TAHUNA WWTP – AN INNOVATIVE CONVERSION OF PRIMARY SEDIMENTATION TANKS TO THE HIGH RATE ACTIVATED SLUDGE PROCESS

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ABSTRACT

CH2M Beca Ltd was engaged by Dunedin City Council (DCC) to undertake the concept and detailed design of Stage 2 of the Tahuna Wastewater Treatment Plant (WWTP) Upgrade. The population served is 120,000 and the peak wet weather flow is 4,000L/s. Prior to the Stage 2 upgrade, the WWTP consisted of primary sedimentation and chlorine disinfection. The Stage 2 upgrade to secondary treatment was required to improve the effluent quality and allow ultraviolet light (UV) disinfection to replace chlorination.

The liquid stream upgrading included the new processes of Grit Removal, and High Rate Activated Sludge (HRAS). The length of the existing primary sedimentation tanks (PSTs) allowed establishment of three zones (grit removal, aeration, sedimentation) using new partition walls and a modified inlet. Conversion of the PSTs included a number of novel approaches such as; converting former sludge hoppers to grit hoppers, rubber-lined grit pumps, suction removal of sludge from rectangular tanks, modification of existing travelling bridge scrapers, coarse screw collection of scum, submerged tube launders coupled with a weir at the sedimentation tank outlet, and very high speed aeration blowers with direct-coupled motors and integral variable speed drives (no gearboxes).

This paper describes the methodology and reasons for selecting the HRAS process, the innovations and other unique features required for the conversion of the PSTs to this process, and how the process has performed.

KEYWORDS

Wastewater treatment, primary sedimentation, tank conversion, high rate activated sludge process, high speed aeration blowers, grit removal, Tahuna Wastewater Treatment Plant, Dunedin

1 INTRODUCTION

1.1 TAHUNA WWTP

Dunedin City Council's (DCC) Tahuna Wastewater Treatment Plant (WWTP) serves a population of 120,000 and the design peak wet weather flow is 4,000L/s, making it the second largest treatment plant in the South Island. Recently, the plant was upgraded to improve the effluent quality and enable ultraviolet light (UV) disinfection to replace chlorination.

1.2 STAGE 1 UPGRADE

The Musselburgh Pump Station delivered wastewater from most of Dunedin to the Tahuna WWTP where wastewater was settled in three relatively large (16 m wide by 75 m long) Primary Sedimentation Tanks (PSTs) housed in a building. Settled effluent was dosed with chlorine (sodium hypochlorite) at a flow measurement flume.

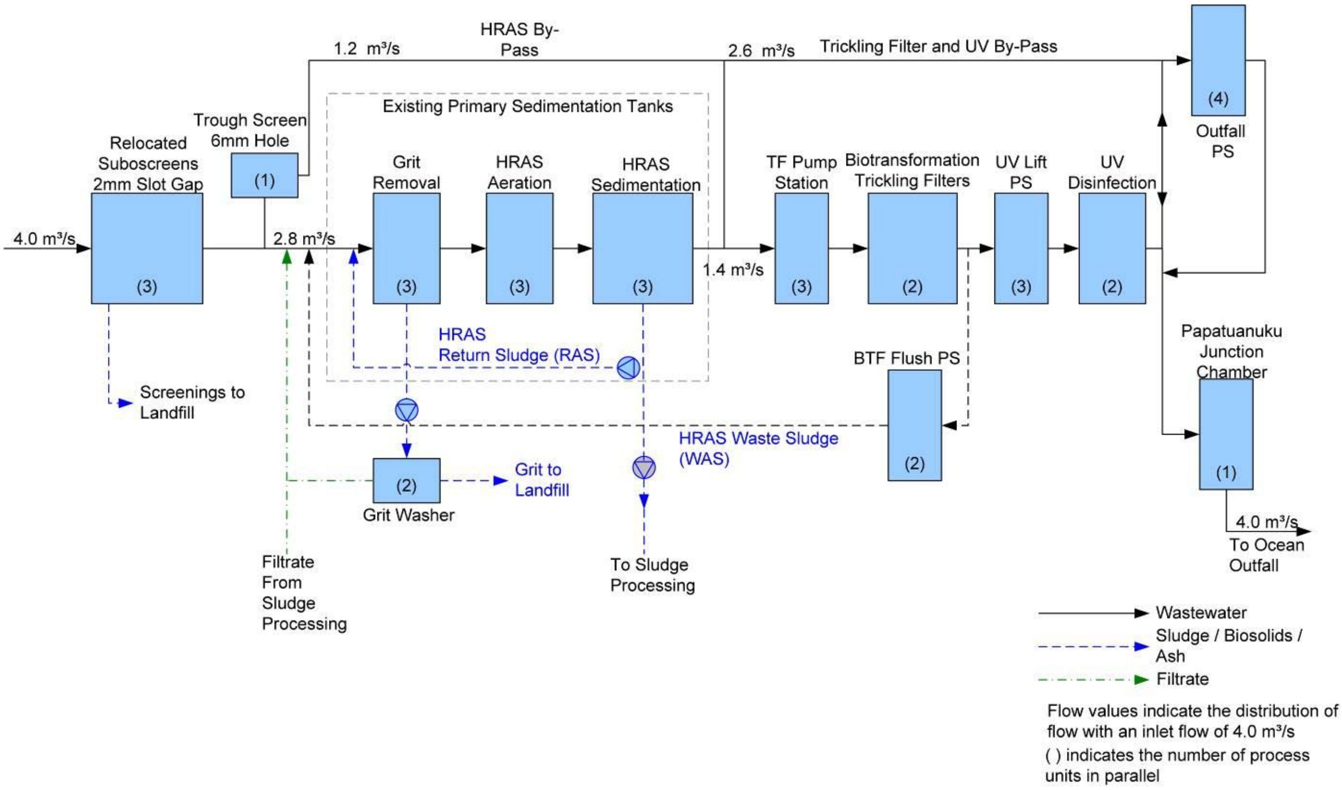
The Stage 1 Upgrade entailed installation of a 1,100m-long Ocean Outfall and Outfall Pump Station to replace a short sea outfall (at Lawyers Head), with work completed in 2009. Disinfected flow could travel by gravity to the Ocean Outfall, or via boost pumps at the Outfall Pump Station during wet weather flows or during outfall flushing. Prior to the outfall is the Papatuanuku Junction Chamber (PJC), which has large rocks in the base to fulfil the Papatuanuku function of "contact with Mother Earth" that makes the discharge of wastewater to the ocean more culturally acceptable.

