

ROTORUA WASTEWATER TREATMENT PLANT



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WATER - TE WAI ORA (THE WATERS OF LIFE)

He tapu to te wai, he oranga to te wai, he waiariki
Water is sacred, water is life, indeed it is from God

We are one of many species living on earth and all of us rely on water for life. Water and water bodies are gifts with a life force referred to as 'mauri' by tangata whenua. We all have a responsibility to work together for the benefit of all, to safeguard water from pollution, degradation or damage, and to take full responsibility for our actions.

Water has been on earth for millions of years, flowing in a cycle from one form or place to another. From surface water to vapour, rain, groundwater passing through the earth to restore the mauri, through wetlands, streams, rivers and lakes to the sea. All the water on the surface of the earth can be evaporated once again, part of 'Natures Water Cycle'.

ROTORUA LAKES REGION

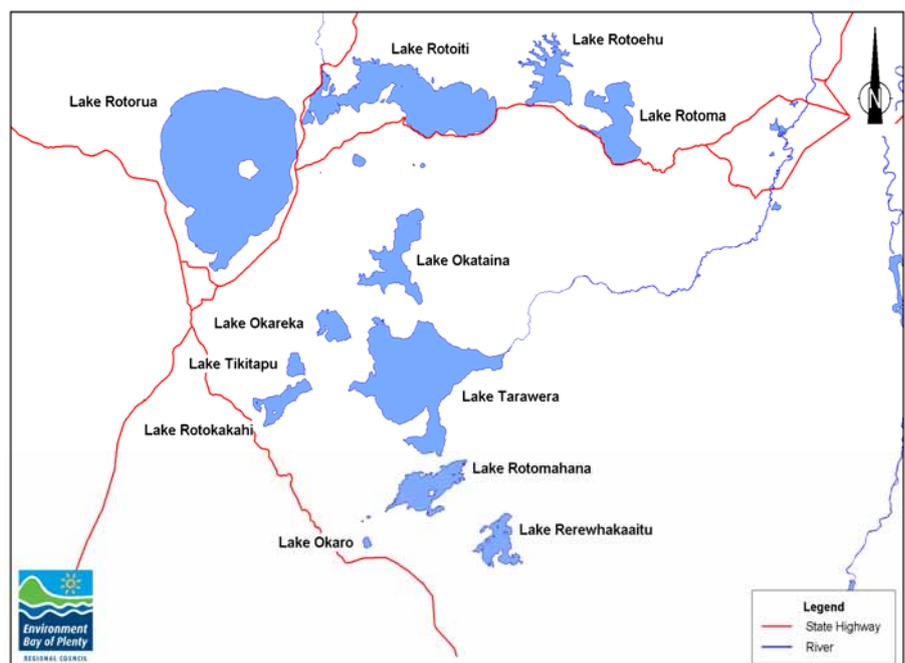
The Rotorua Lakes Region is located in the central North Island of New Zealand on a landscape sculptured by volcanic activity and the action of water. The Rotorua catchment is a caldera, a volcanic basin. Streams, rivers and groundwater via springs, transport nutrients and particulates into Lake Rotorua. After a long residence time, lake-water flows through the Ohau Channel to the adjacent Lake Rotoiti, and eventually down the Kaituna River to the sea.

On the shores of Lake Rotorua is the city of Rotorua. It has a resident population of around 68000 and being one of 14 lakes in this natural, diverse and beautiful environment, it is visited by many tourists.

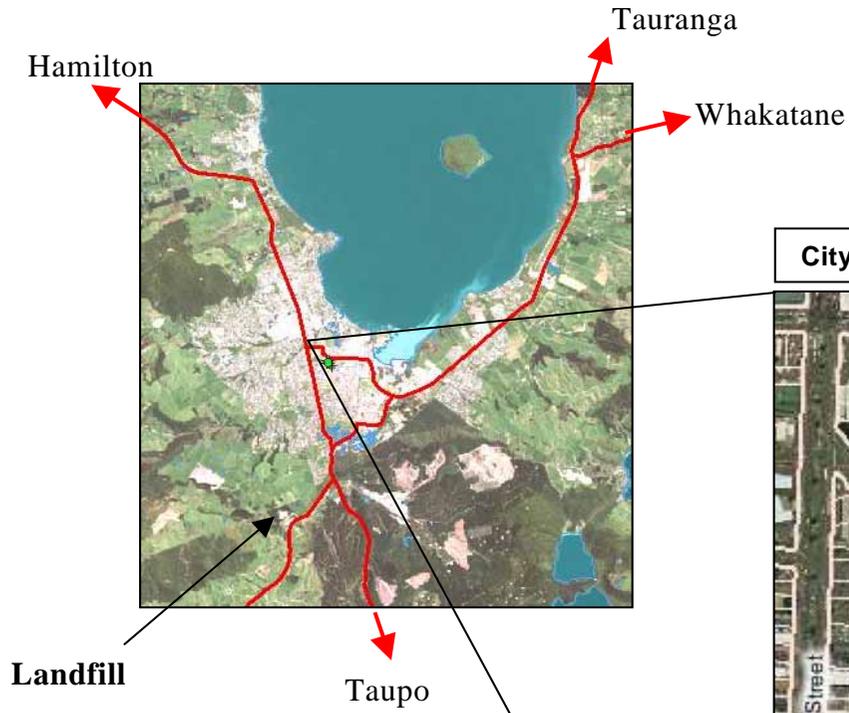
Water is an important resource for everybody in the region.

