“ONE OF A KIND” – UNIQUE TREATMENT OF GRINDER PUMP EFFLUENT.

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ABSTRACT

The Maketu community in Bay of Plenty required a modern and cost effective sewerage scheme to be built in a tight timeframe. A consent was obtained for a grinder pump system feeding into a local treatment plant and subsequent sub-surface drip disposal system. This scheme is unusual as only grinder pump effluent supplies the treatment plant and therefore there is minimal stormwater dilution of the plant influent. The paper describes the challenges faced by the technical team in setting appropriate performance criteria for the plant and disposal field. The advantages and disadvantages of using of the new FIDIC Gold Book for the design, build, operate contract are discussed as well as the use of collaborative contract procurement techniques to provide a robust and cost effective outcome for the community. The paper also describes the implementation of a number of initiatives to minimise capital and operating costs, minimise environmental effects whilst maintaining a robust solution for a community with widely fluctuating population.

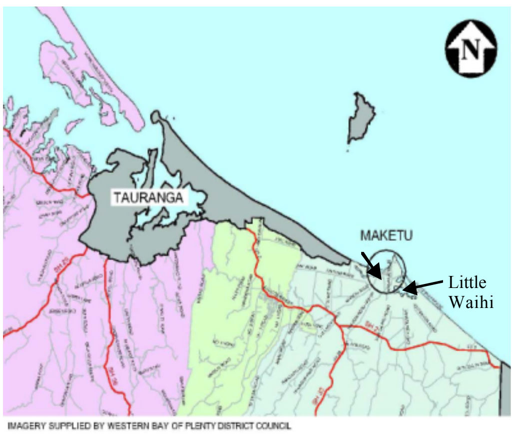
KEYWORDS

Grinder pumps; SBR; land treatment; FIDIC gold book.

1 INTRODUCTION

Maketu and Little Waihi are small and relatively compact coastal communities on the east coast of the north island of New Zealand located about 40 minutes’ drive south east of Tauranga. Figure 1 shows the general location.

Figure 1- Maketu location plan



The communities are located between two large estuaries on the Maketu Peninsula (known as Okurei Point). There are extensive shellfish beds in both estuaries, and popular swimming and surfing beaches. The area is of historical significance as Maketu was the landing place for the Tainui canoe of the great Maori migration and is named after an ancient kumara pit in their traditional home, Hawaiiki.

The topography comprises a wetland and low lying areas on both sides of the Okurei Point peninsula. The peninsula itself has steep incised gullies with properties located both in low lying areas as well as on the higher ground on the ancient “sea cliffs”.

The whole community has relied on septic tanks for wastewater treatment with subsoil disposal, and in some cases “long drops”, some of which went directly into the estuary. The septic tanks do not adequately treat the effluent and in particular do not adequately control the key concerns of nutrients and public health risk. The disposal fields in the low lying areas are often under water in winter and during king tides and are therefore dysfunctional, while the disposal fields on the sea cliffs result in increased instability of the cliff faces due to the added water volume.

The resident population is around 1800 people. There are three camp grounds, a large marae, a primary school and the small Maketu pie factory. In summer the population can swell to over 4000. In addition large gatherings at the marae (due to Maketu's historical significance) can impose significant loads and input flows on the existing septic tank systems. The community is on a reticulated bore water supply provided by Western Bay of Plenty District Council (WBoPDC).

2 COMMUNITY WIDE WASTEWATER OPTIONS

2.1 BACKGROUND

In 1993 WBoPDC commenced consultation on providing a community based wastewater system. Bay of Plenty Regional Council (BoPRC) introduced requirements for septic tank maintenance in its On-Site Effluent Treatment Regional Plan (OSETR) updated in 2006 and required that the Maketu and Little Waihi communities upgrade each household system to an advanced wastewater treatment system or to connect to a community scheme by December 2013. WBoPDC elected to provide a community scheme.

2.2 COUNCIL DRIVERS

Key scheme drivers for the council were:-

i. Minimise operating costs.
ii. Ensure overall community system reliability so that the end result met the objective of the prevention of contamination into the harbour.
iii. Minimise Inflow and Infiltration (I/I) by taking the community scheme back to each householder's gully trap and if necessary replace or re-position the trap.
iv. A desire to make householders responsible for, or at least aware of, their own system on their properties in order to minimise wastewater flows and adverse materials entering the sewer system.
v. Provide a flexible system to manage flow and wastewater biological load range.
vi. Fit within the relatively constrained Wastewater Treatment Plant (WWTP) site, and have as small a footprint as practical (as the land was to be leased for the WWTP based on the area used).
vii. Council ownership of the system including any on-site treatment or pumping.
viii. Reasonably high certainty of outcome, both operationally and in terms of capital cost.
ix. Ability to easily stage the project.
x. Must meet the project deadlines in order to be eligible for the Government subsidy and to meet the Regional Council Operative Plan deadlines.

