KAIKOHE WATER RESOURCES ASSESSMENT

AUGUST 1992

NORTHLAND REGIONAL COUNCIL

CARING FOR NORTHLAND AND ITS ENVIRONMENT

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CONCLUSIONS

THIS REPORT

1. This report outlines the findings of an assessment of the water resources associated with the Kaikohe basalt aquifers.

2. The investigation was undertaken because of competing demands for the water resources of the area, the (general) lack of information about the resource and its uses and the need to provide for more informed resource management.

3. This report is not a resource management plan. Policies, and any rules needed, for the management of this resource will be developed through the public process of preparation of the forthcoming Regional Plan for water and soil management, to be prepared by the Northland Regional Council under the Resource Management Act.

GROUNDWATER & STREAM FLOW RESOURCES

4. Groundwater is recharged by rainfall and, in turn, discharges to springs and streams. The summer low flow of streams is supplied by discharging groundwater.

5. The critical natural factor controlling late summer groundwater levels and spring flows appears to be the time since significant recharge of the groundwater last occurred.

6. One of the main specific objectives of this assessment was to examine the relationship between groundwater and stream flow and the likely effects of the taking of groundwater.

7. The results of this assessment clearly show that groundwater and stream flow should be considered as a single interdependent resource and any management strategy must reflect this. In general terms, spring flow is directly dependent on groundwater level. The taking of groundwater will reduce spring flows.

8. However, the Kaikohe basalt aquifers are typically variable in nature and therefore effects of pumping at a specific location on the flow of a specific spring cannot be accurately predicted without site specific investigations. Concurrent groundwater level and spring flow gaugings are needed, as are the hydraulic characteristics of the aquifer in that area, as determined from pumping tests.

9. Estimates of the volume of the recharge, throughflow and storage of groundwater in the Kaikohe basalt aquifer, as well as pump test results, indicate that the quantity of water that can physically be pumped from a properly constructed bore could be large, greater than 1000 m^3/day. However, the quantity of water that is permitted to be taken ultimately depends on the level of reduction of spring and stream flow that is accepted.

10. If summer spring and stream flows are to be preserved for instream and downstream uses, then any further groundwater use must be restricted to modest quantities, generally less than 100 m^3/day from individual bores. In addition, bores need to be located away from both aquifer boundaries and important springs, and well spaced to avoid interference and cumulative effects.

11. Greater quantities, of the order of 200-500 m^3/day could be taken from individual bores or groups of bores if some significant loss of local spring flows and downstream flows is acceptable.

12. Larger quantities again could be taken during significant recharge periods, with little impact on summer spring and stream flows.

13. Water yield could be maximised by increasing groundwater abstraction and suppling existing users affected by the reduction or loss of spring and stream flows. It would also be necessary to accept the loss of other cultural, aesthetic, recreational and ecological values associated with the lost flow of streams and springs.

RESOURCE USE

14. Spring and stream flow use is close to, or exceeds the limits of available flow over significant areas of the Kaikohe basalt flows, in particular, the upper Otangaroa and Waikaka Stream catchments.

15. The Far North District Council currently has access to water sources that are adequate for current community water supply usage if carefully managed. That is without the use of Rangihamama groundwater. However, any increased demand would require the development of new supply sources.

HABITAT & ECOLOGICAL VALUES OF STREAMS

16. General instream ecological values were found to be low, largely due to agricultural activities. There are some wetlands that, if fenced, would create good potential habitat.

WATER QUALITY

17. Stream low flow water quality was found to be typical of that of small streams draining farm land.

18. The groundwater sampled was of good quality. However, the groundwater resource is vulnerable to potential contamination from the overlying Kaikohe urban area and farmland.

WATER AVAILABILITY FOR FUTURE DEVELOPMENTS

19. Groundwater and stream flow associated with the Kaikohe basalts can only provide for relatively small increases in demand for water, such as a number of small (2 to 4 ha) horticultural developments or a small industry.

20. Other sources will need to be developed to provide for any large increase in water demand in this area.

21. Other options for increased water yields which could usefully be investigated include development of storage dams, particularly on the steeper, less permeable siltstones surrounding the basalt aquifer, other more distant rivers, and artificial recharge of the aquifer using summer storm runoff.

1.0 INTRODUCTION

1.1 PURPOSE

This report presents a summary of the information available on the water resources associated with the Kaikohe basalt flows, and the uses of those resources.

1.2 AREA COVERED

The area covered is the Kaikohe basalt flows bounded by the Mangamutu and Wairoro Streams to the north and east, Otangaroa Stream to the north west, Mataraua Road to the west and the Punakitere River to the south. A map of the locations and topography of the area is shown in Figure 1.

1.3 BACKGROUND

In 1983 a severe blue-green algal bloom in Lake Omapere made the lake water unsuitable for public water supply. Until that time, Kaikohe Borough Council had used the lake water as one of the major sources (45%) of supply for the Kaikohe urban area. The Kaikohe Borough Council investigated options for a replacement water source and in 1987 applied to the Northland Regional Council for water rights to take up to 2300 m^3/day from bores adjacent to Rangihamama Road from basalt aquifers. At the same time, the Kaikohe Borough Council also had to apply for new water rights for its existing Kaikohe Hill bores and Squires Spring water supply sources.

The applications attracted numerous objections from farmers and others who rely on the flow in the springs and small streams and bore water from the Kaikohe basalt aquifers.

Hearings of the applications and objections were held in late 1988. The applications were granted. However, the consent granted to take groundwater from the Rangihamama area was for considerably less than was applied for, ie. an average of 600 m^3 per day as opposed to the 2300 m^3 per day applied for. The Northland Regional Council hearings tribunal considered that a conservative allocation should be made because of uncertainty about the likely impacts of the proposal. The tribunal further recommended that, given the existing and potential demands on the water resources and the limited knowledge about the resource at that time, a more comprehensive water resources survey should be completed.

At the time of the hearings there was little groundwater level data, stream flow gaugings for only a few streams, and predictions about the likely interaction between groundwater and streamflows was difficult and not well defined.

Based on the recommendation of the tribunal, the Northland Regional Council resolved to undertake an assessment of the groundwater and associated streamflow resources of the Kaikohe basalts, and the uses of those resources.

The main objectives of the resource assessment were to:

* quantify the groundwater and stream flow resource;
* examine the relationship between groundwater and streamflow;
* quantify existing water uses; and
* relate current and potential demand to water availability.

1.4 INVESTIGATIONS

The investigations undertaken for this water resources assessment included the following:

* monitoring of groundwater levels in a selection of existing bores, particularly the investigation bores drilled for Kaikohe Borough Council in the Rangihamama Road area;

* gauging of spring and stream low flows; including using two spring flow recorders;

* geophysical survey: (Reedy, 1992);

* a summer low flow water quality survey;

* a brief survey of the ecological and fisheries values of the streams and wetlands;

* a rural water use survey.

