APPENDIX E

Conceptual Design

Meatworks Effluent Discharge Conceptual Design

Prepared for

AFFCO NZ, Manawatu

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Meatworks Effluent Discharge Conceptual Design

AFFCO NZ, Manawatu

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1 EXECUTIVE SUMMARY

AFFCO NZ, Manawatu (ANZ) operates a beef processing plant on Campbell Road, Feilding. As part of the operation meatworks effluent (MWE) is produced which requires treatment and discharge. MWE is treated through a series of anaerobic and aerobic ponds. An existing discharge system directs a portion of the MWE produced to the Oroua River and a portion to a land application system on an adjacent farm (Byreburn Farm).

In addition to MWE, there are a number of organic sludges and solid materials that require management.

The existing MWE discharge system needs improvement to:

- Reduce the effect of the discharge to the receiving environment;
- Increase the recovery of water and nutrients in the land treatment system and therefore improve pasture production without fertiliser addition;
- Provide a system which minimises risk of resource consent non-compliance; and
- Is straight forward to operate for both land manager and treatment plant.

This report describes a design concept for an improved MWE combined land and water discharge (CLAWD) system for the plant's discharge. The design has been optimised to provide the greatest amount of operational flexibility, while reducing the environmental effects of the discharge. The CLAWD comprises three components being:

- Discharge to land;
- Discharge to the Oroua River; and
- Provision of pond storage.

The development of the discharge regime was based on daily data for a 20 year period. It was assumed that over the term of the consent MWE flows could increase by 20 %. No nutrient reduction was factored into the increase which enabled the evaluation of a "worst case scenario". This approach helps to make sure that ANZ can achieve the proposed environmental improvements while allowing the business to expand sustainably if and when required. In reality, any increased production is likely to be somewhat offset by improvements in the water management, and as a result there is not likely to be a direct correlation between increased stock processed and water use/wastewater production.

Despite the proposed 20 % increase in wastewater volume, for the river discharge only a 10 % increase in the volume discharged to river is planned to occur. This is achieved due to the improved irrigation management and extra land available, with the remaining 10 % increase being applied to land. It is important to note that while an increase is proposed in the volume discharged to the Oroua River, the proposed changes to the discharge regime result in a reduced potential for adverse effects overall compared to the currently consented lesser flow discharge regime. For instance, in an average year, and allowing for the 20 % increase:

- The actual days of river discharge are reduced from 166 (currently) to 127;
- The volume of MWE discharged below the 20th flow exceedance percentile (20FEP) reduces from ~76,000 m^3/year (currently) to ~18,000 m^3/year (76 % less); while
- The discharge during high river flows (>20FEP) increases from ~39,000 m^3/year to ~109,000 m^3/year (280 % more).

It is by confining the discharge to high flows wherever possible that adverse effects due to the discharge can be avoided. This results in nutrient loading occurring during the river flows which are considered sensitive reducing from 9.5 tonnes N/year to 2.2 tonnes N/year, and from 1.5 tonnes P/year to 0.3 tonnes P/year being discharged below 20FEP.

The available land area for MWE application is to be increased from the current system. There are different limitations and land management considerations for the available area. As a result the land has been divided into land management units (LMU) based on the parameter that is most limiting to MWE application. The LMUs are as follows:

	LMU 1	LMU 2	LMU 3	LMU 4
Description	Byreburn existing (rotorainer)	Byreburn existing	Byreburn new	AFFCO and Dalcam Trust
Area (ha)	56	40	33	13.4
Limiting parameter	P load (60 kg P/ha/year)	Instantaneous hydraulic / P load	Instantaneous hydraulic load	N load (100 kg N/ha/year)

A detailed optimisation procedure was undertaken to minimise environmental effects that could be achieved with the proposed MWE discharge volumes. The final design has been assessed to have effects that are not more than minor on the land, groundwater and surface water. This assessment of environmental effects will be reported elsewhere.

On any day that the MWE treatment system is operating the potential for a discharge to occur is assessed by:

Discharge Location	Criteria to be met	Determined from	Rate of discharge
Land application	Cumulative nutrient loading not exceeded	Continuous record (manual entry)	Discharge at a rate of up to 34 mm/event for LMU 1 or 12 mm/event for LMU 2 - 4
	Soil moisture not more than 1 mm below field capacity following irrigation	Climate data or soil moisture probes	
	Present land use compatible (no harvest, no stock present etc.)	As planned with land manager	
If no discharge to land can occur then:			
River discharge	Date is 1 April to 30 November	Calendar	
	River is above median flow (MF)	Oroua River @ Kawa Wool flow record	Variable rate based on P load to river
	River is above 20th flow exceedance percentile (20FEP)	Oroua River @ Kawa Wool flow record	3,000 m^3/day
If no discharge to land or river can occur then:			
Storage	Store MWE		

The regime proposed results in the following outputs for an average year:

	LMU 1	LMU 2	LMU 3	LMU 4	River
Max volume (m^3/year)	114,000	100,000	98,700	10,075	-
Max application depth (mm/year)	250	250	300	75	-
Max N Load (/year)	360 kg N/ha	360 kg N/ha	400 kg N/ha	100 kg N/ha	-
Max P Load (/year)	60 kg P/ha	60 kg P/ha	66 kg P/ha	17 kg P/ha	-
Average volume (m^3/year)	64,000	61,000	50,100	7,620	126,465

	LMU 1	LMU 2	LMU 3	LMU 4	River
Average application depth (mm/year)	152	152	152	59	-
Average N Load (/year)	203 kg N/ha	203 kg N/ha	202 kg N/ha	76 kg N/ha	15.56 tonnes
Average P Load (/year)	34 kg P/ha	34 kg P/ha	33 kg P/ha	13 kg P/ha	2.40 tonnes
# discharge events	Up to 7	Up to 20	Up to 25	Up to 7	127

The average annual volume of MWE produced may increase to 307,400 m^3, of which 128,100 m^3 (42 %) is predicted to be discharged to the river. As indicated in comparison with the table above there is the ability to apply more MWE to land (maximum) than what is generated in an average year i.e. less total MWE is discharged in an average year than the maximum irrigation capacity available over the given land area. This is because as the summer irrigation occurs the amount discharged to land empties the storage pond more quickly than MWE from the plant fills it up, despite the large storage volume. The consequence is there is insufficient MWE to supply the maximum land application (irrigation) requirements when irrigation is actually possible.

A result of this limited application over the irrigation period is that additional nutrients are expected to be needed for optimum plant growth. These additional nutrients may be in the form of dairy effluent, conventional fertiliser or organic amendments from the ANZ plant (pond sludge, composted punch grass).

There is more land available than what is needed in any one year to apply the MWE at the nominated rates. The use of this additional land and the distribution of MWE between the LMUs can be varied to assist with management flexibility, including the ability to not irrigate some areas in a given year. It also provides the opportunity if needed to apply organic amendments from the ANZ plant. The proposed regime also allows for staged development of the irrigation areas without compromising the land or increasing the river discharge i.e. by applying the maximum discharge on the existing areas the additional areas can be developed as flows increase. This means that rather than increasing the nutrient loading rates a greater portion of the available land area can be used in any one year.

Should nutrient loading rates over the entire area reach a level deemed to be too great for grazed pasture (250 kg N/ha/y), then a partial or dedicated cut and carry component can be introduced to increase the nutrient removal capabilities, thereby allowing a higher nutrient loading rate on those areas without compromising environmental performance. The extent of nutrient removal by harvesting would be in direct proportion to the increase in nutrient application over what would be expected from grazing alone. For example if a nutrient loading of 310 kg N/ha occurred in any year, then there would have to be harvesting of hay/silage to remove 60 kg N/ha (i.e. about 1,200 kg DM/ha removed).

In order to manage the discharge regime on a day to day basis (management decisions) and to determine that the system is in compliance with consent conditions (environmental), a programme of monitoring is needed. The existing monitoring programme will fulfil a number of the information requirements. Some of the currently measured parameters are not needed for future monitoring. Some additional – predominantly automated monitoring will be needed.

2 INTRODUCTION

2.1 Background

AFFCO NZ, Manawatu ("ANZ") operates a beef processing plant on the outskirts of Feilding township. As part of the operation meatworks effluent ("MWE") is produced. The MWE is treated and then discharged to the environment, specifically to adjacent land and to the Oroua River. The discharge of MWE must be conducted in a manner that results in no effects that are unacceptable to the receiving environment. To this end, resource consent conditions must be met, which in turn reflect the requirements of Horizons Regional Council's One Plan.

ANZ has engaged Lowe Environmental Impact ("LEI") to determine an optimal scenario under which a combined land and water discharge ("CLAWD") system can work which minimises environmental effects while enabling flexibility in plant operation and land use. A conceptual design for the scenario details the key inputs, management processes and outcomes of the CLAWD system.

2.2 Scope

This report outlines a conceptual design for a CLAWD system to enable the discharge of meatworks MWE from the ANZ plant.

The report covers:

- Section 3 describes the development of the ANZ CLAWD concept;
- Section 4 summarises the treatment plant and discharge material;
- Section 5 describes the river discharge component;
- Section 6 describes the land application component;
- Section 7 outlines some land management considerations; and
- Section 8 outlines monitoring needs for the system.

While every attempt is made to ensure that the proposed scenario accurately reflects the performance and management of the system, the details given are contingent on the accuracy and completeness of information supplied to LEI.

Criteria and parameters adopted in this report are conservative and there may be scope for refinement at the detailed design stage. Detailed design is not able to be completed until resource consents are decided.

3 DEVELOPMENT OF THE CONCEPT

3.1 Existing Reporting

A range of source material has been used in the development of the CLAWD system. Information specific to the site and relied upon for this report includes:

- LEI report: Site Investigation for Land Treatment Suitability (July 2014);
- Wastewater data: "AFFCO Manawatu Consent Monitoring Data-with AvO modelling" (Albert van Oostrom, 2013); and
- Previous resource consent application: Land Application of Meatworks Process Wastewater at Byreburn Farm, Feilding (CPG, 2010).

3.2 System Concept

MWE can be discharged to land and to water. A low rate application to land enables further treatment of the MWE, and supplies water and nutrients to the soil for plant growth. While the preference for MWE discharge is 100 % land discharge, the available land in the vicinity of the ANZ plant is not well suited to full-time land application. This results in a large storage requirement or over-application of MWE to the land. Specifically the available land is a combination of imperfectly drained soils which are artificially drained, and excessively drained soils which are expected to have a high degree of connection to the adjacent Oroua River. This means that over-application of water to these soils may result in MWE entering surface and ground water in an uncontrolled manner.

ANZ is fortunate to have a large storage capacity available on the site. The provision of additional storage has implications (geotechnical, land area required and cost) that make it unfeasible.

ANZ has operated a CLAWD system for more than ten years. Evaluation of the system performance (CPG, 2010; Aquanet, 2014) has indicated that the effects of the present operation require improvement. There is scope to improve both the land and the river discharge regime.

