BRIEFING NOTE

To: Freshwater Futures: Community Groups – Rangitāiki, Kaituna and Pongakawa-Waitahanui

From: Water Policy Team **Date:** 07 September 2017

Subject: **Workshop 6: Catchment modelling scenarios and use values**

1 Introduction

A key focus for the project team for Rangitāiki and Kaituna-Pongakawa-Waitahanui Water Management Areas ("us/we") at the moment is on developing **catchment models and scenarios to help us to explore water quality and quantity issues now and in the future**.

In workshop 5 (refer to workshop presentation slides), community group members ("you") were introduced to the catchment model and the purpose of scenarios within it.

Workshop 6 will focus in more detail on land and water use, and the catchment model Baseline and Development scenarios in particular. Modelling of the real world involves using a mix of science/data AND educated estimates/assumptions, which will always have a level of uncertainty. To lessen this uncertainty we would like to check some assumptions with you (sections 2-4)**.**

In workshops 4 and 5, you focussed on in-river freshwater values and your preferred future states for these values, with a view to later **discussing the water quality and quantity needs of all current and likely future land use and freshwater use values** (e.g., extraction, HEP, commercial discharges). This will also be discussed in Workshop 6 (section 5).

We will also briefly introduce how management options, identified during the "walk on the wild side" exercise in workshop 5, will be narrowed down and assessed against criteria and principles.

Changes have now been made to the National Policy Statement for Freshwater Management (NPSFM). The government's factsheets about these changes are at this link: http://www.mfe.govt.nz/publications/fresh-water/fact-sheets-changes-freshwater-nps-2017. Implications for this project will be briefly discussed at workshop 6. However, they do not dramatically alter the work programme.

1.1 Workshop Purpose

To seek your understanding of, and input to:

- Reference State ("naturalised" land cover and flow),
- Baseline scenario (current land and water use); and
- Development scenario (future land and water use);

prior to using them in catchment modelling.

1.2 Key outcomes sought

You understand and provide feedback/agreement on the following key items:

1. Current land use practice and water use assumptions
2. Future land use maps
3. Reference state assumptions
4. How use values are being considered/factored in to the planning process.

If time allows, we hope to start discussing management options in more detail.

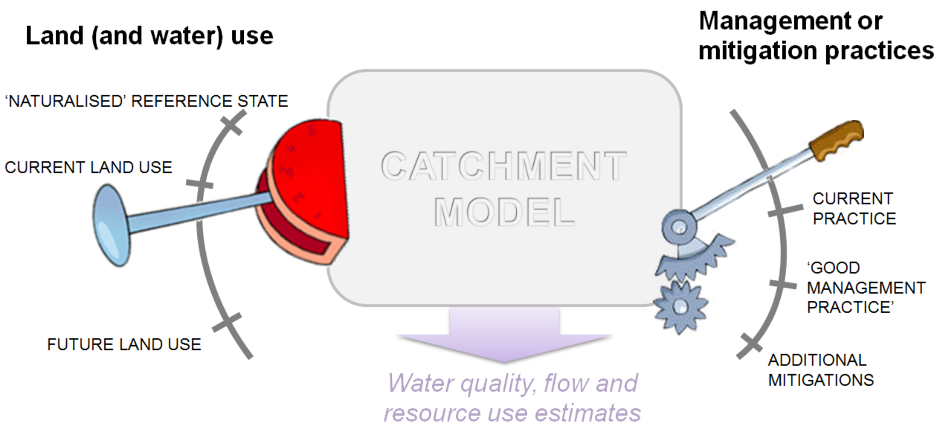
2 Catchment modelling and scenarios

The NPSFM requires us to set objectives and limits for freshwater quality and quantity to provide for freshwater values, and to implement methods in regional plans to meet those objectives and limits.[1] Bio-physical catchment modelling is used to test our ability to meet freshwater objectives given certain assumptions about future use and management of land and water (i.e. scenarios). This involves computer-generated estimates of in-river states, taking into account a range of inputs including land use and management scenarios, climate, soil type and monitoring data.

Catchment modelling will involve testing a range of exploratory scenarios (until early 2018). A more detailed solution-building stage may will also be needed to test a narrower range of scenarios (e.g. those that meet the desired objectives) in more detail (early 2018). During the solution building stage, the impact of climate change will be tested and staff will undertake more detailed analysis on the social, cultural and economic implications of management options.

The purpose of scenarios is to show how changes in land and water use and management may affect water quality and quantity. Informed by engagement with iwi, industry and community stakeholders, BOPRC staff will develop land and water use and management or mitigation practice scenario specifications for the initial stage of catchment modelling, as broadly represented in Figure 1 and Table 1.

Figure 1 – Catchment modelling: conceptual diagram



[1] Objectives are intended environmental outcomes (e.g. minimum flows or in-stream contaminant concentrations) and limits are the maximum amounts of resource use available for objectives to be met (e.g. water allocation limit or total contaminant load).

Table 1 – Conceptual definition of modelling scenarios and reference state (Workshop 6 will focus on A, B0 and C0 (and possibly D and E))

	A. Reference state ('Naturalised' land use and flow)	**A**		
		Current practice	***Mitigation and management practices:***	
			1.Good Management Practice (GMP)	***2. Good Management Practice plus other mitigation (GMP+)***
	B. Current land & water use	**B0 (status quo)**	B1	B2
Development	**C. Land & water use (C)**	**C0**	C1	C2
	D. Land & water use (D)	D0	D1	D2
	E. Land & water use (E)	E0	E1	E2

2.1 Baseline scenario (B0) - current land and water use and management practice

The Baseline scenario is used to:

1. make sure the catchment model matches reality as closely as possible;
2. explore future water quality and quantity issues and effects on freshwater values if there are no changes to land use, land use practice and water use.

