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Job No. 10292

MEMORANDUM

To: Wairoa Wastewater Project Stakeholder Group

From: Katie Beecroft/Phil Lake/Hamish Lowe

Date: 11 September 2017

Subject: A2D2-High Rate Land Passage – A Brief Introduction

Background

The Wairoa wastewater treatment system requires a replacement consent by May 2019. Part of this upgrade requires a consideration of the type of treatment the municipal wastewater will receive before final discharge. An option to be considered if discharge is to water is the preferred option is a high rate land passage (HRLP) system as a means of further treatment and to meet cultural considerations.

Purpose

To describe HRLPs as a means of further treatment of wastewater and to meet cultural considerations for Wairoa. This memo is not intended to provide recommendations for specific land passage systems, it is merely an introduction to high rate land passages and their suitability for specific sites.

Scope

- Describe the principles of high rate land passage systems in current operation;
- Consideration of system selection and design, and;
- Advantages and limitations of HRLP systems.

Introduction

Wairoa District Council (WDC) is undergoing a process to determine the future mode of discharge for the town's wastewater. A number of options which include discharge to land, discharge to water, and combined discharge to land and water are being evaluated.

The Wairoa Wastewater Project Stakeholder Group have been considering discharge options which include land passage of the wastewater. Land passage (as opposed to irrigation) has a number of potential benefits which include:

- Further treatment of the wastewater due to both the action of the soil on the wastewater, and by making the path to ground or surface water longer; and
- To acknowledge the role culturally that land has in purification or neutralisation of the material prior to entering water (transformation of tapu to noa status).

There are many types of land passage along a spectrum which sees more or less contact time with soil and/or treatment media. The land area needed for such systems is dependent on the characteristics of the soil and on the extent of wastewater treatment needed.

Around the Wairoa wastewater treatment plant (WWTP) there is limited land which is suitable for irrigation, which is a low application rate process that provides a high level of treatment while minimising or avoiding discharges to underlying groundwater and/or nearby surface water. The Stakeholder Group has acknowledged that the cost of an irrigation system is significant and potentially prohibitive. An alternative approach that has been discussed is the inclusion of a high rate land passage system, whereby wastewater passes quickly over or through soil or similar media. This latter approach can be feasible in terms of cultural considerations, cost implications, and acceptable environmental effects.

A further report outlining an exact design for a HRLP and RIB system will follow on from this memo that is specific to Wairoa and the area around the WWTP.

This summary introduces and details the concept of high rate land passage (HRLP) and gives examples of options and systems currently in use around New Zealand and provides ideas to develop a system unique to Wairoa.

Principles of High Rate Land Passage

High rate refers to the loading (volume) of wastewater passing over a small area of land in a short space of time. This may mean that there is a lesser degree of treatment when compared to a low rate system (irrigation), but obviously more land treatment than a direct pipe discharge to surface water. A HRLP system may also involve the soil NOT being used as a treatment mechanism; and in such cases there is no requirement to obtain any benefit from the soil (and plant) system. Despite this, there is typically a desire for the wastewater to interact with the soil and plants before entering any surface water body. In many cases a combination of infiltration into the soil and overland flow occurs. The key processes and benefits of HRLP are:

- A reduction in wastewater derived contaminants by filtration and adsorption, and eventually plant and microbe uptake;
- Aeration of the wastewater resulting in a reduction in BOD;
- Storage volume needed at the WWTP is reduced; and
- Most importantly HRLP aims to achieve sufficient contact between the land and the wastewater to effect the metaphysical cleansing attributed to Papatuanuku, and restoring or maintaining the mauri (life essence) of the receiving water (see **Wastewater Info Sheet 7** for additional discussion). This can further assist with avoiding any adverse effect on the receiving water's capacity to be used for kaimoana or ceremonial purposes.

The extent of improvement in some cases can be dependent on the flow rate and how long the water resides within the HRLP system.

This change in wastewater properties following land passage is a key concept in the use of HRLP systems and is also known as **biotransformation**. This means that the wastewater is incorporated into the microbial community that it contacts and, through successive biological transformations becomes a different material, with the exiting water no longer being considered wastewater.

