TE WHĀRIKI – STORMWATER MANAGEMENT IN A RESIDENTIAL DEVELOPMENT

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ABSTRACT

Te Whāriki is a joint venture Ngāi Tahu Property and Lincoln University residential development in Lincoln, Canterbury. This transition of a greenfield site into extensive urban development includes the use of constructed wetlands which have shown improving stormwater treatment efficiencies.

The site receives stormwater from the Lincoln urban area as well as on-site runoff, and discharges into the spring-fed LII River. Water quality monitoring is undertaken to determine if contaminant sources are on-site or off-site, and to manage those sources. The consent conditions have at times proven challenging to monitor; with tight monitoring schedules, and the development's progression affecting the location of monitoring sites.

Through involvement from the early stages of earthworks, to the near fully built Ivey neighbourhood, I have observed and will discuss the variations in water quality and the practicality of monitoring conditions.

KEYWORDS

Stormwater, Ngāi Tahu, Lincoln, residential, TSS, monitoring, treatment, wetland

PRESENTER PROFILE

Sophie South is a chartered professional water engineer with Golder Associates (NZ) Limited in Christchurch. She trained at Canterbury University in Natural Resources Engineering, with interests in ecological and energy engineering.

Sophie joined Golder in 2010 and has since worked in the areas of hydrology, water quality and stormwater. Of particular interest is hydrological and hydraulic modelling. Sophie has been involved in monitoring at Lincoln and other residential developments around Canterbury for 4 years. Prior to Golder, Sophie worked with a small company developing fuels from renewable sources such as algae.

1 INTRODUCTION

Lincoln Land Developments (LLD), marketed as "Te Whāriki", is a residential development situated on approximately 118 ha of land in the township of Lincoln, south

of Christchurch (Figure 1). As part of the development, LLD obtained resource consent from Canterbury Regional Council (CRC) to discharge stormwater and sediment-laden water during construction onto land and into surface water. The conditions of the consent require monitoring of stormwater to determine the effects of the site development on the downstream waterways, specifically Lincoln Main Drain and LII River.

