

# WAIOURU SEWAGE TREATMENT PLANT UPGRADE

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## ABSTRACT

The New Zealand Defence Force (NZDF) owns and operates a Wastewater Treatment Plant (WWTP) at Waiouru, which was originally built in 1957. The WWTP treats wastewater generated from the NZDF military base and from commercial and residential sources within the township, and discharges the treated wastewater (effluent) to a nearby stream. The treatment plant needed upgrading to comply with new discharge consent limits and PDP was engaged to undertake this work after assisting NZDF to obtain the new discharge consent.

The consenting, design and construction of the upgrade have posed a number of challenges, which have included balancing cultural and technical issues during the consenting phase, construction supervision at a remote site, working under climatic extremes, and the need to maintain the plant performance during construction, which has included refurbishment of existing unit processes. It has taken collaboration between all parties involved to achieve successful delivery of each stage of the project.

Construction of the plant upgrade began in April 2013, finishing in December 2013. The construction included adding a dual tank sequencing batch reactor, Alum dosing for phosphorus removal and UV treatment. The upgrade also retrofitted existing sludge management facilities to provide improved sludge handling and dewatering. The plant was progressively commissioned throughout construction with the SBR tanks commissioned in December 2013. Fine tuning of each treatment process was undertaken in early 2014 and the treatment plant is now reliably providing a high quality effluent. PDP continues to work alongside NZDF, providing operational assistance to the plant operator via a SCADA link.

## KEYWORDS

**Waiouru, WWTP, SBR, UV, Alum, Upgrade, Commissioning, Effluent**

# 1 INTRODUCTION

The New Zealand Defence Force (NZDF) owns and operates a Wastewater Treatment Plant (WWTP) at Waiouru, which was originally built in 1957. The WWTP treats wastewater generated from the NZDF military base and from commercial and residential sources within the township a serves a total population of around 3,000.

PDP has assisted NZDF in upgrading the WWTP throughout the consenting, investigation, design and commissioning process and continues to provide operational assistance for the WWTP. This paper provides a brief summary of each phase of the project from start to finish and outlines learnings developed along the way.

The upgrade of the plant includes a new dual tank Sequencing Batch Reactor (SBR), Alum dosing for phosphorus removal, UV treatment, improved sludge handling facilities and the refurbishment of many of the existing treatment processes with a total CAPEX of \$3.5M. The plant discharges into the Waitangi Stream which enters the Whangaehu River a few kilometers downstream.



*Photograph 1: SBR Fitout*

# 2 CONSENTING

Pattle Delamore Partners Limited (PDP) has been closely involved with Waiouru WWTP since 2002. PDP prepared an issues and options study into upgrading the existing sewage treatment plant in 2002, including alternatives to the continued discharge of effluent to the Waitangi Stream.

After considerable consultation with Iwi three potential land disposal options were identified for further study. PDP carried out preliminary subsoil and groundwater investigations for effluent disposal to land. The most

promising option at the time appeared to be disposal using a purpose built infiltration bed with an approximate cost of \$3.6M exc. GST.

Subsequent to this work (and after some extended period of further consultation), Iwi took a pragmatic approach and wanted the best environmental outcome for the budget that NZDF had available. This changed the approach taken by NZDF/PDP and a Biological Nitrogen Removal system (SBR) with continuance of the existing stream discharge was considered going forward.

PDP assisted NZDF through the resource consent process and prepared an AEE for the SBR system. A discharge consent was granted by Horizons Regional Council in 2012 with the following consent limits:

<b>Table 1: Waiouru STP Consent Limits</b>		
<b>Parameter</b>	<b>Unit</b>	<b>Consent Limit</b>
cBOD <sub>5</sub>	mg/L	20
Total Suspended Solids (TSS)	mg/L	25
Total Nitrogen (TN)	mg/L	12
Soluble Inorganic Nitrogen (SIN)	mg/L	10
Total Ammoniacal Nitrogen	mg/L	5
Total Phosphorus (TP)	mg/L	0.9
Dissolved Reactive Phosphorus (DRP)	mg/L	0.7
E. Coli	MPN/100mL	1000
Faecal Coliforms	cfu's/100mL	2000
Note: Consent limits came into force on 30th June 2014. The consent required the UV unit to be operational on 1/10/2013. The consent limit is a rolling median based on the previous 12 monthly samples.		

