Submission of Nathaniel Calhoun, September 1st, 2020.

Kia Ora

It's an honor to be here. My name is Nathaniel Calhoun and I was born in the Northeast of the United States on Penobscot land.

I'm the co-founder of a strategic consulting firm called Code Innovation that focuses on technology and social impact and environmental work.

We've worked with the United Nations, the UK's Department for International Development, the Bill & Melinda Gates Foundation and more than 20 other partners across a dozen countries in Africa, Asia and the Carribean.

Our work has included curricula specifically for drylands climate change adaptation and disaster resilience programming.

I'm also the Faculty Chair at Singularity University, a technology-focused university in Silicon Valley.

I ran Silicon Valley's only 10 week accelerator focused on Climate Change for over 80 business people and leaders from 40+ countries.

I've coordinated closely with the Stockholm Resilience Center who are global leaders on environmental science. I've contributed to their programs and accelerators in Sweden and Estonia.

I'm on the board of three high tech startups, two in artificial intelligence and one focused on biodiversity monitoring. We're pursing the X-prize for rainforest preservation, designing next generation IOT sensors for precision agriculture and conservation.

I also advice the NZ Department of Conservations Bioheritage Challenge on business and solution sustainability.

The idea of these proceedings is to show that the relevant experts and authorities have enough quality information and a good enough plan to prevent lasting damage to our environment.

The experts and authorities are the environment's protective layer.

And as with any system of protection, what matters most is:

are we aware of all possible layers of harm?

are we measuring and observing optimally for these harms?

do we have an adequate contingency plan and enforcement mechanism?

The answer to all three of these questions is "no." or at least "not yet."

The best thinking of the experts is laid out in a variety of Groundwater Monitoring and Contingency Plans (GMCP).

I'm going to use my time to focus on these GMCPs because they do not yet represent the best possible standard of protection for our environment. I will focus on three reasons.

First: GMCPs persistently assume that ecosystem health (and aquifer health) decline steadily (and slowly). There demonstrate no awareness of or vigilance around the possibility of tipping points or collapse. Those terms and concepts are entirely missing from the documents and contingency plans.

Second: The monitoring is not up to existing best practices globally or even within NZ. The low frequency of measurement creates high risk of damage. The lack of diversity of measurements makes it inevitable that indicators of the environment's health (and other warning signs) will go unseen.

Third: the contingency plan is extremely reckless. It allows as many as 7 weeks to pass with all orchards at or above 50% takes even while ecosystem health is deteriorating. The plan is allergic to stopping irrigation to the avocados. The most obvious example: there is no threshold of environmental decay that would require orchardists to completely stop their take. Takes below 25% are not even mentioned. Instead of having a robust list of potential red flags, there are zero.

Let's go deep on each of these three areas.

First: The current GMCP persistently assumes that ecosystem health (and aquifer health) decline steadily (and slowly). There is no awareness of or vigilance around the possibility of tipping points or collapse.

With 6 exceptions (in the form of proposed sentinel bores), all relevant data about water salinity and water levels are gathered monthly.

So, for example, if measurements are taken on the first of the month, you could have a sharp salinity increase begin on the 2nd of January and continue unchecked for four and a half weeks. This increase is then noticed or reported for the first time on the 2nd of February. Let's say it shows that we have just reached

Trigger Level One = a 25% change in salinity

two days are allotted to inform the relevant orchards (depending on weekends). So we could be 5 weeks in to a steady decline before we even consider contingency action. Unfortunately, the contingency action for this drastic salinity increase is simply to go towards weekly monitoring, once a week for three weeks.

If it's declining steadily towards 50%, but hasn't reached 50%, the orchardists could continue their normal water draw for the entire time.

This could be true even if we are in the midst of a drought.