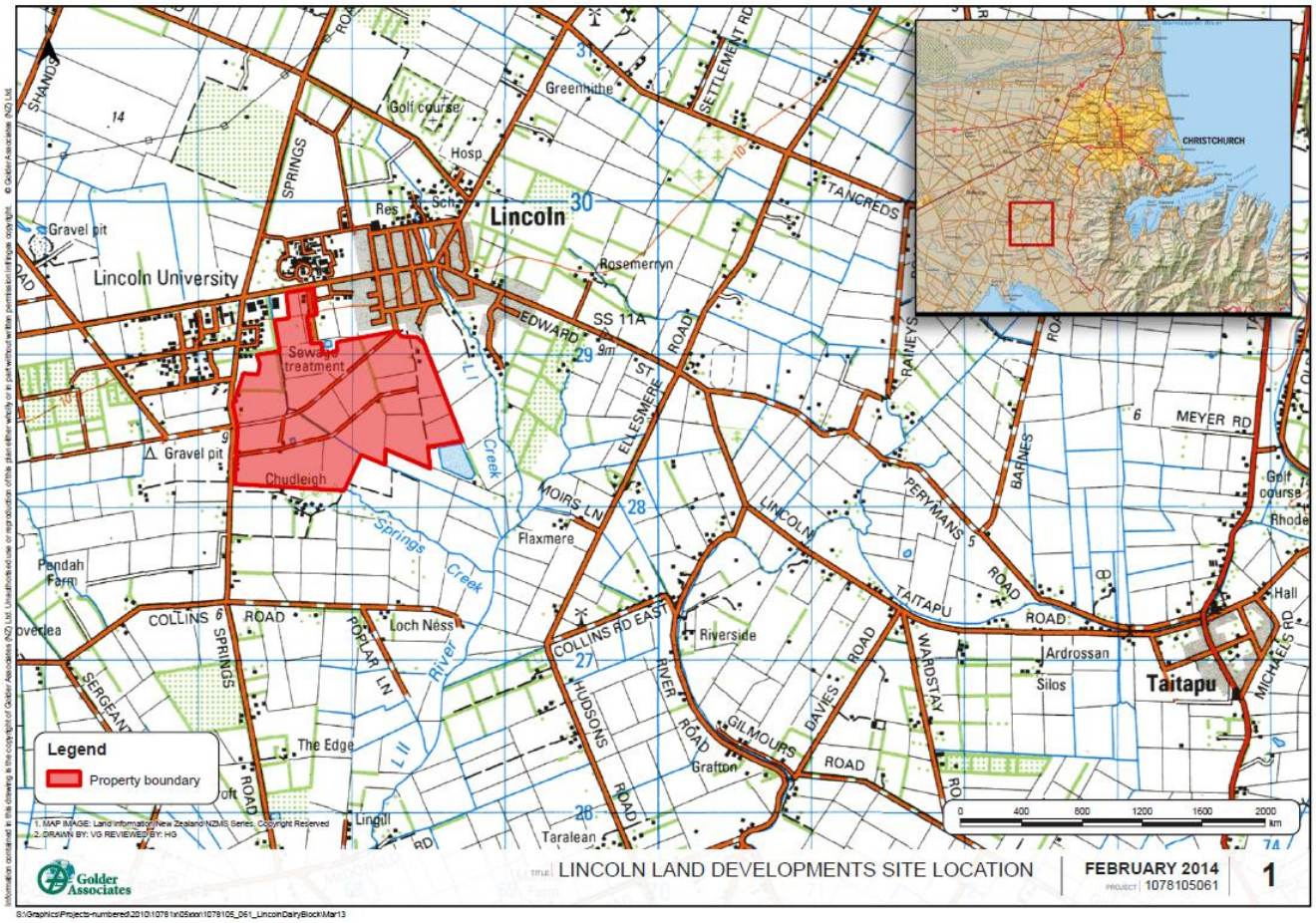

Figure 1: Lincoln Land Developments site location

2 TE WHĀRIKI RESIDENTIAL DEVELOPMENT

2.1 DEVELOPMENT OBJECTIVES

Lincoln University partnered with Ngāi Tahu Property with the aim of "creating a high quality residential development that would enhance the area and create an integrated, harmonious Lincoln township" (Te Whāriki 2014). Ngāi Tahu Property is bound under a number of business values, including kaitiakitanga. This ensures the people, environment, knowledge, culture, language and resources important to Ngāi Tahu, are actively protected for future generations (Ngāi Tahu 2014).

The objectives driving the development of Te Whāriki include (Te Whāriki 2014):

- reducing land consumption
- reducing vehicle dependence
- promoting pedestrian activity
- improving air quality
- decreasing polluted stormwater runoff
- building a more liveable and sustainable environment

2.2 LOCATION

Te Whāriki borders Lincoln township, extending from Springs Road to Edward Street. Lincoln is located approximately 22 km south of Christchurch, with a population of around 3,900 people (Statistics NZ 2013). Lincoln was established to support the surrounding farming district in 1862, and is now home to Lincoln University and various agricultural research facilities.

The township is undergoing a residential expansion, aided by the Canterbury earthquakes and a shift of population from Christchurch City to the Selwyn district. Current subdivisions around the township (including Te Whāriki) are expected to add in excess of 1,200 new residential sections in the coming months.

2.3 PROGRESS

During 2013 the construction of homes in Te Whāriki has continued, with the completion of the Ivey Neighbourhood (shown in **Error! Reference source not found.**) (Stages 1, 2A and 2B). Stage 2 is partially complete, with construction finished and homes being constructed in the Kaituna Neighbourhood (Stage 2B/D). Construction is moving eastward throughout 2014, with the access road north to Gerald Street currently undergoing earthworks, and the development progressing towards Springs Road to the east of the site.

Some stormwater treatment facilities such as treatment wetlands have been completed in the Ivey Neighbourhood. Earthworks have commenced for the stormwater basins located to the east of the site. The development is predominantly driven by section sales, so construction of the larger stormwater basin to the south of the site is likely to commence in 2016 or beyond as part of Stages 3 or 4.

