National Science Challenges

OUR LAND AND WATER

Toitū te Whenua, Toiora te Wai

KSL Kōmanawa Solutions Ltd

Detection power and N-NO_3 management

Going beyond crossing our fingers and hoping for the best

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Slides link (we'll also put it on our website www.Komanawa.com):
https://docs.google.com/presentation/d/1zZNJkfPvLVpVzJY0a6sakW7RZq5oJ-WzbqG6Ervf5_8

Overview

1. Definitions
2. Detection power → What is it; why do we care; what impacts it
3. Selwyn case study
4. National case study
5. Tools / our outputs:
   - Web app → Surface water, Lakes and Groundwater
   - User Guide documents and fact sheet
   - Python tools
     - Groundwater age tools (https://github.com/Komanawa-Solutions-Ltd/gw_age_tools)
     - Mann kendall stats (https://github.com/Komanawa-Solutions-Ltd/kendall_multipart_kendall)
     - Detection power calculator (https://github.com/Komanawa-Solutions-Ltd/gw_detect_power)
6. Where to from here

Note: dense slides for reference information (I don't expect you to read everything on each slide)
Questions in the chat as they come up

A couple of definitions

- **Receptor**: The receptor is the location where the concentration is measured. This is typically a groundwater well, stream or lake.
- **Source**: The source is the location where the concentration is changed. This is typically a point source (e.g. a wastewater treatment plant) or a non-point source (e.g. a catchment/groundwater source area).
- **True Receptor Concentration**: The true receptor concentration is the concentration at the receptor if there was no noise.
- **Noise**: here by noise we include the variation in the concentration at the receptor. This includes true sampling noise, but also includes any other variation in the concentration at the receptor that cannot be identified or corrected for (e.g. from weather events etc.). Typically the noise will be estimated as the standard deviation of the receptor concentration time series (assuming no trend), or the standard deviation of the residuals from a model (e.g. linear regression) of the receptor concentration time series.

What is **Detection Power**? Why should we care?

What is the chance that we detect our planned mitigations of NO_3-N?

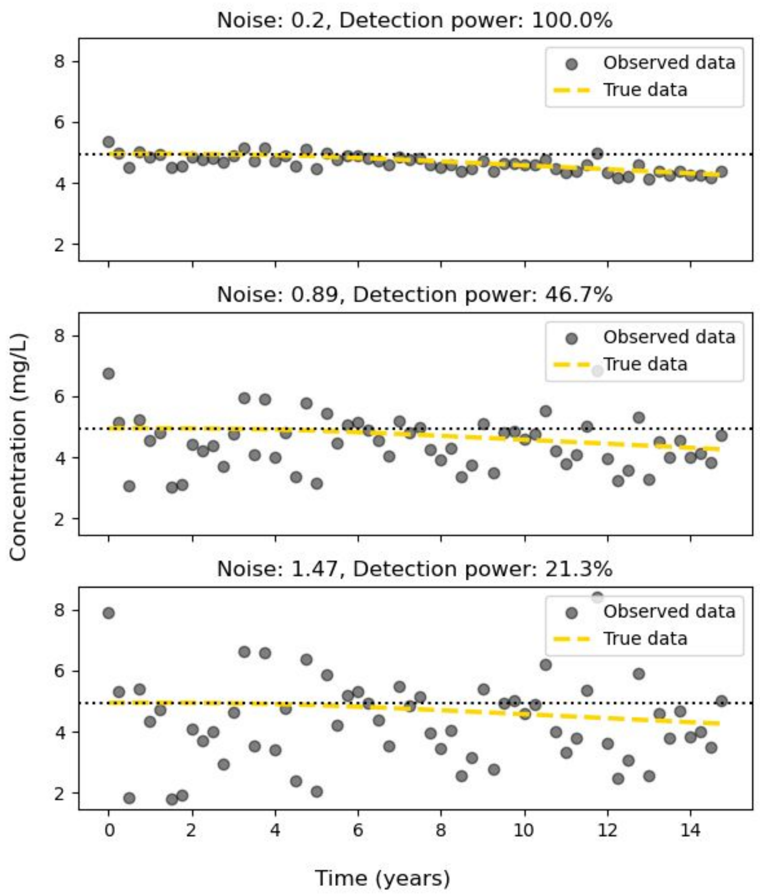
At a receptor:

