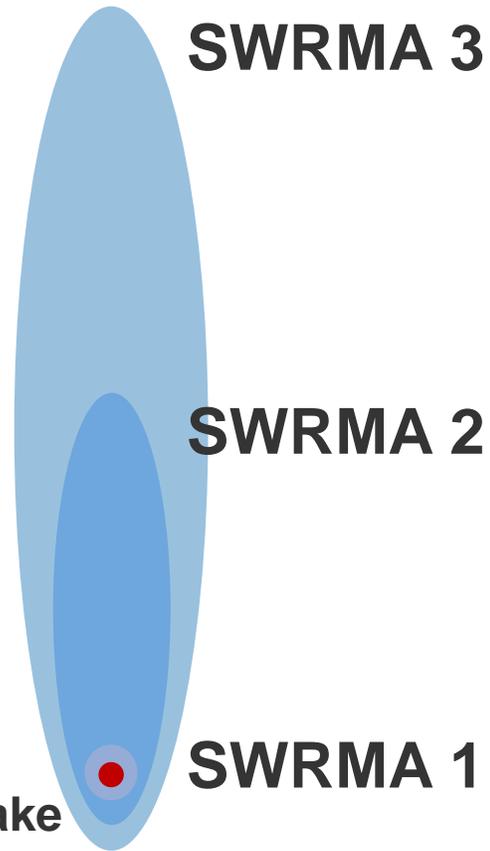
Entire catchment, accounting for hydrogeological boundaries

Intermediate zone

8-hour time of travel to well

Immediate zone

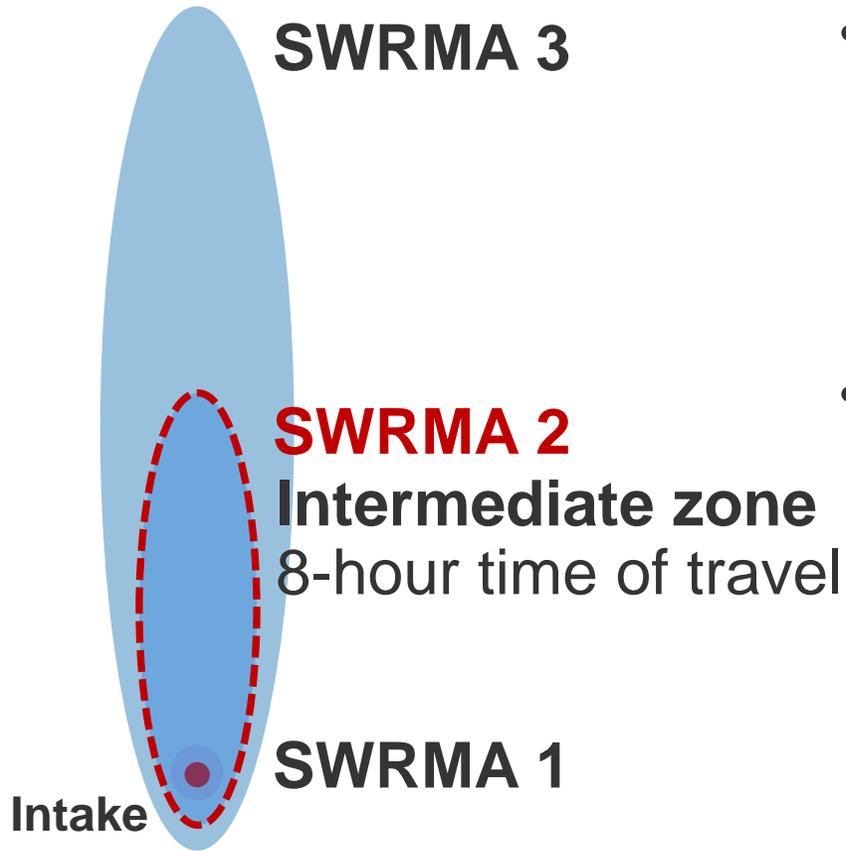
- 500 m radius around lake intake
- 1 km upstream and 100 m downstream of river intake, with 5 m riparian margin



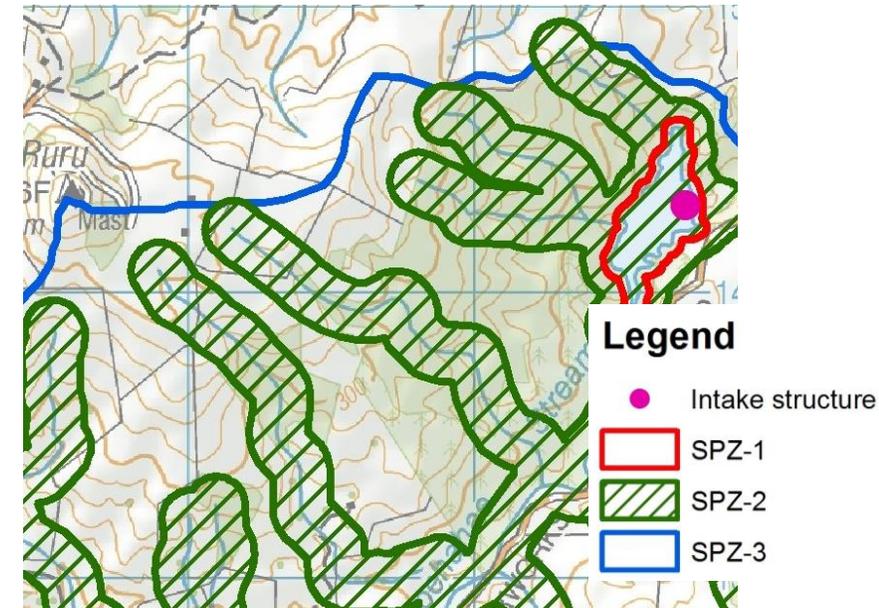
Source Water Risk Management Areas



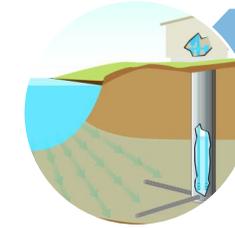
Surface water



- Approximation of river flows/velocities
 - [NIWA RiverMaps](#)
 - Local authority data (flows/geometries)
- GIS analysis
 - Stream network analysis (distance upstream)
 - Buffer of stream network

