PRESSURE SEWER SYSTEM

A Realistic Alternative to Gravity Sewer Systems

Nico Claassen: District Engineer
Rotorua District Council

Greg Manzano: General Manager
HYDRUS Engineering Consultants
Business Unit of Rotorua District Council

Abstract

Rotorua District Council has committed towards the implementation of sewerage schemes to service fourteen lakeside communities within the District. These communities are situated along the four major lakes in Rotorua that are well known for trout fishing and other recreational uses. The implementation of a sewerage scheme in these communities is one of the measures being put in place to improve water quality within these lakes.

The communities are characterised by difficult topography and high groundwater level on lakeside properties. The issues related to these conditions include among others the high cost of pipelaying due to the extensive utilisation of dewatering equipment and extensive disturbance of private properties resulting from open trench excavation creating reinstatement difficulties in terms of meeting the expectation of affected property owners. The reality and magnitude of these issues became apparent during the construction of the just completed conventional gravity sewerage system for two of the above communities.

The Council as part of the options investigations of the succeeding schemes undertook a scoping of alternative sewerage reticulation options that would address the above issues. The investigations revealed that Low Pressure Grinder Pump Systems is the most appropriate reticulation system for difficult areas within the lakeside communities being proposed to be sewered.

This paper will outline the process that Council went through in arriving at a decision to use Low Pressure Grinder Pump Systems within the District. It will also provide an outline of the project plan to enable the implementation of low pressure grinder pump systems within the communities. This will be of interest to infrastructure managers who are responsible for the implementation of sewerage schemes within their areas of responsibility.

1.0 Introduction

1.1 General

The Rotorua district is located at the central North Island of New Zealand and is characterised by its distinct natural beauty dominated by several lakes widely known for their recreational uses specially trout fishing. The district is also known for its geothermal resource which attracts local and international visitors who come and enjoy the hot pools, spas and the awesome display of power of several geysers within the area.

Failure of on site wastewater treatment and disposal systems as a result of seasonal overload, and high groundwater tables on lakeside communities have posed an environmental and public health risk to the otherwise pristine lakes within the district. The leaching of nutrients (nitrogen) from failed septic tanks

have been established as one of the inputs that contributed to the algal bloom experienced on some of the lakes recently.

1.2 Rotorua Lakes Protection Programme

Te Arawa, Environment Bay of Plenty and Rotorua District Council have embarked on a Rotorua Lakes Restoration Programme. The Rotorua Lakes Restoration Programme includes the identification and implementation of management system and capital work projects that would stop the input of nutrients to the district's lakes. Rotorua District Council as the local authority for the area has been given the responsibility to implement sewerage schemes for the lakeside communities.

1.3 Rotorua Lakeside Communities Sewerage Scheme Programme

The objective of the programme was to provide sewerage reticulation to the communities to stop the leaching of nutrients from failed on site systems into the receiving lake including the prevention of potential health risks. The list of the communities included in the programme is shown on the following Table 1. The location of the communities is shown on Figure 1.

Table 1:

Communities	Programmed Completion Date	Physical Description of Community
Mourea/Okawa Bay	Completed June 2006	Okawa Bay fronting Lake Rotoiti. High value property with difficult construction access and high groundwater table. Mourea fronting Lake Rotorua. High groundwater table.
Brunswick/Rotokawa	Late 2008	Large sectors of undeveloped land and large developed sections that could be subdivided further. Combination of flat and rolling topography.
Okareka	Mid 2010	Rolling topography, steep slopes on several building platforms and narrow roadways. High groundwater table on lakeside properties.
Okere Falls/Otaramarae/Whangamarino	Mid 2009	Rolling topography, steep slopes on several building platforms and narrow roadways. High groundwater table on lakeside properties.
Gisbourne Point/Hinehopu	Mid 2011	Slightly rolling topography. High groundwater table on Lakeside properties.
Hamurana/Awahou	Mid 2011	Slightly rolling topography. High groundwater table on Lakeside properties.
Tarawera	Late 2012	There are however pronounced areas of instability. Rolling topography, steep slopes on several building platforms and narrow roadways. High groundwater table on lakeside properties. There are pronounced area of instability.
Rotoma	Mid 2014	Slightly rolling topography. High groundwater table on Lakeside properties.
Hinemoa Point	Early 2008	Slightly rolling topography. High groundwater table on Lakeside properties. Large tracts of undeveloped land in some sectors.