- Identifying the correct direction of travel in the receptor concentration record (e.g. decreasing slopes with implemented reductions)

Within a network:

- Ensuring the expected changes are happening as expected across the catchment
- A function of a receptors' detection power and receptors' "representativeness"

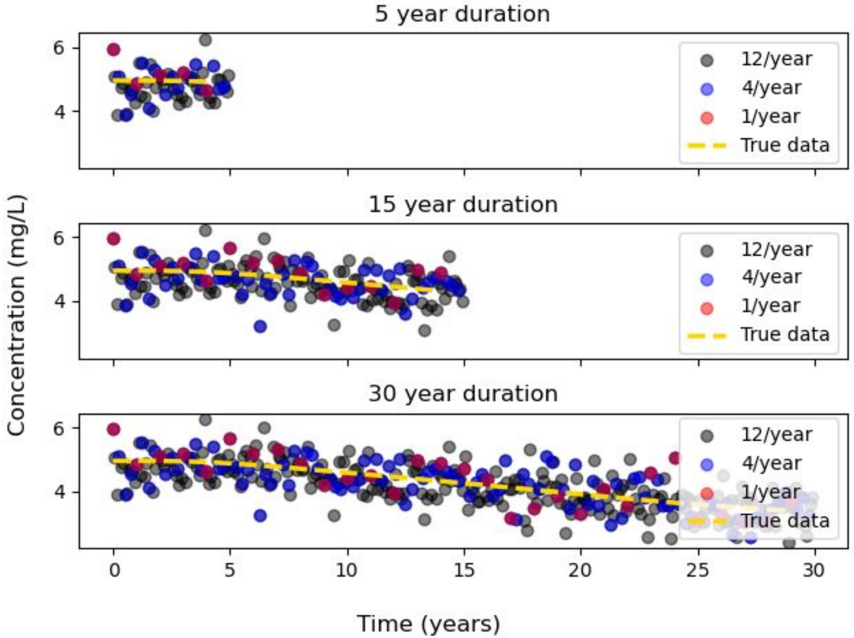
It's probably **impossible** to build a statistically robust monitoring network which fully accounts for spatial variability→ **Targeted monitoring**