HRLP System Selection and Design

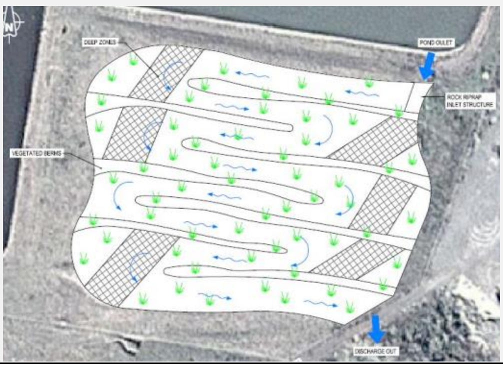
HRLP design begins with what is possible for the site. A design should be prepared with consideration of the following:

- Land area available;
- Slope of the area;
- Soil characteristics;
- Embankment stability to the water source;
- Current land use;
- Ability to maintain the structure;
- Distance to surface water;
- Erosion and flood inundation risk;
- Design wastewater flow rate; and
- Amount of use it will get throughout the year.

There are two key design elements, being some form of land passage and the ability for the residual wastewater to discharge or dissipate after land passage. Both elements need to be incorporated into any design. Land passage provides for soil and plant contact, and essentially the cleansing and treatment of the wastewater (biotransformation). The residual discharge component provides for the mechanism which allows the wastewater discharged to reach the ultimate receiving water, which may be over a river bank and into a stream, or soakage through gravels into groundwater beside a stream.

The following examples are options that have been prepared for a number of communities, with varying needs and available space. There is potential for more than one option to be used in a HRLP system and for the configuration of each option to be adapted for the site.

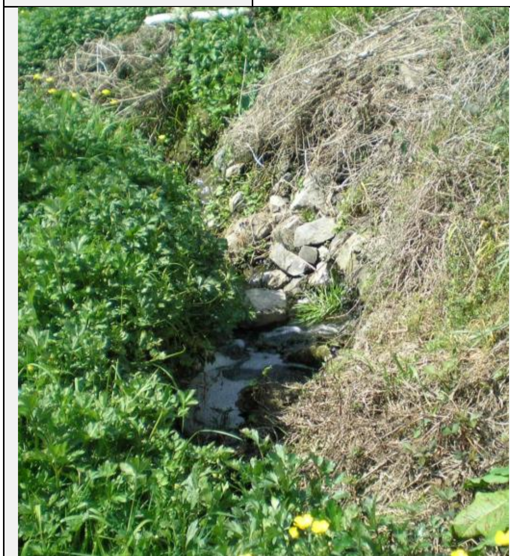
	Open Wetland
Description	Wastewater enters a shallow pond structure which is planted with groupings of wetland plants. Plants can be planted in a wetland media, or as floating rafts. Water exits the wetland at a point, but may travel over a diffusion structure during discharge.
Passage type	Minor contact with soil interface. Predominant treatment is due to contact with biofilm on plant stems or roots growing in a soil or gravel media.
Effects on wastewater	• Can effectively remove settleable solids, resulting in an improvement in clarity (note below, this can be undone). • Reductions in nitrogen can occur with sufficient residence time.
Suited to	Sites with gentle slopes and fine textured soils (silts and clays)
Engineering Considerations	• Can be designed with or without impermeable liners, depending on the sensitivity of the location and the need to separate the wastewater from groundwater. • Design should maximise the flow path of the wastewater to maximise time in wetland. • Incorporation of deep and shallow sections will increase removal of contaminants by changing the oxidation state of the water and the biota in the wetland. • Ongoing maintenance of plants and planting media is needed to avoid "short-circuiting" or blocking of flow paths and a reduction in the treatment/biotransformation process.
Advantages	• Attractive feature • Long residence time can be provided for, resulting in greater degree of biotransformation.
Limitations	• Water fowl attracted to open water are likely to cause the microbial and nutrient load to increase between inlet and outlet. • Conditions in open water may encourage algal blooms at some times of year, resulting in reduced water clarity between inlet and outlet. • Ideally suited to regular (not fluctuating) flows year round. • High maintenance requirements. • Large area required compared to other land passage options.