1.3 STAGE 2 UPGRADE

The Stage 2 upgrade to secondary treatment was required to improve the effluent quality and enable UV disinfection to replace chlorination.

The liquid stream upgrading involved inlet fine screening with Suboscreens (relocated from those at the Musselburgh Pump Station, which were replaced by coarse screens), Grit Removal, a High Rate Activated Sludge Process (within the former primary sedimentation tanks), Biotransformation Trickling Filters (BTFs), and UV Disinfection – refer Figure 1.

Figure 1: Tahuna WWTP Process Flow Diagram of the Stage 2 Upgrade



The solids stream upgrading involved gravity belt thickeners and centrifuges at the Tahuna WWTP. Dewatered sludge cake is either combusted in the existing Tahuna incinerator, or transported to DCC's Green Island WWTP which had spare digestion capacity due to industry closures. Some sludge is taken directly to the Green Island Landfill.

1.4 FLOW CAPACITIES

Design average flow is 500L/s and maximum flow to the HRAS Process is 2,800L/s (or 5.6 times average flow). Flow greater than 2,800L/s bypasses the HRAS process via an actuated penstock. Flow up to 2,800L/s receives grit removal, HRAS aeration and sedimentation.

The Chorine Contact Tank is retained as a blind tank to store volume for Outfall Flushing. The existing chlorination system has been retained as a backup if a discharge to the former Lawyers Head Outfall is ever required.

HRAS-treated flow is pumped to the BTFs along with any recirculation flow from the BTFs. Flow up to 1,400L/s is pumped to the BTFs and UV disinfection stage. Flow greater than 1,400L/s is spilled to the Outfall Pump Station. Treated flow from secondary treatment (BTFs and UV) is recombined with the BTF Feed Bypass flow and either passes to the Papatuanuku Junction Chamber by gravity, or is pumped to the Papatuanuku Junction Chamber by the Outfall Pumps.

The Treatment Plant operates in one of three modes at any given time. These are:

- Normal Treatment Mode (minimum night time flow to peak wet weather flow of 4,000L/s)
- BTF Flushing Mode (once daily for each BTF at 375L/s for 40 minutes duration)
- Outfall Flushing Mode (once daily at 3,200L/s for 10 minutes duration)

Each BTF is sequentially flushed for a period of 40 minutes once a day to control the biofilm within the BTFs. The flushing of each BTF is normally undertaken during the late evening or night to avoid conflict with daily Outfall flushing and to coincide with lower influent flow and load. The timing of the BTF flush can be adjusted to select the desired incoming flow conditions for flushing.

The Ocean Outfall is flushed daily to scour settled solids and trapped air. The Ocean Outfall flushing is undertaken mid-morning to coincide with the diurnal peak incoming flow (dry weather conditions Qi of 500 to 800L/s) to assist achieving the desired flush duration (10 minutes) and flow rate (3,200L/s).

The remainder of this paper focuses on the HRAS process. Archer *et al*. (2013) provides a more detailed description of the complete upgrade. Glasgow *et al*. (2013) discusses the BTF aspects of the process.

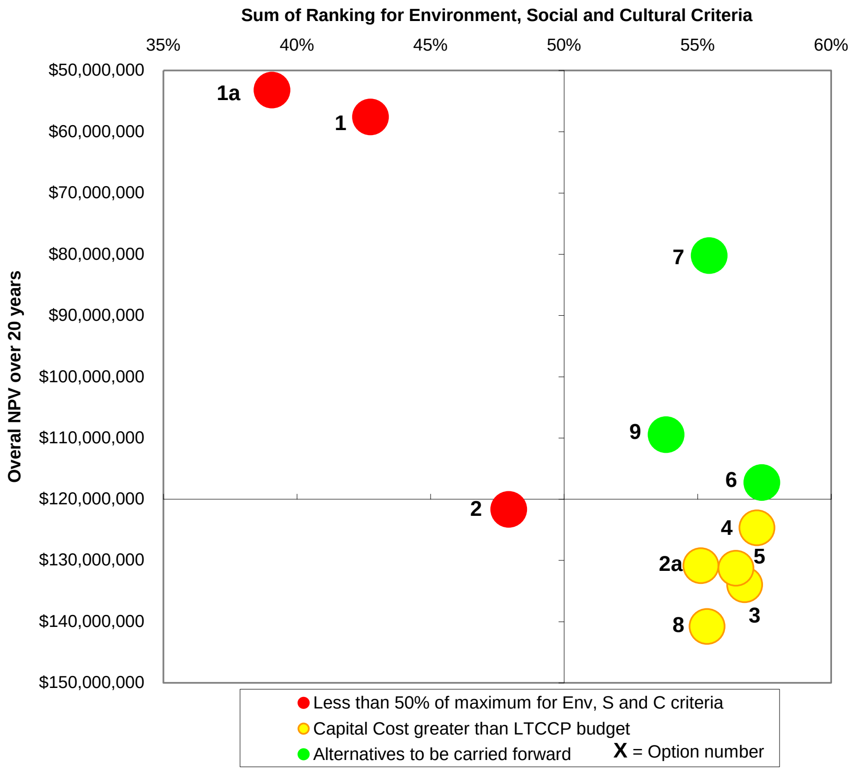
2 HRAS – AN ADVANCED PRIMARY TREATMENT PROCESS

