MINIMISING ENVIRONMENTAL IMPACT THROUGH A TARGETTED RIVER DISCHARGE APPROACH

R.A. Docherty, W.J. McKenzie
Pattle Delamore Partners Limited, Auckland, New Zealand

ABSTRACT

The townships of Waipukurau and Waipawa in the Central Hawke's Bay currently discharge treated wastewater (effluent) directly to the Tukituki and Waipawa Rivers respectively. In 2011 a new scheme was proposed to prevent a large portion of the effluent from entering the rivers and irrigate it to two large parcels of land, planted as production forestry.

Considerable periphyton growth occurs within the Tukituki River system during summer. Generally the periphyton growth is phosphorus limited. For this reason both Central Hawke's Bay District Council and Hawke's Bay Regional Council are trying to reduce the phosphorus entering the river from the effluent discharge.

This paper discusses involvement that Pattle Delamore Partners Limited has played in developing the Dual Discharge scheme for Waipukurau and Waipawa. The scheme which proposed to dispose of effluent to both land and river and store effluent when neither form of discharge was available. It was expected to remove about 50% of the total volume of effluent from the Tukituki River system.

NIWA was engaged to model the expected periphyton growth which would result from operation of the Dual Discharge scheme and compare it with the present situation and other improved treatment scenarios. The predicted reduction in periphyton growth after implementation of the Dual Discharge Scheme mimics the reductions expected if there was zero effluent discharged to the rivers.

KEYWORDS

Effluent, Tukituki, discharge, irrigation, wastewater, storage, periphyton, algae

1 INTRODUCTION

Currently the townships of Waipawa and Waipukurau in the Central Hawke's Bay discharge treatment municipal wastewater (effluent) to the Waipawa and Tukituki Rivers respectively. The existing effluent is partially treated in facultative aerated lagoons which provide for settlement of suspended solids and treatment through oxidation and biological degradation of the wastewater.

The consented discharges require an upgrade in the standard of treatment and improvement in quality of the effluent by 2014. In particular, the concentration of dissolved reactive phosphorus in the effluent is to be significantly reduced.

At times of low flow in the rivers the nutrients in the wastewater, specifically nitrogen and dissolved reactive phosphorus (DRP) result in the growth of periphyton (algae) and aquatic weeds.

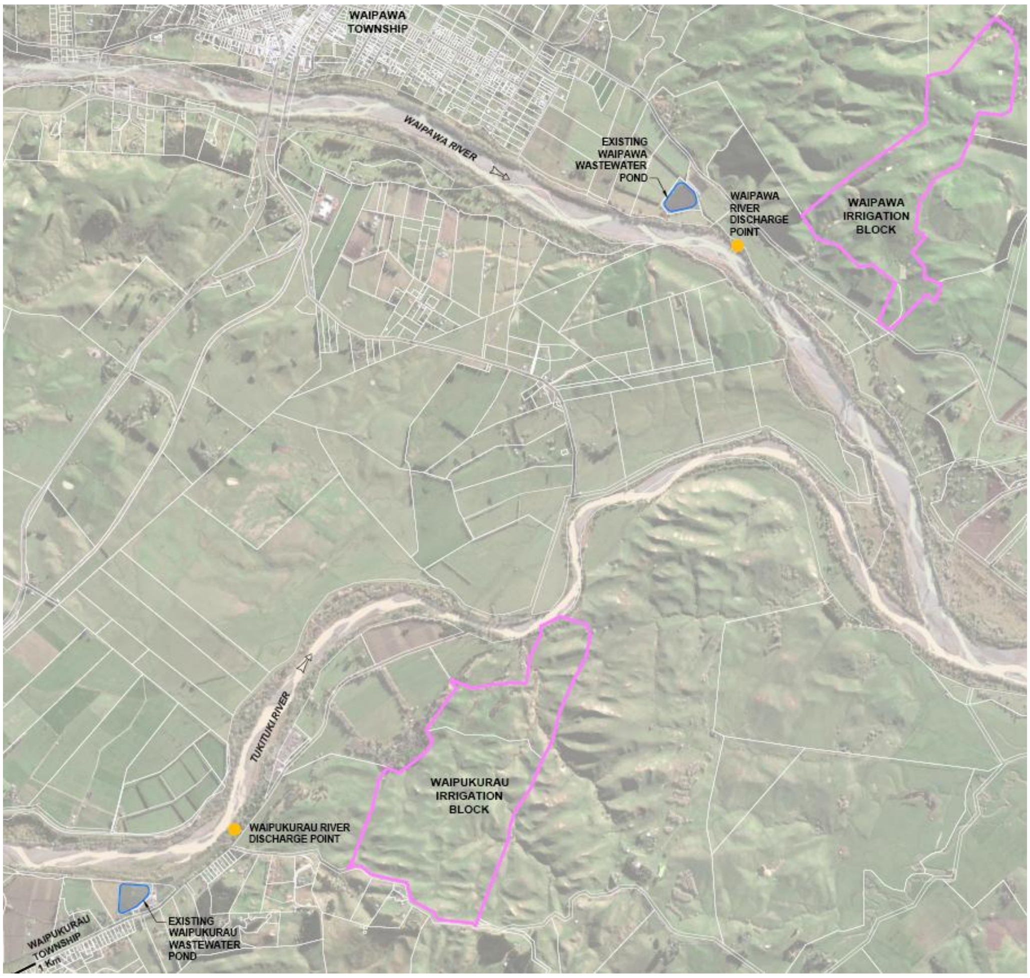
Initially it was envisioned that reductions in phosphorus concentrations in the effluent would be achieved using a conventional 'hard engineered' wastewater treatment solution. However, for a significant period of time, an alternate solution was considered, called the Dual Discharge Scheme.