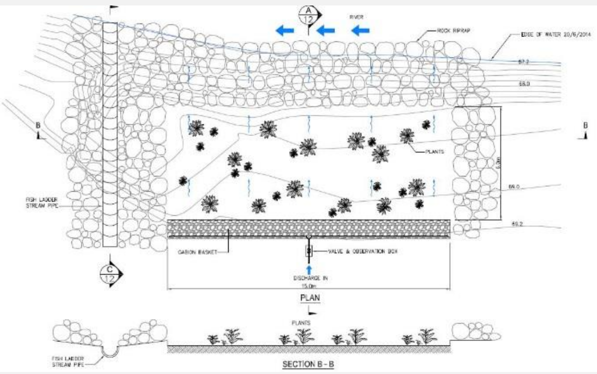
	Subsurface Wetland
Description	Wastewater is discharged by a diffuser to an engineered basin filled with media such as gravel or sand (or slag, woodchips, etc). Wetland plants are planted over the entire surface of the basin and the wastewater level sits within the media i.e. water flows through the gravel or sand. The discharge is as described for the open wetland.
Passage type	Predominant treatment is due to contact with a biofilm on the basin media. Minor treatment is by the biofilm growing on plant roots and plant uptake.
Effects on wastewater	• Can effectively remove settleable solids, resulting in an improvement in clarity. • Reductions in ammoniacal nitrogen and nitrate nitrogen can occur. • Some pathogen reduction is expected. • Different media can treat different contaminants i.e. woodchips enhance removal of nitrate, slag is useful in removing phosphorus.
Suited to:	Sites with gentle slopes and fine textured soils (silts and clays)
Engineering Considerations	• Requires impermeable lining. • Requires method of managing water level. • Ongoing maintenance is required to maintain plant cover, exclude weeds and avoid organic matter build-up in the media.
Advantages	• Smaller area required than open wetlands. • Extensive contact with the basin media results in a greater degree of biotransformation.
Limitations	• "Blinding" of media may occur over time if the wastewater entering the bed has a high solids content. • High maintenance requirements.


	Rapid Infiltration Basin
Description	These systems aim to temporarily flood or pond wastewater within bunded areas of land and force the wastewater to drain through the soils to the underlying groundwater. This may occur above ground or in the shallow sub-surface soils.
Passage type	Predominant treatment is filtration through the underlying soil.
Effects on wastewater	• Can effectively remove solids. • Some pathogen reduction is expected due to filtration. • Little or no reduction in nutrients.
Suited to	Sites with gentle slopes and free draining soils (sands and gravels)
Engineering Considerations	• Requires permeable sub soil conditions, sufficient depth to groundwater and sufficient groundwater flow to minimise mounding of groundwater at and near the site. • Distribution method may include subsurface trenches, overland discharge from a diffusor or a "bubble-up" discharge. • Enough land is needed to "rotate" the discharge location between basins/fields and providing spelling of the recently used areas.
Advantages	• Small area required compared to some other methods. • Potential to have area grassed resulting in easy maintenance. • All discharge is through the land or media.
Limitations	• "Blinding" of media may occur over time if the media is not routinely able to dry out between applications.