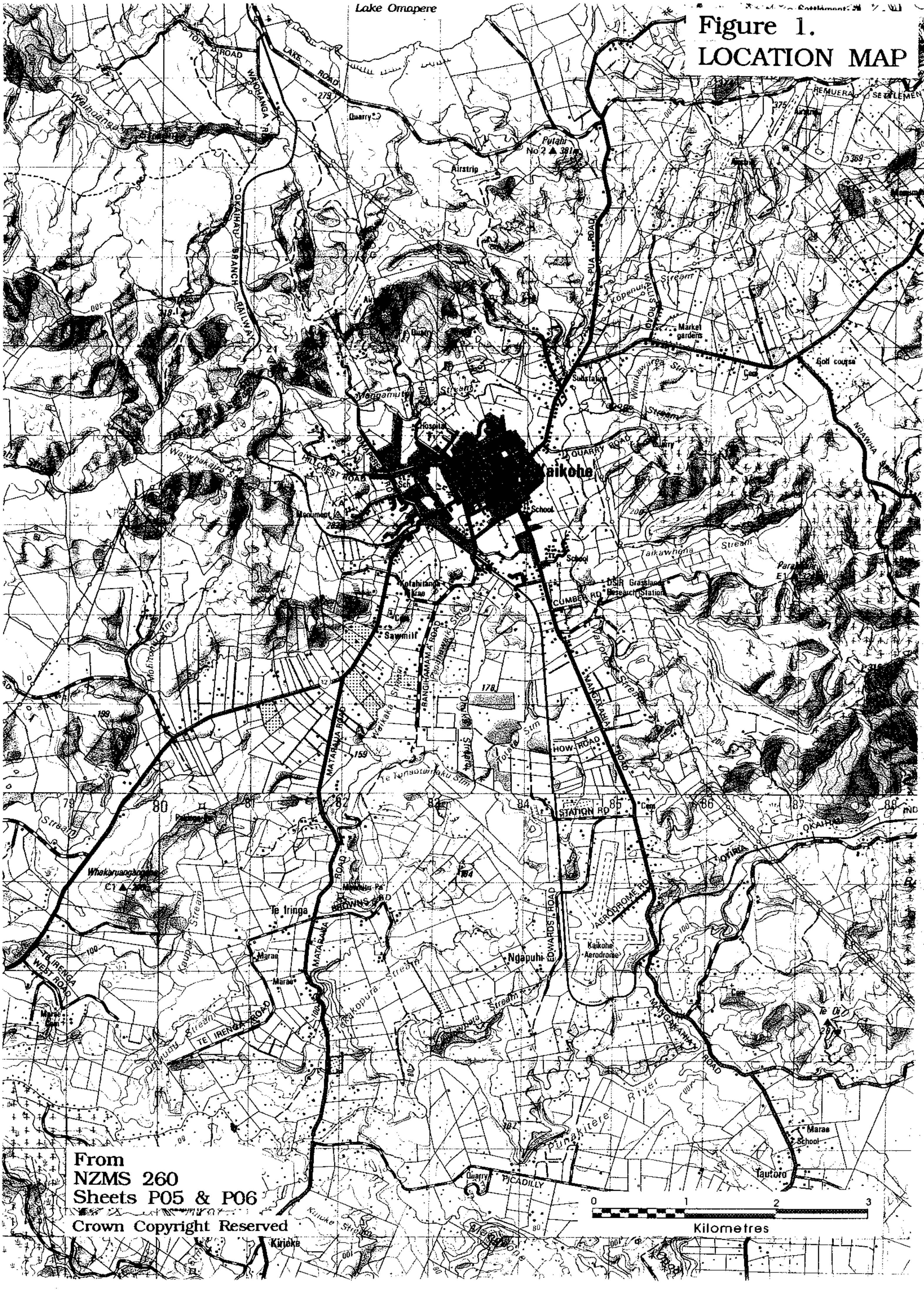

Figure 1. LOCATION MAP

From NZMS 260 Sheets P05 & P06

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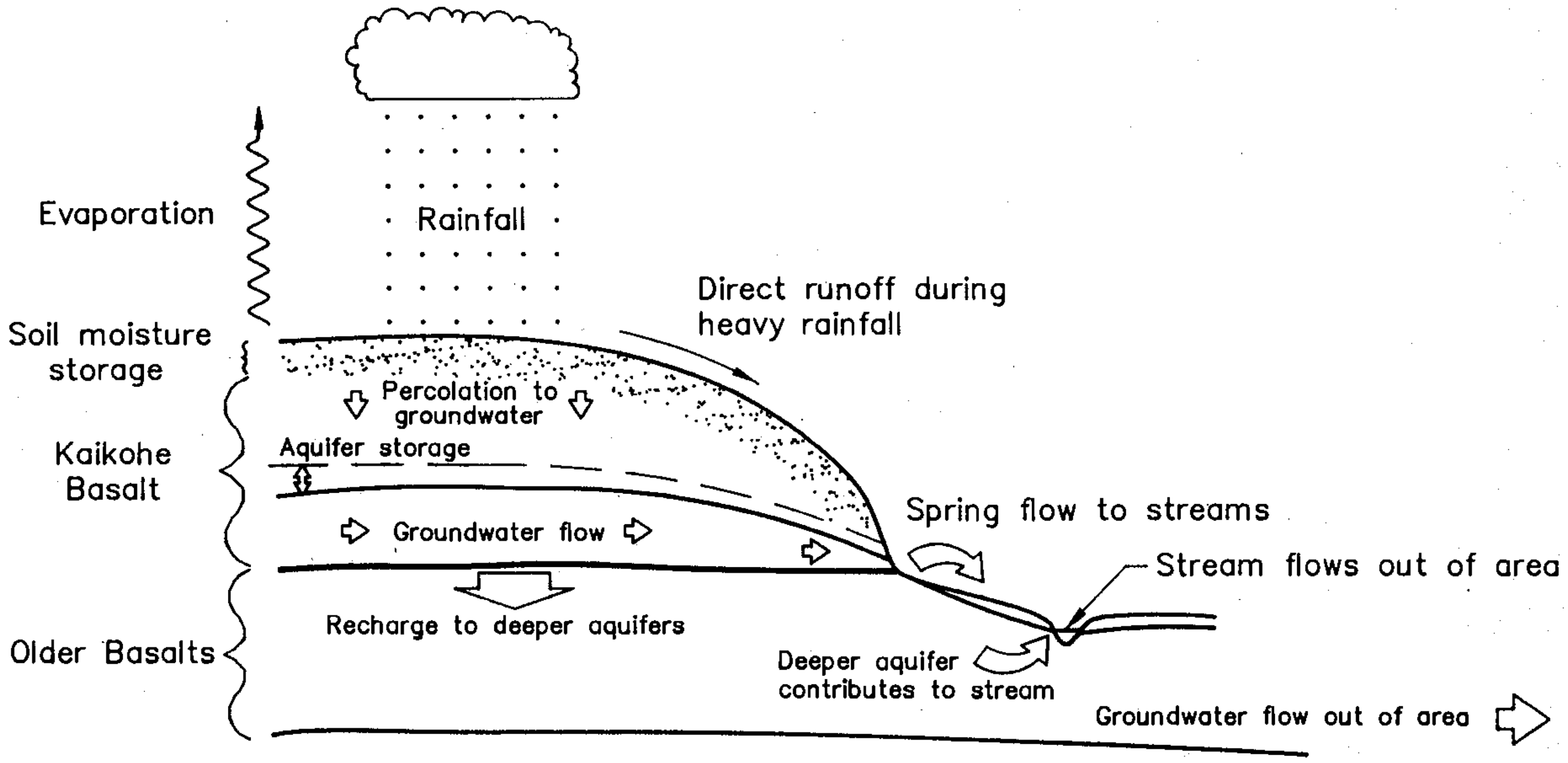

Figure 2.1: Hydrological Cycle

2.0 WATER RESOURCE DESCRIPTION

2.1 THE HYDROLOGICAL CYCLE

Any description of the water resources of an area must be based on an understanding of the hydrological cycle in that area. Figure 2.1 illustrates the main elements of the Kaikohe catchment's hydrological cycle. When rainfall occurs, a proportion evaporates, some runs off to surface streams (quickflow) and some infiltrates into the soil.

If the soil is dry, this infiltration will be absorbed until water contents exceed the soil's moisture holding capacity. At that stage, infiltration will begin to percolate down to groundwater, causing groundwater levels to rise (recharge). Groundwater will flow through fractures in the rock from higher areas to lower ground, eventually discharging to springs or streams (baseflow), or flowing out of the aquifer into a deeper or distant aquifer.

This water is available for use by catching rainfall or surface runoff (quick flow) in roof tanks or dams, and by abstracting water from wells or from springs or streams. The total amount of water available is limited by the net rainfall (rainfall less evapotranspiration). Use of water in one way generally limits the amount of water available in other ways, eg. any trapping of rainfall will reduce groundwater availability, any groundwater take will reduce spring/surface water availability. It is important, therefore, that water resources interactions be understood and measured, and that this information is used in allocating the resource.

2.2 RAINFALL AND EVAPORATION

2.2.1 Rainfall

Rainfall has been measured at a number of points in the study area, as shown in Figure 2.2 and summarised in Appendix 1. Average annual rainfall varies between the various sites, but is typically about 1500 to 1600 mm. The lowest annual rainfall recorded was about 1150 mm (1982) and the highest 2450 mm.

Unfortunately there is no one site with a long term continuous rainfall record. However, a summary rainfall record for the study area has been prepared by combining the records for three sites. A comparison of recent rainfall with the long term record is given in Table 2.1. This comparison shows that the last 10 years contains 4 of the top 10 driest years of the 70 years of record. It should be noted that there was some variations in the rainfall between various Kaikohe sites, and therefore having to combine sites to get a long term record means that the comparison and ranking should be used with some caution.