The Dual Discharge Scheme proposed to irrigate effluent to land (whenever possible) and discharge to the rivers during specific river flow conditions when flows exceeded 3 x median flow. This discharge regime focused on removing phosphorus input to the rivers during times of high nutrient uptake by aquatic plants.

A portion of the effluent was to be irrigated to two large blocks of land purchased by the Hawke's Bay Regional Council (HBRC). The two irrigation blocks are 123 and 79 hectares in size and are situated on hilly land close to the two treatment plants. Figure 1 shows the locations of the WWTP's, rivers and irrigation blocks.

This paper describes the Dual Discharge Scheme which was developed for the two townships and the role that Pattle Delamore Partners Limited (PDP) has played in developing the scheme. It details the key constraints and shows the potential improvements on the river ecosystem.

Figure 1: Plan View of WWTP's, Rivers and Irrigation Blocks



2 DUAL DISCHARGE SCHEME

The dual discharge scheme would utilize a combination of discharge of municipal treated effluent to both land and river. The aim of the scheme was to minimize the environmental impact on the Tukituki River.

The scheme can be summarized as follows:

- Land discharge primarily during summer months.
- River discharge during high river flows when flows exceed 3 x median flow.
- Provide effluent storage during times when neither form of discharge is available.
- Allow storage exceedance events to occasionally occur when storage ponds reach capacity.

Storage volumes were modelled for the scheme, using 22 years of meteorological and river flow data (1989 to 2010 inclusive), along with 22 years of synthesized wastewater flows. The volume of storage varied significantly from year to year, primarily due to the variability in the timing of large river flows which enabled a discharge to the river to occur. The maximum buildup in required effluent storage volume within the modelled time series represented the maximum storage volume that would be required if no storage exceedance events were permitted.

Further information on each component of the scheme is described within the remainder of section 2.

2.1 LAND DISCHARGE

Discharge to land is controlled using a soil moisture model with no discharge permitted when soil moisture is within 5mm of field capacity. This irrigation regime aimed to minimize runoff and leaching of nutrients and pathogens to groundwater and nearby streams.

The irrigation sites have sufficient area during summer periods to dispose of all treated effluent to land. However, during winter, soil moistures limit the volume of effluent that can be applied to the sites. Even if the scheme had significantly more irrigation area available, very little additional irrigation could occur during winter due to consistently high soil moistures.

2.2 RIVER DISCHARGE

The timing of river discharges is an important factor for periphyton growth and hence environmental impact.

Prolonged spring, summer and autumn low flows lead to the accrual of high periphyton biomass (Rutherford, 2011). Temperature and nutrient concentrations within the rivers are higher during these periods allowing rapid growth of periphyton. The periphyton accrues between flood events during extended periods of low flow. Flood events (defined by flows above 3 x median flow) scour algae from the stream bed due to high water velocities.

Therefore, the hydrological regime of the Tukituki and Waipawa Rivers exert strong control on biomass growth and accrual.