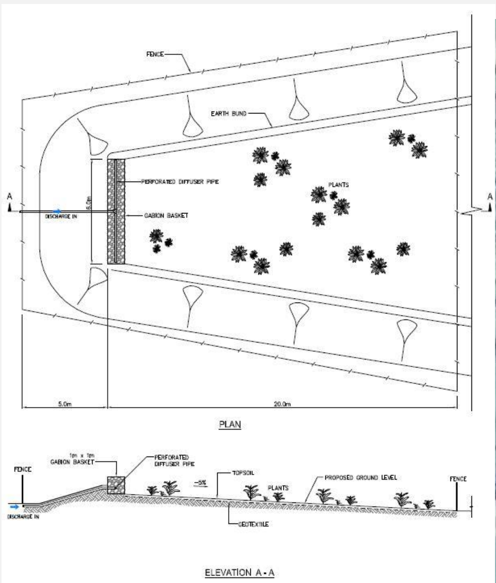
	Rock Filters
Description	These are retaining walls or pits in the ground filled with small rocks over which the wastewater flows. The rocks can be contained in gabion baskets, laid as a sloping rock armouring feature, or set into soil or concrete.
Passage type	Predominant treatment is due to contact with biofilm on the basin and rock media. Minor treatment is by biofilm on plant roots and plant uptake.
Effects on wastewater	• Aerates the wastewater, reducing its BOD.
Suited to	Suited to sites with limited space, and any soil type. Beneficial if adjacent to a waterway.
Engineering Considerations	• Requires impermeable lining. • Requires method of managing water level and flow rate. • Ongoing maintenance is required to maintain plant cover, exclude weeds and avoid organic matter build-up in the media.
Advantages	• Well suited to sites with limited free space. • Very cost effective.
Limitations	• Best suited to wastewater that has already had a high degree of treatment.

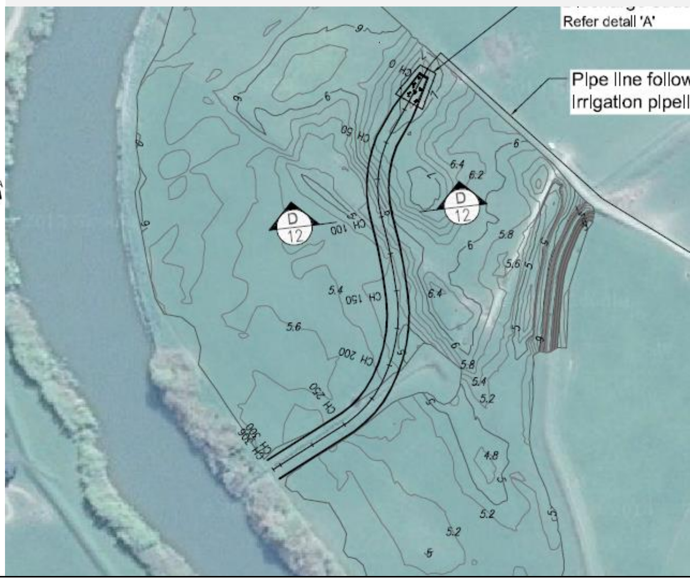



	Cascade Structures
Description	The wastewater is evenly spread along a rock filled structure that spills into a vegetated area or unvegetated media for further earth contact. From the vegetated zone the river embankment is stabilised using rip rap for the discharge to filter through before it enters the surface water.
Passage type	Predominant treatment is due to aeration of the wastewater. Contact with biofilm on the basin media or soil further improves wastewater. Minor treatment is by biofilm on plant roots and plant uptake.
Effects on wastewater	• Reduction in BOD due to aeration. • Can remove suspended solids, resulting in an improvement in clarity. • Reductions in ammoniacal nitrogen can occur. • Minor pathogen reduction is expected.
Suited to	This type of HRLPS is well suited to areas where there is a steep slope or limited distance between the treatment plant and a water body.
Engineering Considerations	• Device needs to be sized and armoured for expected flows. • Design for easy maintenance on steep slopes.
Advantages	• Suitable for small areas and steeper slopes. • Potential to create an attractive feature with different zones.
Limitations	• Best suited to well treated wastewater.