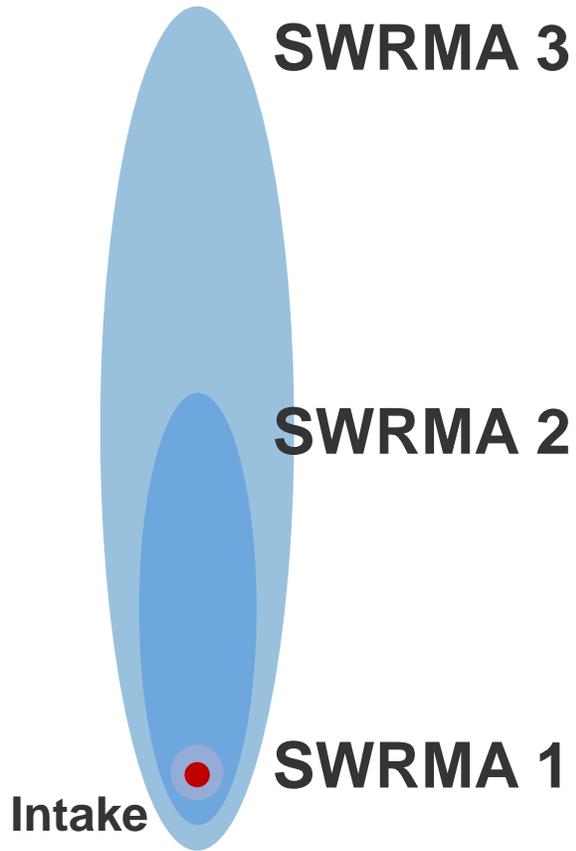
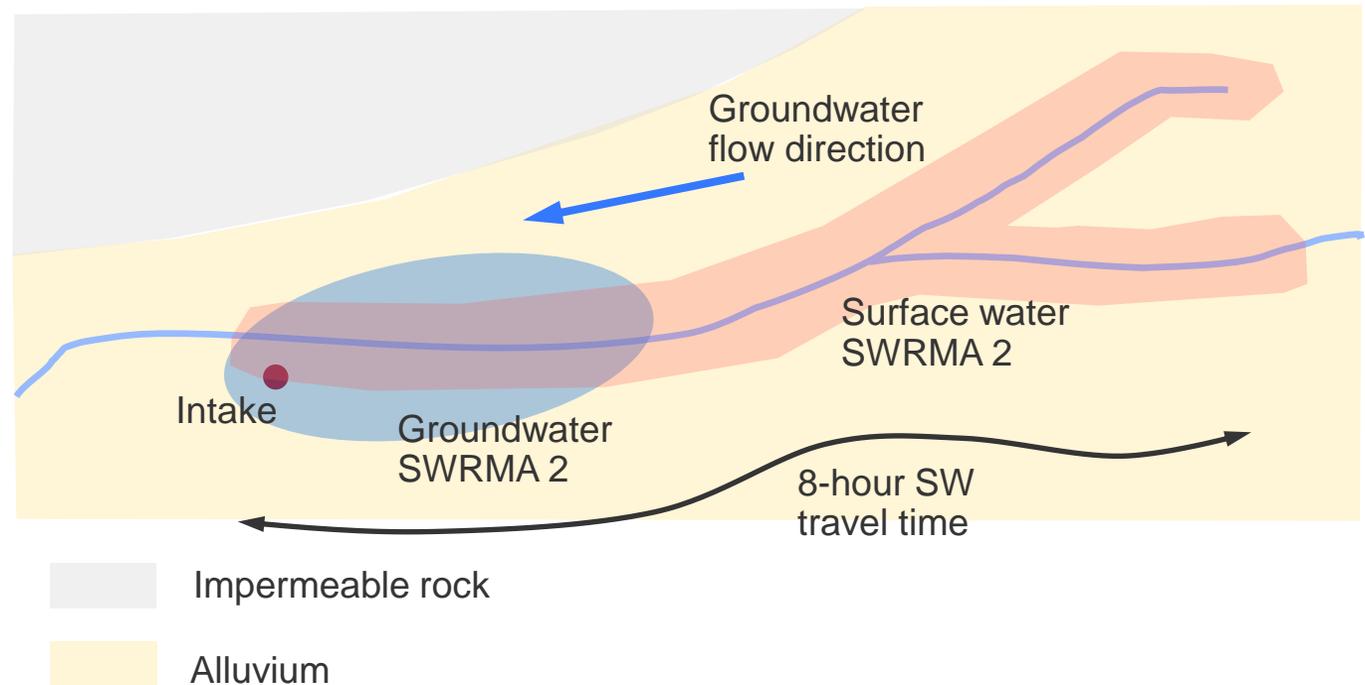


Source Water Risk Management Areas



Conjunctive

- Comes back to the conceptual model



Scale, complexity and uncertainty?