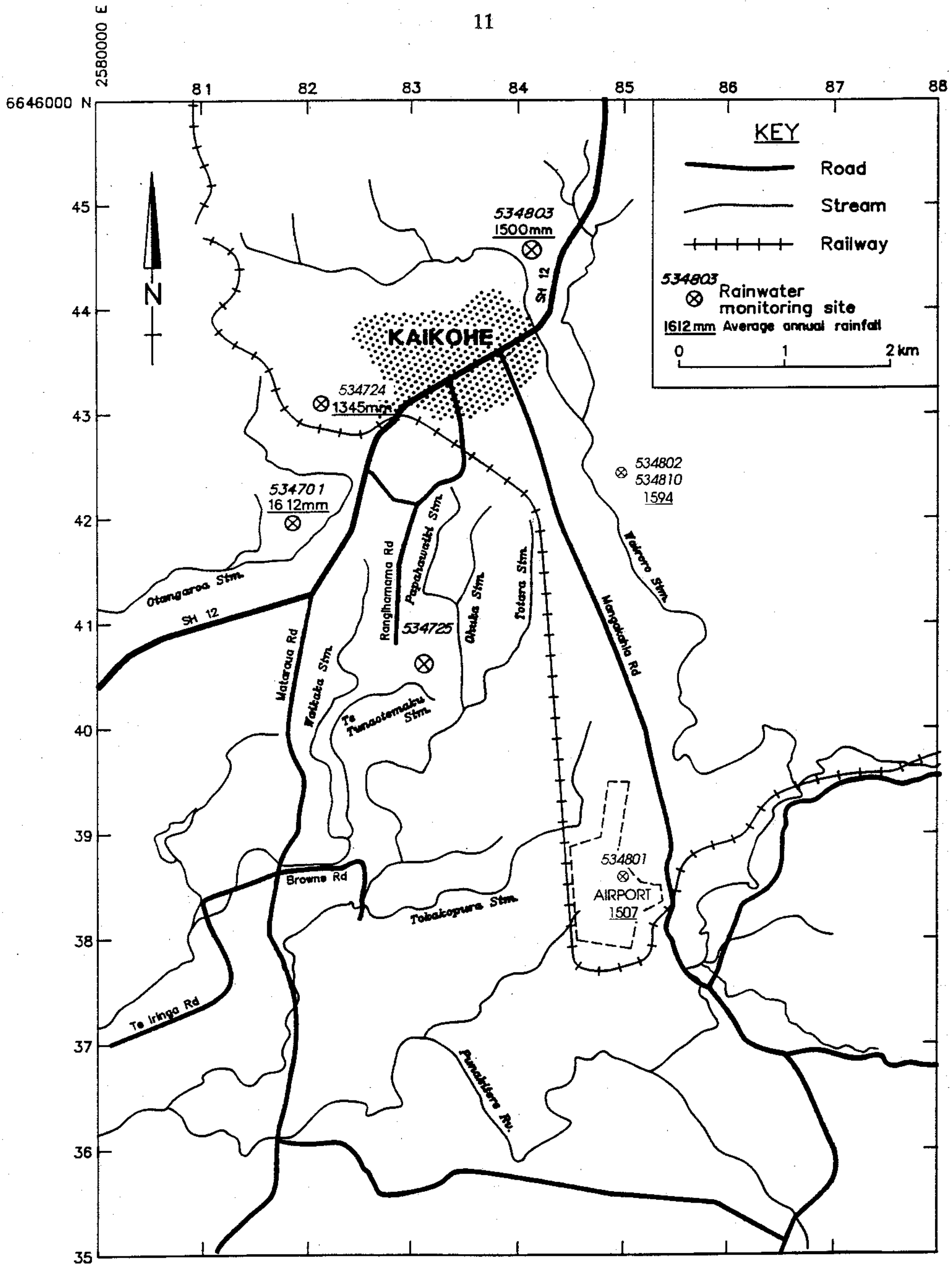

Figure 2.2: Rainfall Monitoring Sites

Long term trends in rainfall have been examined by determining departures from mean rainfall for the 70 years of record; in other words, determining whether a given months rainfall is above or below the average. These departures are then summed to produce cumulative departures over time, as shown in Figure 2.3.

The average distribution of rainfall throughout the year, for the combined sites is given in Table 2.2. This shows that an average 33% of the years rainfall occurs in the winter (June - August) while about 19% falls in summer (December - February). However, there is great variability in rainfall from month to month, year to year, particularly for summer months. For example, the long term records shows that January rainfall varies from only a couple of millimetres to well over 300 mm.

Dry spells, periods of fifteen days or longer with less than 1 mm of rain on any day, are not uncommon in Northland during summer and early autumn (Moir et. al., 1986). There is usually at least one, and frequently two, such periods each year between December and March. Droughts having a significant effect on agricultural production occur on average once every three years in Northland (Martin and Waugh, 1972).

TABLE 2.1 **ANNUAL RAINFALL DATA**

Site	Year	Annual Rainfall	Rank
Combined*	**Mean 1922-1992**	**1570mm**	
534722 Opahi	1982	1147	driest
	1983	1309	11
	1984	1280	6
	1985	1606	42
	1986	1352	17
534810 DSIR	1987	1373	19
Grasslands	1988	1777	50
	1989	1962	61
	1990	1309	10
	1991	1255	5

(* Sites: 534701, 534722, 534810)

Monthly rainfalls for the period of this survey, 1989-92, are listed in Appendix 1.

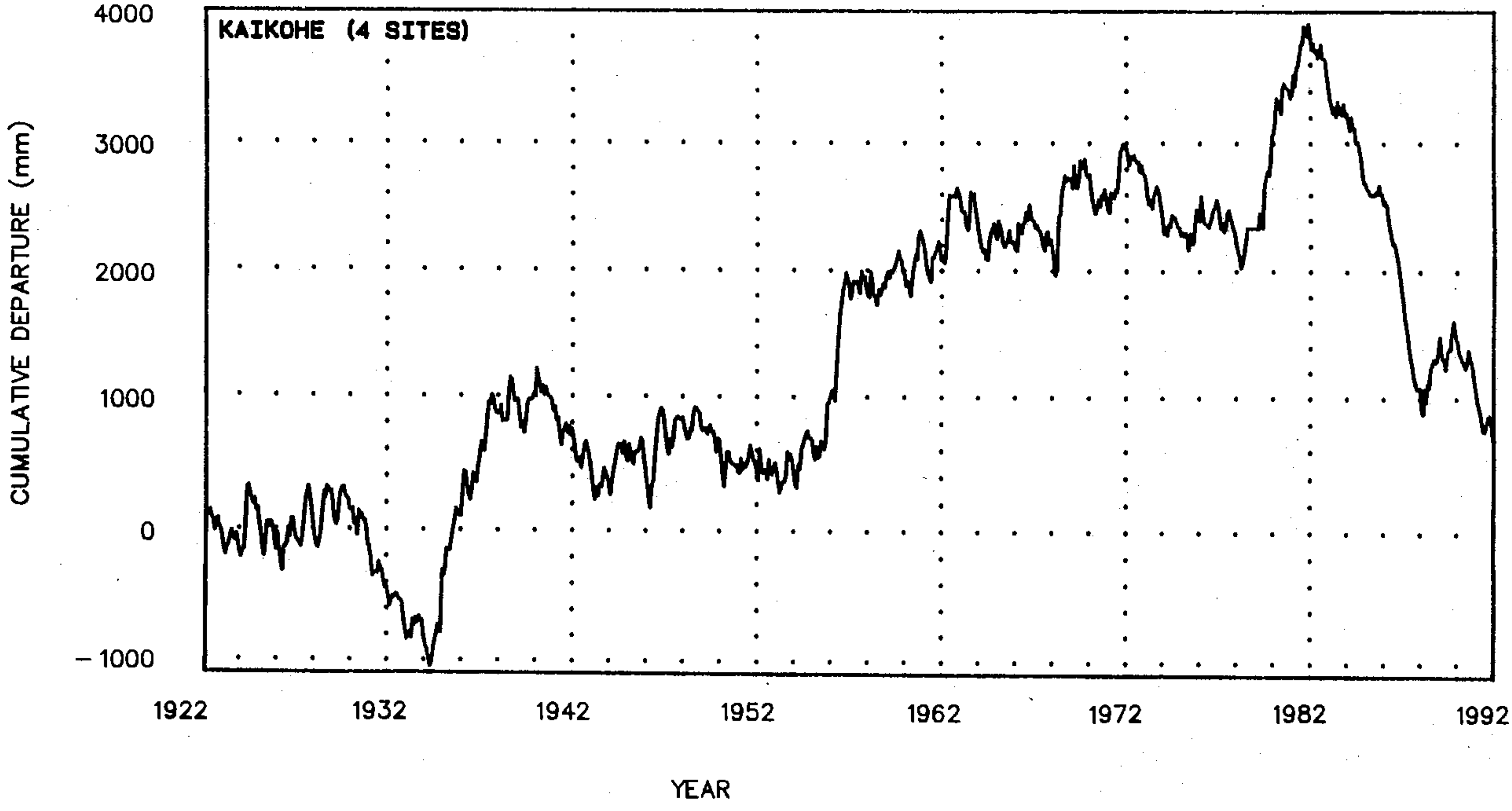

Figure 2.3: Kaikohe Rainfall
Cumulative Departure from Mean Rainfall 1922– 1992

TABLE 2.2 **AVERAGE MONTHLY RAINFALLS 1922-1991**
(Combination of Sites 534701, 534801, 534803, & 534725)

J	F	M	A	M	J	J	A	S	O	N	D	Total
						(mm)						
103	109	106	134	153	176	168	159	133	126	102	101	1570

2.2.2 Evapotranspiration (ET)

ET is the loss of water to the atmosphere by a combination of evaporation from open bodies of water, soil and other surfaces and transpiration by plants. ET is very difficult to measure and has been estimated from raised open pan evaporation measured at Kaikohe, see Table 2.3. The pan evaporation does not vary nearly as much from year to year or from place to place, as does rainfall. The Kaikohe average is similar to that for an overall average for Northland (Moir et. al., 1986). It has been found for other Northland sites that raised pan evaporation multiplied by a factor of about 0.7 to 0.8 closely approximated potential evapotranspiration calculated using temperature, solar radiation and wind data (Penman or Priestly-Taylor methods). Table 2.3 includes Kaikohe pan figures multiplied by 0.7 as an estimate of potential evapotranspiration.

TABLE 2.3 **EVAPORATION - AVERAGE MONTHLY (mm) FOR KAIKOHE**
(Site NZMS A53482)

J	F	M	A	M	J	J	A	S	O	N	D	Total
Kaikohe (raised pan) 1973-84)												
172	128	105	74	57	38	43	57	77	106	128	159	1144
SD26	20	15	8	8	5	8	5	9	10	19	13	
[SD - Standard Deviation]												
Kaikohe [adjusted raised pan (x 0.7)]												
119	88	72	51	39	26	30	39	53	73	88	110	789