2.1 WHY HRAS?

Treatment options for the Stage 2 upgrade were analysed extensively. Considering all practical treatment processes, a long list of 29 liquid treatment options was generated. This was reduced to a short list of nine options for more detailed analysis. These options were evaluated on a quadruple bottom line basis (cultural, economic, environmental, and social), the results of which are shown in Figure 2. From this analysis, three options were carried forward as preferred. These were:

- Contact Stabilisation and UV disinfection – Option 6
- Biotransformation Trickling Filter (BTF) and UV Disinfection (no secondary clarifier) – Option 7
- High Rate Activated Sludge, BTF and UV Disinfection (no secondary clarifier) – Option 9

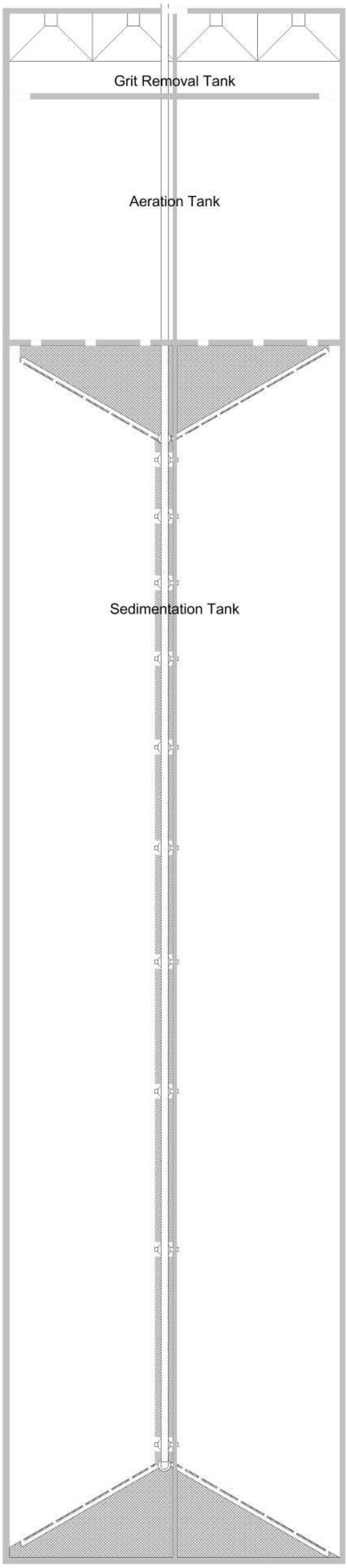
Figure 2: Tahuna WWTP Summary of short list evaluation



Further analysis of these options was presented to DCC, with the HRAS process being selected for implementation. The main advantages of the HRAS process in this case were:

- Reducing the biochemical oxygen demand (BOD_5) load on the downstream BTF, and so reduce its size (and cost)
- Enabling the BTF to treat the wastewater to meet the consent conditions
- Enabling the BTF to produce wastewater that is able to be disinfected by UV irradiation without the need for a secondary clarifier
- The ability to convert the existing PSTs into an HRAS process

Figure 3: Plan showing partitioning of PSTs



2.2 PARTITIONING THE EXISTING PSTs

The length of the existing three PSTs, 75m, enabled the partitioning of the tanks into three zones for grit removal, aeration and sedimentation. The key to this is that the HRAS process only required 1 – 2 hours of hydraulic retention time in the aeration zone and can be loaded up to 2.5kg $BOD_5/(m^3.d)$. Thus, the size of the aeration zone does not need to be large. The partitions are shown in Figure 3. The lengths of the zones are 4m grit removal, 12m aeration, and 59m sedimentation.

2.3 GRIT REMOVAL

2.3.1 OVERVIEW

The original plant did not have a separate grit removal process. Grit was removed along with sludge and incinerated. In wet weather, the grit quantities increased substantially and, due to the greater inorganic content, the sludge could not be incinerated. Because the proposed upgrading required recirculation of sludge and centrifuge dewatering, a grit removal stage was needed, as is normal practice to avoid excessive wear of equipment.

The inlet end of the former rectangular PSTs was modified with partition walls and flow distribution alterations, to become grit removal tanks. Grit settlement is achieved by inducing a ‘roll current’ using coarse bubble aeration, which acts to sweep settled grit into the former sludge hoppers. Grit is pumped from the grit hoppers to the grit washer/classifiers on a timed sequence, where the grit is washed and dewatered. Dewatered grit is discharged to skips for disposal to landfill.

2.3.2 GRIT PUMPS

The grit pumps handle an abrasive liquid, which has the potential to cause significant pump wear over time. Pump wear occurs as grit particles impact at speed on the pump impeller and casing. Pump wear has a significant effect on pump performance over time and therefore selection of the grit pumps was carefully considered to save replacement costs, and reduce maintenance hours and downtime.