### **3 DESIGN**

PDP started the design process in October 2012. Process design was assisted by utilising Biowin wastewater treatment modelling software. The process design was undertaken in parallel with detailed design and site investigation given the tight timeframe required by the consent to have the UV unit operational ahead of the rest of the upgrade. Information was fed from process design and site investigations to the detailed design team and the design progressed quickly with drawings completed in February 2013.

A key part of the project was to incorporate as much of the existing treatment plant infrastructure as possible and particularly to use the existing trickling filters as these were accepted by Iwi as providing some spiritual “cleansing “ of the wastewater.

The upgraded plant includes (new treatment processes bolded):

- Inlet works, with grit chamber and step screen
- Primary clarifier
- **SBR Lift Pumpstation with 40L/s capacity.**
- **2 x 800m<sup>3</sup> SBR tanks (400m<sup>3</sup> live volume per cycle) with diffused aeration, submersible mixers, sludge wasting pumps, floating decants and monitoring probes.**
- **Caustic dosing to increase alkalinity prior to nitrification in SBRs (alkalinity deficient wastewater).**
- **Carbon dosing to assist denitrification (due to an inadequate C:N ratio).**
- Trickling filters (2 of, working in parallel).

- **A recirculation pumpstation with 25L/s capacity (to keep the trickling filters wet during SBR idle phases).**
- **Alum dosing prior to secondary clarifier.**
- Secondary clarifier.
- **Ultraviolet treatment.**

The tender documents were sent out to 4 pre-selected contractors in March 2013.

### **3.1 DESIGN CHALLENGES AND LEARNINGS**

The WWTP wastewater flow data comprised “hand kept” records by the operator and this set of records (some 10 years) was essential in sizing unit processes. Some significant flows have been encountered at the Waiouru WWTP due to stormwater inflow and groundwater infiltration (I and I) in the township. The average daily flow for the plant is around 800m<sup>3</sup>/d but flows have been recorded in excess of 5000m<sup>3</sup>/d. These large flows required the incorporation of overflow points at particular locations through the treatment process, the SBR tanks being one such point where bypassing will occur when inflow exceeds 1,600m<sup>3</sup>/d. Since the plant was made commissioned in December 2013, no flows greater than 1,000m<sup>3</sup>/d have been recorded.

Characterization of loads entering the WWTP is also of particular importance. Post-screen flows were characterized for their contaminant loads to provide valuable process information. This was demonstrated when it was found that the primary clarifier was performing better than expected since refurbishment during the upgrade and removing a higher % of BOD, thereby reducing the Carbon:Nitrogen ratio which enters the SBR tanks. This has required carbon dosing using acetic acid to supplement this ratio and enable a high percentage removal of Nitrogen in the SBRs.

Designing the plant for cold weather was also a challenge, with recorded air temperatures of -6deg°C being common and wastewater temperatures often being less than 10deg°C. Insulated pipework was required in many locations and some chemicals required heating. Stagnant flow in pipework was avoided where possible and some unit processes have been programmed to pulse operated periodically to prevent freezing.

## **4 CONSTRUCTION**

Spartan Construction Ltd provided the lowest price tender and were awarded the construction contract. PDP acted as Engineer to the contract. PDP and Spartan had previously established a strong working relationship on two previous wastewater treatment projects; a \$1.6M WWTP (2011) in Morrinsville for Greenlea Premier Meats Ltd and a \$2.2M anaerobic lagoon build (2012) in Waitoa for Wallace Corporation Ltd. The Waiouru STP Upgrade continued to build on this relationship.