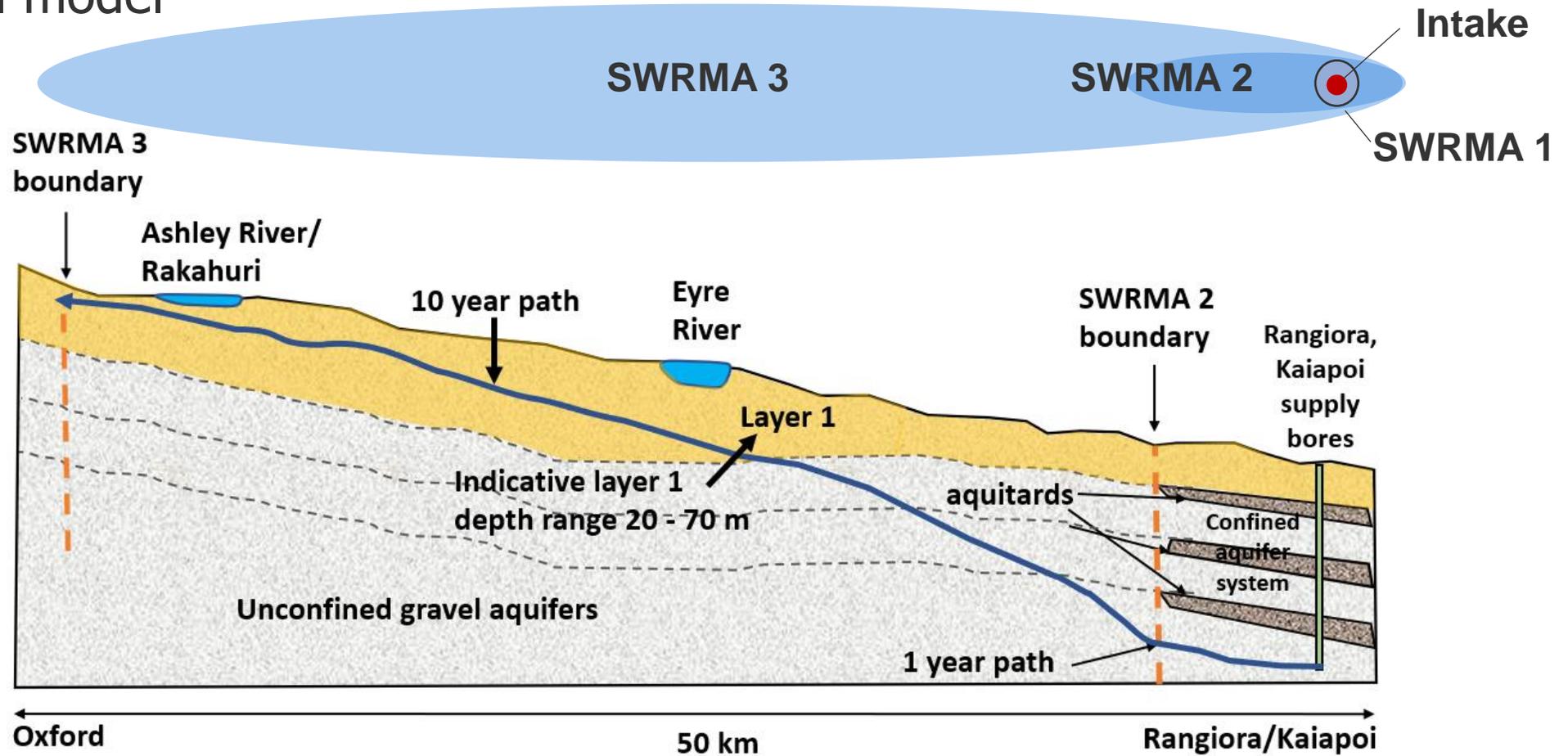
- Population size and sensitivity
- Conceptual model complexity and uncertainty
- Source water quality and variability
- Treatment processes and resilience
- What existing information or modelling is available?
- Model uncertainty:
 - Conceptual model
 - SWRMA modelling approaches



SWRMA Example Rangiora water supply



SWRMA Example Conceptual model



SWRMA Example SWRMA 1 – Immediate area

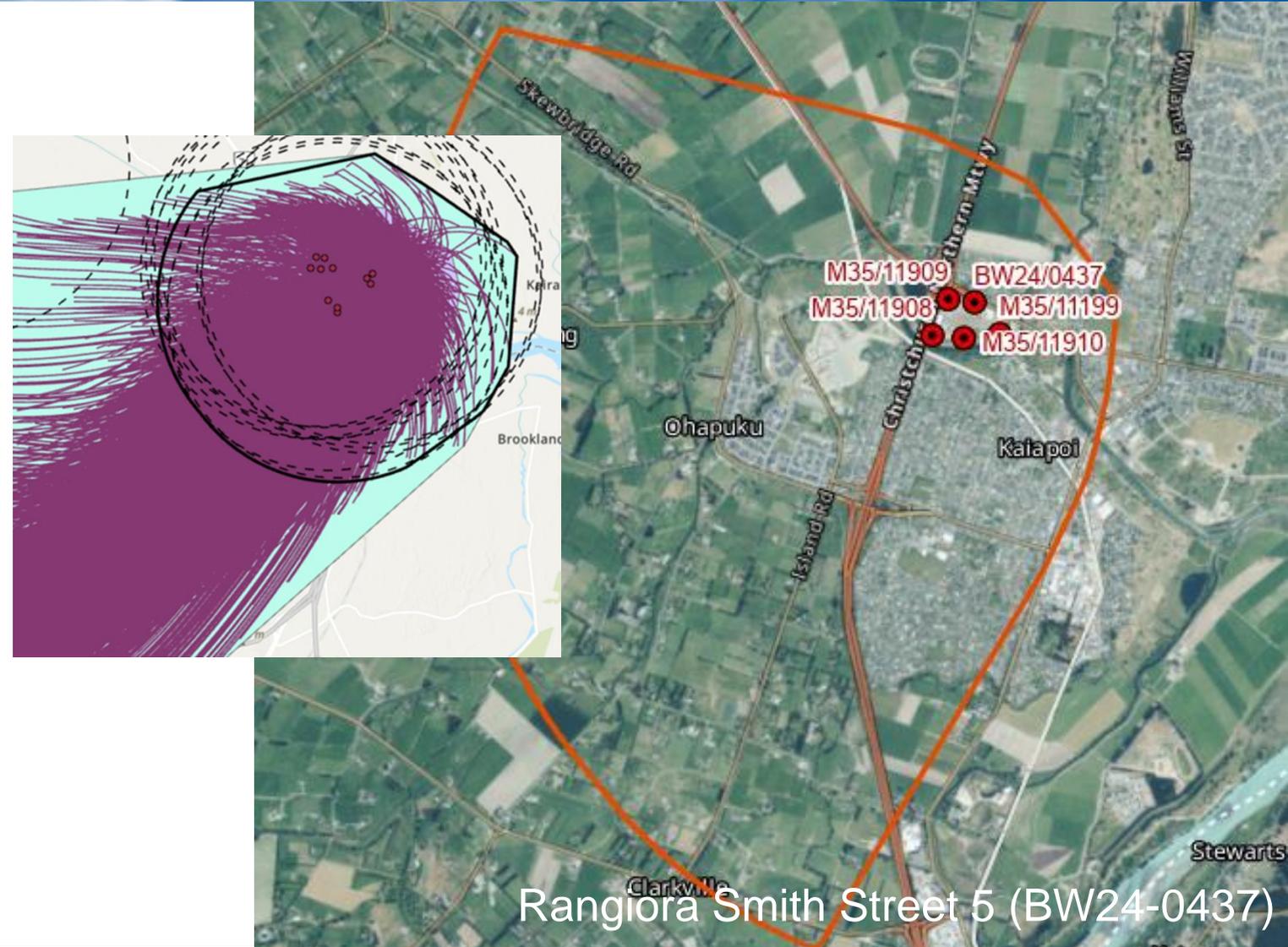
- 5 m buffer of well head



Rangiora Smith Street 5 (BW24-0437)

