Using OVERSEER -

Establishing a national approach for the appropriate and consistent use of OVERSEER by regional councils in setting and managing water quality limits

Working draft for review

July 2016

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1 Introduction

The cumulative effect of diffuse nutrient discharges from farming on water quality is recognised as a significant resource management issue (LAWF, 2010LAWF, 2010LAWF, 2010). Managing the impacts of land use on water quality is a national as well as a regional challenge. Under the National Policy Statement for Freshwater Management 2014 (NPS-FM) regional councils are required to establish freshwater objectives and set freshwater quality limits for water quality. This requirement has increased interest in, and use of, a range of tools and models including OVERSEER® Nutrient Budgets (OVERSEER).

1.1 Purpose

The focus of this report is to provide information and advice to those who are using or are considering using OVERSEER to assist in informing the establishment of freshwater objectives, in setting and managing to freshwater quality limits under the NPS-FM, and in resource consent processes[1]. This report builds on a suite of existing information (Appendix 12.1). There is no single correct approach for managing the impacts of land use on water quality, and OVERSEER may be used in different ways within these different approaches. This report identifies key principles and practical guidance[2] for using OVERSEER in the context of the over-arching imperative to manage the impacts of land use on water quality. This report is primarily intended for regional council staff who are involved in preparing and implementing regional plans, including planning and regulatory staff and those who are providing technical input, consultants who provide advice to regional councils and decision-makers on regional plans.

This document does not specifically address the question of whether a regional council should or shouldn't use OVERSEER in a regional plan and/or resource consent process, although the information contained should assist with such decisions.

1.2 What is OVERSEER?

OVERSEER is a computer software model that models nutrient use and movement within a farm system. OVERSEER estimates the nutrient flows in a farming system and specifically includes estimates of nitrogen and phosphorus loss to water through leaching and/or run-off. The core of OVERSEER is a nutrient budget, which includes the nutrient inputs and outputs of a farm system. A more detailed description is in Watkins and Selbie (2015).

[1] It is acknowledged that achieving freshwater quality objectives and limits is likely to involve a broad range of activities as well as regulation; including education, training, monitoring, non-regulatory mechanisms, farming and industry programmes and leadership.

[2] The scope of this guidance does not extend to:

- software development
- field trials and scientific investigations
- development of user training or certification material
- general guidance on the development or implementation of catchment nutrient management plans
- general guidance on the development or implementation of regional plans
- nutrient allocation methods.

1.3 Key RMA considerations

Consideration of the use of OVERSEER, particularly in plan-making processes, needs to be considered in the wider context of regional plan development under the Resource Management Act (RMA) and the implementation of regional plans. As expanded on in Section 2.1, regional planning is undertaken in the context of regional councils' functions under s30 of the RMA. Regional plans must give effect to the NPS-FM and relevant regional policy statements and plan provisions must be evaluated in accordance with s32 of the RMA.

This report is focussed around the use of OVERSEER to estimate the extent of an effect, that is then used as the basis of regulation through regional plans and resource consents. It is acknowledged that this means that land use and discharge activities are therefore not regulated on the basis of readily measurable effects. However, where it is not possible to accurately measure diffuse nutrient losses, and where an effect-based regime is preferred, OVERSEER is considered to be an appropriate, and in some cases the only appropriate, tool to use in informing the establishment of regional plan provisions that meet the requirements of the NPS-FM (Figure 1). The use of OVERSEER enables a focus on effects rather than activities or inputs into a system. In this context, this report focusses on how the challenges associated with the use of a model need to be considered in, and managed through planning frameworks under the RMA.

Figure 1 illustrates where models such as OVERSEER may be needed depending on which methods are used to manage the effects of diffuse nutrient contamination.

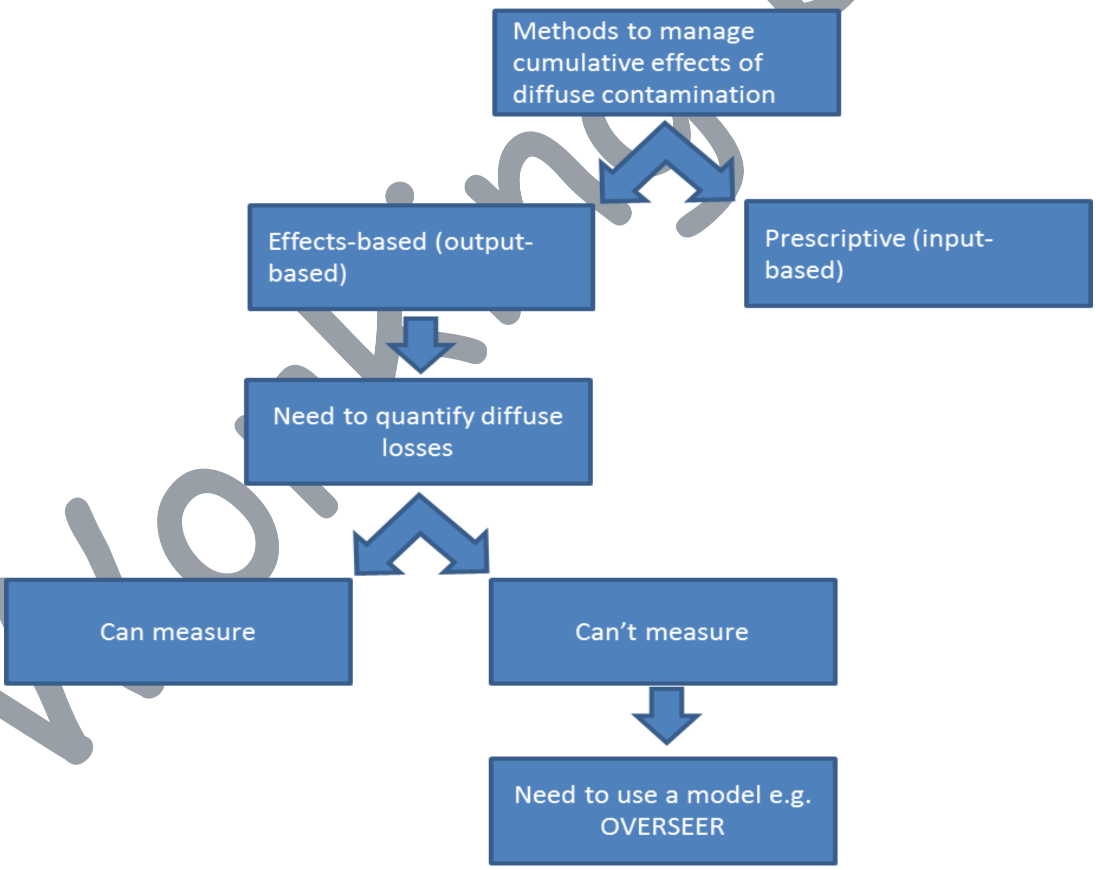

Figure 1 Methods for managing the cumulative effects of diffuse contamination and where models are needed

1.4 Water quality management and OVERSEER

To manage water quality, the sources of the key contaminants in a catchment (amongst other information) need to be established. These contaminants may come from either point sources, (discharged at discrete, identifiable locations and can usually be measured (Novotny, 2003) or diffuse sources (arising from land-use activities (urban and rural) that are dispersed across a catchment) (D'Arcy, 2000).

Of relevance to this report are the nutrients nitrogen (N) and phosphorus (P). Farming is often a significant contributor of diffuse nutrients in a catchment. To help manage the impacts of land use a conceptual model[3] of a catchment can be developed to understand the relationship between nutrient sources and water quality for a specific catchment (Figure 2):
These conceptual models can range from very simple to more complex, depending on the nature of the catchment.

There is no single correct approach for managing the impacts of land use on water quality, and there will be circumstances where it is not necessary to use a model at all to successfully manage water quality. There will also be circumstances where OVERSEER is not the most appropriate model to be used.

If the relationship between land use and water quality is quite simple, there is little pressure on the resource, or the nature of the water quality issue is measurable or such that directed management interventions (such as fencing or tree planting) are likely to be successful, then modelling nutrient losses from land uses into the catchment may not be needed. However, the relationship between land use and water quality is complex, if there is high pressure or risk to the resource, if the diffuse losses are not directly measurable, or if there are possible future policy options that need to be tested for the development of a regional plan, then modelling nutrient losses from land uses into the catchment is likely to be important. OVERSEER is the principal available model to estimate the farming land-use portion of the source nutrient load (point '**A**' in Figure 2).

[3] These conceptual models are created either implicitly by individuals, where knowledge and experience lead to an understanding of how the catchment works or they can be created explicitly with detailed technical descriptions of catchment processes.

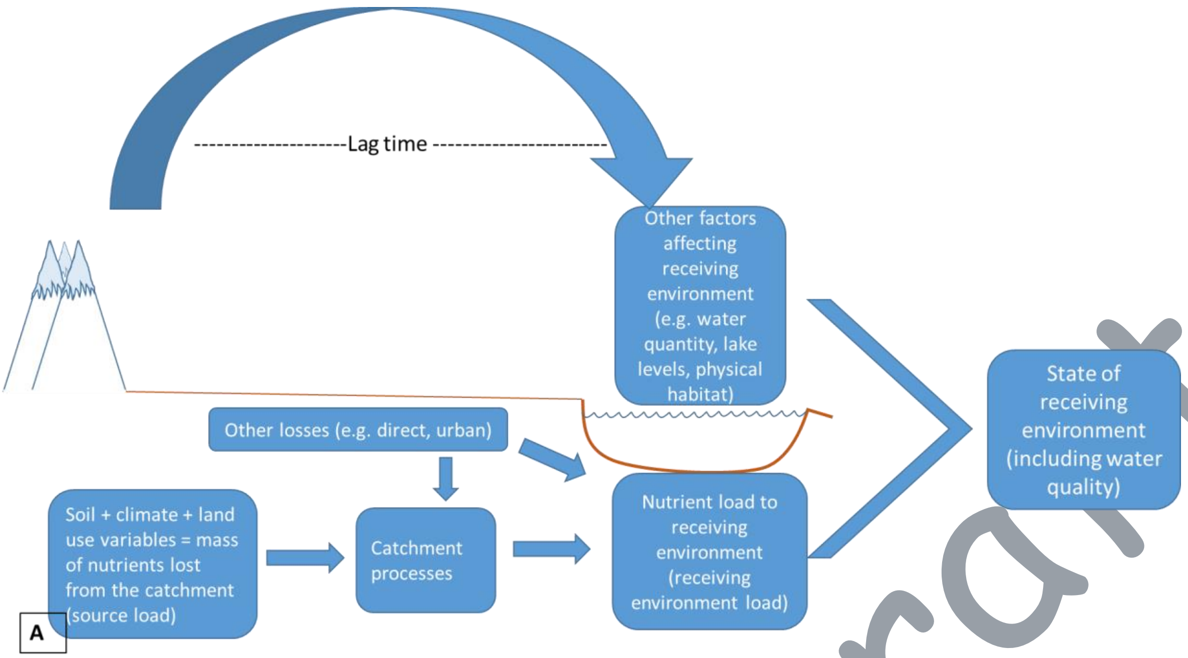

Figure 2 Simplified conceptual relationship of losses of nutrients from the catchment and the state of receiving environment water quality (groundwater, rivers and lakes), 'A' indicates where OVERSEER can be used to estimate the farming land-use portion of the source nutrient load

The decision by a regional council on whether or not to use OVERSEER will be influenced by a range of factors such as:

- the nature and extent of the water quality issue;
- the specific characteristics of the catchments;
- the state of knowledge about the water quality and catchment characteristics and the data available;
- the likely sources of nutrient(s) contributing to the water quality issue;
- whether input-based or output-based methods are preferred; and
- the overall planning approach and philosophy.

The important questions involved in making that decision are:

1) What is the nature of the issue that needs addressing?
2) What is the package of data, tools, models and approaches that is currently available that will be effective in addressing that issue?
3) If there aren't data or other, more effective tools, models or approaches available, can the uncertainties and limitations in OVERSEER be adequately managed for this particular issue?

Whether or not it is preferable or appropriate to use OVERSEER in a particular situation will depend on answers to questions 1, 2 and 3 and this report is intended to help guide regional council to answer these questions for their particular circumstances.

1.5 Structure of report and guidance

The report covers the principles and guidance on key topics for use of OVERSEER in establishing freshwater objectives and setting and managing to freshwater quality limits in regional plans and resource consents.

The guidance information is structured around approaches to using OVERSEER for managing diffuse nutrient discharges; the supporting principles for use; and the plan-making, science and specific OVERSEER guidance to support those approaches (Figure 3). The guidance topics are not exhaustive; they are those specifically required to be addressed by this report.

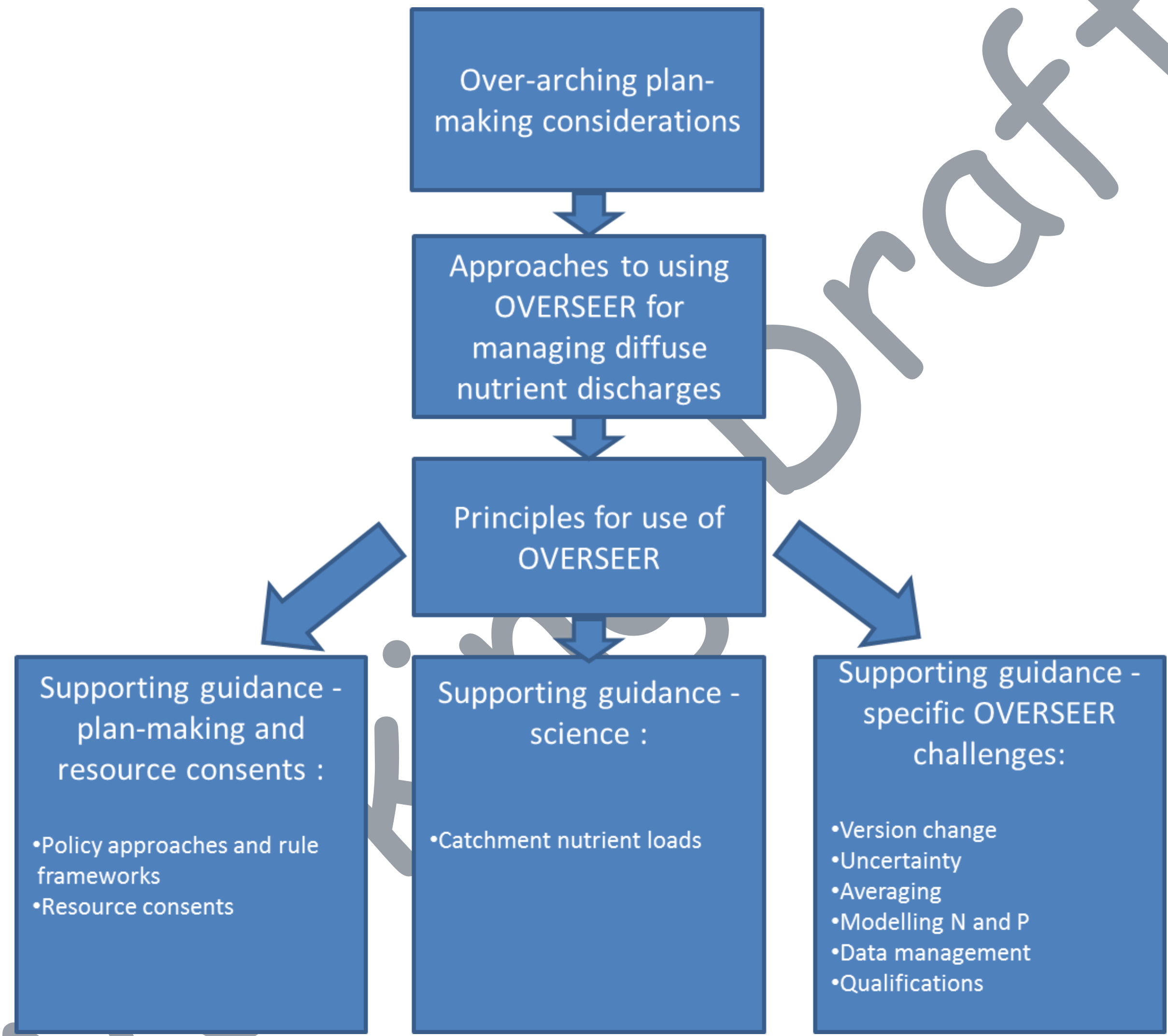

Figure 3 Structure of this report

1.6 Terminology

The following definitions have been used in this report. Words used that are defined in the RMA have that meaning, some NPS-FM definitions have been included, and other commonly used technical definitions have been used.

Accuracy	The accuracy of a measurement system is defined as the degree of closeness of measurements of a quantity to that quantity's actual (true) or accepted value (where actual measurement is impractical). The concept of accuracy has limited application to the estimation of whole-farm nutrient loss because of the great technical difficulty of quantitatively measuring these losses, such as N leaching.
Adaptive management	Flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.
Allocation	An amount of a resource assigned or distributed to a recipient, i.e., the assignment of an estimated total source limit to individual users.
Allowance	The maximum annual amount of N or P loss that is allowed to occur. Usually expressed on a per hectare basis.
Attenuation	A range of processes such as sedimentation, plant uptake, and denitrification, can occur that remove or attenuate nutrients, from a water body or in transit to a water body
Auditing	The systematic and independent examination of the inputs and assumptions made in OVERSEER modelling to determine their accuracy and appropriateness in the context of the use of the modelling outputs.
Benchmark nutrient loss	A reference annual nutrient loss for a property.
Baseline nutrient loss	A type of reference annual nutrient loss for a property usually estimated for a specific previous period.
Block	An area of land within a property/farming enterprise that has common physical and management attributes. OVERSEER categorises blocks into types e.g. pastoral, fodder crop, trees and scrub, house. There may be multiple blocks of the same type within a property/farming enterprise reflecting the different physical or management characteristics of each of the blocks.
Calibration	The process of adjusting numerical or physical modelling parameters in a model for the purpose of improving agreement with experimental data.
Catchment attenuation processes	Processes such as sedimentation, plant uptake, denitrification that can remove nutrients before they enter, or from within a freshwater receiving environment
Catchment load	Generic term for source and/or receiving environment nutrient loads.
Diffuse nutrient sources	Nutrients arising from land-use activities (urban and rural) that are dispersed across a catchment.
Engine	The calculation model within OVERSEER. This uses inputs from an interface or file and produces the outputs.

Error	In a modelling context, error generally refers to the difference between the modelled representation of a system, and the reality of the system. The primary types of error include input, model, and output error; and models could contain combinations of these (See Shepherd *et al.* 2013).
Estimate and calculate	Nutrient losses from a farm are estimated by OVERSEER, these estimates (along with other sources of information) may be used to calculate a source nutrient load. The use of the work calculate for the catchment load does not denote a greater degree of confidence, only that a calculation has been made.
Evaluation (validation)	All quantitative and qualitative methods for evaluating the degree to which a model corresponds to reality.
Farm Environment Plan (FEP) or Nutrient Management Plan	Different regional plans often use different terminology and apply such plans in different ways. However, common features are usually: a detailed description of the property including all aspects that can influence nutrient loss, a requirement to undertake and provide an OVERSEER nutrient budget and a detailed plan that identifies how specific nutrient loss objectives/ requirements will be achieved.
Freshwater management unit.	Is the water body, multiple water bodies or any part of a water body determined by the regional council as the appropriate spatial scale for setting freshwater objectives and limits and for freshwater accounting and management purposes, under the NPS-FM.
Freshwater objective	Describes an intended environmental outcome in a freshwater management unit.
Freshwater quality accounting system	Means a system that, for each freshwater management unit, records, aggregates and keeps regularly updated, information on the measured, modelled or estimated: a) loads and/or concentrations of relevant contaminants; b) sources of relevant contaminants; c) amount of each contaminant attributable to each source; and d) where limits have been set, proportion of the limit that is being used.
Interface	The visual website screens that provide the ability for a user to enter data into OVERSEER to enable the OVERSEER engine to run to produce outputs.
Limit	The maximum amount of resource use available, which allows a freshwater objective to be met.
Load	An amount of nutrient, usually expressed as an annual amount.
Nutrient budget	Report of net inputs and outputs to a given scale (block, farm), defined system over a fixed period of time.

Nutrient Management Plan	See Farm Environment Plan.
Nutrient losses	Nutrient lost from a farm boundary or root zone (may be described as a mass or concentration)
Over-allocation	Is the situation where the resource: a) has been allocated to users beyond a limit; or b) is being used to a point where a freshwater objective is no longer being met.
OVERSEER	OVERSEER® Nutrient Budgets (OVERSEER) is a computer software model that estimates nutrient use and movement within a farm system. OVERSEER estimates the nutrient flows in a farming system and specifically includes estimates of nitrogen and phosphorus loss to water through leaching and/or run-off.
Point source pollution	Pollution that is discharged at discrete, identifiable locations and can usually be measured
Precision	This is also called reproducibility or repeatability, and is the degree to which repeated measurements under unchanged conditions show the same results.
Precautionary Principle	"Where there are threats of serious or irreversible damage, lack of full scientific evidence shall not be used as reason for postponing cost-effective measures to prevent environmental degradation" (Rio Declaration on Environment and Development, 1992)
Quality assurance (QA)	part of quality management focused on providing confidence that quality requirements will be fulfilled
Sensitivity analysis	The systematic computation of the effect of changes in all model input values or assumptions (including boundaries and model functional form) on model outputs.
Significance analysis	A simple analysis to identify which model inputs are likely to have the most impact on the model output of interest. This is neither a full sensitivity nor a full uncertainty analysis.
Source nutrient load	The total annual amount of nutrients (from diffuse and point sources) lost from a catchment prior to any catchment attenuation processes
Sub-model	A distinct part of the OVERSEER engine.
Receiving environment	A water body (e.g. groundwater, streams, rivers, lakes) that receive diffuse and/or point source discharges that a freshwater objective is applied to.
Receiving environment nutrient load	The total annual amount of nutrients entering a receiving environment
Target	A limit which must be met at a defined time in the future. This meaning only applies in the context of over-allocation.
Threshold	A maximum allowed amount or rate of resource use specified in a regional rule (that distinguishes between, for

	example, a permitted activity and an activity that requires consent) or resource consent condition.
Uncertainty	The potential limitation in some part of the modelling process that is a result of incomplete knowledge.
Uncertainty analysis	Investigates the effects of lack of knowledge or potential errors of the model (e.g. the uncertainty associated with parameter values or model design and output).
XML file	The file format used by OVERSEER to store specific input and output data.

2 Informing the establishment of freshwater objectives and setting and managing to limits

2.1 Over-arching plan development considerations

National Policy Statement for Freshwater Management 2014

It is a requirement under the RMA that a regional plan give effect to any national policy statement (s67(3)(a)). The NPS-FM sets out a number of objectives for freshwater management, and through its policies directs regional councils as to how these objectives are to be achieved. Of particular relevance, the NPS-FM directs that freshwater objectives are established in regional plans and freshwater quality limits set for all freshwater management units, to give effect to the NPS-FM objectives (Policy A1) (Figure 4). The process for establishing freshwater objectives is detailed in policies CA1 – CA4. The NPS-FM also directs that targets are specified and methods are implemented to improve water quality where a freshwater management unit does not meet the objectives that are established (this is referred to as 'over-allocation'). The NPS-FM also includes requirements for the monitoring of progress towards and achievement of freshwater objectives (Objective CB1 and Policy CB1); and for establishing and operating a freshwater quality accounting system (Objective CC1 and Policy CC1).