We are going to spend more time with the example above, but let's start with the base assumption:
the GMCP treats these declines like a volume nob that we can control. No individual percentage is treated as worse than another (there are no tipping points acknowledged). And the implied assumption of the first contingency action, which is only a 50% reduction in takes, is that during a drought – when no recharge is happening—a reduced take will either pause or reduce the salinity or water level issues. The third assumption here is that the data is temporally correlated with the exact state of the aquifer's wellbeing and that there is no lag. It could be that salinity level effects lag actual salinity intrusion by days or even weeks. That would be catastrophic. But it is not mitigated against in the GMCP.

The GMCP also seems to assume that no matter how far we go in the wrong direction, we can always somehow return to the place of health that we currently enjoy. Otherwise, why would watch such heavy saline intrusion without intervening?

Across the Tasman sea, at exactly our latitude, intensive orcharding has resulted in lowered water tables that have caused considerable damage to native ecosystems. These have been closely studied and a number of reports have emphasized the **ecosystems have tipping points** and are prone to sudden collapse and permanent destruction.

I'll share a few references and findings just to establish that there is a body of scientific research and ecosystem monitoring that our neighbors are doing. There is no reason that we should not be doing the same or better.

The first two quotes to read may seem intuitive; but they are actually not included in many models—apparently including the GMCPs.

"groundwater is therefore more likely to be taken up in dry seasons"
"Groundwater is therefore a water source that alleviates water stress during dry seasons when surface soil moisture is depleted,"

The dependence of local ecosystems on groundwater has been historically under-rated.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5585407/ ←link to first article

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Relative contribution of groundwater to plant transpiration estimated with stable isotopes

Adrià Barbeta[1,2,3] and Josep Peñuelas[2,3]

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" attempts to integrate groundwater into Earth System Models have increased in recent years[11–13]. In order to improve the representation of groundwater-surface interactions in models, a quantification of the relative contribution of groundwater to transpiration and its variability across environmental gradients is required."

"In the face of current climate change, a more comprehensive understanding of the relationship between groundwater and other subsurface water pools below the soil (saprolite water, bedrock-related water) and vegetation is therefore crucial. "

"all plant types studied here partly rely on these sources, so groundwater pools should also be considered when studying the plant-water relations of shrublands or grasslands."

Once you dry out the roots, a tipping point of death may happen.
Orchardists know this—it's why they got to irrigate during our recent drought—but have we measured and quantified the needs of our native ecosystems? Do we know what levels of salinity or water deprivation each relevant native species can endure? That is the information required before we can protect the species. Using big round salinity numbers like 25% or 50% is divorced from good ecosystem science.

https://www.sciencedirect.com/science/article/pii/S2351989414000286 ←2nd article.

Global Ecology and Conservation
Volume 2, December 2014, Pages 148-160

Original research article

Groundwater decline and tree change in floodplain landscapes: Identifying non-linear threshold responses in canopy condition

J. Kath [a, b, c], K. Reardon-Smith [b, c, d], A.F. Le Brocque [b, c], F.J. Dyer [a], E. Dafny [e], L. Fritz [c], M. Batterham [c]

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https://doi.org/10.1016/j.gecco.2014.09.002

"Non-linear threshold responses in canopy condition in these species may be linked to rooting depth, with chronic groundwater decline decoupling trees from deep soil moisture resources. The quantification of groundwater depth thresholds is likely to be critical for management aimed at conserving groundwater dependent biodiversity. Identifying thresholds will be important in regions where water extraction and drying climates may contribute to further groundwater decline."

"Groundwater depth thresholds might represent 'tipping points' (*sensu*Laurance et al., 2011) beyond which the vulnerability of groundwater dependent species and communities to other water related stressors, such as drought, could substantially increase and from which recovery is uncertain (Groffman et al., 2006, Laurance et al., 2011)."

https://frackinginquiry.nt.gov.au/submission-library?a=446549 ←3rd article

"A Review of Groundwater Dependent Terrestrial Vegetation and Groundwater Depth for the Namoi Catchment Management Authority, NSW. June 2013"

"Groundwater dependent terrestrial ecosystems that rely on groundwater are particularly at risk from water level fluctuations due to the roots being distributed just above the water table in the vadose zone (the unsaturated zone above the water table). Parameters of the

groundwater regime that influence the viability of these GDEs include the alteration of water level and pressure regimes."

