Review of Parliamentary Commissioner for the Environment (PCE) report on "OVERSEER® and regulatory oversight" release in December 2018

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EXECUTIVE SUMMARY

This is my summary and critique of the PCE report on OVERSEER® and its use in regulatory oversight. The PCE report is an important document that addresses many of the concerns that senior scientists and industry people have raised about OVERSEER® in a regulatory context. The PCE has had access to a wide range of people and information. The PCE report is timely and useful as a check on the increased use of OVERSEER® to shape on-farm decision making in areas that the PCE highlights as inappropriate.

Main conclusion from the report

The independent review of OVERSEER® by the PCE concludes the model does not meet the required standards of transparency, validation and accuracy required for it to be used in a regulatory environment. Defending OVERSEER® in its current form in a court of law would be difficult. The level of uncertainty associated with many nitrate loss estimates is unknown. Thus, continued use of OVERSEER® by regional councils and other organizations to regulate on-farm activity is not recommended.

If the Government wants to see OVERSEER® used to assist in the management of water quality then significant resources must be directed to improve its transparency, uncertainty, and documentation.

BACKGROUND

In early 2018 I received calls and emails from irrigated and dryland sheep and beef farmers in Canterbury. They were being advised to reduce their use of legumes and in some cases plant ryegrass and use nitrogen (N) fertilizer to reduce their environmental footprint. This advice was from certified OVERSEER® users based on nitrate model outputs. Such recommendations are contrary to advocacy of legumes as the most viable strategy for positive financial, environmental and social outcomes for sheep and beef farmers. I subsequently set about trying to examine the basis of this advice based on OVERSEER® outputs.

In August 2018 I wrote to the Minister of Primary Industries detailing my concerns. These focussed on the inappropriate application of OVERSEER® for monitoring and regulation of nitrate impacts from dryland sheep and beef farming. Copies of that letter also went to the CEO of ECAN, Parliamentary Commissioner for the Environment (PCE) and the Prime Ministers Chief Science Advisor. I subsequently met with the Minister and outlined my concerns in person on 15th October 2018.

I circulated that letter to interested industry bodies and was alerted to the PCE review on OVERSEER®. His report was released in December 2018. This document represents my summary and critique of that report – it highlights the main points but also what I consider are the anomalies that it contains and areas it has not addressed. My focus is for sheep and beef farmers whereas intuitively it appears the focus of the PCE report is around the use of OVERSEER® in a regulatory sense for dairy farming.

SUMMARY AND CRITIQUE OF THE PCE REPORT ON "OVERSEER® AND REGULATORY OVERSIGHT."

In this document the text in italics represent my comments on the content of the report.

The report is written in eight chapters to outline the historic, current and potential future use of OVERSEER® in a regulatory context.

Chapter 8 concludes that;

1) OVERSEER® is useful for famers to make management decisions about fertilizer application and nutrient management- which is the purpose it was originally designed for.

2) OVERSEER® is used by regional councils because it also estimates nutrient loss from the root zone of the paddock. This has been driven by the National Policy of Fresh Water Management.

Note: OVERSEER® assumes the root zone of all pastures is 60 cm - this is inaccurate for many deep rooted pasture species and therefore is a technical source of major uncertainty in the models output. It makes no claims about what happens to nitrate after it leaves the root zone – but councils seem to assume it then ends up in waterways - there is little direct measurement of this to confirm the link between nitrate leaving the root zone and appearing in waterways - indeed denitrification appears to remove a large amount of the nitrate- this is not discussed in the report.

3) There are farm practices that could be enforced by councils that are beneficial to reduce nutrient loss that could be enforced through farm plans to achieve water quality outcomes – *that do not involve the use of OVERSEER®*.

4) Some councils have turned to OVERSEER® to deal with unsustainably high nutrient leaching because it provides an output. However, using these estimates to enforce legal compliance requires a much higher level of assurance than OVERSEER® provides. OVERSEER® has not been subjected to the rigorous formal scrutiny expected by those being regulated. A significant amount of information required to confirm OVERSEER®s use in this context is lacking.

