Pongakawa/Kaituna Dairy Effluent Disposal Project – Advice to Environment BOP

NIWA Client Report: HAM2002-072
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Prepared for

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Executive Summary

Land application of untreated dairy wastes in the lower reaches of the Pongakawa/Kaituna catchments poses significant risks of faecal matter and urine entry into waterways. Risks escalate during periods when water tables are high or tile drains are irrigated. Using a managed system of deferred irrigation from existing two pond systems and recycling of pond effluents significantly reduces the potential for contamination of waterways, and are preferable to direct irrigation of untreated effluents. The Regional Council and farmer groups should investigate soil moisture deficits in this area in order to confirm such a system is practical, identify periods for optimal utilisation of water and nutrients, and to minimise the potential for environmental impacts of runoff.

Permitting a combination of irrigation and direct discharge of pond-treated effluents during winter periods may prove a pragmatic solution in an area where, even with deferred irrigation and recycling effluents, the capacity of farmers to store effluent may be exceeded. A lack of a land treatment step during these periods means Maori cultural values will not be met.

Advanced Pond Systems with a final land treatment component (e.g. wetlands) produce a high quality effluent and provide an alternative system should deferred irrigation prove impractical or difficult to manage.

Farm management practices that minimise the movement of faecal matter from paddocks and races into waterways provide additional benefits.

1. Brief

Environment BOP has commissioned NIWA to undertake a desktop assessment of issues associated with dairying activities in the Pongakawa and Kaituna catchments based on the following brief:

(a) What is the impact of discharge from dairy shed ponds discharging to water compared to the impact on adjacent waterways from normal farm operations, fertilizer, runoff, etc. in the low lying areas of the Kaituna/Pongakawa catchments (North of State Highway 2)?

(b) Is irrigation (or partial irrigation) a suitably efficient disposal method on this land? Are there other options for disposal or application that could be considered at different times of the year? (e.g. land disposal/pond discharge combination systems).

(c) How effective are these other methods (apart from land disposal of effluent) for achieving stream quality objectives in dairy farming catchments i.e. methods that apply to the whole farming operation? For example, managing the following activities/resource in a better way: farm races, drain and river crossings, riparian areas, grazing management, fertilizer policy and feed pads.

(d) What effect does tile drainage beneath an effluent irrigation area have on adjacent water quality?

(e) What impact will the various options considered in each question above have on the water classifications in the Water and Land Plan and the Coastal Plan?

2. Background

The Pongakawa and Kaituna catchments discharge into the Waihi and Maketu Estuaries respectively (Figure 1), 45 km south-east of Tauranga. The lower reaches of these catchments, north of State Highway 2, are very low lying (15–30 cm above mean high tide). Groundwater is high for much of the year, at approximately 15 cm beneath the surface during winter, and 0.5–1 m during the summer (Environment BOP, pers comm.). Water-table management is undertaken by a local drainage society. Drainage waters are pumped into the river, which is perched above the surrounding land. Although the pumps are appropriately sized, flooding is sometimes a problem, with water lying over paddocks for periods after sudden heavy rains, which can remain if there is a power cut or pumps malfunction. Overtopping of the riverbanks has occurred during storm events at times of high-tide.

Soils in the area comprise Pongakawa peaty loams, Pongakawa shallow peaty loams, Takahiwai clay loams and peaty loams (saline soil types), Maketu Complex soils (mainly peaty loams), Paengaroa shallow sands and Kaharoa Waihi ash. The soils are not prone to cracking during dry periods

Figure 1. Pongakawa, Kaituna and adjacent sub-catchments showing low-lying areas north of State Highway 2.

3. Dairy shed pond discharge effects vs. normal farm operations

What is the impact of discharge from dairy shed ponds discharging to water compared to the impact on adjacent waterways from normal farm operations fertilizer, runoff, etc. in the low lying areas of the Kaituna/Pongakawa catchments (North of State Highway 2)?

Waste stabilisation ponds treating dairy shed wastewater reduce SS (suspended solids) and BOD_5 (biochemical oxygen demand, measured over 5 days) from the raw wastes by around 95%. However, due to the high initial strength of dairy farm wastewater, the treated effluent still has considerable pollution potential (Hickey et al. 1989; Selvarajah 1996; Sukias et al. 2001). Ponds however, only treat the faecal wastes and urine deposited in the dairy shed, where the cows spend less than 10% of the day. The remainder of the wastes are deposited directly back onto the pastures, and thus the discharge from dairy ponds only represents a small portion of the entire faecal waste load of a farm. Faecal matter deposited in paddocks are decomposed and assimilated by natural soil bacterial and plant processes, however a portion of the wastes is leached to groundwater, or may be washed off directly to surface waters. In addition, a proportion of the seasonally applied fertilizer nutrients are also likely to be lost directly from the soil due to leaching and washoff, and may enter streams directly or via subsurface drains.