Let us treat this gift of water with respect, and safeguard the numerous natural water bodies in our environment from further pollution, degradation and damage.

Rotorua Lakes



LOCATION



Rotorua Wastewater Treatment Plant



Our community and the water cycle

Water is *taken* from the surrounding environment for our use (Rotorua Water Supply), and as a city we have impervious structures that intercept rainwater. But the water we use and intercept is *returned* within the catchment, to Lake Rotorua.

- After we use the freshwater supplied to our houses, the wastewater flows down drains and toilets in your house and through sewers (the sewerage system) to the Rotorua Wastewater Treatment Plant.
- After our community intercepts rainwater (houses, roads and driveways etc), stormwater flows down stormwater drains (these are the ones out on your roads in the gutters) and through Rotorua's Stormwater System to Lake Rotorua.

Are we using this precious resource wisely and are we doing all we can to prevent further pollution and degradation of the lake? The Rotorua community has a Treatment Plant that uses natural biological processes to treat the wastewater and then the liquid waste (effluent) is sprayed onto land in Whakarewarwea Forest, within the Rotorua Catchment, so it can pass through the soil to be cleansed and revitalised before it reenters the lake.

FRESHWATER TO WASTEWATER

We depend on freshwater everyday for drinking, washing, farming and industry etc. The Rotorua District Council, on our behalf, and with local consent, removes freshwater from the natural environment around us, and supplies it to us for our use. We change it when we use it by adding human waste, chemicals etc. The once potable freshwater becomes wastewater.

Sources of wastewater in Rotorua

The majority of wastewater in Rotorua is domestic and a small amount industrial. Stormwater does not enter the sewerage system.

Domestic wastewater

Domestic wastewater comes from household activities such as bathing, dishwashing, clothes washing, food preparation, and toilet wastes. Because domestic wastewater includes human body wastes and organic material, it can be offensive and potentially dangerous in that it may contain organisms responsible for such diseases as typhoid, dysentery, and infectious hepatitis.

Industrial wastewater

Industrial wastewater comes from industries that use water for meat processing, electroplating, and dairy, just to name a few. Industrial wastewater can be offensive and dangerous, and it can also contain substances capable of causing expensive damage to sewers, pumps and the Treatment Plant. Furthermore, poisons in industrial wastes can affect the microorganisms responsible for the breakdown of wastewater in the treatment process.

Why do we treat wastewater?

Wastewater has an extremely large number of water borne bacteria and pathogens. Many of these can be responsible for life threatening diseases while others are completely harmless. Wastewater is also nutrient-rich. It contains high levels of nitrogen (N) and phosphorus (P), with N being mainly in the form of ammonia. It is these nutrients that have caused deterioration of lake water quality. While the Wastewater Treatment Plant is no longer a large source of the nutrient load to Lake Rotorua, the Treatment Plant uses natural biological processes to remove as much N and P as possible. Then the final treated effluent is sprayed onto the forest and the water passes through the soil before it enters the lake. The composting facility uses natural materials and processes to produce a rich compost, and nutrients can be returned to the land. Water can be cleaned naturally, but this takes time and usually involves lower loads. The Wastewater Treatment Plant accelerates natural processes.

Wastewater is almost entirely water, > 99.9%. It is only the other 0.1% that is offensive and polluting. This 0.1% consists of both inorganic and organic material.

How does the wastewater get to the Treatment Plant?

When you flush your toilet the sewage flows through pipes in your house and on your section. Once it passes your property boundary, it becomes the Council's responsibility.

The sewage flows underground through pipes called sewers, the sewerage system or the reticulation network. It flows down through gravity mains to various pump stations, which pump water up through rising mains (pipes that travel 'up-hill'). This reticulation process is continually repeated until the wastewater reaches the Treatment Plant.