5) Without OVERSEER® other, potentially less palatable aggressive land input controls such as limiting stocking rates, may be required.

*This point is made by the PCE to recommend continued investment in OVERSEER®. However, this conclusion contradicts the shortcomings of the model outlined in the PCE report – and the additional issues outlined in my letter to the Minister in August (Moot 2018). For example, the report highlights this is a steady state model that can only provide an average annual value of leaching based on average conditions. There are other models (e.g. APSIM) that are open source that could provide real time estimates of nutrient losses over multiple years and account for actual on farm management practices. The PCE report notes this steady state limitation of OVERSEER® (**Chapters 2 and 3**) but ignores these failings in recommending the continued development of OVERSEER®. The changes to the model proposed by the PCE will not address the fundamental flaws in the use of a steady state model to predict a dynamic process. The PCE did not explore the cost benefit analysis of continued investment in a "not fit for purpose model" N management tool (OVERSEER®) versus utilizing a more mechanistic process based model (e.g. APSIM). This appears to be outside the remit of the PCE review. The rationale for continued use of OVERSEER® appears to be its ease of use by consultants etc rather than the need for more sophisticated models that require greater user knowledge. In my opinion, a lack of analysis of alternatives does not justify the recommendation to continue with the use of OVERSEER®.*

The PCE notes that OVERSEER® has not been validated for sheep and beef farms. However, in the recommendations the PCE does not differentiate between land use and model application. It seems that a model that has never been validated for estimating nitrate losses from sheep and beef farms is not fit for this purpose and its continued use in this context is questionable. For dairy farms there is a limited set of validation data that have been assessed and uncertainties estimated.

6) There should be a rapid peer reviewed, transparent process to address the corroboration, uncertainty, sensitivity analysis and documentation associated with OVERSEER® if it is to be used in a regulatory context.

This comment is the basis of the major problem with OVERSEER® as highlighted throughout the report. OVERSEER® does not meet the Mertonian norms for public good scientific research (Merton, 1942). The PCE outlines these failings of OVERSEER® but not in the context of scientific norms – I will outline those here;

Merton (1942) stated scientific research should be;

a) "Communal" – all scientists should have common ownership of scientific knowledge because all science is collaborative.

This is not apparent with OVERSEER® where the science has not been published and the common ownership model of science has disappeared behind base code that is invisible to all but a few OVERSEER® insiders. The PCE highlights this as an impediment to trust and transparency- insiders require outsiders to keep them honest – in the same way Governments require a free press. It is ironic that the PCE should be stating this. The loss of scientific communality is the result of CRI reforms of the 1980s - when successive Governments forced science in NZ from a public good endeavour to a technocentric basis where competition was indoctrinated into public good science. The failings of OVERSEER® represent the failings of those CRI reforms. The consequences of a move from academic to technoscience, are described in Porter and Wollenweber (2017).

b) "Universal" – all science should be evaluated independently, free of socio-political interference.

OVERSEER® has not been independently reviewed – a comment made throughout the PCE report. There is strong political interference from central Govt. with requirements under the National Policy of Freshwater framework that regional councils have sought to address using this model – outside of conditions for which it was intended. The PCE shows OVERSEER® has never been validated for sheep, beef or deer farms but is being applied to those farming systems by regional councils. The political interference occurs with council demands for a model from which to write regulations based on its uncertain outputs.

c) "Disinterested" - science work should remain uncorrupted by self-interest and independent of financial gain.

The consequences of this failing are highlighted for OVERSEER® in its use by third parties. The owners state that any funds generated by the licensed use of OVERSEER® are reinvested in its development. This is laudable but it does not represent the wider industry situation whereby OVERSEER® is commercialised by environmental consultants – i.e. third parties dependent on OVERSEER® for financial gain. Specifically some regional councils are now demanding farm environmental plans based on a non-validated inappropriate model. These are provided by advisors who do not have access to the scientific basis of the model and who frequently "fudge" answers. The use of OVERSEER® therefore fails the "disinterested" norm and this is considered a major problem for the credibility of the model throughout the PCE report.

d) "Organized Scepticism" - science is presented transparently so it can be judged by society using accepted norms.