Funding for the scheme was partially provided by a combination of subsidies provided by the Government subsidy for small community WWTPs, partly by the Regional Council (BoPRC) with the remainder via a Uniform Annual Charge (UAC) of the householder properties. The largest factor on the UAC was the annual operating cost and therefore every opportunity to reduce operating costs was explored in detail.

2.3 OPTIONS ASSESSMENT

A large number of very diverse options were canvassed over many years to try and find an affordable solution as, whilst there are some significant holiday homes in the community, much of the resident community is on a low income. The main options canvassed including pros and cons and comments are given in Table 1:-

Table 1: Options Considered for Wastewater Treatment and Disposal

Option	Description	Pros	Cons / Issues
Individual Systems			
Option 1 - Status Quo	Septic tanks and long drops	• Cheap • Responsibility lies with homeowner.	• Unhygienic (in case of long drops). • Commonly not maintained. • Ongoing contamination and virus issues around shellfish gathering. • Won't comply with OSETR. • Cliff instability
Option 2 - Advanced treatment tank systems	Typically small aeration plants. Many now have UV or membranes incorporated.	• Responsibility lies with homeowner. • Better quality than existing. • Complies with OSETR.	• Still requires householder septage removal/management. • Unable to reliably strip nitrogen- and, • Still requires a disposal field so only a part solution.
Community Systems			
Conventional Collection Systems			
Issues include:- ○ I/I flow risks with any conventional system ○ No responsibility on householder ○ Council controlled collection and treatment			
Option 3 - Pipeline to nearest WWTP	Long pipeline to Te-Puke (15kms away)	• Centralised WW and sludge treatment. • Lower risk conventional approach. • Council controlled	• High cost • Septicity of sewage could affect existing plant. • Management of infiltration and flows.
Option 4 - Localised Treatment	Secondary treatment plant just to serve local community	• Certainty of treatment outcomes. • Certainty over disposal route(s). • Council controlled	• Wide flow and load variations • Limited land availability • Disposal to ground still required. • Sludge management • Remote WWTP- hard to operate.
Alternative Collection Systems			
Option 5 - Retain Septic tanks but off-site treatment	Household responsible for tanks but council picks up septage	• Lower scheme capital cost. • Householder has level	• Loss of carbon in septic tanks – affects denitrification • I/I not adequately managed so

Option	Description	Pros	Cons / Issues
and disposal by council WWTP	for treatment and disposal	of responsibility for WW	could be wide flow variation. • Still need to collect septage • Many tanks too small so need replacement. Added costs
Option 6 - Grinder Pump STEG – local WWTP. Council owned plant for treatment and disposal	• Each household has own grinder pump with 24 hours storage. • Small bore pipework.	• Minimises I/I • Householder has level of responsibility • Some pumping required.	• Still risk of some I/I as pipework system gravity. • Householder responsibility for paying for power remains an issue.
Option 7 - Grinder Pump or STEP – local WWTP. Council owned plant for treatment and disposal	As above but fully pressurised system.	• Virtually eliminates I/I • Council Controlled • Householder responsibility. • Minimising I/I allows to minimise land disposal area	• One of first of its kind in NZ - so has risks. • Uncertainty over wastewater inflow composition. • Control of pumping is critical to ensure WWTP is not overloaded. • Householder responsibility for paying for power remains an issue.

I/I=Inflow and Infiltration; WWTP=Wastewater Treatment Plant; STEG=Septic Tank Effluent Gravity; STEP=Septic Tank Effluent Pressure

The option most adequately meeting all of Council's objectives was Option 7- the grinder pump STEP system with local WWTP and localised treatment and disposal.

3 CHALLENGES

3.1 DISPOSAL AND WWTP LOCATION

The uniqueness of the area, and the strong Maori presence and cultural requirements, meant that disposal of the wastewater by irrigation to land was the most likely to be accepted, however this required a reasonably large land area. Bordered by two large estuaries to the north and east, a wetland and generally low lying ground to the North and North West and a 60 metre high sea-cliff to the South and South-West, the only land for disposal was on the upper terraces.

WBoPDC had discussions with the Te Arawa Trust who own the majority of the land in Maketu. A block of farmland to the west of the community in Arawa Avenue at the top of the hill was identified and, after investigations, was confirmed to be suitable for both the treatment plant and a sub-surface land disposal system. Spray irrigation use for disposal was precluded due to the proximity of a motel and the windy nature of the cliff top site.

This in turn meant that the wastewater had to be pumped up 65 metres to the site. While some of the grinder pumps could pump directly to the site, two conventional wastewater pump stations were required within the community. However no storage was required at these, as the private household grinder units had 24 hour storage.