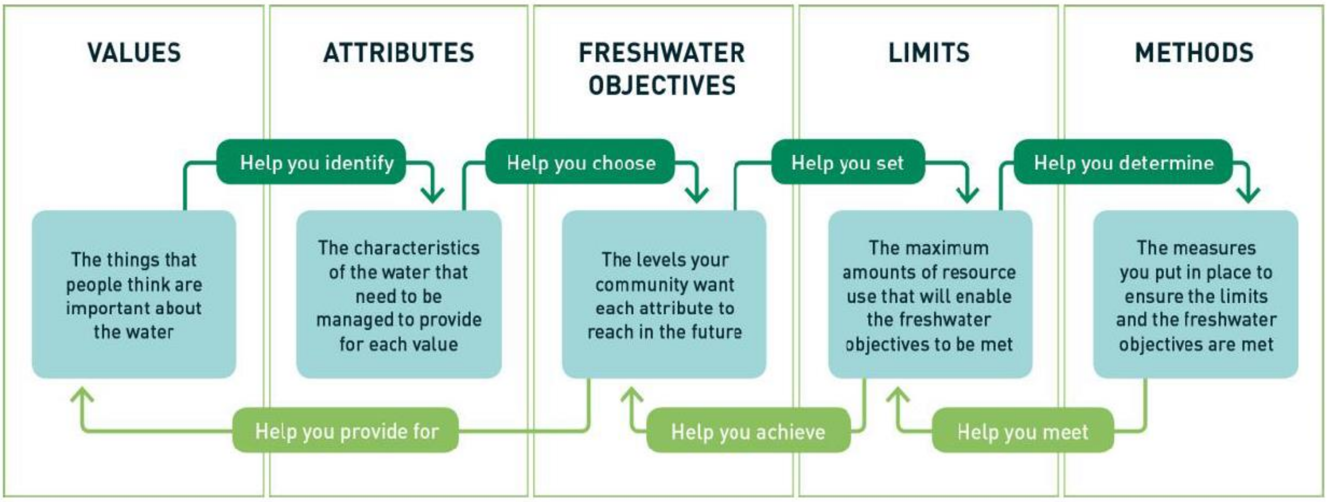

Figure 4 The relationship between freshwater objectives, limits and methods (MfE, 2015MfE, 2015MfE, 2015), adapted from ECan, 2012)

Where it is not feasible or not possible to measure diffuse nutrient discharges from land, reliance needs to be placed on modelled effects in order to inform the establishment of freshwater objectives and setting and managing to freshwater quality limits (Figure 4). Similarly, there will be elements of freshwater quality accounting that will be reliant on modelling where measurement is not feasible.

Regional Policy Statement

It is also a requirement under the RMA that a regional plan give effect to any regional policy statement (s67(3)(c)). As such, any plan provisions that are developed through the use of OVERSEER must be sufficient to give effect to the relevant RPS. In particular, an RPS may contain objectives and/or policies that include nutrient limits, which if not directly measurable may also necessitate reliance on modelled effects in order to inform the establishment of limits in the regional planning process.

Section 32 Analysis
Section 32 of the RMA sets out the evaluation that a council must undertake when a proposed regional plan or plan change is prepared (a 'proposal'). In particular, this must assess the provisions (i.e., objectives, policies and rules) in a proposal.

It is important to consider this evaluation early on in the plan development process and it should also be borne in mind as part of any technical analysis that is undertaken to support plan provisions. This means considering how effective different approaches may be at achieving the plan's objectives. For example, a s32 analysis requires that the limitations and assumptions resulting from the use of OVERSEER are taken into account as part of the cost-benefit analysis. A s32 analysis should also explicitly consider the implications of uncertainties in OVERSEER estimates and alternative approaches that don't use OVERSEER modelling.

Plan Drafting and Activity Status in Rules
There are planning principles and relevant case law that help inform the way a plan is drafted.[4] Any plan provisions that rely on the use of OVERSEER (either explicitly or implicitly) should be drafted cognisant of this best practice. For example, objectives should be a statement of what is to be achieved in relation to a particular issue and policies should set out the course of action to be taken to achieve or implement the objective(s).[5] In relation to rules, there are several commonly accepted principles that apply, namely that they must:

1. be comprehensible to a reasonably informed, but not necessarily expert, person;[6]
2. not reserve to a council the discretion to decide by subjective formulation whether a proposed activity is permitted or not;[7] and
3. be sufficiently certain to be capable of objective ascertainment.[8]

There is also some specific guidance[4] and case law on the very high level of certainty needed for defining permitted and prohibited activities. Some implications of this are expanded on later in this report (See Section **Error! Reference source not found.**).

2.2 General approaches to manage diffuse discharges that use OVERSEER

There are two different approaches that can be taken to actively managing N and P loss to water.

- An output-based approach where the quantitative relationship between source losses and receiving environment state is explicitly derived and nutrient losses are explicitly managed (e.g., N leaching rate thresholds), or
- An input-based or practice-based approach where a series of land use practices are prescribed (e.g., stocking rate thresholds, nutrient application thresholds). Within these broad approaches, OVERSEER can be used in different ways (**Error! Reference**

[4] Guidance can be found on the Quality Planning website: http://www.qualityplanning.org.nz/index.php/plan-steps/writing-plans.
[5] http://www.qualityplanning.org.nz/index.php/plan-steps/writing-plans/writing-issues-objectives-and-policies.
[6] *Re Application by Lower Hutt City Council* EnvC Wellington W046/2007.
[7] *Twisted World Limited v Wellington City Council* EnvC Wellington W024/2002.
[8] *Ibid*.

source not found.) and these are expanded on in Section **Error! Reference source not found.** of this report.

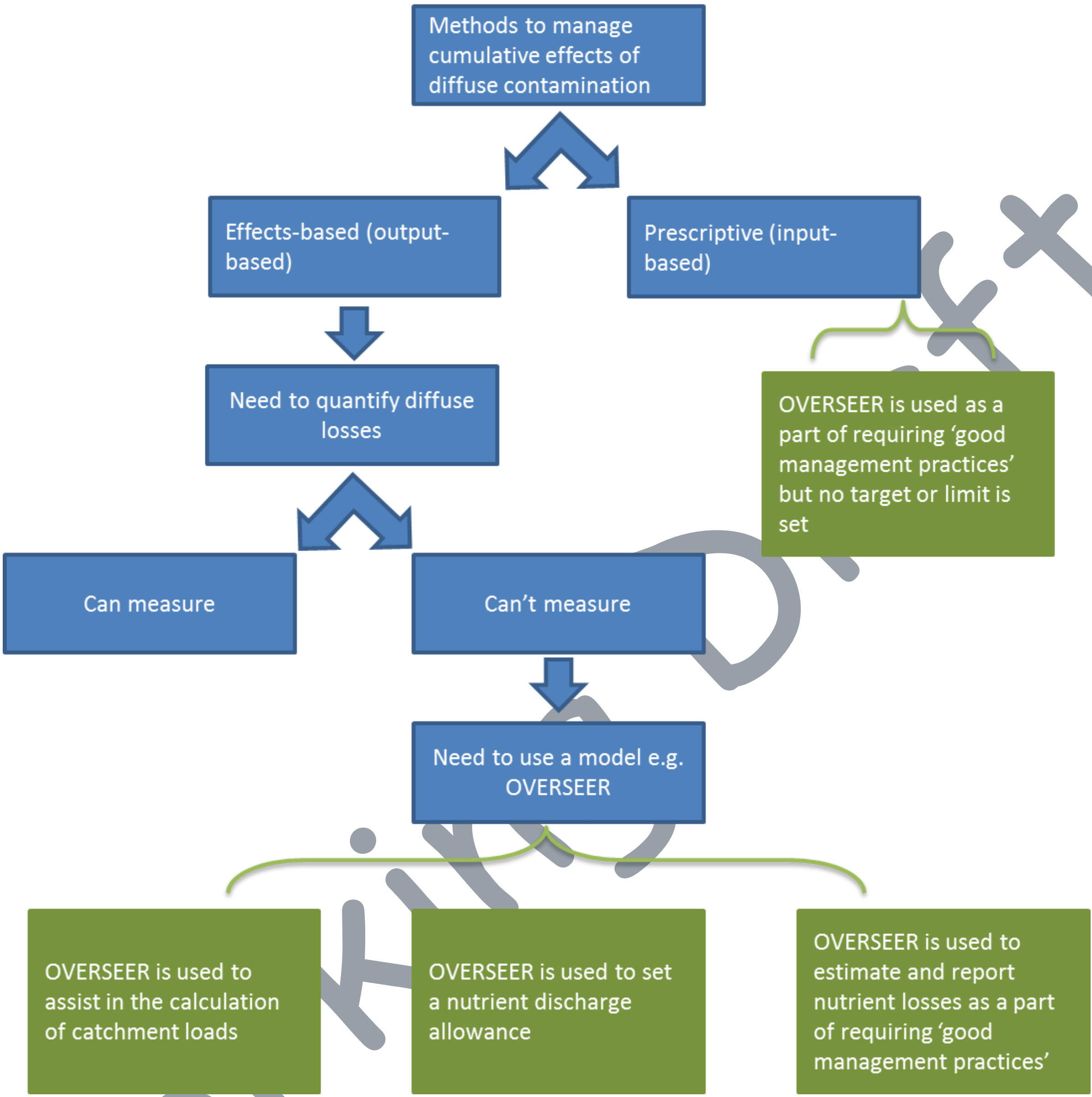

Figure 5 Methods to manage cumulative effects of diffuse contamination and where OVERSEER can be used

2.3 Principles to assist in establishing freshwater objectives and setting and managing to freshwater quality limits

These principles are specifically intended to guide the use of OVERSEER in assisting with the establishment of freshwater objectives and setting and managing to freshwater quality limits. These principles sit within a context of: overarching plan development considerations (Section 2.1) land use and water quality management assumptions, the general use of models in environmental decision-making and important information about OVERSEER (Appendix 12.2).

The principles are supported by the guidance in the remainder of the report. If the limitations, assumptions and uncertainties associated with the OVERSEER model change, the relevant principles may need to be revisited.

Where there has been a decision made to use OVERSEER to inform the establishing of freshwater objectives and in setting and managing to freshwater quality limits, there are four key planning principles and eight supporting technical principles covering its use (Table 1).

Table 1 Principles for the use of OVERSEER in assisting with the establishment of freshwater objectives and setting and managing to freshwater limits

Planning principles	Explanation	Relevant report section
1 Provided OVERSEER's limitations and assumptions are appropriately taken into account, OVERSEER can be used to provide estimates of annual nitrogen and/or phosphorus loss from farm systems that can be useful in water quality management.	These key assumptions and limitations are addressed in the supporting technical principles detailed below.	Estimating nutrient loads (Section 4), Uncertainty (Section 5), Averaging (Section 6), Modelling N and P (Section 8) Data provision and security (Section 9), Qualifications (Section 10)
2 (i)The use of OVERSEER must take into account that new versions of OVERSEER are released regularly and include a mechanism to manage version change if required. **2(ii) Where OVERSEER has been used in calculating source or receiving environment catchment loads there must be a mechanism to periodically re-evaluate and update the assumptions in the supporting catchment science**	OVERSEER is updated regularly (and modelled losses may change) and improved information is expected to result from more water quality monitoring information. A mechanism to accommodate the regular improvements in OVERSEER, manifested through version changes, and the improvements in understanding and knowledge is important to ensure that planning provisions can take advantage of improvements in models and other data where those improvements enhance the	Version change (Section 7), Estimating nutrient loads (Section 0)

		accuracy and effectiveness of interventions.	
3	**Where OVERSEER is used at multiple stages in a planning process (e.g. setting nutrient allowances and for assessing compliance), OVERSEER versions and data input standards should be consistent**	OVERSEER is updated regularly (and modelled losses may change) and assumptions used in building an OVERSEER file can affect estimated losses. Therefore, if losses from multiple versions are being compared or using different input standards, any differences may be in part due to changes in the model, not necessarily 'real' differences in nutrient loss. The uncertainty of outcome (for a consent holder or for the environment) is greater if the uses of OVERSEER are not consistent in terms of data inputting standards and versions.	Version change (Section 7)
4	**The use of OVERSEER must recognise that there are uncertainties in estimates of nutrient loss and this uncertainty must be identified, communicated and, as far as practicable, managed**	OVERSEER outputs, like all models, come with a degree of uncertainty and the biological system that OVESEER is modelling is also variable. Setting and managing to freshwater limits involves dealing with all of these types of uncertainty (MfE, 2016). The uncertainty in the model outputs can be amplified or managed by the way the model outputs are used. Therefore, where OVERSEER information is used, the uncertainty should be assessed and reduced where practicable, communicated, and reflected/accommodated in plan-making and implementation.	Policy approaches and rule frameworks (Section 3), Uncertainty (Section 5)

Supporting technical principles	Explanation
1 The use of OVERSEER must recognise that OVERSEER only models some sources of nutrients.	OVERSEER currently models seven nutrients including nitrogen and phosphorus. For these nutrients OVERSEER models losses from agricultural systems, it doesn't model nutrient losses from all activities that may occur in a catchment e.g. losses from many point sources, land slips, some river bed/bank erosion, non-agricultural land are not captured. Importantly for P, OVERSEER doesn't explicitly model Critical Source Areas (CSA). If only 'OVERSEER' nutrient sources in a catchment are modelled, this would normally underestimate the actual losses. Therefore, when using OVERSEER in any catchment assessment, consider what sources of nutrients are not modelled by OVERSEER, and whether those sources need to be estimated to account for all sources of nutrients.
2 The use of OVERSEER must recognise that OVERSEER does not model all farm management or mitigation practices and that there are some assumed management practices within the OVERSEER model	There are some farm management practices that are used on farm, and are understood to impact on some nutrient losses, but that are not captured in OVERSEER e.g. contour ploughing or wheel dyke ripping. For P, as CSAs are not explicitly modelled, available mitigations cannot be directly applied to CSA in the model. There are also some management practices that are assumed within OVERSEER.[9] If practices are occurring on farm are not modelled by OVERSEER, or the assumed levels of practice are not happening; the modelled losses may over or under-estimate the actual losses from a farm. Therefore, if OVERSEER information is being used and there is a significant gap: between the level of practice occurring on the ground and those assumed within OVERSEER, or between the practices that occur on farm and what can be modelled, this gap, or its consequences, need to be managed at an information-gathering, plan-making/resource consent or implementation stage.

[9] OVERSEER assumes that all activities on farm are being undertaken in such a way that there are no additional impacts on nutrient losses over those being modelled. This is what has been meant when it is said that OVERSEER already assumes 'good management practice'. Examples of these assumed management practices include even application of fertiliser and sealed effluent storage ponds. Such usage of the term good management practice would generally not match up with definitions used in regional plans. For example, OVERSEER could model the impacts of excessive amounts of fertiliser applied (which is not good management practice), but would assume that the fertiliser is being applied evenly and in a way where additional losses are not incurred.

3 The use of OVERSEER must recognise that OVERSEER only estimates nutrient loss from the farm boundary and root zone.	OVERSEER estimates nutrient loss from a farm (through leaching, runoff, direct to streams) as losses from the farm boundary or root zone. A variety of catchment processes can impact on the amounts of N and P that ultimately arrive in a target receiving environment. Therefore, other models need to be used (that include relevant catchment processes) for relating OVERSEER estimated losses to nutrients that arrive at a target receiving environment.
4 The use of OVERSEER must recognise that OVERSEER is a steady-state model and does not model the effects of transition e.g., transition from dryland to irrigated or farm system change such as forestry to pastoral farming	When a system is in transition e.g. conversion from dryland to irrigation or conversion of pasture to cropping, there are likely to be soil processes occurring that significantly impact on the actual nutrient losses during the transition period. However, OVERSEER assumes near equilibrium farm systems and so these losses that occur as the system changes are not captured. Therefore, OVERSEER may under- or over-estimate losses during a transition period. Therefore, other information needs to be used to understand the impacts of transition on nutrient losses.
5 The use of OVERSEER must recognise that data inputs to OVERSEER (actual or estimated) need to reflect a long-term biologically feasible farm system.	In general, OVERSEER doesn't 'sense check' the production data that is inputted to the model. OVERSEER assumes that the system being modelled is biologically feasible. This means that implausible farm systems can be modelled and give an estimate of nutrient loss. Also, a farm practice may be viable for a short time, e.g. mining soil nutrients. However, it is not feasible in the long term and the estimated losses of these 'short-term' practices may under-estimate the actual requirements and impacts of that farm system over the longer term. Therefore, OVERSEER data inputs can be from actual farm data or estimated data. Where estimated, data inputs should be supported by either other modelling (e.g. Farmax or crop calculators) or farm system expertise.
6 OVERSEER requires significant expertise to enable farm systems to be modelled accurately and the use must recognise that the quality of the	As with other models, if the input data and modelling methodologies used to construct and OVERSEER nutrient budget are poor, this will impact on the quality

	data inputs impacts on the uncertainty associated with the estimated nutrient losses.	of the modelled result and in turn the uncertainty associated with the estimated nutrient loss. Where OVERSEER is being used and the quality of the data are poor, this should be recognised as a factor likely to increase uncertainty (see principle 3). Improved data records will assist with improving the quality of data going forward. However, this will not improve the quality of historic or absent records. OVERSEER modelling requires significant expertise. See Section 10 regarding the recommended minimum qualifications.
7	**The use of OVERSEER must recognise the long term climate input assumptions built into OVERSEER and choose data inputs consistent with those assumptions.**	OVERSEER incorporates a number of significant assumptions based on a stable long-term farm system with similarly stable average climate conditions. Any modelling application that does not match these assumptions must be undertaken with care, and is likely to increase the uncertainty of the estimates. Therefore, where OVERSEER is being used, the data inputs should be consistent with the climate assumptions. Guidance on the choosing appropriate data inputs is given in Section 0.
8	**The use of OVERSEER must recognise the differences in N and P loss processes and how these are modelled in OVERSEER.**	There are significant differences in N and P loss processes and the way in which OVERSEER models these losses. These differences are important for modelling nutrient losses, and understanding and implementing mitigations. Therefore, catchment modelling and mitigation strategies will need to account for these differences (Section 8)

3 Plan-making and resource consents

3.1 Introduction

The intention of this section is to focus specifically on the major ways OVERSEER can be used as part of a regional plan policy and rule framework, rather than identifying every permutation and assess the key strengths and challenges of those approaches[10].

The use of OVERSEER in plan development and implementation falls into three major categories:

1. To assist in the calculation of catchment loads (Section 3.2 and Section **Error! Reference source not found.**).
2. To set and define nutrient discharge allowances/thresholds in the plan – for example, setting a permitted activity threshold for the amount of N or P that can be discharged or an allowance for a property (in kilograms per hectare[11] per annum) which is estimated by using OVERSEER (Section **Error! Reference source not found.**).
3. As the tool required to be used to estimate and report nutrient losses from a farm as a part of requiring 'good management practices' – for example, requiring some form of 'farm environment plan' or 'nutrient management plan', within which is a requirement for the calculation of nutrient losses using OVERSEER (Section **Error! Reference source not found.**).

3.2 Calculating source and/or receiving environment nutrient loads

This approach involves using OVERSEER nutrient loss estimates to help calculate the source nutrient load that is predicted to achieve the freshwater quality objective. With additional information this source load can be used to predict the nutrients arriving in receiving environment (Section 4.2).

Within a planning framework, these loads may be:

- Not explicitly stated in the plan provisions, but used implicitly as a basis for the policy and rule framework (Approach A)
- Used as limits (**Figure 4**) and expressed at a policy level or as part of an overarching objective e.g. setting a numerical limit (Approach B).

The key strengths of this general approach (whether using Approach A or Approach B are:

- It attempts to make explicit and transparent the relationship between losses from a catchment (and individual farms) and what arrives in the eventual receiving environment, thus enabling the estimation of a source load that would meet the freshwater objectives (e.g. concentration of a nutrient).

[10] This section assumes a significant level of knowledge about RMA provisions and their general application in regional plans. This section also assumes that the information here would be an input to a wider RMA section 32 analysis that would be undertaken as part of a regional plan development. For example, this section does not address matters relating to costs and benefits of different policy approaches. This section also does not address matters relating to nutrient allocation methodologies i.e., advantages and disadvantages of different methods such as 'grandparenting', Land Use Capability, peak versus average historical losses.
[11] Occasionally expressed as kilograms per property per annum.

- It can assist with clearly giving effect to the NPS-FM.
- Catchment relationship provides a link between a geographic area and an amount of nutrients – potentially facilitating a nutrient allocation framework.
- It can be useful in complex catchments with a mix of rural and non-rural land uses.
- In respect of Approach A, the plan is less affected by OVERSEER version change issues.
- In respect of Approach B, it makes an overall receiving environment and/or source load target clear and transparent and enables clear reporting on progress.

The key challenges this general approach (whether using Approach A or Approach B) are:

- A high level of information about land use activities in a catchment and quality receiving environment monitoring data is required, along with at least a conceptual understanding of catchment processes, such as de-nitrification, sedimentation and plant uptake.
- It is comparatively expensive to develop good quality catchment loads (**Table 2**), both in terms of initial and ongoing monitoring data acquisition and modelling costs.
- There will be uncertainty in the relationship between source and receiving environment nutrient loads.

In respect of Approach B,

- Version changes in OVERSEER (Section 7) may change estimated nutrient losses (i.e., source loads) which may have implications for the plan and its implementation.

Considerations to address some of the challenges:

- Consider whether to specify loads in a plan provision. The inclusion may have greater certainty and transparency, however, this may then require an annual process to accommodate effects of OVERSEER version changes (Section 7). The load estimates used in developing plan provisions can still be made transparent but just not necessarily specified in a formal provision (Approach A).
- Institute on-going and targeted monitoring to collect data to test expected water quality outcomes and catchment modelling assumptions such as catchment coefficients.
- Institute a mechanism by which updated and improved information (e.g. from additional monitoring or new model versions) can be incorporated. There will be ongoing costs associated with this.

3.3 Nutrient Discharge Allowances

This section considers the use of a nutrient discharge allowance that is specified in a plan and which is estimated by using OVERSEER. Within this topic, there are various policy and rule approaches that need to be considered and which are addressed in the following. These approaches should not be seen as mutually exclusive, but are all matters that need to be considered.[12] These are:

- Per property allowances
- Per group allowances
- Activity Status Thresholds
- The use of Farm Environment Plans

[12] For example, in setting a per property allowance, the activity status also needs to considered.

Per Property Allowance

This approach is based on an allowance of nutrients per unit area or per property that can leach or run-off to water (for example, the amount (in kilograms) of N or P that can be discharged per hectare per annum). OVERSEER can be used to estimate the nutrient losses that underpin the property allowances.