The PCE has noted that the datasets required to validate OVERSEER® and evaluate its usefulness for catchment assessment are not available. Thus, the nitrate in water issue that OVERSEER® is being used to address is based on little or no data – there is no recognition by the general public that OVERSEER® is inaccurate in representing farm systems. For example, it only estimates nitrate leaving the root zone at 60 cm. The owners make no claims to represent what happens beyond that zone. However, the outputs from OVERSEER® – without any level of uncertainty become the inputs for other models – this multiplies errors and suggests the confidence in the catchment level evaluations should be low.

The PCE notes the long term monitoring and data required to address the impacts of nitrate on invertebrates and macro fauna has not been collected and should be. Such datasets require significant ongoing investment in public good science – this has not been in vogue since the 1980s. Hence the datasets are incomplete, held by many different organizations, do not have common public ownership, are incomplete – so are unavailable for review either by experts or the public.

The ability of other scientists within CRIs to comment on the shortcomings of OVERSEER® has also been lost due to CRI reforms. These prevent Govt. scientists speaking without manager's approval. In contrast University academics are required to be the critic and conscience of society.

Recommendations from PCE

1) If Ministers want OVERSEER® to be used as a tool in regulation, actions are necessary to support its use in a regulatory context. If this is accepted then a higher level of scrutiny and transparency is required than when the model is used for non-regulatory purposes (fertilizer recommendations).

Requirements to ensure OVERSEER® is acceptable in a regulatory context;

2) Development of best practice guidelines for use of environmental models from international examples.

OVERSEER® has been used to support regulation since 2005 with significant short comings in transparency, peer review, uncertainty and documentation.

3) A comprehensive well-resourced review of the science within OVERSEER®. These should be technical experts independent of the developers and include a formal analysis of the uncertainty of OVERSEER® estimates. This is important because OVERSEER® estimates are used in catchment modelling.

Any analysis of uncertainty must differentiate land use, land class and farm systems.

4-6) Transparent documentation of calibration data, scientific principles, equations algorithms and source code must be made available and open access. This can only be done by the model ownership and governance being changed. This requires Ministerial intervention and long term funding.

In my opinion the first step in the process should be to evaluate whether OVERSEER® is appropriate or are other models more accurate and advanced for use by regional councils – and so OVERSEER® should be dropped for this purpose.

7-8) In the interim MoE needs to direct regional councils on the use of OVERSEER® as part of a framework to assess nitrogen loss. This should include an immediate assessment of where regionally specific research is needed to support the use of the model and how this is to be funded.

This recommendation highlights the variability of land use, land class and farm systems in different regions that OVERSEER® is currently being used across inappropriately.

9-10) Review of ownership of the databases required to inform catchment scale dynamics and investment to ensure these are collated communally.

This is what public good science is supposed to do. We now have poor data being used to develop underfunded models to assess environmental outcomes of land use change with high levels of uncertainty.

Summary and critique of individual Chapters in the PCE report.

Chapter 1. Overview – OVERSEER® for people is a black box – so whether it merits confidence or scepticism is unknown. The PCE notes the divergence of opinions on OVERSEER® from two enthusiasts- one who agrees it needs help – the second suggesting we don't look too hard because it is all we have got.

These positions are frequently espoused in public by regional councils "it's all we have – so better than nothing." To me this is an unsatisfactory response – would people getting a speeding ticket be happy if the tool being used to measure their speed was not fit for purpose? This is the situation being defended by the use of OVERSEER® in a regulatory sense.

Whether OVERSEER® is "good enough" depends on the use to which it is being put – *farmers are spending tens of thousands of dollars defending farm management practices because of uncalibrated OVERSEER® nitrate outputs.*

The report focuses on OVERSEER® in a regulatory context for nutrient loss. However comments on openness and transparency would apply to any other regulatory use e.g. for estimating greenhouse gas emissions.

OVERSEER® was developed for on-farm nutrient management and OVERSEER® Ltd still see it predominantly in this context. The report does not critique this use of the model but focuses on the fact that the same information that is valuable to a farmer is equally valuable to a regulator. The fact the model estimates at the business unit level of a farm is convenient for the regulator because this is the unit where policy implementation occurs.