3.3 Evaluation of Options

An initial evaluation of the options was undertaken between September and November 2013. The evaluation compared the discharge outcomes resulting from changes to the treatment system and the land application system, both separately and in combination. The evaluation determined which changes resulted in the best improvements to the river discharge. From this ANZ was able to make informed decisions about where to focus its expenditure to improve the discharge system.

A base scenario was prepared which was considered to be achievable operationally, and to be consentable in terms of environmental impact. At this stage the environmental effects assessed were on a qualitative basis. The base scenario was modified using:

- Change land area;
- Change available storage;
- Modify river discharge criteria;
- Change nutrient and hydraulic loading to land;
- Include nitrogen and/or phosphorus reduction technologies in treatment system;
- Increase plant production (MWE inflows);
- Change pump rate to river.

In total, 19 scenarios were prepared to determine which changes the discharge regime was most sensitive to. A preferred option was selected and is detailed in an email to ANZ (Appendix B). The preferred option forms the basis for this conceptual design. Further refinement has been undertaken as outlined in the following section.

3.4 Optimisation Process

Following the determination of the preferred option a process of optimisation was undertaken to:

- Quantify effects to the Oroua River and land application areas;
- Compare the proposed regime with the existing discharge; and
- Include specific land management considerations.

The optimisation process was iterative, meaning the preferred option was evaluated, refined and further evaluated to ensure an improvement was made over the current regime, and that the detectable effects to the receiving environments (land and water) were minimised.

Modelling the Current Discharge Regime

To enable the effects of the proposed discharge to be reliably predicted a comparison with the current discharge regime was needed. To compare the current discharge regime to the proposed regime, first the current regime needed to be well understood. This assessment has previously been undertaken for the land treatment area and is described in the previous consent application (CPG, 2011).

However, the correlation between the current river discharge and river water quality had not previously been quantified. The actual MWE discharge volume record was not sufficiently detailed and not of long enough duration to reliably compare the current discharge regime to the proposed discharge regime. What was well understood was the conditions under which the discharge occurs and the concentrations of N and P in the Oroua River up and downstream of the discharge point.

Based on the existing discharge record and the conditions under which the discharge to the river is authorised to occur, the existing regime was estimated. To determine whether the estimated regime accurately reflected the actual discharge the nutrient mass loadings to the river were compared with actual water quality data in the Oroua River in the vicinity of the discharge. This process is discussed in further detail in the water AEE (Aquanet, 2014). Good agreement was reached between the estimated existing regime and water quality records and the estimated regime was adopted for comparison with the proposed regime.

Comparison of the Current and Proposed River Discharge

All variants of the proposed river discharge resulted in an improvement from the current consent conditions, with a corresponding reduction in the effects due to that discharge. Because there is a high degree of confidence that the measured water quality can be predicted by the modelled flows based on the previous step, by comparing the different regimes there is a high degree of confidence that the effects predicted for the proposed regime are accurate.

Optimisation of the Proposed River Discharge

By adjusting the rules and criteria that control the discharge, particularly by adjusting the timing, river flow limits and discharge volume, the impact of discharging the same proposed volume changes. By examining how the impact changes, the optimum regime with respect to nutrient concentrations in the river can be selected. The resulting optimised option is detailed in this report.

Optimisation of the Proposed Land Discharge

The preferred option was selected on the basis of the hydraulic loading of MWE to the soil (i.e. the rate and amount applied). Further refinement was undertaken to take into account the nutrient loading and management considerations such as cropping rotation and stock withholding. In addition, the effects of different irrigation options were considered. The resulting optimised option is detailed in this report.

3.5 Discharge Decisions

The combined land and water discharge (CLAWD) comprises three components being:

- Discharge to land;
- Discharge to the Oroua River; and
- Provision of pond storage.

On any day that the MWE treatment system is operating the potential for a discharge to occur is assessed by:

1. Determining whether a discharge to land can occur by checking:
    a. Whether the cumulative nutrient loading limit has been exceeded (i.e. has 60 kg P/ha/year been applied to the area);
    b. Whether the soil moisture too high (measured from climate data or soil moisture monitoring); and
    c. Whether the current use of the land makes irrigation impractical e.g. stock in stocking yards, harvest scheduled for cut and carry, etc.

    If all of these checks are negative then discharge to land occurs. If one or more of the checks are positive then no discharge will occur on the land which these conditions apply to but discharge to a different area may occur. If one or more of these conditions apply to the entire site then no discharge to land will occur and the assessment proceeds to step 2;

2. Determine whether a discharge to the river can occur by reviewing the previous day's average flow (L/s) in the Oroua River at the Kawa Wool site. It is likely that this monitoring site will be changed to the Almadale Slackline site (which is further upstream) in the future to enable real time monitoring data to be used. For the purpose of conceptual design the existing Kawa Wool site data has been used. The potential for a discharge to water to occur is assessed by:
    a. Whether the river flow is below median (MF = 7,590 L/s.) If yes then no discharge to the river occurs;
    b. Whether the river flow is between MF and the 20th flow exceedance percentile (20FEP = 16,193 L/s.) If yes then the effects in the river due to dissolved reactive phosphorus (DRP) and soluble inorganic nitrogen (SIN) must be considered. Discharge to the river can occur at a variable rate based on the dilution factor of the river water; otherwise
    c. Whether the river flow is higher than 20FEP. If it is then the effects in the river due to toxic levels of ammonium (NH_4-N) must be considered. On this basis discharge of up to 3,000 m^3/day of MWE can occur.

    If no discharge to the river can occur then proceed to step 3.

3. MWE is stored in ponds for discharge when conditions allow. This requires active management of the storage volume to ensure that there is capacity available when it is needed i.e. discharge to land or water should occur on any day that conditions allow.

The discharge system components are described in the following sections.

4 TREATMENT PLANT AND STORAGE

4.1 General

ANZ is a modern, purpose-built beef processing facility, employing up to 340 people and processing up to 670 cattle per day. The supply of cattle is year-round with a seasonal increase in numbers from October to April, peaking in December through to February. The processing of the beef generates MWE as a result primarily of effluent from stockyards and washdown procedures during processing. A summary of the MWE collection and treatment system is as follows.

4.2 MWE and Waste Collection and Treatment

The MWE from different areas of the ANZ plant is collected at various points around the plant and transferred to treatment ponds. Waste streams that contain organic, faecal and stomach contents (yard solids and paunch material) drain to the solid pond first, from where they are pumped with the other waste streams to the main treatment ponds. Solids accumulating in the solids pond are periodically removed by digger for storage in paunch pits, in preparation for separate land application.

The rest of the MWE from the plant, including the hardstand stormwater from the eastern side of the property, is collected at the main drain pump house. From the main drain pump house the MWE is pumped directly to the first anaerobic pond.

The MWE enters the first pond which operates on an anaerobic basis where material is biologically broken down. It is then piped into the second pond which is aerated. MWE is circulated through the pond which has a minimum retention time of around 30 days.

4.3 Storage

The large size of the effluent ponds provides buffering storage for the times when neither the river discharge nor land irrigation is possible. There are two additional ponds which provide buffer storage.

The aerator pond has 1 metre of freeboard, which equates to 6,900 m^3 of available reserve storage. Additional storage in the two ponds on either side of the anaerobic pond provides a further 57,600 m^3. Thus an additional storage capacity of 64,500 m^3 in these ponds is available until a discharge to either land or water is allowable. This additional volume is equivalent to about 90 days' production under the current MWE flow regime year round, or about 63 days during the irrigation season due to higher production in the plant over this period.

4.4 MWE Flow and Quality

MWE from the ANZ plant has been monitored in line with the conditions of Consents 4219 and 4220. Tables 4.1 and 4.2 summarise the MWE flow and quality.

Over time both the volumes produced and the quality of the MWE have changed as improvements and changes have occurred with processing methods and water use. As a result flow data for the last three seasons has been used for determination of future system performance.

It is prudent to produce a conceptual design which can be operated for all flows over the term of the consent. There is potential that operations at the ANZ site could be expanded in the future. As the industry trends are often tied to factors outside of the plant's control it is not possible to predict with certainty what future MWE flows will be. As a result a generous increase in production has been adopted for development of the CLAWD system. This provides certainty that ANZ can operate within the system bounds, and enables the assessment the effects on the environment of a potential "worst case scenario". This approach minimises risk of non-compliance for the plant with future discharges.

An increase of 20 % of MWE flows has been adopted to estimate maximum MWE volumes for the term of the consent.

Table 4.1: ANZ MWE Volumes

Flow statistics	Current Flows* (2010-present) (m^3)	Future flows (m^3)
Annual average	256,132	307,358
Daily average	702	842
Daily minimum	257	308
Daily maximum	1,026	1,231
Daily median	760	912

* Current flows are based on water use at the site rather than outflows from the pond due to concern over the quality and length of the outflow dataset. The current data used here has been compared against paired river water quality to provide some assurance that the dataset is valid.

The MWE quality parameters are tabulated in Table 5.2 below, showing summer, winter and year-round windows for each of 19 quality determinands. A feature illustrated in this table is the comparatively narrow variability of the concentrations of the two main determinands, DRP and SIN, over a long period. DRP means and medians vary between 19 and 21 g/m^3, while SIN means and medians vary between 102 and 124 g/m^3.

Table 4.2: ANZ MWE Quality (Albert van Oostrom, 2013)

	Characteristics of final effluent sampled at aerated pond outlet																	
	TSS	$cBOD_5$	NO_x-N	NH_4-N	TIN (SIN)	TN	TP	DRP	O&G	E. coli	Ent	Ca tot	Na tot	K tot	Mg tot	SAR	Temp.	DO	pH
	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	/100 mL	/100 mL	g/m^3	g/m^3	g/m^3	g/m^3		°C	g/m^3	
Year round																			
Mean	112	34	35	81	117	133	22	20	5	10933	51695	26	229	46	9	10	16	4	8
Median	85	29	23	84	119	132	22	20	3	9550	1000	26	198	44	9	9	15	3	8
95%ile	295	74	100	140	159	176	28	26	12	20750	15800	32	403	52	12	16	24	8	9
Max	770	115	127	170	171	190	30	29	54	24000	8700000	35	442	59	12	17	30	13	9
Count	183	183	183	183	183	183	183	132	176	6	183	19	19	19	19	19	179	177	175
"Summer" (land discharge)																			
Mean	179	41	41	61	102	124	24	21	5	NA	171099	26	216	44	9	9	21	3	8
Median	143	34	27	62	106	128	24	21	4	NA	4700	26	199	44	9	9	21	3	8
95%ile	378	97	100	112	133	155	28	24	10	NA	32600	29	291	49	11	12	25	7	9
Max	770	115	114	132	137	164	30	26	37	NA	8700000	32	333	51	12	13	30	10	9
Count	53	53	53	53	53	53	53	39	52	0	53	12	12	12	12	12	50	48	50
"Winter" (river discharge possible)																			
Mean	85	31	33	90	123	136	21	19	5	10933	3015	27	253	48	9	10	13	4	8
Median	70	27	18	95	124	133	21	19	3	9550	465	26	190	49	9	8	13	4	8
95%ile	188	69	98	146	163	180	28	27	13	20750	11550	33	429	57	11	16	19	8	9
Max	384	104	127	170	171	190	30	29	54	24000	100000	35	442	59	12	17	25	13	9
Count	130	130	130	130	130	130	130	93	124	6	130	7	7	7	7	7	129	129	125

4.5 Organic Amendments

Organic solids are intercepted as described in Section 4.2 above and composted in the paunch pits. This material has previously been analysed and is summarised in Table 4.3.