3.2 POPULATION AND FLOWS

The makeup of the Maketu community has been previously described. There is a community water supply borefield and the WBoPDC is in the process of installing water meters as a flow minimisation measure. The council also has good data from a number of other coastal communities so the flow per person could be reasonably well estimated.

Based on using a STEP system the inflow and infiltration allowance was set at 10% of the average daily flow, as points of entry into the system are extremely limited being mainly at gully traps, via illegal connections and at the two pump stations. Table 2 summarises the population and flow estimates. The plant would be constructed in two stages being up to 635 m^3per day and then up to 835 m^3 per day

Table 2 - Maketu and Little Waihi Projected population and flows estimates

		Population	ADF m^3/day*
Maketu	Resident	1600	315
	Visitor (mixed)	1700	323
Little Waihi	Resident	195	39
	Visitor (camping)	635	83
	Totals	**4130**	**760**

- Excluding 10% I/I allowance.

3.3 ASSESSMENT OF LOAD ON THE TREATMENT PLANT

There was minimal data available on the composition of the wastewater found from typical grinder pump effluent systems as virtually all systems installed in NZ to date pumped into a conventional sewage collection system so therefore there was no need to characterise the grinder pump wastewater.

Only one similar scheme could be located and this was in Karumba in Australia and at the time of contract document preparation this MBR plant was just being commissioned so no reliable data was available.

A number of references were consulted and, in the absence of definitive data, and based on the authors' experiences with characterising composting systems (Cobeldick et al, 2004) the following average daily limits were established.

Table 3 – Estimated average influent concentrations

Parameter	Concentration g/m^3
Suspended solids, SS	400
Biochemical Oxygen Demand, BOD_5	380
Total Nitrogen, TN	100
Ammoniacal Nitrogen, NH_3-N	70
Total Phosphorous, TP	16

In addition to the parameters above, the local water supply is low in alkalinity being on average 73 g/m^3. This raised concerns over whether there would be sufficient alkalinity in the wastewater to allow for biological denitrification on a consistent basis.

During the tender process (discussed later in this paper) there was also concern raised about the carbon to nitrogen ratios, particularly at start-up.

3.4 "ONE OF A KIND"

It quickly became clear to the project delivery team that this project had several unique features, so new initiatives were required to focus on minimising operating costs while still providing a high quality effluent.

The initiatives broadly fell into four categories being: social, environmental, technical and contractual/risk management.

3.4.1 SOCIAL INITIATIVES

Each household was provided with its own grinder pump system incorporating a storage tank. Photograph 1 is an example of the units provided and Photograph 2 the electrical house connection. The household installations entailed laying a new pipeline from the gully trap to the unit to minimise I/I on the household properties as this can be up to 50% of the total I/I of a wastewater system.

Photograph 1: Typical pump station unit prior to in-ground installation

The pump unit stores 600 litres or approximately 24 hours storage for the average family. This provides some level of peak flow buffering to the treatment plant, although the exact amount of buffering will depend on the overall scheme's cyclic operation of the pumps. Due to cost, pump SCADA control for managing pump flows into the WWTP was not provided, so the pumps are on timers with a high level override.

Negotiations were undertaken with each homeowner to agree to the siting of their pump station and the in-property lateral and gulley trap upgrade.

Photograph 2: Example of existing house electrical connection

Photograph 3: Typical new house electrical connection

In many cases the power at the house was not suitable for the pump installation, as shown in by Photograph 2. Therefore the main fuse box was upgraded to permit the installation. This was accepted as a cost to the scheme.

Each home owner pays for the pump power (pump motor size was around 0.75kW) and so this remains as a risk to the system should the homeowner not pay their power bill. An education step was required to explain the pump operation to the homeowner to minimise unsuitable material damaging or stalling the grinder pump (e.g. kitchen clothes, nappies and toys).

3.4.2 ENVIRONMENTAL INITIATIVES

With the primary objective being to minimise environmental contamination at the lowest cost, the disposal field was investigated to specifically include land treatment. The final effluent limits were then based on the assessed sustainable field capacity. The effects of each of the key wastewater parameters were considered and the options for management of these are summarised below.

PHOSPHORUS

It was determined that, similar to many soils in the Bay of Plenty region, the upper ash layers had high phosphorus absorption capacity and therefore there was no immediate need for phosphorus removal, provided the wastewater could be applied at a slow rate using a subsurface dripper system. There was however a desire to maximise this advantage by minimising the phosphorus in the final effluent so that the disposal field could be extended beyond the 25 to 35 years predicted before chemical phosphorus removal in the WWTP was required.