If you need to know the relevance of these studies for us, just consider the experience of the Gumdigger's Museum park in the center of this development. For the first time during our recent drought, the water table fell below the needs of that native ecosystem. Every local in the Far North with a native forest ecosystem has the right to be concerned about the water being drained from beneath their roots. And the GMCP should take it as a warning sign any time a pocket of native flora dries up—such considerations are notably absent.

For comparison, we lost 8 juvenille kauri at our property north of Houhora. They are, as a CBEC arborist told us, the first to "turn up their toes" when it's dry. Normally, we would have used our bore to water these kauri, but it was not legal to do so during the Northland drought. Consider how many native birds of the Far North have to fly from oasis to oasis of native bush. They aren't stopping in the pine lots, the paddocks or the avocado farms. We should know where these native oasis are, and we should know when we're drying them out. Everyone caring for them right now will be using a shallow bore and many will struggle to justify paying $15,000 NZD in a drilling arms race with these avocado orchardists.

As my friend from the Stockhom Resilience Center summarizes:
Has there been an assessment in the region of ground-water dependent ecosystems? If not, there probably should be.

Let's move to our second point:
Second: The monitoring is not up to existing best practices even within NZ. The low frequency of measurement creates high risk of damage. The lack of diversity of measurements makes it inevitable that indicators of environmental health (warning signs) will go unseen.

In our example above, monthly monitoring and then weekly monitoring could result in 7-8 weeks of continuous, rapid decline without any intervention being taken.

Continuous monitoring is possible. There are already 6 sentinel bores scheduled for inclusion. They were supposed to contribute baseline data before the orchardists began irrigating.

Have they been built? Has the baseline been established?
If not, a big pillar of the reliability of the GMCP is being disrespected.

Why are there only 6? Why isn't there one north of Houhora? Why isn't there one East of the Harbor? Why isn't there one behind East Beach where the massive set of orchards are clustered? why aren't there more in Kaimaumau?

As the submission from the Ministry of Education contributes: there are no shallow bore sentinels in and amongst the orchards. Everything is focused on deep water. The Ministry envisions the majority of the primary schools having their bores permanently compromised and asks that the orchardists supply drinking water.

What if the school is gardening? What if it is surrounded by native trees that are now dead and dry? What if their families are on properties with similar misfortunes? None of that is considered. Even though every time a native ecosystem dries out should be a separate warning flag that we are on the wrong path. The fact that the submission from the Ministry of Education envisions this possibility of shallow bore destruction instead of assuming that we can confidently monitoring everything necessary to prevent it speaks volumes.

Why, also, are we limiting ourselves to the simplest forms of monitoring only? Much more powerful sensors are available now that would allow us to take robust water quality measurements, tracking bacteria, nitrogen levels, chemical run-off . . . none of these variables even make an appearance. Why not? Why are we ignoring what technology can deliver us? These orchards are surrounded by streams that run into our wetland and harbor ecosystems and nothing is set to monitor the water quality on all relevant metrics.

I mentioned that we're not keeping up with best standards in NZ. It's worse than that, we're missing an opportunity to create jobs, opportunity and expertise in the Far North related to environmental monitoring.

I'll draw your attention to two kiwi-lead teams that we should interface with to seize this opportunity and raise the bar on our GMCPs:

Toha Foundry, a Maori-lead impact investing company focused on using data to measure environmental impacts. They are particularly interested in using data to demonstrate the economic and long-term advantages of sustainable agricultural practices. the kind that are not mentioned discussed or practiced by the orchardists asking to use our water.

