ASSESSMENT OF SOUTHERN CATCHMENT, WAITANGI BAY LAKE TARAWERA

A report prepared for
Environment Bay of Plenty

Norm Ngapo

Waiora Soil Conservation Limited
10 October 2006

Assessment of Southern Catchment, Waitangi Bay Lake Tarawera

TABLE OF CONTENTS

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1. Introduction

The purpose of this report is to assess part of the Waitangi Bay Catchment at Lake Tarawera in terms of stormwater runoff or erosion problems, and potential impacts on the receiving environment particularly downstream of Spencer Road.

The Waitangi Bay catchment can be divided into two distinct parts;

- The Waitangi Stream catchment; and
- The southern Waitangi Bay catchment draining through Waitangi Forest.

This report only covers the southern catchment area that drains from Playnes property through Waitangi Forest into the Waitangi Lodge Estates property, and then into Lake Tarawera.

This report does not cover the northern Waitangi Stream catchment, which receives water from Lake Okareka via a controlled outlet as well as from springs in the middle/upper catchment. The Waitangi Stream then flows under Spencer Road approximately 300 metres north of the ephemeral channels draining Waitangi Forest, before discharging into Lake Tarawera near Waitangi Lodge Estates.

The outlet of the southern Waitangi Bay catchment draining Waitangi Forest is via an ephemeral flowpath across the property of Waitangi Lodge Estates, into Lake Tarawera, just a few metres south of the Waitangi Stream mouth.

2. Background

The Waitangi Bay catchment is on the western shores of Lake Tarawera. The southern catchment drains pastoral land near the catchment watershed on Playne's farm through Waitangi Forests Limited property across Spencer Road and into the property of Waitangi Lodge Estates at Waitangi Bay, Lake Tarawera. The drainage channels are ephemeral watercourses and overland flow occurs during heavy rainstorm events.

Waitangi Forests Limited owns a title area of 20.95 hectares and the forest was harvested in the late 1990s. The Waitangi Forests area is situated immediately above Spencer Road. The Waitangi Lodge Estates property is situated below Spencer Road and runs down to Lake Tarawera.

Following harvesting of the forest, and flooding problems on Spencer Road, work was undertaken on Spencer Road by the Rotorua District Council. The timing of the work is uncertain, but it is understood that it was soon after the harvesting of the forest. From information provided by the owners of Waitangi Lodge Estates, (CA & J Watmore), flooding problems on Spencer Road were alleviated by the construction of a ponding / soakage area immediately above Spencer Road. At the same time, a culvert was installed to control runoff from Spencer Road into the Waitangi Lodge Estates property. The Watmores contend that following discussions with Rotorua District Council staff at the time, the culvert was intended to only drain water from Spencer Road. The low

valley through the Waitangi Lodge Estates property is the natural ephemeral flow path for stormwater runoff from the southern Waitangi Bay catchment area above.

Correspondence from Waitangi Lodge Estates claims that following the installation of works by the Rotorua District Council on Spencer Road, the flooding problems through their property ceased, even though there were periods when there were heavy rainfalls in the area.

In winter 2005, Mr Watmore noted that heavy machinery had been working in Waitangi Forest. Soon after that, following rainstorms on 24 August 2005 and 18 September 2005, stormwater runoff flowed across Spencer Road, and overland through the valley area of Waitangi Lodge Estates to Lake Tarawera.

Correspondence from Waitangi Lodge Estates to the Rotorua District Council and Bay of Plenty Regional Council (dated 21 September 2005), expressed concern regarding the flooding problems, and requested:

- that the site and all feeder sites be inspected (catchment area within Waitangi Forest and contributing areas);
- a written report on the outcome of the inspection be forwarded to Mr & Mrs Watmore of Waitangi Lodge Estates; and
- that the Watmores be included as part of the decision making when solutions are being decided.

The area was inspected by a Compliance Officer of Rotorua District Council who concluded (in a letter to Waitangi Lodge Estates dated 5 October 2005) that the stormwater flooding is a matter that should be addressed by the Bay of Plenty Regional Council, and the development carried out on the Waitangi Forests Limited block had not breached any rules under the Rotorua District Plan.

Following consultation with the Regional Council, a letter was sent from the Regional Council dated 14 December 2005, noting that the high runoff flows through Waitangi Lodge Estates were natural events emanating from intense rainfall. The regional council staff were unaware of any development that may have resulted in increased problems, and there were possible options to control runoff flows immediately above Spencer Road and then through the Waitangi Lodge Estates property. These options would require careful design to ensure they reduced flood peaks, and may also require consents. In the meantime, Regional Council staff members were working closely with the upstream landowners with a view to implementing runoff/erosion control works on the upstream land that should help to alleviate peak flow problems on Waitangi Lodge Estates.

