Data Supermarket

Land Use Opportunities for Aotearoa

GUIDANCE DOCUMENT

LWP

Potential uses of the data available in the Whitiwhiti Ora Data Supermarket

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INTRODUCTION

The Whitiwhiti Ora Data Supermarket (hereafter the Supermarket) contains various datasets that have been produced by the Our Land and Water Challenge (OL&W) that have been made publicly available. These data may be useful to decision-making processes concerned with the use of land and its impacts on greenhouse gases, water (i.e., aquatic receiving environments), and economic indicators. The data includes land use options under both existing and potential future climate conditions and information pertaining to the impacts of land use options on environmental values. The Supermarket does not have 'answers' but it contains some of the information required to derive information that is relevant to making land use decisions.

To illustrate the potential use of the data, six specific tasks have been identified:

1. Establishing water quality baseline,
2. Catchment contaminant accounting,
3. Exploring catchment management options,
4. Exploring land use options,
5. Defining policy responses, and
6. Developing Farm Environment Plans.

This document briefly describes each task, identifies the parties most likely to be undertaking the task, and describes the datasets within the supermarket that may be relevant. The document also describes the limitations of the data and has notes regarding what the data cannot provide and where users need to look further afield.

The Supermarket is a repository for data only. Much of the data is spatial and therefore specialized tools such as geographic information systems (GIS) and relevant skills are needed to use the data.

BACKGROUND

OL&W was concerned with the wise and sustainable use of land and the impacts of land use on the wider environment. The research therefore considered that agricultural production occurs within a 'land-water system' that includes economic, environmental, social and cultural components that extend beyond farm boundaries (McDowell *et al.* 2018; Snelder *et al.* 2022). Data in the Supermarket may therefore pertain to individual land parcels or the wider land-water system (including the catchment and region) and to economic, environmental, social and cultural aspects of the system. For example, there is data that describes the estimated loss of nitrogen from land parcels under different land uses and there is also data describing the water quality baseline state in downstream rivers, lakes and estuaries. Different datasets therefore describe characteristics that have varying spatial scales (e.g., land parcels versus catchments).

This context defined by the land-water system is relevant to the six specific tasks set out in Table 1 and described below. Although these tasks will tend to be focused on a particular spatial scale, (e.g., Developing Farm Environment Plans will be focused on land parcel and smaller scales), data in the Supermarket that pertains to other spatial scales will often be relevant. For example, when prioritising actions in Farm Environment Plans, it will be relevant to consider the baseline (i.e., current) water quality state in downstream rivers, lakes and estuaries. Users are therefore encouraged to think about the Supermarket as a source of information about various components and aspects of the land-water system. Where appropriate in the task descriptions below, the links between these components and aspects are mentioned.

TASK 1. ESTABLISHING WATER QUALITY BASELINE

Under the National Policy Statement – Freshwater Management (NPS-FM), regional councils are required to evaluate baseline states of attributes (Section 3.10), set target attribute states (Section 3.11), and identify limits and actions that will achieve the target attribute states (Section 3.12). Relevant to these requirements is the requirement under Section 1.6 of the NPS-FM for councils to use data and best information including modelling.

For water quality, these requirements broadly mean that regional councils need to undertake quantitative analyses of current attribute states, use these to help establish desired future states and establish size of the gaps between current and desired states. Establishing the size of the gap is the first step in exploring catchment management options (see Task 3).

The tools that are available in the Supermarket that is relevant to Task 1 are the current state maps.

The current state maps are outputs of national level analyses of the current state for four contaminants (nitrogen, phosphorus, sediment, *E. coli*) and a comparison of these states with a minimum acceptable states represented by national bottom lines (NBL) for several relevant attributes for rivers, lakes and estuaries (Snelder *et al.* 2021). The current state maps are primarily spatial data describing modelled current concentrations and loads of contaminants, and the magnitude of the gaps (expressed as loads in excess of the load that achieve the NBL). These gaps are shown by river segment and by catchment. Catchments with gaps can be regarded as being over-allocated with respect to the contaminant.

The current state maps data layers provide a starting point for regional councils undertaking evaluations of baseline attribute states, setting target attribute states and identifying limits and actions. By describing the current loads and concentrations and identifying catchments where current state is below the NBL, the current state maps data provides catchment context for tasks such as Exploring land use options (Task 4), Developing Farm Environment Plans (see Task 6) and Exploring land use options (see Task 3).

The limitations of these data for these applications are that:

- Gaps are described for only the NBL
- The analysis is nominally for the year 2020
- The models used are national in extent and therefore there is likely to be some bias at finer spatial scales (e.g., at the scale of regions and catchments).

