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Nitrate Dynamics at Quarries

NZ Quarry Conference

24 July 2026

ACKNOWLEDGEMENTS

I would like to acknowledge the innovative and integrated research undertaken by my Green Road colleagues, Julie Palich, Dr Paul Weber, and Wijnand Gemson, whose invaluable contributions and research on today's subject have significantly shaped the content of this presentation.

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NITRATE

1. Why do we care about it?
2. What is it?
3. Where does it come from?
4. What can be done about it?

Credit: Photo from the West Australian, July 2017

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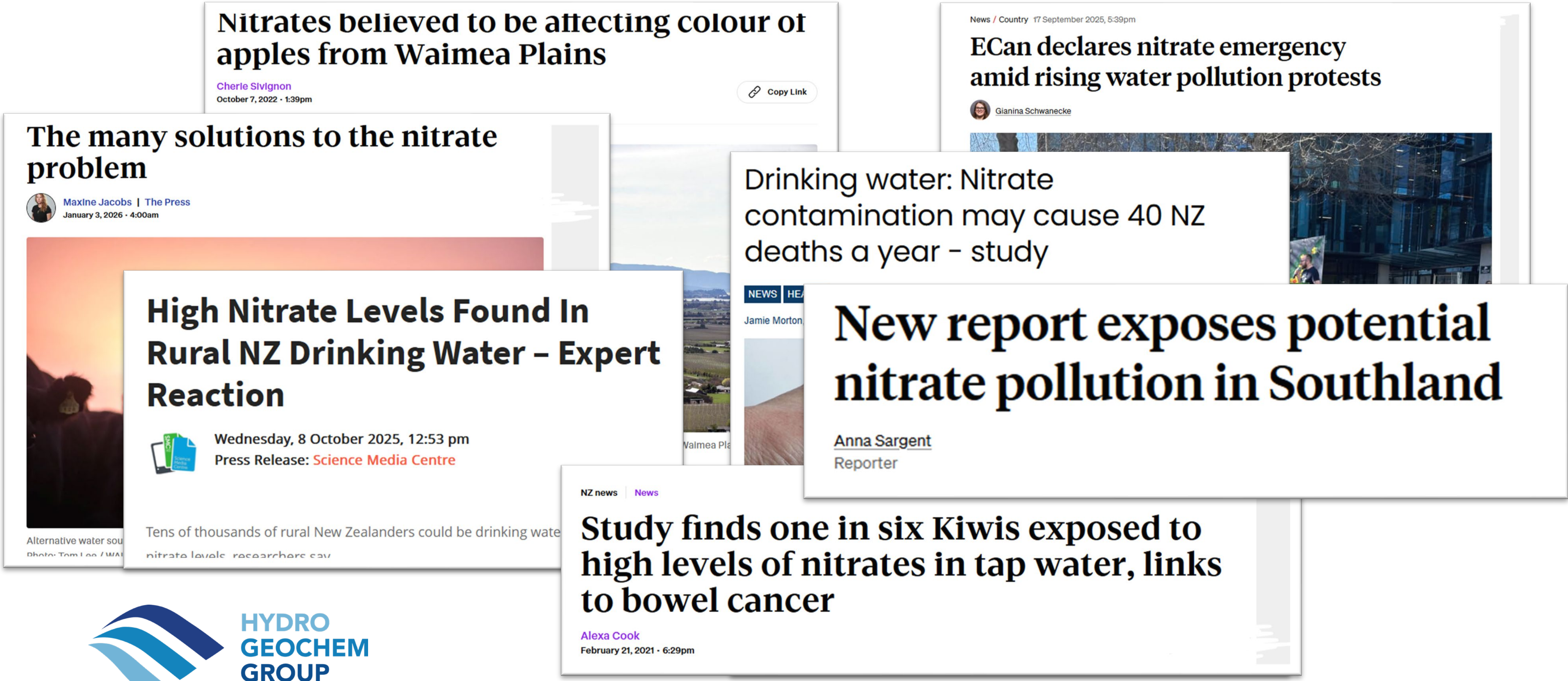
NITRATE IN THE NEWS



Nitrates believed to be affecting colour of apples from Waimea Plains

Cherie Sivignon
October 7, 2022 · 1:39pm

Copy Link

News / Country 17 September 2025, 5:39pm

ECan declares nitrate emergency amid rising water pollution protests

Gianina Schwanecke

The many solutions to the nitrate problem

Maxine Jacobs | The Press
January 3, 2026 · 4:00am

Drinking water: Nitrate contamination may cause 40 NZ deaths a year – study

NEWS HE

Jamie Morton

High Nitrate Levels Found In Rural NZ Drinking Water – Expert Reaction

Wednesday, 8 October 2025, 12:53 pm
Press Release: Science Media Centre

Tens of thousands of rural New Zealanders could be drinking wate

Alternative water sou

New report exposes potential nitrate pollution in Southland

Anna Sargent
Reporter

NZ news | News

Study finds one in six Kiwis exposed to high levels of nitrates in tap water, links to bowel cancer

Alexa Cook
February 21, 2021 · 6:29pm

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WHY DO WE CARE ABOUT NITRATE?