SWRMA Example SWRMA 2 – Intermediate zone

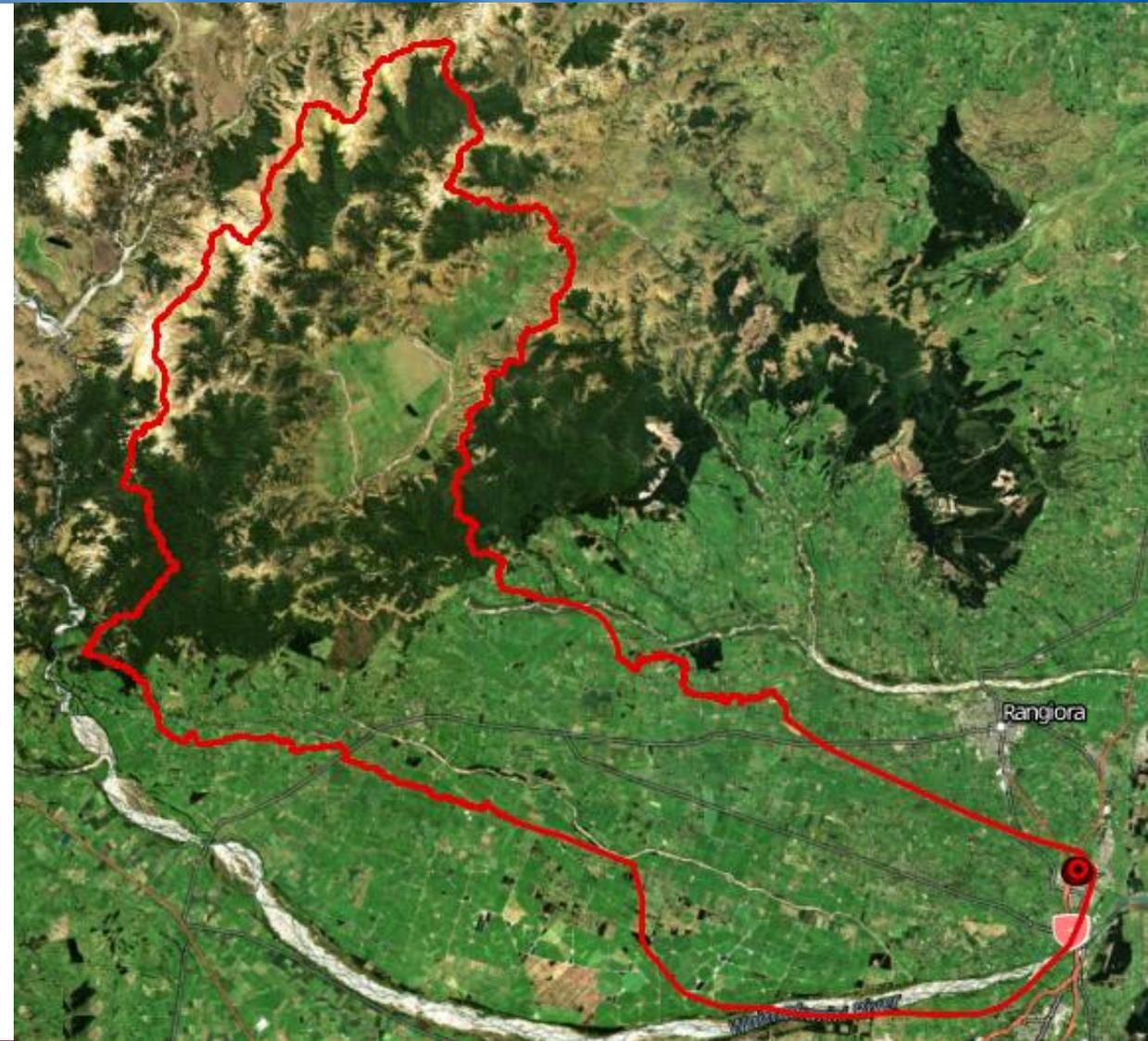
- Existing Waimakariri Numerical model, including an uncertainty analysis comprising model ensemble.
- Particle tracking used to delineate 1-year time of travel.
- Final SWRMA 2 was the envelope of all particle tracks.



Rangiora Smith Street 5 (BW24-0437)

SWRMA Example SWRMA 3 – Entire catchment

- 10-year travel time based on particle tracking.
- Intersection with model boundaries, therefore expansion of SWRMA 3 based on hydrological boundaries.