The methods used to produce the current state maps are described by Snelder *et al.* (2020) and (Snelder *et al.* 2021). The methods used to develop the current state maps can also be applied at other scales e.g., regional analyses with alternative target attribute states.

Table 1. Mapping of WWO tools to tasks associated with managing emissions from land.
The subscripts: N, P, E, S and G identify if the tool pertains to nitrogen, phosphorus, *E. coli*, sediment, or GHG, respectively.

Task	Key user	Description	WWO tools
1. Establishing water quality baseline	Regional councils	Quantitative analysis of current water quality compared to objectives to establish size of gaps.	• Current state maps $_{N, P, E, S}$[1]
2. Catchment contaminant accounting	Regional councils	Compile ledger of water quality contaminant contributions from all sources including land and point sources.	• Typologies and loss rate lookup tables $_{N, P}$
3. Exploring catchment management options	Regional councils	Scenario analysis to examine impact of changes of land use and management on water quality, GHG and economics.	• Typologies and loss rate lookup information $_{N, P, G}$• • Catchment models (LWP empirical) • Crop suitability and farm outputs data (production, economics, carbon) • GHG mitigation information.
4. Exploring land use options	Landowners and industry	Investigating feasible alternative land use options and their impacts on water quality, GHG and economics.	• Current state maps $_{N, P, E, S}$ • Typologies and loss rates $_{N, P, G}$ • Farm outputs/state (production, economics, carbon) • Pasture DM layer • *E. coli* risk map
5. Defining policy responses	Regional councils and industry	Prescribing and prioritizing actions for specific land uses and environmental conditions.	• APSIM susceptibility maps • E-coli susceptibility map? • Physiographic Classification • Typologies $_{N, P, G}$
6. Developing Farm Environment Plans	Landowners and advisors	Defining the right actions in the right locations at the farm scale.	• Current state maps $_{N, P, E, S}$• • APSIM susceptibility maps • Physiographic Classification • GHG mitigation information

[1] **Note** that these maps compare predictions of current state to minimum acceptable states corresponding to National Bottom Lines defined by the NPS-FM.

TASK 2. CATCHMENT CONTAMINANT ACCOUNTING

Under the NPS-FM, regional councils are required to operate and maintain freshwater accounting systems including a freshwater quality accounting system (Section 3.29). A water quality accounting system is a ledger of loads of contaminants from all sources in Freshwater Management Units (FMU) or parts thereof. The NPS-FM sets out various requirements for such systems including requirements to update and to record the proportion of contaminant loads that have been allocated.

Tools in the supermarket that are relevant to Task 2 are the typologies and loss rate look-up tables.

The typologies and loss rate look-up tables contained in the Supermarket can be used to quantify diffuse source contaminant loads. The look up tables provide estimated loss rates for total nitrogen (TN) and total phosphorus (TP) from 'types' of land defined by combinations of factors including land use/cover, climate and topography. The look up tables need to be combined with spatial coverages of the factors to provide estimates of TN and TP loads from land areas including land use maps, and maps describing climate and topographic factors. This task requires the use of GIS and relevant skills.

The typologies and loss rate look-up tables can provide a starting point for regional councils to estimate diffuse source TN and TP losses from all parts of the landscape and use these to build freshwater quality accounting systems. However, there are three limitations of the supermarket data for this application that users need to be aware of. First, the typologies are national in extent and define only coarse types (e.g., Dairy/Flat/Dry, Sheep & Beef/Rolling/Wet; Monaghan *et al.* 2021; Srinivasan *et al.* 2021). Second, TN and TP loss rates for each type defined by Monaghan *et al.* (2021) and Srinivasan *et al.* (2021) are informed by the OVERSEER model. The TN loss rates for each type defined by Snelder *et al.* (2023) were derived from empirical analysis of water quality data. These are therefore independent of the OVERSEER model. However, the types defined by Snelder *et al.* (2023) are very coarse (i.e., the whole country is covered by 11 types). In addition the loss rates defined by Snelder *et al.* (2023) are attenuated (i.e., they can be regarded as the contribution to the TN load from a type at the catchment outlet). The third limitation of the data is that Snelder *et al.* (2023) shows that the loss rates provided by Monaghan *et al.* (2021) and Srinivasan *et al.* (2021) are, to some extent, inconsistent with each other and with measured catchment TN and TP loads.

Table 2. Summary of the typology and loss rate tables in the Supermarket. All typologies are of national extent and only coarsely differentiate spatial variation in factors that drive variability in nutrient loss rates.