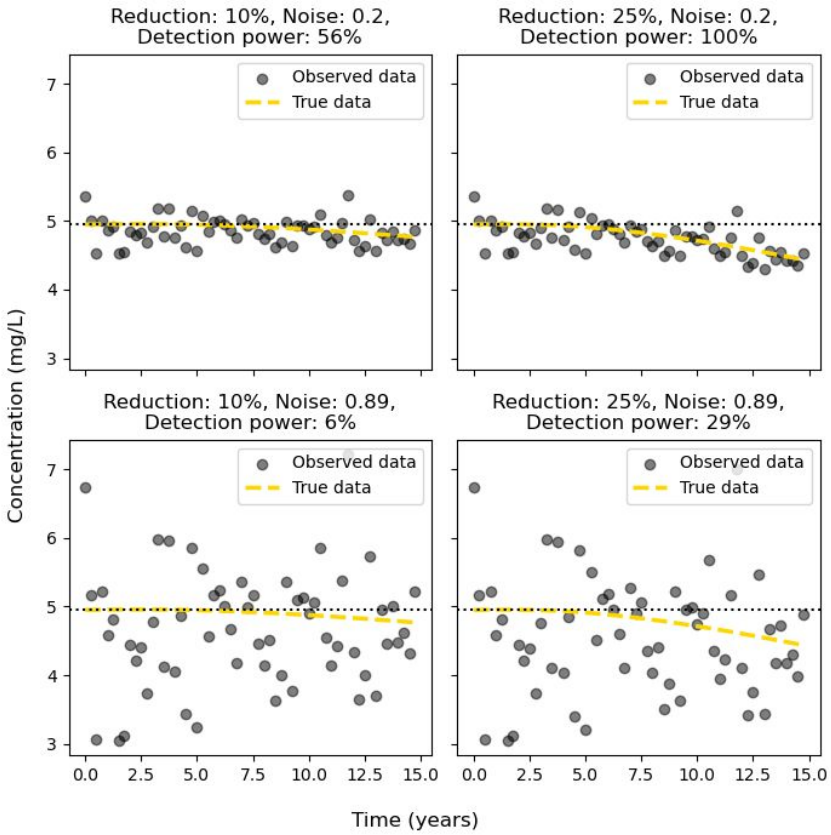


Things that affect detection power: **Noise, Characteristics of Change, and Duration and Frequency of Sampling**