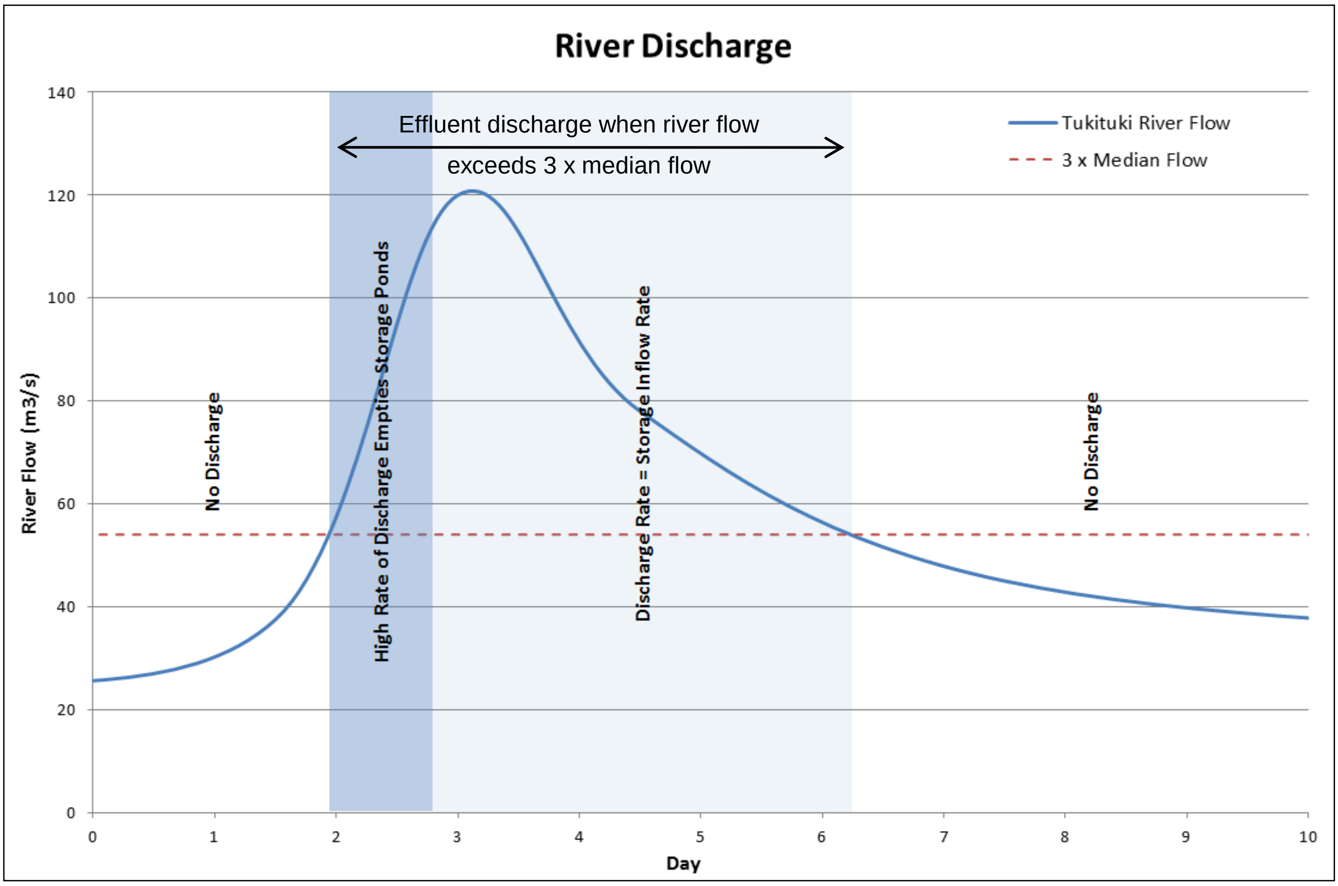
Flood events (greater than 3 x median flow) occur on average 8 times per year. They are highly variable in magnitude and duration but are generally 4 to 9 x median flow with an average duration of 5 days. Large flows can reach 30 to 55 x median flow in the Tukituki River below the Waipawa River confluence.

The time taken for periphyton to regrow following flood events depends on many factors, with nutrient input (particularly phosphorus) being very important.

The Dual Discharge Scheme proposed to discharge treated effluent during flood events. During these times periphyton is unable to grow due to high water velocities and a highly mobile river bed, therefore, the effect on the river ecosystem is minimized. Nutrient input during these times has little to no effect on algae growth. In addition, because of the high dilution available during these events, effluent can be discharged to the rivers at a high rate.

During a river discharge event the majority of high rate discharge coincides with the rising limb of the flood hydrograph ensuring the higher concentrations of effluent are flushed out of the river system. Figure 2 illustrates a typical river discharge period. Once the storage ponds are emptied the rate of discharge reduces to equal that of the sewage flow rate entering the WWTP.