Figure 2: Staged development plan for Te Whāriki

3 STORMWATER MANAGEMENT

3.1 GENERAL STORMWATER LAYOUT

In its pre-development state, a number of farm drains cross through the site. The largest of these drains is known as Lincoln Main Drain, which flows in a north-west to south-easterly direction. The Lincoln Main Drain discharges into the LII River (Ararira), approximately 1 km to the south-east of the site. The LII River is spring-fed and is considered to be of high quality and clarity. The LII River is fed by the LI Creek which meanders through Lincoln township. The LII ultimately discharges into Te Waihora Lake Ellesmere.

Post-development, a network of treatment wetlands and stormwater basins is planned to cross the site (Figure 2). On-site stormwater management includes the use of swales to pre-treat road runoff (Figure 3). Runoff is then piped to wet ponds prior to entering the treatment wetlands. All stormwater basins are permanently wet ponds due to the presence of relatively shallow groundwater. Ultimately, Lincoln Main Drain will be integrated into the site stormwater system and its flow will be conveyed through bypass drains.

Figure 3: On-site stormwater management

3.2 SOURCES

Stormwater discharging from the site comprises both off-site and on-site sources. Five streams and drains supply stormwater onto the site from the west and north. Stormwater is also generated on-site, with its quality depending on the source. Different sources are summarized below:

Off-site stormwater runoff from:

- Rural land
- Lincoln township; including roads, homes, businesses and other impermeable surfaces
- Lincoln University campus
- Crown Research Institutes

Site stormwater runoff from:

- Treated stormwater (via wetland)
- Construction stormwater (via sediment ponds)
- Undeveloped rural land

These sources are a combination of treated stormwater, partially-treated stormwater from construction areas, and untreated stormwater.

3.3 MONITORING

LLD holds CRC resource consent CRC092128 to discharge contaminants onto and into land, and into surface water at the former Dairy Block site in Lincoln. The consent includes several conditions relating to water quality, which can be divided into two broad monitoring components:

- Construction phase water quality monitoring
  - turbidity
- Quarterly water quality monitoring
  - dissolved copper
  - dissolved zinc
  - total petroleum hydrocarbons (TPH)
  - total suspended solids (TSS)

Monitoring is required at a number of sites, with comparison made to a 'compliance site' located on the downstream boundary of the site in the Lincoln Main Drain. The monitoring conditions of the consent, in general terms, require the process in Figure 4 to be undertaken:

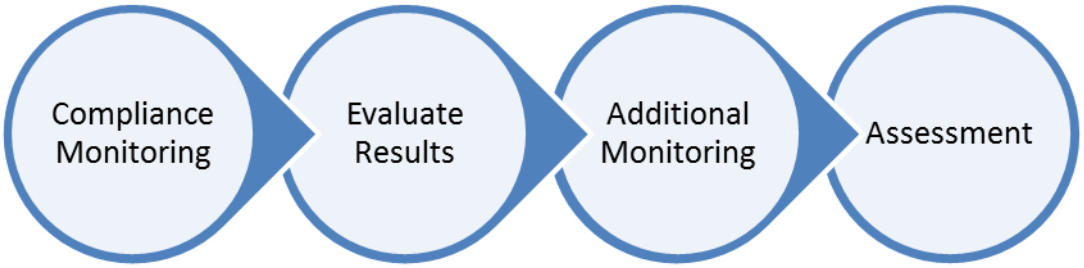

Figure 4: Monitoring process diagram

3.3.1 QUARTERLY WATER QUALITY

Consent conditions relating to quarterly monitoring require that two upstream sites are sampled and compared to a downstream compliance site. This monitoring involves water samples which are submitted to Hill Laboratories for analysis. On receipt of the laboratory results, an assessment is made in accordance with condition 57:

57 *"Should the concentration of contaminants analysed under Condition (56)(c) be ten or more percent greater at the downstream site than at either of the upstream sites, the consent holder shall undertake an investigation and assessment to determine if the exceedances are a result of the stormwater discharges from the project area."*

61 *"The discharge shall not cause the following limits to be exceeded in the LII River: Dissolved zinc – 0.008 g/m³; Dissolved copper – 0.0014 g/m³.*

The additional monitoring requires the re-sampling of the initial three sites, as well as a further 4 more downstream sites. At the request of LLD, three more sites within the LLD development area have been included in the quarterly monitoring programme. These sites were not required by consent, but are used by LLD to assess the efficiency

of the treatment wetland, and to categorise the stormwater entering the site from the north.