The amount of wastes being treated in, and discharged from ponds is readily definable, while the amount exiting a farm via diffuse mechanisms is harder to quantify. The contribution from diffuse sources depends on many soil, environmental and farm management factors. Wilcock et al. (1999) estimated that up to 37% of the DRP (dissolved reactive phosphorus) and TP (total phosphorus) in a Waikato dairy catchment was from pond discharges. The remainder had entered the stream from diffuse sources. Total nitrogen (TN) was consistent with paddock-scale N leaching losses under dairy farming in the Waikato, although pond discharges were known to also contribute to the amounts entering the stream. In the same study, the annual yield of faecal bacteria in the stream was identical to the amount calculated to be discharged from the ponds (cows were largely fenced out of streams and drains in the catchment), and was presumed to be almost entirely from that source. Clearly the discharge from anaerobic/facultative ponds can have significant effects within a “receiving water”, however ponds significantly reduce the flux of such priority pollutants as BOD, SS and ammoniacal-N to streams.

In relation to normal farm operations, consideration must be made of soil physical and hydraulic properties which “influence the extent to which effluent constituents interact with the topsoil where many soil renovation processes take place” (Barton et al. 2000). Soils with a high humic content such as peats, have high cation exchange capacities (CEC), and are thus able to hold positively charged cations such as ammonium (NH_4^+), potassium (K+), calcium (Ca^{2+}) etc. Organic matter and clay in soils can also hold some negatively charged anions such as sulphate (SO_4^{2-}), nitrate (NO_3^-) and phosphate (PO_4^{3-}). However most anions are prone to being leached out by heavy rain or irrigation. Where a high water table is present, as occurs for some periods of the year in the lower reaches of the Pongakawa/Kaituna catchments, nutrients and faecal bacteria are likely to be more mobile and easily transported to the drainage system. The amount contributed by faecal wastes and fertilizer from the paddocks (compared to ponds) in these high water table catchments are likely to be greater than that found by Wilcock et al (1999) in the well-drained Waikato catchment with soils of high p-retention.

In order to accurately assess the percent input from dairy farm ponds in these catchments, it would be necessary to initiate a study of pumping/discharge rates and water quality from farm drainage water and effluent ponds as well as receiving water flow rates and water quality. The Pongakawa/Kaituna areas are ideal sites for such a study because the majority of the discharges from the catchment occur via pumped drains. Two recent papers on pond effluent quality (from various areas around NZ) and discharge rates (from 5 Waikato dairy farms) are appended, which may assist Environment BOP staff in undertaking these determinations.

4. Irrigation and other options for wastewater treatment

Is irrigation (or partial irrigation) a suitably efficient disposal method on this land? Are there other options for disposal or application that could be considered at different times of the year? (e.g. land disposal/pond discharge combination systems).

Land application of dairy shed wastewater using an irrigation system generally gives effective treatment as the waters pass through the soil profile, particularly the plant root-zone. In addition, it minimises the movement of pollutants to water bodies and meets Maori cultural preferences for disposing of faecal wastes. As a result, land application is generally a preferred method of treatment.

In an earlier Environment BOP assessment, Gardner (1999) determined that in the lower reaches of the Pongakawa and adjacent catchments, high groundwater levels result in “unsuitable conditions for irrigation of effluent”. This assessment is supported by guideline documents for irrigating (sewage) effluent (Barton et al. 2000), where soils provide poor treatment at least for those periods when groundwater approaches levels of moisture content termed *saturation hydraulic conductivity* (water logged). As many of the treatment processes occurring in soils are aerobic (requiring free oxygen), water logged soils with restricted oxygen availability have poor ability to remediate effluent. In addition, nutrients in the effluent can remain in macropore spaces, short-circuiting the plant rooting zone rather than soaking into soil aggregates where plant uptake and soil bacterial remediation can occur. Furthermore, the very shallow vadose (= unsaturated) zone found in the lower reaches of the Pongakawa and Kaituna catchments in winter, which can be as little as 15cm, would allow practically no opportunity for effective soil treatment processes to operate.

Recent research on land application of dairy (and sewage) wastes in NZ has tended to concentrate on soils other than peats, however until specific research on them is undertaken, they are assumed to have considerable potential for “by-pass” flow (Malcolm McLeod, Landcare, pers com.), where irrigated effluent preferentially flows around soil aggregates and through fissures rather than permeating in a more uniform fashion. This gives considerable potential for faecal bacterial contamination of groundwater with untreated effluent. In addition, the shallow groundwater for much of the year also increases the potential for contamination. Water-logged soils also have a much higher potential for causing run-off of applied wastes, allowing contamination of waterways with untreated effluent.