The standard methods identified to reduce pump wear and improve a pump’s service life for abrasive liquid pumping include:

- Reduce pump speed – Slowing the pump down reduces the impact energy of the grit particles on the pump impeller and casing, thereby reducing pump wear. Studies indicate impeller wear is roughly proportional to the cube of the speed ratio (i.e. half the speed equals six times the pump life). Slower speeds also generally require heavier, larger diameter impellers, which spreads the impact energy that causes wear over a greater area.

- Hardened materials – Harder materials are less susceptible to wear. The bigger the difference between the hardness of the pump and the grit particle, the longer the pump will last. Typically, high chromium alloy metals are used for abrasive liquid pumping.

As an alternative, a recent technology for abrasive liquid pumping that has gained favour in Europe and the United States, is rubber-lined pumps. Research and experience show that when a hard grit particle meets a soft and flexible rubber surface, the rubber will partially compress to temporarily absorb, and then return, the energy generated by the impact of the grit particle. This allows the pump to operate with minimal damage to the rubber components. Kuhn (2009) compared the performance of a hard chromium alloy cast iron pump versus a ceramic coated pump and a rubber lined pump in an abrasive wastewater grit pumping application, demonstrated that the rubber lined pump had the longest service life.

Experience in the mining industry shows that rubber-lined pumps are susceptible to damage from sharp particles and particles larger than 7mm. Sharp particles can cut the rubber, which can eventually cause it to fail. Larger particles have higher impact energy than the rubber can absorb, which can result in a heat build-up in the rubber, causing it to harden and crack. Large particles were not anticipated at Tahuna WWTP because of the 2mm aperture Suboscreens.

Rubber-lined pumps for abrasive liquid pumping have a proven track record in the mining industry, and wastewater treatment applications in Europe and the United States. The Tahuna WWTP incinerator ash pump is also a rubber-lined pump that has been operating effectively for many years. Therefore, rubber-lined pumps were selected for the grit pumping duty and since installation, they have performed well. During construction, 20 – 50mm concrete construction debris made its way into a working grit hopper, causing rubber impeller damage. Since replacing this impeller, however, no further damage or interruptions have occurred.

2.4 HRAS AERATION

2.4.1 OVERVIEW

Downstream of the Grit Tank, the wastewater enters the HRAS Aeration Tank; a further section of the old PSTs modified with partition walls, and fitted with grids of fine bubble air diffusers. The HRAS aeration stage is a short-retention, highly-loaded, aeration process that reduces BOD by incorporating colloidal solids in the recirculated biomass. Some soluble BOD reduction occurs with associated biomass growth.

The required air flow to each Grit Tank is fixed. Conversely, the required air flow to each HRAS Aeration Tank varies according to the Dissolved Oxygen (DO) concentration to maintain it within a range of 0.1 to 1.0 mg/l. This is lower than conventional activated sludge processes because the HRAS process is a primarily a ‘contact process’, which relies on mixing and flocculation of colloidal solids into the biomass, rather than the full treatment of soluble and solid contaminants. Some references refer to the HRAS process as being anoxic (i.e. near zero DO), or facultative (i.e. functioning in both aerobic and anoxic conditions).

Air is delivered from the blowers via a common discharge pipeline, and then dedicated lines with modulating control valves supply air to each tank. The modulating control valves are automatically controlled between 30 and 70% open, to maintain the DO set-point range within its associated tank.

Air discharge from the Grit and HRAS Aeration Tanks is malodorous. Thus, the tanks are fitted with low level covers and the air is continuously extracted to the odour control system – refer to Photograph 1.

2.4.2 VERY HIGH SPEED AERATION BLOWERS

Very high speed K-Turbo aeration blowers were selected to supply air for the grit tanks and HRAS aeration tanks. These high speed blowers are the first of their type in New Zealand. The blowers operate around 35,000rpm with an efficiency of 68%. The 37kW blowers are compact – refer Photograph 2 – at 0.7 × 1.0 × 1.2m including the acoustic enclosure, and weigh 630kg. This enabled the blowers to be located within the existing building space and use a mobile davit crane for maintenance, as opposed to installing a gantry crane.

Photograph 1: Looking to the inlet end of the empty HRAS tank showing the scum removal screw, closer spaced sludge removal ports and covered aeration tank in the background

Photograph 2: K-Turbo High Speed blowers at Tahuna WWTP

The blowers do not have gearboxes, and have direct-coupled motors with integral variable speed drives. The K-Turbo blowers have an air foil bearing, such that when running there is no contact between the bearing and shaft. This gives the blowers very low maintenance requirements as well as enabling the high efficiencies to be achieved. Some other high speed blowers use a magnetic bearing to achieve this. When housed in their acoustic enclose the blowers are quiet, producing 78dBa at 1m, which allows for a conversation to be heard.

2.5 HRAS SEDIMENTATION AND SLUDGE REMOVAL

2.5.1 BACKGROUND

The remaining area of each former PST, and the existing travelling bridge, are used in the sedimentation section of the HRAS process.

Travelling bridge scrapers are rare in NZ, but common in Europe. Because the original units had required minimal maintenance (in comparison with chain and flight scrapers used in other major plants in NZ) and were in reasonable condition, it was decided to adapt the travelling bridge scraper to remove sludge from close to where it settles, rather than moving the sludge to one end of the tank. This required unique features to be designed.