2.0 Challenges Experienced in the Implementation of Conventional Gravity Sewerage System

The first scheme completed in June 2006, (Mourea/Okawa Bay Sewerage Scheme) is a conventional gravity sewerage reticulation system. The two communities are adjacent to Lakes Rotorua and Rotoiti. Lakeside properties are characterised by high groundwater table and an undulating terrain. The undulating terrain made it necessary to service discrete catchments with a pump station pumping into another pump station up to a final disposal point. For this particular case there were seven local pump stations and four trunk pump stations.

Several challenges were encountered during the implementation of the scheme. These challenges have been anticipated and to a certain extent allowed for in the cost estimate of the project. These challenges are not new as the challenges related to the construction of gravity sewerage reticulation system in difficult areas are well known and documented:

2.1 The necessity for constant and continuous trench dewatering

The high groundwater table and pumiceous soil type in the area made it impossible to dig and lay the pipelines in a dry trench. It was necessary to undertake an extensive dewatering operation within the proposed pipeline trench alignment at least 24 hours before excavation. In most cases it was necessary to install dewatering probes up to at least 3 metres deep on both sides of the trench and run them continuously until the pipeline has been laid. This has contributed much to the high cost of pipelaying in this area. Photo 1 shows a typical dewatering operation on the pipeline trench for this area.

Photo 1 Pipeline Trench Dewatering Operation

2.2 Difficult Site Access to Lakeside Properties

The lay of the land within the lakeside properties necessitates the sewer main to be laid at the lowest point of the property in order that a gravity connection could be provided. For lakeside properties, the lowest point is always on the lake frontage. This situation creates an issue because equipment and material access to the construction/trench site is difficult without undermining established driveways and high value trees and landscaping.

The disturbance brought about by the construction of the pipeline across high valued properties has created some conflict of expectations between the property owner and Council on the level of

reinstatement required. In most cases, it was decided to undertake what was considered a higher level of reinstatement than what was required to maintain the good will of the community. Photo 2 shows the level of property disruption resulting from the construction of the sewerage scheme.

This issue was very challenging because it involved balancing the financial aspects against the political aspects of the decision to go the extra mile on reinstatement works. Although the project was completed within budget and time, in a more straight forward situation, the cost would have been less.

Photo 2 Typical level of property disruption resulting from pipeline construction along lakeside properties.

3.0 Review of Wastewater Reticulation Options for the Other Lakeside Communities

As part of the feasibility investigation of the other areas and taking into consideration the challenges experienced in the implementation of the completed sewerage schemes, scoping of several wastewater reticulation options was undertaken. The objective of the scoping/options review was to determine other wastewater reticulation systems that could be used for the other communities instead of the conventional gravity system with its inherent challenges.

3.1 Vacuum Sewer System

Vacuum Sewer Systems have been used successfully around the world where conventional gravity systems have provided too costly or difficult to install.

Wastewater from each property is conveyed by gravity to a collection pit into which a vacuum interface valve is installed. This valve maintains atmospheric pressure in the sewer system upstream of the valve, i.e. between the house and the valve, while downstream of the interface valve the pressure is the operational vacuum pressure (normal range between -50kPa to -65kPA). The vacuum interface valve is connected to the vacuum main, which conveys it to the vacuum stations where all waste from the catchment is collected for transfer to a final treatment or disposal point.

The vacuum systems are constrained by the maximum static head that they can satisfactorily overcome. A nominal 4.0m static lift maximum is recommended by the supplier to ensure satisfactorily performance of the vacuum system. This is considered a significant constraint in terms of its application on the undulating topography of lakeside communities. For this reason and the significant capital cost of vacuum stations, it is considered that a vacuum system is not appropriate for the lakeside communities' sewerage scheme application.

3.2 Septic Tank Effluent Pumping System

As the name implies, the portion of the domestic effluent being pumped and reticulated is only the liquid part while the solid portion of the effluent settles within the tank which decomposes overtime. The resulting sludge is pumped out periodically similar to a conventional septic tank.

Since this is a pressure sewer system conveying only liquids, the domestic service connection size is 40mm and would follow the contour of the ground towards its connection to a street main. The street pressure mains in the same way could be laid following the contour of the ground and are relatively small in size compared with conventional gravity reticulation system.