You have previously seen and commented on a map of current land use (workshops 4 and 5) and maps of all consented water takes and discharges. When we model the baseline scenario, we make many assumptions, including:

- Current "average" land use practice in the catchment including stocking rates, nutrient inputs and the like, so that we can estimate actual water use and contaminant generation;
- Current actual water use;
- What happens to nutrients (e.g., uptake to plants, immobilisation, or movement down into the semi- saturated zone and in to groundwater, and then in to streams, lakes and wetlands.

We will provide you with full technical reports on all of these estimates when they are finalised. For now, we would **like you to use your knowledge of land and water use in your catchments to advise us on current land use practice assumptions affecting nitrogen generation** (sediment, phosphorous, *E. coli* will follow)**, and estimates of current actual water use.**

These are included in Attachment 1 and 2. Please be ready to discuss these in the workshop and you are welcome to give feedback in writing.

QUESTIONS

- In your opinion, do they reflect what is going on in the catchment, on average?
- Is practice in one part of the catchment so different from another part that we should have two different sets of assumptions for the same land use?
- If you think the assumptions are wrong, are you able to point us to some information/evidence that will support your opinion?

2.2 Development scenarios (C, D, E) – future land and water use

A development scenario is a **credible prediction of how land and water use might change in the future in the WMA**, based on current and anticipated industry, climate and other trends, **assuming no changes to regulation or incentives from Council**. It is used to model and explore what might happen to freshwater water quality and quantity, and to freshwater values, if this prediction of future were to happen.

Community group members provided some thoughts on credible future changes and trends at workshops 1 and 4. We are also using documented growth projections (e.g. growth areas mapped in the Regional Policy Statement), and discussing projections with industry organisations and large landowners to prepare a development scenario. **A working draft land use map and assumptions will be presented at the workshop for your input and feedback.**

Work towards identifying significant likely/potential land use practice changes and significant planned changes to point source discharges (e.g., Fonterra) and takes (e.g., Tauranga City water supply take) is also ongoing.

2.3 Reference state (A) – no human land and water use, or discharges from human activities

The purpose of the Reference State (no human land and water use or discharges), is **to estimate what water quality and flow would be like in freshwater bodies if no human activities were contributing contaminants or using/taking water**.

This is used to:

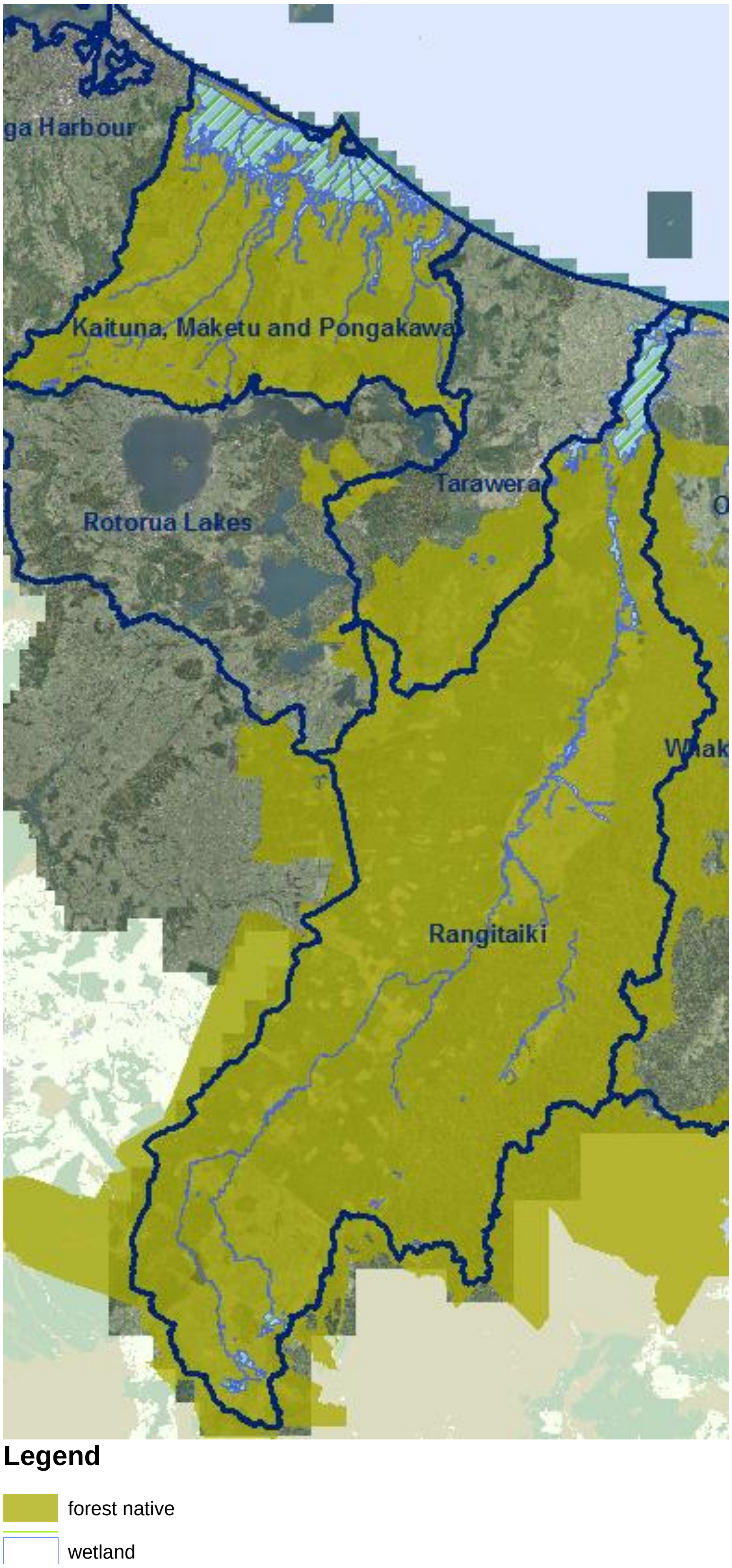
1. make sure we account for natural contaminant generation and flow, and use this when we then estimate all human-induced contaminants and changes in flow;
2. make sure any freshwater objectives we set for freshwater bodies are at least within the bounds of what could occur if there were no human induced contaminant generation or takes.