Name	Methodology	Contaminant	Note
Srinivasan *et al.* (2021)	Overseer	TN, TP	
Monaghan *et al.* (2021)	Overseer	TN, TP	Designed to explore effect of mitigations therefore not appropriate for spatial analysis.
WWO typologies	Overseer & APSIM	TN, TP	Update of Snelder *et al.* (2023)
Snelder *et al.* (2023)	Regression using water quality data	TN only	Only 6 land use categories and 11 types.

TASK 3. EXPLORING CATCHMENT MANAGEMENT OPTIONS

Under the NPS-FM, regional councils are required to set limits on resource use (Section 3.14). Depending on the size of the gaps between current attribute state and target attribute state (see Task 1) and the significance of the implications for resource use, the analyses that are required to robustly undertake this task can be complicated. Briefly, the complications that arise in the context of water quality considerations are due to the spatial heterogeneity in the distribution of resource using activities (primarily land use), spatial variation in the sensitivity of receiving environments to contaminants, and the many possible management options that could be deployed to limit resource use to achieve the target attribute state. These complications dictate that it will often be necessary to use scenario analysis to experiment with the options and find a satisfactory set of limits.

Scenario analysis is reliant on modelling to simulate the 'land-water system' and produce 'indicators' that describe the consequences for values including environmental, social, cultural and economic values (McDowell *et al.* 2018; Snelder *et al.* 2022). A schematic diagram of a model of the 'land-water system' is shown in Figure 1. The schematic diagram shown in Figure 1 is a simplification in that it only identifies model components that are required to simulate the biophysical and economic aspects of the land-water system. Additional components are required to consider the social and cultural values.

A discussion of fit for purpose land-water system models and their development is provided by Larned and Snelder (Submitted). A key point made by Larned and Snelder (Submitted) is that the best approach to development of reliable, useful, feasible and transparent land-water system models is generally by assembling chains of existing component models. These models require various types of data as input. This document only indicates the data available in the Supermarket, that might be required in the process of assembling a chain of component models (i.e., building a land-water system model).

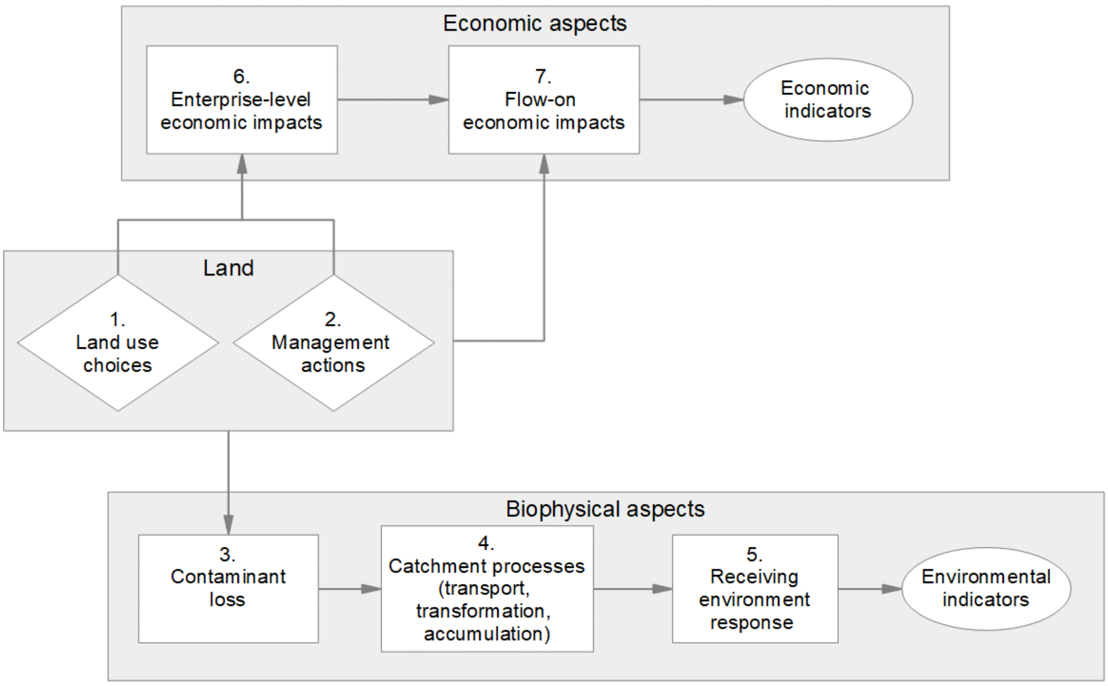

Figure 1. Schematic diagram of the components of a land water system model in the context of setting resource use limits to achieve water quality target attribute states. Central box: modelled representations of land by the model, incorporating land use and management actions. Diamonds: component models that can be manipulated to simulate choices of land use and land management actions. Upper and lower boxes: economic and biophysical aspects of the land water system model. Rectangles: component models that simulate a chain of economic and biophysical processes. Arrows: model outputs being passed to the next component model. Ovals: indicators of economic and environmental impact that are provided to end-users. Indicators can be based on output from any of the component models, not only the final component model.