BAD =

High Noise
Small change
Short duration
Low frequency

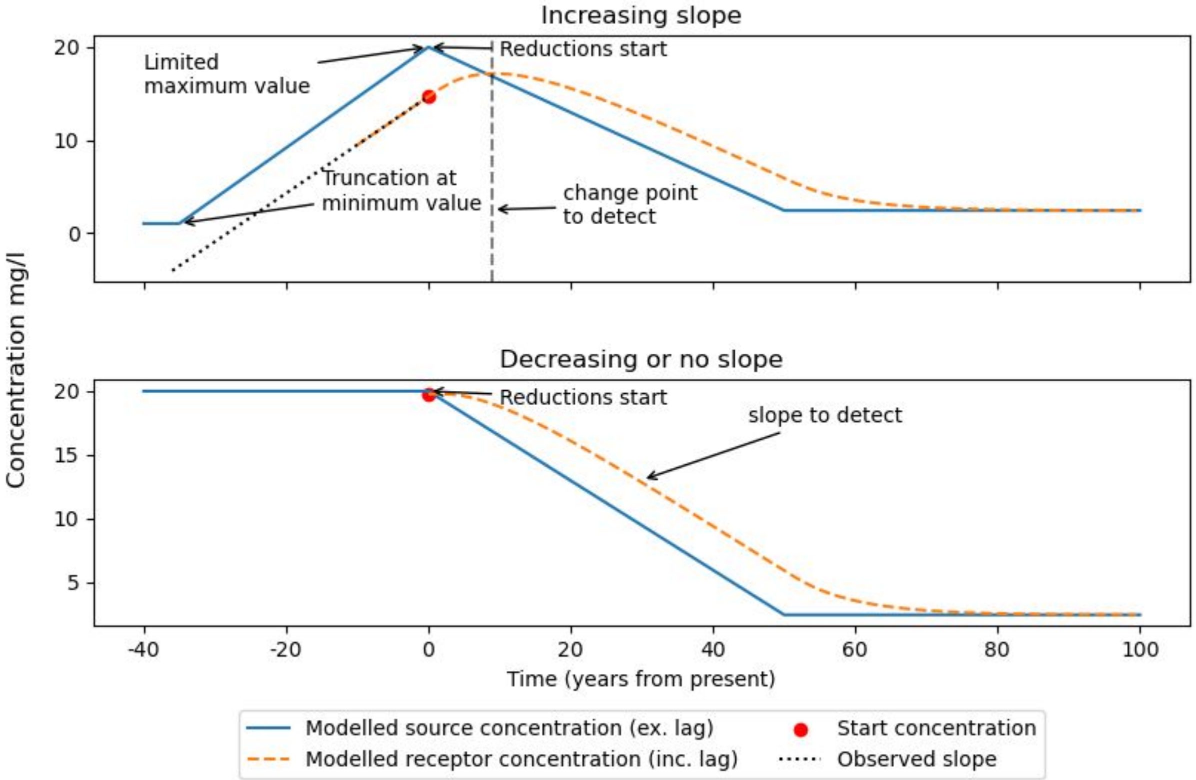




Things that affect detection power: **Travel processes**

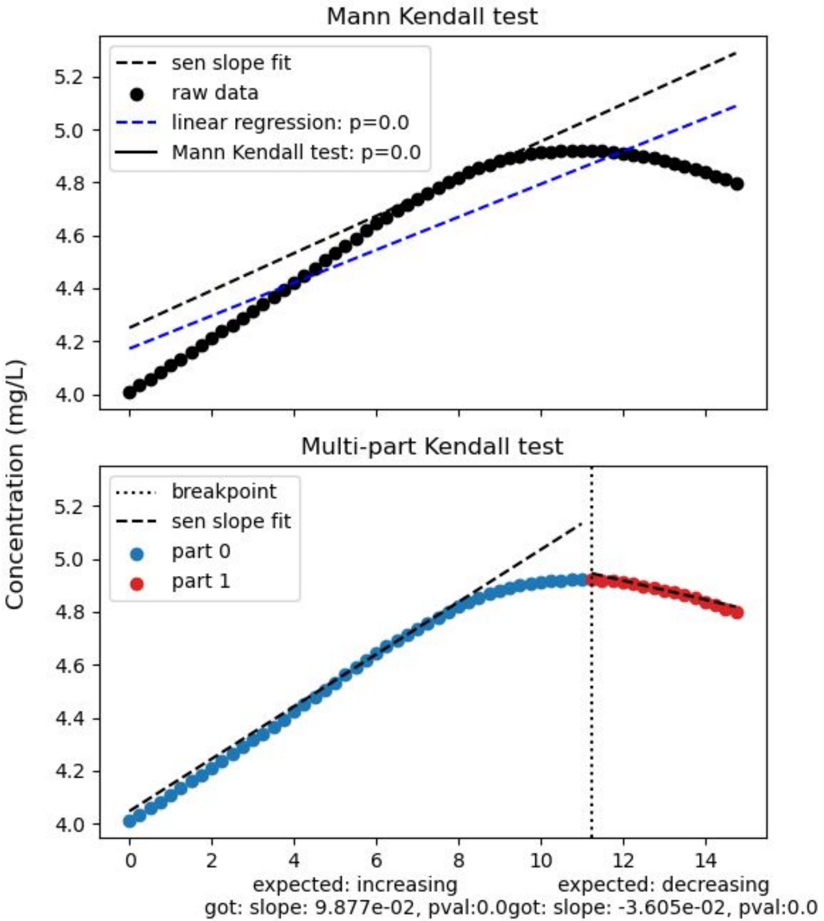
- **Lag**: The wait time between when action happens at the source and when something happens at the receptor
- **Temporal Dispersion**: Mixing of different aged waters which smooths applied changes
- **Hysteresis***: The historical actions at the source that are "in the post" and have yet to show up at the receptor

*I know it's all hysteresis, but indulge my binning for the point of discussion.