Figure 2: Timing of River Discharge on Flood Hydrograph



2.3 STORAGE

Storage ponds were proposed adjacent to the existing facultative lagoons. All treated effluent was to enter the storage ponds prior to discharge to land or river.

Significant storage is required during winter months, when irrigation discharge is limited. Years of very high storage result from limited river discharge during winter months when irrigation discharge is also limited.

2.4 STORAGE EXCEEDANCE EVENTS

Given the variability of storage requirement from year to year, it was impractical to contain all the storage peaks. For this reason, the storage volume was decreased from the maximum value and storage exceedance events were permitted to occur in occasional years.

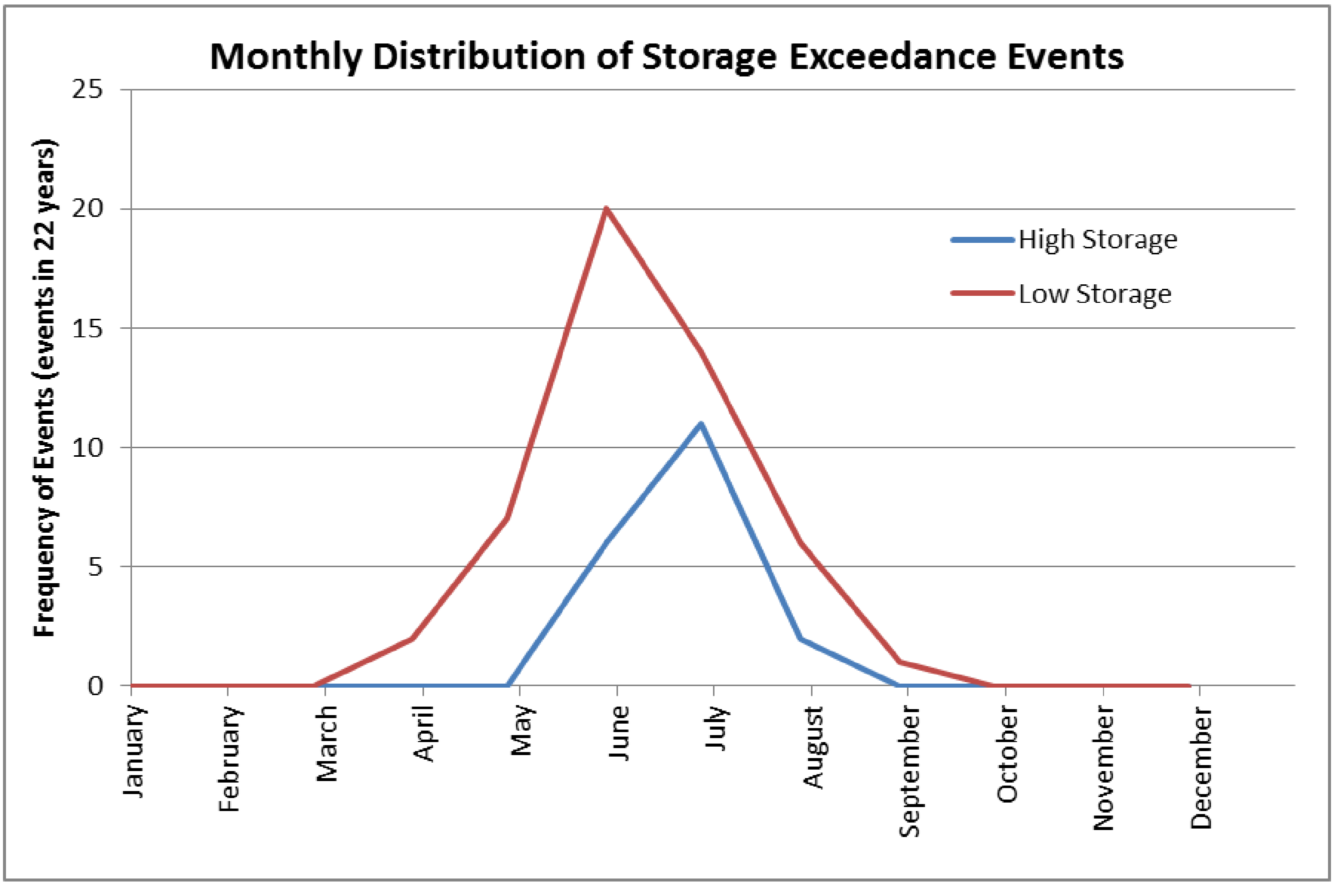
A storage exceedance event consists of a 24 hour discharge at a high rate in order to free up available storage within the storage ponds. A short duration discharge to the river minimizes contact time between the effluent and the existing periphyton within the Tukituki River system. This minimizes the opportunity for periphyton to grow and therefore, minimizes the impact on the Tukituki ecosystem.