The Watmores wrote to the Regional Council on 24 April 2006 at the suggestion of the Chief Ombudsman, refuting that their property is within a natural watercourse and requesting that the Rotorua District Council and Bay of Plenty Regional Council control runoff through their property, rather than refer it to the landowner to address.

In August 2006, Environment Bay of Plenty contracted Norm Ngapo of Waiora Soil Conservation Limited to carry out an assessment of the Waitangi Bay catchment, in order to provide an independent report.

3. Work Brief

The work brief for the catchment assessment is set out below.

Inspect the Waitangi Bay catchment at Lake Tarawera and report on the following:

- Size of catchment and location of natural flow paths
- General catchment condition in terms of resilience to rainstorm events;
- Possible sources of runoff and erosion problems;
- Possibilities for managing runoff and erosion problems;
- Relevant background issues (rainfall history / runoff patterns / harvesting of Waitangi Forest / current land use / future land use / land management issues).

4. Methodology

The methodology adopted for the catchment assessment and report, involved the following tasks.

1. Contact landowners within the catchment prior to site inspection.
2. Carry out catchment inspection to check for any potential sources of erosion, or cause for excessive runoff.
3. Discuss background issues with landowners/representatives of Waitangi Lodge Estates.
4. Discuss development and history of Waitangi Forest with landowner (Don Stewart).
5. Discuss background issues and runoff management options with staff of Environment Bay of Plenty.
6. Research consent files at Environment Bay of Plenty for harvesting of trees on Waitangi Forest (file 1370 05 0471).
7. Research relevant data relating to rainfall in the area over the past 10 years (Environment Bay of Plenty 24 hour rainfall data and HIRDS data).
8. Contact other relevant people if necessary.
9. Report on the results to Land Resource Staff of Environment Bay of Plenty.

5. Output

The output is a written report covering the matters set out in the brief. One electronic copy (in word) to be provided to Environment Bay of Plenty. Hard copies to be produced at cost as required.

Southern Catchment Waitangi Bay
Lake Tarawera

Scale: ~ 1:9700	October 2006	File: EnvBOP.LR.Waitangi

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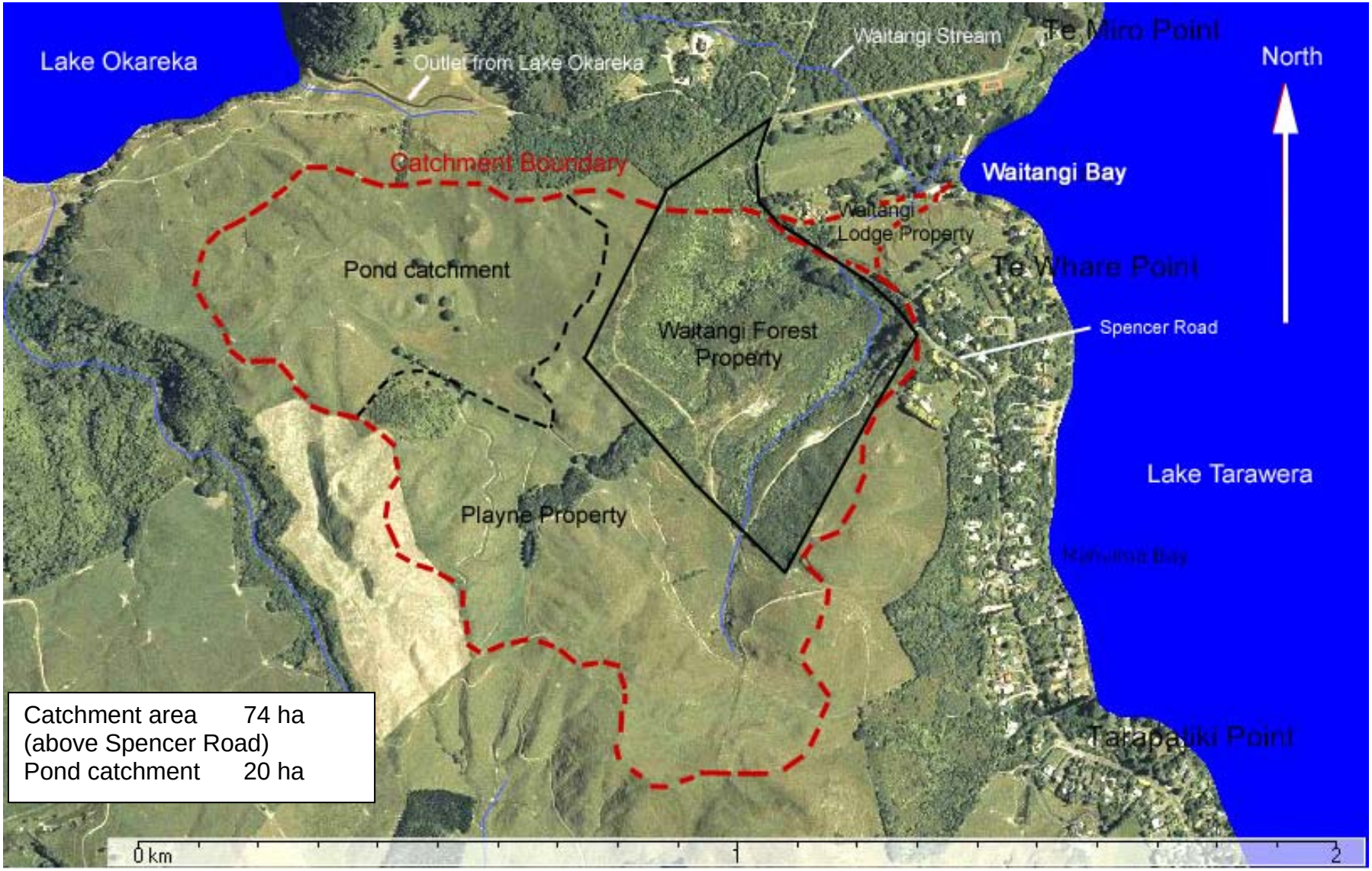