Things that affect detection power: **Detection methodology**

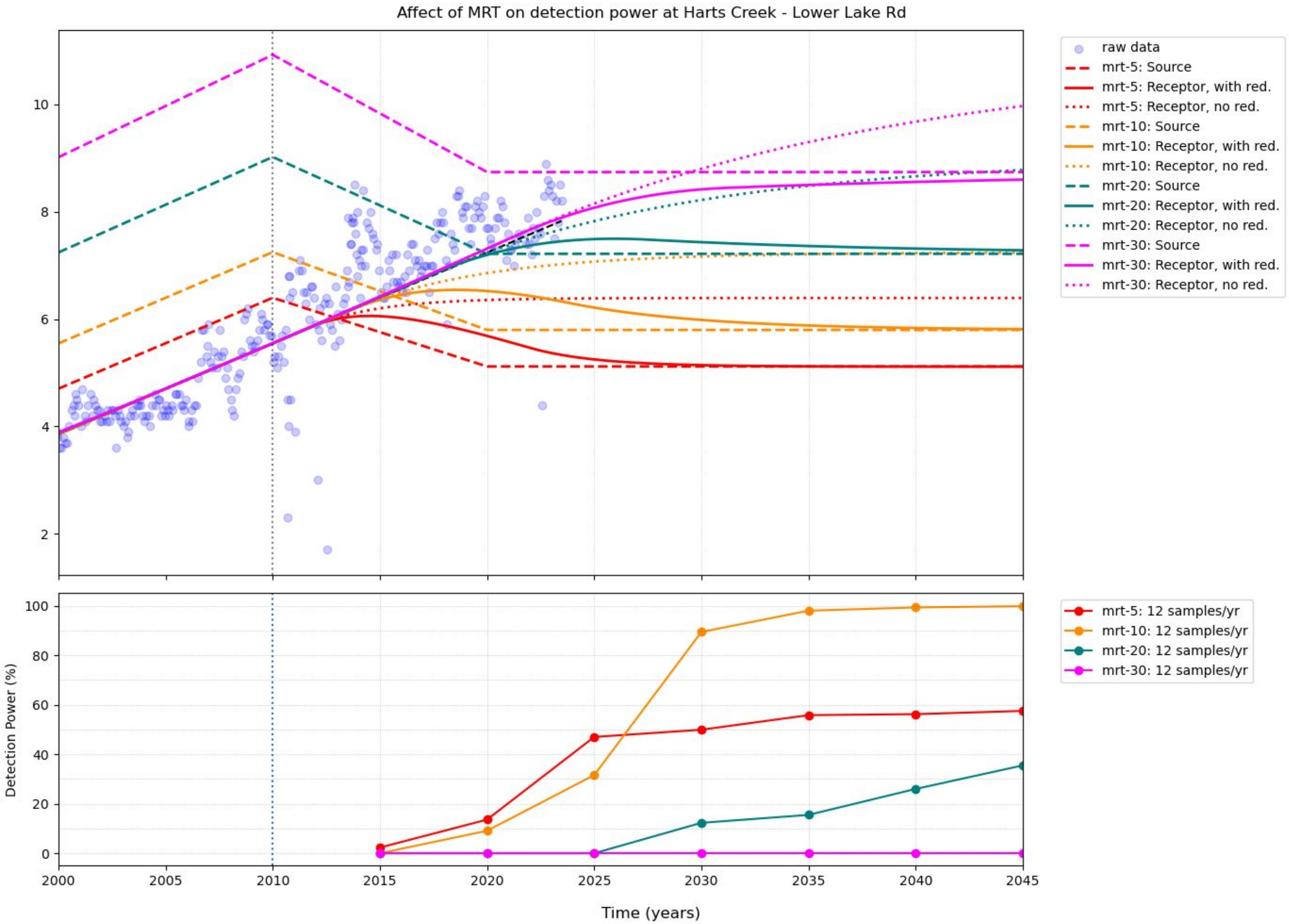
- **Eyeballing it:** needs no introduction, hard to prove unless it's really obvious
- **Linear Regression**: parametric approach and when do you start?
- **Mann-Kendall**: non-parametric but when do you start? Best if you have no historical increases.
- **Multipart - Mann-Kendall**: non-parametric, you don't need to know where to start, but you do need know your expected directions. Best choice for previously increasing records. We have built a python tool for this: https://github.com/Komanawa-Solutions-Ltd/kendall_multipart_kendall