The wastewater treatment service area

The Rotorua Wastewater Treatment Plant has a connected population of approximately 57,000 people. An average of 19,000m³ or 19,000,000 litres of wastewater is treated per day. By 2005 the Treatment Plant will have the capability of dealing with a population of 70,000 and a daily average wastewater intake of 27,000m³ per day.

The Rotorua Wastewater Reticulation Network (sewerage) covers approximately 3150 ha, from the airport through the suburban areas including Ngongotaha and the Atiamuri Landfill. The section on 'future plans' shows the areas that are planned to be reticulated in the near future.

19,000 m³ (19,000,000 litres) is conveyed to the Wastewater Treatment Plant each day through approximately 500 km of pipe, 7000 manholes and 53 pump stations.

HISTORY OF ROTORUA'S WASTEWATER TREATMENT SYSTEM

- 1891** The first sewers were laid in the town of Rotorua. Treatment was by septic tank, and outfall was via sandfilters to Puarenga stream, which flows into Lake Rotorua.
- 1926** The sewerage system was replaced with larger sized pipes, and remained in use until 1969. Sewage travelled down to an original pumping station in Hinemaru Street, where it was pumped to septic tanks near the site of the current Treatment Plant.
- 1935** Ohinemutu and Whakarewarewa were reticulated due to an outbreak of cholera, with a separate septic tank built for Whakarewarewa. From 1935-1969 the suburbs of Rotorua were also reticulated, including extensions of the sewerage system to Ford Block and Western Heights.
- 1969** The population of Rotorua was 28,000 and the sewerage system served only 8000. Loan proposal for \$1,939,000 to extend the sewerage system and construct a Treatment Plant to service 60,000, in 3 stages.
- 1973** Stage 1: an activated sludge Treatment Plant to service 20,000 people was completed. It included facilities to screen and shred incoming sewage, grit separation, primary sedimentation, aeration in the presence of sludge, secondary sedimentation, sludge digestion and sludge disposal (?).
- 1975** Stage 2:
- 1973-1980** Ngongotaha and Eastern suburbs were reticulated.
- 1978** Stage 3: additional primary and secondary sedimentation tanks to service 60,000.
- 1979** Chemical phosphorus stripping was added to remove 70% of the phosphate.
- 1984** Proposal to discharge treated effluent to Kaituna river rejected.
- 1991** A major upgrade included the Bardenpho (biological treatment) followed by spray irrigation to Whakarewarewa Forest.
- 1993** Composting began.
- 2005** A new laboratory.
- 2006** Bardenpho extended and commenced methanol dosing.

ROTORUA WASTEWATER TREATMENT PROCESSES

Our Wastewater Treatment Plant provides preliminary, primary, and secondary treatment of wastewater. Following these stages, the final effluent is spray-irrigated in Whakarewarewa Forest, and sludge is processed and composted at the Treatment Plant.

The various stages of treatment are designed to effectively remove nutrients, bacterial content, and solids. Typical composition of raw domestic wastewater and the composition of Rotorua's wastewater before and after treatment are appended. During treatment we recycle as much of the waste products as possible while safely disposing the treated waste at the end of the treatment process.

Preliminary treatment

Screening

Sewage passes through step screens consisting of metal bars with narrow gaps of 3mm to remove objects such as plastics, rags, and even the odd set of false teeth or tennis ball! These materials are disposed of at the landfill about once a week.

Grit removal

Grit removal is achieved with the use of two vortex pista grit traps. Particles such as sand are removed and are either transported to the compost plant to be added to the compost mix or disposed of at the landfill. It is important that grit is removed at this point as the particles have the potential to damage the mechanical equipment should they continue through the treatment process.

Primary treatment

Sedimentation

The preliminary treated wastewater is pumped to three sedimentation tanks for physical separation to remove as many of the suspended solids as possible. The heavier suspended solids settle to the bottom of the tank forming primary sludge, which is scraped to the centre, removed, and pumped through a thickening and fermentation stage. Floatable suspended solids, greases and fats, are skimmed from the surface and removed. The effluent is pumped to the secondary treatment stage.

Concentration and fermentation

Primary sludge is concentrated in the thickener tank. A proportion of the sludge is pumped to a fermenter tank to produce VFAs (volatile fatty acids) that are important in secondary treatment. The sludge containing the VFAs then returned to the thickener tank. Concentrated sludge settles to the bottom and is pumped to a storage tank to await dewatering, while the effluent containing the VFAs is pumped to secondary treatment.