6. Rainfall Data

Rainfall data was obtained from the Environmental Data Services (EDS) section of Environment Bay of Plenty. The closest rainfall station to the Waitangi Catchment is at Lake Okareka. The centre of the Waitangi Catchment is 3.4 kilometres to the west of the Lake Okareka rainfall station. The rainfall data provided from the Lake Okareka rainfall station for this report includes daily rainfall figures for the period 1995 to 2006. The data is from manual rainfall readings taken by PS Wilson at Lake Okareka. The EDS section also provided a Manual Rainfall Summary, which is included as an Appendix to this report. While it is accepted that there may be some local variation in rainfall, and there is no record of short duration rainfall intensity, the daily rainfall figures from the manual Lake Okareka rainfall station is considered to be indicative of the rainfall within the Waitangi Bay catchment, and sufficiently accurate for use in this report.

7. Harvesting of Pines from Waitangi Forest Area

The harvesting of pines from Waitangi Forest was undertaken in the summer of 1998/1999. The total property area of Waitangi Forest is 20.95 hectares. The area that was harvested under Resource Consent No. 05 0471 was 11.89 hectares. No work was undertaken in the steep gully areas. Harvesting operations commenced in November 1998 and were completed by the end of April 1999. File notes indicate that there was a complaint about stormwater flowing down Spencer Road. An inspection carried out on 18 March 1999 confirmed that there was evidence of overland flow from the northern access road onto Spencer Road, and instructions were given to install runoff controls on the access tracks to control the problems. A final inspection carried out in late April 1999 notes that all runoff controls and stabilisation measures had been installed to the satisfaction of the Compliance Officer.

Rainfall records from the Lake Okareka rainfall station indicate that rainfall from 4 March to 12 March 1999 was persistent, with a total rainfall of 135 mm over the 8 days. 92 mm of rainfall was recorded over the 3-day period of 5/6/7 March 1999. From the data provided by Environment Bay of Plenty, the 3-day period of rainfall was not excessive. A 72 hour rainfall of 167 mm is classified as a 2-year return period rainfall event (HIRDS data).

8. Flooding and Erosion Problems in the Waitangi Catchment

Correspondence from Mr Erasmus on behalf of Waitangi Lodge Estates notes a number of concerns:

- Heavy rainfall following logging operations in early 1999 resulted in flooding on Spencer Road;
- Following consultation with the Watmores, the Rotorua District Council installed a low bund on the upstream side of Spencer Road, and a culvert to drain water from Spencer Road on to the Waitangi Lodge Estates;
- A soak hole/pit was excavated on the upstream side of Spencer Road to help detain / soak stormwater runoff from the catchment;
- Over time this soak hole appears to have been infilled or silted up;
- Earthworks were undertaken on Waitangi Forest some time in the winter of 2005;
- Rainfall on 24 August and 18 September 2005 resulted in overland flow from the catchment through the property of Waitangi Lodge Estates.