Case Study: Why age assessments matter → even in surface water

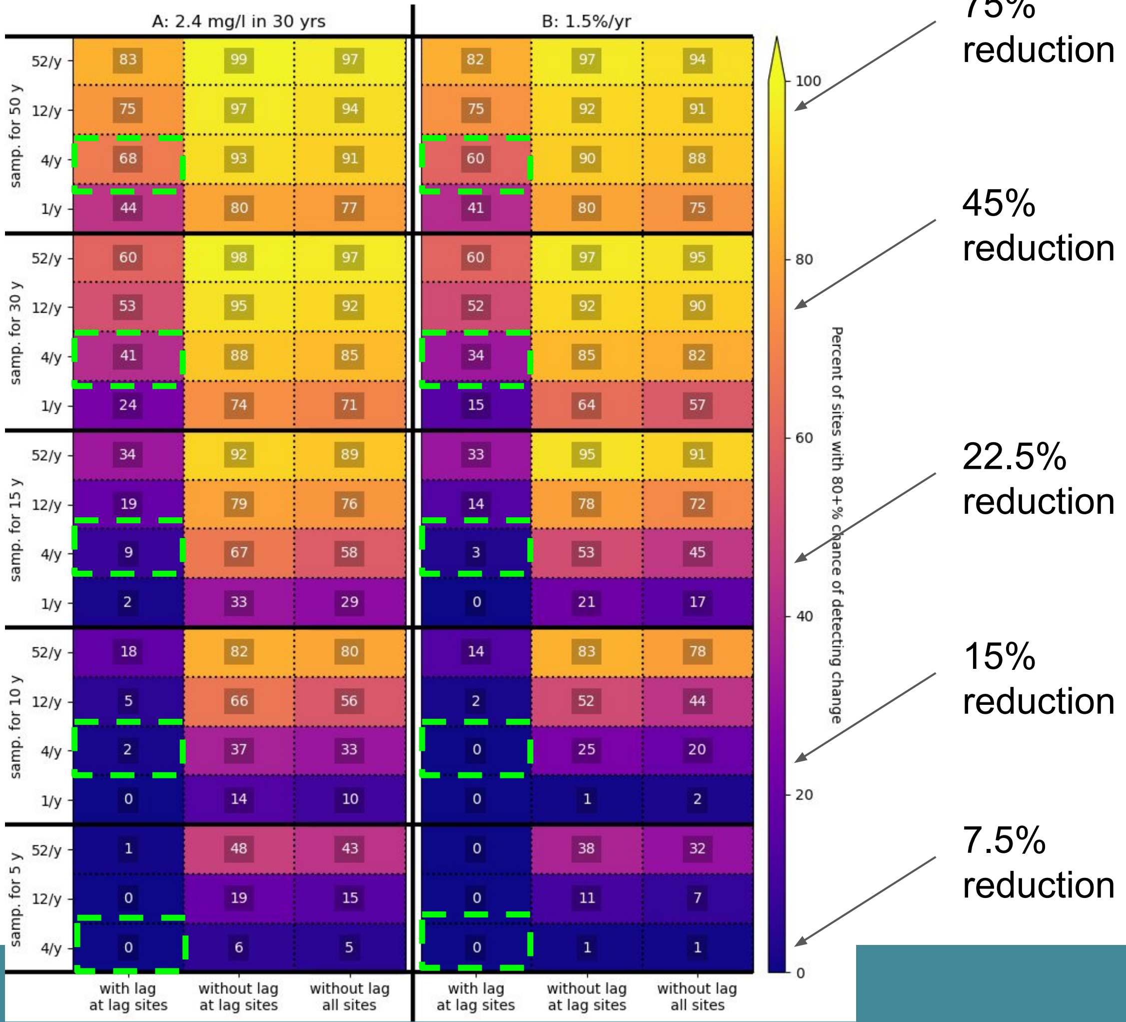
Harts Creek in Selwyn Zone
→ No MRT data → impacts:

- Springfed stream.
- Look at MRT = 5, 10, 20, 30 years.
- Imagine we are in 2010 and 20% reductions are applied → hypothetical.
- MRT can provide info on where concentrations are likely to go.
- MRT drastically affects detection power.