HUMAN HEALTH RISKS

- Through development of methemoglobinemia (‘**blue baby syndrome**’) - infants most suspectable
- Epidemiological evidence suggesting association between nitrate exposure in drinking water and **increased risk of bowl cancer** (2018 ‘Danish Study’).
- NZ researchers have also investigated similar linkages.

ELSEVIER

Environmental Research

Volume 204, Part C, March 2022, 112322

Nitrate contamination in drinking water and colorectal cancer: Exposure assessment and estimated health burden in New Zealand

Jayne Richards [a], Tim Chambers [b], Simon Hales [b], Mike Joy [c], Tanja Radu [a], Alistair Woodward [d], Alistair Humphrey [e], Edward Randal [b], Michael G. Baker [b]

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WHY DO WE CARE ABOUT NITRATE?

ECOLOGICAL HEALTH RISKS

- Ecotoxicity effects on aquatic organisms.
- Environmental effects through **eutrophication of water bodies**:
    - Typically, detrimental to species diversity (e.g., Lake Ellesmere in Canterbury).
    - Can lead to **toxic algae blooms** with direct and indirect deleterious water quality impacts.

Photo credit: Felix Andrews

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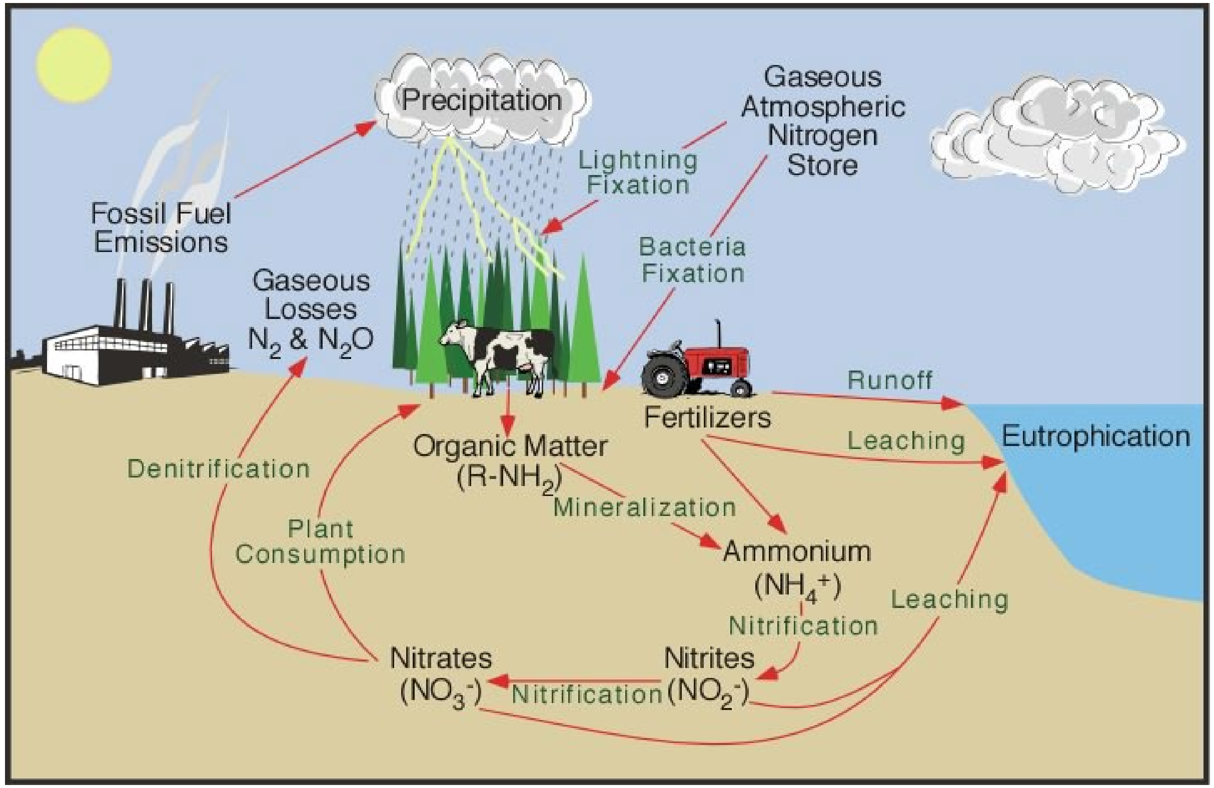
WHAT IS NITRATE, ANYWAY?

NITROGEN CYCLE

- Organic **nitrogen is naturally present** in soils due to decomposing plants, humics, and animal residues.
- Natural sources of nitrate and ammonia include:
  - Bedrock nitrogen and nitrogen leached from natural soils.
  - Microbial activity in wetlands.
  - Subsurface nitrate salts in semi-arid regions.
- These compounds are **essential** for plant growth and ecosystem health.
- When anthropogenic sources are introduced, they can create a **toxic imbalance**.



Source: http://www.physicalgeography.net/fundamentals/9s.html

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WHAT IS NITRATE, ANYWAY?