For Rotorua, considering that the objective of wastewater treatment is to remove nitrogen within the wastewater, STEP system was not chosen because it leaves the solid portion of the effluent within the tank. The solid portion within the wastewater is a major source of carbon essential in the denitrification process within the Wastewater Treatment Plant

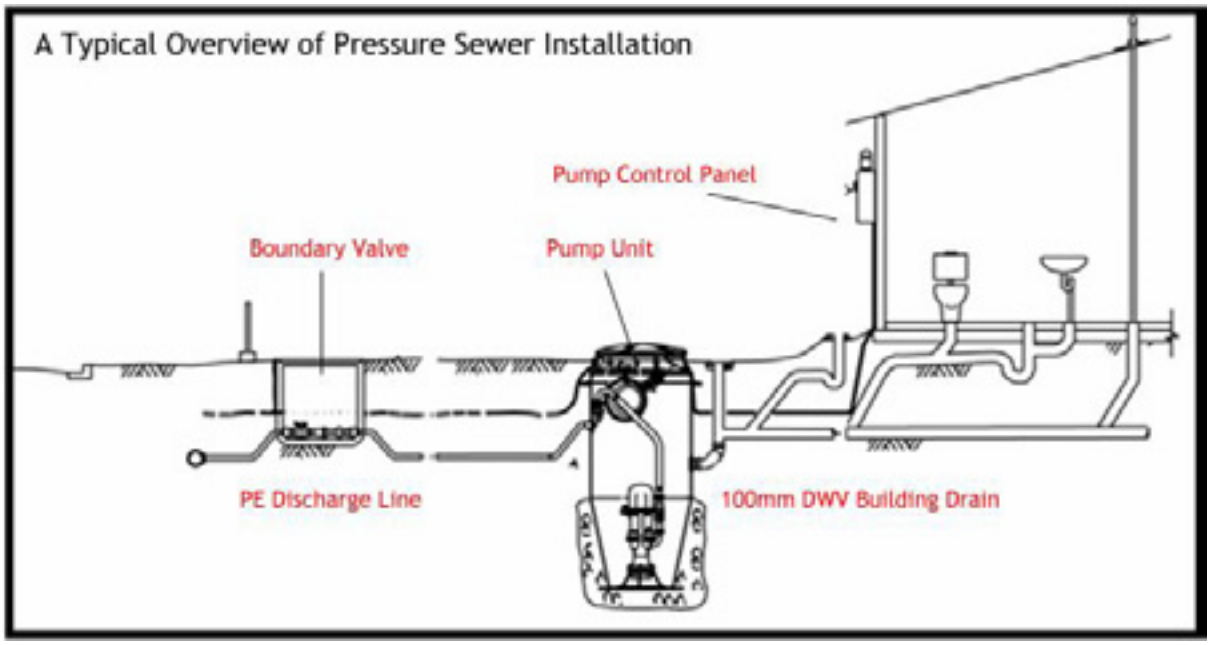
3.3 Low Pressure Grinder Pump System

Pressure sewer technology using low pressure grinder pumps (LPGP) was first adopted in the early 1970's by American engineers and regulatory agencies. The technology has been utilised extensively over the last 30 years, particularly within the United States. There are currently more than 350,000 pressure sewer units in operation worldwide. Sydney Water and South East Water (Melbourne) of Australia have installed thousands of these units in the last seven years. Other Australian Council's have followed suit and are using the technology to complete their backlog sewerage programme.

Pressure sewerage system using LPGP differ from conventional gravity system in that they depend on a pumping unit that is installed on the property to pump the household sewage into Council's sewerage network.

The system consists of a polyethylene or fibreglass chamber into which a single electric grinder pump is installed. The grinder pump is a semi positive displacement pump capable of pumping 0.45l/s up to 40 metres head. Because the pump grinds the household waste into liquid slurry, the outlet pipe (service connection) of the pumping unit to the Council street main could be reduced to 40mm. A typical system installation is shown in Figure 2.

Figure 2 Typical Pump Unit Installation



The chamber has been designed to provide storage of one day for a typical household. This prevents the risk of sewage overflow in case of power failure. Audible and visual alarms are also provided to enable the property owners to detect system failure for them to contact the system operation and maintenance personnel.

The power for the system would be connected to the domestic power supply. Power cost is envisaged to be the property owners' responsibility. Power consumption of installed domestic systems in Australia is about $30 per year.

The installation of low pressure grinder pump system within a property is a lot less disruptive than trenched gravity pipeline. The pumping unit chamber is installed underground using augers and the effluent pipe from the house pumping unit could be installed following the contour of the property either by chain digging or thrusting. Photo 3 shows a typical LPGP Installation.