Identifying Hazards

Data sources

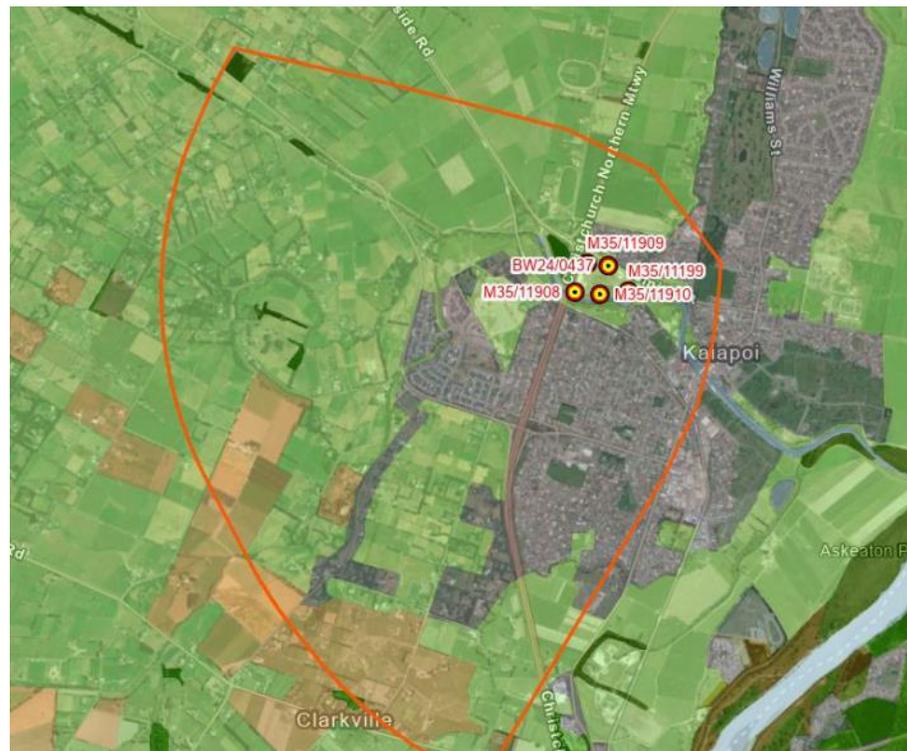
- Regional Councils:
 - Land cover
 - Hazardous activities
 - Consenting
 - Source water quality
 - Environmental monitoring
- Water suppliers:
 - Three-waters networks
 - Raw water quality
 - Operator knowledge
- Catchment / site visits

Water Services Act 2021 Section 43

- (4) Local authorities must contribute to the development and implementation of source water risk management plans prepared by drinking water suppliers, including by—
- (a) providing information to suppliers in accordance with compliance rules, including information about—
 - (i) land-use activities, potential sources of contamination, and other water users that could directly or indirectly affect the quality or quantity of the source of a drinking water supply; and
 - (ii) water quality monitoring of the source of a drinking water supply conducted by a regional council; and
 - (iii) any known risks or hazards that could affect the source of a drinking water supply; and
 - (b) undertaking any actions to address risks or hazards to the source of a drinking water supply that local authorities have agreed to undertake on behalf of a drinking water supplier, as specified in a schedule attached to a source water risk management plan or otherwise agreed in writing.

Land use

- Land cover
- Hazardous Activities and Industries List (HAIL) / Listed Land Use Register (LLUR)
- Consent information, including:
 - Discharge to land and water
 - Wells and bores
- Historic aerial imagery



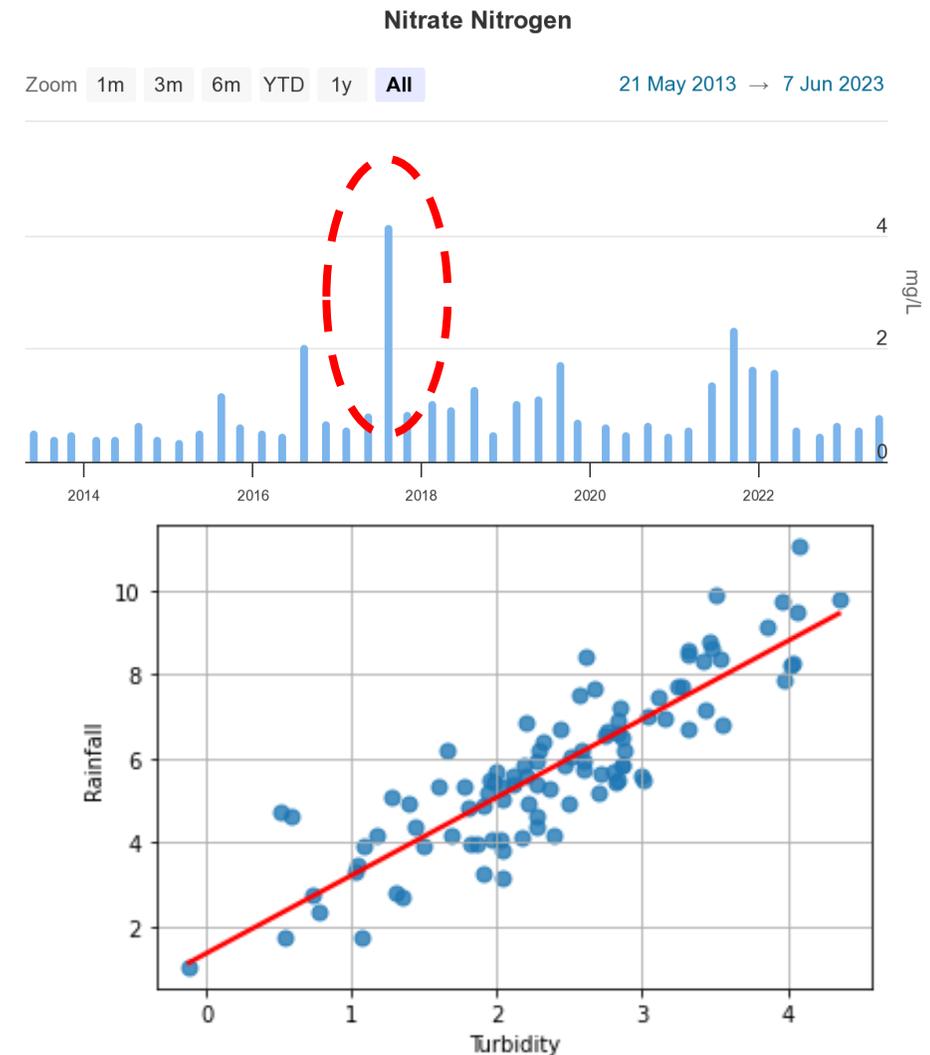
Stormwater & wastewater

- Network coverage
- Pipe age and size
- Infiltration devices
- Incident reporting
- Operator knowledge
- Building footprints (for rural areas)



Source water quality

- Raw water quality at intake
- Source water quality, including State of the Environment reporting
- Consent compliance information, including trade waste composition
- Other relevant information, such as:
 - Rainfall
 - River flow
- When do changes occur?
- Is there a relationship between environmental variables?



Assessing Risk

Defining risk



Risk = **Likelihood** × **Consequence**

Could it happen?