2.5.2 SLUDGE REMOVAL OPTIONS CONSIDERED

The constraints and requirements for the new sludge removal system were:-

- No sludge hoppers available (as these would be expensive to retrofit due to the tank base being below groundwater level)
- Suction removal, from near where the sludge settled, preferred over scraping to one end of the long tanks, because of the risk of the activated sludge aging and becoming gas buoyed
- Equipment located in an existing building which has a low ventilation rate, and hydrogen sulphide corrosion would affect complex electrical equipment such as variable speed drives, if mounted on the travelling bridges
- Increased odour release into the building space could not be tolerated, so sludge could not be exposed to the building atmosphere.

Suction removal of sludge is seen as beneficial because the sludge is removed from where it settles (or with minimal travel distance). This can be compared to moving sludge the full length of long rectangular tanks which could result in the "activated sludge" becoming buoyant and releasing odours as it ages. It is noted that most of the recent secondary clarifiers in conventional activated sludge plants in NZ, have suction removal in circular tanks; e.g. Mangere, Hamilton, Christchurch and Invercargill (15 tanks in total). The suction systems have been of the 'Tow-Bro' type by Envirex/US Filter/Siemens, or close variants from Westech or Smith & Loveless. There are three main types of suction removal which would comply with the above constraints, either in full or partially.

A. Existing travelling bridges retrofitted with angled scrapers moving sludge to multiple withdrawal ports in a fixed suction header, with Return Activated Sludge (RAS) pumps mounted in existing Pump Gallery

B. Return Activated Sludge (RAS) pumps mounted on existing travelling bridges with the RAS discharged to troughs above water level and gravity flow of RAS to the aeration zone inlet

C. Removal of existing travelling bridges and replacement with chain and flight scrapers with suction headers in the floor slab at approximately 10m intervals, and RAS pumps installed in the existing Pump Gallery (hydraulic suction removal portion of the Siemens Envirex "TransFlo" concept).

The features of each option are summarised in Table 1.

From a qualitative evaluation, and discussions with the client, Options B and C were not favoured for these key reasons:

- Option B; increased odour risk; unreliable electrical supply to pump VSDs mounted on the travelling bridges; and the individual RAS systems with separate MLSS characteristics for each HRAS train
- Option C; much higher cost, approximately $1.2 million additional to either Options A and B.

Option A was selected for these key reasons: RAS pumps would be located in the existing main Pump Gallery for ease of maintenance; no odour would be released from RAS pipework; and common RAS manifold and therefore common MLSS characteristics, which would avoid variability in biomass between the three HRAS trains.

Table 1: Comparison of RAS removal options

Option	Retains Bridges	RAS Pumps Location	RAS Removal Method	Advantages	Disadvantages
A	Yes	In main pump gallery	Angled scraper to the half-height central suction pipe with 12 inlet ports with actuated valves, which are opened one at a time as the angled scraper passes each port. The RAS pumps discharge to common manifold which discharges into the main inlet channel.	▪ Fully enclosed RAS pipework with no odour release ▪ RAS pumps in gallery for ease of maintenance ▪ RAS discharge into main influent channel will "smooth" the RAS concentration and will produce a common biomass across all three tanks ▪ Cost moderate	▪ Site specific design ▪ Submerged valves need tank to be emptied for maintenance (expected to be at similar intervals required for tank maintenance)
B	Yes	Mounted on the travelling bridges	"Vacuum cleaner" type suctions, or angled scraper to vertical suction pipes, discharging continuously to gravity troughs mounted above water level, which return the RAS to the aeration tank inlets.	▪ Cost moderate ▪ Used in Europe	▪ Exposed RAS in troughs would release odour and would need to be covered with a sliding seal and ventilated to odour treatment ▪ VSDs mounted on bridges would suffer corrosion ▪ Larger cable feeds to travelling bridges would have high maintenance ▪ Difficult access for RAS pump removal with safety risks ▪ Individual RAS systems for each tank could result in biomass instability in individual tanks
C	No – replaced by chain and flight scraper	In main pump gallery	Chain and flight scraper to suction ports at 10m (approximately) intervals, embedded in the floor slab with suction piping to RAS pumps. Each suction header would be controlled by a valve to a sequence.	▪ Proprietary system ▪ Fully enclosed RAS pipework with no odour release ▪ RAS pumps in gallery for ease of maintenance	▪ High cost (approximately $1.2M for chain and flight scrapers alone) ▪ Extra concrete layer (300mm) required on floor of tanks to embed the suction pipe which would reduce water depth and cost approximately $0.4M

2.5.3 SLUDGE REMOVAL SOLUTION

Sludge is pushed towards central walls at two-thirds of the liquid level by an angled scraper hung from the travelling bridge, where it is removed by intakes at 12 pairs of wall ports that withdraw sludge as the angled scraper passes. A key design feature is that the wall ports are spaced in a tapered fashion to accommodate the fact that a majority of the sludge settle near the inlet of the tank – see Photograph 1, and refer to Section 2.5.5 for more details. The scraper is angled in both directions so that sludge is pushed to the central wall in both bridge travel directions – refer to Photograph 3. The angled scraper creates a 'dead zone' at each end of the tank and this was filled with concrete benching to avoid sludge aging in the dead zones and becoming gas-buoyed – refer to Photograph 1 and 4.

The bridge travels at the same speed in both directions. Two range finders on each bridge are set up to detect excessive bridge skew.

The RAS suction manifolds in the middle of each tank have intakes in each of the 12 wall ports as described above. Each intake has an air-actuated pinch valve, which fails open on loss of air. One valve on a suction manifold is open at all times. Each valve opens when the range finder senses that the travelling bridge is in the opening range for that valve. Once the next valve has opened, the previously opened valve closes. The RAS pumps were retrofitted into an existing gallery. The layout of the RAS pumps was designed to preserve access and clearance for maintenance of these pumps and the other equipment located in the gallery.