Secondary treatment

Biological treatment

In a modified 'Bardenpho' process (developed by Dr James Barnard in South Africa), microorganisms are suspended in the wastewater ('activated sludge'), and through a combination of aerobic, anoxic and anaerobic processes, convert remaining organic carbon into stable inoffensive biological solids and remove phosphorus (P) and nitrogen (N). P is absorbed by the microorganisms and removed, while N is converted to nitrogen gas.

The biological processes occur in 5 stages:

1. Fermentation (anaerobic - no oxygen)

VFAs are introduced as additional food for the P-removing microorganisms. With a lot of food and low dissolved-oxygen levels, these microorganisms are stressed and release the P from their cells. This conditions them to uptake large quantities of P later in the presence of oxygen.

2. 1st Anoxic Stage (no oxygen but nitrates present)

Nitrates are reduced (de-nitrification) and N_{gas} is released into the atmosphere. At this stage 2/3 of nitrogen is removed from the wastewater. Microorganisms adsorb P onto the surface of their cells.

3. Aeration (aerobic - oxygen present)

Carbon dioxide is produced. Ammonia is converted to nitrates (nitrification). Some (4/5) of the nitrogenous compounds are recycled back to the 1st anoxic stage for further de-nitrification. Microorganisms absorb more phosphorus than was previously released, which now remains within their cells.

4. 2nd Anoxic Stage (no oxygen but nitrates present)

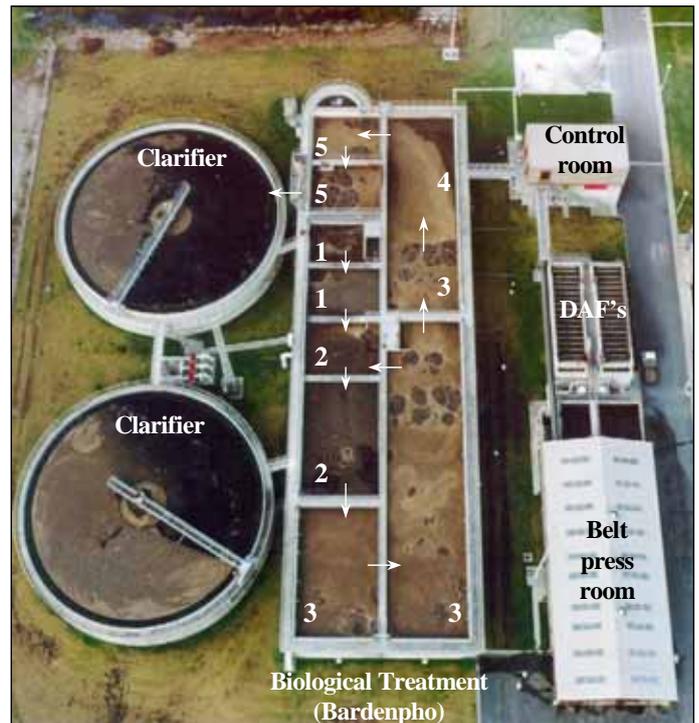
Further de-nitrification.

5. Reaeration (oxygen present)

Super aeration provides sufficient oxygen for the time the microorganisms spend in the clarifier. Excess microorganisms (10%) are continuously removed as WAS (Waste Activated Sludge) in the DAF units, removing P and maintaining a constant population in the Bardenpho.

Final clarifiers

The activated sludge (containing the microorganisms) is settled out in clarifiers and returned to the Bardenpho as RAS (Returned Activated Sludge). The treated final effluent flows to two storage ponds (retention lagoons) before being pumped to the forest for land treatment.



Sludge processing

WAS separation and thickening

The WAS (waste activated sludge) is removed from the secondary treatment stage using DAF (dissolved air flotation) units. It is important to keep the WAS aerobic so the P is retained and removed. Very fine bubbles of air are injected into one end of the DAF unit just below the WAS inlet. As the fine bubbles rise to the surface, they attach themselves to the solids in the WAS in much the same way as rising bubbles in a glass of lemonade stick to the side of the glass. The WAS solids are lifted to the surface where they are scrapped off and flow to a holding tank. The remaining effluent flows underneath the layer of sludge and is pumped back to the Bardenpho. This process will thicken the sludge to 4-5% solids, which can be dewatered using filter belt presses.

Dewatering

Sludge from primary treatment (primary sludge, 3-4% solids) and secondary treatment (WAS, 2-4% solids) is dewatered using filter belt presses to reduce sludge weight and make it easier to handle. Polyelectrolite, an organic chemical flocculent, is added to the sludge to assist in dewatering. The sludge flows onto moving belt presses, and goes through three stages:

- Conditioning Stage. The sludge flows onto the belt where scrapers spread and turn the sludge. This allows the water to flow from the belt in the next stage.
- Gravity Stage. The water trickles through the fine holes in the belt.
- Compression Stage. The sludge is squeezed between two belts forcing the water through small holes in the belt.