There are many permutations on how an individual property allowance/threshold is derived (allocation options), this can be based on land use, on a physical aspect of the land e.g. Land Use Capability, grand-parenting, or by mathematically dividing the agreed source load by some agreed mechanism, such as an equal allocation for every hectare of land in a catchment. As noted earlier, the advantages and disadvantages of allocations options are not assessed in this report.

The key strengths of this approach are:

- Conceptually simple – each property has a nutrient allocation.
- Makes explicit the expectations for the farming activity in terms of losses.
- The relationship between property losses and nutrients in the receiving environment can serve as a basis for assessing required mitigation or allowing increases in nutrient losses in order to meet the freshwater quality limits and freshwater objectives.
- Can assist with clearly giving effect to the NPS-FM.

The key challenges of this approach are:

- There will be some uncertainty in the derived relationship between losses from individual farms and what arrives in the target receiving environment.
- Version changes in OVERSEER are more than likely to change estimated nutrient losses from a farm. This may have implications where an absolute number derived in a previous version has been specified in a consent or a rule, as generally non-current versions of OVERSEER are not available (see Section 7).
- On farm management in plan implementation may be driven by what is 'recognised' and modelled in OVERSEER.
- Depending on how a policy and rule framework is implemented (such as the number of properties, the frequency of compliance monitoring, and whether this is administered under a resource consent framework), there will likely be large resourcing implications.

Considerations to address some of the challenges:

- Consider using a method to accommodate OVERSEER version changes (Section 7).
- Consider the type of consenting framework that will be used, and what thresholds are appropriate.
- Consider staged implementation to allow for industry and farmer capacity and capability to be built up, e.g. largest emitters first.

3.4 Property allowance - group

Per Group Allowance

A policy and rule approach may instead (or as well) focus on an allowance per group, for example irrigation schemes or catchment groups. This allowance can be either based on a land use or a discharge permit. OVERSEER can be used to estimate the nutrient losses that underpin the collective allocation.

An example of this approach would be where the collective scheme or group has been granted a resource consent with an overall discharge allowance (usually a number of tonnes of N per annum) and properties within the scheme/group are then able to be managed flexibly within the overall limit. The land use of individual properties within scheme would usually be a permitted activity, subject to conditions. Some form of management plan (e.g. a Farm Environment Plan (FEP)) for each individual farm in the collective may be part of the conditions of the granted resource consent.

In addition to the per property allowance above, the key strengths of this approach are:

- There is increased flexibility for individual landowners in the scheme/group as 'unders and overs' may be accommodated within the overall limits.
- A single allowance covers multiple properties and may reduce administrative burden on the farmer and council (but this would fall to the scheme or group administration).
- Monitoring and compliance within the group can be based on contractual arrangements between the members, rather than through RMA mechanisms.

In addition to the per property allowance above, the key challenge of this approach is:

- The council needs assurance that there are robust and transparent processes for managing performance to ensure compliance.

Example model rule for nutrient groups from Environment Canterbury Hurunui-Waiau River Regional Plan:

Policy 5.1 To take a tributary and community based approach to managing water quality and improving nutrient management practices.

…the land is subject to:
(i) an Industry Certification System; or
(ii) a Catchment Agreement; or
(iii) an Irrigation Scheme Management Plan; or
(iv) a Lifestyle Block Management Plan

Catchment Agreement [means] … an agreement approved by Canterbury Regional Council that identifies actions to be undertaken to actively manage the use of natural resources in order to achieve high standards of environmental management and optimise production from all properties within a catchment or sub-catchment of the Hurunui, Waiau or Jed Rivers or their tributaries.
…
Any Catchment Agreement must at a minimum, to the extent considered appropriate and corresponding to the scale and significance of the activities within the catchment or sub-catchment contain the elements identified in Schedule 2.

3.5 Property allowance and Farm Environment Plan

Activity status thresholds

As part of all the above options, it is important to consider RMA activity status thresholds. As noted earlier, there are several commonly accepted principles that apply to rule drafting for activity status thresholds.

Permitted activities are generally those where the level at which effects of a land use are not considered significant enough to justify management through a resource consent process. Nutrient loss estimates derived from OVERSEER can therefore be helpful to justify the level at which a permitted activity status is appropriate.

Prohibited activity thresholds are at the other end of the RMA status spectrum - activities that cannot be granted a resource consent, such as a further allowance in an over-allocated catchment. A significant level of analysis and justification is required to define an activity as a prohibited activity and again, nutrient loss estimates derived from OVERSEER can be helpful to assist in such justification

Sitting between the permitted and prohibited activity status thresholds, are those that require resource consent to be obtained. Where it is determined that a resource consent process is appropriate, consideration needs to be given to the appropriate activity status to be used (i.e. controlled, restricted discretionary, discretionary and non-complying) and the supporting policy framework.

There are different thresholds that can be used in plans to determine the status of an activity, some of which do not use OVERSEER, or do not use OVERSEER directly (and which are identified here but not considered in any detail in this report). Examples of thresholds include:

- property discharge thresholds (see property allowance section above);
- land use activity thresholds e.g. 20 ha of irrigation (may not rely on OVERSEER);
- property size (may not rely on OVERSEER).

The key strengths of property discharge threshold approach are:

- conceptually simple
- certain in their wording

The key challenges of this approach are:

- ascertaining compliance, particularly with OVERSEER version changes leading to different compliance outcomes over time, despite no changes in the farming practices.

Similarly, activities that may or may not meet an activity status threshold depending on the content or level of compliance with a management plan requirement (see FEP section below) will need careful rule crafting to ensure there are clear and objective thresholds.

Example model rule for a threshold, based on activities (from Environment Canterbury Plan Change 5 to the LWRP):

the use of land for a farming activity on a property greater than 10 hectares in area is a permitted activity provided the following conditions are met:

1. *…; and*
2. *The area of the property authorised to be irrigated with water is less than 50 hectares; and*
3. *For any property where, as at 13 February 2016, the area of land authorised to be irrigated with water is less than 50 hectares, any increase in the area of irrigated land is limited to 10 hectares above that which was irrigated at 13 February 2016; and*
4. *The area of the property used for winter grazing within the period 1 May to 1 September does not exceed a total area of 20 hectares; and*
5. *A Management Plan in accordance with Schedule 7A has been prepared and is implemented within 12 months of the rule being made operative, and is supplied to the Canterbury Regional Council on request.*

Example model rule for a threshold, based on activities (from Environment Bay of Plenty Plan Change 10 Lake Rotorua Nutrient Management):

Permitted – From 1 July 2017, the use of land for farming activities on properties/farming enterprises greater than 5 hectares in area and up to and including 10 hectares in effective area

The use of land for farming activities on properties/farming enterprises in the Lake Rotorua groundwater catchment:

- *Greater than five hectares in area and up to and including 10 ha in effective area; or*
- *From five hectares in effective area and up to and including 10 hectares in effective area,*

is a permitted activity from 1 July 2017 subject to the following conditions:

(a) The stocking rate that occurs on the effective area does not exceed the stocking rates specified in Schedule LR Two at any point in time; and
(b) No commercial cropping or commercial horticulture occurs on the land; and
(c) There is no increase in effective area or nitrogen inputs from [date of notification] that may contribute to an increase in nitrogen loss onto, into or from land; and
(d) There is no transfer of nitrogen loss entitlement either to or from the property/farming enterprise.

The use of Farm Environment Plans and using OVERSEER to report nutrient discharges

OVERSEER can also be used in the policy and rule framework within a regional plan as the tool that is required to be used to report nutrient discharges. This is in the form of a management plan, within which is normally a requirement for the calculation of nutrient losses using OVERSEER. As these management plans are most commonly referred to as a “Farm Environment Plan”, the term “FEP” is used in the report, whilst noting that other terms may be used such as ‘nutrient management plan’ to which the discussion on FEPs is still applicable.

FEPs may be used as a separate requirement within a regional plan, or they may be used in conjunction with a property or collective allowance (see property allowance section above).

FEPs are generally risk-based, i.e. identify the specific risks on the farm and then put actions in place in order to mitigate those risks. Monitoring or auditing are important steps to give confidence that the FEP meets the requirements of the regional plan and is being implemented.

Industry groups have a strong interest in management plans, with many having either incentivised or voluntary programmes in place. Some also have monitoring, auditing and reporting mechanisms, sometimes referred to as “industry audited self-management” systems (IASM) or “audited self-management” systems (ASM).

The key strengths of this approach are:

- Industry-specific FEPs have been developed and in some industries they are routinely used and audited by the industry groups. There are opportunities for information from existing or developing industry-audits or audited self-management to be used by councils instead of creating multiple FEPs.
- The implementation can be focussed on farm-specific practices that achieve a numeric limit or target that is documented in the FEP.
- Monitoring or auditing provides an opportunity for assessing both practices and numeric losses, and therefore can be used as a mechanism to manage uncertainty in the absolute numbers.
- There is likely to be more certainty in assessing compliance with a consent based on quantifiable requirements specified in a FEP rather than a specific numeric outputs where the model version can change numbers.

The key challenges of this approach are:

- There can be significant resourcing implications of preparing high quality plans and to develop and implement a robust, efficient and cost effective monitoring or auditing system
- There are mixed views as to whether it is appropriate for an FEP to be used as a part of a permitted activity or whether it needs to be under a resource consent framework. Resource consents give a greater level of scrutiny and certainty, but at a cost for all parties.
- There may be tension between an individual auditor's discretion and overall certainty/consistency in the auditing system (e.g. what to do if the farm exceeds a numeric limit, but required practices all in place and being implemented).
- If industry-audits or audited self-management systems in place, the council needs to have confidence in a process for dealing with performance if members are not complying

Example model rule that incorporates a nutrient management plan (from Environment Bay of Plenty Plan Change 10 Lake Rotorua Nutrient Management):

Controlled – The use of land for farming activities on properties/farming enterprises less than 40 hectares in effective area or that were not previously managed by Rule 11 to 11F that do not meet permitted activity conditions

The use of land for farming activities on properties/farming enterprises in the Lake Rotorua groundwater catchment where:

- *The property/farming enterprise is less than 40 hectares in effective area or was not previously managed by Rule 11 to 11F; and*
- *The activity does not comply with permitted activity conditions in Part LR,*

is a controlled activity from 1 July 2022 subject to the following conditions:

(a) A 2032 Nitrogen Discharge Allowance and relevant Managed Reduction Targets have been determined for the land in accordance with Schedule LR One and Policy LR P8; and
(b) A Nitrogen Management Plan has been prepared for the property/farming enterprise by a suitably qualified and experienced person and that person has certified that the Nitrogen Management Plan has been prepared in accordance with Schedule LR Six.

Bay of Plenty Regional Council reserves control over the following:
…

4 Estimating catchment nutrient loads

4.1 Purpose

The purpose of this section is to assess the strengths and challenges of the general methods for estimating source nutrient loads that use OVERSEER. There is also a short section on how OVERSEER information is used in estimating receiving environment loads. This section assumes that other appropriate methods are used to estimate source nutrient loads from activities that cannot be modelled by OVERSEER e.g., from residential, commercial or industrial activities.

Box 1 Key messages - estimating catchment nutrient loads

1. There are several methods for estimating source nutrient loads that differ in their strengths, challenges, resource implications and uncertainty.
2. A better quality source nutrient load estimation generally has a higher resource requirement, although software that allows automated running of hundreds of OVERSEER files partially addresses this.
3. OVERSEER can be used to help derive a catchment attenuation factor. However, this factor will change over time as improved information becomes available

Estimating source nutrient loads

OVERSEER is one model that can be used to estimate source loads from farming land uses (point A in **Figure 2**) in a catchment. Source nutrient loads can be estimated using OVERSEER in several ways, their information needs, strengths and challenges are tabulated in Table 2. If OVERSEER is used, it is important that other sources of nutrients not captured in OVERSEER are also assessed.

Table *2* **Different approaches to estimating source nutrient loads using OVERSEER**

	Generic or literature values	Anecdotal case studies	Representative farms (few)	Representative farms (many)	Actual farm budgets
Description	Industry average or typical nutrient losses are extrapolated to a catchment scale	Some existing individual Overseer budget nutrient losses are extrapolated to a catchment scale	Some virtual farm nutrient budgets are created to represent the mix of catchment characteristics	Many virtual nutrient budgets are created to cover a range of farm systems, soils and climates	All nutrient budgets are collected for a catchment
Main strengths	• Easy access to information • Can generate source loads quickly	• Relatively easy access to information • Can generate source loads quickly • If anecdotal files are available, these can be updated with model version change • Can be used to estimate current source loads	• Can engage farmers/ industry representatives in deriving information for models • As farms are virtual, they can be consistent with OVERSEER assumptions e.g. long term climate • Can produce reference files that can be updated with model version change • Can apply consistent level of practice and data input standards	• Can engage farmers/ industry representatives in deriving information for models • As farms are virtual, they can be consistent with OVERSEER assumptions e.g. long term climate • Can produce reference files that can be updated with model version change • Can apply consistent level of	• Can be used to assess current source load • Files can be updated with model version change • Farm systems modelled more closely represent what is occurring in the catchment than representative farms

	Generic or literature values	Anecdotal case studies	Representative farms (few)	Representative farms (many)	Actual farm budgets
				practice and data input standards • Farm systems not confined to a particular catchment	
Main challenges	• Generic estimates are not specific to the systems, soils and climates in the catchment and therefore may not reflect actual systems, soils or climates • Can be unclear what level of practice has been modelled and what assumptions have been used in modelling	• Characteristics and assumptions of the anecdotal systems may not be valid for the whole catchment and subsequent impact on loss rates is compounded with extrapolation to catchment losses • Confidentiality issues can hinder close scrutiny of input data • Anecdotal files are often based on a single year i.e. snap shot. This can be problematic if the year was atypical • Anecdotal systems may not cover all of the soils, climates and systems in the catchment • Current practice encompasses everything from very poor to best management practice. The level of practice would need to be normalised for use in testing policy options and future scenarios	• Characteristics and assumptions of few representative farms systems may not be valid for the whole catchment and subsequent impact on loss rates is compounded with extrapolation to catchment losses • The virtual farms are catchment specific • Additional modelling may be needed for the representative farms to be plausibly extrapolated across soils and climates in the catchment	• The full range of current land uses in the catchment may not be captured • Farms may need to be aggregated for use in testing policy options and future scenarios	• Current practice encompasses everything from very poor to best management practice. The level of practice would need to be normalised for use in testing policy options and future scenarios • If there are many farms, they may need to be aggregated for use in testing policy options and future scenarios • Risk of variable quality of information • If only a single year is collected, this can be problematic if the year

	Generic or literature values	Anecdotal case studies	Representative farms (few)	Representative farms (many)	Actual farm budgets
	• Mitigations can be problematic to apply to these generic estimates if underlying assumptions are unknown	• If files were built by multiple modellers, may be difficult to get a consistent level of practice and data input standards • Can be unclear what assumptions have been used in modelling • Mitigations can be problematic to apply to these anecdotal files if underlying assumptions are unknown • Risk of variable quality of information	• The full range of current land uses in the catchment may not be captured		was atypical or for systems in transition • Confidentiality issues can hinder close scrutiny of input data
Resource implications	Few resources needed	Few resources needed	Moderate resources needed	High resources needed	High resources needed
Likely uncertainty of data inputs and ability to manage uncertainty (Appendix 12.3)	High uncertainty of data inputs. Low ability to manage uncertainty.	High uncertainty of data inputs. Low ability to manage uncertainty.	Moderate uncertainty of data inputs. Moderate ability to manage uncertainty.	Low uncertainty of data inputs. Moderate ability to manage uncertainty.	Moderate uncertainty of data inputs. Moderate-high ability to manage uncertainty.

	Generic or literature values	Anecdotal case studies	Representative farms (few)	Representative farms (many)	Actual farm budgets
Additional information				Software has been developed that allows many (hundreds) of Overseer files to be generated, run and summarised in very short times (minutes). These tools considerably reduce the resource implications of this approach, but require expert input for initial set up and checking of information produced	Software has been developed that allows a consistent set of modelling proxies (intended to represent industry agreed Good Management Practice) to be applied to existing OVERSEER files. This could overcome the challenge of unknown levels of practice with this approach (portal website ref)

4.2 Estimating receiving environment nutrient loads

Between N and/or P being lost from a farm and arriving at a specific point in a receiving environment, a wide range of processes such as sedimentation, plant uptake, denitrification, can occur that can remove those nutrients from the water body or make them unavailable. This means that the total amount of nutrient that is lost from the farm boundary or root zone is not necessarily the same magnitude as that which is measured in the receiving environment. Understanding the likely magnitude of this attenuation is important in establishing freshwater objectives and setting and managing to freshwater limits. Catchment attenuation is expected to vary spatially and with time because the biophysical processes that contribute to attenuation vary spatially and in time. A range of estimates for catchment attenuation factors have been reported in New Zealand for N[13] but a factor in the order of 50% is common but much smaller and greater rates of attenuation have been reported.

OVERSEER can be used in two ways in estimating receiving environment loads. OVERSEER estimates can be used to derive a catchment attenuation factor[14]. Or if a catchment attenuation factor has already been developed empirically or independently[15], it can be applied to a source load estimated by OVERSEER to estimate the amount of nutrient likely to enter a receiving environment e.g. from future land uses.

A derived catchment attenuation factor is a term used where the amount of N or P attenuated during travel down a catchment may be roughly estimated by subtracting the measured receiving environment load at the measurement point at the bottom of the catchment from the modelled source loads. The difference is expressed as a factor. The CAF is a 'derived' from these two sources of information.

An empirical catchment attenuation factor is a term used where there has been some scientific effort to quantify the attenuation processes through measurement, either at the individual process level or collectively.

In catchments with no significant lag times, deriving the catchment attenuation factor estimates the total amount of attenuation. This method does not attempt to quantify the relative contribution of various complex biophysical attenuation processes such as the amount of denitrification versus uptake by riparian vegetation or periphyton. The derived catchment attenuation factor is thus a lumped catchment estimate of all attenuation processes.

[13] For example; Singh et al., (2014) reported N attenuation factor estimates in Manawatu catchments ranging from 0.2 to 0.7; and an attenuation factor of 0.5 is assumed in both the Taupo catchment (Waikato Regional Council's Variation 5) and in the Manawatu-Wanganui (Horizons' One Plan (Rutherford 2013); more than ten-fold reductions in nitrate concentrations have been measured along a section of the Tukituki River in Hawkes Bay (Wilcock 2013).

[14] Also termed a catchment co-efficient.

[15] In some locations, considerable scientific effort has been applied to quantify individual attenuation processes in a catchment, for example nitrate concentrations have been measured along a section of the Tukituki River in Hawkes Bay where conditions are conducive to large growths (and therefore large nutrient uptake) of periphyton (Wilcock 2013).

Importantly it also includes the uncertainties in the modelled[16] and measured loads. In catchments where there are significant lag times, deriving the catchment attenuation factor must also account for that load which is expected to arrive in the receiving environment at some point in the future. Otherwise there is a risk of overestimating the attenuation factor and therefore underestimating the nutrients that are likely to enter the receiving environment.

OVERSEER estimates change (improve) each time a new updated version is released, and measurement-based estimates improve with more frequent sampling and/or a longer period of monitoring record. Thus a derived catchment attenuation factor is also expected to continuously improve over time, i.e. if either the OVERSEER estimates of the catchment source nutrient losses (for a given land use mix) or the measurement of the receiving environment nutrient estimates change, then the derived catchment attenuation factor will also change. If the attenuation factor has been wholly derived or based on empirical data, then it is not expected to change with updates to modelled information.

Recommendations – estimating catchment nutrient loads

1. Where source loads calculations are used as a basis for setting catchment nutrient load limits, use methods with low or moderate uncertainty.
2. Where derived catchment attenuation factors are used, there should be a process for assessing and updating if required as new information becomes available. This is to ensure that planning provisions can take advantage of improvements in models and other data where those improvements enhance the accuracy of that information and the effectiveness of interventions.
3. The implications of OVERSEER version changes on source loads calculations used as a basis for setting catchment nutrient load limits, should be assessed after each version change.

[16] This relationship is usually derived using predictive OVERSEER nutrient budgets not historic. If historic OVERSEER nutrient budgets are used here, then consideration needs to be given to how representative that historic period was (see Section 0).

5 Uncertainty

5.1 Introduction

The purpose of this section is to outline the background to, and significance of, uncertainties associated with OVERSEER, and to provide specific guidance for regional councils on opportunities for managing those uncertainties in setting and managing to water quality limits.

Box 2 Key messages - uncertainty

- Uncertainty is inevitable and regional plan and resource consent decisions need to acknowledge and incorporate uncertainty
- Uncertainty in OVERSEER modelling losses will be reduced by undertaking and incorporating further science including evaluation
- There are options and methods for using OVERSEER in a way that recognises and manages uncertainty in setting and managing to freshwater quality limits

5.2 OVERSEER and uncertainty

Uncertainty is the situation involving imperfect and/or unknown information. It applies to physical measurements that are already made, to predictions of future events, and to the unknown (MfE, 2016) Uncertainty in the context of modelling can be defined as a potential limitation in some part of the modelling process that is a result of incomplete knowledge (Shepherd *et al*., 2013) and it is inevitable with any model.

The reason that uncertainty is the most useful term to use when talking about annual whole-farm nutrient loss estimates is because it not usually practicable or possible to directly measure whole-farm nutrient losses and therefore there is no measured value to compare a modelled estimate with, and therefore, term like accuracy are less relevant (Shepherd *et al*., 2013). The sources of modelling uncertainty are outlined in Table 3.

Table 3 Sources of modelling uncertainty (Shepherd et al., 2013 based on Walker et al., 2003).

Sources of modelling uncertainty	Brief description and comment
Context and framing	This can include choices about the physical boundaries of the system being modelled, the range of factors to incorporate into a model, and specific prediction choices.
Inputs	Uncertainties about inputs that drive the model, e.g. fertiliser, production, supplements, soil type, climate, etc.
Model structure	Models simplify reality and may be based on an incomplete understanding of the processes and structure(s) being modelled, e.g., the Overseer engine and our understanding of the underpinning science.
Parameters	Parameters used in the model need to be estimated or inferred from sometimes very limited data, e.g. parameters that drive the urine N leaching, crop N leaching, etc.
Model implementation	This can include technical modelling choices and potential software bugs.

Watkins and Selbie (2015) also outline the sources of variability in data input and modelling procedures in OVERSEER that contribute to modelling uncertainty (Appendix 12.4) and describe opportunities to reduce uncertainty in the model outputs as well as detailing the level of evaluation of OVERSEER sub-models that has occurred to date. These recommendations for reducing the uncertainty in OVERSEER are focussed on improving data inputs, improving understanding and description of farm systems and using best practice calibration and evaluation, processes including increasing the number and range of field measurements and farmlet studies.