The above information suggests irrigation of untreated dairy effluents is unsuitable during wet periods in the lower reaches of the Pongakawa and Kaituna catchments.

4.1 Deferred irrigation

An alternative method of land treatment is to use “deferred irrigation”. Essentially this comprises storing effluent in a two-pond treatment system (or storage reservoir), and strategically irrigating from the second pond only when the soil moisture deficit is sufficient to prevent the irrigation water entering the drainage system. Horne et al. (2002) have been testing this regime at Massey University. Applications of up to (approximately) 25 mm of stored effluent were performed four times during the 2001–2002 dairy season. Initial moisture deficits ranged from 63–195 mm, and each irrigation event lasted approximately 6 days. Some effluent did reach the drainage system on occasions, however this accounted for less than 1% of N and P, and less than 2% of K applied. Clearly this method holds potential in situations where high soil moisture seasonally/periodically constrain land treatment. Maximum agronomic and environmental benefits are gained by applying effluents when soil moisture deficits are high and potential for runoff is low. As irrigation is only undertaken infrequently, this system would require less management and operational input from farmers than “normal” irrigation.

Some caveats need to be applied before recommending such a management system. Soil structure and chemical characteristics (e.g. P-retention capacity) need to be considered. This research was conducted on a silt-loam. Concern has been expressed as to the capacity of peat soils to exhibit bypass flow (see earlier comment by M. McLeod). Also, Horne et al. (2002) used hay or baleage crops to increase uptake of excess nutrient loads. The authors note, additional fertiliser may also be required to achieve a balanced nutrient content in the crop. Most importantly, do high soil moisture deficits occur on a sufficiently regular basis for this system to work in the low-lying areas of the Pongakawa and Kaituna catchments?

The nearest weather stations to Pongakawa/Kaituna maintained on the National Climate Database are at Te Puke and Kawerau. Measurement of soil moisture deficit has only recently begun for weather stations, and is only available for some stations. In addition, these are at 91 m and 30 m elevation respectively, and thus differ in both geography and topography from Pongakawa/Kaituna catchments. However, with these constraints in mind, soil water deficits for Te Puke and Kawerau were analysed over the entire data record available (Jan 2000-Nov 2002, and Jan 2001-Dec 2001 respectively). At Te Puke, there were periods as long as 307 consecutive days where the soil moisture deficit was less than 60 mm (i.e. not suitable for irrigation using a 60 mm criterion), and 395 days less than 100 mm. At Kawerau there were more than 267 days with less than 60 mm deficit, and more than 318 days with less than 100 mm deficit (deficits were continuously below 60 mm at the time records halted). Using either of these criteria would necessitate storing wastes for extended periods.

Anaerobic and facultative ponds constructed to recent guidelines published by the Dairying and the Environment Committee (DEC 1996) have recommended storage capacities of 60–90 days each (assuming 50 L per cow per day). Research by Sukias et al. (2002) has shown average outflow volumes from five dairy pond systems in the Waikato to be only 37.6 L per cow per day. Using this flow estimate, and the larger pond sizings associated with the DEC guidelines, combined retention times in the two ponds approach 240 days, suggesting deferred irrigation might be a workable solution in the Bay of Plenty Region. Alternatively deeper ponds providing greater storage volume per unit area could be employed to enable longer storage periods. Determining the suitability for lower reaches of the Pongakawa and Kaituna catchments would require soil moisture deficit measurements within this specific area, and possibly more frequent irrigation at lower rates than used by Horne et al. (2002).

Smaller two-pond systems (built to older specifications) would not be able to store the effluent for sufficiently long periods, however their retention time could be increased by addition of a third storage pond or by recycling of pond effluent for initial yard washdown. This would minimise the amount of water entering the ponds, however it would increase the build-up of salts within the pond water. Excessive salt build-up would be harmful to pond functioning, as well as to soil structure[*]. While Tippler (2000, p. 53) notes that high water tables can effectively prevent leaching of salt, the continuous flow through of water induced by pumping out of the drainage channels in the lower Pongakawa and Kaituna catchments may counteract this concern. Using some form of deferred irrigation (in combination with existing ponds systems) tailored to the soil water deficits found in these catchments would provide a higher level of treatment than would occur with direct discharge from ponds, and is thus worth trialling. However, due to the high water tables in the lower reaches of these catchments, deferred irrigation cannot be recommended without trials first being undertaken.

[*] See Tippler (2000, section 3.3.4) for an in-depth discussion on salt accumulation associated with effluent irrigation.