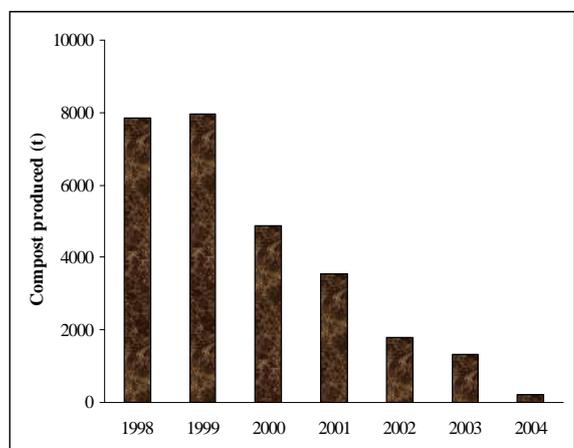
The water or filtrate produced in this stage is pumped back into the Bardenpho. The 9000t of sewage sludge produced each year (16-20% solids) is scrapped off the belt and conveyed to bins to be disposed of in landfill or to be composted.

Sludge use

Most of the sludge produced was composted in 1998 and 1999. An increasing caution around the use of sewage-derived compost caused the market to decline and recently only 10-15% of the sludge produced is composted.

While most of the sludge is currently disposed of in landfill, the Ministry for the Environment has a target for 95% of sewage-sludge to be beneficially used. Other options are being investigated (see the section on Towards a Greener Future”).

Compost production



Composting

Composting operation

High quality, safe compost (*Gardener's Gold*) is produced using guidelines produced by NZWWA and MfE in August 2003 for stabilisation, sampling and analysis for pathogens, and contaminant limits.

Sewage-sludge is mixed with untreated woodwaste and greenwaste from local operations, about 1/3 of each, and composted in aerated bins for around 3 weeks (a minimum of 15 days above 55°C) to reduce pathogens.

The compost is then windrowed and turned weekly to eradicate 'hot spots', and for at least 2 weeks is kept above 40°C (average $\geq 45^\circ\text{C}$) to reduce volatile solids so flies and rodents (which carry disease) are not attracted and the potential for offensive odours is reduced. Before being available for use, it is stockpiled until 90 days have passed since it was first mixed, and tested to ensure that pathogenic bacteria limits are: *E.coli* < 100 MPN/g; *Campylobacter* < 1/25g; *Salmonella* < 1/25g; Enteric viruses < 1PFU/4g; & Helminth ova < 1/4g.

Compost composition and use

Gardener's Gold compost is a soil conditioner with an excellent source of nutrients and organic matter that promotes healthy plant growth. The compost is available in bulk from the treatment plant, or retailed by local landscape supplies outlets. It is being used in home gardens, landscaping, nurseries, horticultural and maize crops.

Gardener's Gold compost typical composition*.

	Dry weight basis	Wet weight basis	Applied @30m ³ /ha
N	1.8 %	0.6 %	94 kg/ha
P	0.7 %	0.2 %	35 kg/ha
K	0.6 %	0.2 %	30 kg/ha
Ca	0.7 %	0.2 %	37 kg/ha
Mg	0.2 %	0.06 %	10 kg/ha
S	0.3 %	0.1 %	16 kg/ha
C	32 %	10 %	1676 kg/ha
C:N	18	18	
pH	6.8	6.8	
Moisture		69 %	
Bulk density		558 kg/m ³	

* September 2006

Land treatment of final effluent

To further reduce the nutrient (N and P) content before entering groundwater and streams, and eventually Lake Rotorua, the treated final effluent is spray irrigated onto about 380 ha in Whakarewarewa Forest. This is the largest effluent spray irrigation system in the Southern Hemisphere.

System and operation

The treated final effluent is pumped from the Treatment Plant lagoons, to Whakarewarewa Forest via a 3.3km long pipeline (66cm diameter), rising 120m vertically. The effluent is mostly pumped overnight when electricity is cheaper. Holding ponds in the forest have two days retention time (40,000m³) and balance continuous treatment at the plant with intermittent spray irrigation. Pumps distribute the effluent through 24km of underground pipes, then a 120km network of over-ground pipes in 16 blocks, and irrigate for approximately 2 hours (9mm) per day amongst the trees. Of the 16 blocks, 14 are used at any one time, and the above ground pipework is easy to remove and reinstate when trees are felled.