There are some sources of uncertainty described in **Table 3** and Watkins and Selbie (2015) that can only be reduced with new knowledge, there are others that can be partially managed through how the model is used and in addition, the model outputs can be used in ways that recognise or manage uncertainty. The next sub-section addresses the requirements for new knowledge and remainder of this section focuses on the question of how we can use OVERSEER in a way that recognises and manages uncertainty in setting and managing to water quality limits.

5.3 Reducing uncertainties in the OVERSEER model

Uncertainties in the OVERSEER model itself can be progressively clarified and reduced through undertaking prioritised science. The choice of what additional science to do, and the way it is undertaken and incorporated can have significant impacts for the model and its use. It is therefore important to have good, transparent processes for: reviewing current model components, deciding what science is needed, establishing the priority of work, and ensuring the robustness of science. While the OVERSEER development processes and concomitant funding is beyond the scope of this project, they are critical factors in reducing uncertainty in OVERSEER outputs.[17]

The science and development processes used to clarify and where possible reduce uncertainty in OVERSEER outputs are a critical ongoing and long-term requirement. However, they are not directly within the control of the regional councils[18] as they engage in setting and managing to water quality limits. Therefore, for the purposes of this section it is assumed that good and strategic policy for science is in place around OVERSEER leading to continual and incremental reduction in uncertainty of the model outputs.

[17] There is a process is already in place for OVERSEER development: *"OVERSEER Limited identifies and prioritises the development programme with input from three independent advisory groups (science, user and stakeholder). Development activities follow structured Science and Software Development Lifecycle processes that are specifically designed to maintain quality and understand the impacts of development on the model outputs and communicate these to users"* (Caroline Read, OVERSEER General Manager, Personal Communication, March, 2016).

[18] On-going and active involvement by regional councils and other stakeholders in the OVERSEER Ltd development process is an important part of OVERSEER's development.

5.4 Reducing and managing uncertainties in setting and managing to water quality limits

In the Ministry for the Environment's draft guidance (MfE, 2016MfE, 2016)Figure 66).

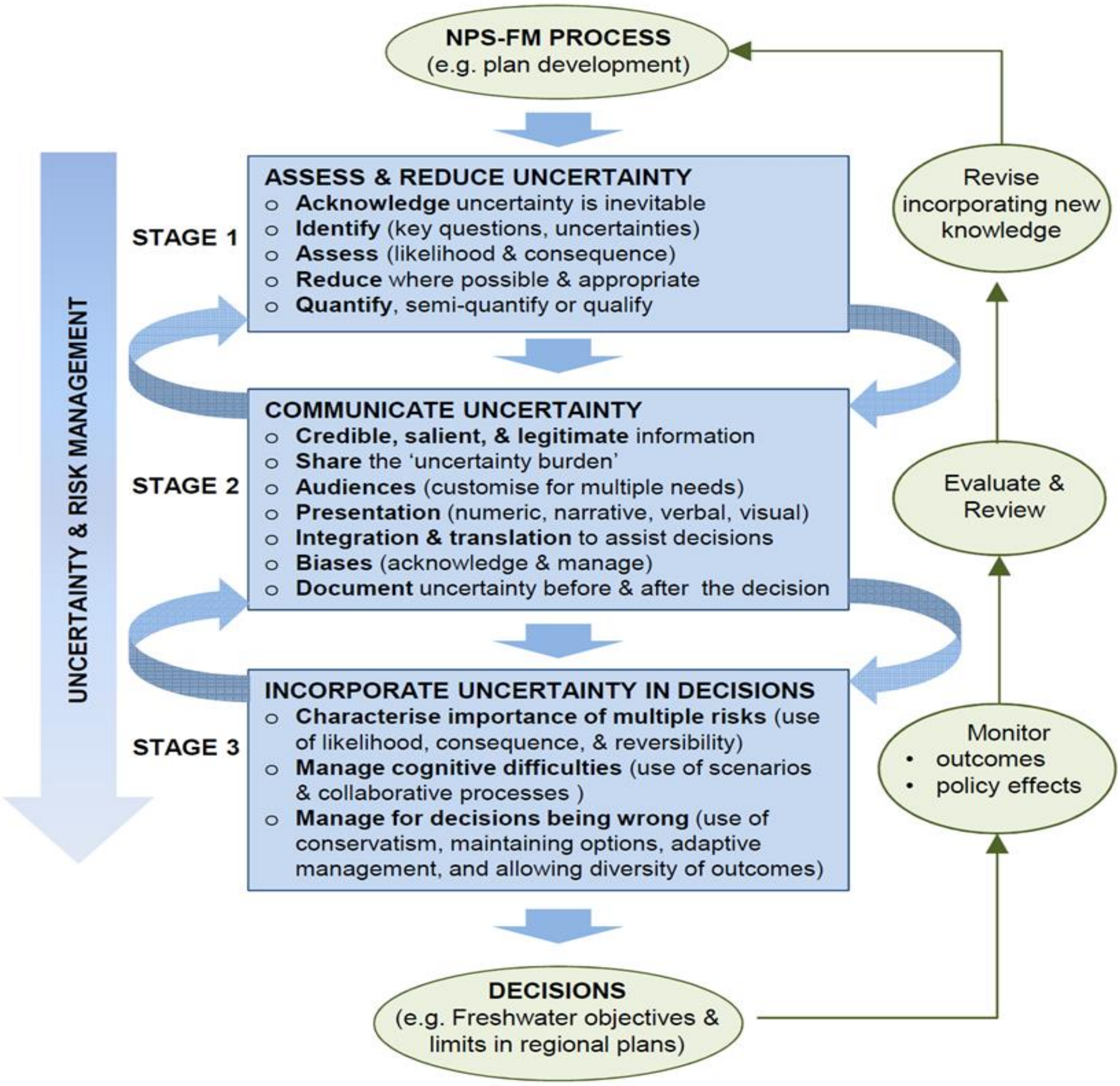

Figure *6* **Three stage iterative process for managing uncertainty in NPS-FM processes from MfE (2016) Guidance on communicating and managing uncertainty when implementing the National Policy Statement for Freshwater Management**

The stages detailed in Figure 6 provide a useful framework for categorising options for managing uncertainty.

Table ***4*** is a summary of the options and methods for managing uncertainty in the use of OVERSEER in setting and managing to freshwater limits using these categories. The rest of this section gives further details of each option.

Table 4 Summary of options and methods for managing uncertainty in the use of OVERSEER in setting and managing to freshwater limits against categories from MfE guidance on managing uncertainty

		Categories of how uncertainty is managed					
		Assess and reduce uncertainty	Communicate uncertainty	Incorporate uncertainty in decisions	Reflect uncertainty in plan	Implement and monitor	Evaluate, review, revise
Options and methods to manage uncertainty in use of OVERSEER							
Managing data inputs	Quality of data inputs	✓			✓	✓	✓
	Expertise of modellers	✓	✓		✓	✓	
	Representativeness of modelled information	✓	✓				✓
	Similarity of farm system/soil/climate to calibration data set	✓	✓			✓	
Using OVERSEER outputs	Significance analyses and use of ranges	✓	✓	✓			✓
	Alternative sources of evidence	✓	✓			✓	✓
	Model outputs used in a relative sense	✓	✓	✓	✓	✓	✓
	Precautionary Principle	✓		✓	✓	✓	✓
	Shortened consent term				✓		
	Resource consent review conditions				✓	✓	✓
	FEP and OVERSEER used together	✓		✓	✓	✓	
	On-going targeted monitoring and revision	✓			✓	✓	✓

5.5 Identifying, reducing and managing uncertainty in model inputs

Quality of data inputs

In simple terms, the quality of what goes in to a model affects the quality of what comes out. The use of unreliable input data (i.e. data that is inputted by the user) is regarded as the major source of uncertainty in modelling (Cichota and Snow, 2009, Watkins and Selbie, 2015). The main inputs that have the most impact on nutrient loss estimates are: inputs that influence the size of the source of a nutrient (e.g. stocking rate, fertiliser input) and inputs that influence the transport of a nutrient (e.g. climate, soil, drainage for N, slope for P). Watkins and Selbie (2015) have identified a list of the main inputs that OVERSEER nutrient loss estimates are sensitive to (See Appendix 12.2).

Uncertainty can be partially managed by using good quality user data inputs, that are supported (and/or verified) through accurate record keeping or supported by using other modelling tools (e.g. crop calculators, Farmax, pasture modelling tools) or farm system expertise. Figure 7 shows an example of the difference in N losses from 74 farms modelled using OVERSEER with two different qualities of soils information; level 1[19] and level 2[20] (Robson *et al*., 2015). The quality of the soil inputs had a significant impact on the losses predicted from many of these example farm systems.

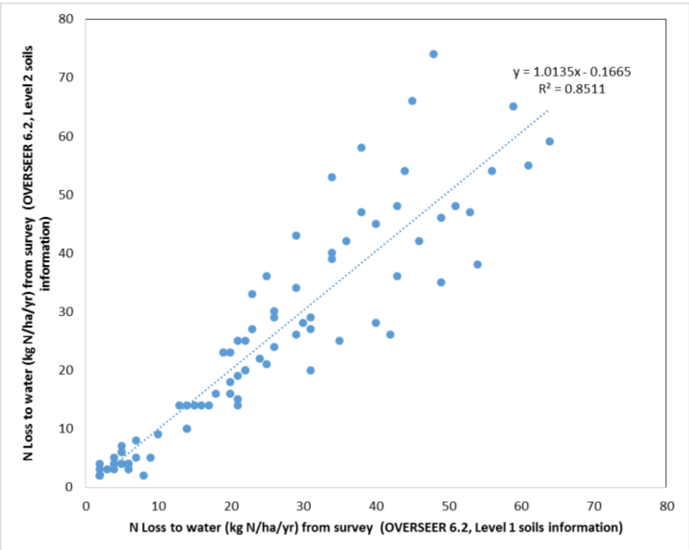

Figure 7: Relationship between N losses from 74 farms when using level one and when using level two soils information (Robson et al., 2015Robson et al., 2015Robson et al., 2015Robson et al., 2015)

In some cases, high quality data may not exist, e.g. trying to establish a benchmark determined by historic activities but where there are no records. In these cases, careful consideration needs to be given to how to generate data to develop such files including the quality of data and the resources implications. In some circumstances, the use of a generic or reference farm systems have been proposed as a means of generating files to fill these gaps.

[19] Level 1 soils information is the use of qualitative *Overseer soil profile* categories (Pollacco et al., 2014).

[20] Level 2 soils information is the use of quantitative soil moisture inputs (Pollacco et al., 2014).

Expertise of modellers

Wheeler and Shepherd (2013) describe OVERSEER as an expert user system and the outputs are dependent on many inputs that rely on expert judgement and understanding of NZ farm systems.

Watkins and Selbie (2013) describe differences in user input of data as a source of uncertainty in OVERSEER outputs. The development and use of the Best Practice Data Input Standards (BPDIS) e.g. OVERSEER (2015); Wheeler and Shepherd (2013), are recognised to be an important aspect of managing the uncertainty in outputs created by variations on users' input of data. In addition to this, ensuring that the correct version of BPDIS is used with the correct OVERSEER version and that if OVERSEER is being used in multiple parts of a planning process, or if there are multiple sources of OVERSEER files, ensuring that the BPDIS version is consistent.

Even with appropriate expertise and qualifications different users may make different assumptions and judgements, particularly if for example, they are estimating practices for periods where data is missing. Further development of the: minimum expertise requirements for modellers, BPDIS and guidance on potential issues (See Section 10) will assist to reduce uncertainty in model outputs associated with the expertise of modellers.

Representativeness of modelled information

The closer the farm system in OVERSEER is to the actual farm system being modelled the more the uncertainty about the model outputs will be reduced.

At an individual farm level, the differences between actual and modelled may arise from different sources, for example, quality of data inputs (addressed above), assumed level of practice not being achieved, or systems/practices that are beyond the model's current capabilities.
The uncertainty in model outputs may arise from the assumed practices or levels of practice that are built into the model not being reflective of reality on the farm. This can be partially managed articulating the assumed practices or level of practice and where OVERSEER is being used in implementation, to use the model in concert with a farm environment plan.

Differences may also come from constraints in the model where current management practices, cultivation, fertiliser application, irrigation or crop types cannot be fully and accurately represented in the OVESEER model e.g., a specific fruit crop that is not available in OVERSEER, the exact timing of fertiliser applications in a month relative to OVERSEER assumptions, etc. This uncertainty will only be reduced as the OVERSEER model evolves and more farm systems and management practices are able to be captured. However, the BPDIS (OVERSEER, 2015) contains some strategies, such as surrogate crop types, that can be used to reduce possible inconsistencies when a system can't be fully represented.

At a catchment scale, where OVERSEER is used to estimate nutrient losses for catchment assessments, there are additional scale, resourcing and practical considerations that impact on uncertainty. For example, in a catchment with 500 farms, generating a source load from actual, high quality nutrient budgets would have the least uncertainty, but the resource implication of this approach would be great (unless the information was already being generated for other purposes such as catchment accounting). In addition, if policy or land use scenarios are run, this may involve individual manipulation of each of the 500 files. Therefore, although the uncertainty with individual estimates increases the further away the model is from the actual farm systems, at catchment scale, especially with large numbers of farms, a pragmatic approach is likely to be needed. The strengths and challenges of different approaches is shown in *Table 2*.

Similarity of farm system/soil/climate to calibration data set

Shepherd et al., (2013)[21] describe OVERSEER as a part-empirical part-mechanistic model. Extrapolation beyond a calibration dataset can be problematic for empirical models whereas if the underpinning science is sound, then there is more scope for extrapolating with mechanistic models (Shepherd et al., 2013). Therefore, OVERSEER can be used beyond the land uses, soils and climates that were used in the field studies used to calibrate OVERSEER sub-models. However, the greater the difference from these calibration field study situations, the more uncertainty there is likely to be in the estimated losses. Most). So OVERSEER can be used beyond the land uses, soils and climates that were used in the field studies used to calibrate OVERSEER sub-models. However, the greater the difference from these calibration field study situations, the more uncertainty there is likely to be in the estimated losses. Most of the field studies used in the N calibration and evaluation to date were carried out on flat, pastoral, dairy enterprises, with primarily free-draining soils and moderate rainfall (Watkins and Selbie, 2015).

A way of partially managing the uncertainty of using OVERSEER to estimate nutrient losses for systems, soils and climates that are beyond the calibration range or where the system cannot be described in OVERSEER is to use well-calibrated process-oriented models such as SPASMO and APSIM[22] to providing supporting information. Models with higher level of detail, such as process-oriented and mechanistic models can often be set to describe systems with greater specificity which seems to generally increase the confidence in the model simulations, even though specificity does not necessarily mean greater accuracy (Cichota and Snow, 2009).

5.6 Managing uncertainty in use of model outputs

Significance analyses of variables to give ranges

Uncertainty can be partially quantified, communicated and accounted for in decision is the use of significance analyses and the subsequent ranges that these analyses produce. These significance analyses indicate the relative influence that changes to key inputs have on outputs. For example, where there is uncertainty or variability in a critical OVERSEER inputs (or a land use configuration), multiple OVERSEER files can be run to explore the implications of that variability or uncertainty and produce a range of possible losses. These ranges can be translated into possible impacts on outcomes. Communicating these ranges helps decision-makers to appreciate the extent of some uncertainties and take that into account in the decision-making process. Significance analyses have been used in some limit setting processes in combination with qualitative uncertainty assessments (MfE, 2016, Robson, 2014).

A significance analysis is neither a full uncertainty analysis nor a full sensitivity analysis, both of which would require significant resources. Watkins and Selbie (2015) acknowledge that although an uncertainty analysis on OVERSEER could usefully be undertaken, it is not possible to quantify all the sources of uncertainty in the nutrient loss value produced and therefore suggest that reducing uncertainty might be a more appropriate use of resources.

[21] They define empirical models as statistical descriptions of observed data and mechanistic models as aiming to construct mathematical representations of the behaviour of a system based on descriptions of processes.
[22] SPASMO and APSIM are more often used as research tools due to their complexity and greater expertise needed to use them.

Multiple sources of evidence

MfE (2016) indicate that “employing more than one model to make independent parallel predictions can be useful for establishing converging lines of evidence, this potentially increasing confidence (i.e. reducing uncertainty) in the predictions”. Where OVERSEER has been used to estimate source nutrient losses, well-calibrated process-oriented models such as SPASMO and APSIM may be useful for providing an independent parallel estimation for source catchment losses. The concept of multiple sources or independent parallel of evidence is also useful for reducing uncertainty around key inputs to OVERSEER.

Using model outputs in a relative sense

Models are often better at describing relative differences, such as the increase or reduction of N leaching after a management change, rather than providing the absolute values of leaching (Cichota and Snow, 2009). The uncertainties in the use of OVERSEER outputs can be partially managed by using OVERSEER to indicate relative changes using the same model version. For example, if incorrect soil information and therefore PAW was used in OVERSEER, then the absolute nutrient loss is unlikely to be accurate, however the relative impact on N leaching of activities such as changing stock type, using a different crop rotation or improving irrigation is less uncertain.

At a catchment scale this could involve the use of scenarios to explore the relative rather than absolute changes from current in estimated catchment nutrient losses under different land use or policy scenarios.

At a farm scale, this could involve relative change from a known point e.g. land use during a period of time or benchmark, or loss estimates monitored over time to indicate a trend. A condition of using the model in a relative sense is that all scenarios need to be in the same version of OVERSEER.

Precautionary Principle

In their guide to managing uncertainty in NPS-FM processes, MfE (2016) discuss the approaches to ‘managing the certainty of being wrong’ and suggest that “all the commonly used elements (of the precautionary principle) can be useful for managing uncertain situations: conservatism, a consideration of irreversibility and adaptive management.” Of these, conservatism and adaptive management are specifically relevant to the use of OVERSEER. A consideration of irreversibility is a key factor in the wider limit-setting process, but not specific to the use of OVERSEER.

Conservatism can be exercised when using OVERSEER through, for example using valid but conservative input data or using the conservative end of ranges of outputs. Conservatism can also be incorporated into decisions about limits as a way of managing uncertainty in model outputs.

Adaptive management is often used as a tool for managing uncertainty and involves a cycle of decisions, implementation of decisions, monitoring, review and changes. It can be used as a planning and/or regulatory mechanism to manage uncertainty in OVERSEER outputs used in setting water quality limits. For example, by setting limits that include environmental outcome triggers that if met allow for further development or staging of development and monitoring outcomes and if not met can be used to limit further development.

Short duration resource consents

A short duration resource consent term is often used as a mechanism to address uncertainties about potential negative effects and may appropriate to be used where the receiving environment is likely to become more sensitive over time, or adverse effects are only acceptable for a limited period (Freeman, 2011). However, such short-term resource consents must include specific requirements to obtain relevant information to ensure that there is an adequate body of knowledge available prior to the expiry of the resource consent to assist future decision making.

Resource consent review conditions

Consent review conditions can be used to address uncertainty, where a general or specific review condition provides for a review in the event of a specific situation and/or an adverse effect occurring. Freeman (2011) notes that there are several limitations to consent reviews as a primary mechanism to address uncertainty and suggests that a review condition as a "backstop" for long-term resource consents.

5.7 Farm Environment Plan and OVERSEER used together

Some of the uncertainty in OVERSEER outputs can arise from poor input data or where OVERSEER assumes certain practices are in place but they are not happening on the ground. These sources of uncertainty may be partially managed by using an audited Farm Environment Plan together with OVERSEER, where records that are used for the model can be verified and an assessment made as to whether the sought after practices or level of practice is being achieved. In some cases, the Farm Environment Plan that includes farm system information and practices is consented instead of the OVERSEER loss rate (Section 3).

5.8 On-going targeted monitoring and revision

Decisions on water quality limits are made with imperfect information and will be regularly revisited through effectiveness and plan reviews. A key way of managing uncertainty when OVERSEER outputs has been used to estimate or calculate catchment loads is to ensure on-going, targeted monitoring and data collection. This information can be used to test (and revise if necessary) the modelling and assumptions that underpin the catchment load calculations and the understanding of the relationship of sources losses and the water quality in the receiving environment.

Recommendations - uncertainty

When using OVERSEER in setting and managing to freshwater limits:

1. Acknowledge that OVERSEER modelling involves significant uncertainties.
2. Use good quality data inputs in particular the quality of the most influential for example through spending more time of sourcing these data, using expert verification or independent modelling sources.
3. Use qualified and experienced OVERSEER modellers and use the appropriate Best Practice Data Input Standards.
4. Where OVERSEER is being used outside its calibration range (system/soil/climate) consider independent parallel source of information e.g. through other models.
5. Use OVERSEER outputs in a way that minimises the impact of uncertainty e.g. use model outputs in a relative sense, undertake significance analyses and impact of ranges of possible nutrient losses.
6. Communicate the potential consequences of uncertainties in OVERSEER outputs.
7. Consider the use of policy and rule frameworks that support adaptive management and review conditions being placed on resource consents, with these conditions relating to what is happening in the wider receiving environment, as more information comes available including from the future use of OVERSEER.
8. The consideration of a permitted or prohibited activity status where the activity status is determined directly or indirectly by OVERSEER outputs should recognise that those outputs are subject to significant uncertainty.
9. Where OVERSEER has been used to generate source loads, ensure on-going targeted data collection within a catchment test and revise if necessary the modelling and assumptions that underpin the catchment load calculations.

6 Averaging

6.1 Purpose

The purpose of this section is to review and summarise information on when OVERSEER estimates should be averaged and over what periods.

When regional plan rules and/or resource consent conditions specify the use of OVERSEER and require the provision of OVERSEER estimates based on actual farm data, the question is often asked whether the use of one year of data is appropriate or whether output estimates or inputs should be averaged over a number of years. A critical aspect of this is whether the purpose is for estimating long-term source loads to a catchment, developing some reference benchmarks, and/or for assessing compliance with some specified limit, threshold or allowance.

Box 3 Key messages - averaging

1. It is important to be aware of potential mismatch issues when mixing long term climate data with annual management data.

2. There are a number of reasons why it might be useful to average either OVERSEER inputs or output including this being a response to the mismatch issue and minimising annual variation in nutrient losses.

3. When considering averaging inputs, it important to understand and consider several points including the underlying steady state assumption, model non-linearity and biological feasibility. Another approach is to define a typical long-term farm system

4. In a compliance setting, a rolling average of estimated nutrient losses over a minimum of 3-5 years helps avoid annual variation in nutrient losses.

6.2 The critical importance of climate inputs

OVERSEER inputs include three climate values: rainfall, potential evapotranspiration (PET) and temperature. These are generally obtained by using the 'climate station tool' in OVERSEER which provides three annual long term mean values from a NIWA generated data layer of 30-year average annual values based on the period from 1981-2010 (Wheeler 2015). These annual climate data values can also be specified by the user. The annual rainfall and temperature values are distributed into monthly values based on the temporal pattern of 30-year monthly data for the region or nearest town. The monthly values are in turn distributed into daily values according to 15 climate modifiers describing the range and seasonality (Wheeler, Shepherd et al. 2014). The climate modifier that drives the long term redistribution pattern of monthly to daily values can be changed (to one of the 15 options). Monthly climate values are now able to be specified by the user (since version 6.3 of OVERSEER).