The PCE does not mention that the primary use of OVERSEER® for nutrient budgeting was and probably still is for P, K and S fertilizer requirements – because these are a major cost to sheep and beef properties that often do not use a lot of inorganic N fertilizer. The PCE then uses the fact that farmers are using OVERSEER® for nutrient management to assume they have confidence in the tool – this is a fundamental flaw in the report – OVERSEER® is trusted in the main by farmers to make recommendations for a different set of macro-nutrients than it is being used for in regulation of nitrate losses.

The RMA 1991 – requires regulators to evaluate the costs and benefits of their proposed remedies – (*it is a moot point whether many of them have done this for sheep and beef farming FEPs?)* so they must have convincing support for the tools they propose to use.

All models incur uncertainty because they are simplifications and approximations – whether the level of uncertainty surrounding OVERSEER® is acceptable depends on its use – *the PCE concludes they are too high for regulatory purposes (see **Chapter 8**).*

The PCE states "nutrient pollution from a wide variety of sources degrades water in NZ and agriculture contributes to that. Regulators need to know how to limit that degradation *(The lack of hard data showing what that degradation is – is noted as a concern in **Chapter 8**)* and have limited tools to determine this which is why OVERSEER® is appealing to them. OVERSEER® began its evolution is the 1980s and is now commonly known in the rural

community – and has received substantial public funding in its development. However, it must be able to withstand the scrutiny of a more sceptical audience e.g. outside scientists and those being regulated.

With that in mind the report sets out to;
Chapter 2 – Summarise different types of models
Chapter 3 – Describe OVERSEER® functionality
Chapter 4 – Different uses by regional councils
Chapter 5 – How OVERSEER® works – and what is known about it compared with best practice for model development and use (transparency and quality assurance requirements).
Chapter 6 – Ownership structure past and present – and how it impedes transparency.
Chapter 7 – Beyond OVERSEER®- what else is required if nutrient pollution it to be addressed at a catchment scale?

Chapter 2 – Models

Nutrient losses are difficult to measure directly – so models are used. To answer questions of nutrient loss at a farm scale complex interactions of soils, plants, animals and weather need to be understood – and then integrated across a larger land area. In the absence of direct measures of these things models are used.

Models are linked equations which simplify the processes being modelled. More complex models have more equations with more uncertainty from natural variation, model inputs and unknown factors (*If each equation has a level of uncertainty then OVERSEER® may simply be multiplying errors by putting several equations together)*.

Understanding this uncertainty is as important as the output if the model is to be relied upon with confidence. Simple models generally don't represent systems well but appeal to a range of audience – increased complexity leads to increased costs and uncertainty.

- Empirical models look for correlations that may not be causal - OVERSEER®.
- Deterministic models use specified parameters to produce the same result with no uncertainty - OVERSEER®
- Mechanistic models try to represent processes.
- Steady state models assume constant conditions – and work off averages – OVERSEER®
- Dynamic models indicate changes over time.

Chapter 3 – OVERSEER® model

OVERSEER® is largely empirical, deterministic and steady states - *appropriate for annual P K S fertilizer recommendations less so for dynamic nutrient losses especially nitrogen as nitrate. How OVERSEER® is used for fertilizer recommendations is generally understood, so only the key points raised by the PCE are discussed rather than a detailed precise of the whole chapter.*

OVERSEER® models nutrient losses as outputs from farm products and losses to air and water – and is best used for dairy systems with more uncertainty for other systems.

As a steady state model OVERSEER® assumes average conditions and management and is thus less useful for examining land use change. The variability of climate is also not captured in OVERSEER® – it uses a 30 year mean *(i.e. November 2017 saw virtually no rainfall in Canterbury, while November 2018 recorded over 150 mm - OVERSEER® treats these years the same and thus there is a mismatch between actual and modelled losses at every time scale used). Dynamic models account for this variability.*

OVERSEER® is largely empirical – it does not cope with changing land use across paddocks over time e.g. cropping is not well represented and it therefore does not reflect day to day management.