Buffer zones

Spray areas have a 15m-wide vegetated buffer zone bordering forestry roads and public walking tracks to reduce spray drift and to provide a visual and physical barrier to the irrigation areas.

Effluent holding ponds in forest



ENVIRONMENTAL LABORATORY AND MONITORING

Monitoring and analysis by staff in an IANZ accredited laboratory ensures the system is functioning effectively and warns if there are problems. Samples of effluent at various stages, compost, groundwater and stream water are collected and analysed using a combination of flow-proportional and grab samples, on-line and continuous analysers to determine constituents. The laboratory is also responsible for monitoring Rotorua's water supplies and trade-waste, testing potable water supplies in and around Rotorua, and providing analytical services for consultants and other organisations.

CURRENT PERFORMANCE OF THE WWTP AND LAND TREATMENT SYSTEM

Sewage and WWTP effluent characteristics*

	Raw sewage	Primary effluent	Final effluent
COD (g/m ³)	470	280	44
BOD ₅ (g/m ³)	195	125	5
Suspended solids (g/m ³)	250	104	16
Total-N** (g/m ³)	47		6
Organic (g/m ³)	15	12	2.3
Inorganic as NH ₄ (g/m ³)	31	31	0.3
Inorganic as NO _x (g/m ³)	0		3.5
TKN (g/m ³)	47	43	2.5
Total P (g/m ³)	8	7	4
DRP (g/m ³)	6	6	3
pH	7.6	7.6	7.6
Alkalinity	207	207	83
E. coli (/100ml)			9051