SODIUM

There was a concern that should dosing for alkalinity be required then the most readily available chemicals were high in sodium (e.g. sodium hydroxide) and that any significant sodium in the effluent would eventually render the disposal field unusable. Alternative methods of increasing alkalinity without the use of sodium may have been required.

SUSPENDED SOLIDS (SS OR TSS)

Since the disposal system needed to be a slow rate irrigation with fine drippers it was important that suspended particles were removed as far as practicable. Therefore a series of filters, being a main automatic backwashing filter followed by finer field filters were required to minimise suspended solids entering the disposal/treatment system. A maximum SS figure was also set to ensure that the disposal field was not overloaded. The SS is managed by a effluent holding pond as well as the filters in case of carryover of solids from the treatment process (which has happened frequently during commissioning and "Start-up" phases of the scheme).

BACTERIA AND VIRUSES

UV systems are commonly used in wastewater treatment to reduce pathogen concentrations in effluents. However UV is expensive to install and run. Therefore ideally WBoPDC sought to avoid the use of disinfection if at all possible. From unpublished work that URS had undertaken on viral fate at the Pauanui wastewater disposal scheme, there was strong evidence that bacterial and viral die-off in sand occurred within 2 metres of the sub-surface drippers. Since the ash soils at Maketu were less permeable and provided higher filtration and absorption capacity, WBoPDC and the Regional Council accepted that initially the scheme could be built without the UV but provision be made to install UV at a later date should future testing show that pathogen breakthrough, as indicated by EColi, was measurement in monitoring bores around the disposal field

There was thus a significant capital and operational cost saving to the scheme by avoiding UV disinfection.

DISCHARGE TO WATER

Even using a slow rate discharge to ground, the applied wastewater will eventually reach water. The groundwater at the site is very deep at around 55 metres. There is a small gully about 50 metres from the disposal field and this reports to an ephemeral stream. Computer modelling of the system indicated that nitrogen and ammonia were critical parameters and so maximum flow and nutrient loading rates to land were established to manage the expected effects on the stream and groundwater.

Using a sub-surface drip system allows irrigation to the root zone of the grass and thereby enhances grass growth and, in the case of Maketu, provides a silage income of around $ 8,000 per annum to off-set operational costs.

CONSENTING

Permits to construct and discharge effluent were obtained from the Regional Council based on the flows, soil assessments and expected wastewater treatment plant performance.

The consents obtained place a limit on total nitrogen of 15 g/m^3 based on a statistical analysis of the effluent quality at the treatment plant with a level of 6 g/m^3 TN in the monitoring bores. Suspended solids and cBOD were set at 30 g/m^3 with maximum suspended solids of 150 g/m^3 measured downstream of the main irrigation filter.

To manage the situation of having no UV, the consent set a maximum plant discharge level of E Coli of 100,000 cfu/100ml and a limit of 260 cfu/100ml EColi in monitoring bores (namely the contact bathing water standard). The level of EColi in the monitoring bores has not been exceeded demonstrating that UV disinfection can be removed from the treatment process in the Maketu situation.

3.4.3 TECHNICAL INITIATIVES

Based on the council's requirements for flexibility, a high standard and reliable level of treatment, a small footprint for the treatment and disposal system as well as considering the nature of the community with its high summer holiday population it was considered that an SBR (Sequential Batch Reactor), an MBR (Membrane Bioreactor) or a contact stabilisation plant would be the most favourable treatment option.

Being a remote site, a fully automated plant was needed, having a high standard of SCADA and communications to alert operators should anything go wrong.

The technical team was also aware that SBR's in particular could occasionally cause carryover of biosolids and it was essential to prevent this material entering the disposal field system. So an emergency storage pond was required to give up to 24 hours storage of effluent that was out of specification.

There was considerable debate about whether inlet screening was required, as the grinder pump effluent reduced all material to a very small size and there were no manhole entry points within the reticulation system where large objects could enter. Omitting the screening would save on capital and potentially operating costs. In the end it was decided to put in a 6 mm screen to protect the plant in the unlikely event of a pipeline breakage or pump failure causing debris to enter the system.

Experience has found that the screen catches virtually nothing, recording only one small drink bottle to date! However the automatically backwashed 120 micron filter prior to the disposal field is catching plastic and some wind-blown debris from the effluent storage pond. This material is then effectively trapped in the system and has to be manually removed from the process.

The treatment process also had to be capable of managing periodic chemical cleaning of the disposal field (about 6 monthly) and sludge dewatering liquor.

An aerial view of the final plant layout and components is shown in attached in Appendix A

3.4.4 CONTRACTUAL RISK MANAGEMENT INITIATIVES

Council was concerned over the delivery risk of the wastewater treatment plant and irrigation system as they needed cost certainty but had had unsatisfactory experiences in the past with design-build (DB) projects.