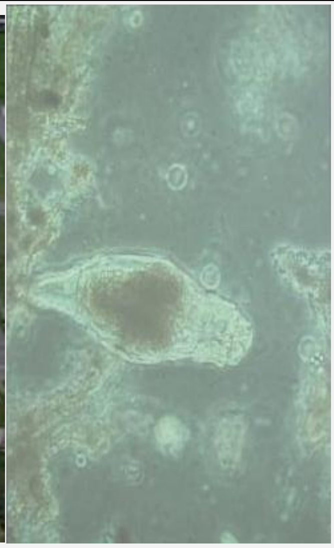


	Vegetated Swale
Description	Where there is a gentle slope on the site and a reasonable distance (100-200 m) between the treatment plant and a waterway the use of a diffusion structure which directs the wastewater along a vegetated swale provides a high degree of soil and plant contact
Passage type	Predominant treatment is by filtration and long residence time over a long channel.
Effects on wastewater	• Can effectively remove suspended solids, resulting in an improvement in clarity. • Reduction in BOD due to aeration. • High pathogen reduction is expected.
Suited to	Gentle slope and large distance (100 – 200 m) between treatment plant and waterway.
Engineering Considerations	• Requires diffusion discharge. • Work with natural fall of land where possible.
Advantages	• Can use land for other purposes when not in use. • Extensive contact with the swale results in a greater degree of biotransformation. • Lower maintenance than other HRLP systems.
Limitations	• Requires large area compared to other HRLP systems. • Need to manage and maintain flow over width of structure.





	Vertical Biotransformation Methods
Description	The same mechanisms of treatment and contact can be achieved using a smaller area by making the device force wastewater to flow vertically. In some systems, a manmade material (plastic or metal) may be used as the media on which the biofilm is established. Other systems may use natural material like stones (trickling filter) or sawdust/wood chips. Wastewater is sprayed on the top of the media and runs over the biofilm growing on the media which treats the wastewater.
Passage type	Predominant treatment is due to contact with biofilm on the media. Additional treatment due to aeration occurs.
Effects on wastewater	• Reductions in all contaminants are expected to occur. • Some pathogen reduction is expected.
Suited to	Untreated wastewater, limited land available and/or close proximity to neighbours
Engineering Considerations	• Requires detailed design due to cost, to avoid under or oversizing. • Construction requirements are the same as any large infrastructure/building project. • Monitoring and sampling ports need to be included in the design.
Advantages	• Provides higher level of treatment so is suitable for untreated or lower grade treated wastewater. • Requires less room since the contact bed is effectively vertical. • Mostly enclosed systems so suitable in high density areas.
Limitations	• More expensive option. • More specialist knowledge needed to operate. • Less visually attractive. • Perception issues due to visible man-made structures.

Summary Table of HRLP Options

	Suitable for:						How it works:			
	Small areas	On slopes	Fine textured soils	Low maintenance	Extra treatment	High Groundwater	Drainage through land	Pass over land	Pass through media	Planted
Open wetland	×	×	✓	×	✓	✓	○	✓	×	✓
Subsurface wetland	✓	×	✓	×	✓	✓	✓	×	✓	✓
Rapid infiltration basin	×	×	×	×	○	×	✓	×	×	○
Rock filter	✓	✓	✓	✓	×	✓	×	✓	×	×
Cascade structure	✓	✓	✓	✓	×	✓	×	✓	✓	○
Vegetated swale	×	✓	○	✓	✓	✓	○	✓	×	✓
Vertical Biotransform	✓	×	○	×	✓	✓	×	×	✓	×

✓	Yes – Option is well suited; or works this way
○	Maybe – Option may be suitable or design can be modified to suit; or can include this design element
×	No – Option not suited; or does not work this way

Example System

There is a wide range of HRLP systems in use throughout New Zealand. The following are a few of them

Piopio

Piopio's wastewater is treated to a high standard and then discharged via a diffuser enclosed in a gabion basket, and then over a series of stepped basins filled with gravel, before finally discharging to the Mokau River. Figure 1 shows the structure installed.

Figure 1: Piopio Cascade Structure

Shannon

Wastewater from Shannon's pond is irrigated at a low rate to land when possible. However, for high rainfall and river flow periods wastewater is discharged to a small open wetland, and then to an armoured diffuser which directs up to 3,000 m^3/d of wastewater along a vegetated swale. The soil is sandy so much of the applied water soaks into the swale along its length. Any water that doesn't soak in travels to a planted drain and then into the Manawatu River during high flows. Figure 2 shows the swale under construction and in use.

Figure 2: Shannon Vegetated Swale

AFFCO, Feilding

Meatworks wastewater from AFFCO Feilding's treatment ponds is discharged to land via low rate irrigation where possible. To manage the periods when discharge via irrigation is not suitable, AFFCO will be discharging treated wastewater over a planted cascade structure. This will replace a direct water discharge. Figure 3 shows the HRLP planned.