This reference state is <u>not</u> intended to be a plausible potential future scenario.

For the Reference State, we have:

- Removed all “human” made land uses and replaced them with “natural” land cover of native bush and wetlands, where these are believed to have existed historically (see Figure 2);
- Removed all water takes and point source discharges;
- Retained any existing/committed major modifications to the *structure* of the water bodies (but assumed no hydro-electric power scheme or pumping station operations) because we are only estimating contaminant generation and flow, e.g., the Rangitāiki River cut to the sea, Kaituna Diversion and Te Tumu cut, drains and canals, and dam structures remain in place.

Figure 2: Reference state land use layer - no human land use.



3 Use values

To date, we have:

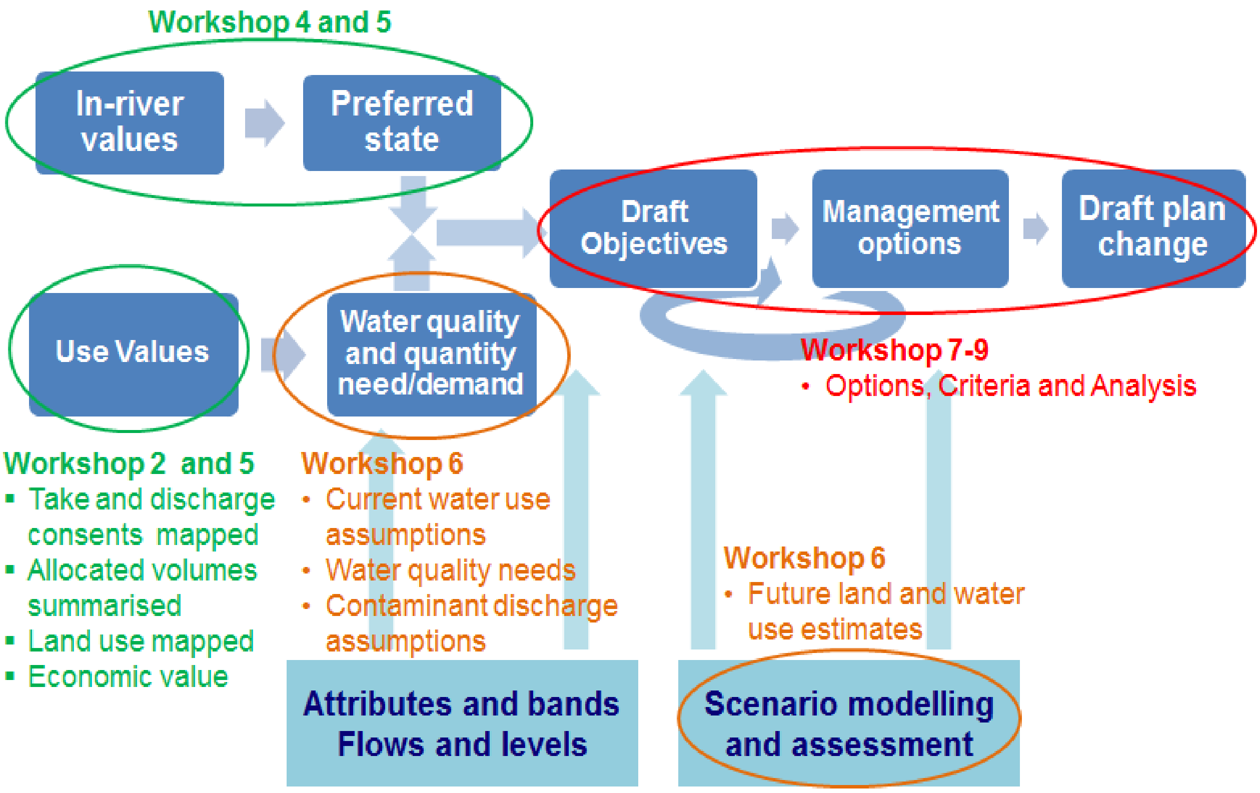
- named and listed types for freshwater uses and started to map these using land use maps, maps of consented discharges and takes, and the like.
- drafted an early, relatively high level summary of water allocation by industry and the contribution of industries to the economy and employment.

Initially, we are **assuming the preference is to provide for the reasonable water quality and quantity needs of all current and likely future use values.** We will discuss this during workshop 6.

When we work up Baseline and Development scenarios, we are essentially estimating a future where use values are provided for, so that we can estimate what this means for water quality and quantity, and other values (particularly in-river values). From this we start to explore the sort of change that would be required to support in-river and other values using mitigation scenarios.

When we work on mitigation scenarios and management options to address water quality and quantity issues, we will need to discuss "good" land, water and discharge management practices. Aside from the "walk on the wild side" exercise about possible management options (Workshop 5) we have not yet discussed that with you in any detail.

All management options will have costs and benefits for different freshwater values and different water users. We are developing criteria to help us to assess the pros and cons of management options, to support decision-making (you gave brief feedback during workshop 5). If timeframe allows, we will very briefly introduce and discuss these with you at Workshop 6.