Summary of monitoring results

Total suspended solids (TSS) were regularly found to exceed the requirements of condition 57, above. However, TSS concentrations entering the LII River were low compared to TSS concentrations upstream of the site, and on the site itself. This implies that a reduction in concentration is occurring across the site. This reduction is not of a large enough magnitude to achieve the water quality of the LII River upstream of the confluence. Therefore, it is concluded that TSS concentrations from the Lincoln Main Drain have influenced the water quality of the LII River. However, where treatment facilities are operational (i.e., the treatment wetland) these facilities are generally providing good treatment efficiencies. As the development progresses and full stormwater treatment facilities come online, the water quality discharging into the LII River is expected to improve.

3.3.2 CONSTRUCTION MONITORING

Construction phase monitoring is undertaken on an on-call basis, when sediment is potentially being discharged from any drains. This monitoring comprises on-site turbidity monitoring only. Turbidity is measured using a calibrated HACH 2100Q portable turbidimeter.

Turbidity is required to be measured at 5 upstream sites and the downstream compliance site. While on-site, an assessment is made as to whether the turbidity exceeds the requirements of condition 26 below:

26 *"Should the water turbidity be 20 or more percent higher at the downstream site than the turbidity measured at either of the upstream sites, the consent holder shall immediately:*

(a) Undertake an investigation and assessment to determine if the elevated turbidity measurement at the downstream site is a result of the discharges from construction within the project area;

(b) Inform the Canterbury Regional Council Pollution Hotline; and

(c) If the elevated turbidity is a result of discharges, determine the downstream extent of elevated turbidity and the actual and potential effects on the Lincoln Main Drain and the LII River from the elevated turbidity."

If further sampling is required, this is carried out immediately, on the same day as the initial monitoring. A further 11 sites are monitored to identify the effects of the discharge on the LII River.

Summary of monitoring results

It was found that the Lincoln Main Drain contributed to elevated turbidity measurements in the LII River on several occasions, but the source of sediment was a combination of both construction and off-site upstream activities.

3.4 TREATMENT WETLAND

3.4.1 PERFORMANCE

The treatment wetland (Figure 5) receives untreated stormwater runoff from the completed residential development. Factors affecting the contaminants present, and the apparent treatment efficiency of the treatment wetland include:

- Rainfall intensity
- Rainfall duration
- Antecedent dry period
- Sampling punctuality
- On-site activities
- Construction sediment control measures
- Establishment of the wetland plants and base stability

Figure 5: Treatment Wetland

The treatment wetland water quality is measured at the inlet and outlet, and analysed for dissolved copper, dissolved zinc and TSS. Performance is calculated by comparing the influent contaminant concentrations with the contaminant concentrations leaving the wetland.

It has been noted that there is variability in the performance of the wetland. However no trends exist between rainfall intensities, durations and performance. It is expected that the factors listed above all contribute to performance.

In broad terms, the treatment wetland is showing an improvement in performance over time (Figure 6) and is providing a high level of treatment of TSS (average 76 % reduction in TSS). On completion of the development, it is expected that all stormwater would be treated to a similarly high standard.