Photograph 3: Angled Scraper

2.5.4 SLUDGE REMOVAL CALCULATIONS

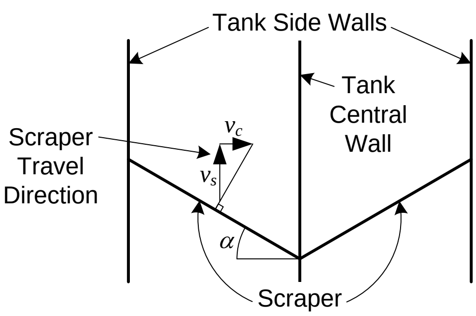
Design of the scraper blade was based on four main reference documents:

- Korrespondenz Abwasser (KA) (1988) *Sludge Removal Systems for Secondary Sedimentation Process*
- German Association for Water (2000) *Standard ATV-DVWK-A 131E – Dimensioning of Single- Stage Activated Sludge Plants*
- Beca Steven Design Guideline for Circular Wastewater Clarifiers, 12 March 1997
- Wang *et al*. (2008) *Three-Dimensional Simulation on the Water Flow Field Suspended Solids Concentration in Rectangular Sedimentation Tank*.

The ATV reports were used for calculating the sludge thickening height and settled sludge concentration.

The Beca Steven Report has a formula for calculating sludge velocity towards the sludge withdrawal point, $v_c = f_1.v_s.\tan\alpha$. Where: v_c is the velocity of sludge towards to wall, f_1 is the efficiency of sludge transport, allowing for slippage etc., v_s is the velocity of scraper blade and α is the angle of the scraper blade from perpendicular to direction of travel. Also refer to Figure 4 for definitions. (Note: only one travel direction shown for simplicity, scrapers will function in both directions.)

Figure 4: Sludge Scrapper Design Definition



Combining the thickened sludge height or the scraper height (whichever is less) with the length of the scraper blade, gives an area of sludge movement. Then multiplying by the sludge velocity gives a volume movement of sludge, and finally multiplying by the sludge solids content gives the dry solids mass movement of sludge to the central wall. Note this assumes that that the liquid above the sludge blanket contains no solids, so is likely to be an underestimate.

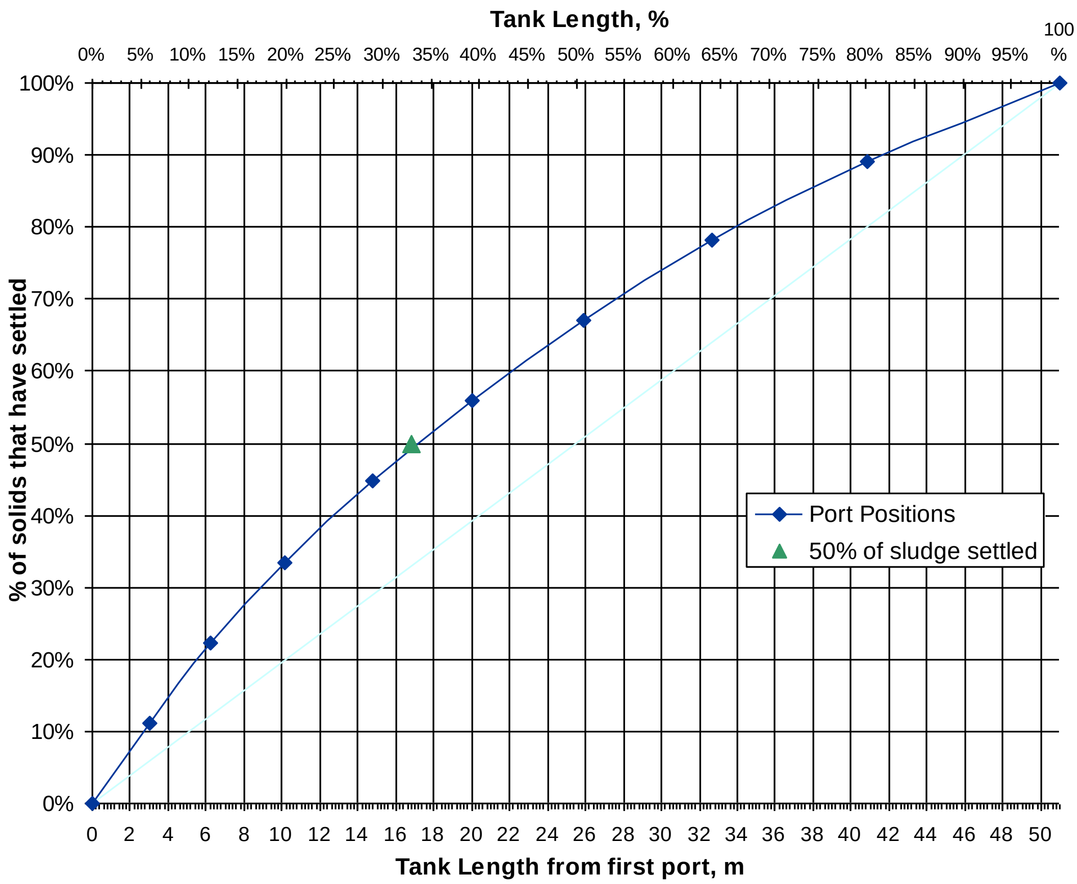
The main factors affecting sludge transport to the central wall are the velocity and angle and height of the scraper blade, although height only has an effect at high loads. A greater scraper angle transports more sludge, but slower scraper speeds can transport more sludge up to a point. This is due to the fact that slower scraper speeds allow the sludge blanket solids content to increase and thus a higher mass of solids can be moved in each pass until the sludge blanket is above the scraper blade.