Attachment 1: Land Use Practice assumptions for the Baseline scenario - current land and water use

The information below is largely drawn from an initial internal draft report 'Eco Logical Australia 2017. *APSIM Modelling of Farm System Nutrient Dynamics: Review of Modelling and Approach for the Bay of Plenty Region*. Prepared for Bay of Plenty Regional Council. Maize cropping assumptions are drawn from local consultant advice.

Dairy Farming

Modelled Farm and Herd - Landcorp Farming Limited (LFL), Upper Waikato catchment in the Wairākei-Lake Taupō area.

- Farm Size = 184 ha
- Herd Size = 456 (approximately 2.5 cows/ha across farm) *Note: feedback to date is that this should be 3.4-4 in KPW WMA. Further input is being sought from Dairy NZ*
- Average weight 450 kg
- Assumed feed requirements
  - Summer = 15 kg DM/cow/day
  - Spring = 14 kg DM/cow/day
- Pasture utilisation = 85%

Paddock and Feed Assessment

The paddock and feed assessment is used to:

1. Determine if the modelled farm is supported by APSIM modelled pasture growth
2. Determine the nitrogen return factors to account for seasonal pasture surplus and deficit and corresponding silage production or supplementary feed
3. Determine average rotation lengths to set grazing intervals in urine patch paddocks.

<u>Summer</u>

- Available pasture = 1200 kg DM/ha
- Average 4.2 rotations during summer (considered as Jan to April), based on test APSIM runs, model farm pasture growth rates and long term pasture growth rates (Dairy NZ).
- Requires 30 paddocks (120 days in season / 4.2 rotations = approx. 29 days per rotation + 1 paddock used to grow high energy forage crop for winter consumption)
- Each paddock would therefore be 184 ha /30 = 6.13 ha
- Total feed required per paddock on a grazing day = 456 cows x 15 kg DM/cow/day x (1/85% utilisation) = 8047 kg DM
- Feed available in paddock = 1200 kg DM/ha x 6.13 ha = 7356 kg DM
- Additional feed required = 691 kg DM/ha or 9% of available feed
- Assume that supplementary feed is maize or other lower protein feeds at 60% of pasture protein.
- Summer default N return factor = 0.72 x (1.09 x 0.6) = 0.75

<u>Spring</u>

- Paddock number and size assumed to be limited by summer availability – therefore 30 paddocks available at 6.13 ha (paddock withdrawn during summer for fodder crop growth available for pasture in spring)
- Feed available in paddock = 1200 kg DM/ha x 6.13 ha = 7356 kg DM
- Total feed required per paddock on a grazing day = 456 cows x 14 kg DM/cow/day x (1/85% utilisation) = 7510 kg DM
- Deficit considered negligible – no supplement required (to be modelled) on paddock
- Average 5 rotations during spring (considered September to December)

- Requires approximately 24/30 paddocks for herd grazing (122 days in season / 5 rotations)
- Therefore 6 paddocks used for silage production (no excreted nitrogen)
- Spring N return factor – 0.72 (default) x 24/31 = 0.58

Winter

- Requires 120 days feed overall
- Typically 1 grazing event per paddock during winter (considered May to August)
- Assume 50% intake (not milked)
- Therefore grazing event maintains the herd for 2 days. Therefore 60 days in winter supported by pasture
- Fodder crop yield of 6.13 x 10 tonnes/ha = 60000 kg. Equivalent to 15 days feed
- Silage produced during spring = 6 paddocks x 5 rotations x 7356 kg DM = 220680 kg DM
- Silage can support 60 days grazing (45 days needed).
- Total supplements fed = 225000 kg DM
- Nitrogen content of supplement = 3% = 6750 kg N consumed
- Nitrogen excreted from supplement = 6750 kg N consumed by 0.72 N return = 4860 kg N excreted
- Nitrogen returned by ha = 26 kg N/ha, which includes 16 kg N/ha urinary and 10 kg/ha
- faecal excretion

Urine Patches

On dairy farms urine excreted from cattle is the primary source of leached nitrogen, hence appropriate treatment of urine patches in the models is a primary objective of modelling of dairy farms. Several New Zealand studies have suggested that urine patches are deposited on approximately 3-5% of a paddock within a given grazing event (Chicota, et al., 2010). Over multiple grazing days throughout a year approximately 15-25% of the paddock can be affected by urine patches. The greatest leaching typically occurs from patches deposited during late summer and autumn. Leaching from overlapped urine patches is typically 40% greater than single urine patches (Romera et al 2012).

Our approach to account for the effects of urine patch nitrogen loads involves use of background' (i.e. no urine deposited) and 'urine patch' paddocks which are then spatially weighted. The following steps through issues considered in our approach and how these have been reconciled in the modelling.

1. Urine Patch coverage in a single grazing event - urine patches affect 3-5% paddock on a given grazing day (Chicota et al 2010); we model urine returned to 4% of the paddock. As pasture is consumed evenly over 100% of the paddock (as modelled) and returned to 4% of the paddock, the amount of N returned through urine is 25 x higher than what is consumed from that part of the paddock. This concentrated return can be modelled by adjusting the nitrogen return factor within the AgPasture management module.
2. Method to model concentrated urine return – we model the grazing of pasture over the entire paddock and the concentrated return of urine to patches covering 4% of the paddock (on that given grazing day) as follows:
    a) Multiply the 'default' nitrogen return (0.72 for dairy, 0.85 for sheep/beef) by any factors accounting for pasture harvested as silage across all paddocks (reduces default) or by additional supplement fed (increases default, assume lower protein feeds for supplement).
    b) Multiply (a) by the utilisation factor (0.85 for dairy, 0.7 for sheep and beef) to account for uneaten pasture (calculations as part of (a) account for incomplete utilisation of pasture)
    c) Multiply (b) by the proportion of urine – 60%
    d) Multiply (c) by 25 to account for concentration of urine in 4% of the paddock
    e) Set proportion of N returned through urine to 1 (100%). The additional amount that would also be deposited as manure is considered negligible.

f) For all other months set N return factor to background levels by multiplying (a) by 0.4 (40% manure). Set proportion of urine to 0 for these months.

g) Accounting for supplement fed during winter – we currently use a fertiliser application (urea) to represent the returns from supplements fed on the paddocks during winter (May-Aug). The amount applied accounts for the amount fed, excreted, and the proportion of urine vs manure. The contribution of this feed source within the urine patches is modelled by multiplying supplement returns for applicable months by 25. A separate manure application (to surface organic matter pool) is also applied to account for faecal returns from supplement.