* Mean for the year 1/10/05 - 30/9/06

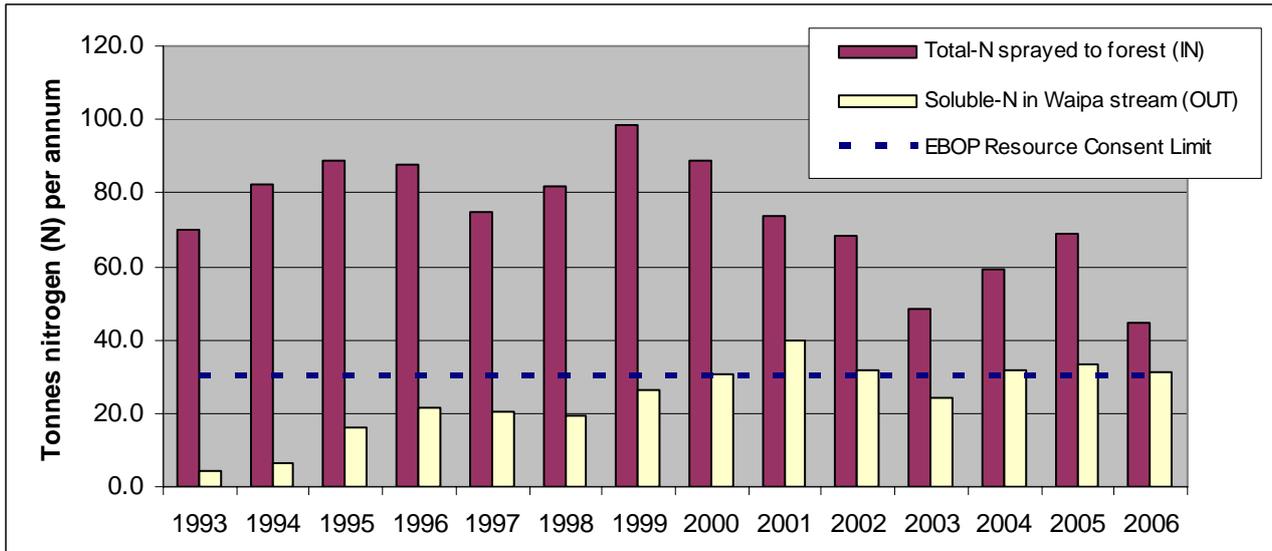
** Sum of TKN + NO_x

Load of BOD, solids and nutrients in sewage, final effluent and Waipa Stream*

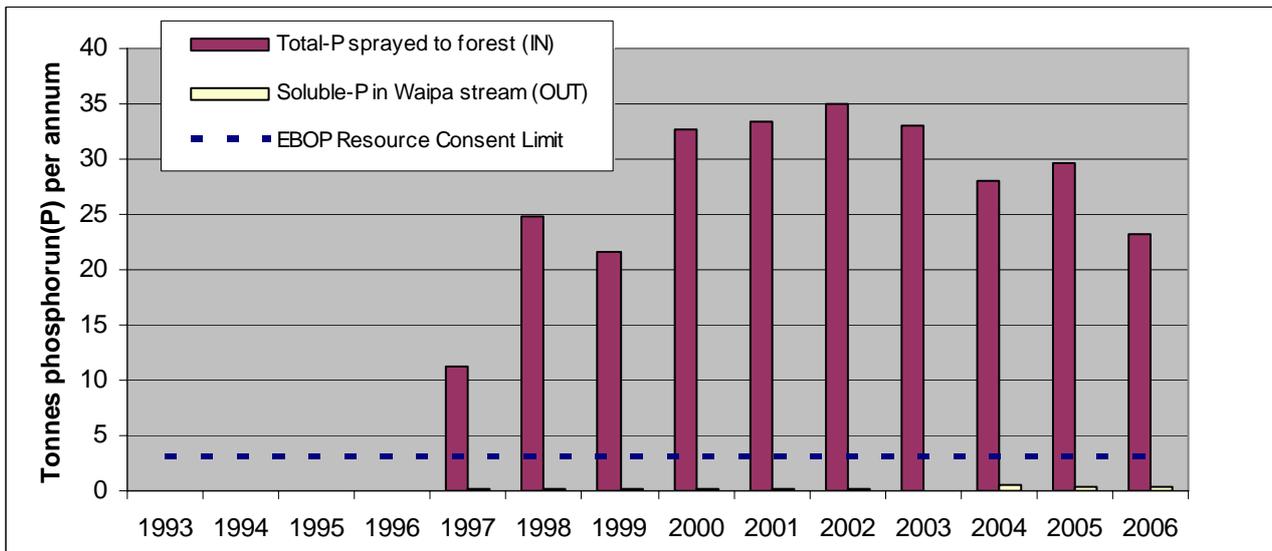
	Raw sewage*		Final effluent (to the forest)		Waipa Stream (sewage-derived)	
	kg/d	t/a	kg/d	t/a	kg/d	t/a
BOD ₅	3700	1400	95	35		
SS	4800	1750	311	115		
N	900	330	104	38	81	30
P	160	59	68	25	1.2	0.4

* Mean for the year 1/10/05 - 30/9/06

N renovation through the Land Treatment System over time



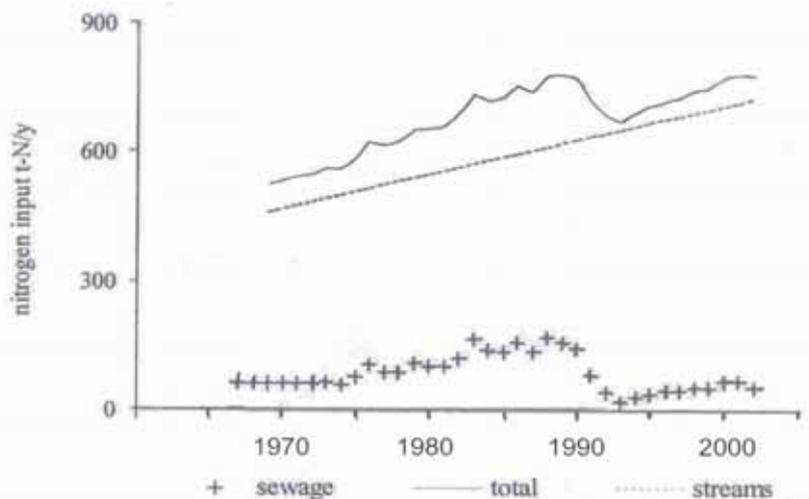
P renovation through the Land Treatment System over time



The Land Treatment System retains almost all of the P applied. It now appears to now be in equilibrium for nitrogen, with a load around 30 tonnes of sewage-derived soluble-N entering the lake each year.

This is substantially lower than the increasing amount of nitrogen entering the lake via streams as a result of 50-years of intensive land-use within the catchment.

N-load to Lake Rotorua from



THE FUTURE

Any improvement in the amount of nutrients removed from our wastewater in an environmentally sound way, is a move towards preventing further pollution and degradation of the groundwater, streams and lakes in our environment.

We are working towards reducing the load of sewage-derived nutrients to the lake by:

1. Reticulating lakeside settlements;
2. Improvements at the Treatment Plant to reduce nutrients in the effluent;
3. Optimising renovation by the Land Treatment System.

Given the decline in the market for compost, we are also looking into other options to beneficially use the sludge, rather than dumping it in the landfill.

Reticulation of lakeside settlements

Homes that are not connected to the sewerage system generally have septic tanks and these have been found to leach nutrients to the groundwater. Environment Bay of Plenty has new specifications for systems in some situations. The performance of Advanced On-Site Treatment Systems is being assessed at the WWTP to determine if they meet the specifications set by Regional Councils. This is a joint project between RDC, the Bay of Plenty and Waikato Regional Councils and suppliers. Results are available to the public.