Adopting smaller storage volumes results in more storage exceedance events with greater impact on the river system, however, this also lowers the capital cost of the scheme. These competing factors present a conundrum to establish an acceptable balance between environmental impact and the capital cost of the scheme.

NIWA was engaged to look at the effect of effluent discharges to the river resulting from different storage scenarios which PDP had developed. NIWA's work was used to determine a level of storage that would minimize the capital cost, whilst also minimizing any adverse environmental effects on the Tukituki River system.

Depending on the volume of storage proposed, the number of storage exceedance events varies. Lower (smaller) storage volumes result in more frequent effluent discharge events, occurring in a wider range of months. Two proposed storage volumes are shown in Figure 3; one high, one low. The lower storage scenario results in discharges occurring in months outside of the winter period (June, July and August) and into autumn and spring.

Figure 3: Distribution of Storage Exceedance Events



Throughout stakeholder and public consultation, storage exceedance events became a regular topic of discussion, with the number and timing of these events becoming an important factor. Given the high level of importance, sensitivity trials were completed on several model parameters to identify highly sensitive parameters and assess the risk if these were changed.

This sensitivity analysis was extensive and no parameters displayed a high level of risk to the scheme in terms of the number of storage exceedance events.

2.5 EXAMPLE YEAR

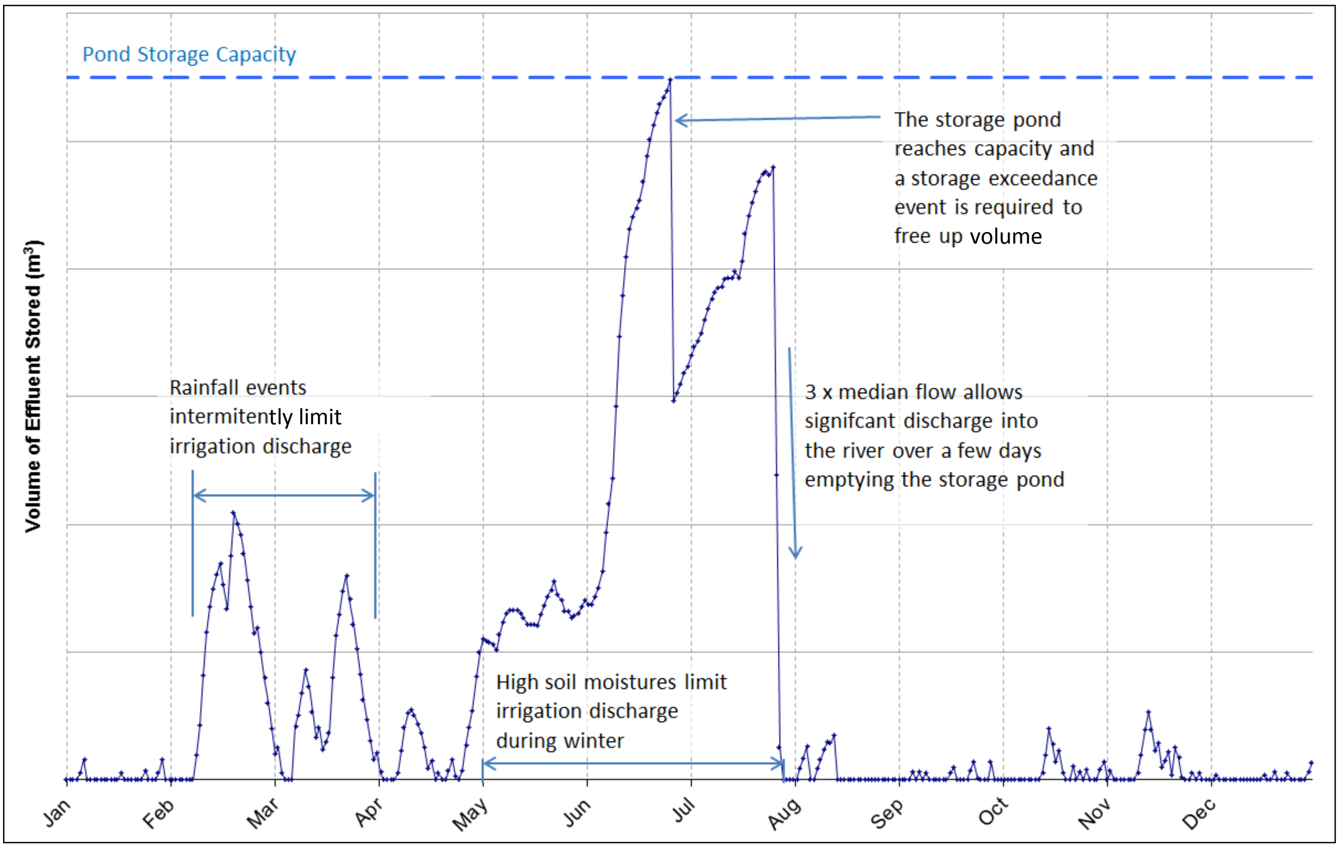
One year of storage modelling is shown in Figure 4 in order to help explain the various factors determining storage requirements from year to year. A year when a high storage volume occurred year is shown in the figure.