The tools that are available in the Supermarket that are relevant to the Task 3 are as follows.

Crop suitability and farm outputs data (production, economics, carbon)

Land use options are input data for a component of the land water system model that is represented by diamond 1 in Figure 1. Any catchment water quality model requires that land use is represented, and scenario analysis requires that plausible alternative land uses can be simulated. The first use of the crop suitability and farm outputs data in the supermarket is to provide options for other land use choices. In addition, the crop suitability and farm outputs data are associated with economic information describing farm inputs and outputs (production, economics, carbon). These data are required for simulating the enterprise level that is represented by box 6 in Figure 1.

Typologies and loss rate lookup tables

Typologies and loss rate lookup tables can provide input data for a component of the land water system model that is represented by box 3 in Figure 1. Any water quality simulation requires parameters that represent the loss of contaminants from land. Typologies and associated look up tables provide these parameters and account for differences in loss rates that are attributable to both land use and environmental factors (e.g., climate, topography and soils). The caveats associated with these datasets are set out in the Task 2 description above.

Mitigation options

A scenario analysis may be needed to determine the effect of potential land management mitigation options on outcomes such as water quality and economic impacts. Potential land management options are input data for a component of the land water system model that is represented by diamond 2 in Figure 1. Any water quality simulation can include the reduction in the baseline loss of contaminants from land that can be achieved by using an alternative management. Mitigation tables in the Supermarket indicate the relative reductions in emissions for a set of management options relevant to dairy, sheep and beef, and arable farm systems.

Climate change metrics

This information can inform the possible land use scenarios being considered. Climate change can offer new opportunities for growing crops in areas that were previously marginal, or can increase risks for existing land uses. For example, the increase in intensity and locations of drought may require land use scenarios that transition to land uses or management practices with lower water requirements.

TASK 4. EXPLORING LAND USE OPTIONS

Investors in land including landowners and banks, industry organizations, consultants and advisors working for these groups, need to understand the feasible use options for a land parcel of interest and the impacts of these choices on water quality, GHG and economics. These groups also need to understand the wider context (land-water system) that the land parcel is part of including, for example, the current state of water quality in the surrounding catchment.

The tools that are available in the supermarket that are relevant to the Task 4 are as follows.

Current state maps

The current state maps provide high level information describing whether land parcels can be regarded as being in catchments that are over-allocated with respect to four contaminants (nitrogen, phosphorus, sediment, *E. coli*). The caveats that are relevant to the current state maps are described under Task 1. The most important of those caveats is that the current state maps are specific to NBLs. Existing or future target attribute states that are established by regional limit setting processes may be more stringent than the NBL, so the pressure maps indicate the best case with respect to over-allocation.

Typologies and loss rate look-up tables

The typologies and loss rate look up tables can be used to estimate differences in loss of contaminants (TN, TP, GHG) under alternative land use options. The caveats associated with the Supermarket typologies and loss rates are described under Task 2. The most important of these caveats is that the typologies are a coarse subdivision of national land use. This means that there will be appreciable variability in loss rates between land parcels within a type. For example, the loss rates indicated for the dairy/wet/flat/well drained type are based on one of three rainfall levels for the whole country and a single set of soil properties (of three sets for the whole country). This needs to be kept in mind when using the typologies to make inferences about a single land parcel. The user should expect that the absolute loss rate for a type is an imprecise estimate for a land parcel that is assigned to that type. Greater confidence can be placed in the relative change in loss rate for a change on land use for a given land parcel, however, this should also be regarded as imprecise.

APSIM N loss susceptibility maps

This spatial data layer indicates the relative risk of N losses across the country. The layer was generated by using the APSIM model to simulate and track a single spike of nitrogen on a rye grass pasture, thus generating indices of inherent (i.e., non-anthropogenic) risk of nitrogen losses to water across New Zealand. The most detailed soil and climate data that is nationally available was used. The risk layer is more spatially detailed than the typologies and loss rate look up tables. Therefore, the APSIM N risk layer may be suitable for discriminating variation in the risk of N loss at the scale of catchment or farms.