The overland flow problems followed earthmoving operations on the Waitangi Forest area, and Mr Erasmus blames the earthmoving operations as a potential contributing factor to the flooding problems.

Lake Okareka rainfall figures for these days do not show excessive amounts of rainfall over that period. Mr Erasmus may have an incorrect date for the August rainfall as records show no rain on 24 August 2005. Rainfall records give 26 mm of rainfall each day for the 6 and 7 August 2005, and 40 mm of rainfall on 18 September 2005.

Mr Erasmus also notes that, prior to September 2005, there have been heavy rainfall events over the five year period since harvesting of Waitangi Forest, with no overland flow through the property of Waitangi Lodge Estates.

Lake Okareka rainfall figures over the period 1999 to 2005 do show that at various times, there have been heavy rainfall events (e.g. July 17 2004 recorded 105mm in 24 hours).

Following the letter from Mr Erasmus, the area was inspected by C McCarthy, Monitoring Compliance Officer for Rotorua District Council. Mr McCarthy inspected the Waitangi Forest area and did not find evidence of any earthworks that may have caused the flooding and erosion problems noted by Mr Erasmus. Mr McCarthy noted that stormwater runoff from the pastoral property of Playnes in the upper catchment was aggravating gully erosion in the steep ephemeral gullies through the Waitangi Forest property.

9. Contact with Landowners

Prior to carrying out the on-site inspection, contact was made with the relevant landowners or their managers. A meeting was held with the Watmores who own Waitangi Lodge Estates, to ensure that their concerns were adequately covered.

Telephone conversations were held with Mr W Morrissey (Manager for the Playne property) and with Mr Don Stewart as owner of Waitangi Forest.

10. Southern Waitangi Bay Catchment Description

The catchment was inspected on foot. Two days were taken to carry out the inspections. The first inspection covered the lower catchment area of Waitangi Forest and Waitangi Lodge Estates properties on 21 August 2006. The second inspection (undertaken on 21 September 2006) covered the Playne property and was delayed to avoid the lambing season.

The Southern Waitangi Bay catchment drains an area of 74 hectares above Spencer Road. The catchment watershed is approximately 500 metres above sea level (asl) and is on the catchment boundary with Lake Okareka to the east. The fan shaped catchment drops down to 320 metres asl at Spencer Road over a distance of approximately 950 metres.

The upper catchment is in pastoral land use and is a combination of flat plateau areas and steep faces that drop down through Waitangi Forest towards Spencer Road. The catchment is drained by two main ephemeral gullies that join immediately above

Spencer Road. The ephemeral gullies show evidence of gully erosion, just inside the upper boundary of Waitangi Forest, and this has been reasonably well controlled by erosion control structures installed in conjunction with the Bay of Plenty Catchment Commission in the 1970s. The two gullies drain down to a small flat area immediately above Spencer Road, before continuing down an easy valley system through the Waitangi Lodge Estates property to Lake Tarawera. The small flat area immediately above Spencer Road has been planted in native shrubs as part of a larger native planting programme within Waitangi Forest.

Approximately 69% of the catchment is in pasture. The balance is in a mix of native bush, and mixed native/exotic shrubs and trees. All of the pastoral area above Spencer Road is on the Playne property.

The underlying geology is mapped by Nairn (1999) as Okataina Rhyolites (Rhyolite lava domes and flows) in the upper catchment, Mamaku Ignimbrite in the vicinity of Spencer Road, and undifferentiated pumiceous terrace deposits in the lower flats. The whole area has been overlain by tephra deposits, although the depth of tephra on the steeper slopes is very thin. The soils are influenced by Rotomahana Mud, which is from the most recent volcanic eruption from Mount Tarawera and Lake Rotomahana in 1886. However, the underlying tephra layers of Kaharoa Ash, Taupo Pumice, Whakatane Ash, Rotoma Ash, Waiohau Ash and Rotorua Ash may also be present in flatter sites. The soils have been mapped by Rijkse (1979) as Rotomahana hill soils above Spencer Road, and Rotomahana soils below Spencer Road. These soils are characterised by having a severe erosion potential (moderate sheet and slump erosion, some gully and rill erosion where the Rotomahana mud is more than 30 cm thick), and poor physical properties (difficult to work under wet conditions).

Inspection of the catchment confirmed that the steep pastoral faces in the upper catchment are subject to sheet erosion, and the steep ephemeral gully systems show signs of both historical and active gully erosion.