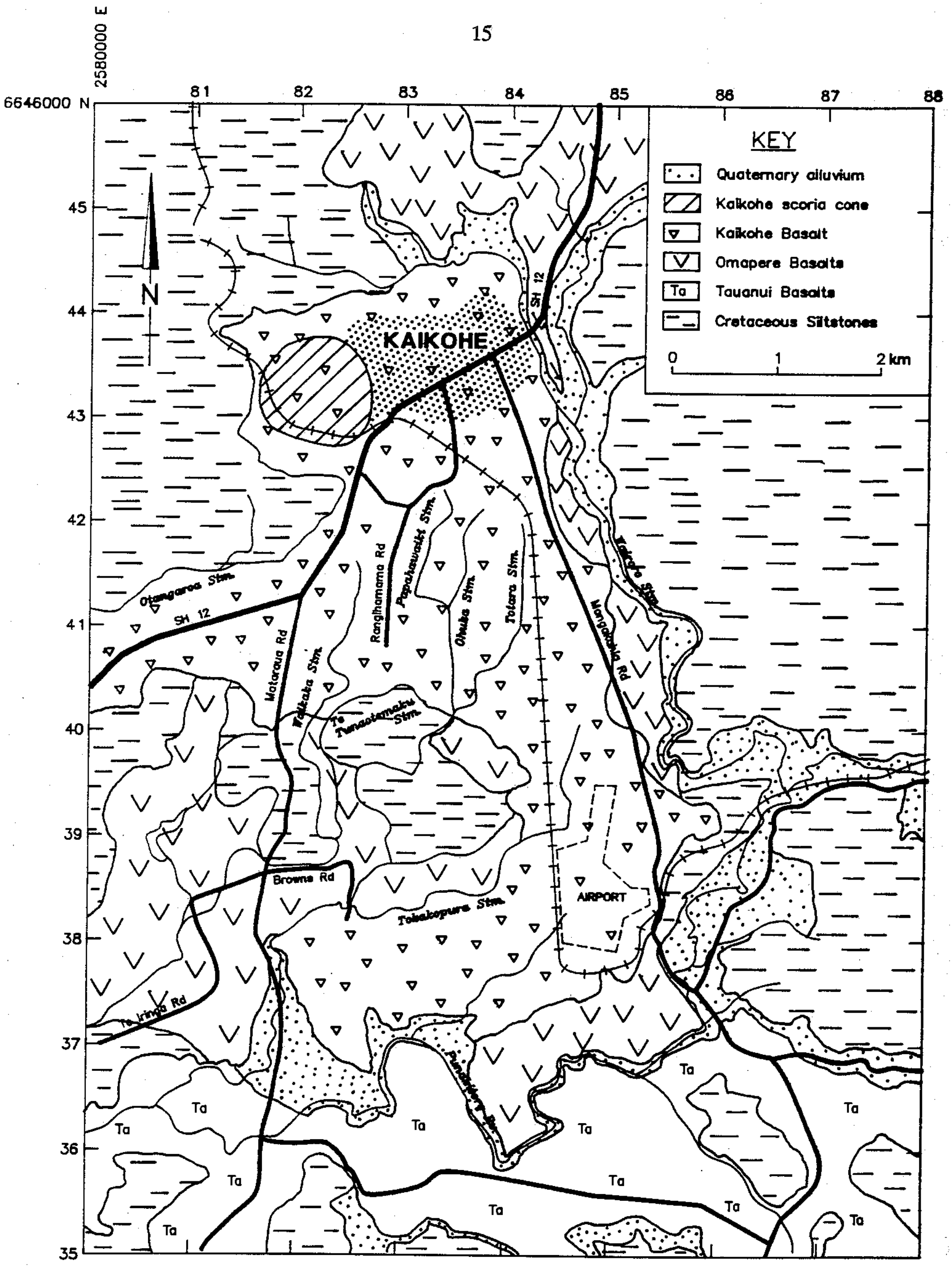

Figure 2.4: Geology

2.3 GROUNDWATER RESOURCES

Kaikohe's groundwater resources are described by first documenting the nature of the aquifer, then discussing the characteristics of the groundwater and its flow regime, and finally estimating the extent of the resource.

2.3.1 Aquifer Description

Geology

The Kaikohe aquifer comprises a scoria cone immediately west of Kaikohe township, and associated basaltic lava flows extending to the south and southwest of the cone (refer Figure 2.4). The cone is largely made up of erupted layers of scoria, with some basalt rock, which tends to be highly vesicular (porous). Erosion appears to have reduced the elevation of the cone since eruption: its peak is currently some 60 metres above surrounding ground level. Cone diameter is of the order of 1 km.

The basalt flows associated with the Kaikohe centre comprise hard rock, generally less vesicular than the basalt found in the cone itself. The flow deposits are relatively linear, and appear to follow valleys which existed at the time of the eruption (see Figure 2.4). Some 2 to 3 km southeast of the cone, the basalts split into two main lobes, one extending approximately 4 km to the west, the second extending a further 5 km south before turning west.

Drilling and geophysical investigations (Roberts, 1987; Thompson, 1987; & Reedy, 1992) have confirmed the extent and thickness of the basalt deposits in most areas (refer Figures 2.6 to 2.9), however, some ambiguity exists in geophysical interpretations for part of the extensive southern lobe. There are as yet no bores that penetrate the basalt near the centre of the southern lobe. One interpretation of basalt geometry suggests the basalt is thickest immediately south of the eruptive cone and near its southern limit, with a thinner area between. An alternative interpretation predicts more consistent basalt thicknesses.

The basalt flows slope from north to south, with elevations of 200 m (above sea level) close to the cone, falling to 100 masl to 120 masl near the southern limit of the basalt. Much of the flows' upper surface forms a sloping plateau at 180 masl to 160 masl, with steeply sloping edges.

The basalt lobes appear to be the product of numbers of lava flows rather than a single discrete flow deposit. Borelogs (Appendix 2) show vertical variations in basalt vesicularity and jointing, with layers of low porosity ash and tuff up to 10 metres thick.