4.2 Land disposal/pond discharge combination systems

A system of land application of effluent during drier periods, and direct discharge during wetter periods may provide environmental benefits that are not apparent in discharge-only systems. The theory behind this system is that during soil moisture deficit periods, when land application is suitable, receiving water flow rates are low, and thus discharge to them is unsuitable. Conversely, during wetter periods when land application is unsuitable, receiving water flow rates are high, and therefore their capacity to assimilate discharges from waste treatment ponds is higher. This system is currently used in the Taranaki Region for 53 of their 2233 dairy farm consents as well as a meat works and a rendering plant. Taranaki Regional Council staff considers there are some important constraints for the system. Firstly they encourage as much application to land as is feasible (without causing undue elevations in groundwater nitrate concentrations). The discharges are to waterways with high levels of flushing, and there is no food gathering activities downstream of the discharge. In addition, the treatment system must be kept in good order, with consent conditions on phosphorus, ammoniacal nitrogen and BOD_5 in some instances (pers. comm. James Kitto, Taranaki Regional Council).

With regard to the suitability of such a system in the Pongakawa and Kaituna catchments, it clearly provides benefits over pond-only discharges, and when combined with knowledge of soil water deficits and deferred irrigation, may allow farmers to have minimal pond discharges. As with “deferred irrigation”, soil water deficits must be adequate when land application is undertaken. Clearly the effectiveness of these systems depends to a large extent upon farmers’ commitment to managing their treatment systems to achieve the best environmental outcomes. Lack of a land treatment component (to meet Maori spiritual beliefs) at some times of the year is clearly a deficiency of this system. Also shellfish resources in downstream estuaries may be subject to contamination during high-flow periods. Bacteriological quality of river waters during high flow periods needs to be investigated to determine whether this poses significant additional risks.

4.3 Advanced pond systems

Advanced pond systems (APS’s) incorporate a range of modifications that provide improved treatment over conventional two pond systems. They consist of a series of four specially designed ponds that provide an optimum sequence of treatment processes. The arrangement of the ponds can be modified to meet the treatment requirements of each specific waste flow, however an “idealised” design for dairy ponds is as follows:

The first pond is an anaerobic pond (AP, see Figure 2), essentially the same as used in existing two-pond systems. For intensified dairying operations, an anaerobic digester could replace this. Organic matter is broken down into inorganic forms, with methanogenesis resulting in the release of methane and carbon dioxide. The second, High Rate Pond (HRP) forms a shallow "race-way" with a slowly revolving paddlewheel that keeps the water moving and mixing. High exposure to sunlight promotes algal growth in this pond, re-absorbing nutrients into (more stable) algal biomass and efficient inactivation of faecal indicator bacteria. The third pond is a small, but deep "algal settling pond" (ASP) where the algae are removed by settling. Algal settling ponds require desludging on a 3–4 month basis, allowing recycling of nutrients in a concentrated form (requiring minimum soil water deficit). The supernatant water from the ASP then flows into a maturation pond (MP), or series of maturation ponds, where additional polishing occurs (including removal of pathogens, BOD and nutrients). In combination, the area required by APS is only a little greater than existing two pond systems designed to Dairying and the Environment Committee guidelines (DEC 1996). Currently there are four full-scale APS systems treating dairy wastewater in NZ (in Northland, Southland, and two in the Waikato- Toenepi and Newstead at Dexcel). Costs for construction of an APS to treat dairy wastewater are comparable to setting up an equivalent land treatment system.

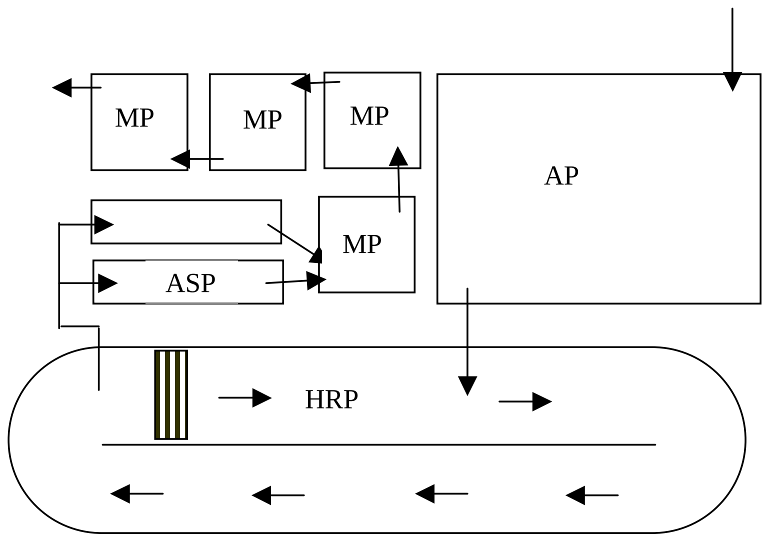

Figure 2. Schematic diagram of advanced pond system (after Craggs et al. 2002).