The second is "Calm the Farm" an organization specifically helping to raise the bar on agricultural data gathering, monitoring and analysis, also to help keep environments not just healthy, but thriving and increasingly biodiverse.

If we're going to invite avocado orchards to be our neighbors it should be while creating jobs and technical expertise in environmental management and monitoring—not just season picking labor. And we should do it with kiwi data scientists and technologists. This is the empowered, self-sovereign way to design the future of agriculture.

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of environmental decay that would require orchardists to completely stop their take. Takes below 25% are not even mentioned.

There must be an absolute boundary somewhere, otherwise what are you defending? It is hard to understand why these documents don't even agree on a floor—a level of deterioration that results in the immediate stoppage of the avocado irrigation. Can we not imagine saying "stop"? If we haven't imagined it in advance and put a number on it, we'll be dancing around and negotiating when our ecosystems collapse.

The experts and leaders in this room are supposed to create a plan that assures us that collapse and failure will not happen. To do that, they'd need to show that they were monitoring everything relevant, continuously and openly.

More continuous monitoring is possible and must be included. We need to explore other types of sensing and variables to compliment the more costly bore-based technologies. Cheaper sensors, drone based sensors: the IOT ecosystem is full of options.

The **openness of the monitoring also matters**: the sentinels are meant to stream data to the council. That should be streamed to open data platforms for citizen scientists, academics and civil groups to interpret. They can find correlations between different data streams and provide a level of vigilance that will not be compromised by staff turnover, holidays or attentiveness.

Other bores with continuous monitoring technologies should be streamed publicly. Instead, the report states:

"No trigger levels will be established for groundwater levels in the production bores as water levels in the production bores can be impacted by well efficiency and pumping schedules so are not necessarily representative of groundwater levels in the surrounding aquifer."

This is saying: our bores are too powerful, they'll temporarily generate frightening numbers that you will be unable to contextualize. Orchardists have already convinced the council that their continuous data is of no use. . . and this is unacceptable. Is it not valid data during the night? during periods of inactivity? Can they not include context and caveats to help citizen scientists understand any aberrant numbers? Their hesitation to share this data erodes trust. It's public water. If monitoring is available it should flow publicly. Why would it not?

An additional sign of recklessness: Why isn't there a clear and different monitoring and groundwater take regime during droughts or even heatwaves? Monitoring monthly through the rainy winter and monthly during a drought is not logical. Larger meteorological conditions should impact the monitoring regime.

You'll remember from our first point that we should know about the ground level requirements of our indigenous ecosystems. We should know for each indigenous species: how long can their roots be dry before they die? (And how deep do their roots go).

When we're entering a dry spell, we should be monitoring around them daily. It's the only way we might spot a decline in time to reverse it. If you farm and grow things, you know that leaving plants high and dry for days (let alone weeks) during a drought can be enough to kill them. If we care for these species we cannot use distant monthly measurements.

Finally: why are there not specific red flags related to multiple readings from multiple bores?

There is no specific GMCP provision that says more evasive action must be taken if 4 sentinels report problems in a row, vs just one. What if multiple community bores run dry? Why is that not even included as a yellow flag for aquifer health or as a proxy for the likely suffering or death of oasis of indigenous species? There should be a threat matrix that treats multiple different yellow flags as a red flag, invoking strong aquifer protections. Many weak signals could be a bigger threat to ecosystem health than a single strong signal. There is no sensitivity to the magnitude or breadth of potential failure, which ties back to our first point: the failure to understand and incorporate ecosystem collapse.

Without very sensitive monitoring how can we submit that we are experts or authorities or protectors?

There is an opportunity here to ensure, to 100%, that our ecosystems are here and healthy for our grandchildren. But that will take stronger boundaries, better monitoring and much more aggressive contingency plans. Fortunately, it can also create more high skilled jobs in ecosystem monitoring and bring wider prosperity to the community.

The GMCPs are full of confidence but based on a weak sensing regime and shallow environmental science.

Please do better.