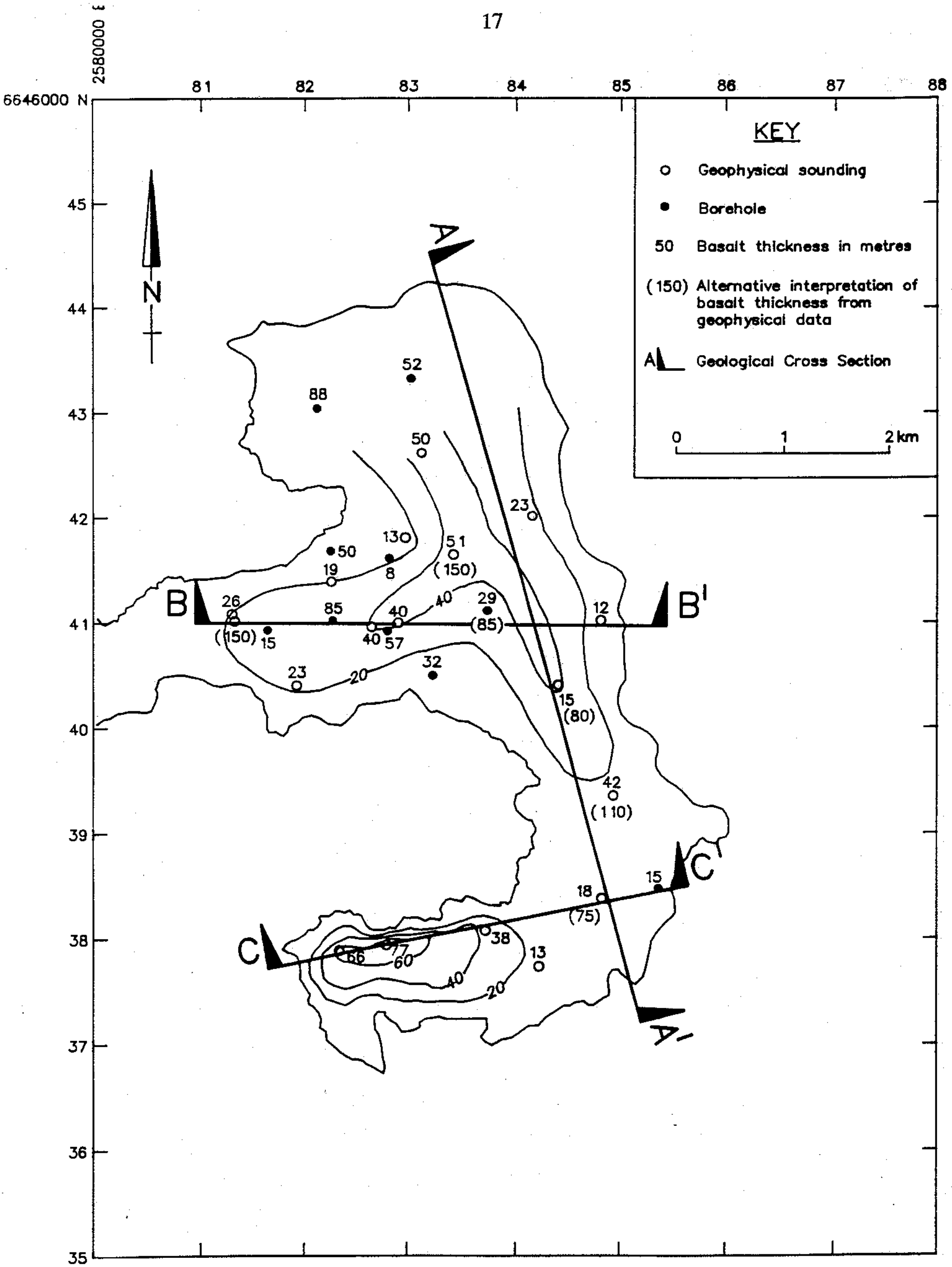

Figure 2.5: Kaikohe Basalt Thickness Data

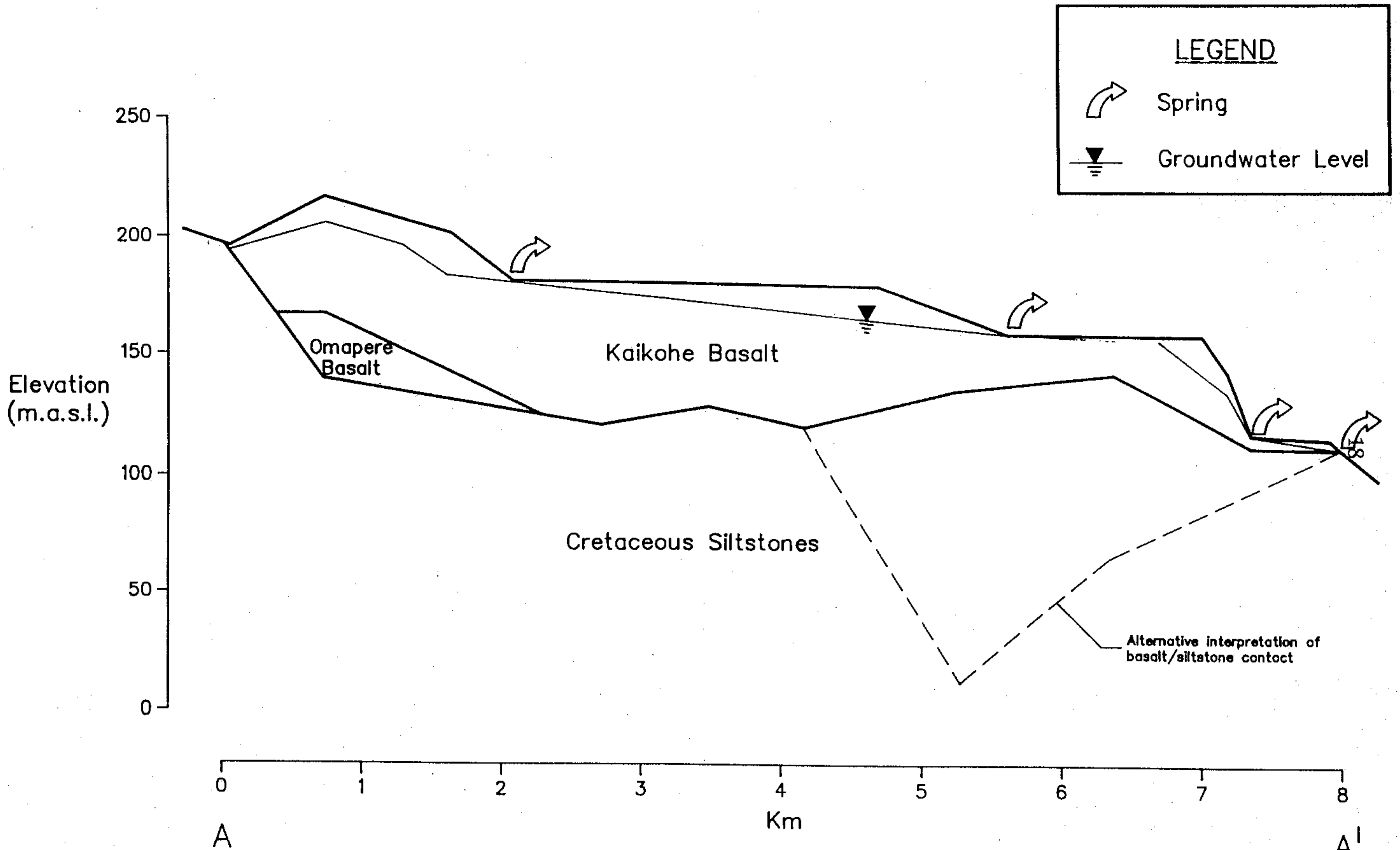

Figure 2.6: Geological Section A–A'

KEY

↗	Spring
▼	Groundwater Level
K	Kaikohe Basalt
O	Omapere Basalts
C	Cretaceous Siltstones

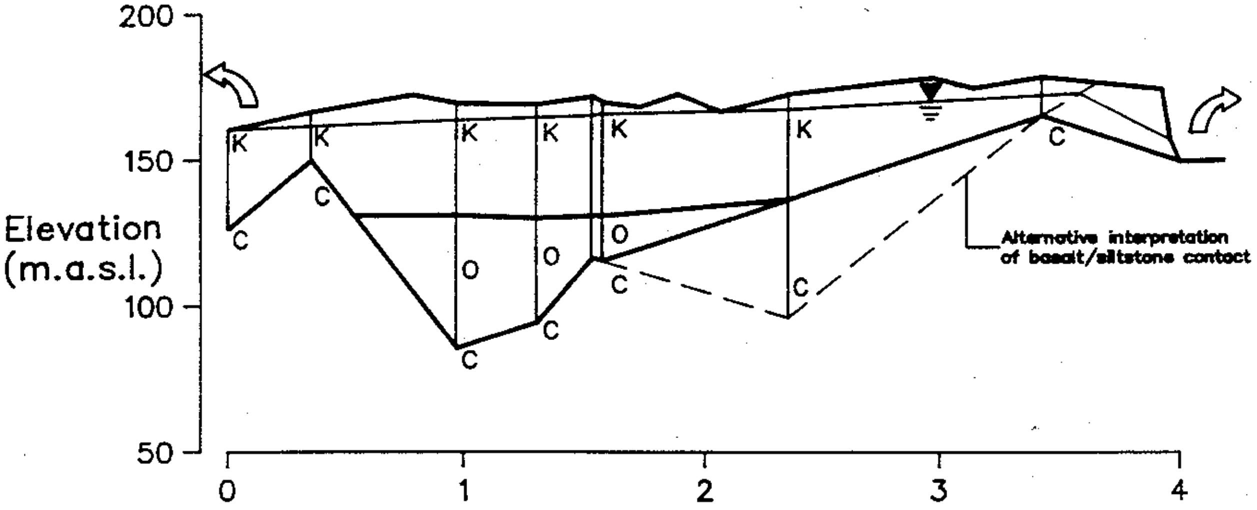

Figure 2.7: Geological Section B–B'

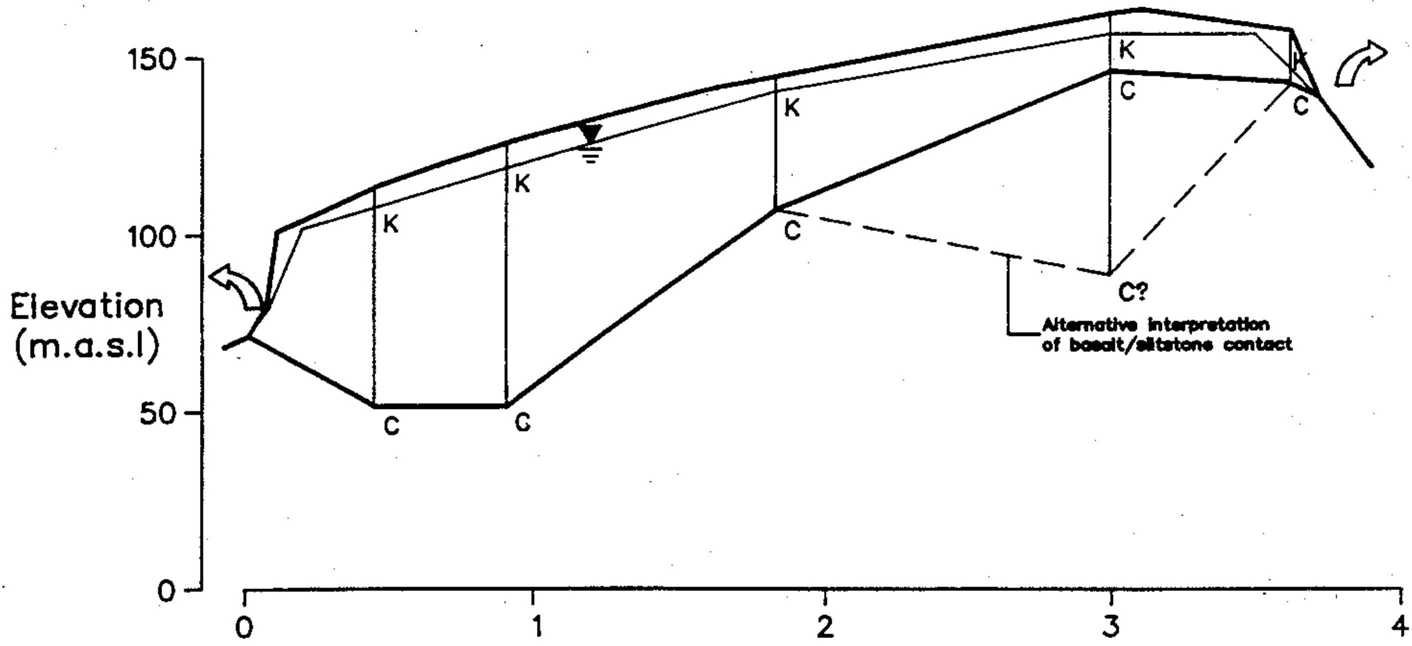

Figure 2.8: Geological Section C–C'

Older siltstone ridges rise alongside the basalts and separate the two east-west trending lobes (Figure 2.4). These sedimentary rocks are fine grained and of low porosity.

In places, the Kaikohe basalts overlie older, apparently denser and less vesicular basalts, termed the South and North Omapere basalts in a recent geophysical study (Reedy, 1992). These basalts outcrop around the edge of the Kaikohe basalt, as shown in Figure 2.4, but their extent beneath, and contact with the Kaikohe basalts is not well understood.

Hydraulic Characteristics of the Aquifer

Basalt aquifers are typically variable in nature, with relatively large changes in permeability and water storage capacity over short distances. The Kaikohe basalt aquifer is typical of this pattern, and is likely to have distinctively different characteristics in the cone and flow areas.

The scoria cone materials are known to be highly permeable, yielding substantial groundwater supplies, although no detailed pumping test data was available at the time of writing.

A number of pumping tests have been carried out in the Kaikohe basalts (Table 2.4). These show typical transmissivities of the order of 80 m^2/day ($k = 1$ to 2 m/day), but also indicate considerable local variability in aquifer conditions. Detailed analyses indicate that substantial leakage occurs between aquifer layers or sections shortly after commencement of most tests, suggesting that minor localised aquitards (layers of lower relative permeability) may be common within the aquifer.