A review of procurement options was undertaken based on the Council's desire to have a design-build (DB) contract (to place responsibility on buildability with one party), minimise risks and provide cost certainty but have an operational component so that the plant could be demonstrated to be operating reliably prior to council taking over. Various forms of DB-Operate contracts were reviewed. These included the following:-

- NZTA (New Zealand Transport Agency) DB form of contract. However this had no commissioning or operational component and would require extensive modifications so it was rejected.
- NZS3910:2003 – Had no satisfactory commissioning, testing and operational components so, whilst a well-known and commonly used civil engineering contract in NZ, extensive modifications would have been needed.
- NEC3 – (New Engineering Contract Version 3). This is a widely used international contract and has some testing, operating and commissioning provisions. However overall the document was quite weak in these areas and was not well known in NZ.
- FIDIC – Yellow book (1999) – Specifically written for design-build so had good testing and commissioning provisions but had no operational component. This contract is well known in NZ, but is missing NZ law provisions around contract payment and uses a 365 day a year working calendar (namely no provision for Christmas break which is typical needed for NZ contracts). It also has very long approval and lead times.
- FIDIC Silver Book – This is a turnkey contract and Council decided that it wanted more input during the design, construction and commissioning process so this form of contract was rejected.
- FIDIC Gold Book (2008) – Specifically setup for design-build and operate, but was written around a 20 year operational period. The contract has similar issues to the FIDIC Yellow Book. No experience in NZ although one other contract was due out using this document.
- Purpose written contract document – One of the authors (Mr. Evans) has written a number of design-build-operate contracts for wastewater and other facilities, however such documents take time, typically require costly legal review and are not generally familiar to NZ contractors.

None of the contracts reflected the need to gradually bring the wastewater treatment plant from no flow and contaminant load up to full treatment capability without adverse effects on the environment. So modifications to all contracts were likely.

On balance, and due to the timescales required, it was decided to use the FIDIC Gold Book as a "standard" form of contract as this was very similar to the Yellow Book with which contractors had a familiarity. FIDIC is widely used by all the world development banks and therefore is well recognised and used internationally.

4 MODIFICATIONS TO THE FIDIC GOLD BOOK

4.1 CONTRACT PREPARATION

Whilst the Gold Book had many desirable standard features, it required amendments to suit NZ legal requirements and also the special requirements of the Maketu Project. However these were no more than typical special conditions under NZS 3910, except as noted as follows.

The book is "generalised" for any DBO situation, in any remote part of the world and is not specific to wastewater treatment plants. Therefore modifications to the book included the following (with the various contract terms shown with capital letters leading):-

(a) There was a need to add in a "Start-up" period of 90 days to allow household connections to be made while still managing wastewater.

(b) Conversion of the relevant clauses from envisaging a 20 year operational period to a one year plus operational extension of one year period as sought by WBoPDC was required.

(c) The preparation of an "Operational Licence" was required. This document needed to be included in the tender and sets out the operational requirements of the "Employer" (owner). This presented quite a challenge as the type of treatment plant had not been selected and therefore no operational information was available. Therefore the Licence was written to reflect the owner's requirements on information, reporting, response times, compliance with consents and other similar broad issues. Effectively it is a form of operating contract attached to a design-build contract document.

(d) The addition of Construction Contracts Act provisions.

(e) Amendment of timelines for approvals, delivery of designs and payments to meet Maketu timelines and be more reasonable such as recognising long NZ Christmas holiday breaks.

(f) Adjustment of insurance terms and requirements to suit NZ environment.

(g) There were no conditions of tendering or tendering processes in the standard document, so these had to be included and were based on NZS3910 for familiarity reasons.

Although the testing, pre-commissioning and commissioning provisions were excellent and well defined, a new step labeled "Start-up" had to be introduced into the contract to reflect the fact that the wastewater connections would occur gradually over some weeks during which time the raw sewage either had to be stored or treated or removed from site or all of these.

Since the rate of uptake and the method of treatment were uncertain, it was decided to leave this choice up to the contractor as there were many options (such as temporary partitioning of the reactors or temporary storage of wastewater) until volumes built-up. Therefore a flexible but robust commission and testing system had to be used.

4.2 TENDERING

Tendering was by Registration of Interest (ROI) requiring relevant experience, track record, quality and personnel followed by tender by four selected parties, although one dropped out shortly after the selection. The scoring of tenders was linked back into the ROI to minimise the risk of change of personnel or teams, namely previous scores could be revisited if necessary.

A contractor briefing meeting was held and it quickly became apparent that some form of interactive tendering was going to be required although this had not be anticipated in the tender documents. Therefore acceptance of a change to the process was sought from the three contractors, all three of whom welcomed the opportunity for a more interactive process.