This use of long term climate data and distribution patterns means that there can be a mismatch between climate and farm management when annual management data is entered into OVERSEER, especially where annual differences in management are due to changes in the actual climate. For example, irrigation inputs in any given year are normally driven by the actual climate in that year, and may not match the long term climate pattern. Thus too little irrigation might be applied in a drier than normal year or too much in a wetter than normal year. This mismatch can lead to under- or over-estimates of nutrient losses (Wheeler, Shepherd et al. 2014).

OVERSEER is driven by user-specified levels of production. This value has “an important effect on the calculation of feed and nutrient intakes” (Watkins and Selbie 2015). OVERSEER assumes the farm is operating in a ‘steady-state’ and actual and reasonable inputs have been entered. If, for example, annual production, irrigation and fertiliser inputs are combined with long term climate data, the resulting farm system may not be viable as the long term climate may not be consistent with the specified level of annual production.

The impact of using different annual rainfall inputs is illustrated by Journeaux (2014) in a numeric analysis of a dairy farm case study in which the effects of different averaging strategies were compared. OVERSEER runs were made under three rainfall levels of 800mm, 1200mm and 1600mm with corresponding changes to the production, stocking number and fertiliser applications. There was a decrease in nitrogen losses of 51% and 54% for the drier year under two soils, and an increase of 54% for the two soils in the wetter year. **Figure 8** shows the smoothing effect of averaging the annual losses over 3 and 5 years where drier and wetter rainfall years are randomly distributed over twenty years. Similarly, Lincoln University Dairy Farm (LUDF) did an analysis of annual variability in estimated nitrogen losses using actual farm inputs finding a range in nitrogen loss estimates of 55% (Pellow, Lee et al. 2013).

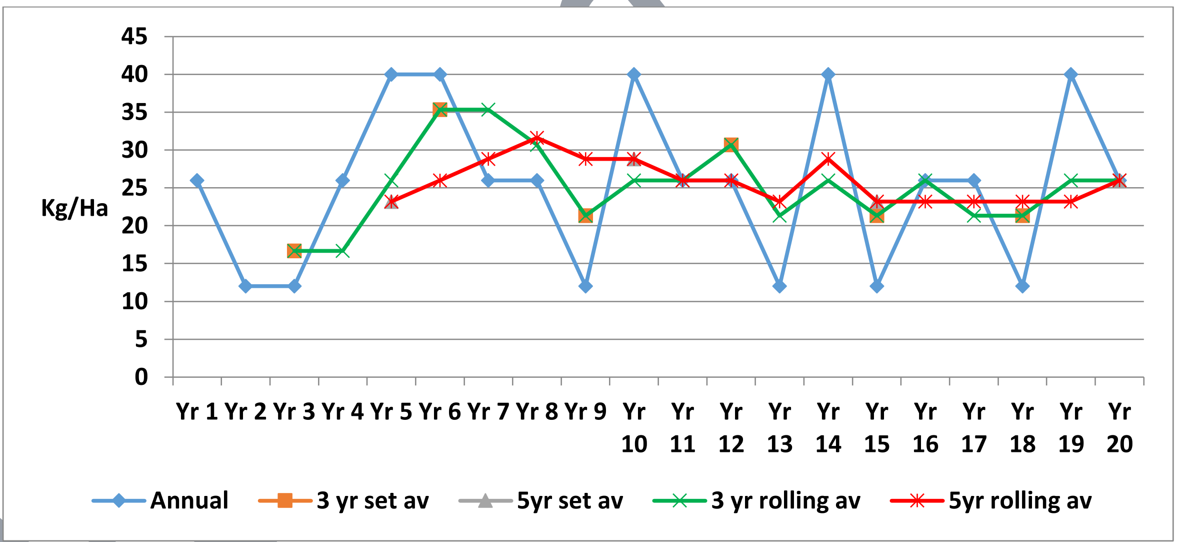

Figure 8 Nitrogen losses under a random rainfall pattern on a sedimentary soil type where management is changed to reflect the change in rainfall. Compares annual estimates of nitrogen loss with an average taken every 3 and 5 years, and rolling 3 and 5 year averages. Reproduced from Journeaux (2014).

6.3 Existing recommendations for averaging

Regional councils have variously been recommended or advised (e.g., Wheeler 2013; Park 2014; Overseer Management Services Limited 2015) to average OVERSEER inputs or outputs as follows:

a) That farm system inputs from more than one year be first averaged, then put into OVERSEER

b) That annual nitrogen losses for a farm be estimated for more than one year, then averaged.

The rationale for this advice varies but essentially there appear to be four main reasons behind this recommendation of averaging inputs or outputs. The context for these is that OVERSEER assumes, as has been detailed earlier, that the farm system is in a 'steady-state' mode, and nutrient losses are long term annual averages that are estimated using long term climate data (Watkins and Selbie 2015). The first reason 1) is based on averaging the farm system inputs as a means of defining a typical year that represents the steady-state conditions, and is thus a better fit with the long term climate data used in OVERSEER. It has also been suggested that 2) users define a typical representative actual farm system by averaging farm inputs in the case where historical farm management information is too difficult to obtain, or as a means of minimising data entry by farmers. Similarly, the idea 3) of averaging outputs is suggested as a means of balancing the advantage of collecting and using actual management data with the potential mismatch of using annual farm input data with historical long term climate data. Finally, 4) it has also been suggested as a means of managing ups and downs in an individual's estimated annual nutrient losses due to year to year variations in farm management, particularly in a consenting or monitoring context.

Looking at the advice in more detail, the OVERSEER Best Practice Data Input Standards (BPDIS) recommend that the long term climate data, climate patterns and production are used when the model is being applied in a long-term predictive mode (Overseer Management Services Limited 2015). Where OVERSEER is being used in annual mode (e.g., for monitoring purposes) the guidelines recommend that the annual farm inputs be used with long term climate data and that a rolling average be calculated of the nitrogen losses from multiple years. Note the BPDIS also contains some more specific recommendations, e.g., averaging annual fertiliser use over a minimum of three years.

Wheeler (2013) in his evidence for the Board of Inquiry into the Tukituki Catchment Proposal recommended the use of rolling averages for monitoring purposes to reduce the effect of year-to-year variability, and suggests a minimum period of three years. For forward prediction purposes, he recommended that a farm system that describes typical management in the future, be used with long term average climate data and patterns. Millner (2013) concluded that a three-year period is appropriate for benchmarking pastoral systems and seven years for arable farming and cropping. In his evidence for the same Board of Inquiry, van Voorthuysen (2013) supported the use of a rolling three-year average whilst noting Roberts' (2013) suggestion of averaging estimates over 6 or 7 years for some arable land uses. Van Voorthuysen recognised the long rotation period for forestry might require averaging over an even longer timeframe. Park (2014) writes that the expert consensus at a BOPRC workshop and the Board of Inquiry into the Tukituki catchment proposal was to estimate an average nitrogen loss taken across three consecutive years, with seven years for cropping systems due to the greater variability across crop rotations. Journeaux (2014) recommended averaging input data for a minimum period of three years and averaging outputs over a 3 to 5 year period.

6.4 Points to consider when averaging inputs

Steady-state assumption

Wheeler, Shepherd *et al*. (2014) explain that when calibrating the N sub-model of OVERSEER, farm management inputs for field trials were averaged and put into OVERSEER in order to compare predicted losses with the mean measured losses. They note that the relatively constant management of the field trials along with the lack of long term trials makes it very difficult to test and estimate the effect of averaging input data over different time periods e.g. 2 years, 5 years etc., on model outputs, without further investigation.

OVERSEER is a steady state model that has been developed on the basis that, particularly for pastoral farm systems "inputs and site characteristics are in equilibrium with farm production and stock policy". It does not model transition periods from one farm system to another (Watkins and Selbie 2015). This clearly stated caveat means that it is not appropriate to estimate nitrate losses from a farm system in transition by averaging the inputs to a 'half way' farm system.

Model linearity

While it is interesting that in Journeaux's analysis, running OVERSEER on averaged rainfall gave a very similar result to the average of the modelled outputs for each of the three rainfall levels, in general, averaging model inputs is only successful where the model response is linear with respect to the input (ref). This concept is illustrated in Figure X.

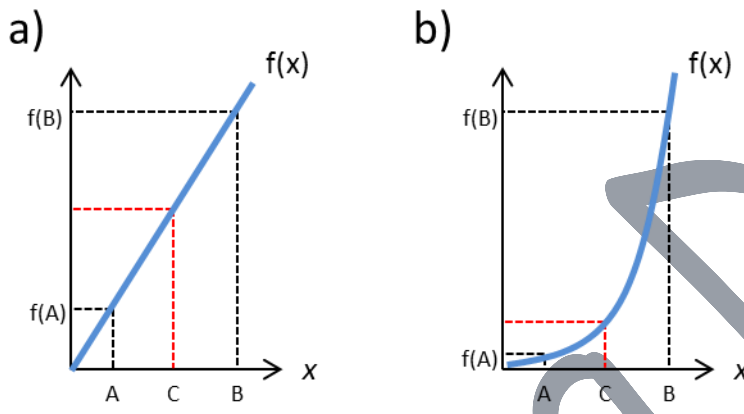

Figure 9 Schematic to show the effect of non-linearity of model response f on averaging. Point C is the average of input values A and B. In plot a) the model response is linear so f(C) (i.e. the point where the red dashed line intersects the vertical axis) is the same value as the average of model outputs f(A) and f(B). In plot b) however, where the model response in non-linear, f(C) is not the same value as the average of model outputs f(A) and f(B).

OVERSEER comprises many modules and algorithms. In some cases, depending on the module, the model response will be linear. In others it is not. Denitrification, for example, is a non-linear process (Wheeler 2015). So averaging farm inputs that impact on the modelled wetness of the soil in a single OVERSEER file might result in a different nitrogen loss to the average of the estimated nitrogen losses. In general, the smaller the difference between the farm system inputs that are being averaged, the more likely the model response will be approximately linear, the further apart the farm inputs, the more inappropriate an input-averaging approach is likely to be.

Biological feasibility

Any attempt to average OVERSEER inputs must be accompanied by an assessment of the biological feasibility of the averaged system. A key assumption is that OVERSEER *assumes* that a farm is feasible given the user-specified farm inputs including production (Watkins and Selbie 2015). Consequently, changing farm inputs by averaging them, could, depending on the inputs, result in a biologically unrealistic farm. Furthermore, some of the OVERSEER farm inputs do not lend themselves to being averaged. For example, cropping rotations. Wheeler, Shepherd *et al*. (2014) also note that it is not clear as to how to average some management inputs such as stock numbers and supplement feeding.

A more common approach (when the OVERSEER outputs are required for predictive purposes) is to derive a 'typical' farm system under typical climate conditions. The MGM project followed this approach by defining a set of farm types based on industry surveys of actual farms in Canterbury (Robson, Brown et al. 2015). HBRC developed representative farm systems from a range of sources for use in predicting nutrient loads (Millner 2013). BOPRC defined a set of reference files that describe typical farm systems although these are used for compliance rather than predictive purposes (BOPRC 2016).

Similarly, where some actual historical farm input data are not available, it can be appropriate to develop a set of data inputs that are representative of a long-term actual farm system for benchmarking or regulatory purposes.

6.5 Use of output averaging by Councils

Many regional councils have used an averaging approach or selection from a multiple year period for defining 'baseline' nitrate losses in regional plans. The various output timeframes are detailed in Table 5.

Table 5. Time periods that define 'baseline' nitrogen losses as applied by regional councils

Waikato Regional Council	Waikato Regional Plan Variation 5 – Lake Taupo catchment (WRC 2011)	"the single best year (year with the highest leaching value) of nitrogen leached between July 2001 and June 2005"
Canterbury Regional Council	LWRP Variation 5	Average of 2009-2013 losses, i.e. four years
Bay of Plenty Regional Council	Regional Land and Water Plan Rule 11 & Plan Change 10 (BOPRC 2016)	Actual benchmark (average of losses between July 2001- June 2004 i.e., three years) or Derived benchmark: losses from actual land use for three years prior to 1/1/2016

Regional councils have, for annual compliance purposes, adopted different rules as to how many years of estimated nutrient losses are required (**Table 6**).

Table 6. Time periods for testing compliance of estimated nitrogen losses with rules as applied by regional councils

Canterbury Regional Council	Canterbury LWRP Plan Change 5	Rolling average of modelled nitrogen losses from the most recent 4 years
Bay of Plenty Regional Council	Regional Policy Water and Land Plan Change 10 – Lake Rotorua Nutrient Management (BOPRC 2016)	Three year rolling average of modelled nitrogen losses but also may be assessed on an annual basis
Hawkes Bay Regional Council	Plan Change 6 – Tukituki River Catchment	Losses from each property should be calculated as a four-year rolling average, derived from nutrient budgets prepared after 1 June 2013
Otago Regional Council	Otago Water Plan Change 6A (ORC 2014)	One year losses

Waikato Regional Council	Waikato Regional Plan Variation 5 – Lake Taupo catchment (WRC 2011)	One year losses
Horizons Regional Council	One Plan. Chapter 14	"Cumulative nitrogen leaching maximum" is defined as the total kilograms of nitrogen leached per hectare per year for the total area of the farm (Horizons 2011), i.e. one year losses.

6.6 Averaging in the limit setting process

The relevance of each of the three approaches (averaging inputs, defining a typical farm system, and calculating a rolling average of outputs) to managing the potential inconsistency with the key assumption that (long term) climate and site characteristics are in equilibrium with production and managements inputs is considered in terms of four stages of informing the establishment of freshwater objectives and setting and managing to limits (Information, Plan-making, Implementation and Review).

Table 7. Relevance of different averaging approaches to setting and managing limits Update?

Methods for managing the temporal mismatch	Information	Plan-making	Implementation	Review
Averaging annual farm inputs	maybe		maybe	
Defining a typical farm system	✓	✓		✓
Calculating a rolling average of Overseer outputs	✓		✓	✓

6.7 Summary

OVERSEER incorporates a number of significant assumptions based on a stable long-term farm system with similarly stable average climate conditions. Therefore, any modelling application that does not match these assumptions must be undertaken with extreme care and with a detailed understanding of the issues and implications. An estimate obtained with one single year's actual inputs may not represent the long-term N loss *unless* the farm system is constant, that the climate that year matched the relevant long-term climate data in OVERSEER, and the farm inputs are consistent with the long-term climate from both an annual and monthly perspective.

Recommendations – averaging

1. The formulation of regional rules and resource consent conditions should recognise that one year's actual annual farm system data, as input into OVERSEER, may not be consistent with long term climate data. Where they are inconsistent, nutrient loss estimates are likely to be highly uncertain

2. Typical representative farm systems or averaging OVERSEER outputs can be used to endeavour to address the potential inconsistency that is otherwise likely to occur using one year's actual annual farm system data with OVERSEER's long-term climate data. Note that if the climate over that averaged period is significantly different from the long-term climate, the result may over or under-estimate actual nutrient losses.

3. OVERSEER averaging should generally be done on outputs rather than inputs. Averaging OVERSEER inputs should only be done if there is a clear understanding of the limitations and risks involved

4. Averaging OVERSEER inputs should only be done if there is a clear understanding of the limitations and risks involved.

5. Any typical representative farm systems used for predictive purposes should be well defined e.g. as in the Matrix of Good Management (Robson *et al* 2015).

6. For the purpose of assessing compliance with a quantitative threshold in a regional rule or resource consent, a rolling average of a minimum of 3-5 years would reduce annual changes between compliance and non-compliance, and generally provide a meaningful indication of long-term compliance of that farm system.

7. OVERSEER should not be used to model nutrient loss estimates for farm systems over a significant farm transition period e.g., dryland to irrigation.

8. OVERSEER should not currently be used to simulate the nutrient loss consequences of annual variability in climate or climate change trends.

9. Where short term estimates of nutrient losses are required, e.g. seasonal or where the target water bodies respond very quickly to changes in nutrient loading, an alternative to the currently available OVERSEER version should be considered, such as the use of a more process based model may be appropriate e.g. APSIM (2016)

7 OVERSEER version change issues

7.1 Introduction

The purpose of this section is to clarify what is involved in an OVERSEER version change, the implications of that for some applications of OVERSEER, and an analysis of options to address version change issues.

OVERSEER is being used in a range of ways in the development and implementation of regional plans and resource consents. Many of these approaches and some of the issues associated with them have been summarised in Arbuckle (2015). An ongoing potential issue with some of the uses of OVERSEER in regional plans and resource consents is the potential outcome and regional rule/resource consent compliance implications of regular version changes. The two key issues can be summarised as follows:

Catchment nutrient loss estimates	A version change could result in a change to an original estimate of catchment nutrient loss and the policies and rules developed in part on the basis of those estimates to achieve a specific water quality objective, i.e., a consequence could be the implementation of those policies and rules may result in more nutrients entering the receiving water than originally anticipated, or alternatively, resulting in less nutrients entering the water body, or from a different perspective, unnecessarily strict policies and rules.
Implementation of regional rules and/or resource consent conditions	Where a regional rule or resource consent condition has a threshold/limit/allowance defined by the current version of OVERSEER, a version change could result in an activity changing from being defined as one activity type to another, e.g., from being defined as a permitted activity to requiring a resource consent application, or for a resource consent, potentially changing from compliance to non-compliance.

Box 4 Key messages about OVERSEER version changes

1. OVERSEER version changes are an essential consequence of improvements to the accuracy of OVERSEER estimates and broadening of its applicability.
2. OVERSEER version changes can result in significant changes to estimates of N or P loss to water.
3. There are a range of methods that can be used in regional plan policies and rules, and resource consent conditions, to avoid or mitigate the consequences of version changes.
4. Methods that provide for an OVERSEER version change to update a component of a regional rule need to be carefully formulated to avoid the potential for an OVERSEER version change to result in a change in activity class.
5. There would be advantages in having additional RMA process that provides an efficient and effective consultative method for incorporating OVERSEER version changes into a regional plan.

7.2 OVERSEER version management

OVERSEER is usually updated twice per year, with one significant version change in April, and a minor one later in the year, often in August. A version change can range from relatively minor matters such as: the model interface wording or an output report wording, improving the data entry methods, fixing a minor software bug, or adding some functionality that doesn't change the 'engine' calculations; to a significant new or upgraded module such as happened in April 2015 with the introduction of the new irrigation module (Refer to Watkins & Selbie (2015) for a technical description of OVERSEER).

Significant changes to OVERSEER estimates of nutrient loss to water can result from: incorporation of new research information, reviews of model components, responses to investigations into reported anomalies, updating a model component with new data, addressing a significant software defect, improving an algorithm with new information, etc. There are also important linkages with other input systems such as the S-map soils database (http://smap.landcareresearch.co.nz/home) that can impact on the estimates of nutrient loss. The effects of changes on nutrient loss estimates can vary considerably depending on the farm system, the soil and the climate being modelled. Even for one sector, such as dairying, some types of changes may affect some, and not other, modelled systems depending on the exact nature of the change.

Version changes that result in changes in estimates of nutrient loss to water should be considered as moving towards a closer approximation of what the actual losses are likely to be, i.e., reducing the uncertainty associated with nutrient loss estimates.

Overseer version numbering follows generally accepted software revision control protocols[23] with the numbering indicating the degree/extent of the significance of changes i.e., major.minor.maintenance. OVERSEER is currently referenced by a three sequence numbering system, currently (April 2016) version 6.2.1. However, these terms are relative and because of the complex nature of OVERSEER and the range of farm systems and locations in New Zealand, the relative scale of change signalled by a 'minor' or 'maintenance' change will frequently not indicate the significance of potential changes in estimates of nutrient loss to water for all farm systems in all locations.

The updating of OVERSEER is managed by the OVERSEER General Manager, on behalf of OVERSEER Limited who seeks advice on model development priorities from three advisory groups. Science and software development services are outsourced primarily to AgResearch and Rezare Systems using robust quality assurance requirements.

The current OVERSEER Limited policy is that when OVERSEER is updated previous versions are not made available. The internet version is updated to the new version and older internet versions are archived and not maintained. The standalone version (https://secure.overseer.org.nz/live/) has an expiry date built into it which ensures that that version expires at the end of the month that is scheduled for the new version to be made available for downloading and installation.

OVERSEER Limited has agreed to allow the Waikato Regional Council to continue to use the standalone OVERSEER 5.4.3 version that is specified in the current (2016) version of the Waikato Regional Plan. In exceptional circumstances an archived version has been made available for limited use for example, to complete a major technical or research investigation.

7.3 OVERSEER version change issues

A key issue with OVERSEER version changes is that they can result in changes to estimates of nutrient loss to water made with a previous version, and those changes can vary from

[23] https://en.wikipedia.org/wiki/Software_versioning

situation to situation depending on the changes and the farm system being modelled. Some changes may only affect some farm systems or a specific component, while some may be more broadly applicable. For example, an enhancement of a sub-model related to dairy cow urine N may have an effect on estimates of N loss to water for a dairy farm but won't affect P loss estimates for an arable cropping farm.

The likely consequences of version changes are usually investigated and signalled in advance if they are likely to be significant. However, because of the complexity and range of farm systems, because of the range of soils and climate in New Zealand, and because version changes often incorporate multiple changes to the software, it can be extremely difficult to predict all the consequences of all changes on nutrient loss to water estimates for all farm systems.

There are potentially very significant policy and regulatory implications of OVERSEER version changes depending on the specific way that OVERSEER is used, for example, catchment modelling assumptions about nutrient losses to a catchment could change and the basis for policies and implementation methods may need to be reassessed. This would generally mean that a regular assessment should be undertaken after significant OVERSEER version changes to assess the extent to which a change might have an effect on the basis for objectives, policies and rules. The results of such an assessment can be used to determine whether or not it would be appropriate to undertake a specific review of a regional plan's provisions.

Similarly, if a regional rule or resource consent condition, that is not locked to one OVERSEER version, specifies a maximum numerical nutrient loss threshold or NDA, a version change could result in a change in the status of an activity e.g., from permitted to requiring a resource consent or could change the status of a consented activity from compliance to non-compliance. Similarly, if a prohibited activity rule is written with a numerical or narrative threshold there is a possibility that an activity that was previously not prohibited could become prohibited as a consequence of an OVERSEER version change. These are clearly very significant implications.