Given the tight construction timeframe required to in order to have the UV operational by October 2013, construction began immediately in April 2013. The construction programme ran throughout the year until the final process (the SBRs) were brought online in December 2013.

### **4.1 CONSTRUCTION DIFFICULTIES AND LEARNINGS**

#### **4.1.1 WEATHER**

Given the construction period started in April and running through to December, weather conditions were interesting, with several snowfalls throughout the duration of the project making groundwork difficult/impossible and also providing challenging conditions for the substantial in-situ concrete work required for the SBRs, not to mention difficult and harsh working conditions. To protect against freezing of concrete insulated blankets were used on the SBR floor and the SBR wall formwork was kept in place for an extended period of time.

#### 4.1.2 WORKING IN A LIVE PLANT

Several existing unit processes had to be worked around during construction; inlet works, primary clarifier, trickling filters and secondary clarifier. A key goal throughout construction was to minimize the down time of any of these treatment process to provide the best effluent quality possible at all times.

To achieve this, PDP worked with Spartan to develop a particularly ordered and detailed construction schedule. Several temporary pumping systems also had to be setup and run 24-7 for portions of the works.

#### 4.1.3 REFURBISHMENT OF EXISTING PLANT

Perhaps the most challenging aspect of construction was the refurbishment of many of the existing treatment process. During tendering, a site visit was setup with each of the 4 tenderers to describe in detail the requirements of the work and provide a better handle on pricing these works.

In saying this, many of the submerged parts could not be observed (scraper arms, digester mixer etc) during this site visit. If more time had been available (prior to construction) a pre inspection (draining) of each of the to-be-refurbished items could have been undertaken. This, in theory could have provided greater cost certainty around these items. However, it probably would have been of little benefit because so much sludge had accumulated in the various treatment processes anyway.

The primary clarifier was the first existing treatment process to be drained, photographs of which are shown below.



*Photograph 1: The Sludge Merry-go-round*

The primary clarifier steelwork was in a heavily deteriorated condition and a significant rebuild of the scraper mechanism and central column was required. Concrete work was, however, in very good condition for its age.

The existing sludge digester roof was determined to be unsafe for continued operation due to large cracks passing through the roof. The lid was cut off (9m diameter, 200mm thick and weighing 23 tonnes) and replaced by a new concrete lid in order to provide safe continued service. The walls and floor of the digester (once eventually emptied) were in particularly good condition.

Sludge drying beds were excavated to find that leachate was draining directly into the ground without a collection network (the 1950 design drawings had indicated a collection network). This resulted in the sludge drying beds undergoing an over-haul and being converted into geobag dewatering sites. This required existing channels to be filled with concrete. Drainage gravel and pipework was installed above the original concrete slab

base to collect all leachate and return it to the head of the WWTP. A progressive cavity pump and polymer dosing setup were installed as part of the geobag system.

The trickling filters had significant vertical cracks in their external walls. To provide ongoing support and prevent damage in event of an earthquake (and safety for the operator) a tension cable was installed around the perimeter of each trickling filter.

Following the various refurbishment works, each of the existing treatment processes are likely to continue to provide NZDF with many more years of continued service.

## 5 COMMISSIONING

Items of the plant were brought online as they became available. The UV plant was commissioned just prior to the consent requirement of October 2013 and ran smoothly throughout the remainder of the construction process.

The recirculation pumpstation was also brought online prior to many other systems to provide additional flexibility when diverting flows around the trickling filters (for various construction purposes).

The SBR tanks were commissioned in December 2013. Each tank was filled with fresh water (for a full-scale water test) and every item of mechanical equipment was tested thoroughly prior to introducing wastewater into the tanks for the first time. As the individual tanks filled, an activated sludge seed (from Acacia Bay WWTP near Taupo) was added together with molasses as a supplementary food source. The activated sludge volumes grew quickly to target levels.

Testing of the carbon dosing system was undertaken and a reduction of Nitrate from 12mg/L down to 5mg/L in a single cycle could be readily achieved.