REGULATION CONTEXT

Table 6 – Nitrate (toxicity)

Value (and component)	Ecosystem health (Water quality)	
Freshwater body type	Rivers	
Attribute unit	mg NO_3 – N/L (milligrams nitrate-nitrogen per litre)	
Attribute band and description	**Numeric attribute state**	
	Annual median	Annual 95th percentile
A High conservation value system. Unlikely to be effects even on sensitive species.	≤1.0	≤1.5
B Some growth effect on up to 5% of species.	>1.0 and ≤2.4	>1.5 and ≤3.5
National bottom line	**2.4**	**3.5**
C Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.	>2.4 and ≤6.9	>3.5 and ≤9.8
D Impacts on growth of multiple species, and starts approaching acute impact level (that is, risk of death) for sensitive species at higher concentrations (>20 mg/L).	>6.9	>9.8

This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes may be more stringent.

National Policy Statement for FWM (amended 2025)

Table 2

Maximum acceptable values for inorganic determinands

Determinand	Maximum acceptable value (mg/L unless otherwise stated)	Notes
Aluminium	1	
Antimony	0.02	
Arsenic	0.01	
Barium	1.5	
Boron	2.4	
Bromate	0.01	
Cadmium	0.004	
Chlorate	0.8	
Chlorine	5	Expressed in mg/L as Cl_2
Chlorite	0.8	
Chromium	0.05	Total chromium content
Copper	2	
Cyanide	0.6	
Cyanogen chloride	0.4	
Fluoride	1.5	
Lead	0.01	
Manganese	0.4	
Mercury	0.007	Inorganic mercury only
Monochloramine	3	Expressed in mg/L as Cl_2
Nickel	0.08	
Nitrate, short-term	50	Expressed in mg/L as NO_3, or 11.3 mg/L as NO_3-N
Nitrite, short-term	3	Expressed in mg/L as NO_2
Nitrate and nitrite	Σ ratio < 1	The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs must not exceed 1
Perchlorate	0.08	
Selenium	0.04	
Uranium	0.03	

Watch Units

Water Services (Drinking Water Standards for New Zealand) Regulations 2022

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WHAT IS NITRATE, ANYWAY?

CURRENT LEVELS - CANTERBURY

- Most groundwater **less than 50% of MAV**, with locally higher levels.
- Frequently see nitrate concentration in groundwater over 50% of the maximum allowable limit (MAV, 11.3 mg/L as Nitrate-N).
- In some areas groundwater is locally **above the drinking water limit** (MAV).

