SHOTOVER DELTA DOSE AND DRAIN EFFLUENT DISPOSAL SYSTEM

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ABSTRACT

Queenstown Lakes District Council (QLDC) Shotover Wastewater Treatment Plant (WWTP) receives municipal sewage from Queenstown in addition to the Arrowtown, Lake Hayes, and Arthur's Point communities and in the past consisted of a facultative treatment pond system located on the Shotover River Delta. This WWTP has recently been upgraded by the installation of a Modified Ludzack-Ettinger (MLE) system that treats two thirds of the flow, then blends with the oxidation ponds effluent prior to UV sterilisation.

Phase 2 of this upgrade project was to Install a Land Dispersal system between 2016 and 2022 and have all dry weather flows discharge into land. The original consent (2008) had a reasonably standard Low Pressure Effluent Disposal (LPED) field located inside the Otago Regional Council (ORC) revetment. Groundwater mounding modelling showed that due to the relatively low permeability material on the land side of the revetment, 2.5 m depth would need to be excavated and replaced, resulting in more than 500,000 m^3 of material needed to be imported. The cost to import this gravel to construct the LPED platform was estimated to have increased at least 3-fold from the time the original concept was proposed in 2008 to time of design in 2017, resulting in the LPED construction costs going from $7.7 M (2010) to estimated $21 M in 2016.

To reduce cost, a system was investigated on the river-side of the revetment protection works. To meet iwi and other stakeholder's concerns, the new land dispersal system had to drain naturally through the underlying silts, rather than being forced through under pressure. To allow for this, high void space plastic stormwater storage cells have been used into a gravity flow system instead of a LPED system. A large diameter feeder pipe was designed to allow for large volume doses to be applied to the field with minimal pressure that would rapidly fills the voids and then allows the effluent to drain naturally through the underlying silts and sands. This innovative design reduced the estimated capital cost to $5.3 million.

To prove the operation, a number of piezometers have been installed that will be monitored to confirm groundwater mounding modelling predictions undertaken during consenting. This overall saving has resulted in the direct discharge of effluent to the Shotover River stopping four years earlier than planned.

KEYWORDS

Dose, Drain, Land Dispersal, Silts, Storm Water Cells

PRESENTER PROFILE

Lane Vermaas has been associated with the three waters Industry for the past 52 years of which 33 years were in Africa (Rhodesia now Zimbabwe) and the past 19 years here in New Zealand. His experience has been largely associated with Municipal Water and Wastewater Infrastructure and Treatment and currently he is the Senior Construction Engineer for the Queenstown Lakes District Council

1 INTRODUCTION

For a number of years Queenstown sewage has been treated in Oxidation Ponds situated on the Shotover delta and the outflow of these ponds have always been discharged directly into the Shotover River. Queenstown Lakes District Council have always been of the opinion and desire to improve this situation with the condition of the environment related to the Shotover River Delta being of foremost concern.

In May 2015 Council embarked on a 30 million dollar project to improve the treatment of the sewage with the installation of a Modified Ludzak-ettinger (MLE) system that treats two thirds of the total inflow, then blends with the remaining one third of the inflow through the existing Oxidation ponds prior to UV sterilisation. In February 2017 this activated sludge treatment plant was commissioned on the Shotover delta and has since then been producing treated effluent of a greatly improved quality. As an example the Escherichia coli in the treated discharged effluent has not exceeded 20cfu/100 mL where the acceptable river swimming standard is 250cfu/100 mL and total Nitrogen content is also well below the 23 mg/L consented annual mean requirement.

Even though this greatly improved the quality of the treated effluent and was a leap forward in the QLDC concern for the receiving environment, the effluent was still being discharged directly through an open channel to the Shotover River. Part of the new consent conditions related to this new treatment plant, was that within 5 years of completion (being February 2022), Council would undertake to change the direct flow of treated effluent via an open channel directly to the Shotover River, to a Land disposal system dispersing treated effluent into the silty gravels of the Shotover Delta. In the interest and concern for the environment, Council decided not to wait the 5 years to do this, but with the input and agreement of the Local IWI, Public Health Southland and Otago Regional Council immediately embark on the design and construction of the Land Disposal field in the Shotover basin.