Table 3.1 lists the calibration of OVERSEER® - there are no examples listed from sheep, beef or deer farms that have been used for calibration.

A limitation of OVERSEER® is to identify critical point sources of e.g. P loss – *so this is best done on farm using experience.*

OVERSEER® does not consider leaching beyond 60 cm (the root zone for pastures) and it assumes all pasture species have a root zone of 60 cm (*red clover, lucerne chicory all have measured water extraction beyond 1.5 m which is not represented in OVERSEER®*).

A lack of experimental data means limited calibration sets exist to fine tune OVERSEER® –

- No formal assessment of OVERSEER® as whole has been conducted.
- Uncertainty estimates of OVERSEER® are frequently quoted but not publically available. (*The value of 25-30% quoted does not include uncertainty associated with data inputs or measurements and only those who did the analysis know how it was done.)*
- The developers note a similar level of uncertainty exists for farms within the calibration range – *given no sheep and beef farms have been calibrated for N loss the uncertainty of those farms is unknown* – it is quoted as >50% (**Figure 3.4**) but on what basis this was estimated is unknown (*analogous to the police said you were speeding (= OVERSEER® estimate) at 110 km/h plus or minus at least 50% - would that stand up in court?).*

An uncertainty analysis for P losses suggests at least 30%. But being a steady state model it does not account for catastrophic losses e.g. major slips etc.

Estimated losses of N come from urine based on feed intake and animal output (*This is why legumes are penalized – they contain high N and the animal outputs have not been calibrated).*

OVERSEER® can;

- Estimate farm and block N loses from the root zone for farms it has been calibrated for with at least 30% uncertainty.
- Estimate maintenance fertilizer requirements

OVERSEER® cannot;

- Accurately model situations when farm management changes
- Be used for day to day decision making
- Model plantain, chicory, lucerne based pastures for mitigation
- Produce accurate estimates outside its calibration range (dairy farms only)
- Provide uncertainty associated with nutrient loss
- Provide information about what happens to N below 60 cm (*basic soils knowledge suggests a lot of the nitrate below this zone will be denitrified and never end up in water ways – (Addiscott, 2005)).*

Chapter 4 – OVERSEER® and councils

Six councils use OVERSEER® with regulatory consequence to the amount of N leached (**Table 4.1**). ECAN uses OVERSEER® to determine permitted activities and those that require consents. If a farm requires resource consent it will be subject to an N loss limit (*but given most of Canterbury land use is sheep and beef farming and these have never been calibrated for OVERSEER® the legal enforcement of this requirement is questionable – **Chapter 8**)*. Farm plans are needed for resource consent and OVERSEER® is used to prepare these FEPs, nutrient managment plans etc – *there is now an environmental consultancy industry that has a vested interest in ensuring this requirement continues).* Costs on farms business are $2500 - $7500 per farm – but go up with each resource consent application.

OVERSEER® is also used as part of a catchment scale analysis for regional councils – *without regard to the uncertainty of OVERSEER® – and its inaccuracies e.g. in rooting depth, lack of calibration, denitrification below the root zone. This means publications that report modelled nitrate leaching trends are also of dubious scientific value (Dymond et al., 2013).*

Allocated losses for farms are frequently based on previous losses or grandparenting - *this is a major concern for sheep and beef farmers assessed as having low N losses initially. It may penalise best practice and the viability of a farm enterprise.*

Currently P losses are not limited by councils but are required to be estimated by some.

Issues with OVERSEER® application;

1) Data input uncertainty for numerous reasons including a deliberate manipulation, and work arounds because OVERSEER® does not model the farm system or practices being used.

Operators of OVERSEER® usually need to be certified and there is currently a lack of staff able to do that.

Auditors should be used for compliance – *the validity of this is questionable when the model is so uncertain and the PCE states it should not be used for regulatory purposes.*

Data storage by councils and the ongoing ability of farmers to update submitted plans is a problem related to file sharing etc. *Who owns the FEP and what legal status does it have have not been challenged.*

2) Version change
Version changes may make previously compliant farms non-compliant and vice versa. ECAN has worked around this by making certain activities permitted or needing a resource consent but this does not address the issue of version changes in the consent process.