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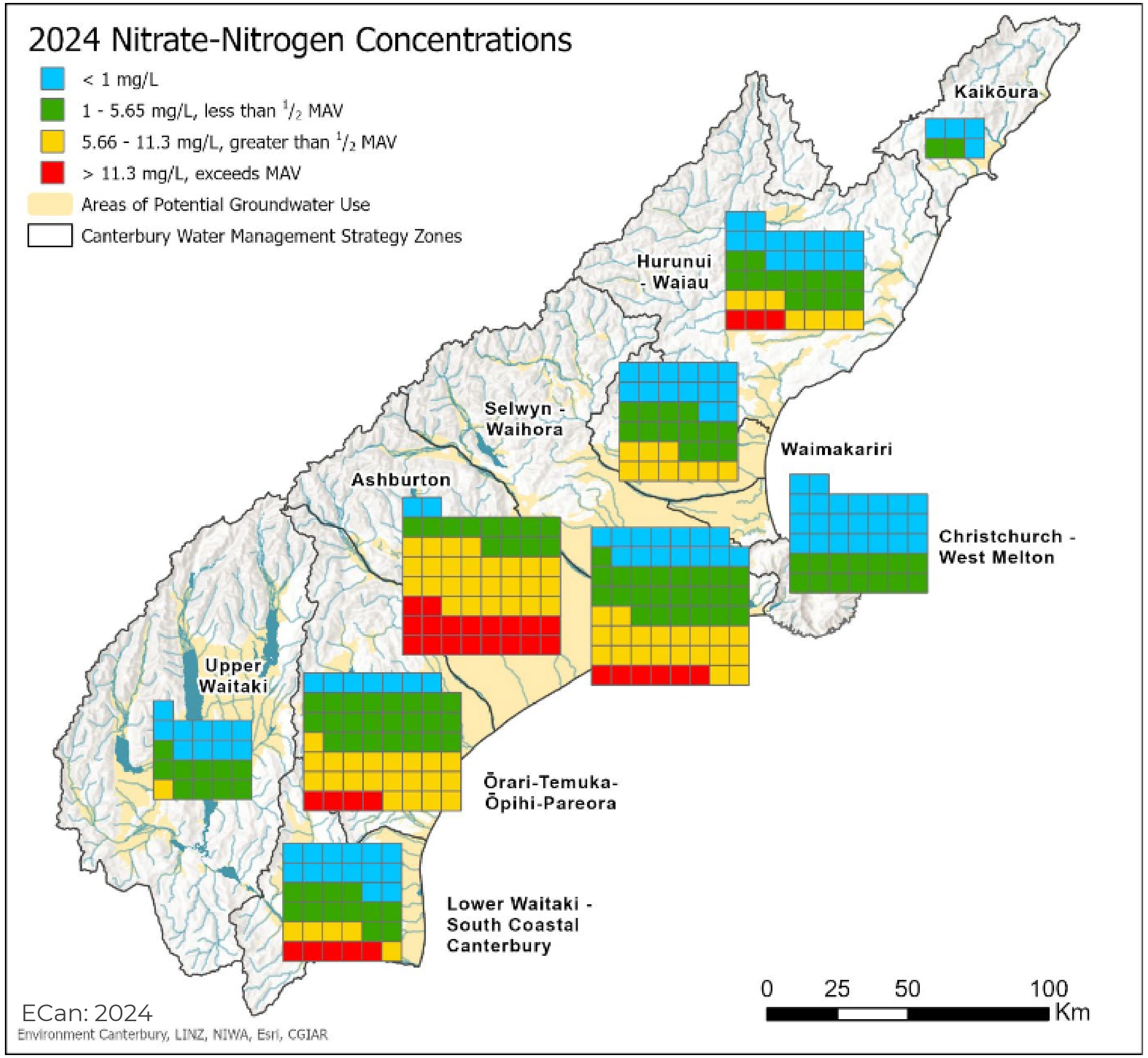
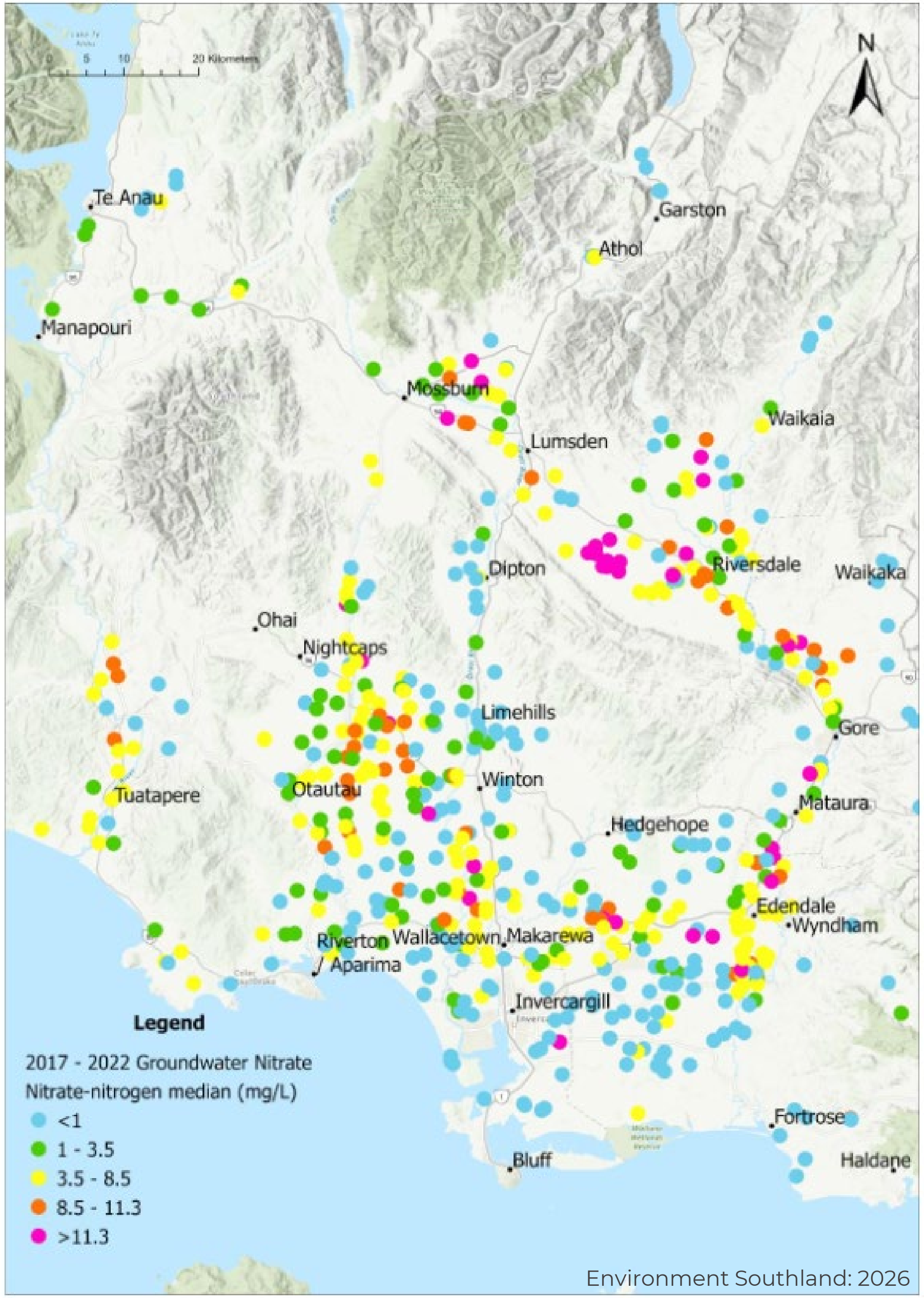


Figure 4: **Summary of nitrate-nitrogen concentrations sampled in the 2024 annual survey for each CWMS zone. One square represents one well**

WHAT IS NITRATE, ANYWAY?

CURRENT LEVELS - SOUTHLAND

- Situation also shows groundwater impacted to varying degrees.
- However, many locations with **lower nitrate concentration**.
- Higher concentrations reported tend to be clustered together.