Table 4.3: Composted Paunch Pit Solids

Sample	Units	Concentration
pH		6.85
Electrical Conductivity	(mS/cm)	1.45
Phosphorus	(mg/L)	2
Phosphorus	(mg/kg)	2,435
Sulphur	(mg/L)	92
Sulphur	(mg/kg)	3,080
Potassium	(mg/L)	19.5
Potassium	(mg/kg)	1210
Calcium	(mg/L)	193.5
Calcium	(mg/kg)	23,600
Magnesium	(mg/L)	13
Magnesium	(mg/kg)	2,340
Sodium	(mg/L)	87
Sodium	(mg/kg)	610.5
Carbon	(%)	15.1
Nitrate-N	(mg/L)	98
Ammonium-N	(mg/L)	1
Nitrogen	(%)	1.355
Nitrogen	(mg/L)	13,550
Plant available nitrogen (PAN)	(kg N/tonne)	2.08
C/N	Ratio	11
Organic Matter	(%)	26.1
Dry Matter	(%)	50.55
Iron	(mg/kg)	13,050
Manganese	(mg/kg)	964.5
Zinc	(mg/kg)	164.5
Copper	(mg/kg)	18.5
Boron	(mg/kg)	10.5

In addition to the composted solids, the existing treatment pond system accumulates settleable solids over time and it is necessary to desludge the ponds to maintain pond capacity for incoming MWE. This is particularly important for the proposed discharge regime, which requires active management of storage volumes to ensure there is sufficient storage available.

Sludge has been accumulating for a number of years (exactly how many is not known). As a result an initial desludging operation is expected to result in the one-off removal of a comparatively large volume of sludge. Following this, more regular desludging is proposed approximately every five years. Once more regular desludging is adopted the volume of sludge requiring discharge on each occasion will be lower as indicated below.

The composition of the sludge has not been evaluated to date, however based on similar materials that LEI has dealt with it is expected the composition will be similar to the composted paunch grass.

It is estimated that the volume of organic solids material is:

- 627 m^3/year of composted paunch material;
- 9,000 m^3 in total of pond sludge assuming 150 mm of material on the pond base; and
- An additional 200 m^3 of pond sludge expected to be produced each year.

5 RIVER DISCHARGE

5.1 General

The river discharge portion of ANZ's CLAWD system avoids the need for prohibitively large storage facilities. The objective of the river discharge design is to carry out the discharge of ANZ MWE to surface water under conditions which result in an effect on the surface water environment that is acceptable and short lived, while providing for the economic operation of the ANZ plant. This section describes how the discharge is to be managed to achieve this objective.

5.2 Discharge Environment

The river discharge component of the ANZ CLAWD system is to the Oroua River. Details of the river environment including water quality and river health are given elsewhere (Aquanet, 2014; Resource Consent Application document), however key river parameters for the design of the discharge are given below. Flow statistical data for the Oroua River from the modelled period (01/01/1993 to 04/09/2013) have been used for developing the discharge regime. These values vary slightly from published values which span the entire data record (Henderson and Dietrich, 2007 for period 1967-2004). The use of the most recent 20 years of data for modelling the discharge gives a higher value for median flow and so is more conservative than the Henderson and Dietrich numbers. The more recent data is considered to be more representative of the river flow conditions likely to occur over the term of the consent. Data is from the Oroua @ Kawa Wool monitoring site (Horizons).

River Flow:

- Median flow (MF) – 7,590 L/s;
- 20th Flow exceedance percentile (20FEP) – 16,193 L/s; and
- Summer discharge threshold (SDT) – 20,913 L/s.

River water quality has been monitored up and downstream of the site by ANZ and Horizons. Dissolved reactive phosphorus (DRP) is considered to be the most limiting parameter in the Oroua River for the period (1 April to 30 November) that river discharge occurs.

5.3 Discharge Criteria

The current discharge regime is controlled by consent conditions which vary by season and by river flow as follows:

1. *This consent authorises the discharge of treated effluent from the Manawatu Beef Packers Limited Campbell Road, Feilding site to the Oroua River via the Effluent Outfall (approximate map reference NZMS 260 S23:298-048) for a term expiring on 14 May 2011. This discharge shall be restricted to:*

    - *A rate of up to 2,000 cubic metres per day while the river flow exceeds 4000 litres per second;*
    - *A rate of up to 1,000 cubic metres per day while the river flow is between 3,000 and 4,000 litres per second,*

    During the period 31st March to 1st December of any year; and:

A rate of up to 2,000 cubic metres per day while the river flow exceeds 20,913 litres per second, and when the pond storage levels are at 100% prior to discharge taking place,

During the period 2nd December to 30th March of any year.

Under the current regime it has been determined that there is an effect in the river likely to be caused or contributed to by the ANZ discharge (Stark, 2011; Aquanet, 2014). Significant changes to the existing river discharge regime are proposed to reduce the impact of the discharge to the Oroua River. The river discharge criteria are given in Table 5.1.

Table 5.1: Criteria for River Discharge

Discharge criteria	Date Range	
Flow: Oroua River@Kawa Wool	**1 December – 31 March (Summer)**	**1 April – 30 November (Winter)**
Below median flow (0 – 7,590 L/s)	No discharge	No discharge
Median flow to 20th flow exceedance percentile (7,590 – 16,193 L/s)	No discharge	Discharge at rate based on DRP based dilution load to the river up to a maximum of 3,000 m^3/day.
Above 20th flow exceedance percentile (>16,193 L/s)	No discharge*	Up to 3,000 m^3/day.
* Emergency contingency above SDT (>20,913 L/s)	If land application is not possible and pond is 100 % full then up to 2,000 m^3/day.	NA

The criteria were adopted following a comprehensive assessment of the in-river effects and feasibility of operation for ANZ, summarised as follows:

- Median flow (MF) was used as a discharge cut-off since it represents an improvement on the present discharge and results in reduced effects to the Oroua River. While it is possible to discharge to the river at flows below median and still achieve an improvement ANZ has optimised the CLAWD system to minimise discharge to the river;

- The use of a date range which excludes flows over the summer period, when there are high daylight hours and elevated water temperatures, has been retained from the previous consent as it is considered good practice for the location;

- A variable discharge rate between MF and 20th flow exceedance percentile (20FEP) is tied to the P loading from the discharge. The rate of discharge results in an increase in DRP in the river of no more than 0.005 µg/mL. This level was arrived at following iterative evaluations of the effects, and was a level at which the effects to the river were considered to be acceptable and in line with Horizons One Plan water quality targets. Detailed discussion of how the effects on water were determined is given in Aquanet, 2014;

- A discharge rate of 3,000 m^3/day above the 20FEP is higher than the maximum rate of discharge under the current consent. This rate is selected as a feasible pumping rate following the modification of the discharge structure described in Section 5.6 below. The increase enables a greater proportion of the river discharge to occur above 20FEP i.e. because more MWE is discharged above 20FEP there is less need to discharge below that flow;

- Above the 20FEP corresponds to the flow regime used for One Plan target limits, whereby the parameter of concern in the wastewater changes from phosphorus or soluble inorganic nitrogen to ammoniacal-nitrogen. At the proposed discharge rate the One Plan target for ammoniacal-nitrogen is not exceeded; and

- The inclusion of the summer discharge under exceptional circumstances provides an assessable contingency for the system evaluation i.e. while this may not occur every year, by including it in the modelled discharge a "worst-case" scenario can be evaluated to ensure the corresponding effects are not unacceptable. The river flow above which a summer discharge is currently authorised by consent 4219 is nominally 20,913 L/s. In order to ensure that future effects on the Oroua River environment are less than current effects, it is proposed to retain this Summer Discharge Threshold.

5.4 Days of Discharge

The proposed discharge was modelled for the period 1993-present to determine how the discharge would have worked under actually occurring conditions. The proposed discharge was compared to the actual discharge to enable environmental effects to be predicted. Over the modelled period the number of days on which the discharge occurs is given in Table 5.2.

Table 5.2: Discharge days for Proposed River Discharge

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	0	0	0	6	19	20	11	12	22	12	7	0	109
1994	0	0	0	5	24	30	31	29	23	11	13	0	166
1995	0	0	0	11	16	30	31	31	20	15	9	0	163
1996	0	0	0	23	22	30	31	30	13	11	0	0	160
1997	0	0	0	22	2	26	26	27	11	15	0	0	129
1998	0	0	0	7	12	25	31	30	9	15	5	0	134
1999	0	0	0	4	13	24	27	27	7	0	4	0	106
2000	0	0	0	6	4	20	19	15	26	20	0	0	110
2001	0	0	0	2	16	18	19	26	0	4	9	0	94
2002	0	0	0	2	10	30	31	31	19	6	0	0	129
2003	0	0	0	0	5	17	19	16	29	9	4	0	99
2004	0	4	1	3	7	27	31	31	16	18	0	0	138
2005	0	0	0	1	20	30	27	7	12	15	0	0	112
2006	0	0	0	12	27	27	31	31	3	19	18	0	168
2007	0	0	0	0	0	27	31	31	0	7	2	0	98
2008	0	0	0	0	11	12	31	30	12	19	4	0	119
2009	0	0	0	0	21	16	31	25	11	23	4	0	131
2010	0	0	0	0	7	24	31	31	28	1	0	0	122
2011	0	0	0	14	16	11	31	31	11	19	14	0	147
2012	0	0	0	0	5	15	29	31	15	5	0	0	100
2013	0	0	0	0	4	24	30	31	4				-

Table 5.2 shows the distribution of discharge days throughout the year. The timing and frequency of discharge varies based on river flow conditions and production at the plant. The difference in the number of discharge days between the current discharge regime and flows and the proposed regime and flows is given in Table 5.3.

Table 5.3: Comparison of Discharge days – Current and Proposed River Discharge

	Current	Proposed
Average (days/year)	166	127
Minimum (days/year)	130	94
Maximum (days/year)	202	168
Median (days/year)	168	126

As shown in Table 5.3 the proposed regime, while having increased flows from the plant, results in a lower number of discharge days. This is achieved by limiting the discharge to above MF, and by enabling a higher maximum discharge rate when the river is above 20FEP. The increased maximum discharge rate results in a greater proportion of the discharge occurring above the 20FEP meaning there is less MWE in storage that needs to be discharged below 20FEP.