Table 1. Median effluent quality of conventional and advanced pond systems. Values in g m^{-3} except where noted.

Effluent characteristic	Conventional two-pond system	Advanced pond system
Dissolved oxygen	2.8	4.9
Biochemical oxygen demand	98	34
Suspended solids	198	64
Total kjeldahl nitrogen	129	25
Ammoniacal-nitrogen	106	7.5
Oxidised nitrogen	0.1	0.9
Total phosphorus	26.7	15.2
Dissolved reactive phosphorus	12.2	12.8
E. coli (MPN 100 ml^{-1})	1.62×10^4	1.46×10^2

(Source: Craggs et al. 2002 and recent NIWA trials)

A comparison of effluent quality from conventional and advanced pond systems is presented in Table 1. As can be seen, effluent quality is substantially improved over conventional two-pond systems, with further reductions of 65% of BOD and SS, 80% of nitrogen, 40% of phosphorus, and a two-log (99%) improvement in faecal bacteria (as measured by *E. coli*). Effluent volumes could be minimised by re-using supernatant water from the maturation ponds.

Overall treatment in APS's is lower than achieved with deferred irrigation by Horne et al. (2002). An additional land treatment component after the APS could be employed, both to meet Maori spiritual considerations as well as giving improved effluent quality. Such treatment could be in a constructed wetland (this system is currently employed in a dairy farm APS trial in the Waikato) or a small passive land application zone. Overall, an APS with a small land treatment component is likely to give much improved treatment than wet weather land application from a two-pond system. Consultation with iwi would be recommended so their input on suitability and design could be included.

It is possible to combine APS with conventional land application. In this instance, the maturation ponds would not be necessary, and effluent could be irrigated from enlarged algal settling/storage ponds. The algal solids are more stable than faecal wastes, and thus release their nutrient over an extended period.

5. Whole farm management

How effective are these other methods (apart from land disposal of effluent) of achieving stream quality objectives in dairy farming catchments i.e. methods that apply to the whole farming operation? For example, managing the following activities/resource in a better way: farm races, drain and river crossings, riparian areas, grazing management, fertilizer policy and feed pads.

5.1 Stream and drain crossings

There are various suggestions for improving farm management to minimise faecal contamination of waterways. While intuitively they appear likely to improve stream and drain water quality, their relative effectiveness in reducing contamination has generally not been directly evaluated. Recent research into some of these areas gives us insights into the effectiveness of these strategies.

The Sherry River catchment (Nelson, NZ) has a high level of dairying, with cows crossing the river via fords in many instances. At one location, cows crossed the river each day to reach the dairy shed. Davies-Colley et al. (2002) found that cows were 50 times more likely to defecate in the river than in the raceway leading to and from the river. Faecal bacteria from the cow-pats were re-suspended by the cows walking through the river as well as by farm vehicles fording the river. Concentrations of *Escherichia coli* (the key indicator bacterium used to identify mammalian faecal wastes) increased from 300 MPN[†] 100 ml^{-1} upstream of the crossing to a peak of 52,000 MPN 100 ml^{-1} immediately downstream when the cows were fording the river. Bacteria that are not immediately entrained act as a reservoir, contributing to "back-ground" levels in the river during low flow, as well as causing high concentrations when resuspended during high flow events. Farmers in the catchment are now building bridges for cow crossings over the river, and are planning long-term strategies for streams and other tributaries that are used less frequently (See NZ Dairy Exporter article, Anon. 2002)

5.2 Fencing of streams and drains

Wherever cows have direct access to a stream or drain, there is obviously a similar potential for them to defecate into that water body, causing contamination as noted above. In addition, farmers will be familiar with the streambank erosion caused by

[†] MPN = most probable number, a standard statistical estimation used in measuring bacteria.

cows entering and leaving waterways causing drain infilling and bank collapse. As well as requiring more drain clearing, this increases the potential for eroded soils to become suspended in waterways, increasing turbidity, reducing the aesthetic appeal of the water, and adding nutrients, leading to increased weed growth (macrophytes and algae) in drains.