2 DESIGN

The originally designed Queenstown land dispersal area proposed in 2008, was to be inside the river protection works on the Shotover River Delta. Preliminary modelling had shown that due to the relatively low permeability material on the land side of the ORC revetment, a significant amount of material would need to be excavated and be replaced with free draining gravel and coarse sand. The depth required was 2.5 m, resulting in more than 500,000 m^3 of material needing to be excavated and replaced to ensure that groundwater did not mound to the surface and limit final land use and landscaping options. The gravel required to build this platform limiting groundwater breakout, was to be made available at low cost during the removal of the delta islands by ORC as part of the Shotover River training (revetment) works. However, due to timing, the cheap material from the Shotover River islands available in 2008, had by 2016 been utilised in the building of the airport RESA (Runway Extension Safety Area) and the revetment and training wall. As a consequence of this, the cost to import gravel to construct the LPED platform was estimated to have increased at least 3-fold, resulting in the LPED construction costs going from $7.7 M estimated in 2008 to more than $21 M in 2016.

Therefore, a number of alternative solutions were now considered by QLDC and discussed with a number of stakeholders. Eventually, an alternative solution was selected which would be relatively easy to construct in a timely manner and at a reduced cost to the community. The system selected was a Dose and Drain (DAD) system designed to disperse treated effluent into the silty gravels at natural drainage rates – not forced –

this recognises cultural significance of this activity to Kai Tahu and Te Ao Marama in relation to the Kaitiakitanga of the Shotover, Kawarau and Clutha Rivers. In addition the Otago Regional Council required that there would be no groundwater mounding resulting in a breakout on the surface, even though the land dispersal system was never relied on for any improvement in effluent quality, as the treatment at the WWTP met recreational bathing water standards. This required the filling of low spots within the dispersal area to eliminate potential for this mounding to occur. Figure 1 below shows the position of the relocated site to the East of the revetment line in favour of the wooded area shown to the West of the revetment and roadway at the bottom of the RESA

Figure 1: Siting of the Shotover DAD System in the Shotover Delta

The eleven drainage sectors (shown in plan view on figure 2) could be extended to the Southern end of the field in the future if so required. A special block and cut off system has been installed to provide for this if ever required.

Treated effluent is gravity fed from the UV treatment plant via a 800mm HDPE delivery pipeline to the eleven individual dose and drain sectors.

Figure 2: Plan view of the eleven DAD dispersal fields with 800 mm distribution pipe shown in red in centre

Each of the fields are fed by smaller diameter 200mm HDPE pipes from the main delivery pipeline, with four discharge points per field. Each dose and drain dispersal field comprises of two T-shaped trenches containing high void HDPE water storage cells. The trenches are surrounded by no-fines gravels that together increase the open void "storage" volume within the ground within each field. This "storage" volume allows effluent to be fed into a particular field at a higher rate than it might disperse through the base of the field, facilitating side-wall dispersal as well when the water rises within the cell. This allows the treated effluent to drain at natural rates via gravity into the underlying subsoils, rather than being forced under pressure – this was a requirement of Iwi. The design also accommodates groundwater mounding after a period of sustained inflow, or when groundwater levels are temporarily elevated when the Shotover River is running high.

Groundwater level monitoring piezometers are installed throughout the full field, and additionally 8 groundwater sampling/monitoring piezometers are installed for resource consent monitoring compliance purposes. Only the latter 8 have permanently installed real-time water level monitoring installed - the others are there only to provided for periodic manual water level observation during commissioning, and as future operational circumstances might dictate. Each of the fields are individually controlled by actuated valves on the off-take from the main 800mm delivery line. The control system looks at the flow coming from the treatment plant at any time and decides how many fields, and which fields should be operated at that particular time.