3. Annual urine patch coverage - estimates of yearly urine patch coverage range from 14-35% (Chicota et al, 2010; Moir et al 2010; Dennis et al 2011, Romera et al 2012), with most studies reporting 20-25%. We have adopted a figure of 25% urine patch coverage. This represents the accumulation of urine patches within the paddock through multiple stock rotations during the year.

4. Urine Patch Overlap – relative proportions of urine patch overlap are based on Romera et al (2012), who found approximately 23% of urine affected area was affected by multiple urinations. As we assume that 25% of the paddock is affected by urine patches, then (0.23 x 25%) approximately 5% of the paddock area is affected by multiple urine depositions, and 20% of the paddock is affected by a single urination (25% minus 5%).

5. Spatial weighting of urine patch and background sub-models – From the total paddock area impacted by single and multiple deposition of urine patches over a year (see (#3) and (#4)) we have adopted the following spatially weighted sub-models for the dairy modelling:

   a) No urine patches (background)– 75% of paddock area

   b) Impacted by a single urine patch – 20% of paddock area

   c) Impacted by multiple urine patches over a year – 5% of paddock area

6. Impact of different timings of urine patch deposition – Vibart et al (2015) report that the greatest contribution to nitrogen leaching is from urine patches deposited during summer and early autumn. We tested this using a preliminary dairy model where urine was deposited in selected Preliminary Results – Based on median years/stations leaching rates have increased by approximately 25% compared to the uniform return model (with fodder crops also included as a spatially weighted sub-model) for the dryland dairy, and by approximately 40% for the irrigated dairy. Table 3-2, below, shows selected percentiles for yearly NO3 leaching. Based on this information we have modelled three sub-paddocks to account for the heterogeneity of urine patch deposition and leaching impact. These were spatially averaged based on typical coverage:

7. Based on the analysis in #4, deposition in February and Winter was selected to represent multiple urinations (median leaching of overlapping set) and January was selected to represent leaching of single urine patches. These periods, along with the background model are applied as spatially weighted sub-models as per #5.

8. Differences between background and urine patch pasture growth – The increased nitrogen return to urine patch models results in higher pasture growth and more frequent triggers to graze (and thus return N). To control for this the grazing interval for urine patch models were fixed based on typical recurrences seen in the background model (approximately 30 days for summer and 24 days for spring; winter allowed to run on the available pasture trigger). It is acknowledged that there will still be some variation between the number and timing of graze/return events between the background and urine patch models; however, this has been deemed to be within the bounds of our modelling precision.

Three sub-paddocks were modelled to account for the heterogeneity of urine patch deposition and leaching impact. These were spatially averaged based on typical coverage:

Sub-paddock 1 – Background (75% of paddock area)

- No urine deposition
- Manure deposited on each grazing event
- Fertiliser applied
- Used to ensure yearly harvest supports modelled herd.

Sub-paddock 2 – Single or Low-Leach Urine patch (20% of paddock area)

- Represented by urine patches deposited in January based on selection of ‘upper middle’ yearly

- leaching rate from test models of urine deposited in single alternating months
- Grazing during January results in urinary and faecal n returned to soil
- Grazing during other months only results in faecal n returned to soil
- Timing of gaze events and mass of pasture consumed on paddock based on typical intervals and harvest of background sub-paddock (i.e. fixed days between graze and fixed harvest amount).
- Fertiliser applied as per background paddock

Sub-paddock 3 – Multiple or High Leaching Urine Patch (5% of paddock area)

- Represented by urine patches deposited during February and in winter (i.e. June-August), based on the middle yearly leaching rate from selected trials of urine deposition on two months of the year
- Grazing during February, June or July results in urinary and faecal n returned to the soil
- Grazing during other months only results in faecal n returned to the soil
- Timing of gaze events and mass of pasture consumed on paddock based on typical intervals and harvest of background sub-paddock (i.e. fixed days between graze and fixed harvest amount).
- Fertiliser applied as per background paddock

Component/Variable	Value	Justification	References
Manager Folder			
Fertilise on Fixed Dates (for pasture blocks)			
FertiliseOnFixedDates – Application Dates	1-mar 1-apr 1-jul 1-aug 1-oct 1-nov	Avoid application during low plant response	
FertiliseOnFixedDates – Application Depth	10		
FertiliseOnFixedDates – Amount Applied (type)	200 kg N/ha/yr (urea_n)	DairyNZ FarmFact 7/11	Agribusiness OVERSEER model – pasture block reports
Fertilise on Fixed Dates (in lieu of effluent addition)			
FertiliseOnFixedDates – Application Dates	1-jan 1-feb 1-mar 1-apr 1-sep 1-oct 1-nov 1-dec	Regular stir and spray during spring and summer only	Agribusiness OVERSEER model – pasture block reports
FertiliseOnFixedDates – Application Depth	3	Surface application via spray	
FertiliseOnFixedDates – Amount Applied	19 (urea_n)	Agribusiness modelling assumed application of 64 kg N/ha over 57 ha of the farm. We assume the same quantitiy of effluent applied uniformly across paddocks, therefore: 64 kg/ha x 57 ha/190 ha of effluent application = 19 kg N/ha/yr	
Fertilise on Fixed Dates (in lieu of urinary-N from supplement consumption)			
FertiliseOnFixedDates – Application Dates	15-jun	Applied once during winter	
FertiliseOnFixedDates – Application Depth	90	Average of urine1 and urine2 application depths in AgPasture module (account for centre vs edge of patch, splash and direct stream)	
FertiliseOnFixedDates – Amount Applied	68 (urea_n)	17 kg N/ha urinary-N (from Paddock and Feed Assessment) x (1/4% paddock coverage during single grazing) = 68 kg N/ha/yr	
Manure on Fixed Dates (in lieu of faecal-N from supplement consumption)			