Currently regional councils are all developing their own strategies for dealing with version change. Govt. may need to prescribe best management practices

3) OVERSEER® representing farm systems
OVERSEER® is empirical and thus cannot represent a farm system – especially those that have not been calibrated for and for which basic data are unavailable e.g. soil type.

4) Uncertainty in compliance setting
Absolute outputs from OVERSEER® could not be relied on for enforcement purposes. Prosecutions must be proven beyond reasonable doubt – OVERSEER® cannot be relied upon to provide this. Councils relying on OVERSEER® to set nitrogen loss limits to trigger requirements for resource consent face a similar problem. It may be possible to use OVERSEER® in a regulatory context for assessing relative change not absolute values. Councils take widely differing approaches to these issues which concerns their staff.
Abatement notices may be more effective than prosecution for creating compliance.

Chapter 5 – Assessing OVERSEER® as a model

There is no official guidance for regulators in NZ as to what constitutes an acceptable model. The use of OVERSEER® by councils has been driven by the National Policy Statement on Freshwater Management 2014 which requires councils to operate a freshwater quality accounting system – but regulators and the regulated need confidence in the model.

This sole focus on freshwater quality standards of dubious scientific basis (see Moot et al. 2018) is directing the debate.

Evaluating a model for regulatory use is different from its use for private purposes.
The PCE notes he was unable to make a comprehensive review of OVERSEER® because some information is not in the public domain e.g. science, calibration, corroboration and robustness are not transparent.

1) Is the model based on sound science?

The scientific pedigree of OVERSEER® is difficult to assess because there is limited public information around some of the sub routines and no publically available scientific description. *The PCE notes that because the relationship between metabolizable energy (ME) requirements and intake are used in the GHG Inventory they are acceptable – this is now questionable for many of the farm systems and breeds and feed sources used in NZ.*

Computational data for some routines are not publically available so their validity cannot be assessed e.g. urine patch sub model. The rationale for parameter choice is frequently missing (*and no sensitivity analyses for parameters undertaken*).

No source code is publically available – *a consequence of the IP.*

The underlying assumptions of OVERSEER® are published but their limitations and interpretation in a regulatory sense are not described. The lack of documentation makes assessing their scientific basis difficult.

Peer review of OVERSEER® occurs but there is little feedback to the reviewers of what if any implementation has been undertaken as a result – fuller explanations of changes are required in published documents.

Peer review has noted the need for inclusion of "the latest science, better documentation, increased transparency, expanded calibration, quantification of uncertainty and sensitivity analysis" *Note: these things are routinely done for most models used in science – but not for OVERSEER® – probably due to IP issues and a lack of resources to implement changes –which is highlighted within the report.*

A whole model review is required given the complexity of the model and the disciplines that interact.

2) Is OVERSEER® quality assured?

Historically quality assurance falls on the model developers and their decision to include or not scientific understanding – changes are not always explicit or documented. Good practice would suggest decisions made by OVERSEER® Ltd are open to scrutiny and therefore increase trust.

Current release notes document what has changed but provide little basis for why or the implications of those changes and how they may affect each routine (*This is standard practice in most model development with sensitivity analyses provided).*

Data use for model development and parameterisation is not readily available for peer review and how it is used is unclear. The limited number of soils tested and climate regimes used means formal model evaluation hasn't been undertaken. (*And therefore how the model can be used outside of its area of development is highly questionable*).

3) Does the model reflect reality?

Within a regulatory context, failure to communicate and manage uncertainty may result in legal challenges. (*To date no legal challenges have occurred – the PCE implies OVERSEER® would fail to meet legal requirements in a regulatory context.)*

Formal uncertainty analyses have not been undertaken and this is a significant short-coming. This lack of uncertainty means council staff cannot engage in a meaningful way with interested parties. ECAN has used expert judgement panels – *I am not aware of any related to sheep and beef.*

There has been little validation of OVERSEER® due to insufficient datasets and what has been done has not been documented. Benchmarking against more mechanistic models such as

APSIM highlighted problems but the lack of transparency and access to source code means the reasons for discrepancies cannot be determined. This has been particularly true with cropping – *it has never been assessed for sheep and beef.*

4) Is the model appropriate for regulatory purposes?