A typical cross section of the field is shown in Figure 3 and the layout of half a field is shown in Figure 4

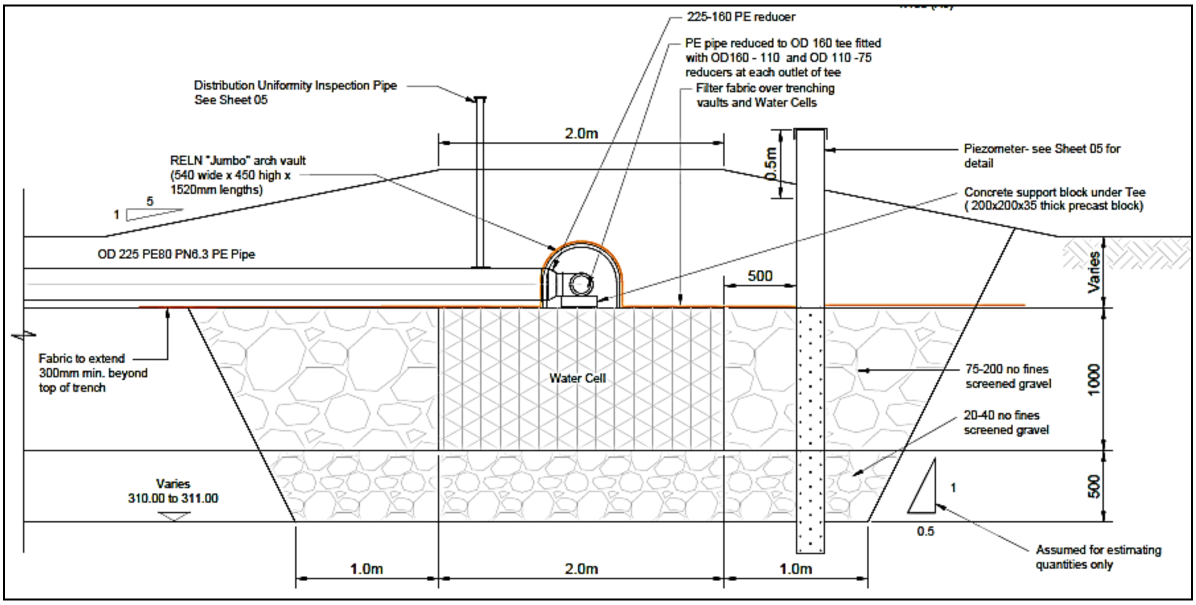

Figure 3: Typical Section through the DAD Effluent Distribution System

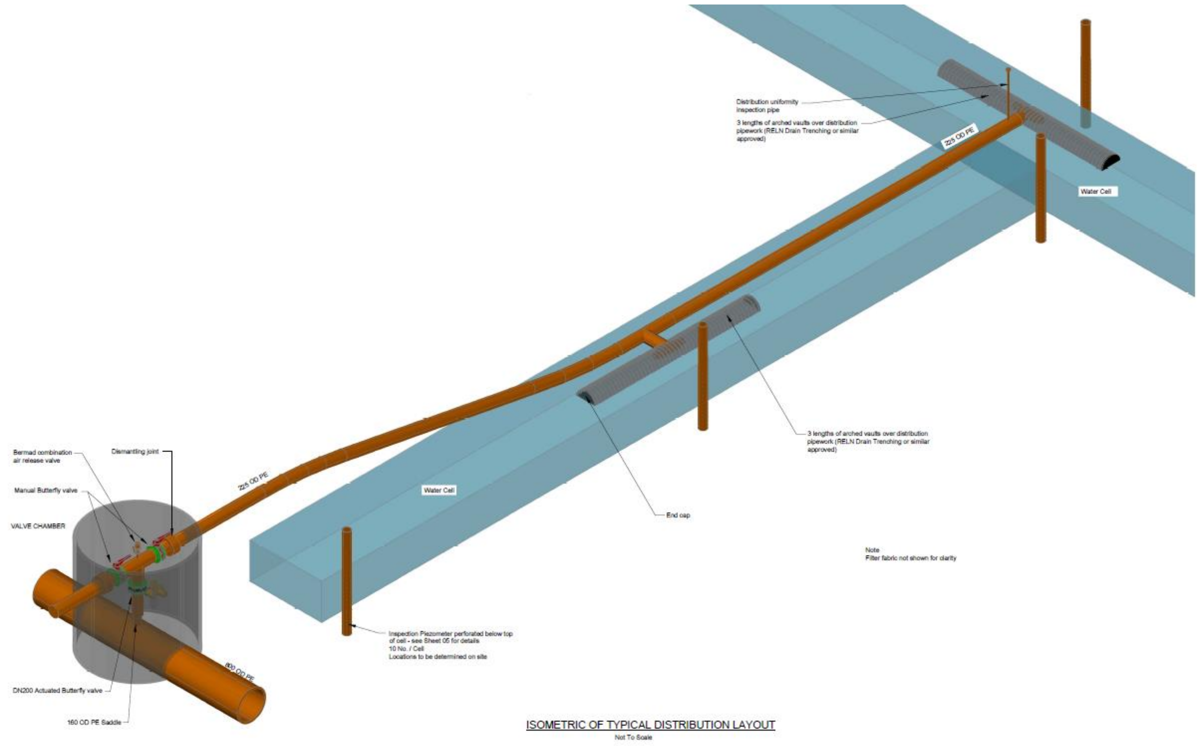

Figure 4: Layout of half of one field

The effluent dispersal system is designed to accommodate a storm flow discharge from the treatment plant of 440 l/s with all 11 fields operating - that is, 40 l/s per field, being the nominal design flow of each field.

The 40 l/s per field design value has been derived from groundwater flow modelling at a sustained ultimate storm flow of 440 l/s, taking expected groundwater mounding into account. In reality, peak storm flow discharges only occur for a relatively short period of time (say 4-6 hours, more or less). Groundwater mounding is therefore not likely to be as great as that indicated by the modelling undertaken, meaning that a reasonably high degree of conservatism has been built into the dispersal system design. Similarly, the pipework to each field will hydraulically be able to convey greater flows than 40 l/s.