Environment Southland: 2026

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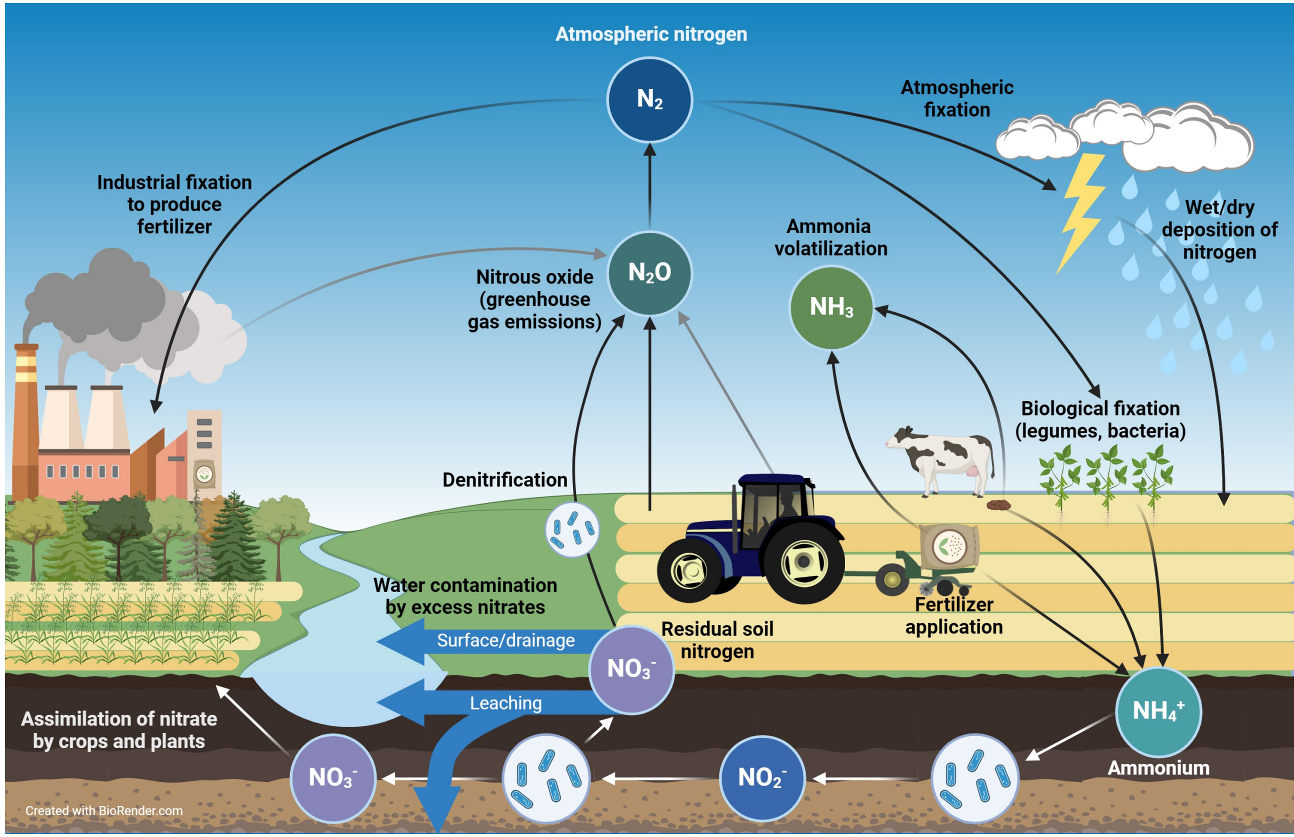
HOW DOES IT GET INTO OUR WATER?

CONTAMINATION SOURCES - PRIMARY

- **Agricultural fertiliser application**
- **Livestock effluents**
- Septic systems
- Industrial discharges
- **Storage and use of explosives**



https://agriculture.canada.ca/en/environment/resource-management/indicators/risk-water-contamination-nitrogen

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HOW DOES IT GET INTO OUR WATER?

CONTAMINATION SOURCES - EXTRACTIVES

Blasting agents such as ammonium-nitrate-fuel oil (**ANFO**) can result in the distribution of a significant load of nitrogen across the extractives environment.