5.5 Volume, Rate and Mass Loading of Discharge

If, following the decision-making process given in Section 3.2.1, a river discharge is to occur then the volume of MWE discharged to the river is controlled by the P mass loading from the MWE (between MF and 20FEP) as described in Section 5.3. Table 5.4 gives the key annual data for the river discharge including comparison to the current discharge. A detailed assessment of these is given in Aquanet (2014).

Table 5.4: Comparison of Discharge Volumes and Mass Loading – Current and Proposed River Discharge

		Current	Proposed
Discharge volume (m^3/year) for average year	**Discharge below 20FEP**		
	Average	77,576	17,603
	Minimum	30,835	9,279
	Maximum	106,954	24,135
	Median	82,346	17,748
	Discharge over 20FEP		
	Average	38,624	108,862
	Minimum	16,789	70,248
	Maximum	77,204	150,056
	Median	35,213	107,355
Mass loading N (tonnes/year) for average year	**Discharge below 20FEP**		
	Average	9.54	2.17
	Minimum	3.79	1.14
	Maximum	13.16	2.97
	Median	10.13	2.18
	Discharge over 20FEP		
	Average	4.75	13.39
	Minimum	2.07	8.64
	Maximum	9.50	18.46
	Median	4.33	13.20
Mass loading P (tonnes/year) for average year	**Discharge below 20FEP**		
	Average	1.47	0.33
	Minimum	0.59	0.18
	Maximum	2.03	0.46
	Median	1.56	0.34
	Discharge over 20FEP		
	Average	0.73	2.07
	Minimum	0.32	1.33
	Maximum	1.47	2.85
	Median	0.67	2.04

Table 5.4 demonstrates that there is an increase in the total volume and mass loading to the river. However, there is a substantial decrease in the volume and nutrient mass loading at flows below 20FEP.

5.6 Discharge Structure

Following consultation with stakeholders, in particular local Iwi, ANZ is proposing to change the existing mode of discharge to the river. The previous discharge had been to a site drain, thence to an unnamed stream which entered the Oroua River. For varying reasons, including enabling the separation of land use effects on water quality, it has been decided that the discharge should go directly to the Oroua River. A preliminary design has been prepared which uses a planted land based diffuser structure (High Rate Land Passage System) to discharge ANZ MWE at the true left bank of the Oroua River at an approximate location of 40.233591S, 175.583195E. Figure 5.1 below shows the proposed discharge structure design. It should be noted that the final design is subject to change based on further consultation with stakeholders.

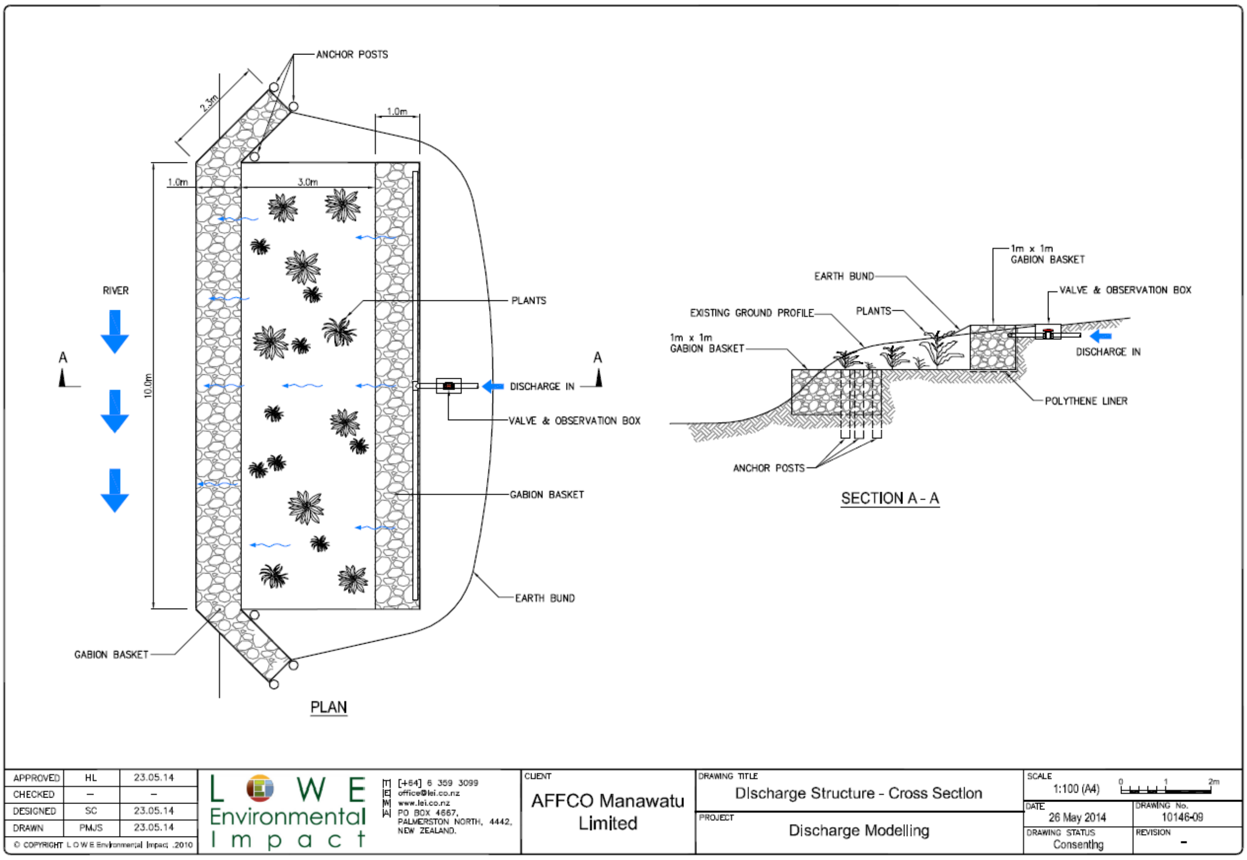


Figure 5.1 River Discharge Structure

5.7 Air Quality

The proposed river discharge point is closer to Feilding township than the existing discharge point, which means there is potentially a higher risk for odour from the discharge to travel to receptors. The MWE discharge from the pipe will be by diffusion to a planted media. No aerosols will be created due to the diffuser structure creating an effectively passive and overland flow system. Discharge will also occur during the cooler months when there is a lower potential for odorous compounds to be released from the MWE. In addition, the plants act like a biofilter to trap and treat volatile compounds. The potential for odour can be further mitigated by flushing the discharge line with clean water, as discussed below.

5.8 Septicity and Flushing

Septic or anaerobic conditions can develop in MWE pipelines. This can result in odours when the MWE is exposed to the air (covered above). It can also cause compounds to be generated that can corrode pipes and result in the MWE changing colour, producing noticeable plumes when discharged. These problems can be exacerbated the longer MWE is kept in a pipeline. It is proposed to have the ability to flush the lines with clean water after a discharge to ensure MWE is replaced with clean water. This practice will be used if anaerobic problems develop.

6 LAND APPLICATION

6.1 System Description

Available land near to the ANZ MWE treatment ponds has been identified that can receive a portion of the ANZ MWE flows (Appendix A, Land Management Units). Close to 60 % of the MWE produced by ANZ, and critically, all of the summer MWE production, can be applied to the land available. Land discharge has historically been to the adjacent farm via large travelling irrigators. Limitations with this system were identified and described in the 2011 consent application. As a result ANZ has considered a number of other land areas for incorporation into the land discharge scheme. The land areas include a range of land uses and management histories. The variation in properties requires different management and a different discharge regime. The advantages of the variable management include that when some areas are unable to receive land discharge there is still potential for discharge to other areas.

The division of the land areas into management units is discussed in Section 6.3 below. Buffer zones will be maintained to avoid irrigation close to dwellings, boundaries and waterways.

The irrigation system will consist of low rate irrigation methods such as small moveable irrigators (e.g. k-line) or fixed impact sprinklers in areas that have not previously received MWE application. Over the existing irrigation area improved management will enable the continued use of travelling irrigators. The adoption of these methods is discussed in further detail in Section 6.4 below.

River flow, soil moisture conditions, rainfall and wind speed will be monitored and used to determine whether irrigation is suitable each day. The irrigation system described in this section includes soil limitations, the irrigation pumps and infrastructure, effluent, pumping and controls, application rates and soil health.

6.2 Criteria for Discharge to Land of MWE

There is a step wise decision-making process to determine when, how and where a discharge to the available land occurs (Section 3.2.1). Land discharge can occur to any area that meets the following criteria:

- Where a cumulative nutrient load applies (see Table 6.1), it has not been exceeded; and
- The soil moisture content following irrigation will not be higher than 5 mm below field capacity i.e. irrigation will not exceed field capacity and induce drainage;
- Fertiliser has not been applied within 48 hours;
- Harvest activity has not occurred within 24 hours;
- Harvest is not scheduled to occur within 48 hours;
- Rainfall of 50 mm or more has not occurred in the previous 24 hours as recorded at ANZ; and
- NW and NE wind speeds do not exceed 12 m/s for more than 15 minutes.

If all of these criteria are met then discharge to land occurs. If one or more of the criteria are not met then no discharge will occur on the land which these conditions apply to, but discharge to a different area may occur. If one or more of these conditions apply to the entire site then no discharge to land will occur and the decision making process proceeds to evaluate whether river discharge can occur or whether the MWE will be stored.

Details of the nutrient loading limitations and land use considerations for different parts of the site are given in Section 6.3. Application of additional nutrient sources is likely to occur on the site, particularly Byreburn Farm. These will be managed to ensure that specified nutrient limits are not exceeded. The additional nutrients may be supplied by conventional fertiliser or by organic amendments as described in Section 4.5 above.

6.3 Adoption of Deficit Irrigation

It has been decided that a deficit irrigation scheme will be adopted across all the available areas. Deficit irrigation refers to a regime whereby wastewater is applied at a rate equivalent to plant water use. The wastewater will be applied at a rate which does not cause the soil's field capacity to be exceeded, thereby avoiding drainage directly following wastewater application.

The reason for adopting a deficit regime for ANZ's MWE is for the protection of soil quality and the management of irrigation within an operative dairy farm. Specifically, it is intended that grazing of the areas will occur; and under this management regime, and on the soils that occupy the site, it is advisable to allow soil to "dry" between irrigation events to minimise the risk of treading damage by animals.

6.4 Determination of Land Area

There is a total of 182 ha available of which 142 ha has been determined to be irrigable (allowing for buffers from boundaries, dwellings and waterways). Buffer distances are 20 m from boundaries and waterways, and 150 m from dwellings (Figure "Buffer Zones", Appendix A). The available areas have been divided into four management units based on soil properties and land use (current and historic) and are shown in the figure "Land Management Units" (Appendix A). The land management units (LMU) are summarised in Table 6.1 and described as follows:

Land Management Unit – LMU 1
LMU 1 corresponds to areas of Byreburn Farm that have historically received MWE from ANZ. The area is predominantly fine textured Kairanga soils with established hydrant and rotorainer runs. Actual areas are shown on maps given in Appendix A and include blocks identified as 1.1, 1.2, 1.3, 1.4 and 1.6.