*Photograph 2: Water testing of the SBR tanks*

### 5.1 CHALLENGES

Each SBR tank has a floating decant which allows the clear supernatant to be drawn from each tank following the settling cycle. Upon first opening the decant(s), the discharge rate was significantly greater than that communicated by the supplier. To remedy this, orifice plates were installed in the outlet pipe of each decant to reduce flows.

One of the diffuser heads had not been correctly secured during construction. This resulted in air escape during SBR cycles of non-aeration (particularly the decant cycle, which would upset the settle sludge). The tank was drained and the head was correctly fastened.

Some issues were experienced with Dissolved Oxygen (DO) control. Programming of the system could not seem to alleviate what appeared to be a significantly fluctuating incoming load. However, upon some investigation and testing, it was discovered that installing a shielding system beneath each probe (to protect against direct bubble contact) remedied the issue.

## 6 OPERATIONAL ASSISTANCE

PDP has been providing operational assistance on the plant to NZDF since commissioning finished in early 2014. Operational assistance is provided remotely (using a SCADA connection) and monthly site visits undertaken in order to provide training to the existing plant operator to better understand the more involved treatment process.

A SCADA link is used by PDP staff from the Auckland and Tauranga offices to remotely access key information from the plant; flows, DO, pH, temperature, valve positions, equipment status and tank wastewater levels. The development of the SCADA system was discussed in some detail within the construction contract documents and with the contractor’s programmer throughout construction to ensure it provides the correct level of detail in an “easy to use” format. The SCADA link also provides plotting ability for each of the measured parameters which is invaluable for troubleshooting purposes. A well performing SCADA link is a key requirement in providing operational assistance to any technologically advanced WWTP such as this.

Figure 1 shows a screenshot of the SCADA link to the SBR tanks.

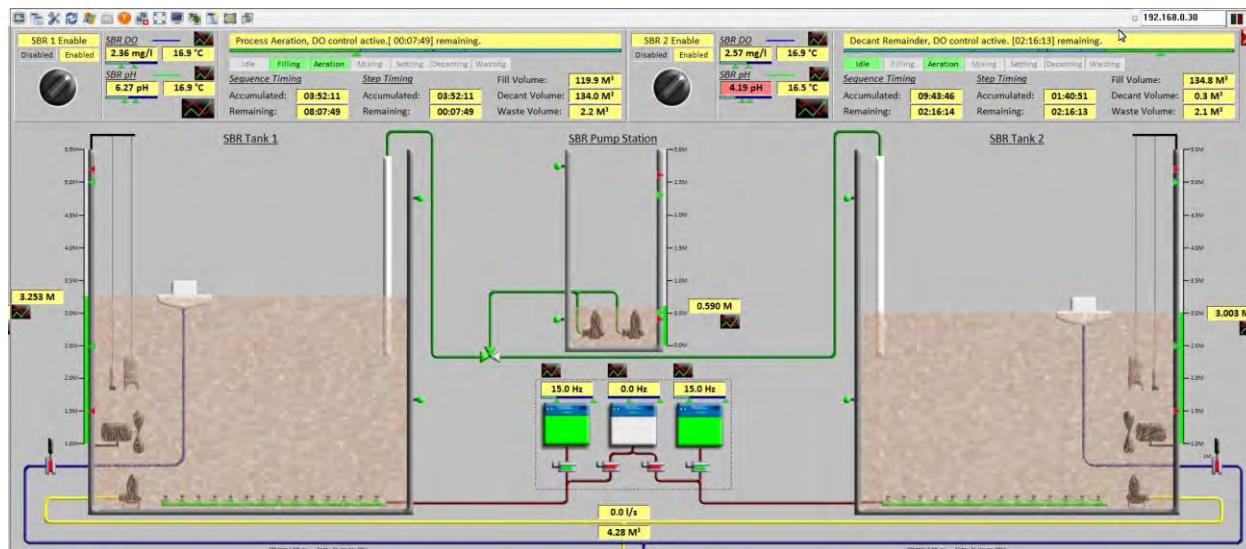


Figure 1: SBR SCADA Screenshot

### 6.1 CHALLENGES AND LEARNINGS

#### 6.1.1 PORTALOO DISCHARGES

Some difficulties were experienced in early 2014, with poor treatment being achieved from the SBR tanks, particularly tank 1 which received inflow from 9am to 3pm (and 9pm to 3am).