It works for maintenance fertilizer requirements (*these are P K and S not N)* because this is based on long term trends and is not expected to be perfect or be used to impact on farm businesses.

For models used in environmental regulation transparency is required to build trust. Scientists and farmers want more transparency than is currently available.
OVERSEER® has been used in environment courts in regional planning but not subjected to necessary level for formal scrutiny. Significant information is lacking to assess OVERSEER®.

While tempting to conclude OVERSEER® should not be used- the need to address the National Freshwater Plan means OVERSEER® should be used (*This claim is difficult to reconcile with the limitations outlined in the previous sections and appears to represent the "we have nothing else view" while the PCE report highlights clear limitations and notes several shortcomings. The PCE makes a politically expedient conclusion here based on dubious science – and the clear need for "*speedily addressing the short comings" *sits more realistically with the lack of confidence in OVERSEER® – especially for systems it has not been calibrated for*.

Chapter 6 - Ownership and governance.

Development of OVERSEER® has been hampered by a lack of funds – and the widening application of OVERSEER® in a regulatory setting since 2005 has not been funded at an appropriate level. Income is reinvested in OVERSEER® but emphasis has been on user interface rather than science development and documentation. OVERSEER® Ltd has at no stage sought to create a regulatory tool despite its use by regulatory agencies – and this is one reason it falls short of the transparency required in a regulatory setting.

Despite the current ownership model the public have invested significantly in the development of the tool. The lack of transparency is in part deliberate on the owners part to maintain control and prevent competitors developing products.

Greater transparency would allow quicker development, more scientists working on problems and providing solutions (*which is what happens with other science models in other countries e.g. STICs, APSIM*).

NZ has a small pool of people available to undertake modelling – should these limited resources be concentrated on OVERSEER® – (*personally I would suggest no- for all the other reasons this model fails – not mechanistic, static model- there are better options out there).*

The PCE then outlines how he would like to see OVERSEER® funded – *this appears to be well outside the evidence presented in the report- at no point has the PCE interrogated other models or assessed alternatives so this conclusion lacks supporting evidence –particularly with*

the issues highlighted earlier. NZ scientists are not going to work on OVERSEER® if it is privately owned and they cannot publish results - this is unscientific.

A buyout of the model is advocated by the PCE – with recognition of the significant contribution of the Fertilizer Association. *The PCE appears to confound two issues here- OVERSEER® is useful and appropriate for fertilizer recommendations- it is less so for nitrate leaching analyses- it is this component that needs addressing.*

Chapter 7 – Beyond OVERSEER®

This section addresses knowledge gaps;

- How much of the nutrients leaving the farm actually make it to a water body?
- What sort of water body do they make it to and how vulnerable is it?

Attenuation processes that convert nitrate to gaseous forms may actually remove a great deal of the nitrate leaving the root zone and the rate varies – this is a key factor in nitrate impacts.

The actual impact of e.g. nitrate and phosphorous in catchments is difficult to predict. *There is evidence that our freshwater nitrate levels are out of line with the rest of the world and 50% lower than the WHO values (Moot, 2018).*

We have few measurements of the impacts of nutrients and their flow in real time are required potentially more than investment in OVERSEER®! We also need long term datasets for many aspects of nutrient modelling across catchments. Currently emphasis is on OVERSEER® – it cannot do the job by itself. They also do not provide the only source of uncertainty.

Large public investment is needed in models and databases (*the current emphasis on OVERSEER® restricts debate about what is the most appropriate way to spend research money – would it be more appropriate quantifying impacts to see where we really do have a problem and solve those or should we continue to put resources towards a steady state model that fails the norms of public good science).*

There are several areas that the PCE did not address in his report about OVERSEER® that I outlined to the Minister of Primary Industry in August 2018. Of most concern is the singular focus on nitrate leaching as an assessment tool for farm environmental impacts (Online: http://www.lincoln.ac.nz/PageFiles/23598/Damien%20O'Connor%20Letter%202018.pdf).

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