Storage

Releases from spillage, seepage of damaged containers, drips from valves

Transport

Releases from damaged bins, and during unloading and blending

Sleep Time

Between loading and detonation if not appropriately contained

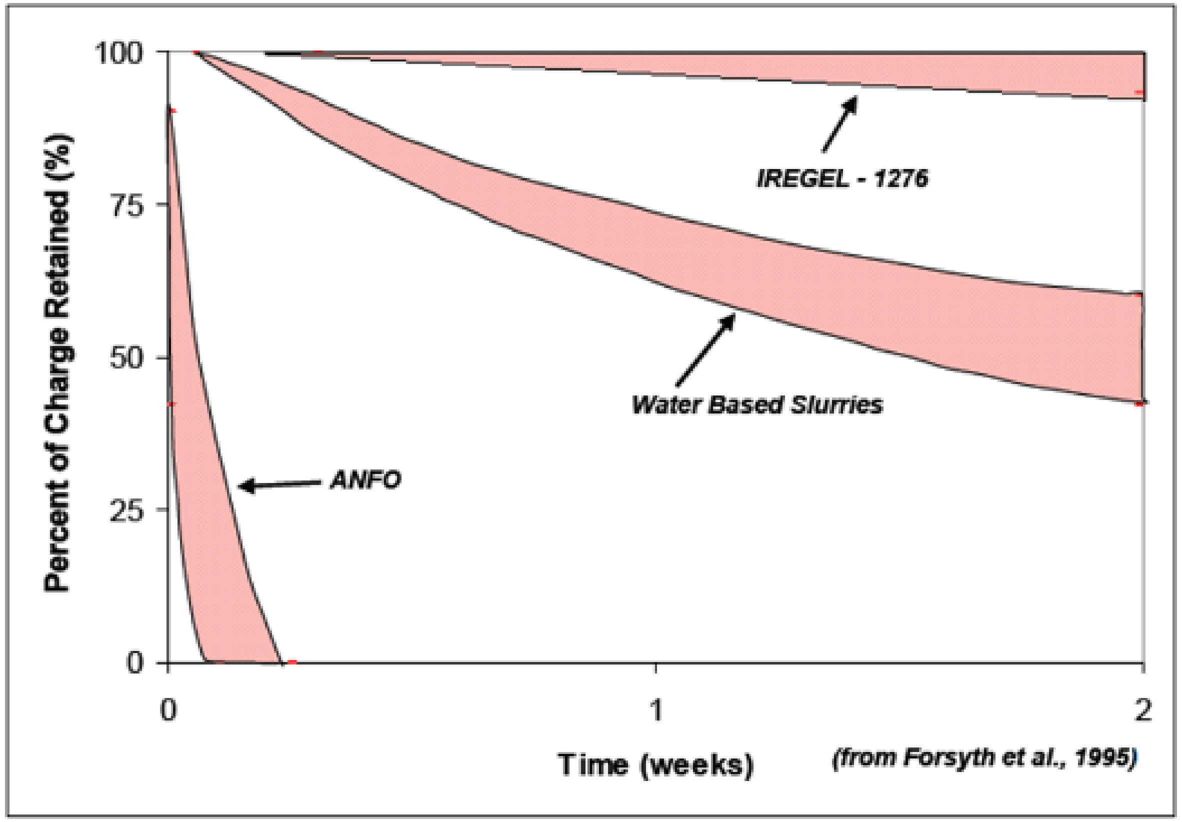
Incomplete Detonation

Remains in-situ in blast area rocks. Adheres to blasted rock as residue

HOW MUCH NITROGEN IS LOST TO THE ENVIRONMENT THROUGH BLASTING ACTIVITIES?

- Nitrogen compounds (**ammonia** and **nitrate**) will leach out of ANFO, even from highly resistant emulsions.
- Global case studies conclude that the proportion of nitrogen lost, compared to the amount of nitrogen used in blasting can range from **<0.5%** to **>5%**.
- Losses are dependent upon:
  - climate.
  - type of explosive used (**see graph**).
  - blasting efficiency.
  - spill controls/management.
  - nature of operations (opencut vs underground).

Relative Leaching Rates



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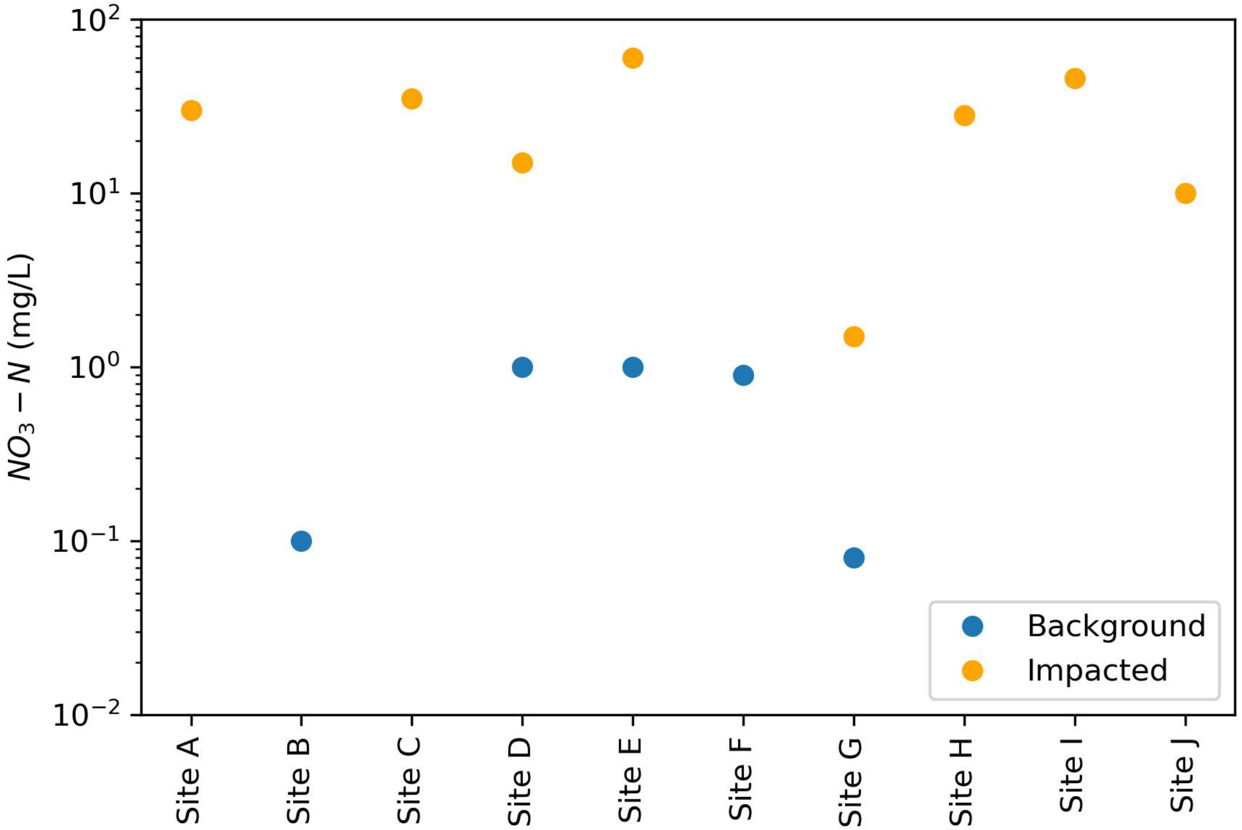
NITRATE DYNAMICS - EXAMPLES