In normal operation each field is tentatively intended to be run at a flow of 40 to 50 l/s The number of fields open at any one time will depend on the flow discharged from the treatment plant. Figure 5 shows the flow profiles for flows from the treatment plant on a high rainfall day (30 May 2017) and typical dry weather day (29 April 2017). Figure 5 then takes the high rainfall profile and annotates it, by way of example, with the number of fields open at any one time (numbers in red circles).

During the early morning hours, flows are seen to be low and only two fields operate. Increasingly high flows due to rainfall infiltration then occur, leading to the progressive opening of up to 6 fields, before flows start to reduce again and the number of fields open reduces to 4.

Looking at the dry weather profile, it can be seen that under 2017 dry weather flow only 2 to 4 fields need to be run at any one time.

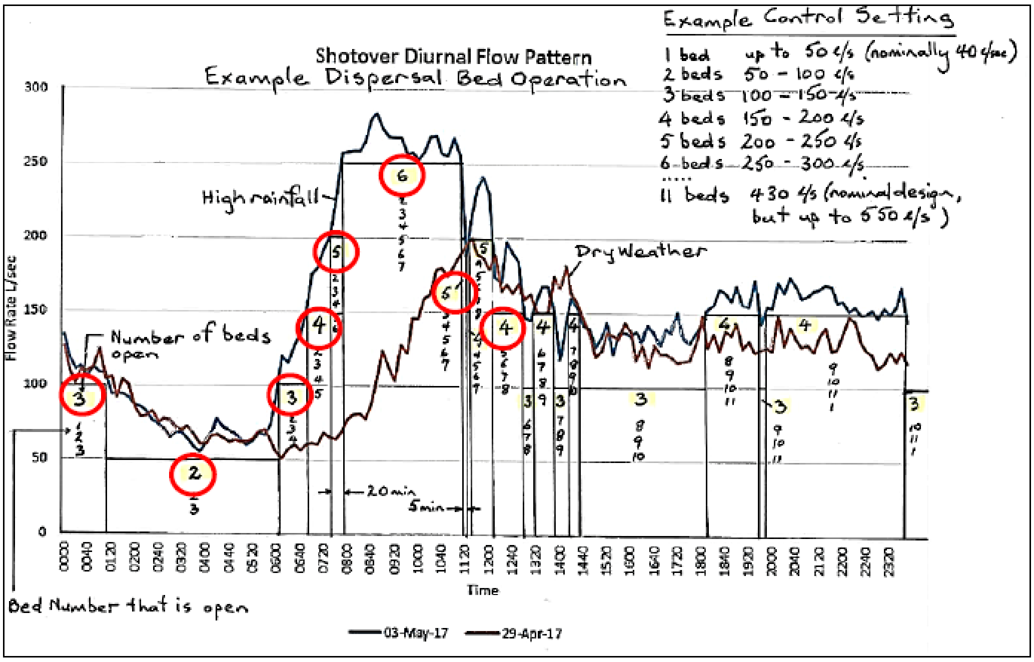

Figure 5: Typical Treatment Plant Flow Profiles (2017) with number of fields operating at any one time for the Wet Weather Flow Profile