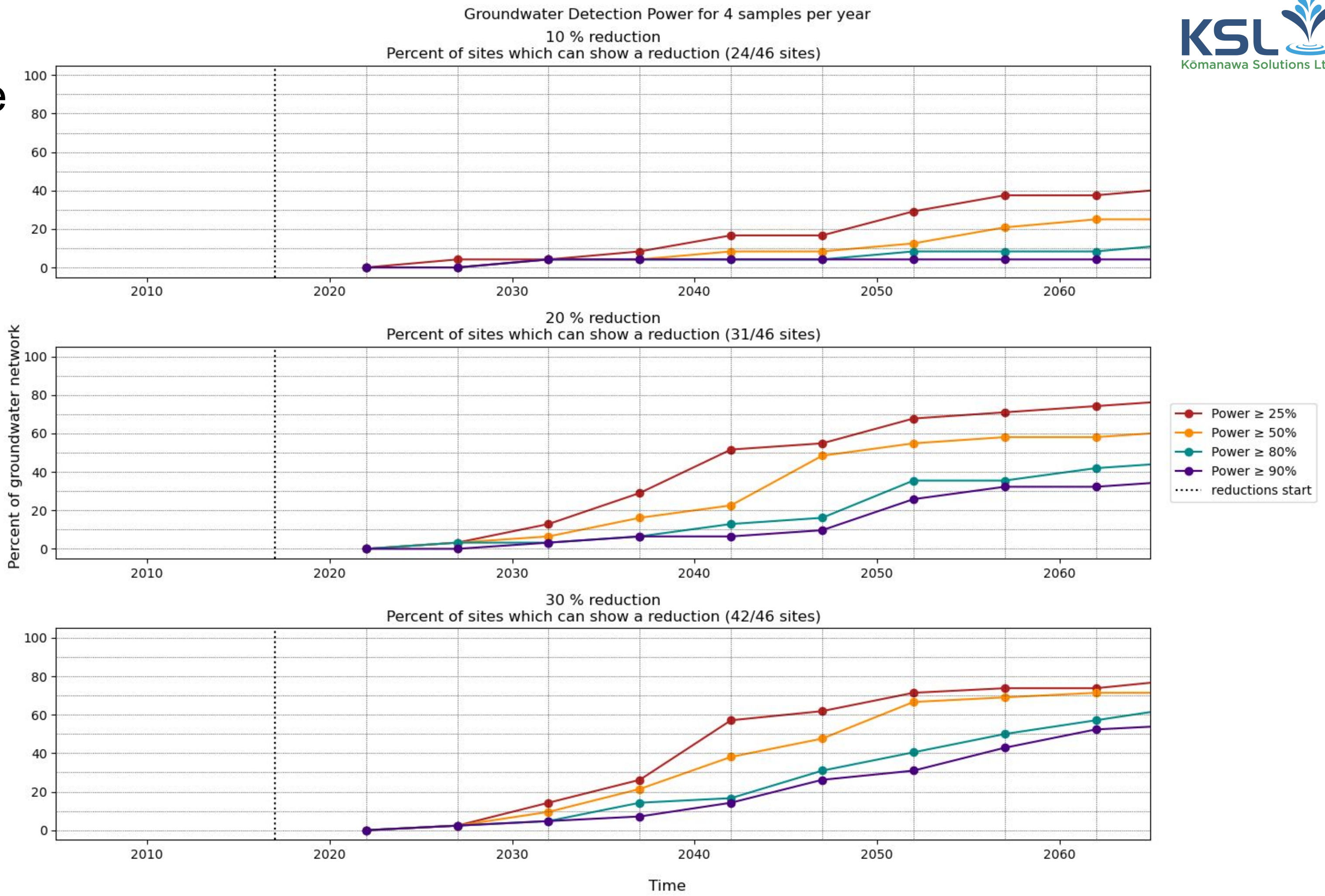


Case Study: National detection power

- Excluding lag yields a sizable bias in detection power
- There is **no** chance of detecting change with quarterly sampling within 10 years
- **Less than half** of sites nationally are likely to detect a change with 30 years of quarterly sampling
- Increasing sampling frequency **can help, but only at certain sites**



Case Study: Why could we detect the increases?



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Outcome:

We've entered a world of pain:

Monitoring ≠ Need

~~Compliance~~ ~~Improvement~~ ~~Feedback~~

~~Recognition~~ ~~Obligations~~ ~~Trust~~

Web app
Groundwater, Surface water, & Lakes

URL: https://www.monitoringfreshwater.co.nz/

When to use:
- First pass for **Maximum** detection power
- **Site Rejection**

Limitations:
- Does not consider travel processes which can **significantly overestimate** the detection power
- Implementation period = sampling period
- National scale… a lack of rigour on a site by site basis

Mitigation effectiveness monitoring design user guide

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- Review of current approaches & key requirements for change detection monitoring
- Detailed discussion of detection power evaluation and lag
- Spatial representativeness & spatial change detection power
- Monitoring design recommendations
- Monitoring cost data
- Case studies


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Our Land and Water National Science Challenge

Report No: Z22014_01

Mitigation Effectiveness Monitoring Design:

Groundwater quality monitoring design user guide for management of diffuse nitrate pollution