There is a plateau area of approximately 20 ha in the north eastern part of the upper catchment that is relatively flat and holds has a small ponding area. This plateau appears to have been historically part of the Lake Okareka catchment. However, at some time in the past, a small bank (approximately 1 metre high) has been installed to prevent water flowing back towards Lake Okareka, and a drainage swale formed to divert stormwater into the Waitangi Bay catchment and then into Lake Tarawera. The area is very flat, and a small change in flow patterns has been sufficient to divert the stormwater towards Lake Tarawera. Note that even if the historical flow path towards Lake Okareka was to be reinstated, the flow would be directed over an old gully head, and then picked up by the controlled outlet channel from Lake Okareka to the Waitangi Stream. This would then divert the flow back to Lake Tarawera via the Waitangi Stream.

11. Discussion

The Southern Waitangi Bay catchment of 74 ha drains the upper pastoral catchment on Playnes property, through the two ephemeral gullies in Waitangi Forest, across Spencer Road and then overland through the grassed ephemeral valley on Waitangi Lodge Estates into Lake Tarawera.

The natural flowpath for stormwater from the catchment is through Waitangi Forest and then down the valley within Waitangi Lodge Estates property to Lake Tarawera. Overland flow will occur when there is sufficient rainfall. Using the rational formula, the calculated stormwater discharge from a 5 year storm event of 30 minutes duration (29 mm of rain – HIRDS data) equates to approximately 3.7 cubic metres per second discharge from the Southern Waitangi Bay catchment at Spencer Road. The daily rainfall figures from the Lake Okareka rainfall station do not provide rainfall intensity data. It is therefore unclear whether the catchment has experienced a storm of this magnitude over the last 10 years, although unrecorded isolated local intense rainfall events have occurred.[1]

A flow rate of 3.7 cubic metres per second is very likely to flow overland through the natural flow path in the valley draining through the Waitangi Lodge Estates property. The culvert that takes stormwater under Spencer Road is 300 mm diameter, with a low bank approximately 500 mm high, providing a small degree of stormwater detention. The existing 300 mm culvert and bund will serve to choke most peak flows and impound water above Spencer Road until the rain stops or overflow occurs.

Following the harvesting of pines in 1999, Rotorua District Council installed the culvert systems under Spencer Road to drain the Waitangi Forest catchment. At the same time, it appears as though a low basin was excavated to detain stormwater during peak flow events and help control discharge through the culvert. This system appears to have worked very well for a number of years. However over time, the low basin has infilled from sediment wash and litter, and stormwater detention storage has been reduced.

The stormwater coefficient of runoff from the steeper upper pastoral catchment is estimated to be reasonably high (up to 0.4) meaning that 40% of the rain falling on an area of ground surface will end up flowing overland as stormwater runoff and not be absorbed into the ground, or held up in the vegetation. Ground conditions prior to rainfall may also have an influence on runoff rates. Heavy stocking, hard ground conditions or saturated ground can all have differing effects. The Waitangi Forest area will effectively act as a sponge for rainfall events, particularly small to medium sized rainfall events (rainfall intensities of less than 1 year return period).

It is likely that overland flows through the Waitangi Lodge Estates property will become more commonplace if no remedial work to reduce peak runoff rates is carried out in the upstream properties. The overland flow path through the Waitangi Lodge Estates property is in dense pasture. It is unlikely that overland flow over the pasture will result in erosion problems as a result of scouring. However, there may be problems of sediment deposition from sediment-contaminated stormwater, or problems of flood inundation from excessive peak volumes of stormwater.

Earthworks operations in soils formed from Rotomahana Mud will always carry a risk of erosion problems that can impact on the downstream receiving environment. The Rotomahana soils have a high clay content, and a poor soil structure. When

[1] A field trip during the NZARM Conference on 16 September 2003, experienced extreme rainfall over a 20 minute period within this catchment. The 24 hour rainfall recorded at the Lake Okareka rainfall Station for 16 September was 20mm. Estimates of that 20 minute rainfall event range from 1-3 year return period.

disturbed, these soils are particularly susceptible to surface erosion problems and high suspended sediment loads. When undertaking earthworks in Rotomahana soils, care should be taken to ensure that exposed ground surfaces are stabilised as soon as operations are completed, and that stormwater controls are installed to prevent concentration of stormwater and scouring of water tables and watercourses.

The erosion problems in this catchment are not new. The Bay of Plenty Catchment Commission and Regional Council have had involvement with gully control works as well as protection planting within Waitangi Forest.