The potential consequences of a significant OVERSEER version change depend on the specific way(s) that OVERSEER is explicitly or implicitly applied in regional plans and/or resource consents. Four very broad types of application of OVERSEER are summarised below (

Table 8), with clarification of the potential consequences of an OVERSEER version change:

Table 8 Potential consequences of an OVERSEER version change for different applications of OVERSEER

Application of OVERSEER	Example	Potential consequence of a significant OVERSEER version change
1. Information used for regional plan development and monitoring/evaluation of regional plans	OVERSEER is used as part of a catchment study to estimate an acceptable catchment source nitrogen load.	For example, if a policy package is developed on that basis, then a significant change in OVERSEER estimates could result in an eventual catchment under or over-estimate.
2. Specification of an OVERSEER defined numerical or narrative limit/ threshold/allowance **Version specification** **(a) Version specified** **(b) Current/partial/no version** **Version change linkage** **(a) No linkage mechanism** **(b) Linkage mechanism**	Catchment source load limit, numerical regional rule thresholds/allowances or numerical resource consent condition load limits/thresholds/allowances	If the plan does not specify a version, a significant version change could change the implications of limits/ thresholds specified in a plan that explicitly or implicitly require the use of OVERSEER to interpret/ apply. For example, unless a plan provides otherwise (S68(7)) a version change could result in an activity that was previously a permitted activity requiring a resource consent application or *vice versa*. Similarly, if a resource consent has been granted that specifies a numerical nutrient loss limit estimated using OVERSEER, a consent holder could potentially move from a situation of compliance to non-compliance.
3. Specification of OVERSEER but no defined limit/ threshold/ allowance **(a) Version specified** **(b) Current/partial/no version**	Specified as an acceptable or the required method for estimating nutrient loss to water but not linked to any numerical limit or threshold	This type of specification is generally unlikely to result in immediate significant version change management issues.
4. Mention of Overseer as an optional method of providing information	Mentioned as part of a regional rule assessment criteria, or a resource consent condition requiring a nutrient management plan.	This type of specification is unlikely to result in significant version change management issues.

7.4 Overseer version specification approaches

Current practices for specifying the use of OVERSEER in regional plans and resource consents can be grouped into the following general approaches:

- Specific version number e.g., Waikato Regional Council – version 5.4.3
- Current/latest version e.g., Environment Canterbury
- Partial version number e.g., Otago Regional Council – version 6 (effectively the current version).
- No version specified e.g., Horizons Regional Council – effectively the current version

Because previous versions of OVERSEER are not generally available, the last three approaches are essentially the same i.e., the only version generally available is the current version.

The Waikato Regional Council has developed policies and rules for the management of nitrogen loss to Lake Taupo and is the only regional council that has specified a precise OVERSEER version in an operative regional plan, i.e., version 5.4.3. This was done to meet the need for outcome, community and legal certainty (Barns & Young 2013). However, one disadvantage of this approach is that it makes it challenging to easily take account of model improvements that might for example, include new N loss reduction strategies or enhance the accuracy of N loss estimates.

While OVERSEER can be used in various ways in regional plans and resource consents there are three general ways limits, thresholds or allowances are specified that require the use of Overseer:

1. As a condition of a permitted activity.
2. As part of the description of an activity for the purpose of determining what resource consent status applies (e.g., if < 30 kg N/ha/yr = a controlled activity).
3. As a consideration in terms of the conditions that may be imposed on an activity requiring resource consent because of some other trigger (i.e., farm size/type, date, location, etc.).

7.5 Overseer version change response approaches

Response to implications for the information base for regional plan development

The most appropriate approach to respond to an OVERSEER version change that may change the understanding of the relationship between nutrient source losses and receiving water targets is to undertake a technical review of the implications of the changes for the objectives sought by the plan. The results of such a review should determine the significance of the changes and assist in determining an appropriate response.

Responses to implications for regional plan provisions and resource consent conditions

In response to concerns about the implications of OVERSEER version changes for numerical and/or narrative limits/thresholds specified in regional plans and/or resource consents, a range of approaches have been adopted or proposed to date. These are outlined below (

Table 9) with more details in Appendix 12.5 on the advantages and disadvantages of each approach. Many of these approaches are not mutually exclusive.

Table 9 An outline of approaches to address issues that arise from OVERSEER version changes

Options primarily relevant to regional plan development and implementation, particularly for setting freshwater quality limits (may have broad or partial application). Some can be combined.
1. **Lock in a specific OVERSEER version number for regional rules and/or resource consent applications, for example, a rule may state "…estimated using OVERSEER version 6.X.Y"**
2. **Explicitly or implicitly specify/refer to the current/most recent version for regional rules and/or resource consent applications, for example, a rule may state "…estimated using Overseer."**
3. **Specify in the appropriate rule that when a new OVERSEER version change occurs that results in a change to a relevant nutrient loss threshold or property nutrient loss estimate, that would not affect the exercise of specific existing resource consents (S68(7) RMA)**
4. **Development of a plan framework that avoids or mitigates the consequences of OVERSEER version changes**
5. **Provision of a version updating method specified via plan provisions to address the effects of an OVERSEER version change on benchmark/threshold/**limit/allowance **estimated losses.**
6. **Provide the ability for a council or a council Chief Executive to certify alternative models (to estimate property nutrient loss) or versions of models e.g., to certify that a new version of OVERSEER does not result in any material change in estimates of nutrient loss to water compared to a prior version.**
7. **Ensure permitted activity rule condition wording allows for a certificate of compliance to be issued that specifies that "an activity could be done lawfully in a particular location without a resource consent" (S139 RMA).**
8. **Use OVERSEER information to develop readily understood narrative rule thresholds e.g., maximum hectares of irrigation, maximum area of specified land use on a specified soil type, specific good management practices, etc.**
9. **Amend Schedule 1, Part 3 of the RMA to allow for more effective incorporation of a new OVERSEER version into a regional plan. Or provide some other route such as that used to update a National Environmental Standard.**
Options primarily relevant to resource consents (many resource consent applications would be made under provisions of a proposed or operative regional plan with OVERSEER related provisions, many will also be made in circumstances where there are few provisions specific to OVERSEER) Some can be combined.
1. **Lock in a specific version number for any granted resource consent.**
2. **No version or current version specified.**
3. **Include a condition in a granted resource consent that provides for a version updating method that provides for a calculator, reference file system, or 'data input transfer' system to address the effects of an OVERSEER version change on benchmark/threshold/ estimated losses.**
4. **Condition wording that requires an OVERSEER estimate to be undertaken within a specified timeframe while a specified OVERSEER version is available**
5. **Use OVERSEER to develop readily understood narrative resource consent condition thresholds e.g., maximum hectares of irrigation, or maximum area of specified land use on a specified soil type, specific good management practices, etc.**

Additional option
Modify the current OVERSEER version change frequency and/or content, and availability of earlier versions.

OVERSEER version updating methodologies

One important conceptual approach that has developed in recent years is OVERSEER version updating methods to explicitly accommodate a version change. For example, a regional rule can specify a narrative rather than a numerical threshold e.g., to be classified as a controlled activity the current farm system N loss must be less than the peak N loss to water during a specified period. Then a system is established, e.g., a website that enables simultaneous comparisons using the most current version of OVERSEER. The combination of a narrative threshold and a mechanism to allow both the current nutrient loss estimate and the threshold to be updated with a version change, means that the plan itself can remain unchanged but an OVERSEER version change could be accommodated with only a small risk that the status and/or compliance status of an activity would change as a consequence of an OVERSEER version change.

The reason that there would still be a risk under such updating systems of an activity changing status is firstly, because there is some scope for inputs to change slightly while still complying with the BPDIS, and secondly, and most importantly because a version change may not result in a proportional change in both the activity and the threshold when moving from one version to another. As indicated in the averaging section (See section 7), OVERSEER has a number of non-linear and stepped processes incorporated into the model that mean that model changes can result in non-linear output responses. So for example, it is possible that for example, as a consequence of a version change a land use activity estimate might increase proportionally more than an increase in a threshold estimate.

The RMA and case law[24] have determined that permitted activities need to have provisions with the highest level of certainty. A consequence of this is that, because of the potential, even with version updating systems, for an activity to change from being a permitted activity to requiring a resource consent as a consequence of a version change, it does not appear appropriate to define permitted activities via reference to OVERSEER nutrient loss estimates. Similarly, this indicates that prohibited activities should not be defined with reference to OVERSEER nutrient loss estimates, with or without updating systems.

A potential disadvantage of OVERSEER version updating systems that rely on input from OVERSEER that sits outside of a plan, is that they are different from the way that RMA plans have conventionally operated and there is very limited case law to provide guidance on the legal robustness of these systems. It is also important to appreciate the difference between the resource consent process compared to the regional plan process. There is significantly more scope in the resource consent process for example, for an applicant to propose and/or agree to an OVERSEER updating system that may not provide the level of certainty needed for a regional plan rule condition.

The types of OVERSEER version updating methods that are either currently used, have been proposed, or are indicated as possible combinations of current/proposed systems, in regional plans are summarised below (Table 10). These do not include rules that don't specify the use of OVERSEER. In addition to these methods, there are complementary methods that can be used to minimise the consequences of a version change on an activity e.g., the use of Section 68(7) of the RMA to specify in the appropriate rule that when a new OVERSEER version

[24] For example: Application by Lower Hutt City Council, EnvC Wellington W046/2007, 31 May 2007, Twisted World Limited v Wellington City Council, EnvC Wellington W024/2002, 8 July 2002, TL & NL Bryant Holdings Ltd v Marlborough District Council (2008) NZRMA 485 (HC).

change occurs that results in a change to a relevant nutrient loss threshold or property nutrient loss estimate, that would not affect the exercise of specific existing resource consents.

Table 10 Summary of existing or proposed OVERSEER regional plan rule updating methods

Overseer version updating methodology		
Rule	**Threshold**	**External link and calculator**
1. Permitted activity	Nutrient loss threshold as a percentage of a reference file nutrient loss rate, specified in a regional plan rule.	Reference files* are rerun using a new version of OVERSEER and published on a council website.
2. Controlled activity	Area of land having a defined use or activity type (e.g., area irrigated) or similar easily defined threshold.	Requirement to follow a process that sets nutrient allocations that require the use of a reference file system that is updated using the current version of OVERSEER and published on a council website.
3. Permitted activity	Numerical thresholds e.g., current N loss estimate compared against specific numerical thresholds, specified in a regional plan rule.	All numerical thresholds updated on a website referenced from the plan using the current version of OVERSEER.
4. Controlled, discretionary, non-complying, prohibited	Numerical thresholds e.g., current N loss estimate compared against specific numerical thresholds, specified in a regional plan rule.	All numerical thresholds updated on a website referenced from the plan using the current version of OVERSEER.
5. Controlled, discretionary, non-complying, prohibited	Narrative thresholds e.g. baseline N loss, GMP N loss, etc., specified in a regional plan rule.	Narrative thresholds updated using an external website based calculator that provides for specific farm systems, climate and soil inputs modelled by OVERSEER and uses the current OVERSEER version.
6. Controlled, discretionary, non-complying.	Narrative thresholds e.g. baseline N loss, GMP N loss, etc., but with detailed process specified in linked policies rather than the rule. The policies, rather than the rule, specify matters that include consideration of an OVERSEER version updating system.	Narrative thresholds updated using an external website based calculator that uses the current OVERSEER version.

Key legal issues related to version change management

The currently available legal advice and analysis has been reviewed and a number of key conclusions can be summarised:

1. Where incorporation of OVERSEER into a regional plan is intended, achievement is problematic because OVERSEER may not be “written material” as required by the Schedule 1 Part 3 process of the RMA.
2. There are no significant impediments associated with including a reference to OVERSEER in a regional plan provision as one of the optional methods to provide for nutrient loss estimates.
3. The level of legal certainty required for permitted and prohibited activities indicates that the use of thresholds/allowances/limits in such rules that require the use of OVERSEER, particularly where version change occurs, may be vulnerable to challenge. The level or extent of vulnerability will depend on the precise nature and context of the rule.
4. Regional plans and any associated overseer version updating methodology used in regional plan should be designed carefully to ensure that an activity status cannot change as a consequence of an OVERSEER version change.
5. If the intention is to include within a regional plan any OVERSEER version updating methods, then consultation and notification processes need to ensure that persons likely to be affected by such version updating methods are fully aware of both the intention to include the method and how implementation of the method may impact on activities.
6. There are possible additional processes that could be explored and developed, such as national planning templates and/or regulations to create effective and efficient consultative processes for the purpose of providing for and including updating of models such as OVERSEER, which are increasingly important in the RMA context.

Recommendations – OVERSEER version changes

1. Regional councils should regularly assess the implications of OVERSEER version changes for regional plan policies and rules where OVERSEER was used to inform the development of those policies and rules.
2. Regional councils should endeavour to avoid using OVERSEER defined nutrient loss limits/thresholds/allowances in permitted activity or prohibited activity rules, unless they are linked to a specified and available version of OVERSEER.
3. Regional councils should endeavour to ensure that regional plan policies and rules are developed using a framework and/or methods to avoid the potential for an OVERSEER version change to change the status of an activity, e.g., having permitted activities not defined by an OVERSEER estimate and other rules written such that an OVERSEER version change cannot change the activity class of a land use or discharge.
4. Resource consent conditions should not specify OVERSEER defined nutrient loss limits/thresholds/allowances in resource consent conditions unless there are complementary conditions that provide a mechanism to update those limits/thresholds/allowances in response to a specified event or situation such as an OVERSEER version change. (This assumes that OVERSEER version specific conditions are feasible because non-current OVERSEER versions are generally not available.)
5. The specification of nutrient loss model alternatives to OVERSEER in regional plan provisions or resource consent conditions need to be complemented with technical

specifications to enable an appropriately qualified person to be able to certify or not that such models comply with those specifications.

6. OVERSEER Limited should consult with OVERSEER stakeholders and users to review the frequency and content of OVERSEER version changes e.g., to consider the option of having only one version change per year that involves an OVERSEER ‘engine’ change that would affect N or P loss to water estimates.
7. Regional councils, the Ministry for the Environment, and the Ministry of Primary Industries should consult and review the options for developing an effective and efficient process for the incorporation of changes to environmental models (e.g., OVERSEER, air quality dispersion models, river flow estimation models, groundwater allocation models, etc.) specified directly or indirectly in regional plan rules or resource consent conditions.

8 Implications of the differences between nitrogen and phosphorus modelling

8.1 Introduction

The purpose of this short section is to look at the implications of the differences between N and P loss modelling, for the application of OVERSEER in regional plans and resource consents. The earlier section on uncertainty (See section 5) provides an outline of the broad sources of uncertainty and the methods to manage uncertainty. The report by Watkins & Selbie (2015) discusses the broad assumptions and limitations of OVERSEER. This section focusses specifically on differences between N and P modelling.

There are fundamentally different processes driving N loss to water, i.e., primarily N in drainage water, compared to P loss to water predominantly via run-off to surface water (OVERSEER includes P leaching to sub-surface flows but excludes deep drainage (Gray *et al* 2016)). The report by Watkins and Selbie (2015) outlines the differences between the methods used by OVERSEER to estimate N and P losses to water. A recent review of the P loss sub-model (Gray *et al* 2016) has identified a number of gaps and limitations in the current P loss sub-models, and opportunities for enhancing OVERSEER's P loss modelling.

Box 5 Key messages - OVERSEER modelling of N versus P

1. There are fundamentally different processes driving actual N versus P loss to water.
2. OVERSEER uses very different sub-models to estimate N versus P loss, and consequently there are some specific limitations and assumptions that apply to OVERSEER N versus P loss estimates.
3. For OVERSEER modelling situations within the respective original sub-model calibrations, the uncertainties associated with OVERSEER N and P loss estimates are likely to be of a similar order of magnitude.
4. Provided that the specific limitations and assumptions are taken into account, OVERSEER modelling of N and P can be useful in water quality management.

It is critical to appreciate the different approaches to N and P sub-models to understand whether or not there are any significant differences in the uncertainties associated with the approaches that are taken in OVERSEER to modelling P versus N losses. And therefore also important to appreciate the significance of this for RMA applications. Roberts (2014) notes that OVERSEER models "…N loss to water (leaching), P run-off risk…". It is important to appreciate that a P loss risk approach does not inherently result in greater uncertainties than the drainage estimation basis for the N sub-model. The 'risk' component of the P sub-model involves linking well established factors that drive P loss e.g., rainfall, topography, soil properties, etc., into a model that has been shown to calibrate well with measured P loss for 23 locations (McDowell *et al*, 2005).

Catchment modelling studies have noted the greater uncertainties associated with catchment P loss estimates (e.g., Rutherford, 2014). However, this report was specific to the estimate of total loading to the receiving water body and recognised the limited sources of P loss that OVERSEER models and the limited simple mitigation options available in OVERSEER for P loss mitigation, rather than an observation of any inherent difference in the uncertainties of OVERSEER estimated N loss versus OVERSEER estimated P loss to water. In a similar manner, Parfitt *et al* (2007) used both OVERSEER and NZEEM to discriminate between P inputs to the upper Manawatu River during major flood events and during the rest of the time.

The issue of N versus P modelling has been commented on at regional plan hearings for example, one regional plan hearing received evidence that stated that the Section 32 analysis concluded that "…the phosphorus module in OVERSEER™ is not as well developed as the nitrogen module…" (Hansen, 2014). The concept of a sub-model developed using a risk component appears to have been interpreted as meaning that there is an inherent quantitative difference in the relative uncertainties of N versus P loss estimates. The results of the original calibration work on these sub-models do not appear to support this view.

A combination of factors (possibly misunderstanding of the use of the term 'risk' in the P sub-model calibration, misinterpreting what P sources are modelled, and confusing the drivers for a focus on N) appears to have resulted in a commonly held view that OVERSEER is more suitable for modelling N loss than P loss. The technical evidence does not appear to support this simplistic view.

Nitrogen loss to water has been the predominant focus of the application of OVERSEER to nutrient water quality management in New Zealand. This has generally been because of catchment specific studies that have identified N as the primary or most important limiting nutrient for plant growth in a specific receiving surface water body (e.g., Lake Taupo & Lake Rotorua). In New Zealand there is evidence that "…lakes N-limitation and co-limitation occur with greater frequency than P-limitation (Abell et al. 2010; Larned et al. 2011). While in streams and rivers, P-limitation is more common than either co- or N-limitation (McDowell et al., 2009)" (McDowell *et al*., 2013). In the case of groundwater, the focus on N is because of concerns about the concentrations of nitrate-N in groundwater that is used as a source of drinking water.

There are a range of existing publications that highlight the options available for reducing both N and P losses to water e.g., Mackay & Power (2012). Many of these mitigation strategies are focussed at the farm level, block level or at a specific action such as a riparian strip or wetland, and can be directly or indirectly modelled in OVERSEER. One potentially significant difference with P loss reduction options is that a combination of critical source areas (CSAs) (relatively small areas that can be responsible for a relatively large proportion of P loss) and normal 'blocking' guidelines, can combine to make it extremely challenging to model mitigation strategies that target CSAs. This has been the driver behind the development of complimentary models with a higher resolution that could estimate the consequences of mitigation strategies aimed at CSAs.

The following table highlights the key differences in how OVERSEER models P loss to water compared to N loss to water and the implications of that for the application of OVERSEER under the RMA.

Table 11 Key differences in N and P modelling in OVERSEER and their RMA implications

Key modelling difference	Comments	Significance for application of OVERSEER under the RMA
1. Different sub-models used to model different processes that transport N and P to water. Surface runoff is often the most important pathway for P loss; N is primarily transported in drainage.	P loss sub-model uses a rainfall event risk model compared to N loss sub-model that uses drainage estimates as a key driver. Significant opportunities available to enhance the detailed P loss sub-models. However, there are also recognised opportunities to enhance the calibration range of N loss studies.	Two very different processes and two very different models doesn't necessarily mean that either method has an inherently higher uncertainty.
2. Broader range of farm systems and farm management practices modelled that include consequences for N loss but not P loss.	P loss is not adequately modelled for some farm systems. However, there is also a limited calibration basis for non-pastoral N loss estimates. Recognition of many farm management practices that can reduce N loss but fewer recognised in P loss estimates. More detailed information is in Gray *et al*., 2016.	Care is needed for modelling P loss from some farm systems e.g., arable and vegetable cropping systems, cut and carry systems and fruit crop blocks. However, similar issues apply to modelling N loss from cropping farm system (FAR, 2013). OVERSEER does not provide for all possible nutrient loss mitigation practices. It is currently relatively easy and intuitive to apply various N mitigation options in OVERSEER (e.g., reduce N fertiliser); while P mitigation options often require more knowledge and understanding of farm systems (e.g., installing riparian strips). This needs to be considered in property or catchment modelling.
3. Limited calibration and evaluation studies have been undertaken for both N loss and P loss sub-models.	The primary P loss calibration was undertaken with pastoral, forestry and two arable farm systems and there is a recognised need to extend the calibration and evaluation studies for a broader range of farm systems, soils and locations. More detailed information is in Gray *et al*., 2016. It has also been recognised	It is not feasible or appropriate to make any generalisations comparing the uncertainties associated with OVERSEER N loss estimates with OVERSEER P loss estimates. However, the closer the modelled scenario is (farm system, climate, soil type, etc.) to the calibration studies the smaller the uncertainties associated with nutrient loss to

	that there is a need to update and extend the N loss calibration and evaluation for a broader range of farm systems, climates and soil types (FAR, 2013; Watkins & Shepherd 2014)	water estimates.
4. Farm system transition may be less of an issue for modelling P loss than for modelling N loss.	Transition effects may be less significant for P loss estimates. However, this would depend on the type of transition.	Expert advice would be needed to assess the potential impact of specific likely farm system transitions on catchment modelling. The potential effects of farm system transitions would need to be taken into account in developing specific regulatory approached and their implementation.
5. Methods used to 'block' up a farm for OVERSEER modelling	The current guidelines for developing farm blocks for OVERSEER may not always be the best method for estimating and mitigating P losses, e.g., blocks may not be setup to 'capture' P critical source areas.	If the primary concern is P loss to water, then a P-specific approach to 'blocking' a farm would be appropriate.
6. Phosphorus modelling assumes that block run-off will leave the property and enter surface water.	OVERSEER doesn't take account of what may happen if for example, there is another property between the modelled property and a surface water body.	Significant care is needed to interpret losses from blocks and/or properties with no surface water boundary, and consequently the consideration of source P loss estimates at any catchment scale.
7. Phosphorus loss to water from some types of river/stream /lake bank erosion and mass flow events are not modelled.	These processes require additional different modelling approaches (Gray *et al*, 2016).	If an assessment of all catchment P sources is needed, these additional sources must also be considered and where appropriate estimated.
8. Limited spatial resolution recognition	The focus of OVERSEER on relatively large block scale nutrient loss limits the ability to focus mitigation on smaller scale priority contaminant source areas which are often particularly relevant to P loss to water.	The resolution scale needed to identify mitigation opportunities for potentially relatively small critical source areas is not currently available in OVERSEER. Additional, more spatially appropriate models are being developed that should allow the estimation of mitigation measures to specific high risk contaminant source areas.

Recommendations – modelling N versus P

1. The use of OVERSEER must take into account the different processes involved in N and P loss, the different modelling approaches taken in OVERSEER for N and P, and the assumptions and limitations that may apply specifically to N or P (See Appendix 12.2),

2. Investigations should be undertaken to assess the feasibility of developing guidance for 'blocking' a farm on the basis of P critical source areas. This may also assist with linkage to models with the resolution needed to identify, and target mitigation to, critical source areas.

9 Data provision and security

9.1 Introduction

The purpose of this section is to identify the issues that arise when councils may need to receive and manage individual OVERSEER property outputs/files provided as part of voluntary programmes, regulatory requirements or occasionally, catchment modelling investigations. Key issues include: the level of prescription on the information required, the criteria for auditing, and receipting, managing and using OVERSEER files for compliance and/or catchment management planning purposes. In addition, privacy and security protocols are identified to ensure that any data collected by a regional council for a specific purpose is not used for any other purpose.