Storage requirements vary for different factors within any one year. If significant rainfall occurs in warmer months, small volumes of wastewater are stored, before irrigation is recommenced. This is shown in the months of February and March in Figure 4.

During winter (once May or June is reached), the evaporation from the irrigation sites declines and irrigation can no longer keep up with influent volumes. This results in a slow increase in stored effluent. The stored volume continues to increase until a large river flow event occurs which then allows discharge into the river.

If a large river flow event does not occur to relieve this storage (through river discharge), a storage exceedance event is required when the storage pond becomes full. This storage exceedance event frees up storage within the pond allowing additional time for a flood flow (and associated river discharge) to empty the storage pond.

Figure 4: Storage Requirements for a Single Year



3 PERIPHYTON GROWTH

3.1 NIWA MODEL RUNS

NIWA modelled a 3 year period (1989 to 1991) to determine the periphyton growth for various scenarios of effluent being discharged into the rivers. The 1989 to 1991 period was selected because it is the worst period in terms of the frequency of storage exceedance events. Running the full 22 years of storage modeling (1989 to 2010) was not practical due to the length of time each model run required.

Table 1 shows the modelled reduction in periphyton biomass for three scenarios when compared against the present situation of continuous discharge of effluent to the Tukituki River system

a) Dual discharge scheme: best represents the proposed scheme.

b) 2008 consent: represents the implementation of the existing 2008 consent that will become enforced in 2014. Treatment of the wastewater is increased to significantly reduce E Coli, Phosphorus and Nitrogen in the discharge.

c) No sewage: this scenario represents that of zero effluent discharged to the rivers from the Waipawa and Waipukurau WWTP's.

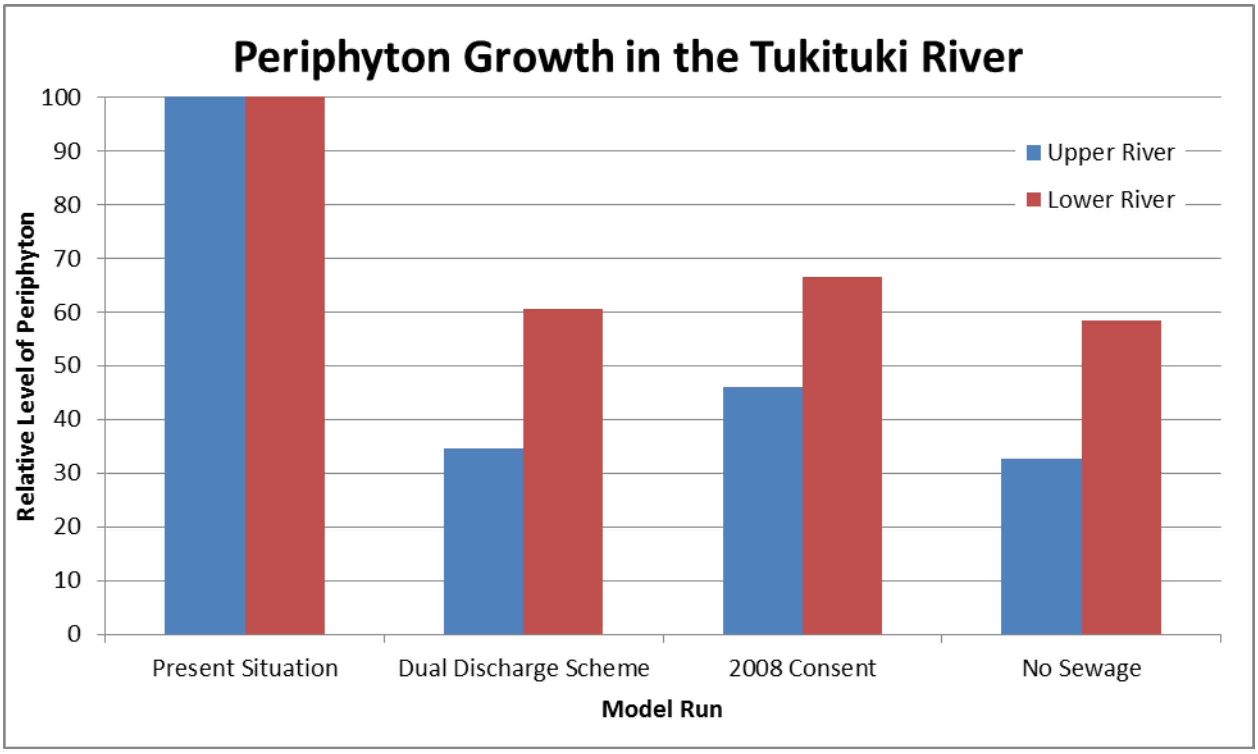
As shown in Table 1, following the implementation of the dual discharge scheme, a 60 to 70% decrease in periphyton is expected in the upper river (Tapairu Road, Walker Road and Shag Rock), whilst a reduction of approximately 40% is expected in the lower river (Red and Black Bridges).