Component/Variable	Value	Justification	References
ManureOnFixedDates – Application Dates	May 15, June 15, July 15, August 15	Entered as day of year in block script	
Manure amount	60 kg/ha	Total manure set so that N returned from manure = 11 kg N/ha divided by 4 applications = approx. 3 kg N/ha per application i.e. Manure kg/ha = 3/(ratio of N to C) = 3/(1/20) = 60 kg manure/ha	
Manure CNR	20	default	
Rotational Grazing Between Two Limits *Time intervals added through following alterations to management module script:* • *Change 'Todays Date' parameter to a 'Day of Year' range* • *Replicate script block using if/elseif/else based on different time periods* • *Alter upper amount, lower amount, and dm_frac directly in script block*			
Herbage to Start Grazing [upper_amount]	(i) 2700 (Sep – Apr) (ii) 2200 (May - Aug)	(i) Approximately 2.5 leaf stage ryegrass height (Dairy NZ 2011) (ii) Slightly under mass representing 3-leaf stage of ryegrass development during winter (recommended benchmark) - Dairy Australia (2016).	
Herbage to End Grazing [lower_amount]	(i) 1500 (August – Apr) (ii) 1200 (May– July)	(i) Dairy NZ recommended residual (Dairy NZ 2008, 2011) (ii) Reduced residual ok in winter due to reduced carbohydrate usage (Dairy NZ 2011)	
Daily amount or remove once (-1) [amount]	(i) -1 (Sep – Apr) (ii) 600 (May – Aug)	(i) Assume optimal stocking rate for summer graze (12-24 hour stay) – paddocks assumed to be sized to enable feed demand to be met (ii) See Paddock and Feed Assessment for pasture demand calculations	
Fraction Returned as Excreta [dm_frac]	0.72 (default dairy return factor). This is multiplied by the following factors (i) Summer = 0.75 (ii) Spring (Sep – Dec) = 0.57 (iii) Winter (May – Aug) – 0.72 (iv) Urine return month = multiply the above factors by 12.75	(i) Default + 7% additional feed required as supplement (i.e. 7% more excretion than is grazed from pasture). Feed assumed to be lower protein such as maize. Assume 60% of pasture crude protein. Therefore N return in summer = = 0.72 x (1+(0.07*0.6) =0.75 (ii) Default x # of paddocks required for spring regrowth interval. Remainder of paddocks to silage with no excrement return = 0.72 x 25/31 paddocks (based on average pasture regrowth for spring in trial APSIM runs) = 0.57 (iii) Default N return used as additional supplement is accounted for using an additional fertiliser and manure application (iv) Includes the following calculations: (a) Any factors considered in (i) to (iii) above (b) Multiply by 0.6 (60% of excreted N as urine) (c) Multiply by 85% pasture utilisation (uneaten pasture will not contribute to excreted N) (d) Multiply by 25 (urine deposited on 4% of paddock area so urine patches have 25 x the N excreted than was consumed from the corresponding area)	Powell and Rotz (2015) Castillo (2000) FAO (1996)
Fraction of Returned N in Urine [urine_n_frac]	Default = 0.6 (i) Background paddocks = 0 (ii) Urine return month(s) = 1	AgPasture default/FAO (1996) (i) Manure assumed to be uniformly deposited (ii) N returned through manure considered negligible in comparison to urine patch	FAO (1996)
Urine Deposit Depth	200		

Sheep and Beef

Paddock and Feed Assessment

The sheep and beef model is designed to replicate available OVERSEER modelling (Agribusiness Group 2015) of the Ministry of Primary Industries Waikato – Bay of Plenty Sheep and beef Farm Monitoring Model. The approach described for the Dairy model has been adapted to account for different herd management and stocking within a sheep and beef farm. The main changes include:

- Sheep and Beef farm stocked at approximately 36% of dairy farm based on revised stock units and monthly pasture consumption within AgriBusiness OVERSEER modelling.
- Therefore, the same pasture target and residuals as for Dairy, however, pasture consumed over three days

Treatment of Urine Patches

- Urine patches from beef cattle assumed to be major source of leached N
- Urine patches from sheep more evenly spread and less volume than those from cattle. Bell et al (2012) suggest that the return of excrement within sheep grazing systems can be considered uniform for stocking rates up to 1200 sheep/ha. The modelled stocking rate (paddock maximum) is well below this density. Nitrate leaching at 60cm below sheep urine patches is less than 3% of that under cattle urine patches (Williams and Haynes 1994). Therefore we assume that sheep urine is largely taken up by pasture.
- Modelling of urine patches assumes deposition during January – corresponds with the peak of cattle stocking and period of higher leaching impact. Due to minimal cattle on farm during winter we do not model winter urine deposition.
- Assume reduced urine patch coverage over the year due to the lower cattle stocking rate. We use a figure of 15% of paddock coverage. Therefore, the following sub-paddocks are modelled:

Sub-paddock 1 – Background (85% of paddock area)

- No urine deposition
- Manure deposited on each grazing event
- Fertiliser applied
- Used to ensure yearly harvest supports modelled herd.