Using the average flow design parameters, gave a thickened sludge height of 0.13m, with a concentration of 12kg/m³ (1.2% DS), and a total solids flow to the wall of 907kg/hr. This results in build-up of sludge of 1,058kg/hr, which ultimately will increase the sludge blanket level to 0.28m to balance the sludge flow.

2.5.5 WITHDRAWAL PORT SPACING CALCULATIONS

Two ports at each end of the tank connect to suction headers that run the width of the tank at the base of the benching – refer to Photograph 1 and Figure 3. This is to remove any remaining sludge at the tank ends. At either end of the sedimentation tank, the penultimate two ports are positioned a metre from the end suction headers. These are on the central wall and remove the sludge that has been transported to the wall, to avoid overloading the end ports. The remaining eight ports are distributed along the central wall, biased to the inlet end. Modelling done in *Three-Dimensional Simulation on the Water Flow Field Suspended Solids Concentration in Rectangular Sedimentation Tank* by Wang *et al.* (2008), shows that approximately half of the solids settle out in the inlet third of a rectangular sedimentation tank. Thus, the remaining wall ports are spaced so that half the ports are in the inlet third of the tank, and half are in the remaining two-thirds, with the spacing between ports progressively increasing. Figure 5 shows the distribution of these wall ports.

Figure 5: Location of Sludge Withdrawal Wall Ports (excluding end ports)



The final design of 12 ports per tank is a cost balance between having a larger number of valves (which would imitate nearly continuous withdrawal but would be too expensive) and having a smaller number of valves and relying on the scraper to move RAS to the suction ports.

2.5.6 RAS PORT VALVE SELECTION

The suction pipework and port valves have to be submerged. The most suitable valves for submerged duty are 'pinch valves' which are fully enclosed with only an air pipe connection needed to 'pinch' the internal sleeve. Air pressure is needed to close the valves and the air solenoid valves are located in groups at each end of the tanks, for ease of access and maintenance.

Pinch valve suppliers indicated that the sleeves should last for decades in this duty, and routine maintenance of valves can be effected when a tank is emptied for routine maintenance of the scraper's flexible blade wiper and travelling bridge; expected to be once a year.

2.5.7 RANGE FINDER CONTROL

Two laser and reflector sets are installed on each bridge to determine its position in the tank and relative to the suction ports. Each valve opens when the range finders sense that the travelling bridge is in the opening range for that valve. Once the next valve has opened, the previously opened valve closes. Having two range finders provides redundancy, but they are also used to determine if the bridge has skewed and will stop the bridge in extreme cases of skewing.

2.5.8 COARSE SCREW COLLECTION OF SCUM

A Tschuda floating screw scum collector is located at the inlet end of the HRAS sedimentation tank (see Photograph 1). These were supplied from Austria and this is thought to be the first use of these in Australasia.

Scum that floats to the surface in the sedimentation tank, is moved to the scum screw by the travelling bridge. The coarse screw can remove scum derived from both the sedimentation tank and the aeration tank.

The screws concentrate the scum around the surface of small scum sipping troughs at one side of the tanks. The screw and trough floats so that the trough is always at a fixed distance below water level. A submerged scum pump, adjacent to the trough, discharges to the Gravity Tank Thickener (GTT).

2.5.9 OUTLET WEIR WITH SUBMERGED TUBE LAUNDERS

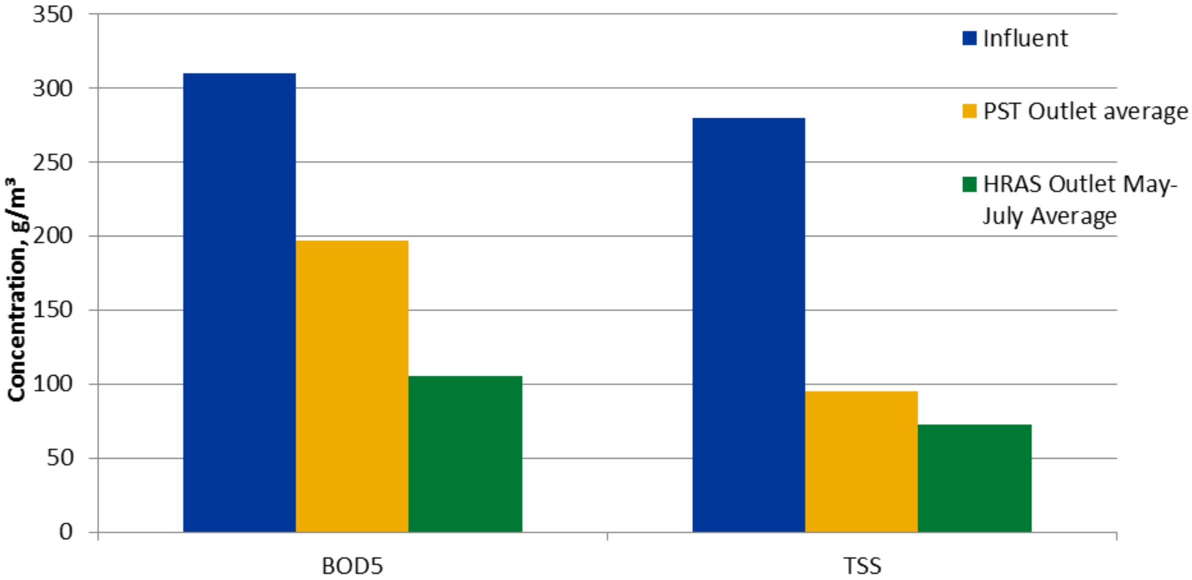
The original PSTs had a simple weir along the end wall of the tank. The overflow rate per metre length of weir was much higher than recommended to minimise solids carryover caused by upwelling currents below the weir. In order to overcome this, submerged tube launder pipes were retrofitted to reduce the upflow velocity, in addition to the end weirs. During average flows, wastewater flows out through the launder tubes only. At high flows, the level rises and some water flows over the end weir as well as through the launder tubes.