LMU 1 would continue to be irrigated using the existing infrastructure resulting in up to 7 irrigation events per block per year. The maximum yearly discharge to LMU 1 would be 114,000 m^3 but when climatic conditions and availability of MWE in storage is taken into account the average yearly discharge volume would be around 64,500 m^3 (152 mm/y assuming 14 ha is unavailable every year as described in Section 7.2 below).

Land Management Unit – LMU 2
LMU 2 corresponds to areas of Byreburn Farm that have historically received MWE from ANZ. This area is distinct from LMU 1 due to the more free-draining soils (Manawatu, Parewanui and Rangitikei soils). Actual areas are shown on maps given in Appendix A and include blocks identified as 1.5, 1.7, 1.8, 1.9 and 1.10.

These soils are mostly course-textured and have a low capacity to retain applied water. To minimise excessive drainage from these sites the adoption of a low rate application system such as k-line is proposed.

Irrigation would occur on up to 20 days per year. The maximum yearly discharge to LMU 2 would be 100,000 m^3 but when climatic conditions and availability of MWE in storage is taken into account the average yearly discharge volume would be around 61,000 m^3 (152 mm/y).

Land Management Unit – LMU 3

LMU 3 corresponds to land that is currently part of Byreburn Farm but which has not previously received MWE. LMU 3 includes blocks identified as 2.1-2.9.

LMU 3 is to be irrigated by small moveable sprinklers. The use of these will assist to maximise crop (pasture) uptake of the applied MWE and its nutrients, while minimising losses to ground or surface water. Irrigation would occur on up to 25 days per year. The maximum yearly discharge to LMU 3 would be 98,700 m^3 but when climatic conditions and availability of MWE in storage is taken into account the average yearly discharge volume would be around 50,100 m^3 (152 mm/y).

Land Management Unit – LMU 4

LMU 4 comprises land identified as available for MWE discharge in and around the plant. These areas are relatively small and well suited to the use of small moveable irrigators. However, some areas may suit the use of fixed impact sprinklers i.e. the stock yards and the amenity areas.

There is a range of management types and land uses within these areas however the overall discharge regime for these areas over a year is the same. It is considered that limiting the discharge to a maximum loading of 100 kg N/ha/y will result in protection of the receiving environs. There is scope to irrigate around 10,075 m^3 to the combined areas to supply the maximum N load.

Management considerations have the greatest control on the discharge to LMU 4. Some issues which influence discharge decisions are:

- 4a Organic enriched: This area corresponds to blocks 4.9, 4.10, 4.12 and 4.13. These areas have had large additions of organic material (e.g. paunch, heads and ears, biofilter material). Discharge to these areas will be constrained by ensuring that applied MWE does not cause mobilisation of nutrients and soluble humic compounds from the soil to groundwater;
- 4b Amenity: This area corresponds to blocks 4.7 and 4.8. Access by ANZ staff may occur, and this area is maintained to provide an attractive and tidy appearance for people accessing the site. Discharge to this area will be constrained by the ability to remove nutrients and the need avoid contact with the MWE.
- 4c Stock yards: Area 4c is the holding yards for animals brought to the site and corresponds to blocks 4.4 and 4.5. There may be high intermittent stocking rates in the yards. A high rate of nutrient application may occur via excreta deposits. Discharge to this area is largely controlled by the presence of stock, and by controlling the discharge to minimise mobilisation of excreta derived nutrients.
- 4d AFFCO_extensive: This area corresponds to blocks 4.1, 4.2 and 4.6. The area is grazed by sheep and possibly by cattle for the purpose of keeping grass down. The stocking rate is low and the area has low inputs in terms of nutrients and management. Discharge to this area is controlled by the ability to remove nutrients from the site (i.e. by removal of grass).
- 4e Dalcam_extensive: This area corresponds to blocks 3.1 and 3.2. The management of this area is the same as for 4d. The two areas are considered separately due to the different ownership.

Table 6.1: Land Management Units

LMU	Description	Irrigable area (ha)	Limiting parameter*	Irrigation type	Vegetation/ management	Average yearly discharge (m³)	Average application depth (mm/year)	Maximum discharge days	Maximum yearly discharge (m³)	Max annual application depth (mm/year)
1	Byreburn travelling existing	56	Phosphorus loading @ 60 kg P/ha/y	Travelling irrigator (existing rotorainer @ 34 mm/event)	Grazed pasture	64,000	152	7	114,000	250
2	Byreburn k-line existing	40	Phosphorus loading @ 60 kg P/ha/y	Small moveable (k-line or similar @ 12 mm/event)	Grazed pasture	61,000	152	20	100,000	250
3	Byreburn new	33	Hydraulic loading @ 12 mm/event	Small moveable	Grazed or cut and carry pasture	50,100	152	25	98,700	300
4	AFFCO									
4a	Organic enriched	2.3	Nitrogen loading @ 100 kg N/ha/y and land use management	Small moveable or fixed impact (@ 12 mm/event)	Extensively** grazed pasture	10,075	75	7	10,075	75
4b	Amenity	1.6			Mown and removed grass					
4c	Stock yards	2.2			High intermittent stocking, low feed					
4d	AFFCO_ extensive	3.1			Extensively** grazed pasture					
4e	Dalcam_ extensive	4.2			Extensively** grazed pasture					

* The limiting parameter determines the maximum yearly discharge volume however climatic conditions may result in a lower yearly application.
** The use of the term extensive refers to a low management input and correspondingly low stocking rate grazing system.

6.5 Infrastructure, Pumping and Control

MWE can be pumped from the aerated pond or from either of the two storage ponds. The pump shed, containing both the river discharge pump and irrigation pump, is located adjacent to the boundary with Byreburn Farm. The pumps are currently manually controlled, as are the varying irrigation zones. While specific details are still being finalised, the pumping system will be largely automated with various input information allowing remote operation of the pumps, with overriding controls (i.e. ability to stop pumping) from weather station and soil moisture inputs.

Meters and pumping rates, and the identification of blocks being irrigated, will be able to be viewed remotely from a web-based platform.

6.6 Air Quality

Aerosols and Spray Drift
The land treatment system has the potential to impact on air quality through production of aerosols generated by the spray irrigators to be used. In order to minimize the production of aerosols and minimise spray drift, the system pressure and nozzle size will be selected to produce droplets greater than 200 μm in size, which do not travel far and typically do not form aerosols.

Some proportion of smaller droplets, which have the potential to become aerosolised, will still be produced and so the following methods for reducing spray drift effects are to be used:

- Minimise travel distance: Use of small moveable irrigators which have a low height of discharge to reduce the travel distance of aerosols;
- Buffers: utilise separation distances between irrigation and any receptors; and
- High wind speed directional buffers: Buffers can be extended in the event that average wind speeds higher than 4 m/s in the direction of Feilding are forecast (around 260-310 degrees). If wind gusts of 12 m/s are detected in a direction of 260-310 degrees (Feilding township) then a whole system shut-down is recommended until 30 minutes following the last measured gust. Additional directions and wind shut off rules can be added to address concerns of individual neighbouring property owners.

Odour
The ANZ MWE has the potential to produce odorous compounds. While the MWE is in an aerobic state, as it is when it exits the pond, the potential for nuisance odour is low. The odour produced is in keeping with the ANZ plant's rural surrounds and can be managed by the methods outlined for aerosols above.

Should there be an issue with odour, it is likely to be a result of MWE having gone anaerobic in the irrigation lines where there is a long period between irrigation events. Should this be the case, a volume of clean water can be pumped through the irrigation lines to flush them.

7 LAND MANAGEMENT

7.1 General

As described in Section 6.3 above the site has been divided into management units based soil and land use. Specific land management considerations are as follows.

7.2 Land Ownership and Management Responsibility

The bulk of the land identified for discharge of ANZ MWE is owned by a third party. It is acknowledged that the diligent management of the land, including the irrigation, is critical to achieve effects that are no more than minor to the environment due to ANZs MWE discharge. It is also desirable to maximise the value of the MWE for pasture production.

ANZ has entered into an agreement with Byreburn Farm for the continued use of LMU 1 and LMU 2, and the provision of LMU 3 to establish a new irrigation area. In the event that the land is no longer available to ANZ the agreement ensures there is sufficient time to develop an alternative land treatment scheme.

Byreburn Farm is responsible for the management and maintenance of irrigation infrastructure within LMU 1 and LMU 2. ANZ is responsible for the management and maintenance of irrigation infrastructure, including pumping facilities within LMU 3 and LMU 4. ANZ is also responsible for monitoring that the irrigation is being managed to comply with conditions of consent.

Byreburn Farm is responsible for the day-to-day operation of the irrigation system on LMU 1, LMU 2 and LMU 3. This is to allow for practical management within the farming system. It is the responsibility of Byreburn Farm to manage the irrigation rotation to ensure the consent is complied with.

7.3 Land Management Unit 1

A detailed evaluation of LMU 1 is given in the CPG report. The key outcomes of the evaluation were that the daily hydraulic load needed to be determined and managed better, and that the phosphorus loading (P) should be the limiting parameter for discharge on an annual basis.

The site is currently managed as grazed pasture and it is expected that this will continue under the proposed regime. The addition of a cut-and-removal silage regime may be included if the nitrogen loading exceeds 250 kg N/ha/year. Further discussion of this is given in Section 7.5 below.

Animal Grazing

Stock should not be present during and immediately after irrigation for animal health reasons. Animal health considerations are predominantly with regard to contact with MWE and MWE derived contaminants. Land treatment of MWE guidelines impose stock withholding periods of:

- 48 h for MWE which has undergone helminth (intestinal worms) removal (NZLTC, 2000); or
- 6 months where helminth removal processes are not included in the MWE treatment (NZLTC, 2000); or
- There is no withholding period required where MWE is treated to California Health Law Title 22 standards (*E.coli* <23 MPN/100 mL).

It is recommended that stock is excluded for no less than 48 h for the protection of soil health and plant growth following an irrigation event, primarily to avoid treading damage.

Crop Rotation

To manage current elevated P levels in the soils of this area it is recommended that one quarter of the available area (14 ha) is excluded from the irrigation schedule for one year out of four. During the nil irrigation year a maize crop is grown and removed from the site i.e. not fed out on these paddocks. Under this management a four year rotation of areas would assist to "mine" P from the soil. In order to minimise mineralisation of soil nitrogen (N) stores, causing leaching, the maize and replacement pasture should be direct drilled with no, or minimal cultivation.

7.4 Land Management Unit 2

LMU 2 was also evaluated by CPG and it was determined that excessive drainage was the issue of most concern over most of this area. The recommendation at that time was to cease irrigation to LMU 2. LEI considers that the irrigation can be continued with an irrigation system capable of discharging at a low rate.