Tenders were scored on price, methodology attributes and technical robustness of the proposed process. All tenders offered SBR systems. No MBR or contact stabilisation systems were offered.

As part of the interactive process council elected to include a sludge dewatering component to the plant in order to minimise sludge cartage and with a view to installing a vermiculture composting facility on the site in the future.

A number of risk mitigation measures were also agreed upon including temporary carbon dosing during "Start-up" as well as the addition of optional chemical dosing for alkalinity.

4.3 ADMINISTERING THE CONTRACT USING THE FIDIC GOLD BOOK.

WBoPDC decided to undertake the administration of the resulting FIDIC Gold Book contract using in house staff, including the coauthor of this paper (Mr Brown) being the Employer's Representative (effectively the "Engineer" to the Contract).

The Gold Book has two primary phases being the "Design-Build" phase and the "Operational Period".

This is the first project that WBoPDC had used the FIDIC Gold Book. Initially it took time to become familiar with the new terminology, new procedures and time frames allowed for tasks to be performed. One has to be vigilant to ensure the allowable time frames for the parties to act are achieved.

A number of actions assisted greatly in allowing the contract to go relatively smoothly. That is not to say there were no challenges to overcome. Council commissioned URS to carry out preliminary investigation, prepare the contract document and provide technical advice

The latter stage of the tender process included an interactive meeting with each of the tenderers and this proved to be successful with clarifications provided and tags removed.

At the 60 percent complete process design stage, a two day Hazard and Operability Study (HAZOP) meeting was held with all parties present to systematically analyse the various components of the system. This resulted in an extensive list of resolutions and recommendations and some variations. Another HAZOP was held at the 95% design stage to further review the submitted final design package.

The contractor provided the Employer with a Risk Register which identified, assessed and classified the risks together with management and mitigation measures.

The FIDIC Gold Book requires the contractor to design, execute and complete the works and provide the Operation Service in accordance with the contract. When completed the works must be fit for the purposes for which they were intended and the contractor is to ensure they remain that way through the "Operation Service Period" until the "Contract Completion Certificate" is issued and all handover conditions are met.

It should be noted that the FIDIC Gold Book has no "Defects Liability Period" since it envisages a 20 year operational period, so this needed to be introduced at Maketu due to the short timeframe for the "Operational Period" and consequential handover of the plant.

Administration of the Contract using the FIDIC Gold Book was relatively straight forward and user friendly.

The Gold Book has different procedures and terminology from other conditions of contract. Although the words used are different, there are similarities and in many instances these are self-explanatory and there is a full list of definitions provided.

The FIDIC drafters have included at the front of the document a comprehensive series of flow charts which outline the critical sequences of key activities and defined periods of time for the Parties to act that are specific and unique to the Design, Build & Operate form of contract.

There are over 70 sub-clauses requiring one party to give notice to the other party regarding an occurrence or an event, therefore it is very important to know what constitutes a "Notice" and what a simple communication is.

The "Contract Price" includes amounts for each phase of the design, build and operate contract and includes an "Asset Replacement Schedule" (as a standard contract clause) to cover cost of assets that may have to be replaced in the first five years.

Tenderers are required to submit with their tender a "Schedule of Projected Monthly Progress Payments" based on the "Accepted Contract Amount" for each of the design, build and operation phases of the contract.

On issue of the "Letter of Acceptance" the contractor submits a performance security bond. Then the "Employer" issues an advance payment of 5% of the accepted contract amount (in the case of Maketu) which provides the contractor income during the design period when construction works have not started.

Each month of the contract the Employer issues an "Interim Payment Certificate" in accordance with the agreed "Schedule of Payments". Retentions were fixed at 10%. Half of the retention is returned with the "Commissioning Certificate" after the "Design-Build" phase. The "Advance Payment" is claimed back by the "Employer" after several "Interim Payments" have been made.

Disputes and determinations are handled by the "Employer's Representative" who is required to consult with both parties to try and reach agreement. Fair determination is made in accordance with the contract taking due regard to all relevant circumstances. Should agreement not be reached by the parties then a "Dispute Adjudication Board" is requested to make a decision or it may have to go to arbitration. It should be noted that FIDIC, like NEC, does not require the Engineer (Employer's Representative) to have the joint roles of expert advisor to the "Principal" as well as the role of independent adjudicator as is the case in NZS3910.

5 CONSTRUCTION

The grinder pump reticulation and pump installation contract was let as a separate contract to the WWTP and disposal field contract package. The interface point between the grinder pump reticulation contract and the WWTP contract being at the inlet to the inlet works of the WWTP. Spartan Construction with AWT and Ecogent (for the disposal field) were awarded the treatment plant contract.