How bad would it be?

Defining risk – Hazards



Hazardous activities

- Historic / ongoing
- Short-term/long-term contaminant source
- Volume of contaminant stored used

Potential contaminants

- Physico-chemical properties
- Toxicity / pathogenicity
- Acute/chronic health effects

Other environmental hazards

- Saline intrusion
- Cyanobacteria

Defining risk – Pathways

Hazard location

- Distance and direction between hazard and receptor (travel time)

Hydrogeological controls

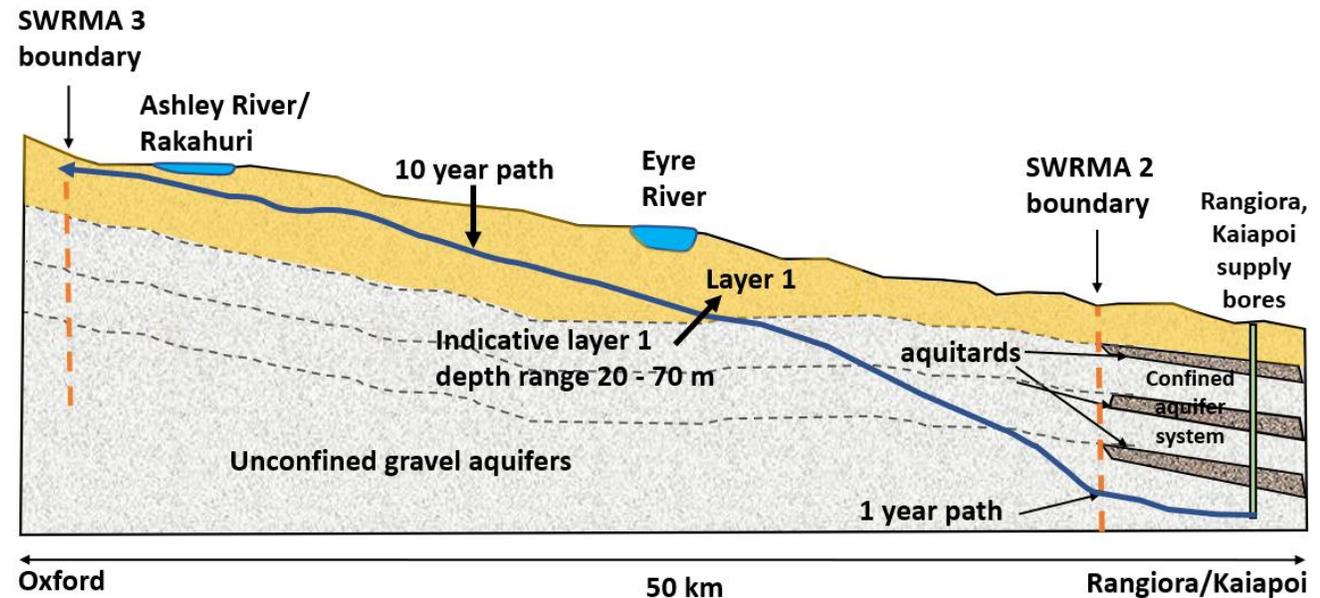
- Hydrostratigraphic controls
- Attenuation processes
- Groundwater – surface water exchange

Hydrological controls

- Residence times in surface water bodies
- Seasonal / event-based changes

Source water monitoring

- Sentinel wells
- Cyanobacteria surveillance



Defining risk – Receptors



Population served

- Water demand / abstraction volumes
- Number of people
- Sensitivity

Water treatment processes

- Treatment train
- Resilience

Raw water monitoring

- Frequency



Qualitative risk matrices

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

Ranking	Description
Rare	May occur only in exceptional circumstances
Unlikely	Could occur
Possible	Might occur at some time
Likely	Will probably occur
Almost certain	Is expected to occur in most circumstances

Ranking	Description
Insignificant	Insignificant
Minor	Minor impact for small population
Moderate	Minor impact for large population
Major	Major impact for small population
Catastrophic	Major impact for large population

		Consequence				
		Insignificant	Minor	Significant	Major	Severe
Likelihood	Almost certain	Medium	High	Very High	Extreme	Extreme
	Likely	Medium	Medium	High	Very High	Extreme
	Moderate	Low	Medium	Medium	High	Very High
	Unlikely	Very Low	Low	Medium	Medium	High
	Rare	Very Low	Very Low	Low	Medium	Medium

[Ministry of Health. 2017. Guidelines for Drinking-water Quality Management](#)

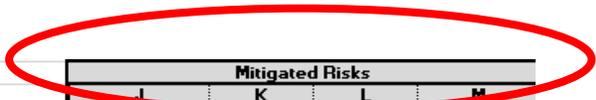
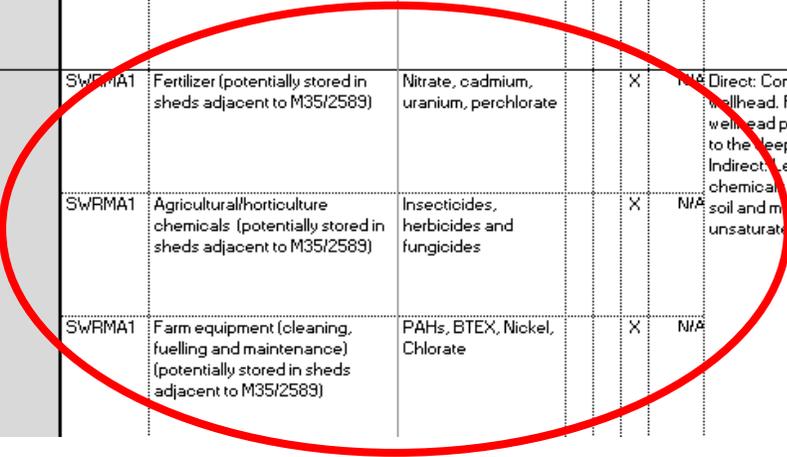
Risk matrices