Photograph 3: Outlet end of HRAS tank during construction, showing the submerged outlet launder tubes

3 RESULTS

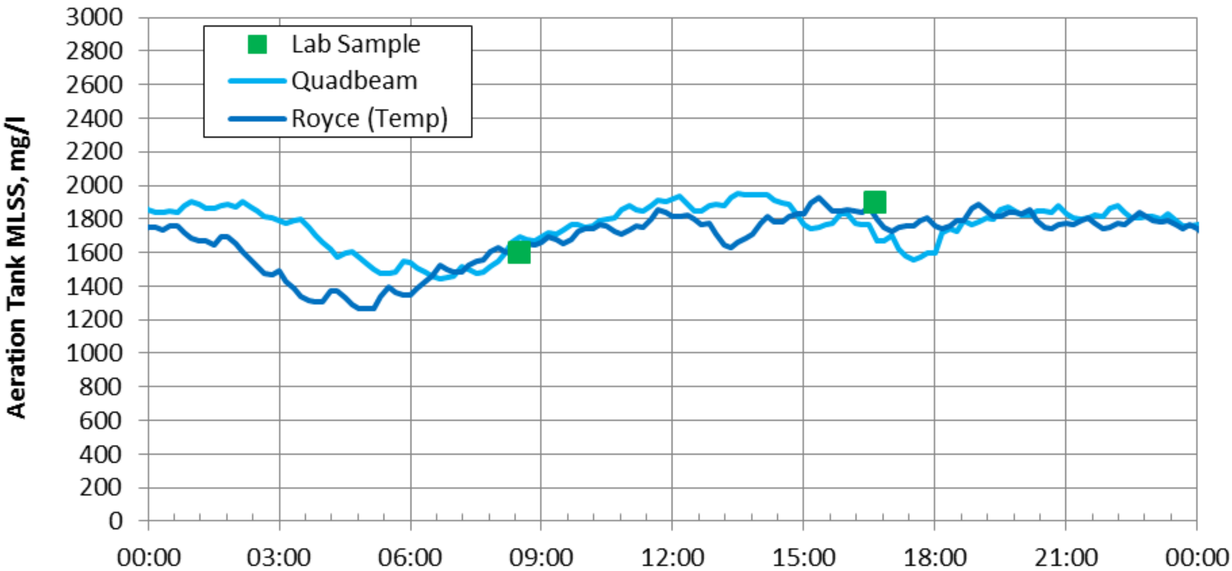
The first PST was converted to the HRAS process and commissioned on wastewater in September 2011. The final tank was commissioned on wastewater in October 2012. The BTFs started to receive wastewater at the beginning of 2013. The overall process train was producing consistent results around May 2013. Figure 6 compares the results of the previously-used primary sedimentation process to the newly-installed HRAS process. This shows significantly improved BOD_5 removal from 36% to 66%, as well as some improvement in TSS removal from 66% to 74%.

Figure 6: HRAS Performance compared to the PST which it replaced



The sludge removal system has been effective with no observable rising sludge blanket level. The variability in MLSS has been acceptable, with a small typical variation of 100mg/l over the 1-hour cycle time of the travelling bridge, as shown in Figure 7.

Figure 7: Mixed Liquor Suspended Solids (MLSS) variation over a day



Increasing the Ultra-Violet Transmissivity (UVT) is primarily a function for the BTFs. However, it is worth noting that the HRAS process itself has improved the UVT to a typical value of 19% compared to 13% achieved by the PSTs. This reduces the performance requirement for the BTFs, which increase the UVT to around 35%.

4 CONCLUSION

The conversion the existing Primary Sedimentation Tanks to a High Rate Activated Sludge process at the Tahuna WWTP has contributed to Dunedin City Council being able to meet its new effluent discharge consent. The implementation of the HRAS process in the existing PSTs required the combination of recent technologies and unique design features in a novel way:

- Converting former sludge hoppers to grit hoppers
- Use of rubber-lined grit pumps
- Suction removal of sludge from modified rectangular tanks using angled scraper and fixed wall ports
- Modification of existing travelling bridge scrapers
- Use of a floating coarse screw for scum collection, the first of this type in Australasia
- Submerged tube launders coupled with a weir at the sedimentation tank outlet
- Very high speed aeration blowers with direct-coupled motors and integral variable speed drives (no gearboxes), their first usage in New Zealand.

The conversion achieved all of the client's requirements within the constraints, i.e.:

- Capital and operating costs are minimised by using the existing PSTs and retaining the existing travelling bridges which had required minimal maintenance
- Significantly improved BOD_5 removal compared to the previously used primary sedimentation process
- Suction removal provides recycling of fresh sludge, which is essential for activated sludge systems
- Grit removal prior to sludge removal to protect sludge process equipment
- Odour release is minimised by not exposing the sludge at any point to the building atmosphere.

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