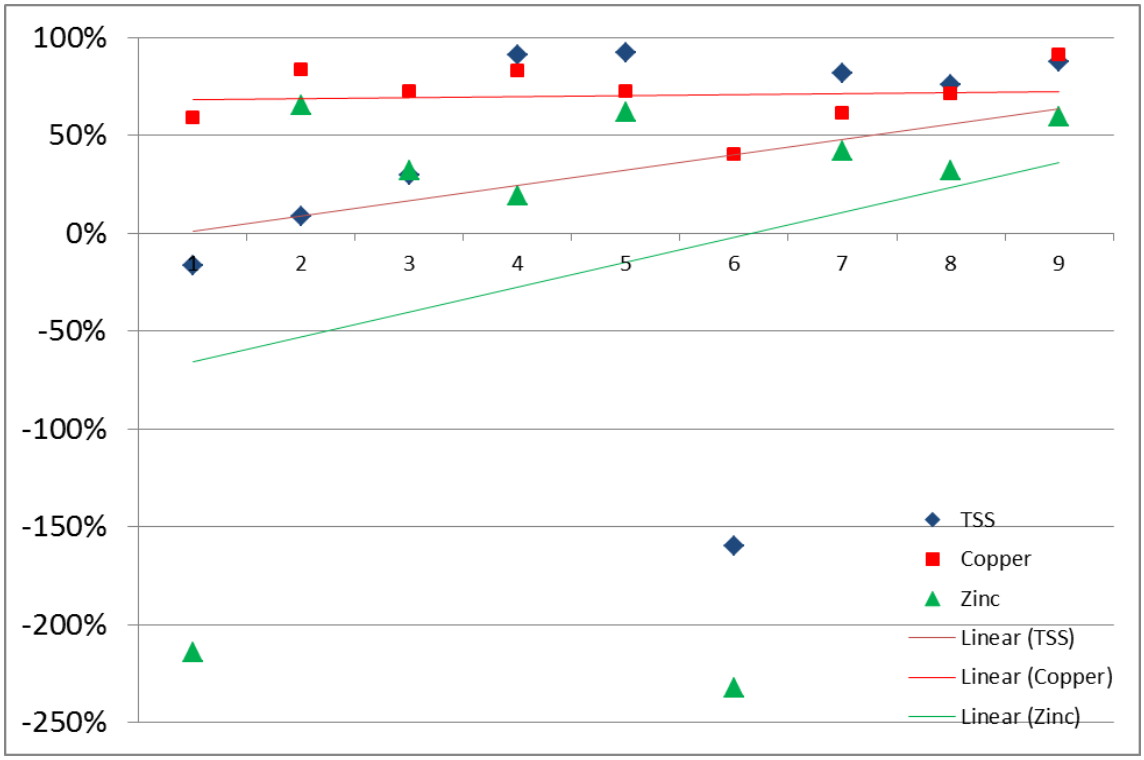

Figure 6: Treatment wetland contaminant removal efficiency over 9 sampling events.

4 RESOURCE CONSENTS

LLD holds CRC resource consent CRC092128 to discharge contaminants onto and into land, and into surface water. This consent holds specific monitoring conditions which can be challenging to monitor from a practical perspective. A number of these challenges are common to all stormwater monitoring, or common to construction projects.

4.1 CHALLENGES

4.1.1 TIMEFRAMES

The consent conditions state that:

> *"(b) Water samples shall be collected:*
>
> *(i) On completion of the sealing of roads for Stage 1 subdivision;*
> *(ii) From all sites, on the same day and within two hours of each other;*
> *(iii) During or no later than two hours following a continuous rainfall event exceeding 30 minutes in duration;*
> *(iv) At least once during very three month period, unless there are no continuous rainfall events during the three month period exceeding 30 minutes in duration…"*

The requirement to sample during or within 2 hours of a rain event is necessary to ensure the sampling is representative of a storm event. However, this time constraint can be difficult to achieve. Once a rainfall event has been identified and confirmed with nearby rainfall monitoring sites then equipment preparation and a 30 minute travel time to site dramatically reduce this sampling window.

Due to health and safety factors, it is impractical to sample outside of daylight hours, and particularly in winter sufficient time must be allowed to complete the sampling before it gets dark. Overnight rainfall is eliminated (unless it continues into the morning) as the 2 hour timeframe has lapsed. Weekend sampling is possible however this requires organisation and resourcing in advance.

The requirement for a continuous rainfall event exceeding 30 minutes in duration can also limit sampling opportunities. Often rainfall is staccato rather than continuous and as there is no rain gauge on site, reliance is put on a CRC gauge at Halswell which is updated hourly.

The nature of manual stormwater sampling means that a quick response is required. However, this rapid response can be difficult to achieve.

4.1.2 REVISITING FOR FURTHER SAMPLING

There is a requirement to resample if an exceedance occurs when comparing upstream contaminant concentrations to the compliance site. This exceedance cannot be identified onsite during the initial sampling as laboratory analysis is required which takes some days. This results in a time delay, and a new sampling visit must be undertaken to evaluate the effects and sources of the exceedance.