Discussion with Mr D Stewart of Waitangi Forests has confirmed that substantial further native planting has been undertaken within the Waitangi Forest Property, as well as some minor earthworks in 2005. The proposed land use for this property is to provide for a small number of house sites on flat land within the block, and retain the bulk of the area including the steep land and gullies, in native vegetation.

The problems of stormwater runoff and sediment-contaminated flows as noted in the correspondence from Waitangi Lodge Estates, is most likely due to a combination of factors as set out below:

- Following harvesting of Waitangi Forest in 1999, there would have been a short period when exposed ground and /or tracking operations would have been responsible for elevated levels of suspended sediment in stormwater runoff.
- The harvesting of Waitangi Forest would have resulted in a period when there was a change in runoff patterns due to the removal of trees.
- The establishment of runoff controls, ground cover vegetation and follow up planting in Waitangi Forest would have reduced the potential for erosion, sedimentation and flash flooding.
- The remedial works undertaken by Rotorua District Council at Spencer Road (excavation of the detention basin, installation of the low bund, and culverts) would have resulted in more control over flash flood events and reduction in overland flow through the lower catchment area.
- Background erosion problems within the catchment (sheet erosion on steep pastoral land, and gully erosion in the steep ephemeral waterways) have continued to contribute sediment that has been transported as suspended sediment in runoff to the lower catchment area, and deposited in the excavated basin immediately above Spencer Road.
- Over time, the excavated basin area immediately above Spencer Road has infilled from sediment wash and vegetation litter, meaning that the beneficial effects of the remedial works undertaken by the District Council after harvesting has been reduced.

12. Photos

The following series of photos were taken during the two field inspections of the catchment.

Photo1: Southern Waitangi Bay catchment: Looking from Playnes property down the catchment to Waitangi Forest property and Waitangi Lodge Estates property in the lower valley.

Photo 2: Southern Waitangi Bay catchment: Looking from Spencer Road down the ephemeral valley on the property of Waitangi Lodge Estates. Lake Tarawera in the background.

Photo 3: Looking from Waitangi Forests property southwards into the steep upper catchment on Playnes property

Photo 4: Steep pastoral land on the Playne property. Sheet erosion on steep Rotomahana soils.

Photo 5: Looking into the flat plateau area encompassing the 20 ha of 'pond catchment' on Playnes property. Runoff from this plateau drains via the grassed drain/swale in the middle of the photo towards the right and then down into Waitangi Bay. It is recommended that a low detention bund be installed towards the right hand end of the grassed swale to detain peak runoff from the plateau area, and drain slowly via a small pipe through the base of the detention bund.

Photo 6: Looking towards the south east at the pond on the plateau area on Playnes property. The pond now drains away from the viewer towards Waitangi Bay. In the foreground, a low bund has been constructed. This prevents runoff from draining towards the viewer and then into the Lake Okareka catchment.

13. Recommendations

The following recommendations are made with the objective being to reduce the flash flooding problems and erosion potential within the catchment. In particular, the benefits of the recommendations would reduce adverse effects of erosion and flooding on Spencer Road, as well as on the property of Waitangi Lodge Estates, and the receiving environment of Lake Tarawera. The recommendations are made without prejudice; landowners and/or statutory authorities can accept or reject them. However, each recommendation that is accepted will have a beneficial effect on reducing the flooding problem and/or erosion potential within the catchment.

While the recommendations set out below are considered to provide some degree of benefit to erosion and/or flash flooding problems, it should be noted that the stormwater runoff from medium to large storm events are likely to produce overland flow at Spencer Road. This will in turn result in runoff flowing down the ephemeral valley through the property of Waitangi Lodge Estates. Intense rainfall events on a saturated catchment, or on a particularly dry catchment (when the ground surface is hard), will result in higher rates of runoff from the upper catchment. Therefore, depending on predisposing catchment conditions, even small storms are capable of producing overland flows in the lower catchment.

- That the Rotorua District Council re-instates the small excavated stormwater detention basin, and bund immediately upstream of Spencer Road, and implements an ongoing maintenance programme to ensure the structure retains its storage volume, and ability to slow down the velocity of the stormwater runoff.