Unmitigated risk

Mitigated risk

Activity category	A	B	C	D					E	Unmitigated Risks				Current monitoring and management by WDC (Type A - reducing likelihood)	Mitigated Risks			
				Hazard						Consequence of the hazardous event	Likelihood of hazardous event occurring	Maximum (unmitigated) risk (F x G)	Uncertainty		Consequence of the hazardous event	Likelihood of hazardous event occurring	Maximum (current mitigated) risk (J x K)	Uncertainty
				Protozoa	Bacterial/virus	Chemical/Aesthetic	Radiological	Disruption to										
In-ground water supply bore infrastructure	SWRMA1	Surface contaminant enters bore directly due to damage/aging to in-ground water supply bore infrastructure	Fertilisers, pesticides, fuel/hydrocarbons, heavy metals, pathogens	X	X	X	N/A	Direct: Contamination of the wellhead. Flooding of the wellhead providing a pathway to the deep source aquifer.	Major	Rare	Medium	Estimate	A8; A9; A11; A12; A25	Inspections as per SLA; Asset Age Assessment and Renewals Programme; Well Head Exclusion Zone; Locked Well Head Enclosure; Maintenance	Major	Rare	Medium	Estimate
Rural	SWRMA1	Fertilizer (potentially stored in sheds adjacent to M35/2589)	Nitrate, cadmium, uranium, perchlorate		X	N/A	N/A	Direct: Contamination of the wellhead. Flooding of the wellhead providing a pathway to the deep source aquifer. Indirect: Leaching of chemical and pathogens to soil and migration through unsaturated/saturated zone.	Moderate	Rare	Low	Estimate	A8; A9; A31	Inspections as per SLA; Asset Age Assessment and Renewals Programme; Sampling Procedures; <u>Sampling raw water monthly and annually</u>	Moderate	Rare	Low	Estimate
	SWRMA1	Agricultural/horticulture chemicals (potentially stored in sheds adjacent to M35/2589)	Insecticides, herbicides and fungicides		X	N/A	N/A		Moderate	Rare	Low	Estimate	A8; A9; A31	Inspections as per SLA; Asset Age Assessment and Renewals Programme; Sampling Procedures; <u>Sampling raw water monthly and annually</u>	Moderate	Rare	Low	Estimate
	SWRMA1	Farm equipment (cleaning, fuelling and maintenance) (potentially stored in sheds adjacent to M35/2589)	PAHs, BTEX, Nickel, Chlorate		X	N/A	N/A		Moderate	Rare	Low	Estimate	A8; A9; A31	Inspections as per SLA; Asset Age Assessment and Renewals Programme; Sampling Procedures; <u>Sampling raw water monthly and annually</u>	Moderate	Rare	Low	Estimate

Groups of contaminants

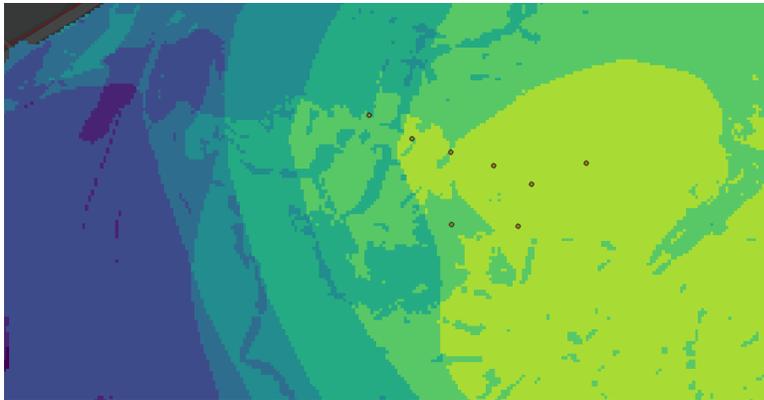


Semi-quantitative risk assessment

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

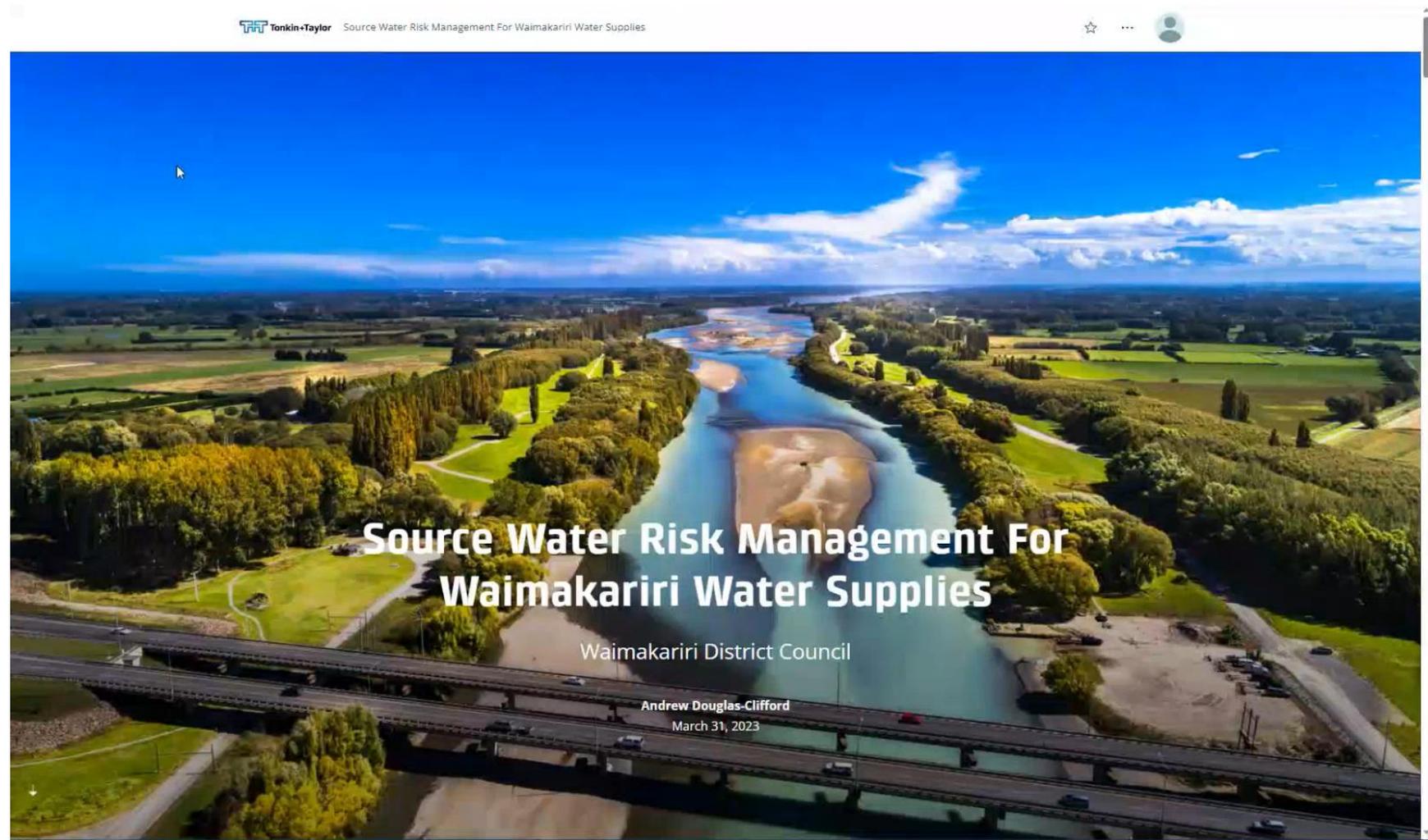
$$\text{Relative risk score} = (a + b + c) \times (d + e)$$