The project was due to be completed and accept sewage on 5 th December 2011.

However subsequently there was concern around the plant's ability to handle the Christmas peak load near the plant start-up and in addition the community requested that all reticulation construction in the community cease over the main holiday period and thus wastewater connections and flows would be affected.

Therefore the pump connections were delayed during a 3 week holiday break to meet the community and process needs. Consequently the "Start-up" period didn't commence until early 2012, although the plant was receiving a small amount so wastewater prior to Christmas and commenced a nominal form of treatment then.

6 LESSONS LEARNT

6.1 WASTEWATER COMPOSITION

A key question at "Start-up" was, did the projected wastewater inlet load meet actual? Table 4 summarises the range of predicted and actual flows into the plant (after removing obvious data anomalies from recycling of off specification effluent during commissioning; irrigation flushing flows and sludge dewatering supernatant). The dataset after the removal of erroneous data is quite small at only 24 samples. So caution is needed if using this dataset for wider scale use, although the information is still informative.

Table 4: Summary of Inlet Wastewater Parameters (units g/m^3)

Parameter	**Predicted Average**	**Actual (excluding data anomalies)**				**Typical conventional sewage (*Burks et al 1994)***
		Min	**Mean**	**Median**	**Max recorded**	
Suspended Solids, SS	400	124	334	312	600	200 to 300 (100 to 400 also reported)

Parameter	Predicted Average	Actual (excluding data anomalies)				Typical conventional sewage (*Burks et al 1994)*
		Min	Mean	Median	Max recorded	
Biochemical Oxygen Demand, BOD_5	380	233	381	374	605	200 to 300 (100-400 also reported)
Total Nitrogen, TN	100	29	75	76	107	30 to 50 (15-90 also reported)
Ammoniacal nitrogen NH_3-N	70	18	58	59	86	25, (10 to 50 also reported)
Total Phosphorous TP	16	4.5	9.5	9.4	14	6 to 10 (5-20 also reported)
Alkalinity	+73	226	375	383	501	No data available
COD range	not given	441	659	633	1090	450 to 700 (200 to 1000 also reported).

Considering the mean parameter values as at July 2012, (near end of trial testing period) the predicted suspended solids were slightly lower than, and cBOD figures were effectively the same as, the expected average. The average nutrients were generally lower than expected. Note that the data differs from the published figures for conventional sewage for some parameters due to the lower infiltration rates into the wastewater system.

Despite the low level of alkalinity in the water supply, the all-plastic system and lack of stormwater ingress into the sewer system, the alkalinity was relatively high with the lowest figure being 226 mg/l. The mean and median are very close to each other reflecting minimal outliers

In conclusion, the grinder pump effluent is unique. As more experience is obtained, better quality data will be available giving more reliable indications for the sizing of future facilities.

6.2 WASTEWATER FLOWS

Table 2 gives the expected wastewater flows from Maketu and Little Waihi. Connections were still being made through the Easter period 2012 and therefore the Easter peak was not really noticeable. Some connections are still to be made (as at July 2012) and therefore a clear picture on actual flows is not available. Peak inflows into the treatment plant have been up to 450 m^3 per day but this includes flushing flows and/or supernatant and/or periodic cleaning of the effluent storage pond.

Excluding peak flows, the current influent is around 250 m^3 per day during July (as at July is an off peak period). This is slightly lower than expected.

6.3 OVERVIEW

From the authors' perspective, and in hindsight, the following lessons were learnt from this unusual project (in no particular order):

- Grinder pump wastewater has a unique characteristic and future treatment plants need to allow for this more concentrated wastewater.
- The alkalinity of the wastewater was not found to be an issue.
- The need for carbon dosing during start-up was required but it appears unlikely that any permanent dosing will be needed, thus saving operational cost.
- The E Coli in the effluent is around 40,000 cfu/100ml so falls within the consent limit of 100,000 cfu/100ml. To date, there is no evidence of any E.Coli in the monitoring bores for the disposal field. Therefore the decision not to install the UV disinfection has saved substantial costs.
- The 6 mm wedge wire inlet screen was unnecessary and a simple bar screen would have sufficed. However a grit removal and fine particle surface skimmer or collection system for small material is desirable.
- A pond system to minimise accidental carry over of biosolids from the SBR decanter(s) is essential. A method to manage issues of extraneous detritus falling or blowing into the ponds is needed. Typically this could be a scum baffle or pond outlet screening with operator access. The ponds need to be able to store around 24 hours of wastewater flow. A recycle system to allow out of specification effluent to recycle back into the inlet is required.
- The administration of FIDIC Gold Book took more time than expected, so adequate allowance for contract administration needs to be made. Overall however, the form of contract proved to be ideal for a Design-Build- Operate procurement as the provisions in the contract seamlessly fitted to meet the overall intent of this type of contract.
- In any complex scheme, such as at Maketu, there is a strong advantage in having an interactive tender process (ITP) requirement as part of the tender process. The ITP ultimately saved everyone time and reduced misunderstandings of the contract documents, the owner's requirements and of the technical specifications.
- The SBR system is ideal for a variable influent but regular checking and adjustment of cycle times, and checking of sludge inventories will be required for small communities such as Maketu.
- Protection of the disposal field using a 120 to 150 micron filter is essential, as some carryover of solids from the treatment process and pond system is inevitable. The filter prevents the small pieces of ground-up plastic from entering and damaging the disposal field irrigation system.
- The authors believe that further reductions in costs and operational efficient could be made possible by closer linking of the reticulation grinder pump flow buffering capability and the WWTP operation. However this would require a more sophisticated, probably SCADA based, control of the grinder pumps.