- That Environment Bay of Plenty staff continue to work with landowners in the catchment to design and implement measures to control erosion and peak flood flows. In the upper catchment it is recommended that Regional Council staff investigate the option of installing a small on-farm stormwater detention bund with small diameter (200 mm approx) pipe to control up to 2000 cubic metres of stormwater runoff from the 20 ha ‘pond catchment’ on Playnes property. The crest level of the stormwater detention bund should be set so that flood water is not diverted back towards the Lake Okareka catchment. It is expected that the crest level would be approximately 1.5 metres high, and the design would include an emergency spillway on undisturbed ground to cater for flows that exceed the storage capacity of the bund. Following investigations, installation of a stormwater detention bund will require the agreement of the Playne family, and provision for on-going maintenance. The off site benefits to Spencer Road and Lake Tarawera would indicate that the works could be eligible for grant assistance under the Environmental Programme policy or similar from Environment Bay of Plenty. It may also be possible that the Rotorua District Council could assist with financing of the local share.

- That any future development within the Waitangi Forest property be undertaken with the following considerations:
    - Earthworks (including construction of roads) should be carried out carefully to avoid erosion and/or concentrated stormwater flows.

- Earthworks should follow the principles of erosion and sediment control set out in Environment Bay of Plenty's Guideline No. 2001/03 (Erosion and sediment Control Guidelines for Land Disturbing Activities"
- Future development should be undertaken in a manner that avoids any increase in peak stormwater runoff. This means that any houses should cater for stormwater discharge from roofs and hard surfaces to ground soakage or on-site storage. Note that on-site storage will normally only be able to cater for small sized storm events.

- That gully control works on Waitangi Forest property be regularly checked and maintained.

- That the current programme of establishing native vegetation in the Waitangi Forest property is a sustainable land use option, and therefore should be continued.

- That the owners of Waitangi Lodge Estates ensure that the capacity of the ephemeral flowpath through their property is of sufficient size to ensure that stormwater runoff from the catchment following extreme rainfall events does not flood buildings or other capital assets. In addition, the ephemeral flowpath should be sufficiently robust to prevent scour from high velocity floodwaters. The flowpath should be capable of handling the 50 year flood event, and should allow for water surge and super elevation of stormwater as it flows around bends.

- That the owners of the Playne property consider alternative land use options for the steep pastoral land draining into the Waitangi Forest property that would reduce peak flood flows and control sheet and gully erosion. When considering alternative land uses, plantation forestry may not be a viable option unless the area is established in long term rotation species and the ephemeral gullies are planted into long term protection vegetation (such as native shrubs), not production species.

Norm Ngapo

Waiora Soil Conservation Ltd 10 October 2006

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File 2120 04 22 – Drainage and flooding – Tarawera catchment, Lake Tarawera

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Appendix 1

Summary Data from Manual
Rainfall Recording Station
Lake Okareka

Environment B·O·P
Manual Rainfall Recording Station

Raingauge	Wilson, P. & S.	Location	Lake Okareka
Site Number	861302	NZMS 260 Reference	U16:034 310
Recorder Type	Manual	Altitude	360 metres
Start of Record	January 1966	Data Capture Rate	90%
Data Summary From	January 1966	To	December 2000
Data Audited From	January 1966	To	December 2000

General Comments

Site is operated by Environment B·O·P as part of its Natural Environment Regional Monitoring Network.

Rainfall from January 1966 to December 1970 was recorded by Beckett, J. S. Gauge was read daily at 0800.