After some investigation, it was discovered that a local contractor was regularly discharging portaloos contents into the sewer network. The products used in these portaloos for odour control are anti-microbial and were having an adverse effect on SBR treatment. While these portaloos discharges may have been acceptable in small quantities, during army exercises 75 to 100 portaloos were being emptied every 3 days into the plants relatively small 800m<sup>3</sup>/d inflow.

The portaloo discharges completely inhibited any nitrification in SBR 1. SBR 2 was also partially affected, however, given the tanks have different fill cycles, SBR 2 managed to survive the episode. SBR 2 was then used to reseed SBR 1 with some healthy activated sludge. SBR 1 fully recovered in 7 to 10 days following reseeded. The ability to reseed an affected tank has proven very useful in a dual SBR system and an allowance should be made in any design to allow the operator to transfer activated sludge between SBR tanks.

To prevent future reoccurrence of the portaloo discharges, the portaloo contractor is now required to use a wastewater treatment friendly product that relies on enzymes for odour control. No issues have been experienced at the plant since this new product was introduced.

### 6.1.2 WASTEWATER TEMPERATURE

Wastewater temperatures within the SBR got down as low as 8 degrees C during/after snowfall in mid July 2014. PDP expected these cold temperatures to have a negative effect on the nitrification and denitrification ability of the SBRs, however, no such effects were seen.

### 6.1.3 HANDHELD COLORIMETER

Troubleshooting of performance difficulties in a WWTP can prove difficult, particularly given the 7 day turnaround time of any effluent sample sent to a laboratory for analysis. To overcome this a colorimeter was purchased allowing real-time measurement of Ammonia, Nitrate, Nitrite, DRP and SS. This has proved to be an invaluable tool for the operator as it allows him to make proactive adjustments to the plant control. The colorimeter results were compared against laboratory results and were remarkably similar for the nitrogen species, and within acceptable limits for DRP and SS

## 6.2 PLANT RESULTS

Median results since commissioning was completed in June 2014 are shown in Table 2. The plant is showing comfortable compliance with all parameters.

<b>Parameter</b>	<b>Unit</b>	<b>Consent Limit<sup>1</sup></b>	<b>Median Effluent Quality<sup>2</sup></b>	<b>Recent Effluent Quality for TP<sup>3</sup></b>
cBOD <sub>5</sub>	mg/L	20	2	
Total Suspended Solids (TSS)	mg/L	25	10	
Total Nitrogen (TN)	mg/L	12	8	
Soluble Inorganic Nitrogen (SIN)	mg/L	10	6	
Total Ammoniacal Nitrogen	mg/L	5	1	
Total Phosphorus (TP)	mg/L	0.9	0.92	0.25
Dissolved Reactive Phosphorus (DRP)	mg/L	0.7	0.19	
E. Coli	MPN/100mL	1000	80	
Faecal Coliforms	cfu's/100mL	2000	80	

Note:

1. Consent limits came into force on 30th June 2014.
2. Median effluent quality determined from a mix of laboratory and colorimeter results.
3. The recent TP results have shown a significant improvement in TP due to an increase in the Alum dose.

## 7 CONCLUSIONS

PDP has worked alongside NZDF throughout the full project lifecycle of the Waiouru Sewage Treatment Plant Upgrade which was commissioned in early 2014. The new plant has significantly reduced the discharge of nitrogen, phosphorus, faecal coliforms, BOD and suspended solids to the Waitangi Stream. PDP's wide skill base ranging from consenting, through design and contract management, to operational assistance have provided NZDF with a highly functioning WWTP that will serve NZDF for many years to come.