Another potential concern is for stock health, where livestock are repeatedly exposed to drinking water contaminated with pathogens from other stock. An American study has shown 39% of "healthy" dairy cattle carry *Camplyobacter jejuni* (Wesley et al. 2000). New Zealand has one of the highest reported rates of enteric diseases for industrialised nations (Crump et al. 2001), and unpublished New Zealand data (Marion Savill, ESR presented at specialist *Camplyobacter* workshop, NZWWA Conference, 1998) has shown similar levels of *Camplyobacter* in a survey of Waikato dairy herds. An English study found that dairy herds supplied exclusively with uncontaminated water had no *Camplyobacter* in their faeces (Humphrey & Beckett 1987). It is unclear how much *Camplyobacter* or other waterborne diseases affect cow productivity, but farmers may find economic benefit by excluding cows from waterways.

Riparian strips have several potential functions, and goals for riparian management should be determined before any recommendations are made. Riparian plants can stabilise stream banks and also provide shading of the stream (preventing excessive heating). Elevated water temperatures may not be an issue in deep drains fed by groundwater however, and shading can lessen pathogen removal caused by sunlight.

Inputs of particulate contaminants can be reduced as overland flow is filtered through plant swards, and dissolved contaminants passing through the root zone of stream bank plants are taken up and utilized by the plant. Shading and reducing nutrient inputs to drainage areas may also reduce nuisance weed growths (although benefits from riparian zones may take some time to become apparent) (Collier et al. 1995). Aquatic plants however should not always be considered a nuisance, as they can provide habitat for invertebrates and fish, and can attenuate nutrients passing through a drainage system (Nguyen et al. 2002b).

A form of riparian protection that has been suggested for dairy farms is to provide a set-back from streams or drains during winter. This allows a thick grass sward to be maintained near the edge of waterways, which can filter and attenuate solid particles and faecal matter carried in overland flow. The set-back can be grazed in spring, or when overland flow is unlikely.

It is suggested that the potential for interception of surface runoff in riparian zones be assessed and downstream water quality objectives be carefully considered before embarking on a riparian protection/planting strategy.

5.3 Grazing management, fertilizer policy and feed-pads

Grazing management during wet periods is important to minimise treading damage, which can cause soil compaction or pugging. Soil compaction has been found to reduce spring pasture yield, and a pugged soil may take 3–4 months to recover to undamaged levels (Drewry et al. 2002; Ledgard et al. 1996). Soils compacted by treading or damaged by pugging have reduced infiltration rates, and are more likely to cause runoff of rainwater and effluent to adjacent streams or drainage areas. Under circumstances where soil compaction is likely, it is recommended that on/off grazing (grazing 3–4 hours) and a feedpad be used to minimise damage to soil and pasture (Ward & Greenwood 2002).

Feedpads obviously have the potential to generate effluents, as cows may be on them for 20 hours per day during wet weather (compared with 2–3 hours in the milking yard). Any runoff from the feedpad must be dealt with in an appropriate treatment system.

Fertilizer policy can influence nutrient losses to drains and streams. Several management options can minimise the potential for fertilizer runoff. These include: applying maintenance levels of nutrients (as determined by soil tests); spreading fertilizer applications through the growth season; applying fertilizer when the risk of heavy rain is low; choosing the most appropriate type of P fertilizer (perhaps favouring reactive phosphate rock over more soluble super-phosphate on areas that are susceptible to runoff) (see Nguyen et al. 2002a); or reducing P addition.

Each of the above strategies is likely to reduce effluent, faecal wastes and/or fertilizers entering waterbodies to different degrees. The extent of potential improvement depends to a large extent upon existing farm practices, and how closely they currently conform to “best management practices”. For instance, on farms where the amount of fertilizer added to paddocks is carefully managed (using soil testing as a guide), the amount of nutrient entering drainage systems may not be great. Use of slow release fertilizers may only give marginal improvements on soils with low gradients. However, as a general guide we have ranked the various strategies in order of their potential improvement to receiving water quality. Particular importance has been placed on strategies that minimise direct faecal contamination of waterbodies due to the potential for food gathering in downstream areas:

1) Providing livestock crossings over major waterways and avoiding direct drainage from farm races into waterways,

2) Fencing of streams and drains,

3) Use of feedpads (to protect pugging prone soils),

4) Providing crossings over minor waterways,

5) Fertilizer management on paddocks prone to runoff,

6) Retiring and planting riparian zones.

6. Tile drainage beneath effluent irrigation areas

What effect does tile drainage beneath an effluent irrigation area have on adjacent water quality?

Tile drains are a means of transporting water away from soils, thus lowering the water table. This increases the capacity of soils to accommodate rainfall or irrigation water before overland flow or sub-surface drainage occurs. As noted by Barton et al. (2000) "many of the biological processes that renovate effluent occur in the soil rooting zone, therefore retaining effluent in this part of the soil profile will maximise effluent treatment". If the amount of irrigation exceeds the soil field capacity (the amount of water a soil naturally holds), drainage or surface runoff must occur, and any solutes (dissolved nutrients) or faecal bacteria in the water are transported away from the "bio-active" soil-rooting zone where remediation can occur.