Box 6 Key messages - data management and modelling quality assurance

1. The receipt and long-term management of individual OVERSEER property files needs well designed data management and security systems to ensure that all legal, technical, and long-term information needs are met.
2. A full OVERSEER XML file is needed to be able to assess the extent of compliance of that modelling with the BPDIS and to undertake a quality assurance assessment.
3. Only modelling that has been shown by independent auditing to have a quality assurance rating of ‘medium’ or ‘high’ should be accepted for quantitative purposes as part of a regional plan or resource consent requirement.
4. Documented protocols and controls for management of OVERSEER XML files will provide farmers and advisors confidence in supplying information. Accreditation under the Farm Data Code of Practice would further enhance confidence in the management of OVERSEER XML files.
5. Enhancing the interoperability of models used in RMA processes that involve OVERSEER inputs or outputs has significant potential to reduce uncertainties in those model outputs and enhance the cost effectiveness of those RMA processes.

9.2 Legal framework

There are a number of significant pieces of legislation that apply to the collection of information by a regional council that may also contain personal information (i.e., information about an identifiable natural person, as distinct from a company or partnership). The key acts are the: Local Government Official Information and Meetings Act 1987 (LGOIMA), Privacy Act 1993, and Public Records Act 2005. This section does not review all the detailed relevant legal requirements for how information provided to, or collected by, a regional council should be managed. However, given the importance of Privacy Act principles a summary is provided below (Privacy Commissioner website March 2016):

1. *"Only collect personal information if you really need it*
2. *Get it straight from the people concerned where possible*
3. *Tell them what you're going to do with it*
4. *Collect it legally and fairly*
5. *Take care of it once you've got it*
6. *People can see their personal information if they want to*
7. *They can correct it if it's wrong*
8. *Make sure personal information is correct before you use it*
9. *Get rid of it when you're done with it*
10. *Use it for the purpose you got it*
11. *Only disclose it if you have a good reason*
12. *Only assign unique identifiers where permitted."*

There are some additional dimensions to the management of OVERSEER data provided to a regional council, e.g., if OVERSEER data and or output information is provided to a regional council as part of a voluntary programme, how would any potential compliance issues be managed? This would need to be managed at both a policy and technical information management system level.

There are also potential intellectual property issues associated with OVERSEER files. For example, some OVERSEER modelling of complex farm systems can take many days to develop the inputs to accurately represent the farm system and concerns have been expressed by some involved in the preparation of such complex files that there is a risk that unless appropriate security provisions are established, such files could be accidentally released to competitors.

9.3 Different sources and types of Overseer data provided to regional councils

OVERSEER data is obtained by regional councils from a wide range of sources and for various uses, from specific property information provided as part of a specific resource consent application, to broad-scale catchment information used as part of a catchment modelling process. The context and technical specifications of this data have implications for the methods used to store, access and utilise such information. For example, the scale used to identify soil characteristics for properties at a catchment scale means that that soil data is likely to be inappropriate to use as an input for individual property modelling. Similarly, OVERSEER files provided to meet a specific regulatory requirement may not be able to be used for another purpose, unless permission was obtained.

Similarly, OVERSEER file information (e.g., a full .XML file) and/or specific output information (e.g., Kg N/ha/yr for a property) may be provided to a regional council as part of different programmes e.g., averaged over different periods and/or with different levels of quality assurance. Therefore, great care is needed in the interpretation of such data and information management systems need to be developed to ensure that these differences are recognised and catered for.

Regional councils also need to specify the information requirements and establish systems for entering and/or transferring data into information management systems, and the subsequent analysis of that data. For example, there is increasing recognition that in many situations only the full OVERSEER .xml files contain enough information to enable an independent assessment of the quality assurance of a provided budget and associated nutrient loss estimate.

9.4 Methods to ensure OVERSEER input data is fit for purpose

There has been significant input in to developing standard protocols for all users for the input of data and the specific parameters around the use of Overseer. To this end the Overseer Best Practice Data Input Standards (BPDIS) were developed. "The Overseer Best Practice Input Standards (the Standards) were developed by a group of seven technical expert users, who drew on their personal knowledge plus that contained in the DairyNZ Input Protocol, the AgResearch Expert User Group Guidelines and the Waikato Regional Councils Protocol for Variation 5 (West Taupo Catchment). The standards are a consensus of the views of the seven technical experts" *(Overseer Best Practice Input Standards, April 2015).*

Although compliance with the BPDIS is a significant part of ensuring consistency across users, adherence to these standards will not guarantee that the files accurately reflect a farm system. The additional following factors are important for ensuring a high level of integrity and accuracy in OVERSEER model inputs.

Assessment of risk and level of input accuracy
If there are significant catchment nutrient loss reduction requirements and/or specific catchment nutrient water quality issues, then this increases the requirement for an OVERSEER model file preparation to be of a very high standard i.e., a high accuracy of model inputs. If the total losses, by property, are significant, either because of the size of the property or the losses per hectare then this also increases the need to have a high standard of file preparation.

File Provision
The data to be reviewed as part of a regulatory requirement must be based on a full provided XML file. There are a large number of variables within an OVERSEER file that can potentially have conflicting impact on the outputs thus creating an inaccurate file. Therefore, the robustness of the outputs must be viewed in the context of the quality of the data within the XML file.

Other Supporting Data
The provision of additional data to support the XML file can also be used to provide a level of confidence that actual information has been used. This could include:

- Annual taxation accounts showing opening and closing stock numbers, stock transactions, feed inputs, cropping and fertiliser usage. However, it is important to appreciate that this information may not have been independently audited.
- Annual fertiliser statement of use.
- A summary of cropping activities undertaken.

Once an OVERSEER XML file has been provided as part of a regional plan or resource consent requirement, the following key checks need to be performed by a person with qualifications and experience at least equivalent to a Certified Nutrient Management Adviser (See Qualifications Section 10), to determine a quality assurance rating of the modelling:

Table 12 Proposed modelling quality assurance assessment methodology

		Model QA rating		
Model characteristics	**Protocol Checks**	**High**	**Med**	**Low**
Qualification of modeller	Does the modeller have the minimum qualification of the Advanced Sustainable Nutrient Management Certificate or an equivalent qualification? If not, do not proceed.			
Experience of modeller	Does the modeller have sufficient experience in farm systems modelling to ensure that the system being modelled is a long-term biologically feasible farm system? If not, proceed with additional caution.			
	Professional judgement is needed to score some yes/no answers into a high/medium/low rating, e.g., if the annual average rainfall input is accurate, a QA rating of “high” would be appropriate.			
Key Inputs				
Best Practice Data Input Standards (BPDIS)	Have the BPDIS been fully complied with and any departures or ‘second choices’ justified?			
Farm Area	Does the total farm area match any relevant FEMP/FEP, copy of title provided to show area, no obvious errors?			
Rainfall	Is the average annual rainfall used representative of the specific location? Was the climate station tool used to generate the rainfall data?			
Block Set up	Has the farm been appropriately split into blocks to represent variable soil type, contour, intensity, and land use including cropping? Are any departures from normal blocking justified?			
Soil inputs	Do the soil inputs used appear to be appropriate for the farm location? Was S-map used? If data was transcribed manually from S-map was it done accurately?			
Irrigation	Do the irrigation inputs look appropriate (system, management option & application depth)? Are they normal for such farm systems in that location? If irrigation inputs appear relatively low has corroborating data been provided e.g., water meter data?			
Stock Numbers / Type	Do the opening and closing numbers match the annual accounts (if provided) and the stock classes (gender and age) appear normal.			
Stock Sales / Production	Do the total sales and purchases and or farm production figures match those provided within the annual accounts or typical productivity parameters?			
Fertiliser Inputs	Do these closely match the annual nutrient statement provided by the fertiliser company (if provided), do they match normal industry practice for this farm system in this location?			
Soil Nutrient Status	Are soil tests based on three-year average data to ensure this is an accurate reflection of			

	potential P losses? Does this create any issues for an annual nutrient loss estimate?			
Effluent Management (Dairy)	Is the system, as reflected in OVERSEER, a workable and realistic effluent solution?			
Clover fixation	Is the input justified? Is it similar to other similar farm systems in that location?			
Outputs				
Nitrogen losses	Are nitrogen losses per hectare within accepted/ published/measured ranges for the type of system being modelled for those soils/location?			
Phosphorus losses	Are phosphorus losses per hectare within accepted/published/measured ranges for the type of system being modelled?			
Pasture production	Is annual pasture production within accepted/ published/measured/modelled ranges for the locality, soil and pasture involved?			
Stocking rate	Are the stocking rates representative of the system being modelled? Are they within the normal range for the farm system and location? If the stocking rate is relatively low or high, has corroborating data been provided?			
Soil moisture, drainage & run-off	Do these estimates make sense? Are they consistent with information from other relevant reliable/published sources?			
N block pools	Do the estimated values make sense? Are they consistent with information from other reliable/published sources?			
	Overall QA rating Professional judgement needed and explanation required for the overall QA rating.			
Any unusual outputs?	Are there any unusual outputs that might indicate an input error, an unusual situation, or defect/bug in OVERSEER? If any significant anomalies are observed, they should ideally be resolved before an overall rating is made.			
Audit comments	Audit comments should be added to explain any unusual findings and to summarise the reasons for the overall QA rating.			

There may be additional QA requirements set by individual regional councils.

Data and Results Manipulation

It is imperative that the process of QA assessment removes the ability for any party to manipulate the results or outputs for the gain of one party. Provided that the same methodology is used each year it is difficult to manipulate results on a year on year basis. Therefore, the level of scrutiny within a file must be at its highest in the first year of any review.

OVERSEER version changes

Where OVERSEER files have not been completed to the highest QA rating possible there is a risk of additional variability in outputs occurring between version changes and/or between comparisons with any regulatory thresholds. Refer to Section 7 on version change.

Cross check dataset

Regional councils could collectively or individually create datasets that contain information such as typical range of stocking rates or pasture grown (or consumed) for different soil types of land classes to act as a quick check for OVERSEER file information. Specific additional methods could include the following:

1. Development of an anonymised data set that calculates distributions of stocking rate (or pasture consumed) and other parameters by land class (utilising Council GIS systems to locate farms and approximate land class). New farm models received could be checked against this statistical data and outliers flagged for more in-depth review.
2. Use of the Pasture Growth Forecaster (http://www.pasturegrowthforecaster.co.nz/) with NIWA VCSN climate data for the last 40 years to establish a 90th percentile potential pasture growth for each farm model, and compare that to the monthly pasture consumed as calculated by OVERSEER (livestock demand less brought in/stored feed consumed). Again, outliers would be flagged for more in-depth review.

9.5 Database systems for storage and use of Overseer data

Farm models are a representation of a specific farm system in a format that can be utilised by systems such as OVERSEER. When a farm system is modelled in OVERSEER the detailed input and output information is stored in an XML file (a type of file that enables data to be readily inputted into the OVERSEER engine and stores key outputs).

Currently Regional Councils employ a variety of techniques for storing and utilising OVERSEER farm model data:

- Store source data (farm questionnaires and support documents such as invoices) and build farm models as required. This approach is likely to be most applicable to specific catchments where a regional council has a very proactive role. This approach can require significant resources to build an accurate farm models for all properties.
- Store only the outputs of a farm model supplied by a primary producer or their advisor. This approach has advantages from a privacy perspective but means the regional council is unable to utilise the data to assess the impacts of an OVERSEER version change or other plan change. In addition, output data alone does not enable a regional council to undertake any quality assurance checking of the farm system information.
- Store the farm model XML file in a council file system folder. This approach could provide granular access control (folders can be protected) but would not typically record accesses. This would simply be an electronic filing system with no efficient mechanism to manage or analyse the data.
- Store the farm model XML file in a document management system, along with the other supporting documents relating to a property or a resource consent. This can be a useful approach as long as the document management system supports the appropriate level of controls and logging. Catchment analysis or analysis of OVERSEER version changes must be accomplished in this case by identifying and checking out each relevant farm model; a process that becomes complicated as the number of farms and files to be assessed grows. A document management system will not typically provide detailed search functions able to identify OVERSEER files with specific sets of parameters.

- Store the farm model in a dedicated database or in a separate table or structure in an existing database. This approach allows versioning and bulk selection and use of data, but may risk disconnecting the farm model from other supporting documents.

These techniques highlight the advantages and disadvantage of different approaches and a number of recommendations are made at the end of this section.

It is also important that there is a high level of backward compatibility when a new OVERSEER version is released, so that an OVERSEER XML file created under a previous version of OVEREER should be able to be run successfully on a new version of OVERSEER. Forward compatibility (the ability to run an XML file created or modified with a new version of OVERSEER using an old model) is not required. While full long-term backwards compatibility would be an ideal situation, it appears that a four-year period would enable most regional council requirements to be met. The need to incorporate a significant new module or function may make full backward compatibility difficult, but in most cases re-coding data to a new format or prompting the user for additional information should allow an old file to be updated to the new format. If changes that break compatibility are needed prior consultation should occur with regional councils to discuss measures needed to achieve effective backwards compatibility.

9.6 Privacy and security requirements and systems

In addition to the controlled document frameworks implied by the Local Government Official Information and Meetings Act, the Resource Management Act, and the Archives Act, use of farm information in OVERSEER farm models raises privacy and data control issues (under the Privacy Act and more broadly) for:

- Primary producers; and
- Advisors or consultants who have been involved in preparation of farm models.

Regional councils and contractors or advisors will need to show that they have:

- An information security policy for the organisation (as documented in ISO 27001) that defines appropriate policies and controls for the type of data held and allows the organisation to audit or check that those policies and controls are implemented.
- A mechanism to determine the identity of any person attempting to access farm model data (authentication) and to provide appropriate access controls (authorisation) for that person. Access controls might include denying access, allowing read access, or allowing modification.
- A mechanism for logging all access to farm model data (including read access) to provide confidence that privacy requirements are being followed, and appropriate policy guidance for staff and contractors. A similar approach is used by banks, police and government service organisations to log access to individual accounts or case files.

In addition to the above, there are three principal areas of concern for farmers and advisors that should be addressed:

- Primary producers are concerned that information from other sources or even ad-hoc observations (for instance, of stock numbers on farm) might be incorporated into a farm model without their knowledge.
  Regional councils could address this by making farmers aware of their processes for monitoring, triggers, and response protocols.
- Advisors invest their reputation in developing OVERSEER farm models for their clients (farmers or Regional councils). They are concerned that later unauthorised modifications to farm models might damage their reputation, or that they may be held

responsible for inappropriate use of the farm models they have created.
OVERSEER Limited could address this by implementing a publishing protocol that identified the purposes for which an advisor had created and released a farm model, and by implementing additional "digital signing" so that later modifications could be identified and repudiated.

- Advisors invest their intellectual property in the process of collecting data and transforming this into a biologically feasible and accurate steady-state model of a farm system. Some advisors are concerned that a farm model might later be released by a regional council or a primary producer to a competing advisor or organisation, without recognition of their efforts.
Regional councils could address this by ensuring they have appropriate controls around the use and redistribution of farm models. Advisors who are developing farm models for primary producers could address this by appropriate agreements and by utilising a publishing protocol such as that identified above to assert their authorship of the farm model.

9.7 Farm Data Code of Practice

In 2015 the Farm Data Code of Practice was created and endorsed by a number of industry organisations, in order to provide leadership and increase transparency about the use of detailed farm data by organisations. The Farm Data Code of Practice encourages organisations to become accredited by having clear Terms and Conditions and supporting documents that tell primary producers their rights and responsibilities and how organisations will utilise and manage the data they collect, and then having policies that support those terms. A key focus of the Farm Data Code of Practice is to provide confidence around data sets that may not be covered by the Privacy Act, as it is data pertaining to a (farm) company or trust rather than a natural person.

The Farm Data Code of Practice is administered through an independent review panel, appointed by its shareholding organisations: Beef+Lamb New Zealand, Dairy Companies Association, DairyNZ, Federated Farmers, Meat Industry Association, Te Tumu Paeroa (The Maori Trustee), and the Veterinary Association.

Regional councils implementing the information security policy and controls described above would find it straightforward to achieve accreditation under the Farm Data Code of Practice, which would provide further assurance to farmers and advisors.

9.8 Overseer data and model interoperability

There are a large number of models used in agriculture, water quantity and water quality management (e.g., TRIM, CLUES, Farmax, Pasture Growth Forecaster, Mike 11, IrriCalc, S-map, etc.). The majority of these models operate either independently or have limited interoperability e.g., S-map and OVERSEER. Given the significance and importance of some common data sources e.g., climate data, farm data, and soil information, there is a need to enable enhanced model interoperability to enhance the efficiency and consistency of modelling. There are significant potential benefits to regional councils if there is enhancement of interoperability between models that are relied on directly or indirectly by regional councils.

An example of the issues that can arise are regional plan and resource consent hearings being provided with evidence from expert witnesses using models that use different climate data and farm management data. Similarly, components of one model or data sets can be incorporated into another but over time models and datasets are developed and enhanced on different timeframes which can result in older components remaining in other models. This can lead to inconsistencies in model outputs that can be significant e.g., if the estimate of annual drainage from a water resource model differs significantly from that of OVERSEER (which may be because of different climate datasets and/or soil information used in each model). In addition, currently outputs from one model have to be manually entered or manipulated prior to use in another model e.g., outputs from OVERSEER used in catchment modelling, or data from Farmax used in OVERSEER. This may require additional adjustments to make the models somewhat consistent, which means that the original source of the data can become hard to trace.

Some work has been done on these issues (e.g., Snow *et al* 2014, Elliott *et al* 2014). However, it is worth summarising two overall conclusions of those studies:

1. There is a need for technical advisory committees to provide advice on data standardisation including the potential for common datasets that could be form the basis for a number of models e.g., Farmax and OVERSEER.
2. Enhanced interoperability of freshwater modelling has been demonstrated as possible. However, there are a number of significant technical, institutional and resourcing challenges that need to be addressed before significant improvement of model interoperability occurs.

From the perspective of endeavouring to enhance the accuracy, interoperability and efficiency of OVERSEER inputs, three key model inputs stand out: climate data, soil data and farm system data. Given the importance of these inputs to OVERSEER and other farm system modelling there would be significant potential benefits in developing and enhancing model interoperability with for example, common datasets that could be inputted to different models.

Where other data sets are utilised in OVERSEER farm models, it will become increasingly important to trace the source of this data. In some cases, this is possible by a policy (for instance, input protocols that specify a common source and use of climate data), but more generally it would be advantageous to include a reference to source data in the OVERSEER farm model XML file. OVERSEER should consider a simple linking or reference mechanism to enable documentation of data provenance and assist traceability of data from multiple sources.

Recommendations – data management, security and quality assurance

1 Regional councils should:

(a) Store OVERSEER XML files using a method that enables file data to be extracted using an automated process, and that provides for access controls and logging e.g., in a controlled system (document management system or database), or in a dedicated database table or store machine-readable references to the document which may be stored in a document management system.

(b) Include additional database information to track:

- The provenance (original source) and date of the farm model.
- The OVERSEER version used to develop the farm model, or used to calculate its results.
- For QA reviewed OVERSEER XML files, the reviewer, date of review, OVERSEER version used, QA rating, and any review notes.
- For any modification to OVERSEER XML files (for example, after a QA review or to ensure the farm model complies with required

practices), the date, originator and purpose of the modification, as well as the OVERSEER version used.

(c) Consider automated extraction of key farm model data or calculated outputs (such as farm areas, stocking rates, N and P nutrient budgets) to a separate table or area to enable rapid reporting without needing to extract individual results from XML or recalculate (OVERSEER version and date of calculation would also need to be stored with the extracted data); and

(d) Consider developing methods to export OVERSEER file data from the database via a secured process and anonymised to support use for purposes such as auditing, catchment studies or sensitivity analyses.

(e) Ensure that an information security policy for the organisation defines appropriate policies and controls for the type of data held and allows the organisation to audit or check that those policies and controls are implemented, including mechanisms to determine the authentication or identity of people accessing farm model data along with their authorisation to access such data, and to record such data access.

(f) Once the above information security policy and controls are implemented consider seeking accreditation under the Farm Data Code of Practice, which when accredited would provide further assurance to farmers and advisors regarding the rights and controls surrounding identifiable farm data.

(g) Implement processes to ensure that all parties who provide OVERSEER XML files as part of a regulatory requirement are advised of the processes and protocols used to manage that information.

(h) Consider collectively or individually creating datasets that contain information such as typical range of stocking rates or pasture grown (or consumed) for different soil types of land classes to be able to be used as a quick check for OVERSEER file information.

(i) Ensure that OVERSEER modelling undertaken to meet a regional plan or resource consent requirement is audited against a comprehensive suite of factors, including those detailed in Table 12 to obtain a quality assurance rating of High, Medium or Low. Only those model outputs that have a modelling QA rating of High or Medium should be accepted for a regulatory requirement. Note: refer to modelling and auditing minimum qualifications – Section 10.

2 OVERSEER Limited and users such as regional councils and advisors should consider development and implementation of a mechanism that allows the creator of an OVERSEER XML file to identify the purposes for which it was created and released, supported by “digital signing” so that later modifications could be identified and repudiated.

3 OVERSEER Limited should consider a simple linking or reference mechanism to assist traceability of data from multiple sources. This could be implemented within the nodes or sections in an OVERSEER XML file.

4 OVERSEER Limited should endeavour to maintain backwards compatibility for at least four years i.e., to ensure that OVERSEER XML files generated four years previously can still be successfully run on the current OVERSEER model. If the need for significant model improvement/enhancement means that this cannot be achieved, there should be prior consultation between

OVERSEER LIMITED and regional councils to enable the development of a methodology to achieve backwards compatibility.

5 Regional councils and OVERSEER Limited should support initiatives to enhance the interoperability of models used in Resource Management Act processes that involve OVERSEER inputs or outputs.

10 Qualifications

10.1 Introduction

The purpose of this section is to outline the need for qualifications and experience in OVERSEER modelling and the recommended qualification requirements for those preparing and auditing OVERSEER files.

The importance of OVERSEER modelling estimates and the complexities involved in ensuring that inputs and associated assumptions are as accurate and realistic as possible means that only appropriately qualified and experienced practitioners should prepare or audit OVERSEER file information that is being used in a significant RMA regulatory or planning process. However, as in financial accounting, it is also critical that reliance is not placed solely on qualifications and experience. There is also a need to have transparent auditing processes so that all involved in processes that rely on OVERSEER modelling can have an appropriately high level of confidence in the output results while appreciating the inherent uncertainties in OVERSEER modelling (See Section 5).

Box 7 Key messages - qualifications

1. OVERSEER modelling requires detailed knowledge of New Zealand farming systems and a minimum qualification of the Massey University Certificate in Advanced Sustainable Nutrient Management or an equivalent qualification.
2. OVERSEER modelling of particular significance requires independent auditing.
3. Auditing of OVERSEER modelling requires a minimum qualification of a Fertiliser Association of New Zealand Certificate as a Nutrient Management Adviser or equivalent qualification and experience.