Photo 3: Typical LPGP System Installation

4.0 Technology Evaluation Process

Low Pressure Grinder Pump System has not been widely used in New Zealand therefore it was necessary to undertake an evaluation of the suitability of the technology to the particular application in Rotorua. The evaluation process included a two phase study which involved a comprehensive comparative research regarding the equipment and system supplier and a study tour to observe the installed technology.

4.1 Comparative Research of Equipment and System Supplier

A research of all information related to low pressure grinder pump was undertaken. This involved making a comparative analysis of all known suppliers of the technology with respect to their technical and performance features, operation and maintenance requirements, track record including length of time that the technology has been in use and price. Research on the performance of each product was also undertaken by contacting some of the project owners in the United States and Australia.

The study concluded that the two known systems are comparable technically but one system has more available track record internationally.

4.2 Study Tour in Australia

The study tour in Australia was organised to continue the due diligence evaluation of low pressure grinder pump system as they will be applied to the Rotorua Sewerage Scheme Programme. It enabled the study team to get familiarised with the application and performance of installed systems.

The study tour included:

a) Meeting with water authorities that have implemented or currently implementing low pressure grinder pump system in their area. These water authorities included Sydney Water, South East Water (Melbourne) and Bega Valley Shire Council. The discussions with representatives of the above authorities centred around:
   - Project delivery methodology of low pressure grinder pump system.
   - Operation and maintenance issues
   - Technical performance and reliability of the system.
   - Performance of specific suppliers
   - Installation issues
   - Policy issues regarding level of service; ownership and delineation of public and private ownership.
   - Cost comparison with conventional gravity system (capital and operational maintenance)

b) Visit of completed installation

   This enabled the study team to view first hand the operation of the systems installed including its visual impact to the property. In some instances interviews with property owners were conducted to determine any issues related to the installation and operation of the system particularly failures, odours and noise. Overall the general impression is that property owners with LPGP installed in their property are satisfied with the performance of the system.

   After the one week study tour, the study team concluded that low pressure grinder pump system is a realistic alternative to conventional gravity reticulation system for the Rotorua sewerage programme. A strategy on progressing the implementation of LPGP in Rotorua was also developed.

5.0 Strategic Review of Application of Low Pressure Grinder Pump System in Rotorua

5.1 General

The strategic review of the application of Low Pressure Grinder Pump System on the proposed lakeside communities' sewerage scheme programme, was undertaken collaboratively by HYDRUS Engineering Consultants and an Australian Consultant specialising in the technology.

The objective of the review was to undertake a relative economic comparison between the proposal to implement low pressure grinder pump systems and conventional gravity and hybrid systems within a community. The comparison took into consideration the capital cost, operation and maintenance cost and replacement cost over a 25 year period at 7% interest rate.

5.2 Result of Review

A summary of the cost comparison between conventional gravity system/hybrid system and low pressure grinder pump system is shown on the following table:

COMMUNITY	Conventional Gravity [1.]		Low Pressure Grinder Pump System [1.]		Cost Difference	
	Capital [2.] ($m)	Net [3.] Present Value ($m)	Capital [4.] ($m)	Net [5.] Present Value ($m)	Capital ($m)	Net Present Value ($m)
Okareka	7.59 (Hybrid)	8.22	6.16	7.20	1.43	1.02
Okere/Otaramarae/ Whangamarino	10.19 (Hybrid)	11.57	7.62	9.81	2.57	1.96
Gisborne Point/ Hinehopu	7.50	8.72	6.19	8.72	1.31	-
Tarawera	10.16 (Hybrid)	11.00	8.57	10.00	1.59	1.00
Rotoma	5.10	6.05	4.55	6.55	0.55	-0.50
Hamurana	8.14	9.60	6.66	9.08	1.48	0.52
Hinemoa Point Existing Properties	1.83	1.92	0.77	0.89	1.06	1.03

[1.] All estimated cost does not include cost of wastewater treatment and disposal, power supply upgrades, resource consents, contingencies and engineering and supervision cost.

[2.] Includes cost of local street main and pump stations and transfer main and pump stations and connection of existing properties from the house plumbing system. Capacity of the local and trunk systems allows for future connections.

[3.] Includes [2.] plus additional future properties connection cost and operation and maintenance cost brought to their present value.

[4] Includes cost of onsite installation, street mains and transfer mains and pump stations and connection of existing properties from the house plumbing system. Capacity of transfer main allows for future connections.

[5] Includes [4] plus cost to connect future additional properties operation and maintenance cost and replacement cost of pump and control units brought to their present value.