Time delays make it difficult to compare sampling results, as different storm events will have very different temporal characteristics such as antecedent dry period, intensity and duration. This delay also can effectively double the number of sampling events required, if a revisit is required following each quarterly sample.

4.1.3 ACCESSIBILITY

As part of ongoing developments, existing streams are realigned or put underground into pipes, and other previously underground waterways may be daylighted. This means the locations of monitoring sites can move throughout the development. For example an initially open channel was piped and inaccessible, and at another site, a new manhole

was installed which allowed alternative access. These changes can interfere with long term analysis of sampling results due to the change in location, or result in data loss.

Also site orientation to identify the correct waterway can become an issue when extensive earthworks occur. Also intermittent sampling, such as once every 3 months reduces site familiarity. For example a large stand of pine hedging was cut down which removed the sampling site landmark and caused disorientation on site. This requires the assistance of site staff to identify the correct sampling locations.

The nature of sampling in rain events can mean site access is not ideal. Muddy, wet, windy, and poor visibility conditions all contribute to sampling challenges.

4.2 COMPARISON TO OTHER CONSENTS

The Canterbury Regional Council supplied copies of commonly used consent conditions which apply to the discharge of stormwater to water. These conditions include monitoring conditions which are generally consistent with those for the Te Whāriki site. Some points of difference include:

- A requirement to check for changes in visual clarity due to the discharge, under the commonly used conditions.
- The commonly used conditions refer to the rain event in terms of rainfall depth (mm), rather than storm duration (minutes).
    - Rainfall depth has advantages as a suitable rain event may be identified faster, giving more time to respond. However, both depend on the quality of the reference rainfall station.
- The commonly used conditions specify three samples be collected at each discharge point with 15 minutes separating each of the samples.
    - This would prove challenging to achieve due to the number of sites at LLD.
- The LLD consent requires further sampling if an exceedance occurs. This is not required in the commonly used conditions.

Selwyn District Council also holds a global stormwater consent for the Lincoln area. Although this does not apply directly to the LLD site, it is of interest to compare the requirements of each. This global consent has broad requirements for surface water monitoring which state:

31 *"The consent holder shall prepare a monitoring programme to investigate the effects of stormwater discharges on surface water quality, stream sediment quality and the ecology of surface waterways within the Global Consent Area. The monitoring programme shall:*

a) be sufficient to detect any trends in surface water quality, stream sediment quality and the ecology of surface waterways; and

b) be sufficient to measure compliance with the objectives for the surface waterways in the area as set out in the Table which forms part of this consent."

If the stated objectives are not being met, then an investigation and mitigation is required as per the consent for the Te Whāriki site.

The allowance for the applicant to develop a stormwater monitoring programme, rather than prescriptive monitoring being supplied has advantages and disadvantages. There is the opportunity to tailor the monitoring for ease of use. However, the potential scope of the monitoring is broader, with sediment and ecological effects also considered. These are not specifically monitored under the Te Whāriki site consent.

5 CONCLUSIONS

Te Whāriki is a residential development situated on approximately 118 ha of land in the township of Lincoln, south-west of Christchurch. As part of the development, LLD obtained resource consent from CRC to discharge stormwater and sediment-laden water during construction onto land and into surface water. The conditions of the consent require monitoring of stormwater to determine the effects of the site development on the downstream waterways Lincoln Main Drain and the LII River.

The Lincoln Main Drain contributed to elevated turbidity measurements in the LII River on several occasions, but the source of sediment was a combination of both construction and off-site upstream activities. The data shows that the treatment facilities that are operating are enabling compliance of TPH and dissolved metals with consent conditions. TSS concentrations from the Lincoln Main Drain have influenced the water quality of the LII River. The treatment wetland is generally providing a high level of treatment, particularly in the removal of suspended sediment.

Consent conditions pose a number of challenges to monitoring. These include tight timeframes for sampling, accessibility issues and the requirement to re-sample if exceedances occur. A number of these challenges are due to the nature of stormwater and construction monitoring. Although a comparison to other consents has identified slight modifications to the monitoring conditions, those applied at Te Whāriki are consistent with current monitoring conditions in Canterbury

ACKNOWLEDGEMENTS

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