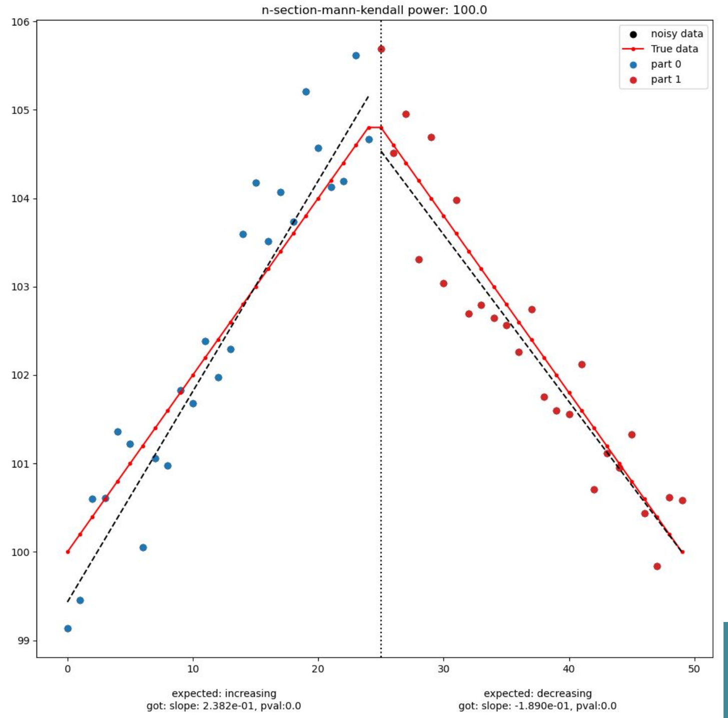
DRAFT

python tools: **Detection power calculator**

- **URL:** https://github.com/Komanawa-Solutions-Ltd/gw_detect_power
- **Python class:** ***calculating bespoke change detection***
  - Handle travel processes: (lag, temporal dispersion, and hysteresis)
  - Multiple methodologies:
    - Linear regression (from start, max, min).
    - Mann-Kendall (from start, max, min).
    - MultiPart Mann Kendall.
    - Pettitt Test (instantaneous change).
  - Pass your own “True receptor concentration”.
  - Plotting functions.
  - Worked examples in the github readme.
  - Install from github via pip.

- Training workshop coming up

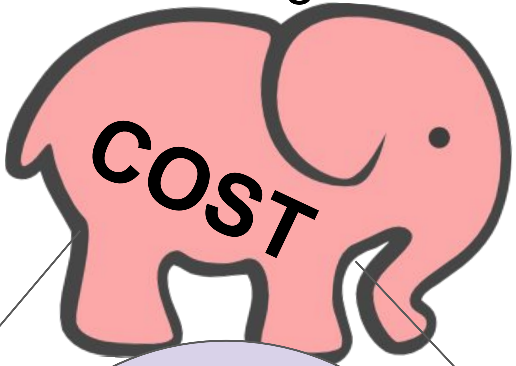
  so keep an eye out!



Outcome: Moving to wholistic monitoring for change detection

Where

- **Enough Detection power?**
- SW is an integrator
- Shallow GW may be closer to the source

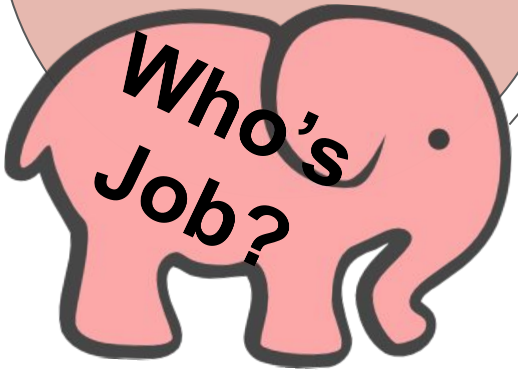


Why

- Just for change detection or other?
- Does the **detection power** of the site suit the purpose?

When

- How long? How frequently?
- Continuous sampling or several high frequency campaigns
- How to reach needed **Detection power?**



Important beyond NO_3-N reductions → other contaminants & for increases!