Sub-paddock 2 – Single or Low-Leach Urine patch (15% of paddock area)

- Represented by urine patches deposited in January based on the peak of cattle stocking within the summer/autumn period (shown to be the time period associated with the greatest risk of leaching).
- Grazing during January results in urinary and faecal n returned to soil
- Grazing during other months only results in faecal n returned to soil
- Timing of gaze events and mass of pasture consumed on paddock based on typical intervals and harvest of background sub-paddock (i.e. fixed days between graze and fixed harvest amount).
- Fertiliser applied as per background paddock

Component/Variable	Value	Justification	References
<u>Manager Folder</u>			
Fertilise on Fixed Dates (for pasture blocks)			
FertiliseOnFixedDates – Application Dates	1-sep 1-nov 1-apr	From OVERSEER modelling	Agribusiness (2015)
FertiliseOnFixedDates – Application Depth	10		
FertiliseOnFixedDates – Amount Applied (type)	100 (urea_n)	Lower than dairy farm due to reduced pasture consumption, both from lower stocking rate and lower pasture utilisation. Corresponds with value used in Agribusiness OVERSEER modelling	Agribusiness (2015)
Manure on Fixed Dates (N excreted from consumption of feed supplements during winter)			
FertiliseOnFixedDates – Application Dates	15-may 15-jun 15-jul 15-aug		
Amount manure to apply (kg/ha)	50	From feed calculations	
Manure CNR	20	Module default	
Manure CPR	50	Module default	
Rotational Grazing Between Two Limits *Time intervals added through following alterations to management module script:* • *Change 'Todays Date' parameter to a 'Day of Year' range* • *Replicate script block using if/elseif/else based on different time periods* o *Summer – Jan to Apr = (day >= 1) and (day <= 120)* o *Winter – May to Aug = (day >=121) and (day < 214)* o *Spring – Sep to Dec = (day >= 215) and (day <= 365)* • *Alter upper amount, lower amount, and dm_frac directly in script block*			

Component/Variable	Value	Justification	References
Herbage to Start Grazing [upper_amount]	(i) 2800 (Sep – Apr) (ii) 2400 (May - Aug)	(i) 2800 represents approximately 2.5 leaf stage ryegrass height (Dairy NZ 2011) (ii) In winter 2400 kg DM/ha approximates the 3-leaf stage of ryegrass development (recommended benchmark) - Dairy Australia (2016)	Dairy Australia (2016) Dairy NZ (2011)
Herbage to End Grazing [lower_amount]	1500	Beef/lamb industry recommendations	
Daily amount or remove once (-1) [amount]	-1		
Fraction Returned as Excreta [dm_frac]	0.8 (default dairy) (i) Summer (Jan – Apr) – 0.8 (ii) Spring (Sep – Dec) – 0.72 (iii) Winter (May – Aug) – 0.8	(i) Default (ii) Default – 15% of pasture to silage = 0.8 x 85% = 0.72 (iii) default	AgPasture documentation
Urine Deposit Depth	200		

Kiwifruit

- Growth Nov-Apr. Dormant after leaf drop in winter
- Stems pruned in winter
- Soil N uptake flowering to harvest Dec – Apr
- 110-120kg N/ha x2 applications Oct and Nov
- Older vines can buffer for short term N shortage

Plant Physiology	**Kiwifruit**	***Management Implications and Impact on Soil Water/Soil N***
Evapotranspiration and water demand	Evapotranspiration • approx. 900mm/yr (Deurer et al) over growing season • agrees with daily evapotranspiration reported by Judd et al (1986) – 4.8 to 6.1 mm • Silva et al reported 2.5 to 5.5 mm per day Kiwifruit grows preferentially on well-drained soils. Drainage below root zone – approx. 300-400 mm/yr in BoP region (Deurer et al. 2011)	Although moderately high water use, only approx. 30% of BoP orchards are irrigated • Rainfall significantly higher than evapotranspiration • High soil water storage
Soil N demand, N partitioning and remobilisation	• Early season growth requirements met by N remobilised from senescing leaves of previous season. Uptake mainly from flowering to harvest. • Based on studies of fruit N content and also N tracer studies it is estimated that approximately 50-60% of N added to soil is recovered by plant (e.g. Tagliavani et al 1999, Ledgard et al 1992). This may be higher due to 'priming' and 'pool substitution' effects (Morton 2013, Jennkinson et al 1995). • Kiwifruit can take up N in excess of demand (supply driven uptake). Therefore older vines can buffer for short term N shortages	• Soil N uptake following flowering until harvest (Dec-April). • Fertiliser applied (110-120 kg N/ha) over two applications October/November to supplement/replace root N losses and increasing N concentration in leaves and fruit (Kotze and de Villiers 1989). • Much of the applied fertiliser N is expected to be utilised, however, significant high soil moisture after application could result in leaching of fertiliser N. • Organic orchards apply N requirements through composts, liquid fish products, and less frequently, foliar sprays (slow release).