Aquifer testing to date has been on too small a scale to show whether the Kaikohe basalt flows would act as a single aquifer if stressed by a major water abstraction. Geological data (Reedy, 1992) and hydrogeological experience elsewhere suggests that these internal aquitardes are likely to be localised features, and that the Kaikohe basalt would, in fact, act as a single aquifer under stress. However, this cannot be regarded as conclusively proven. More extensive (higher discharge, longer period) aquifer testing would be required to prove this assumption. Such a test should be undertaken before any abstraction of large quantities of water from a single well or group of wells. The test rate should be close to or greater than the proposed use.

The deeper basalts which underlie the Kaikohe basalt appear to be of lower permeability, on the basis of visual descriptions (Reedy, 1992), but it is likely that these materials do comprise an effective aquifer. Hydraulic interactions between the Kaikohe and older underlying basalts have not been investigated, but it is likely that interaction does occur.

More extensive pump testing may also clarify the extent of these interactions.

TABLE 2.4 **SUMMARY OF PUMP TESTING RESULTS**

Grid Reference	T (m^2/d)	S	Test Rate/Duration	Comments
P05:826409	82.7	0.00066	400m3/d 70hr	}Alternative analyse of a
	69.2	0.00072	400m3/d 70hr	}single test. Leakage
	93.6	0.00058	400m3/d 70hr	}observed.
	174.9	0.00064	400m3/d 70hr	}
				}
P05:813409	50	-	18m3/d 5hr	}Substantial leakage }observed
P05:813409	130	-	64m3/d 22hr	}Drawdown/recovery tests
	87	-	64m3/d 22hr	}leakage observed.
N15:292456	4	-	79m3/d 7 min	Well capacity exceeded.

Aquifer storage capacity can be estimated from pump test data (see Table 2.4) and groundwater level records (refer Appendix 3.3). Estimates for the Kaikohe Basalt vary widely, from 0.0006 to 0.025 (Thompson, 1988; Roberts, 1988), indicating considerable variability in aquifer characteristics.

This storage data suggests that the aquifer is semiconfined in places, as shown by pump test results, but appears to act as an unconfined aquifer in overall terms, as shown by Roberts' (1988) modelling analyses. Low storage coefficients (eg. 0.0006) indicate that water is released from the aquifer by pressure release, rather than by emptying of rock voids, which yields a higher storage coefficient (eg. 0.025). The available data suggest that much of the Kaikohe basalt comprises an unconfined aquifer but, in some places, permeable basalts are confined by lower permeability ash layers or other aquitardes to give locally confined (or semiconfined) conditions.

This reinforces the degree of uncertainty regarding the likely behaviour of the Kaikohe basalt under stress by a large abstraction.

Aquifer Extent

A primary purpose of this study is to study the nature of the water resource in the Kaikohe area, and relevant interactions between surface water and groundwater. The major areas of concern comprise wells and springs in the northwestern part of the Kaikohe basalts close to Kaikohe township. Therefore, for the purposes of this study, the "aquifer" is considered to comprise the area of exposed Kaikohe basalts, including any underlying older basalts. Areas where the older basalts only are exposed, beyond Kaikohe outcrop, are excluded.

There may be some potential for abstraction from these older basalts, where they are exposed, and this may affect the resource in the defined aquifer area. However, no such abstractions are currently known to exist. Should a large groundwater abstraction occur close to the Kaikohe basalts, and should significant connections exist between the Kaikohe and older basalts, the Kaikohe aquifer could be underdrained, reducing groundwater levels and spring flows in the area. Should any exploitation of groundwater from the older basalts be considered, the potential for impacts on existing water users supplied by the Kaikohe basalt aquifer should be addressed.

Aquifer Shape - Subcatchments

The Kaikohe basalt aquifer is relatively linear in form, and has a large variation in elevation, relative to its thickness as described above. Most parts of the aquifer are relatively narrow and potential well sites are in many places close to aquifer boundaries.

The slope and linear form of the aquifer suggests it would be useful, in management terms, to consider it in terms of a few smaller groundwater catchments rather than a single aquifer body. Groundwater levels in the southwestern lobe are lower than the base of the aquifer near its northern extent. A well abstracting in the wider western lobe would experience significant boundary constraints before inducing effective flow from any part of the southern lobe.

2.3.2 Groundwater Flow

Groundwater is recharged by rainfall flows in a pattern broadly reflecting surface topography to discharge to the surface via springs or seepage, or to deeper aquifers.

Interpreted groundwater flow patterns are shown in Figure 2.9, along with the major known areas of spring discharge.

Recharge occurs over the entire basalt outcrop, although it is reasonable to infer that recharge rates are greatest in the scoria cone area where the porous scoria allows a high infiltration rate.

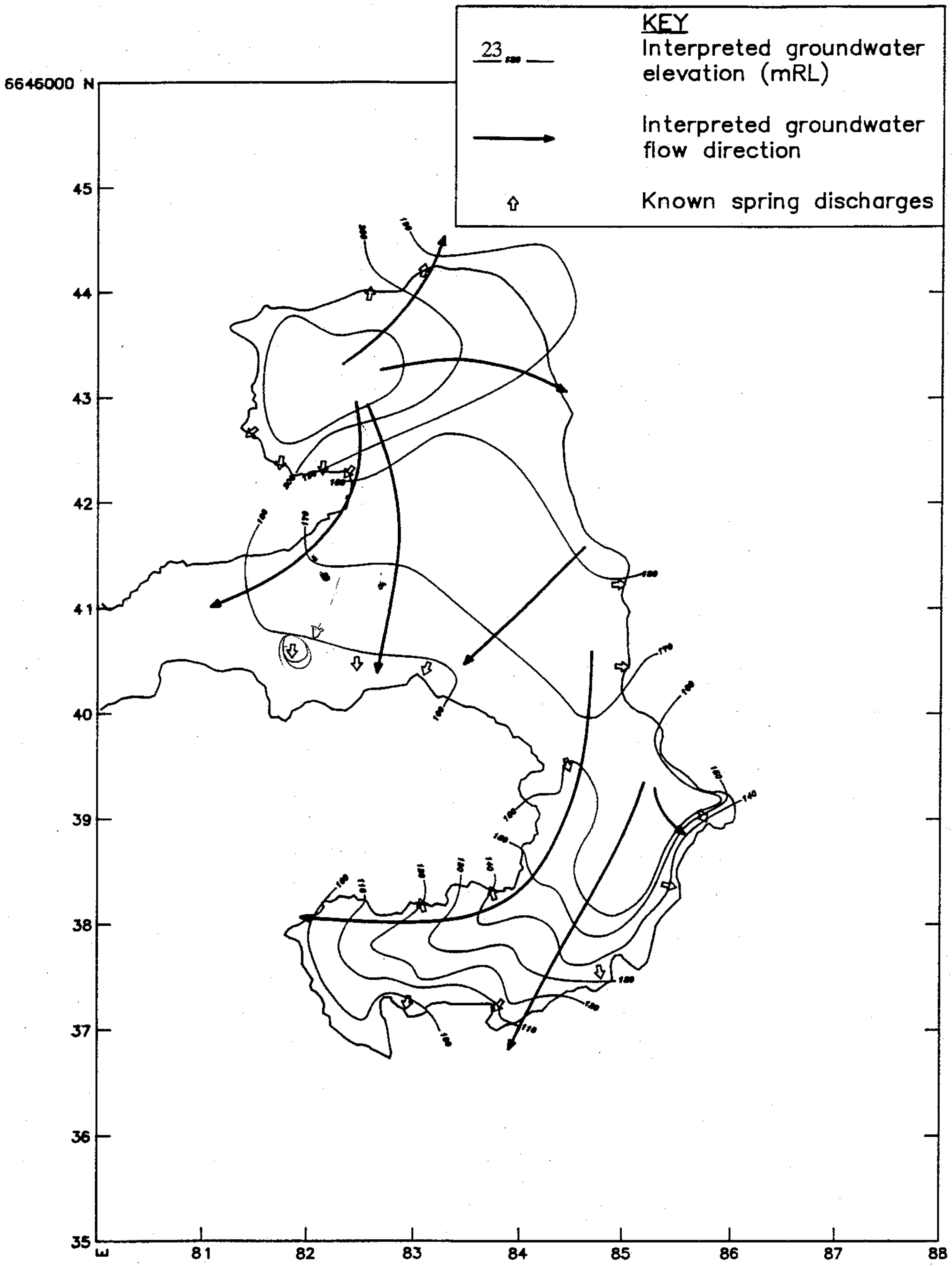

Figure 2.9: Estimated Groundwater Level and Flow Patterns

Groundwater level records for four monitoring wells in the Kaikohe basalt, see Figure 2.13, show almost identical responses to winter rainfall, indicating relatively even recharge over the study area.

The predominant groundwater flow direction is from northeast to southwest, with radial flow outwards from the elevated recharge area of the scoria cone. Discharges to surface occur around much of the aquifer's margin, particularly along its topographically low southern edges. Marked local springs occur particularly in the south, where low bluffs mark the limit of the basalt lobe, and on the southern edge of the western lobe, downgradient of an extensive flat area where substantial infiltration is likely to occur. Spring locations in this area suggest some local structural control of groundwater flows may occur, such as the presence of major fractures within lower permeability basalt mass.

These springs, and seepage to streams, comprise the only source of dry weather stream flow in the smaller streams directly south of Kaikohe, and contribute a significant part of dry weather flows in the larger streams which partly derive from the siltstone catchments surrounding the basalt outcrop. Groundwater discharges to streams are discussed in greater detail in Section 2.4 below.

The magnitude and significance of groundwater leakage to deeper aquifers is not known. Leakage to the low permeability siltstones is likely to be negligible, but significant flows to deeper basalts may occur.