Byreburn Farm presently has a resource consent to discharge farm dairy effluent (FDE). Areas which receive FDE are located within LMU 2 and are shown of the figure "FDE Application Areas" (Appendix A). As a condition of the FDE consent no area which receives FDE can also receive MWE. As a result of this, it is proposed that in any year (taken from July to June) any area that receives FDE will not have MWE applied. However, areas within LMU 2 that do not receive FDE may receive MWE.

As with LMU 1 the site is currently managed as grazed pasture and it is expected that this will continue under the proposed regime. Proposed management is the same as for LMU 1 except there is no need to include a 4 yearly maize (or other crop) rotation. In addition, a cut-and-removal silage regime may be included if the nitrogen loading exceeds 250 kg N/ha/year. Further discussion of this is given in Section 7.5 below.

7.5 Land Management Unit 3

Under the present MWE flows it is considered that LMU 3 can be managed similarly to LMU 1 and LMU 2, as grazed pasture. The area has some challenges with regard to stock on moist soils, notably LMU 3 is not as extensively artificially drained as LMU 1, and so moisture is retained in the soil longer increasing the potential for pugging. This can be minimised by ensuring a 14 day stand down between irrigation and grazing, not grazing the pasture too low and avoiding over-stocking.

Should the annual wastewater loading increase, this area could adopt a cut-and-carry (grass harvesting and baleage) operation, overseen by Byreburn Farm but almost entirely carried out by contractor. The use of contractors is recommended to negate ANZ or Byreburn Farm having to purchase any equipment for this relatively small operation.

The 33 ha (plus buffers) of land identified in Table 6.1 is likely to provide a practical operating size for a cut-and-carry operation; the larger the cut and carry operation, the greater the returns and the more viable it becomes. Any smaller and the efficiency of the operation decreases and the use of time and equipment becomes uneconomic. Contractors also become more reluctant to operate on small land areas.

Specific land management considerations, discussed in more detail below, include:

- Crop selection, cultivation and performance;
- Nutrient management;
- Harvest and fallow management of cropped areas; and
- Animal grazing rotation.

Cropping Practices

Should nutrient loading rates over the entire area exceed a level deemed to be too great for grazed pasture (250 kg N/ha/y), then a partial or dedicated cut-and-carry component can be introduced to increase the nutrient removal capabilities, thereby allowing a higher nutrient loading rate on those areas. The extent of nutrient removal by harvesting would be in direct proportion to the increase in nutrient application over what would be expected from grazing alone. For example if a nutrient loading of 310 kg N/ha occurred in any year, then there would have to be harvesting of hay/silage to remove 60 kg N/ha (i.e. about 1,200 kg DM/ha removed).

The selection of pasture or crop species requires consideration of the soil, climate, irrigation regime and the cut-and-carry system. The site is presently in pasture (ryegrass and clover) and it is intended that this will remain the predominant crop. The following description provides the criteria for crop selection to offer scope for variations, but will need to accommodate the priority for MWE application.

Seasonal crops can achieve high growth rates and along with that high rates of nutrient removal (see Table 7.1 below). However, during cultivation and harvest, prior to establishment of the crop, and at post-harvest prior to replacement crop establishment, there is little capacity for nutrient removal. If poorly managed there can be a net release of nutrients, particularly nitrogen. Irrigation will need to be withheld during these phases of the crop rotation to ensure leaching of nutrients does not occur.

The critical irrigation periods for the management of MES storage are in autumn and spring. If opportunities to irrigate are lost this will place additional pressure on storage requirements. Consequently this may limit cultivation during these periods, and thereby influence the choice of crops. Minimum tillage techniques should be encouraged to reduce cultivation-induced leaching losses and periods of no irrigation.

Winter grazing by animals may be included in the LMU management following the same guidelines as given for LMU 1.

Harvest Regime

The harvest regime proposed for a cut-and-carry operation that could be used on LMU 3 is more frequent than a typical farming system to ensure crops are kept in a vegetative growth phase. Irrigation needs to cease prior to harvest. The ability to maximise irrigation application while accommodating the necessary time out for harvesting will need to be included in the irrigation schedule. Due to the number of applications that occur during the season this will be simple to plan based on rotation within the LMU and between the LMUs.

Ceasing irrigation one week before harvest is important to ensure there is minimal compaction from machinery used and to avoid potential pathogen contamination of the harvested material. Appropriate machinery e.g. flotation tyres, may need to be considered to avoid compaction, future poor irrigation distribution and to assist with regrowth.

7.6 Land Management Unit 4

As described in Section 6.2, LMU 4 comprises a number of different land uses, all with a low potential to remove nutrients from the site. No changes to the management of LMU 4 to that currently occurring is proposed apart from the establishment of irrigation. Changes to the existing land uses of LMU 4 are considered to be impractical. The key management consideration for the sites is access by stock (LMU 4a, 4c, 4d and 4e) and by humans (LMU 4b). Exclusion from the site in accordance with Section 7.3.1 is recommended.

For the Dalcam Trust land (4e), if it is not purchased by ANZ, then a formal agreement should be entered into with the owner to ensure that no unauthorised (other than by ANZ) access to the site occurs. Fences should be maintained in good order.

7.7 Nutrient Management

Annual soil nutrient testing is to be carried out in September to enable calculations to determine appropriate supplementary fertiliser or organic amendment additions to each irrigation zone to suit the crop selected.

Table 7.1 gives the potential nitrogen and phosphorus uptake for various cropping regimes. Nutrients to meet the crop needs may be supplied by MWE, dairy effluent, fertiliser or organic amendments. Nutrients applied should not exceed the crop requirements allowing for some sequestration by soil and slow release from organic amendments.

Table 7.1: Crop Nutrient Uptake, Mixed Cropping and Grazing

Crop / Land use	N uptake (kg/ha/rotation)	P uptake (kg/ha/rotation)	Reference
Pasture – irrigated, cut and carry	500-600	130-160	Morton et al. (2000)
Animal excreta return	(300-360)	(78-96)	FLRC (2009), Williams and Haynes (1990)
Maize silage (20 t/ha)	220	40	FAR (2009)
Kale (18 t/ha)	380	50	Beare et al. (2010)
Peas (16 t/ha)	106	16	Hortnet (1995)
Squash (30 t/ha)	107	20	Hortnet (1995)
Sweetcorn (16 t/ha)	62	9	Hortnet (1995)

Brackets () indicate a net return of nutrients

The objective for nutrient management on the site is to limit nutrient concentrations being lost to the ultimate receiving environment, being the Oroua River system, at or downstream from farming operations which can currently be undertaken on the site. This is predominantly pastoral farming, including dry stock and dairy.

8 MONITORING

8.1 General

Monitoring is required to assist with management decisions and to demonstrate environmental compliance. While monitoring criteria will be developed in accordance with resource consents set by Horizons Regional Council, monitoring will also be essential to allow the diligent operation and management of the scheme as a whole. Monitoring may be required to cover:

- Effluent inflows, outflows and quality;
- Soil characteristics;
- Crop quality;
- Groundwater quality and levels;
- Surface water flow and water quality; and
- Air quality.

8.2 MWE

The volume of MWE leaving the treatment plant will be recorded. This will include recording of flow volumes pumped to the irrigation area and to the river.

Analysis of the MWE nutrient and microbiological levels will be undertaken on a regular basis (two-weekly) when a discharge is occurring to provide information regarding final discharge quality, and to demonstrate that the quality is as indicated in the initial design assumptions. When there is no discharge no sample will be taken. Proposed parameters for measurement are:

- Total suspended solids;
- Soluble carbonaceous biochemical oxygen demand;
- Total N;
- NO_3-N, NO_2-N, NH_4-N;
- Total P;
- DRP;
- *E. coli*;
- Temperature; and
- pH.

In addition to the final effluent, further monitoring is recommended to assist with monitoring the treatment progress i.e. influent quality, and anaerobic pond MWE quality. These MWE streams need only be tested monthly. Additional parameters are recommended for management decisions regarding the irrigation, and which may impact pond performance and septicity e.g. calcium, magnesium, potassium, sodium, sulphide. These parameters can be monitored monthly.

8.3 Soil Monitoring

The objective of soil monitoring is to maintain awareness of changes in the quality and variability of the physical and chemical properties across the land discharge. This will allow for management decisions as described in Section 6 and 7 and will assist with monitoring nutrient build up (or depletions) and the need for fertiliser applications. Yearly testing of soil properties is recommended.

Routine or continuous monitoring of the soil moisture status is required to enable day to day decisions about irrigation to be made. It is considered appropriate to use weather station data based at the irrigation pump shed to determine whether irrigation can occur. Specifically, rainfall and evapotranspiration data should be used to estimate soil moisture deficit. Use of this data is considered to provide unambiguous information at an appropriate scale/accuracy for management of irrigation. However, in the event that infiltration testing as described below, or farmer observation, indicates that the irrigation scheduling based on weather data is not ideal then the inclusion of direct soil moisture monitoring using a method that is accurate near to field capacity can be adopted. This methodology is not suggested in the first instance due to the increased technical complexity of measuring near field capacity soil moisture, and therefore potential for suboptimal use, associated with its use.

Testing the soil infiltration capacity will provide information to determine whether the management practices from irrigation and the cut-and-carry are impacting the soil structure and its ability to maintain MWE applications. Soil hydraulic properties change slowly and it is considered that two yearly testing is appropriate.

Details of soil monitoring are proposed to be included in a monitoring plan to be producing following the granting of resource consent for land discharge.

8.4 Surface Water

There will be no discharge of irrigation water directly to surface water. There may be an indirect discharge via groundwater, however, based on the MWE nutrient loading and hydraulic application rates the potential for nutrient leaching is minimal, and not dissimilar to farming operations. Due to historic differences between up and downstream monitoring sites it is proposed that river monitoring will be continued on a 3-monthly basis during the winter season (1 April to 30 November).

The river discharge component of the proposed scheme results in an average of 127 discharge events per year based on future flows; i.e. expected to be less for much of the consent term when the flow will be less than the maximum discharge rate sought. It is prudent to continue monitoring of the river water quality. Recommended parameters for measurement are:

- *E. coli*;
- pH;
- Temperature;
- Dissolved oxygen;
- Soluble carbonaceous biochemical oxygen demand;
- DRP;
- NO_x-N, NH_4-N (SIN); and
- Visual clarity.

These parameters enable measurement against the One Plan water quality targets. In addition, annual biological monitoring should be undertaken. Details of the sampling programme will be given in the monitoring plan referred to in Section 8.3 above.

8.5 Groundwater

A groundwater monitoring programme has been commenced by ANZ in the vicinity of the ponds and surrounding the site. Details of the results of this monitoring to date are given in the resource consent application document. It is proposed that this monitoring programme will be continued intensively until groundwater in the vicinity of ANZ is better understood. Thereafter the testing regime is proposed to be scaled back to enable changes in groundwater properties to be detected and tracked e.g. 3-monthly testing.