7 CONCLUSIONS

The needs of the community to have a robust yet cost effective wastewater solution focused the technical and management teams to undertake a critical strategic review of the whole wastewater scheme (reticulation, stormwater inflows, collection, treatment and disposal) as a holistic scheme rather than considering the individual parts.

An integrated system was developed. This involved taking risks with a new form of contract, an uncertain wastewater composition, overcoming treatment challenges and implementing alternative disinfection and disposal/land treatment concepts. The risks also needed to be managed so that the system had contingency provisions to ensure the required robustness of the outcome.

The net result has been a highly collaborative project involving the customer, council, contractor, consultant and Tangata Whenua working together to successful delivery a unique wastewater scheme. Hopefully the Maketu scheme is "One of a Kind" that will be repeated elsewhere in NZ now that a better understanding of grinder pump wastewater composition is available. This offers potential savings in capital and operating costs for other similar schemes.

The treatment plant is in one of New Zealand's most picturesque settings. Unlike many WWTP which are at the lowest points in the wastewater system, the Maketu WWTP is on a hill due to the pumped system. There are magnificent views over the Bay of Plenty (see Photos 4 and 5) from the treatment plant which could be seen as adding a social bonus to the scheme, at least for the operators.

Photograph 4- Looking East from the Maketu WWTP towards White Island

Photograph 5- Looking South from the WWTP towards Rotorua area

8 NOMENCLATURE

Abbreviation	Description
ADF	Average daily flow
ADWF	Average dry weather flow
BoPRC	Bay of Plenty Regional Council
cBOD	Carbonaceous Biochemical Oxygen Demand
cfu	Colony forming unit. Common measure for bacterial populations.
COD	Chemical Oxygen Demand
DB	Design Build
DBo	Design Build operate – meaning a short term (typically less than 3 years) operation
DBO	Design Build operate – meaning a long term (typically more than 3 years) operation
Ecoli	Gram-negative, rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms. Used as an indicator of wastewater contamination.
FIDIC	Fédération International des Ingénieurs-Conseils
HAZOP	Hazard and operability study. A systematic technique used to assess risks in process equipment and systems in order to identify and evaluate problems that may represent risks to personnel or equipment.
I/I	Infiltration and inflow
ITP	Interactive Tendering Process
MBR	Membrane Bioreactor
MLSS	Mixed Liquor Suspended Solids
OESTR	On-Site Effluent Treatment Regional Plan (OSETR) updated in 2006, published by Bay of Plenty Regional Council (BoPRC) setting out requirements for septic tank maintenance.
NEC	New Engineering Contract
NZ	New Zealand
ROI	Registration of Interest
SBR	Sequential Batch Reactor
SCADA	Telemetry communications system
SS	Suspended Solids
STEP	Septic Tank effluent Pressure
STEG	Septic Tank effluent Gravity
TN	Total Nitrogen
TP	Total Phosphorus
UAC	Uniform Annual Charge
URS	URS New Zealand Limited
WWTP	Wastewater Treatment Plant
WW	Wastewater
WBoPDC	Western Bay of Plenty District Council

ACKNOWLEDGEMENTS

Our thanks go to Western Bay of Plenty District Council s (WBoPDC) staff for assisting in the preparation of this paper and to Mr. Joseph Stewart from WBoPDC for photos 1 to 3 of the grinder pump installation. Finally we would like to thank WBoPDC for granting permission to prepare and present this paper.

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Appendix A

Final Plant Layout

Photograph 6 – View of Maketu WWTP layout looking south west

1. Inlet works and grit removal and associate biofilter for odour control
2. SBR reactors
3. Effluent Storage Pond
4. Effluent Pump Station
5. Control Room and Blower Building.
6. Disposal Field
7. Dewatering Building
8. Temporary WAS Storage
9. Chemical Storage Area