2.3.3 Groundwater Recharge and Throughflow

Rainfall and groundwater level records for the Kaikohe basalt aquifer are shown in Figures 2.10 and 2.11. It is clear that groundwater levels normally rise in mid to late winter in response to heavy and consistent rainfall. Recharge may also occur after very large storm events, such as Cyclone Bola, or a sequence of wetter than average summer months. However, isolated heavy rainfalls occur but produce little or no rise in groundwater level as illustrated in Figure 2.11. This is because rainfall is absorbed by the soil until its storage capacity is reached, and only then can downwards percolation to the aquifer (recharge) commence. This is illustrated in Figure 2.12, taken from a more detailed study by Petch et al (1991), comparing similar rainfall and groundwater level data for the Pukekohe basalt aquifers.

Soil testing data (Gradwell, 1971) indicate that a soil moisture storage capacity of 75 to 100 mm is typical of Kaikohe soils. This means that, after any appreciable length of dry weather, as much as 100 mm of rainfall is required before any groundwater recharge can occur. Seasonal distribution of rainfall is also important, as a reduction in summer rainfall

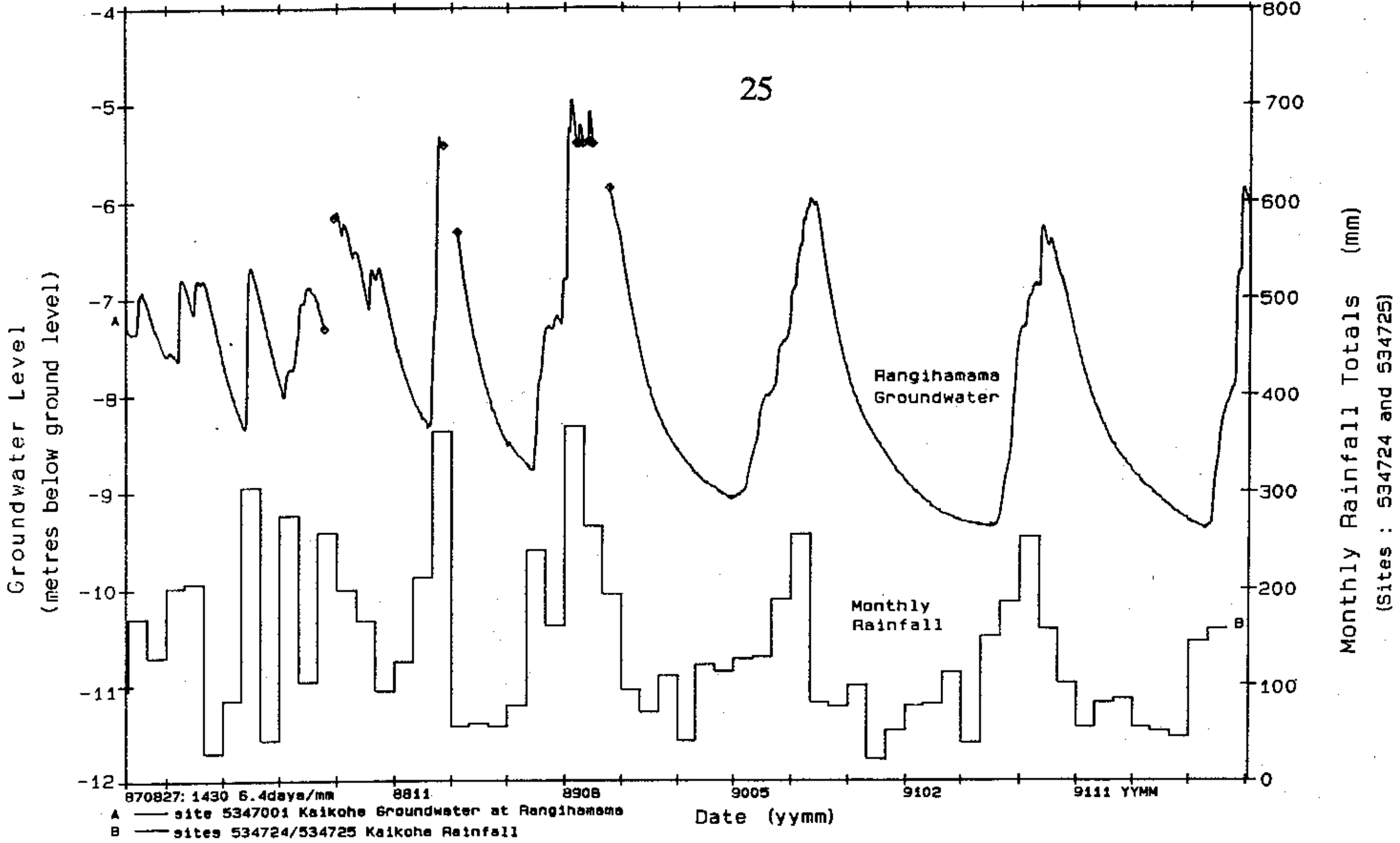

Figure 2.10 : Comparative Plot
Kaikohe Rainfall vs Rangihamama Groundwater Level
(Aug 1987 -Aug 1992)

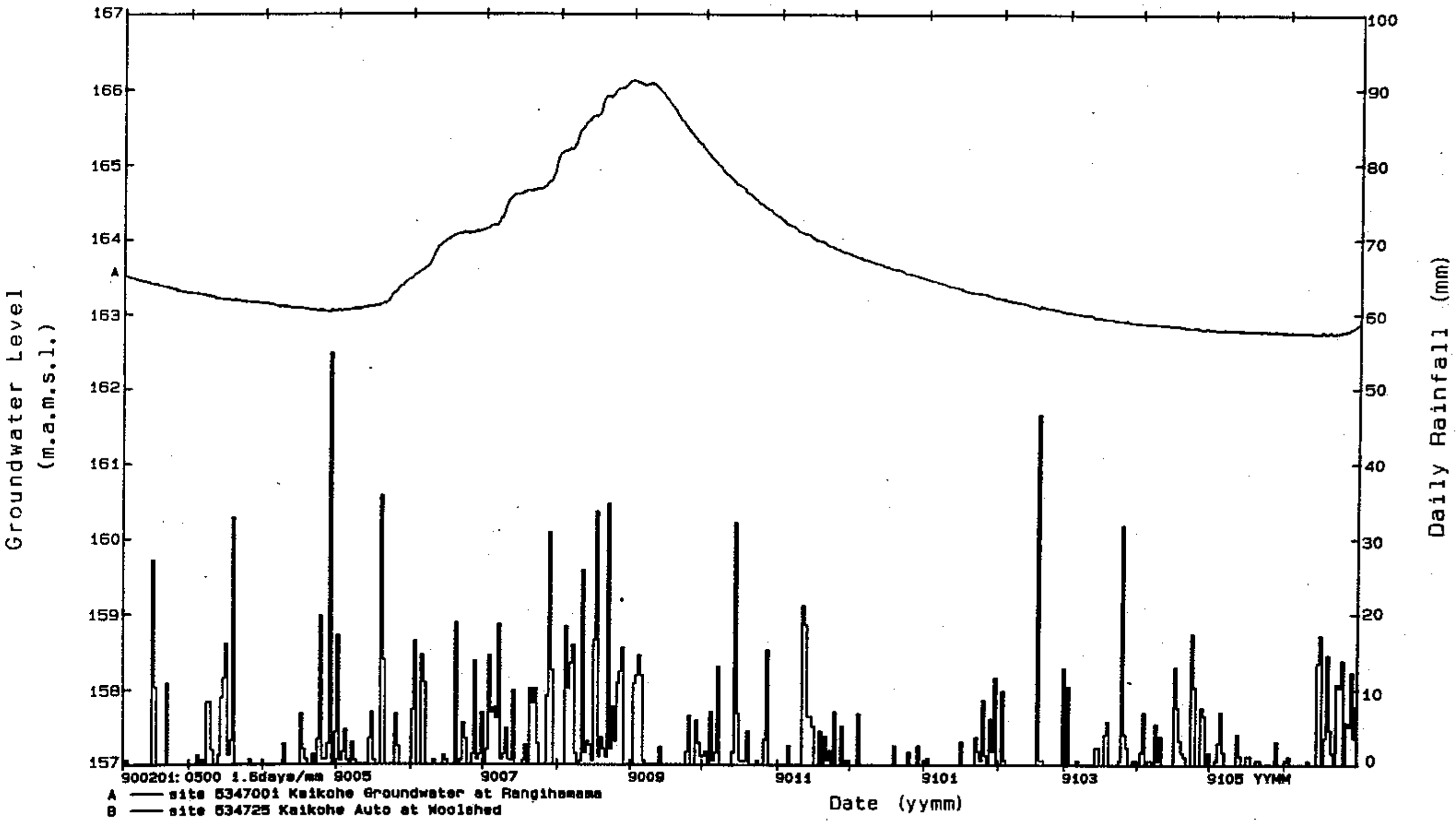

Figure 2.11 : Kaikohe Daily Rainfall (mm) (site: 534725)
Rangihamama Groundwater Level (site: 5347001)
(Feb 1990 - July 1991)

can occur with little impact on groundwater levels, but drier than normal conditions during winter months can result in reduced recharge. However, the rapid fall in groundwater levels following winter recharge events suggests that much of the recharge quickly flows out of the aquifer and has little effect on groundwater levels later in the year. This suggests that, provided a minimum recharge occurs (about $^1/_3$ to ½ of recent winter events, say 150 mm to 250 mm, see Appendix 3) then late summer groundwater levels are not affected by summer drought. **The critical factor affecting late summer groundwater levels, therefore, is the length of time since the last significant recharge event.** Critically low groundwater levels may occur in the summer after an early wet winter if there is no further recharge in the rest of the winter and spring.