Component/Variable	Value	Justification
Manager Folder		
Sow		
Sowing date	13-may	
Sowing density (plants/m2)	1	vine test simulation provided
Sowing depth (mm)	50	vine test simulation provided
Row spacing (mm)	3100	vine test simulation provided
Max crop cover	0.5	vine test simulation provided
Bud Number (/Plant)	92	vine test simulation provided
Harvest		
Trigger to harvest (from script)	Growth stage = senescent	
Harvest action (from script)	Prune	Trigger for plant to move to 'bare' and begin dormancy

Arable – Maize

- One crop per year - harvest window is approx. 135-140 days
- Planted from 25 September when soil temps >14 degrees
- Maize yield: 18 – 23 T dry matter/ha/yr in lowlands, and around 14 – 16 T up around Rotorua
- After harvest: fields sown with rye grass which is grazed once over winter, and then harvested for grass silage in spring
- Yield from the rye grass 2.5 – 3.0 T DM/ha for the grazing and another 2.5 – 3.0 T DM/ha for the grass silage
- Total yield from the cropped land is in the range of 23 – 32 T DM/ha in the lowlands
- The fertiliser regime:
  - 200 kg/ha DAP by mid-October (18% N)
  - 350kg/ha urea or Sustain N as a side dressing in late Nov or Dec (46% N)
  - 150kg/ha DAP in March when re-sowing in rye grass (18% N)
  - 100-125 kg/ha urea or sustain N in late May (46% N)
  - 100-125 kg/ha urea or Sustain N in late July or August (46% N)
  - In addition, potentially also use MOP, Kaeserite and Calmag fertiliser products

Vegetables

Seeking further info from Plant and Food Research. Current APSIM info based on sweetcorn/ broad bean rotation:

- Summer sweetcorn (sow Oct-Jan)
- Winter broad beans (sow May-July)
- Each fertilized with 50kg N/ha at planting
- Approx. yields
- 15t/ha sweet corn
- 4 t/ha beans
- Leaching (all soils/years) – approximately 31 kg N/ha

Component/Variable	Value
Manager Folder	
Sow using a variable rule – Sweet Corn	
Start sowing window	15-oct
End sowing window	1-jan
Cultivar	Dekalb_xl82
Must sow	yes
Sowing density (plants/m2)	100
Sowing depth (mm)	30
Row spacing (mm)	250
Fertilise at sowing – Sweet Corn	
Amount of starter fertiliser (kg/ha)	50

Component/Variable	Value
Manager Folder	
Sow using a variable rule – Fababean	
Start sowing window	15-May
End sowing window	10-jul
Cultivar	fjord
Must sow	yes
Sowing density (plants/m2)	25
Sowing depth (mm)	30
Row spacing (mm)	250
Fertilise at sowing – Fababean	
Amount of starter fertiliser (kg/ha)	50

Forestry

- Summer planting – January
- Sowing density – 1000

Component	Value
Soil Organic Matter	
Root C:N ratio	60
Root Weight	1000
Soil C:N ratio	14
OC Total %	0-10 = 5, 10-30 = 4, 30-60 = 4, 60-100 = 2, 100-120 = 1, 12-150 = 0, 150-180 =0
Surface Organic Matter	
Mass	3500
C:N ratio (cnr)	40

Manager Folder	
Planting Rule – Planting Date	01-jan
Planting Rule – Sowing Density	1000

Attachment 2: Actual *irrigation* water use assumptions for the Baseline scenario

Below is the Executive Summary of: Williamson Water Advisory (2017). *Kaituna and Rangitāiki SOURCE Catchment Models: Actual irrigation water use modelling.* Prepared for Bay of Plenty Regional Council. WWA0033 | Rev. 2. 13 July 2017. Further work will estimate animal drinking water (based on stocking rates), municipal and domestic drinking water use, and takes of water that are permitted without a resource consent by the Regional Water and Land Plan (Plan Change 9). Industrial and commercial takes are modelled base on consent monitoring records.

Bay of Plenty Regional Council (BOPRC) commissioned Williamson Water Advisory (WWA), Hydrology and Risk Consulting (HARC) and Eco Logical Australia (ELA) to develop integrated catchment models for the Kaituna and Rangitāiki Water Management Areas. The models are being developed using the eWater SOURCE modelling framework.

The development of the integrated catchment models requires data on actual water use within the catchments, as any significant water abstractions are likely to influence the catchments' water balance and flow regimes. As measured water use data was not available over the entire model period, a modelling approach was taken to estimate actual irrigation water use over time for each of the sub-catchments of the Kaituna and Rangitāiki Water Management Areas.

The modelling approach comprises the estimation of irrigation water demand from climatic conditions and the resulting soil moisture conditions. The Soil Moisture Water Balance Model (SMWBM) was used to simulate the climatic drivers and the soil moisture content, with the Irrigation Module of SMWBM used to calculate the soil moisture dynamics during the irrigation season based on specified irrigation application depths and rules governing when to start and stop irrigating.

The following assumptions have been made for the calculation of irrigation water use:

- Farmers irrigate efficiently, i.e. apply small amounts of irrigation water frequently. For kiwifruit, 10 mm of water are applied whenever the soil moisture falls below 50% of plant available water; for pasture, 3.5 to 4.5 mm of water (depending on the optimum for each area) are applied whenever the soil moisture falls below 50% of plant available water.
- Application efficiency is 80 percent; i.e. irrigators abstract 20 percent more water than required to maintain soil moisture at appropriate levels due to system losses.
- Actual irrigated area is 80 percent of consented irrigated area.
- A daily water cap on water use is applied based on annual consented volume and average number of irrigation days.

Telemetered water use data were compared with modelled water use for some individual users and showed reasonable agreement although some slight over-estimation. Error components include recorded irrigation area, soil type utilised, land of representative soil moisture calibration data, differences between actual and modelled application rate and frequency; differences in rainfall on a paddock scale compared to the catchment scale utilised in the model.

For each SOURCE sub-catchment that contains consented water takes, time series of daily irrigation water use were generated by aggregating individual water users. Separate time series were generated for water use from groundwater and surface water. These time series are then assigned to water user nodes in the SOURCE models of the Kaituna and Rangitāiki Water Management Areas (WMA).