The planned sewerage systems (reticulation) for lakeside communities will also help prevent nutrients reaching the lake. The wastewater from these communities will either come to the main Treatment Plant, or to smaller satellite Treatment Plants.

The installation of sewerage networks, pump stations and Treatment Plants is planned for:

- | | |
|------|------------------------------|
| 2005 | Morea / Okawa Bay (complete) |
| 2006 | Brunswick |
| 2006 | Rotokawa |
| 2008 | Okere Falls and Otaramarae |
| 2008 | Gisborne Point and Hinehopu |
| 2010 | Hamurana |
| ? | Okareka and Tarawera |

PERSONNEL

A small, dedicated team of fourteen staff (excluding Council engineers) at the Treatment Plant and 5 laboratory staff with specialist skills are based on-site and ensure that the operation runs smoothly and performs to standard.

Utilities Plant Manager oversees the operation, administration, finances and maintenance.

Engineers design and direct any construction and modifications, and study factors that might hinder treatment to ensure the process operates effectively.

Process Technicians oversee maintenance, are responsible for the control of the treatment processes to maximise Treatment Plant effectiveness. They frequently communicate with laboratory staff to assess test results to make decisions on process changes.

Plant Operators / Attendants ensure that all treatment process systems are maintained and that no failures occur due to blockages, pump seizures, algae growth, and grease build-up etc. This involves cleaning tanks, screens, valves, water lines, servicing pumps and generators.

Service and Goods Administrator purchases goods such as tools, safety equipment, uniforms, stationery and office equipment, administers accounts and invoices, compiles timesheets, and performs general reception duties.

Process/Data Analyst processes plant data and laboratory results for reporting for Councillors, Resource Consents, State of the Environment, national databases etc, hosts school groups and tours, and is involved in plant optimisation.

Cleaner is responsible for the administration building cleanliness. Relieves Service and Goods Administrator's reception duties. Provides a laundry service and cafeteria provisions.

Laboratory and Scientific Services Manager is responsible for managing the laboratory, environmental impact investigations and reporting, research studies, wastewater treatment investigations, and provides scientific advice to the council.

Laboratory Supervisor is responsible for the day-to-day running of the laboratory, the laboratory information management systems, equipment calibration, workload, report generation, method investigation and troubleshooting, maintaining laboratory equipment and chemicals, and general office administration.

Laboratory Technicians collect and analyse samples at the Treatment Plant, in the forest and for potable water monitoring.

All staff work five days per week, with some staff carrying out minimum duties on weekends and public holidays.

WWTP TECHNICAL DATA (2006)

General

Population connected	57,000	
Population capacity with 2005 extension	75,000	
Number of sewage pump stations	52	
Length of pipework for reticulation	490	km
Average daily flow	19,000	m ³
Peak daily wet weather flow	42,000	m ³
Flow rate	100 - 450	L/s
Hydraulic residence time (mean)	24	hours
Sludge age (mean)	9-10	days
Treatment Plant land area	8	ha
Total replacement value (including pipes)	\$132	million

Plant dimensions

Primary tanks each (3)	1000	m ³
Sludge thickener	260	m ³
VFA fermenter	260	m ³
Secondary treatment (Bardenpho)	7500	m ³
Secondary clarifiers each (2)	3600	m ³

Sludge-biosolids

Total sludge production	9000	t/a
Daily sludge production	25	t/day
DAF % solids	2.7	%
FBP (primary) % solids	25	%
FBP (WAS) % solids	15	%
FBP (mixed) % solids	16-20	%
Fraction landfilled / composted 1998	10 / 90	%
Fraction landfilled / composted 2005	90 / 10	%

Forest irrigation

Holding ponds (2) total volume	40,000	m ³
Area available	380	ha
Area irrigated	240	ha
Wetland area	50	ha (scattered areas)
Buffer width	15	m
Irrigation frequency	2	hr/day
Application rate	5	mm/hr
Short term site permeability	100	mm/hr

Financial data

	Capital value (\$)	Operating (\$/a)	Operating (\$ per person/a)
Pump Stations (ex pipes)	\$5,000,000	\$462,000	\$8.11
Treatment Plant	\$30,000,000	\$2,138,000	\$37.51
Composting Plant	\$1,200,000	\$93,000	\$1.63
Land Treatment	\$15,000,000	\$651,000	\$11.42

SCHEMATIC DIAGRAM OF ROTORUA WASTEWATER TREATMENT PLANT PROCESSES