INTERNATIONAL CONTEXT

- Nitrate concentrations (as NO_3-N) attributed to background conditions ≤ 1 mg/L.
- Concentrations attributed to **ANFO influence**, ranged between 1.5 and 60 mg/L NO_3-N (median of 28 mg/L NO_3-N).
- **Nitrate dominant form of nitrogen** (concentrations one to three orders of magnitude higher than reported ammonium concentrations).



Gemson et al. (2022)

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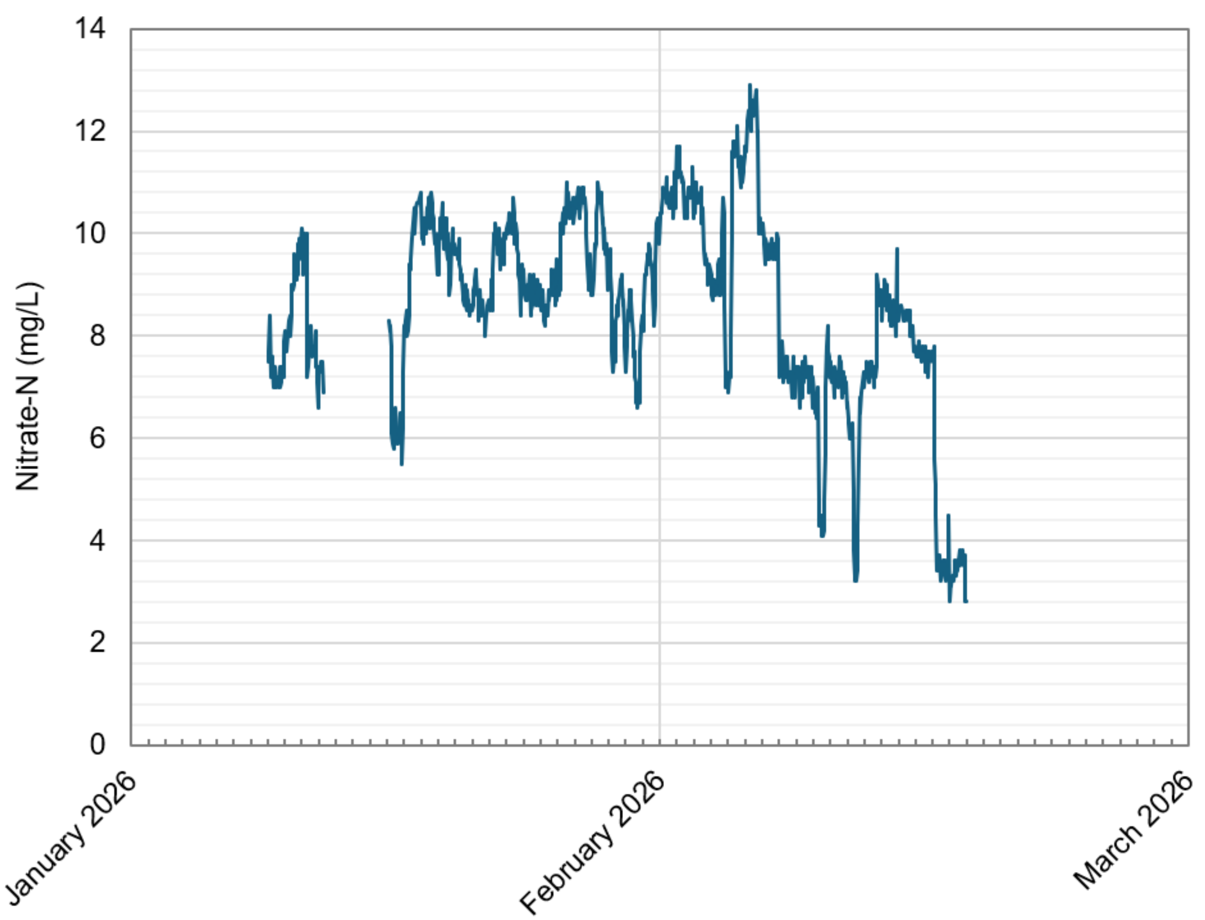
NITRATE DYNAMICS - EXAMPLES

NEW ZEALAND EXAMPLE

- Automatic sensor installed into a groundwater monitoring bore down gradient of a waste rock storage area.
- Alluvial aquifer with high permeability.
- Nitrate-N higher than drinking water standards (11.3 mg/L) on occasion.



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WHAT CAN WE DO ABOUT IT?