Based on the above, it could be seen that there is a saving of about 15% - 20% per community on the capital and NPV cost if a low pressure grinder pump system is implemented. The savings could be attributed to the flexibility of pipeline siting and grades inherent with low pressure grinder pump systems, resulting in less disruption of properties and shallower trenches and the elimination of sub catchment pump stations which on areas with rolling topography represents considerable cost.

6.0 Planning and Implementation of Low Pressure Grinder Pump Sewerage System Projects

The implementation of pressure sewer system projects is more involved when compared with conventional gravity sewer system. A lot of forethought is required on different aspects of the project especially as the technology is relatively new in New Zealand.

6.1 Project Delivery/Procurement

The project delivery and procurement method depends on the risk culture and level of staff resourcing of the project owner. Risk averse organisations tend to transfer most of the risks associated with the project to the contractor hence their choice of project delivery/procurement would reflect this.

Several project delivery/procurement methodology could be used for the implementation of pressure sewer system. Several of the methods are as follows:

a) Supply, design, install and commission
   This method usually transfers all the risk to the contractor. The manufacturer of the equipment is usually not the main contractor, but would be part of the team that would deliver the project. Similarly the designers and installers are usually not the main contractor.

   This option has the distinct advantage of contracting only with one entity and all the risks associated with project implementation is transferred to the contractor. The project owner however has to pay a level of premium for the transfer of risks and responsibilities.

b) Separate procurement for the supply of equipment, design of the system, installation and commissioning of pumping units and street mains.

   This will involve entering into different contracts for each phase of the project and will require a considerable degree of coordination from the project owner or their consultant. A certain level of risk is also absorbed by the project owner.

6.2 Policy Development

Existing Council policies are based around and adequately cover the installation, operation, maintenance and delineation of private and public ownership of existing and proposed conventional gravity sewerage system. It is considered that existing policies in their present form are inadequate to provide guidance in the implementation of pressure sewerage system which is more complex than conventional gravity system.

A policy document needs to be developed prior to the implementation of pressure sewerage system within the area to cover several aspects which includes:

a) Extent where pressure sewer system will be applied within the area.
b) Design and installation requirements and standards both for pumping unit and street mains.
c) Cost of installation.
d) Requirements for connections of pumping units to the existing domestic plumbing and electrical system.
e) Ownership of pumping units.
f) Responsibility for operation and maintenance.
g) Responsibility for damage to individual pumping units and appurtenances.
h) Application of pressure sewer systems for new development.

6.3 Community Consultation

There are two levels of consultation in terms of getting pressure sewer systems implemented in a community.

a) Community acceptance to implement Pressure Sewer System within their area
   This consultation process involves establishing the point of difference between conventional gravity sewerage system and pressure sewer system as they are applied specifically to the community. Economic comparison for each option is provided to the community including identifying differences in installation, operation and maintenance requirements. At this point the community is asked to choose their preference between the two options.

b) Specific Consultation with Individual Property Owners
   This follows on after community acceptance for pressure sewer system to be implemented. This involves visiting every property to determine, agree and obtain approval from the property owner in the siting of the pumping unit within the property including connection to the existing domestic power supply.

   During this stage an audit of the existing plumbing and electrical system is also undertaken to determine their suitability to be connected to the installed pumping unit.

7.0 Current Progress in Rotorua

The detailed design of the system being proposed for Hinemoa Point (refer to Section 1.3) is currently being undertaken by HYDRUS Engineering Consultants. The Hinemoa Pont system will involve the installation of 60 domestic pumping units and one commercial pumping unit including house connection and street mains.

A contract for the supply of the 61 pumping units has just been awarded to Environment One Corporation. The tenders for the installation contract are programmed to be called for in late July 2007.

HYDRUS Engineering Consultants is providing the design and overall management of the project as Council has decided to procure the different phases of the project separately.

8.0 Conclusion

The issues and challenges faced by Rotorua District Council in implementing conventional gravity sewerage reticulation system in two of their lakeside communities motivated them to investigate reticulation options to address the issues and challenges.

After a due diligence evaluation, it was considered that pressure sewer systems utilising Low Pressure Grinder Pumps is a realistic alternative to conventional gravity system. The distinct economic advantage of this option has been proven after a comparative strategic review of both options has been undertaken.

Realising the distinct advantages of this option, Rotorua District Council has committed towards the application of Low Pressure Grinder Pump System on other lakeside communities included in their Lakeside Communities Sewerage Programme.

Figure 1 – Communities included in the Rotorua Lakeside Communities Sewerage Scheme Programme.