- a) Hazard distance/travel time
- b) Aquifer vulnerability
- c) Likelihood of contaminant release
- d) Microbial concentration
- e) Toxicity/pathogenicity



Tools

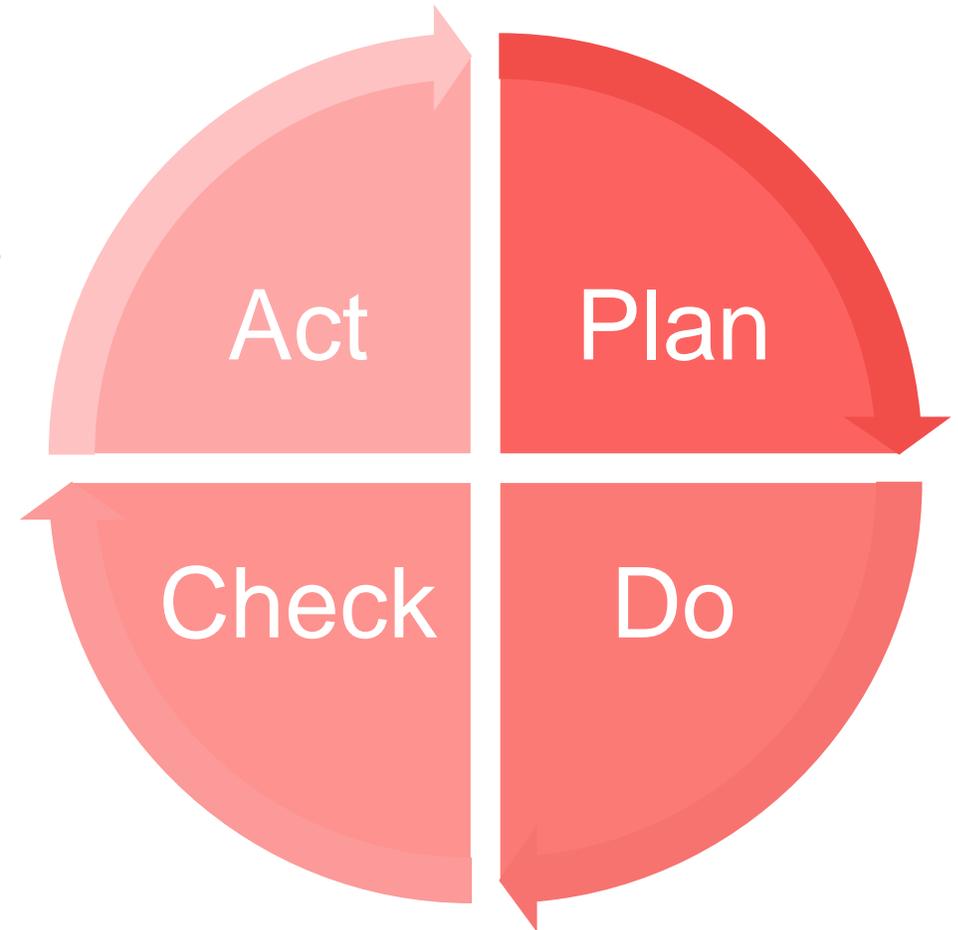
- ArcGIS web maps for information review and commenting
- ArcGIS Pro for spatial analysis
- ArcGIS Field Maps for site visits
- ArcGIS StoryMaps for presentation and ease of access



Living documents

➤ Water suppliers need to anticipate and respond to emerging and potential risks

- Reproducible, transparent workflows for source water risk identification
- ArcGIS StoryMaps for presentation and ease of access
- Feature Manipulation Engine (FME) for updating change
- Linking SCADA and water quality information to identified source water risks

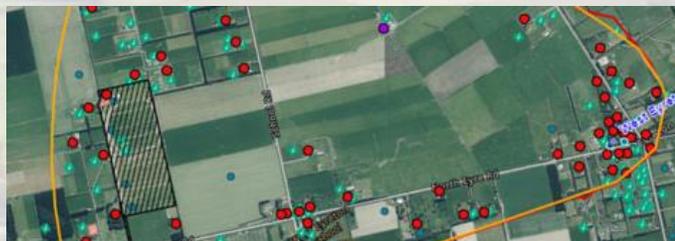


Summary

Delineating Pathways



Identifying Hazards



Assessing Risk



$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

		Consequence				
		Insignificant	Minor	Significant	Major	Severe
Likelihood	Almost certain	Medium	High	Very High	Extreme	Extreme
	Likely	Medium	Medium	High	Very High	Extreme
Moderate	Unlikely	Low	Medium	Medium	High	Very High
	Rare	Very Low	Low	Medium	Medium	High
		Very Low	Very Low	Low	Medium	Medium

Questions? Patai?

Practical examples of source water risk
identification in Aotearoa New Zealand

Jeremy Bennett