Source Control

Spill prevention and management (Housekeeping + Education)
Improved **blast efficiency**
ANFO usage **monitoring and audits**

Pathway Interference

Infiltration reduction – water shedding, rehabilitation
Infiltration diversion – stormwater capture, perimeter trenching,
Seepage collection
Sediment traps with **drain seeding**

Treatment

In-situ Bioremediation – bio stimulation, phytoremediation, electrokinetic remediation, permeable reactive barriers
Ex-situ Bioremediation – reverse osmosis, ion exchange processes, adsorption-based processes, passive treatment systems

WHAT CAN WE DO ABOUT IT?

EMPLOYEE EDUCATION

- At Golden Giant Mine (ON, Canada), employee nitrate management **education program** in 'summer' 1991.
- **>30% decrease in Total Ammonia-Nitrogen** concentration in monitored mine water following education program.
- **Simple measures** such as employee education (i.e., to improve housekeeping processes) can result in **significant reduction**.

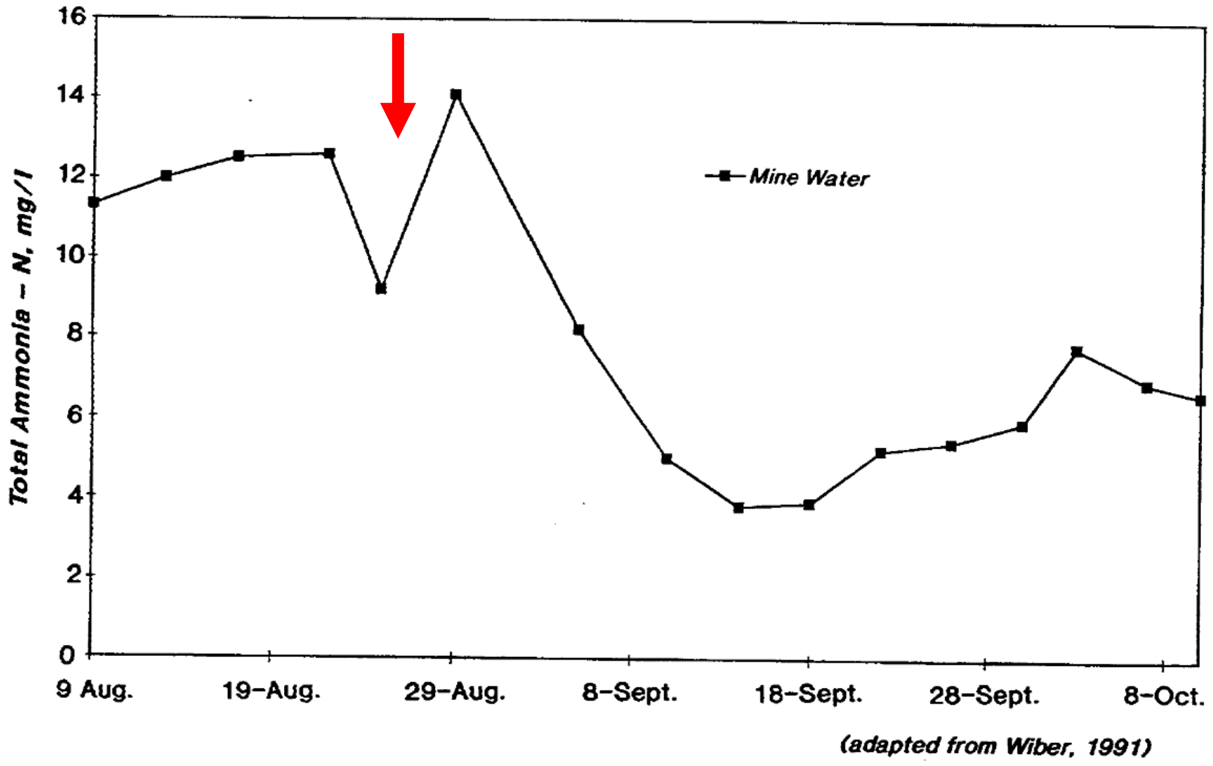

Figure 3 – MINE WATER MONITORING FOR TOTAL AMMONIA AS N
Summer 1991, Hemlo Gold Mines Inc., Golden Giant Mine.

Forsyth et al., 1995

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WHAT CAN WE DO ABOUT IT?

CONSTRUCTED WETLAND

- Titoki, Northland (2000)
- Treats farm tile drainage
- Relatively simple with construction and planting by Farmer
- 900 m^2 area
- **20 to 40% reduction** in nitrogen.
- Higher nitrate reduction reported with higher spec designs (**60 to 80%**)

Two-stage constructed wetland soon after construction and planting (top) and one year later when plants have established (bottom). Arrows show inflow of subsurface tile drainage and its passage through the wetland, finally discharging to the stream behind.

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Tanner et al., 2022

TAKE HOME POINTS

WRAP UP:

- Nitrate pollution risks are gaining public and regulatory attention.
- Pollution can negatively impact human and ecosystem health.
- While agriculture and wastewater discharge are often the largest contributors of nitrate loading to the environment, **explosive residues (ANFO) from quarry and mining operations can pose risks**.
- Management of nitrate **sources, pathways, and treatment** are practicable options to mitigate risks at mines and quarries.

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Questions ?

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