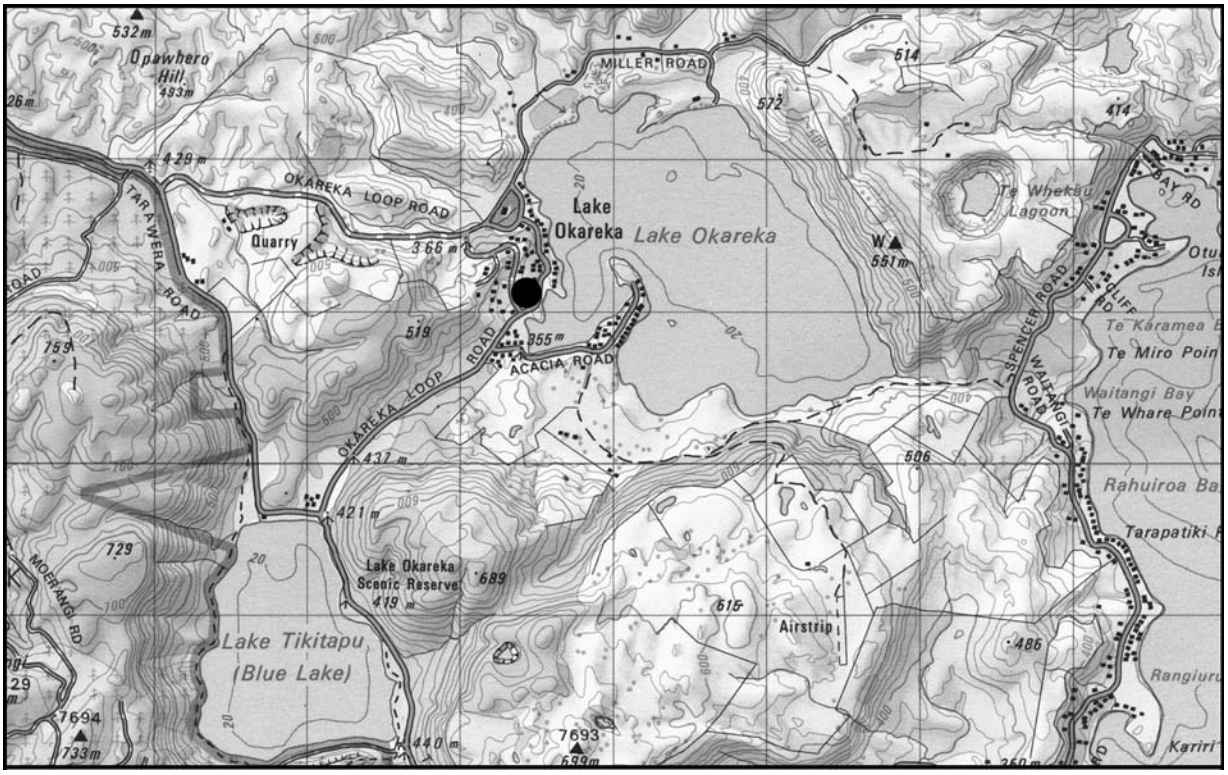
No record exists between December 1970 and March 1973 due to gauge reader leaving.

Rainfall from March 1973 to July 1990 was recorded by Turner, J. Gauge was read daily at 0900.

No record exists between July 1990 and June 1991 due to gauge reader leaving.

Rainfall from June 1991 to July 1996 was recorded by Mercer. Gauge was read daily at 0700.

Rainfall from August 1996 is recorded by Wilson, P. & S. Gauge is read daily at 0800.



SITE LOCATION
Wilson, P. & S. at Lake Okareka

Environment B·O·P
Manual Rainfall Summary

Date Compiled	April 2001	Site Number	861302
Compiled by	Leanne Bodle	Raingauge	Wilson, P.S.
NZMS 260 Reference	U16: 034 310	Location	Lake Okareka
Altitude	360 metres		
Catchment	Lake Okareka	Period of Summary	1966 to 2000

Rainfall Totals (mm)

Mean Annual Rainfall	1529	Mean Summer Rainfall	334
		Summer Rainfall as % of Annual	22%
		Mean Autumn Rainfall	365
		Autumn Rainfall as % of Annual	24%
		Mean Winter Rainfall	455
Max. 24 hr. fall (on 22/01/1966)	155	Winter Rainfall as % of Annual	30%
Max. 48 hr. fall (on 22/01/1966)	185	Mean Spring Rainfall	375
Max. 72 hr. fall (on 02/01/1986)	229	Spring Rainfall as % of Annual	24%

Rainfall Intensities (mm) Depth-Duration Frequency

EV1 Probability Weighted Moments (HIRDS)

Return Period (years)	2	5	10	20	50	100
Duration						
24 hours	80 (121)	105 (162)	122 (188)	138 (214)	159 (247)	
48 hours	101 (151)	132 (201)	152 (234)	171 (265)	197 (307)	
72 hours	115 (167)	151 (222)	175 (259)	197 (294)	227 (340)	

Monthly Statistics (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Min.	9	3	13	32	41	46	31	32	61	33	45	57	1102
Median	89	99	101	120	123	149	151	145	130	107	103	120	1529
Mean	100	101	120	119	126	152	150	153	139	125	111	133	1529
Max.	340	268	356	258	251	268	280	329	253	339	253	296	2013

Annual Summary

Year	Total (mm)	Rain Days	Year	Total (mm)	Rain Days	Year	Total (mm)	Rain Days
1977	1502	141	1985	1565	143	1993	1102	109
1978	1349	137	1986	1529	144	1994	1620	151
1979	1908	159	1987	1353	144	1995	2013	184
1980	1406	164	1988	1715	165	1996	1595	153
1981	1593	162	1989	1779	171	1997	1443	109
1982	1158	136	1990	Incomplete Record		1998	1489	121
1983	1399	139	1991	Incomplete Record		1999	1552	125
1984	1551	159	1992	1459	154	2000	1497	141