10.2 Experience and understanding of New Zealand farm systems

OVERSEER is not a 'self-adjusting model' i.e., it does not automatically change all aspects of a farm system in response to inputs. Therefore, it is critically important to have a detailed understanding of both how the model operates and the farming systems that it models. For example, adding fertiliser or irrigation does not cause OVERSEER's estimates of pasture production to increase.

Many of New Zealand's farm systems have become increasingly complex over the past 50 years and there are also many mixed farm systems. Many complex factors combine to explain why for example, adjacent dairy farms may operate differently and modelling those differences accurately in OVERSEER requires detailed knowledge of both OVERSEER and dairy farming systems. Therefore, a fundamental requirement for appropriate OVERSEER modelling is a full understanding of relevant farm systems and what is required to operate and model a realistic long-term viable farm system.

10.3 Currently available qualifications relevant to OVERSEER

The key relevant qualifications are the following:

- Massey University Intermediate and Advanced Sustainable Nutrient Management
- The Nutrient Management Adviser Certification Programme

Massey University describes the Intermediate Sustainable Nutrient Management Course:

> "*To be up to the challenge, participants should have completed at least one tertiary level course in Soil Science or Land Resource Management or have significant practical or professional experience in production agriculture/horticulture or environmental science. You need a good understanding of farm systems; it should not be your first introduction to the concepts of nutrient cycling and you should have prior knowledge of the Overseer Nutrient Budgets software. You may need to confirm with us that your qualifications and experience are appropriate.*
> *Two options have been developed:*
> *- Pastoral agriculture - with a focus in the case studies predominantly on dairy systems, and*
> *- Orchard and Arable - with case studies including tree, vine, vegetable and cropping systems.*
> *Participants on the Intermediate SNM course must complete a short pre-course assignment, attend a three-day contact course and sit a two-hour examination on the final day*."

Massey University describes the Advanced Sustainable Nutrient Management Course:

> *"To enrol in this course, participants must have successfully completed the Intermediate SNM Course. [**Note**: An exemption may be granted if an applicant can demonstrate prior equivalent learning and/or an in-depth knowledge of sustainable agricultural practices and use of the Overseer Nutrient Budgets software. Please contact us if you think you may qualify for being exempt the Intermediate SNM course as a pre-requisite.]*
> *Participants must complete four assignments over a five-month period, attend a three-day contact course and pass a two-hour examination. The assignments are case studies using the latest version of Overseer Nutrient Budgets software and include both pastoral and arable examples. These are intended to assist participants to develop nutrient management plans that meet production goals for actual farm enterprises whilst minimising the negative effects of nutrient losses on the environment."*

The Fertiliser Association of New Zealand run the Nutrient Management Adviser Certification Programme and describe its purpose as:

> *"… to build and uphold a transparent set of industry standards for nutrient management advisers to meet, so that they provide nationally consistent advice of the highest standard to farmers."*

These courses and their related qualifications can form a natural progression towards developing the knowledge to undertake OVERSEER modelling for a range of farming systems. However, it is also important to appreciate that expertise in modelling one type of farming system e.g., dairying is not necessarily a guarantee that a person would have an equivalent level of expertise in modelling for example, complex arable cropping systems.

10.4 Auditing of OVERSEER modelling keep here or shift to data section or have one section specific to qualifications and auditing??

As the potential significance of OVERSEER modelling increases, both in terms of water quality outcomes being sought and potential impacts on land owners/managers, so too does the need for appropriate auditing with transparent criteria to ensure that there is an appropriate level of confidence in the output results (See Section 9).

If OVERSEER modelling results are only being used for information purposes the level of auditing needed is relatively low and auditing can usually be done by the person who undertook the modelling or by another non-independent qualified person. However, for more critical modelling where the results may have particularly significant implications for regional plan development and/or implementation, and/or a regional plan activity type classification or resource consent compliance status of an activity, then independent auditing against clear and transparent criteria is needed (See Section 9).

Industry audited self-management systems may be appropriate in certain situations provided that there is an acceptable level of independence, transparency and reporting, and the auditors are suitably qualified and experienced. There are a number of significant quality assurance benefits that are provided by independent auditing.

The recommended criteria for auditing OVERSEER modelling are set out in Section 9 of this report.

Recommendations – qualifications

1. The minimum qualification requirement for undertaking OVERSEER modelling should be a Massey University Certificate in Advanced Sustainable Nutrient Management, or an equivalent qualification.
2. For any OVERSEER modelling of particular significance, independent auditing of the modelling should be undertaken by a person with the minimum qualification of a Massey University Certificate in Advanced Sustainable Nutrient Management or an equivalent qualification, against the criteria specified in Section 9.
3. The minimum qualification requirement for auditing OVERSEER modelling should be a Fertiliser Association of New Zealand Certificate as a Nutrient Management Adviser or equivalent qualification and experience.

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Abell
Hansen
Larned
Parfitt et al

Rutherford C
Mackay & Power
Uncertainty refs x 3
Check forward and reverse.

12 Appendices

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12.1 Relationship with other OVERSEER documents

It is important to appreciate how this guidance document fits with other information available on OVERSEER. The following is an outline of the key documents and sources of information available to assist in understanding OVERSEER and its application to water quality management issues:

Report or information source	Brief description
http://www.overseer.org.nz	Website for OVERSEER with direct or indirect references to a significant collection of technical reports that explain the development, operation, and many applications of OVERSEER. This includes many science papers that explain specific technical aspects of OVERSEER.
OVERSEER Best Practice Data Input Standards, (Usually updated with each version change)	The purpose of these best practice 'standards' is to reduce inconsistencies between different users when operating OVERSEER. They do not prescribe input requirements, but have been adopted by many organisations as a key reference.
Technical Description of OVERSEER for Regional Councils, Watkins, N. & Selbie, D., 2015. Need website url	A brief description of how OVERSEER works, including descriptions of the different methods used to estimate N leaching and P runoff, limitations, assumptions and uncertainties in model outputs.
Stocktake of Regional Council Uses of OVERSEER, Arbuckle, C., 2015. Need website url	A summary of the different ways that regional councils currently use OVERSEER
Individual regional council guidance on input requirements or preferences, e.g. Waikato Regional Council and Environment Canterbury.	These documents usually specify some information requirements to ensure that OVERSEER modelling is consistent and meets specified standards.
OVERSEER: Answers to commonly asked questions, Wheeler D. and Shepherd M., 2013	Responses to a series of questions posed by a variety of users, compiled into the following categories: general, uncertainty issues, performance for different sectors and policy development and application.

12.2 Assumptions for principles of use of OVERSEER

Land use and water quality management assumptions

- The loss of N and P to water from agricultural (and urban) land use is contributing to significant water quality issues in many water bodies and estuaries in New Zealand.
- Soil type, climatic conditions, topography land use and management practices can all impact on the magnitude of human induced nutrient losses to water
- N and P have significantly different loss to water pathways. N loss to water is predominantly via leaching while P loss to water is primarily via overland flow with soil /runoff, or shallow sub-surface drainage.
- Nutrient losses via overland flow are generally more visible than those lost direct to ground and mitigation strategies for tackling losses via overland flow are generally more intuitive and easier to gauge success.
- Direct and reliable measurement of diffuse N and P loss from a farm is not generally feasible.
- Modelled or estimated nutrient losses can be useful in the management of diffuse nutrient loss from land.
- Information obtained from both modelling and measurements involves uncertainties.

Guidance for general use of models in environmental decision-making

The USEPA (2009) developed guidance in 2009 to provides recommendations for the effective development, evaluation, and use of models in environmental decision making. These recommendations are summarised below:

- Sound science principles are used in model development.
- The model is supported by the quantity and quality of available data.
- Evaluation of the model is undertaken to assess how closely the model approximates the real system of interest and how well the model performs against a quality assurance objective.
- There is appropriately comprehensive documentation of all aspects of the model.
- There is effective communication between modellers, analysts, and those using the model.

Key OVERSEER limitations, assumptions and uncertainties

OVERSEER incorporates important limitations, assumptions and uncertainties that are outlined below (derived from Watkins and Selbie, 2015):

Limitations

- The OVERSEER model boundary relevant to this report is the farm boundary and the root zone.
- OVERSEER assumes steady state conditions (i.e., inputs and site characteristics are in equilibrium with farm production).
- OVERSEER is not spatially explicit beyond the level of defined blocks.
- Not all management practices or activities that have an impact on nutrient losses are able to be captured in the OVERSEER model.
- OVERSEER does not represent all farm systems that occur in New Zealand

- Components of OVERSEER have not been calibrated against measured data from every combination of farm systems and environment.

Key Assumptions

- OVERSEER estimates annual average outputs assuming that the farm management and inputs are constant
- OVERSEER assumes reasonable input data
- Assumed management practices. OVERSEER assumes that certain practices or levels of practice are occurring e.g., fertiliser is spread evenly, dairy shed effluent ponds are sealed
- OVERSEER assumes long-term average rainfall, PET and temperature and a specific rainfall pattern based on location (Note: May release will provide for optional monthly climate input - update).

Uncertainties

- Modelling uncertainty derives from:
    - Difference between users' input of data
    - Variability in the representation of the actual farm system via data records
    - Errors in input and boundary condition data, model structure, parameter values, observations used to calibrate or evaluate, errors of omissions, commensurability of modelled and observed variables and parameters
    - The unknown 'unknowns'
- There is the temporal and spatial variability in field measurement data associated with component sub-model calibration.
- Scientific knowledge has been used to add components and to extrapolate to circumstances where calibration data has not been collected. The uncertainty around the estimated losses is likely to increase in circumstances that are substantially different from those in the calibration range.

Version changes

- New versions of OVERSEER are usually released twice per year to: improve estimates of nutrient losses, improve the ability to characterise farm systems, enhance the model interface and associated reports, address software bugs/defects, etc.

12.3 Assessing methods to generate source loads against methods and tools to manage uncertainty

		Generic or literature values	Anecdotal case studies	Representative farms (few)	Representative farms (many)	Actual farm budgets
		Uncertainty				
Managing data inputs	Quality of data inputs	High	Moderate	Low	Low	Variable
	Expertise of modellers	Unknown	Unknown/ moderate	Low	Low	Unknown/variable
	Representativeness of modelled information	High	High	Moderate	Low	Low
	Similarity of system to calibration data set	Unknown/depends on catchment				
		Use				
Using OVERSEER outputs	Significance analyses and use of ranges	Not possible	Generally not possible	Possible	Possible	Possible but resource intensive
	Alternative sources of evidence	Possible	Possible	Possible	Possible	Possible
	Model outputs used in a relative sense	Possible	Possible	Possible	Possible	Possible
	Precautionary Principle - conservatism	Not possible	Generally not possible	Possible	Possible	Possible but resource intensive
	Precautionary Principle - adaptive management	Possible	Possible	Possible	Possible	Possible
	Shortened consent term					Possible

	Resource consent review conditions	Not possible for use in consents - - lacks specificity			Mod-high uncertainty - lacks specificity needed for consent	Possible
	FEP and OVERSEER used together					Possible
	On-going targeted monitoring and revision	NA	NA	NA	NA	NA
Can incorporate updates to OVERSEER?		No	Possible	Yes	Yes	Yes

12.4 Uncertainty in OVERSEER

Modelling uncertainty includes all the variability associated with data input as well as modelling procedures. Sources of variability in data input and modelling procedures include:
Difference between users input of data,
Variability in the representation of the actual farm system via data records,
Errors in input and boundary condition data, model structure, parameter values, observations used to calibrate or evaluate, errors of omissions, commensurability of modelled and observed variables and parameters, and
The unknown 'unknowns'. (Watkins and Selbie, 2015Watkins and Selbie, 2015)

12.5 A summary of the approaches used to address the implications of OVERSEER version changes

Approach	Explanation	Advantages	Disadvantages
Options primarily relevant to regional plan development and implementation, particularly for setting freshwater quality limits (may have broad or partial application)			
Lock in a specific OVERSEER version number for regional rules and/or resource consent applications, for example, a rule may state "…estimated using OVERSEER version 6.X.Y"	A regional rule can state that a specific OVERSEER version be used to determine for example, compliance with a nutrient loss threshold or that a specific version be used for resource consent applications. For example, OVERSEER version 5.4.3 is specified as the version to use for the Lake Taupo catchment since new regional plan rules became fully operative in 2011.	Provides certainty for land owners/managers that actual rule thresholds and/or resource consent thresholds won't change. Provides user certainty if nutrient allocation trading is established as occurs in the Lake Taupo catchment. No need to respond to OVERSEER version changes. Plan provisions can allow for resource consent applications or applications to change resource consent conditions to use a subsequent version of OVERSEER.	Can make it difficult to take advantage of model enhancements/ improvements/new mitigation options in a new version. Obtaining access to an old version needs permission from the OVERSEER owners. If this approach became common, it could result in multiple versions in use in a region and/or around the country. Can result in a significant implementation workload for council and land owners/managers.
Explicitly or implicitly specify/refer to the current/most recent version for regional rules and/or resource consent applications, for example, a rule may state "…estimated using Overseer."	This is currently included in a number of regional rules that state a nutrient loss threshold and individual property nutrient loss estimates would be determined using the current version. If the version is not specified, to the same approach is implicit, because at any one time only one version is generally available.	Can take advantage of model enhancements/ improvements/new mitigation options in a new version. Updated versions generally involve model improvements that reduce the uncertainty involved in overall catchment nutrient source loss estimates. If a new version includes additional mitigation options, these can be used to both better reflect existing practices and encourage their uptake.	Unless version change management strategies are implemented this can create uncertainty for land owners/managers because numerical threshold rule compliance status could change with each version. The extent of this issue would vary depending on the specific plan provisions. The use of different versions over time could result in different actual

Approach	Explanation	Advantages	Disadvantages
			consented losses if consented under different versions.
Specify in the appropriate rule that when a new OVERSEER version change occurs that results in a change to a relevant nutrient loss threshold or property nutrient loss estimate, that would not affect the exercise of specific existing resource consents (S68(7) RMA)	This is a relatively common approach used in similar situations to provide certainty to parties who may be potentially affected by a new rule that relates to minimum standards of water quality.	Could enable new OVERSEER versions to be applied over time. Could provide certainty for specific resource consent holders.	Depending on the application of such a provision, this may create uncertainties in estimating consented source loads, and anomalies in treatment of similar resource consent applications may result. Would need to identify all such resource consents to ensure status is understood.
Development of a plan framework that avoids or mitigates the consequences of OVERSEER version changes	Use of permitted activities that don't rely on OVERSEER defined thresholds/limits. A limited number of activity class rules that can prevent an activity changing from one activity class to another e.g., if sheep and beef land use doesn't meet permitted activity requirements, it defaults into one other activity class.	Can prevent OVERSEER version changes causing any activity class changes. Can assist in developing simple to understand and apply permitted activity requirements. A clear policy framework and/or updating mechanism can minimise any inequities that could otherwise arise between any consents granted before and after an OVERSEER version change.	May not provide the degree of specific control that a full range of activity classes would provide. Would put significant reliance on the resource consent process and would need a very clear policy framework to ensure plan objectives are achieved and farming sectors treated equitably.
Provision of a version updating method specified via plan provisions to address the effects of an OVERSEER version change on benchmark/threshold/ estimated losses.	Such systems are being proposed to provide a transparent independent system to endeavour to address the effects of an OVERSEER version change by specifying via plan provisions a methodology e.g. a calculator, reference file system, or 'data input transfer' system. The methodology allows the footprint of an activity to be recalculated with new	Depending on the details of the rule wording and the updating system, can be an effective method to address the effect of a version change on the status of an activity. Provides certainty to landowners/ managers about compliance after OVERSEER version changes.	Updating systems may still result in a change in the status of an activity because a version change may not affect the activity and the limit/threshold/allowance 'symmetrically'. Input updating systems rely on the input structures of OVERSEER remaining constant and establishing protocols for dealing with any minor

Approach	Explanation	Advantages	Disadvantages
	versions of OVERSEER without changing the classification or compliance status of a farm system.	Would not appear to require a plan change or a Schedule 1 Part 3 process.	model changes that may create technical challenges for 'transferring' input data. .
Provide the ability for a council or a council Chief Executive to certify alternative models (to estimate property nutrient loss) or versions of models e.g., to certify that a new version of OVERSEER does not result in any material change in estimates of nutrient loss to water compared to a prior version.	A certification process could provide a mechanism for certifying a new version against specifications. Similarly, an alternative model for an unusual land use that is not modelled by OVERSEER could be certified against specifications. This could provide for a land use for example, to be subject to a permitted activity rule. Need to clearly distinguish between a certification process and an 'arbitration'/approval process.	Certification against clearly defined measurable specifications could be a robust route to provide for alternative models and/or new versions. A plan would need to include clear technical standards/specifications that a model or new version would be assessed against by an appropriately qualified person.	Would require significant resources to establish robust specifications and certification process. Needs certainty for users to know what the requirements are.
Ensure permitted activity rule condition wording allows for a certificate of compliance to be issued that specifies that "an activity could be done lawfully in a particular location without a resource consent" (S139 RMA).	A high level of certainty is required to issue a certificate of compliance and therefore the wording of a permitted activity rules should take into account the need to be able to issue certificates of compliance.	This can provide certainty that an activity does not require resource consent and combined with other approaches can also provide certainty for land owners/managers in the event of a subsequent regional plan change.	Wording of a condition that requires assessment with a current OVERSEER version may (depending on the interpretation of S139 requirements) represent a challenge for issuing certificates of compliance, because the version will change. No significant disadvantages for land owners/managers provided that the relevant rule is clear enough to allow certificates of compliance to be issued.
Use OVERSEER information to develop readily understood narrative rule thresholds e.g., maximum hectares of irrigation, maximum area	This allows for OVERSEER information to inform the process of developing appropriate thresholds e.g., permitted activity thresholds.	This could address OVERSEER version issues at least for those activity categories where it is used (e.g., permitted activity threshold).	This would result in more of a focus on inputs rather than outputs. This could result in a narrow focus on

Approach	Explanation	Advantages	Disadvantages
of specified land use on a specified soil type, specific good management practices, etc.		Enables easily understood rule thresholds.	specific inputs and less of a focus on outputs and effects. Would limit land owner/manager flexibility May not treat all situations equitably, e.g., it would be a challenge to ensure that all possible land uses are recognised with equivalent narrative thresholds .
Amend Schedule 1, Part 3 of the RMA to allow for more effective incorporation of a new OVERSEER version into a regional plan. Or provide some other route such as that used to update a National Environmental Standard.	This has been suggested to develop a quicker process than that currently required by Schedule 1 Part 3. For example, if a specific consultative process has been followed to incorporate a new version change.	If practicable and acceptable, would enable new versions of OVERSEER to be incorporated into regional plans faster than could currently occur, while still providing for input on the implications of a new version.	There are likely to be reservations about developing a 'fast-track' system solely to manage OVERSEER version changes.
Options primarily relevant to resource consents (many resource consent applications would be made under provisions of a proposed or operative regional plan with OVERSEER related provisions, many will also be made in circumstances where there are few provisions specific to OVERSEER)			
Lock in a specific version number for any granted resource consent	As described above for regional plan approach. Assumes that ongoing access to an old version would be provided, or a resource consent change or review process used to update to a new OVERSEER version.	Similar advantages as described above for a regional plan. An additional advantage is that it is significantly more straightforward (at least for limited numbers of consent holders) to apply for a change to a resource consent condition to take account of enhancements/improvements to OVERSEER in a new version. Resource consent conditions could specify a process for responding to version changes.	Similar disadvantages as described above for a regional plan.

Approach	Explanation	Advantages	Disadvantages
No version or current version specified.	Where a resource consent is granted that explicitly or implicitly requires the most current version of OVERSEER to be used to estimate nutrient loss to water.	Similar advantages as described above for a regional plan. More flexibility in a resource consent process than regional plan process to agree conditions that provide for future versions to be used and an updating process (i.e., Augier Principle).	Challenges in assessing resource consent applications over time using different OVERSEER versions. Potential challenges in using data provided as part of a resource consent requirement to estimate catchment source loads and wider catchment modelling. Depending on the detailed conditions, could result in uncertainty for the consent holder and other parties about future compliance.
Include a condition in a granted resource consent that provides for a version updating method that provides for a calculator, reference file system, or 'data input transfer' system to address the effects of an OVERSEER version change on benchmark/threshold/ estimated losses.	As described above for regional plan approach.	Similar advantages as described above for a regional plan. More flexibility in a resource consent process than regional plan process to agree conditions that provide for a version updating method (i.e., Augier Principle).	Similar disadvantages as described above for a regional plan.
Condition wording that requires an OVERSEER estimate to be undertaken within a specified timeframe while a specified OVERSEER version is available	This would require modelling to be undertaken within a specified period of time while an OVERSEER version is available and records maintained and/ or provided to the regional council.	This could be used with a 'batch' of resource consent applications to ensure that estimates were al undertaken within a specific timeframe while one version is available. Would not be affected by an OVERSEER version change and would provide certainty. Could be complemented by conditions providing for OVERSEER estimates to be undertaken at a later period.	Unlikely to be feasible for large catchments with many land owners or on a region scale. Would require significant coordination with many parties to be feasible. May require an additional mechanism to enable ongoing compliance monitoring.

Approach	Explanation	Advantages	Disadvantages
		May be applicable where there is no need for ongoing nutrient loss estimates.	
Use OVERSEER to develop readily understood narrative resource consent condition thresholds e.g., maximum hectares of irrigation, or maximum area of specified land use on a specified soil type, specific good management practices, etc.	Develop narrative statements of land management that are consistent with estimated property nutrient loss targets designed to achieve estimated catchment limits. Instead of using OVERSEER numerical thresholds, these are translated into narrative land use thresholds.	This would partly address OVERSEER version issues. Enables easily understood resource consent condition thresholds.	Would limit land owner/manager flexibility. This would result in more of a focus on inputs rather than outputs. Any narrative resource consent conditions that referred to e.g., 'good management practices' would need to define exactly what is required to ensure that such conditions are certain.
Combination of approaches	Many of the above approaches can be combined to address a number of related issues, e.g., input defined permitted activities and consent rules using a version updating system.	Depends on the combination. A combination of approaches could be designed to meet the needs of a specific situation. Any disadvantages could be minimised by careful selection of options.	Depends on the combination.
General options			
Modify the current OVERSEER version change frequency and/or content, and availability of earlier versions.	This could include limiting intermediate version changes to matters that don't affect nutrient loss estimates, e.g., interface improvements. This could include a possible longer-term version change cycle e.g., every two or three years, that could tie in with a review of a regional or catchment nutrient management plan. The OVERSEER owners have also, under certain situations, made specific version(s) available.	Less frequent version changes would enable version response systems to be more manageable.	Less frequent version changes would limit the ability to quickly incorporate model improvements/enhancements. Achieving agreement on an ideal version change frequency/content between all key stakeholders would be difficult to achieve.

Approach	Explanation	Advantages	Disadvantages