At present monthly monitoring of groundwater bores on Byreburn farm is undertaken during months when irrigation is occurring, however the historical data has been of limited value and it is proposed to improve the care of the bores (there have been issues with absent bore caps and the like) and sampling protocols, and change the monitoring frequency to 3 monthly including during periods of no irrigation of MWE.

The parameters currently monitored and proposed to continue are:

- Standing Water Level;
- Temperature;
- pH;
- Electrical Conductivity (EC);
- Chloride;
- Total Nitrogen;
- Total Ammoniacal-N;
- Nitrite-N;
- Nitrate-N;
- Nitrate-N + Nitrite-N;
- Total Kjeldahl Nitrogen (TKN);
- Dissolved Reactive Phosphorus;
- Total Phosphorus;
- Total Sulphide;
- Carbonaceous Biochemical Oxygen Demand ($cBOD_5$); and
- Escherichia coli.

8.6 Air Quality

Buffer distances are sufficient to protect neighbouring properties from being impacted by spray drift. This will be assisted with automatic shut-offs when wind speeds exceed a nominated value and in a certain direction, as measured by an onsite climate station.

No air quality monitoring is proposed. A procedure to record and respond to complaints will be maintained regarding air quality concerns from the site.

9 REFERENCES

Aquanet. 2014. AFFCO (Feilding Meat Processing Plant) discharge to the Oroua River: Water Quality modelling and assessment of effects of proposed discharge regimes.

CPG. 2011. Land Application of Meatworks Process Wastewater at Byreburn Farm, Feilding: Resource Consent Application and Assessment of Environmental Effects.

Stark JD. 2011. Biomonitoring of the AFFCO beef processing plant discharge on the Oroua River near Feilding (19 November 2010). Prepared for CPG. Stark Environmental Report No.2011-01. 32p.

Van Oostrom and Associates. 2013. Spreadsheet of monitoring data provided for AFFCO consents.

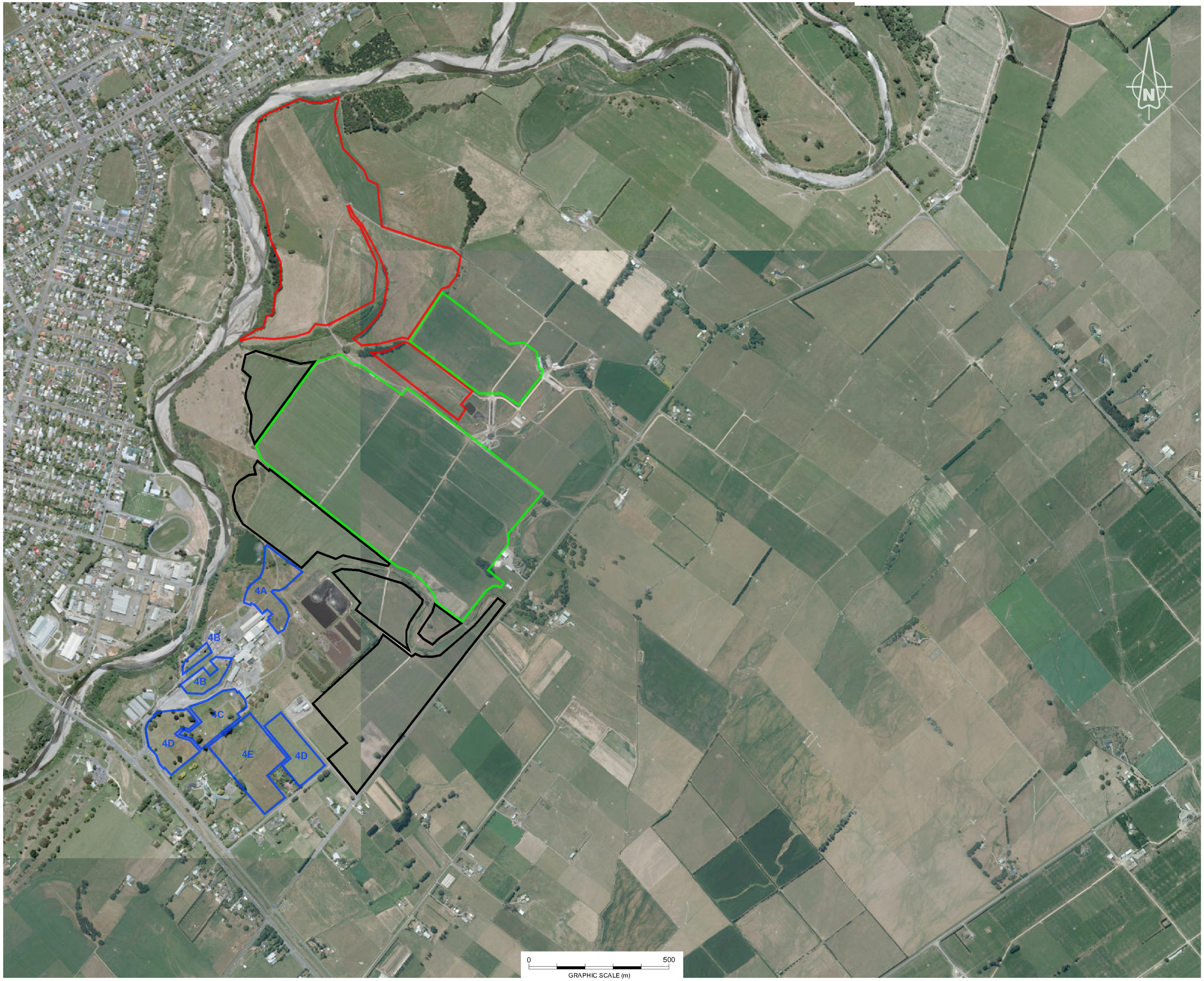
10 APPENDICES

Appendix A Figures
Appendix B Sensitivity Evaluation

APPENDIX A

Figures

Location (refer to Land Investigation Report)
Buffers
Land Management Units
Farm Dairy Effluent Application Areas



NOTES

LEGEND

LMU 1
LMU 2
LMU 3
LMU 4

LMU 4A ORGANIC ENRICHED
LMU 4B AMENITY
LMU 4C STOCK YARDS
LMU 4D AFFCO EXTENSIVE
LMU 4E ST DOMINICS EXTENSIVE

REV.	DESCRIPTION	DATE
–	–	–

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CHECKED	–	–
DESIGNED	SC	28.03.14
DRAWN	PMJS	28.03.14

CLIENT

AFFCO Manawatu Limited

PROJECT

AFFCO Manawatu

DRAWING TITLE

Land Management Units

DRAWING STATUS

Conceptual Design

DATE	DRAWING No.
24 Jul 2014	10146-09

SCALE	REVISION
1:12,500 (A3)	-

NOTES

LEGEND

- BOUNDARY - 20 m
- SURFACE & ARTIFICIAL WATER COURSES - 20 m
- BORES - 20 m
- BYREBURN FARM
- AFFCO
- ST. DOMINICS
- CURRENTLY IRRIGATED
- NON IRRIGATED
- POWER LINE

REV.	DESCRIPTION	DATE
–	–	–

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CLIENT

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AFFCO Manawatu Land Investigation

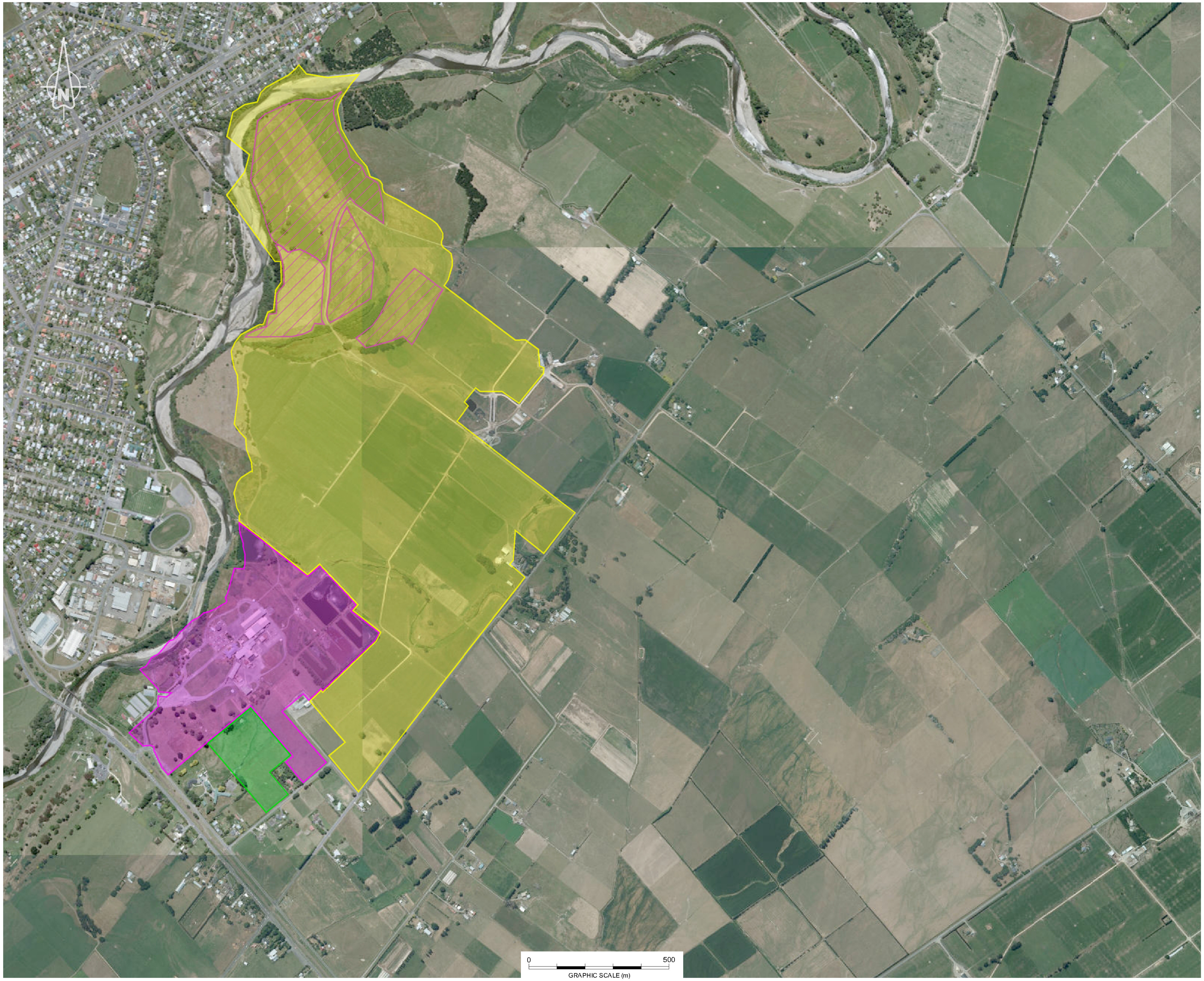
DRAWING TITLE

Buffers

DRAWING STATUS

Conceptual Design

DATE	DRAWING No.
12 Apr 2014	10146-04
SCALE	REVISION
1:7,500 (A3)	-



NOTES

LEGEND

- FDE APPLICATION
- BYREBURN FARM (IRRIGATED)
- AFFCO
- ST. DOMINICS

REV.	DESCRIPTION	DATE
–	–	–

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DRAWN	PMJS	04.07.14

CLIENT
AFFCO Manawatu Limited

PROJECT
AFFCO Manawatu

DRAWING TITLE
FDE Application Areas

DRAWING STATUS
Conceptual Design

DATE	DRAWING No.
04 Jul 2014	10146-07

SCALE	REVISION
1:12,500 (A3)	-

APPENDIX B

Sensitivity Evaluation

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From: Hamish Lowe [mailto:hamish.lowe@lei.co.nz]
Sent: Wednesday, 27 November 2013 9:09 a.m.
To: 'Andrew Talley'; 'Nuku, Ann'
Cc: avo@albert.co.nz
Subject: RE: AFFCO Discharge Scenarios