Some soils are prone to by-pass flow through cracks, worm-holes, or simply because the soil forms "blocks" around which effluent flows. Thus even a well-constructed drainage system (i.e. of appropriate depth) beneath an effluent irrigation area may cause rapid flow of poorly treated effluent into the drainage system. In a recent example, a dairy farmer in Southland stopped using irrigation after realising (in consultation with the Regional Council) that the effluent applied to his mole drained clay soils was rapidly entering the drainage system through cracks in the soil, and causing obvious pollution to an adjacent stream. He has since put in an Advanced Pond System. Although the soils in the Pongakawa/Kaituna catchments are not prone to cracking, by-pass flow is still considered a possibility with peat soils.

As noted previously, organic soils have high potential to adsorb nutrients, although this is somewhat dependant on the height of the water table. High water tables are sometimes deliberately maintained in peat areas to prevent mineralisation and shrinkage, which lead to soil subsidence. Finely graded ash soils, as are also found in these catchments, are very efficient for attenuating faecal bacteria (M. McLeod, pers comm. See also Aislabie et al. 2001; McLeod et al. 2001). For systems treating sewage, guidelines recommend that irrigation only take place when available pore space within a soil is less than half full of water (Barton et al. 2000). For dairy wastewater however, Horne et al. (2002) note there is "no rigorous criteria (based on soil water status) for the day-to-day management of effluent irrigation, particularly in difficult situations, such as those presented by imperfectly drained soils, [and] it is not surprising that land treatment of dairy effluent is causing widespread pollution of surface waters via runoff or rapid movement through artificial drainage systems".

Irrigation must not be undertaken at a rate that exceeds the capacity of the soil (particularly the rooting zone) to accommodate it without drainage occurring. If the specific soil hydraulic properties are not already known, specific studies should be undertaken to determine the soil moisture deficit at which irrigation can be safely employed. Surface ponding and non-uniform application also cause localised high application rates that can exceed the soil infiltration capacity causing bypass flow to, and thus pollution of, groundwater.

Preventing effluent entering a drainage system may be possible by using applications at lower rates than non-drained areas. Clearly irrigation must also be scheduled with due regard for the possibility of rainfall, which might also induce drainage if it occurred immediately after irrigation.

The fate of faecal matter and urine applied to soil in irrigation water depends to a large extent upon the state of the water table and soil hydraulic properties. Thus improved drainage holds potential risks, and warrants controlled studies specific to each region. Whether a sub-surface drainage system will be of benefit when effluent is applied must then be determined on a case-by-case basis.

7. Implications for the Water and Land Plan and the Coastal Plan

What impact will the various options considered in each question above have on the water classifications in the Water and Land Plan and the Coastal Plan?

Environmental issues raised in this report have implications for Environment BOP's "Proposed Regional Water and Land Plan" (Environment BOP 2002, hereafter referred to as the Water and Land Plan) and "Proposed Bay of Plenty Regional Coastal Environmental Plan" (Environment BOP 1999, hereafter referred to as the Coastal Plan).

Within the Water and Land Plan, the drains and canals in the lower reaches of the catchment are classified as "drain water quality class" (see rule 19, p. 140) which then enter larger "drains with ecological values water quality classification (see rule 18, p. 139). As such, they must meet a range of standards including not causing "any significant adverse effects on aquatic life" and "any adverse effect on aquatic life" respectively. Trigger values for these definitions are contained in ANZECC guidelines (2000). Adverse effects (section 4.1, p37) may be caused by "point-source discharges of contaminants to water, discharges of water to water, discharges of contaminants onto or into land where the contaminant may enter water as controlled by section 15 of the Resource Management Act 1991". It states (Policy 30, p.40–41) that "for discharges to rivers and streams that flow directly to the open coast, or are tributaries of harbours and estuaries, the effect on the water quality of coastal waters will be considered", and thus the Coastal Plan must also be referred to. The Water and Land Plan also states (Issue 18 [4], p.39) that "the discharge of contaminants to land is generally preferred, rather than point source discharges to surface water..." but that "the adverse effects of discharges to land need to be compared with those of discharges to water, on a case by case basis". Thus even where the receiving water has high environmental or food-gathering values, there is no direct restriction against using a treatment system that discharges to surface water. However, Issue 16 (p. 37) identifies the significance of contaminants that enter water which "have the potential to degrade water quality below that necessary to sustain heritage values and allow for use of water by the community, and degrade the mauri of the waterbody". Also that "the discharge of sewage to water, may be particularly culturally offensive to Maori". While livestock wastes do not have the same spiritual values as human wastes, widely held views amongst Maori are that livestock wastes entering a waterbody would degrade its mauri.