Table 1: Reduction in mean periphyton biomass at flow below median compared with present situation (1989 to 1991)

Site Name	Relative Location	a) Dual Discharge Scheme	b) 2008 Consent	c) No Sewage
		%	%	%
Tapairu Road	Downstream of Waipukurau WWTP, upstream of Waipawa / Tukituki river confluence	71	58	75
Walker Road	Just downstream of Waipawa / Tukituki river confluence	66	54	67
Shag Rock	Approximately 7km downstream of Waipawa / Tukituki river confluence	59	50	60
Red Bridge	Approximately 15km from the Tukituki river mouth	40	33	41
Black Bridge	Approximately 1.5km from the Tukituki river mouth	41	34	42

Figure 5 shows a graphical representation of the periphyton growth expected for the different scenarios. This clearly indicates the model's prediction of a significant reduction in periphyton growth compared with the present situation.

Figure 5: Periphyton Growth for Modelled Scenarios



Note: "Upper River" is an average of "Tapairu Road", "Walker Road" and "Shag Rock" results. "Lower River" is an average of "Red Bridge" and "Black Bridge" results.

3.2 EXAMPLE OF PERIPHYTON GROWTH

Figure 6 shows a single year of predicted periphyton growth for the different model runs.

The reduction in periphyton seen under operation of the dual discharge scheme is very similar to that of no sewage input into the Tukituki River system, with the same periphyton growth at all times except for short periods in winter when storage exceedance events occur. It is important to note that the year shown is a year with an unusually high number of storage exceedance events.

The "2008 Consent" run also shows a significant reduction in periphyton growth from the present situation, but the periphyton growth remains above that of the dual discharge scheme.