The intended control scenario for the full field is as follows:

- Fields will be opened and closed in a cyclical rotation (1 to 11, then back to 1)

  Each successive field opened will be 2 or 3 downstream of the last one opened, to minimise interaction of ground water mounding between fields.

- A maximum run time per field of 2 to 3 hours - but this control is overridden when say 10, or all, fields are required to operate. Run times may vary between fields, depending on established performance in service.

An overarching overview of the system, to ensure that the system is not becoming hydraulically overloaded due to some operational issue, is provided by pressure measurement made in the delivery pipeline located at the head of the field at Chamber 1. The pressure in the main pipeline at Chamber 1 is continuously monitored, first to establish the pressure range for different numbers of fields operating simultaneously, and secondly to identify occasions when the pressure is markedly above or below the established ranges, in which case an alarm is raised.

3 CONSTRUCTION DETAILS

3.1 Pipe Trenches

No ground water was encountered in the pipe and cell trenches with the invert levels being approximately 500mm above the ground water. This made the trench and cell construction simplistic with the plastic water cells being approximately 1M above the normal average ground water level. Figure 6 shows typical arrangement.

Figure 6: Bed of gravel laid at base of trench, water cells tied together and installed in trench. Monitoring piezometers installed. Manholes installed in centre of each field, above 800 mm dia distribution pipe.

3.2 Willow Trees

The highly invasive nature of willow trees was underestimated during the design period. The Shotover Delta is infested with invasive willow trees and removal of trees in close proximity to each field was included in the construction tender. However, the high density of the willow roots in some of the DAD dispersal field area became evident following the commencement of excavation of the DAD trenches and 800mm dia. pipe trench (shown in Figure 7). Significant concern was raised around the potential for the willow roots to clog the HDPE water cells. Options for willow tree management were investigated and the following actions taken during construction to mitigate the risk of willow growth:

- All roots in the trenches cut neatly;
- Herbicide applied to roots; and
- All willow trees within the DAD dispersal field fenced area felled.

Willow growth is being closely managed as part of the ongoing DAD dispersal field maintenance going forward due to the risk of clogging of the nutrient-rich DAD dispersal fields with willow roots. New willow saplings within the dispersal field are sprayed with herbicide on an annual basis.

Figure 7: Dense willow root growth in the 800 mm dia pipe trench. The adjacent willow trees were subsequently felled.

3.3 Gravels

The clean gravels were obtained from a nearby quarry which screened the gravels from the Shotover River itself. Volumes used were as follows

4480 CuM clean gravel 15mm-40mm

5530 CuM clean gravel 40mm – 200mm

15243 CuM of pit run used as a fill volume (fines below 15mm)

3.4 Water cell construction

Significant labour was required to construct the water cells. The cells were delivered to site 'flat packed' and each cell required assembly. In total 11,432 cells were assembled. This required approximately 6 people working five days a week over more than four months. The cells were however easy to be assembled and very few cells were broken during assembly..

Figure 8: Water cells were delivered to site as 'flat packs', requiring assembly on site

4 CONCLUSIONS

To date the field has operated above expectations and each field is now dosed at a rate of 70 l/s which is well above the theoretical design of 40 l/s and whilst the current field can be extended in the future this is now anticipated to be 10 to 20 years later than originally thought. The field was stripped of all its invasive vegetation but is now replanted with native plants as shown if Figure 9. These plants are currently irrigated to encourage growth and will spread further in the future. The plants have been selected in agreement with the local IWI and the ORC but are species with short root systems.

Figure 9: DAD Dispersal field backfilled to finished levels and planted with native species.

Final cost (which was one of the critical alternative design criteria) was $ 5.33 Million giving a saving for the Queenstown ratepayers of approx. $ 15 Million.

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