The cascade structure includes a diffuser discharge and a combination of planted and rock armoured zones. The structure is designed for the steep bank of the Oroua River, and the design also takes account of the high and low water levels in the river.

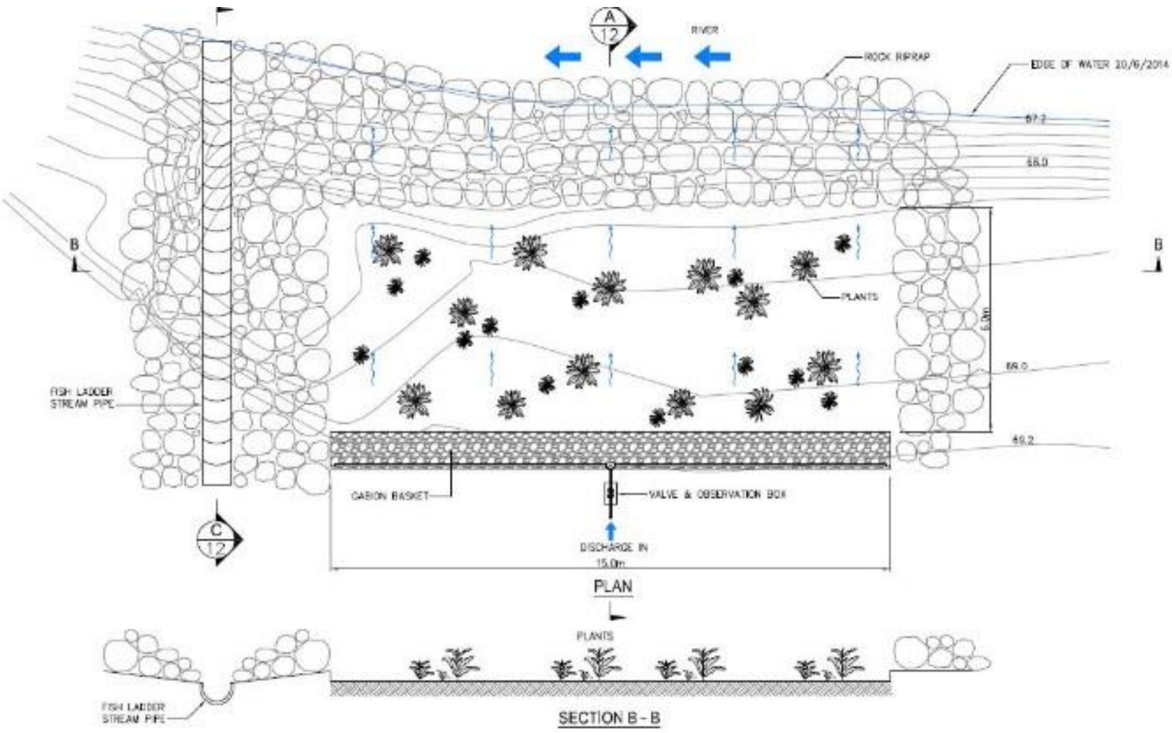


Figure 3: HRLP Concept for AFFCO Feilding

Rotorua

Rotorua has, for many years, discharged its wastewater to the Whakarewarewa Forest. The forest discharge is not able to be continued into the future and so the Rotorua community has been through a process to establish a new discharge option. The favoured option is a high rate discharge of highly treated wastewater to the Waipa River shortly before it enters Lake Rotorua. Figure 4 shows the proposed design.

This HRLP structure incorporates a range of the elements described above including rock filters, open and subsurface wetlands and cascade structures. Because of its proximity to the township, and a belief that the people should have access to the structure there are a number of aesthetic choices incorporated like water fountains and bubble-up diffusers, attractive layout of plantings and structures which reflect the surrounding landforms. A walkway across the structure shaped as a stylised tewhatewha is the centrepiece of the HRLP system.

Figure 4: HRLP Concept for Rotorua