E. coli risk map

The *E. coli* risk map comprises a typology and associated lookup table that indicates the relative risk of *E. coli* losses across the country (Muirhead et al. In prep). The layer was developed based on interrogation and summarisation of several national scale spatial models describing *E. coli* concentrations and loads in rivers. The risk of *E. coli* loss is quantified by an ordinal scale from 1 to 11 for land classes that are defined by categories for four factors: land use, soil moisture, soil drainage, and elevation. The typology is a coarse subdivision New Zealand, which means that there will be appreciable variability in risk between land parcels within a type. This needs to be kept in mind when using the typology to make inferences about risks for individual land parcels. In addition, the ordinal scale represented by the lookup table is only describing the ordering of risk and not the absolute risk or *E. coli* loss rate. This means that the data can be used to identify where the risk for a change in land use for a given land parcel or across a catchment, increases or decreases, but not by how much.

Land use suitability and farm outputs data (production, economics, carbon)

The crop suitability and farm outputs data can be used to identify possible alternate land use options and the associated economic indicators, e.g., revenue, expenses, etc. The data is based on national information so the information should only be used in for screening purposes. A more detailed feasibility study should be done before embarking on any land use change. Note that suitability only considers biophysical constraints. It does not include political constraints such as consenting requirements, the availability of irrigation water, proximity to processing and transportation infrastructure.

TASK 5. DEFINING POLICY RESPONSES

Regional councils and industry groups are concerned with developing policy responses to land and water management issues. Appropriate policy responses are mandated or recommended management actions that are justifiable for specified land uses and environmental conditions. For regional councils involved in implementing the NPS-FM, defining policy responses is a subsequent step to Task 3 (and part of Task 3 will have been to simulate the impact of several potential policy responses).

The tools that are available in the Supermarket that may be relevant to the Task 5 are as follows.

APSIM N loss susceptibility maps

This information is discussed under Task 4. It could be useful for developing rules constraining certain land use activities, or prioritizing areas for targeted interventions, community education, environmental testing etc. Note that this information is about relative risk, it cannot be directly linked to water quality objectives.

E-coli risk map

The *E. coli* risk map could be useful for developing rules constraining certain land use activities, or prioritizing areas for targeted interventions. Note that this information is about relative risk, it cannot be directly linked to water quality objectives. The limitations associated with the *E. coli* risk map that are described under Task 4 apply also to its use in defining policy responses.

Mitigation options

Mitigation options are discussed under Task 3.

Typologies and loss rate look-up tables

The typologies and loss rate look up tables can be used to estimate differences in loss of contaminants (TN, TP, GHG) under alternative land use options. This information can have a similar role in defining policy responses as for Task 3 and Task 4. The same caveats for the use of typologies listed under Task 2, Task 3 and Task 4 apply to the task of defining policy responses.

TASK 6. DEVELOPING FARM ENVIRONMENT PLANS

Developing farm environment plans involves defining the right actions in the right locations. Farm Environment Management Plans (FEMP) are specific to individual farms and are concerned with characteristics that vary at the farm scale (e.g., spatial variation in landscape vulnerabilities to contaminant loss such as critical source areas). Many of the tools in the Supermarket are much larger in extent than individual farms (i.e., often national extent) and describe spatial variation at a level of detail that is very coarse compared to individual farms. The tools need to be used carefully and with these limitations in mind when being applied to developing FEMPs (Task 6).

The tools that are available in the Supermarket that are most appropriate for Task 6 are as follows.

Current state maps

The current state maps are described under Task 1. Current state maps identify catchments and contaminants (nutrients, sediment, *E. coli*) where current state is below the NBL. The maps therefore provide 'catchment context' i.e., an indication of whether the catchment needs to reduce contaminant loads. An important caveat is that Regional Councils can set target attribute states that are more stringent than the NBL. This means that the current state maps cannot definitively define catchments where contaminant load reductions might be required because more stringent target attribute states will imply that larger load reductions than are indicated by the current state maps are required. The current state maps could also potentially provide a basis for prioritizing the contaminants of most concern for individual farms.

APSIM N loss susceptibility maps

This information is discussed under Task 4. This dataset is spatially detailed and may therefore indicate where there is a higher inherent risk of loss of N at the farm-scale. This sort of information can be used to direct land management practices in FEMPs. The APSIM N loss susceptibility maps include maps of monthly risk. This information can be used in FEMPs to direct the timing of certain management practices and farm activities.

Mitigation options

Mitigation options are discussed under Task 3. Specific mitigations might be mentioned in a FEMP as the means of limiting contaminant losses.

E. coli risk map

This information is discussed under Task 4. The same caveats that are discussed for the use of the *E. coli* risk maps under Task 4 apply to their use in developing FEMPs.

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