The Maketū area is highly sacred (waahi tapu), and forms a geographical boundary for the local confederation of tribes. The Maketu estuary's original name is Te Awa o Ngatoroirangi, or Ōngatoro for short. Ngatoro-i-rangi was the rangatira of Te Arawa waka, and the site was the final resting place of Te Arawa/Tuwharetoa waka (Maketu refers to the original settlement). The Maketu and Waihi Estuaries are also widely used for food-gathering and constitute New Zealand’s second designated taiapure (see attached copy of Aniwaniwa, Issue 17). Clearly the area has ongoing significance to Maori as a food resource, as signified by names in the region (Kaikokopu and Kaituna = “food fish” and “food eels”) and evidenced by the fact that there are (at least) two Waitangi Tribunal claims regarding the damage caused to Maketu Estuary by the diversions of the Kaituna in interests of reclaiming low-lying farmland.

In addition, the Maketu and Waihi Estuaries, and Okurei point are identified in the Coastal plan as meeting “Ramsar criteria for an internationally significant wetland” (p171–172), being an important feeding and roosting area for migratory and wading birds.

Based on the classifications of drains (and canals) in the Pongakawa/Kaituna catchments within the Land and Water Plan it appears clear that whatever treatment system is utilised must have a sufficiently high degree of treatment to prevent any adverse effect within the major drains or in the Waihi and Maketu Estuaries. Incorporation of a land treatment component is also highly desirable to meet Maori cultural requirements.

The specific conditions within the low lying areas of the Pongakawa/Kaituna (and associated) catchments can be adequately addressed within the provisions of the Land and Water Plan and the Coastal Plan in their present form. They stipulate a preference for land application of effluent, but recognise that other forms of treatment may be more appropriate depending on the conditions of each site.

Other farm management practices such as riparian retirement, planting and fencing, and use of stock crossing are identified as areas in which Environment BOP has a role in education and provision of information (section 3.4, Water and Land Plan). Control of stock in waterbodies is also addressed in section 9.3 (Rules 7–10). The explanation of Rule 7 states the “Environment BOP will encourage landowners to retire and fence riparian areas, and install single span bridges or culvert through non-regulatory methods”. The rules however do allow the council to take a regulatory approach if they see fit. As such, the Water and Land Plan provides the council with sufficient discretionary powers to address the farm management issues also raised in this report.

8. Summary and Recommendations

The Maketu and Waihi Estuaries are important features of the local area, providing a significant wetland preserve as well as being a food gathering resource for local people. The series of canals in the area also act as a habitat for native fish. As such, the lower reaches of the Pongakawa (and other nearby) catchment and the coastal areas they drain to, are sensitive to effluent discharged to them. Two-pond systems built to existing guidelines discharge relatively high levels of contaminants (particularly faecal bacteria), and do not give adequate treatment for discharge into a sensitive water body. However, high water tables and occasional overtopping of the canals mean that land application systems will clearly require a high degree of management in order to ensure adverse effects do not occur, particularly during prolonged periods of wet weather, or during high rainfall events. It is recommended that either land application of effluent with some degree of pre-treatment, or improved pond treatment systems (such as APS) be required.

Where land application is used, a minimum requirement would be for adequate wet weather storage volume for dairyshed effluent, and retention of existing two pond treatment systems or alternative storage facilities would be strongly advised, in order to ensure adverse effects do not occur. This will give farmers the ability to manage irrigation events for periods when the water table is sufficiently low to ensure effluent does not run-off or enter the drainage system before soil processes can renovate the effluent (deferred irrigation). Environment BOP, perhaps in combination with dairy farmer representative groups, may consider installing soil moisture monitors in this (and other) catchments and posting results on their web pages to guide farmers as to when effluent irrigation is advisable. Permitting a combination of irrigation and discharge, as is used in Taranaki, provides benefits over existing discharge from two-pond systems, by reducing the amount of effluent discharged to a waterway, however it may be feasible for farmers to have nil discharge (irrigation only) by using a managed system of storage and irrigation (and/or recycling), especially if soil moisture deficit information is available.

Improved treatment of dairy shed effluent prior to land application would minimise the risk of poorly treated effluent entering the drainage system, however combining advanced pond systems with a passive land treatment step such as a wetland may be an acceptable compromise while also meeting Maori spiritual requirements.

Instigating a monitoring programme from pumped discharges could be used to assess the relative inputs of nutrients to the Pongakawa and Kaituna waterways from general farm practices as opposed to pond discharges. This information would provide a more accurate measurement of mass inputs to these waterways, and assist Environment BOP in determining the effects of farm management practices and the requirement for remedial action.

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