Hi again…

despite more scenarios the path is becoming clearer. In summary the following is recommended forward planning and consenting purposes:

- **Wastewater** flows at 25 % higher with no change to nutrient concentration (no plant nutrient reduction)
- **Land discharge** to 75 ha with cut and carry as land use;
- **Storage volume** as 50,000 m^3
- **River discharge** at 400 times dilution above median flow (MF) to a maximum daily discharge of 3,000 m^3/day. Effects of this regime are still to be assessed.

The basis for this is as follows.

A total of 19 scenarios have been evaluated. The purpose of this was to see what parameters the discharge to land and water from the plant, and required storage volume are sensitive to. Key observations from the valuated are as follows.

Changing Land Area: Increasing the land area for discharge from 50 ha to 75 ha reduces nutrient loading to land to an acceptable level. The storage volume required is reduced, however with the extra land the discharge to river is not substantially reduced. There is a significant benefit from increasing the land area to 75 ha but this benefit decreases with areas greater than 75 ha.

Recommendation – Land discharge area of 75 ha used.

Change Storage volume: Storage volumes do not create a limitation to discharges if the current plant flows are used. However, if wastewater flows increase due to increased production i.e. by 25 % then greater storage is needed if no other changes are made. However, if the rate of pumping to the river increases then no volume increase is needed. Increasing storage volume has a high cost for a marginal benefit and an increase in river discharge pumping rate would be more benefical.

Recommendation – No increase in storage volume.

River discharge criteria: It is possible with the current wastewater flows to limit discharge to the river to times when the flow in the river is above 80 FP (also known as 20 FEP). If the wastewater volumes from the plant increases by 25 % then discharge to the river between median flow (MF) and 80 FP is needed (essential without additional storage). Under all modelled scenarios no discharge to the river occurs from December to March. This is really good and is managed by balancing irrigation and storage.

Recommendation – Determine the effects to the river for discharge between MF and 20 FP with an increased wastewater flow.

Nutrient Loading to Land: Under most conditions the amount of nitrogen (N) or phosphorus (P) is the parameter that limits discharge to land (not the volume of water). By limiting the amount of N and P to levels suitable for discharge to a dairy farm the amount of storage required becomes unfeasible (need more). If a nutrient loading rate suitable for a cut and carry system is adopted then all other criteria can be met with no increase in storage, even if the flows from the plant increase by 25 %. An alternative would be nutrient reduction changes equating to a 25 % in P concentrations.

Recommendation – A cut and carry system should be considered in preference to grazing for dairy cattle, or the implementation of nutrient reduction.

Nutrient Concentration Reduction: The inclusion of N and/or P reduction technologies in the treatment plant (-15 % and -25 % respectively), does not result in a change to the relative or total volumes discharged to land or water, or stored. However the mass loading of nutrients to both the river and the land are reduced. Without other modifications to the discharge system the reduction in the load to land brings the yearly nutrient loading down to a rate which is appropriate for cut and carry, but is not low enough for dairy grazing. Nutrient reduction technologies are likely to have a minor benefit in terms of reduced environmental effects compared to the large cost.

Recommendation – Further investigation into nutrient reduction is not recommended at this stage but may be considered in light of future production increases at the plant and concurrent nutrient concentration increases (due to water use efficiencies). Nutrient reduction may be beneficial in future to allow for a dairy operation to be used in preference to a cut and carry operation.

Increase inflows: All variants of the water-balance were run with flows at 25% more than the current level. At these higher flows the days of discharge to the river are higher and days of discharge between MF and 80 FP are about 10 days per year more. In order cope with increased flows the discharge system needs at least 75 ha of land. Discharge will need to occur at flows between MF and 80 FP, as well as above 80 FP. To minimise the river impact (and number of days of discharge) the rate of pumping to the river will need to be increased from the current 2,000 m^3/day maximum.

Recommendation – Increased flows from the plant should be included in the refined option to "future-proof" the consent.

River Pumping Rate: We examined the impact of increasing the maximum rate of discharge to the river from 2,000 m^3/day to 3,000 m^3/day. This resulted in a higher annual volume being discharged to the river on a lower annual number of days. It also meant that a lower volume was discharged between MF and 80 FP at the higher pumping rate. This means that the cumulative mass loading to the river is higher but the acute effects are likely to be lower.

Recommendation – Include higher pumping rate in preferred option.

Cheers

Hamish

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From: Hamish Lowe [mailto:hamish.lowe@lei.co.nz]
Sent: Friday, 22 November 2013 3:59 p.m.
To: Andrew Talley; Nuku, Ann
Cc: avo@albert.co.nz
Subject: AFFCO Discharge Scenarios

Hi all

The table below presents a range of discharge scenarios. It may seem complicated but a couple minutes to understand the coding system is worth it!

It basically says that with increased production (and associated water increase) 75 ha of land is needed. While the nutrient loading rates to land are relatively high assuming no reduction, the reality is there will be some reduction and the nutrient loading rate will be less. A key to managing the discharge to the river is the criteria for managing storage. AF2 and AF2_D shows that discharging up to 2,000 m3/y when needed vs only discharging when the ponds reach 80 % full reduces the number of days discharge from 67 to 14 days.

Based on the information below we are in the process of running two scenarios based around land use:

1) Dairy – 75 ha, 200 kg N/ha, 40 kg P/ha
2) Cropping – 75 ha, 350 kg N/ha, 71 kg P/ha

Both using 60,000 m3 storage.
Both discharging at 2,000 m3/day at river flows over 80 FP (even when ponds are below 80 %) and at a dilution of 1:400 between 80 FP and MF providing the pond is 80 % full.

I hope to report back on these results Monday.

Keen to hear your thoughts.

Thanks

Hamish

Summary Table for Scenarios

Unit	Parameter	Scenario Descriptor (refer below for details)									Scenario combinations (all include increased production)						
		AF1	AF2	AF2_A	AF2_B	AF2_C	AF2_D	AF2_E	AF2_F		AF2_AC	AF2_AD	AF2_ACD	AF2_AE	AF2_AF	AF2_AEF	AF2_ACEF
Land	Average yearly volume (m3/y)	142868	179970	212495	179970	183404	283447	179970	179970		214302	309347	350905	212495	212495	212495	214302
	Land Area (ha)	50	50	50	50	75	50	50	50		75	50	75	50	50	50	75
	Application depth per year (mm/y)	238	299	354	299	306	472	299	299		357	515	584	354	354	354	357
	Average drainage (mm/y)	337	411	476	411	295	618	411	411			669		476	476	476	
	Average yearly days of application (# days)	57	72	85	72	49	113	72	72		57	124	94	85	85	85	57
	Average annual N loading (kg/ha)	340	428	506	428	291	675	428	364		340	736	557	506	430	430	289
	Average annual P loading (kg/ha)	69	86	102	86	59	136	65	86		69	148	112	76	102	76	51
Storage	Max required voume (m3)	25534	30398	59835	30398	22800	47984	30398	30398		29070	63515	49018	59835	59835	59835	29070
River	Criteria for discharge	RIV1	RIV2	RIV2	RIV2	RIV2	RIV2	RIV2	RIV2		RIV2	RIV2	Riv2	RIV2	RIV2	RIV2	RIV2
	Average yearly volume (m3/y)	169118	132120	161178	132119	128543	27304	132120	132120		159303	62905	22582	161178	161178	161178	159303
	Volume discharged Dec to Mar (incl)	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	Volume discharged Apr to Nov (incl)																
	Average yearly discharge days	108	67	82	67	66	14	67	67		82	32	12	82	82	82	82
	Days of discharge Dec to Mar (incl)	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	Days of discharge Apr to Nov (incl)																
	Average annual N loading (kg/ha)	18434	14401	17568	14401	14011	2976	14401	12241		17364	6857	2461	17568	14933	14933	14759
	N load (kg) Dec to Mar (incl)	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	N load (kg) Apr to Nov (incl)																
	Average annual P loading (kg/ha)	3213	2510	3062	2510	2442	519	1883	2510		3027	1195	429	2297	3062	2297	2270
	P load (kg) Dec to Mar (incl)	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	P load (kg) Apr to Nov (incl)																

<u>Base case</u>

AF1 Storage = 50,000 m3, Effluent discharge from AvO worksheet "AFFCO Manawatu Consent Monitoring Data-with AvO modelling", discharge to land is low rate system and irrigation does not increase soil moisture above FC; River discharge criteria are RIV1

AF2 Storage = 50,000 m3, Effluent discharge from AvO worksheet "AFFCO Manawatu Consent Monitoring Data-with AvO modelling", discharge to land is low rate system and irrigation does not increase soil moisture above FC; River discharge criteria are RIV2

<u>Change to base case</u>

A Increase production - water use + 25%
B Increase storage available by 10,000 m3
C Increase land area to 75 ha
D Discharge to river only occurs if pond is over 80% full under all conditions
E Decrease P in effluent by 25%
F Decrease N in effluent by 15%

River discharge criteria

RIV1

Dec-Mar IF riverflow <20,193 L/s (80 FP) THEN no discharge
IF riverflow >20,193 L/s (80 FP) AND pond > 80% full THEN discharge up to 2,000 m3
Apr-Nov IF riverflow <3,000 L/s THEN no discharge
IF river 3,000 L/s to 4,000 L/s THEN discharge up to 1,000 m3
IF river discharge >4,000 L/s THEN discharge up to 2,000 m3

RIV2

Dec-Mar IF riverflow <20,193 L/s (80 FP) THEN no discharge
IF riverflow >20,193 L/s (80 FP) AND pond > 80% full THEN discharge up to 2,000 m3
Apr-Nov IF riverflow <6,971 L/s (MF) THEN no discharge
IF river discharge >6,971 L/s (MF) THEN discharge @ 400x dilution up to 2,000 m3

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