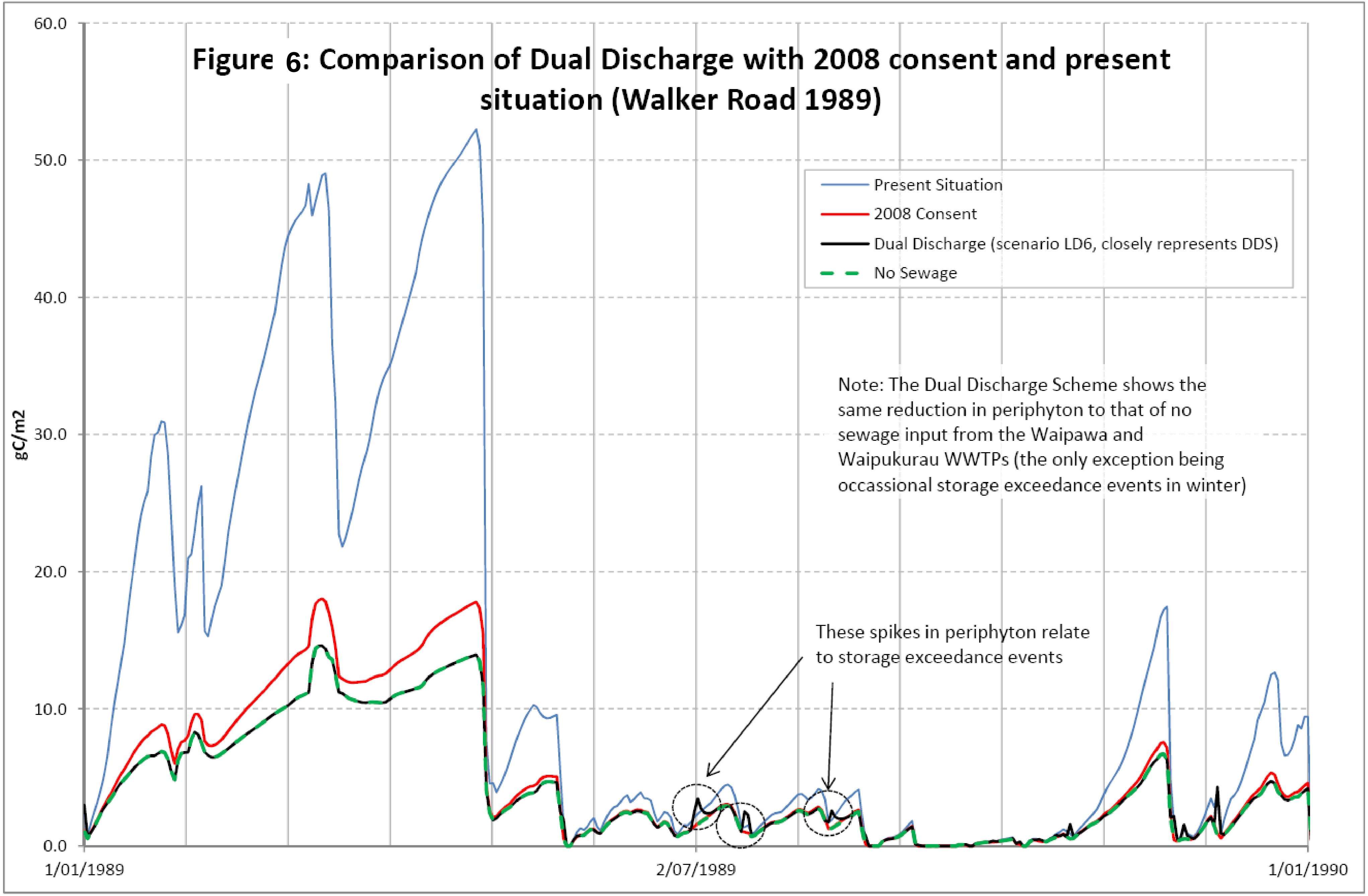


Figure 6: Comparison of Dual Discharge with 2008 consent and present situation (Walker Road 1989)
gC/m2
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1/01/1989
2/07/1989
1/01/1990
Present Situation
2008 Consent
Dual Discharge (scenario LD6, closely represents DDS)
No Sewage
Note: The Dual Discharge Scheme shows the same reduction in periphyton to that of no sewage input from the Waipawa and Waipukurau WWTPs (the only exception being occassional storage exceedance events in winter)
These spikes in periphyton relate to storage exceedance events

4 CONCLUSIONS

The dual discharge scheme has the potential to provide significant improvements on the ecological health and aestheticsof the Tukituki River system. Two separate models have been developed for the scheme; one to predict the timing and volume of river and irrigation discharges and one which allows the periphyton growth within the Tukituki River system to be predicted for various nutrient input scenarios.

The key conclusions that can be drawn from this work are:

d) Removing effluent from the Tukituki River system during spring, summer and autumn periods has the potential for substantial reductions in periphyton growth.

e) Effluent storage volume requirements vary significantly from year to year due to the unpredictable nature of flood events for the Tukituki River system.

f) Discharging during flood events has little to no effect on periphyton growth.

g) Lowering the proposed effluent storage volumes and permitting storage exceedance events has minimal effect on the periphyton in the river system.

h) Storage exceedance events occurring in winter (when background periphyton is low because of low temperature, nutrient input and high background river flows) have little effect on the river system.

Although the proposed dual discharge scheme is not going to be implemented due to financial constraints, there is potential for similar dual discharge schemes to have significant improvements on the health and aesthetics of receiving streams and rivers.

5 ACKNOWLEDGEMENTS

Thank you to Kit Rutherford of NIWA for the development of a model predicting periphyton biomass in the Tukituki River and the time spent running various scenarios.

6 REFERENCES

Rutherford, J. (2011) Computer Modelling of Nutrient Dynamics and Periphyton Biomass in the Tukituki River, Hawke’s Bay Scenario Predictions. Report prepared for Hawke’s Bay Regional Council and Central Hawke’s Bay District Council.