Groundwater recharge and throughflow can be estimated in a number of ways. By using measured rainfall, evaporation, soil moisture storage capacity and runoff data, an infiltration "budget" may be calculated. This has been carried out for the study area (Appendix 3.1), producing an estimated average annual recharge rate of 500 mm. Comparison with a similar study in the Pukekohe area (Appendix 3.2) produced an estimated average recharge rate of 350 mm per year.

To obtain a volumetric estimate, it is necessary to estimate catchment area. Total area of the Kaikohe basalt outcrop is 20 km^2, yielding annual recharge estimates of 1×10^7 m^3 and 7×10^6 m^3, based on the figures above.

An alternative estimate of the total available water resource may be produced by measuring the rise in groundwater level due to the winter recharge event and estimating proportion of aquifer storage (aquifer storage coefficient). This exercise for the Kaikohe basalt aquifer (Appendix 3.3) yielded resource estimates of 2.3 mm per year and 87.5 mm per year (4.6×10^4 m^3 per year and 1.75×10^6 m^3 per year) (refer Appendix 3.3).

Finally, the annual throughflow was estimated using the groundwater gradient and transmissivity estimates, (Appendix 3.4), to be between 9.4×10^5 m^3 and 2.6×10^6 m^3.

In summary, the total recharge and throughflow for the whole Kaikohe basalt aquifer appears to be of the order of 1 to 5 x 10^6 m^3 per year. Only one fifth or less of this resource is likely to be readily available at any one point in the aquifer.

Previous comments regarding the effective size of well catchments in the aquifer (Section 2.3.2) should be noted. A representative catchment area for a major well in the widest part of the aquifer, south of Kaikohe, might

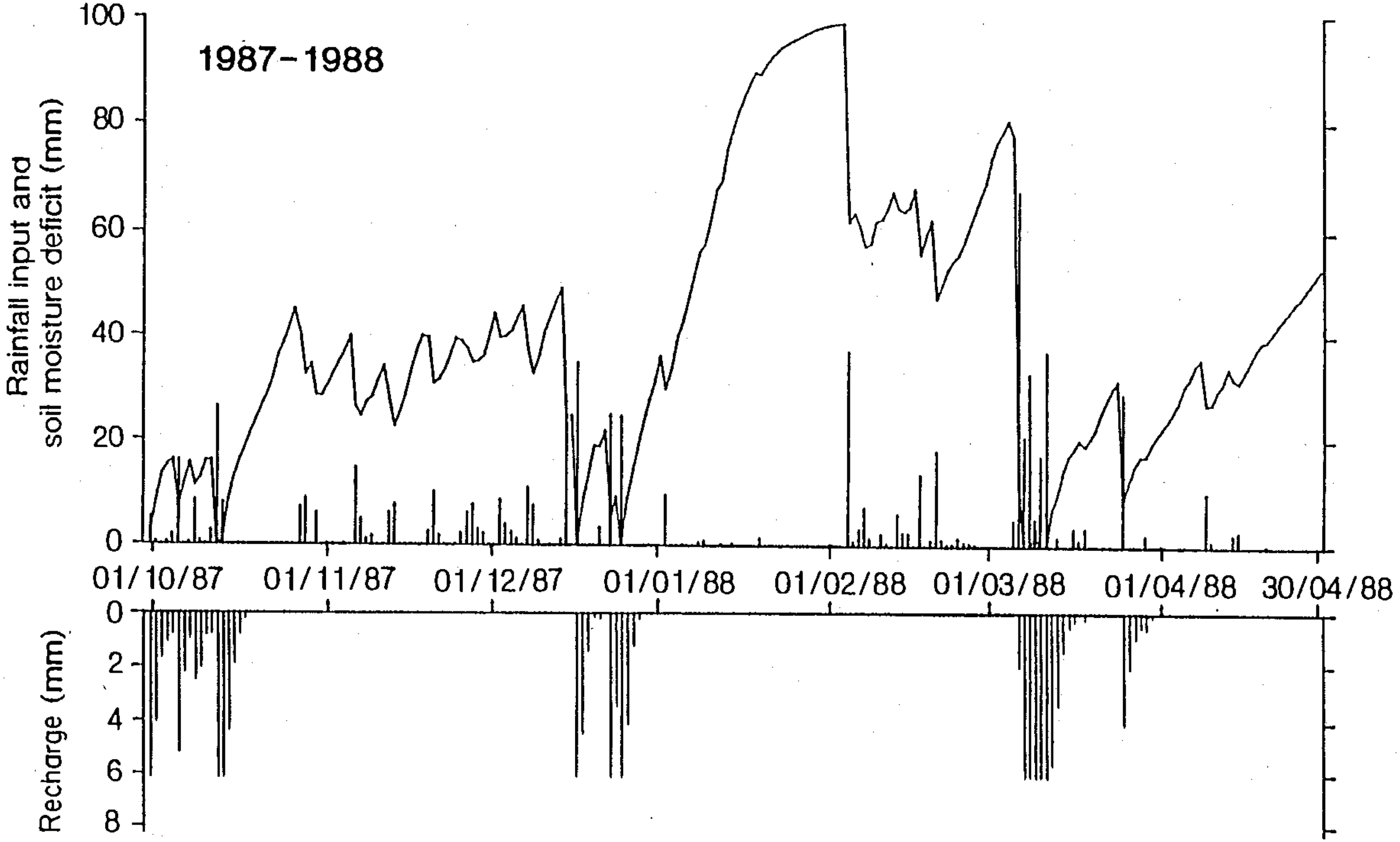

Figure 2.12: Pukekohe area soil moisture deficit, rainfall and recharge

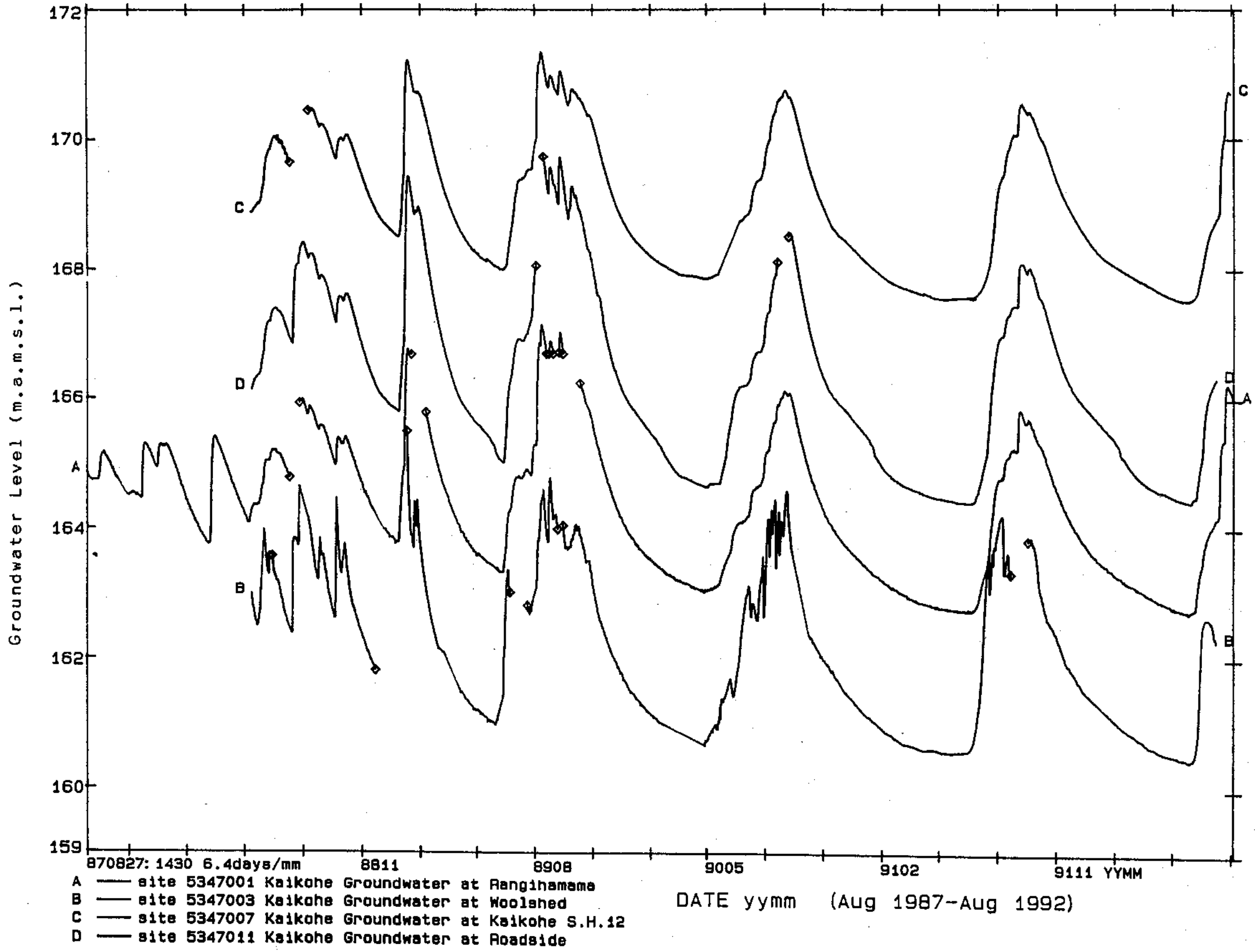

Figure 2.13 : Groundwater Levels - NRC Kaikohe Recorders

be 4 km^2, while a well towards the south of the aquifer might have a catchment area of less than 2 km^2. The recharge for such a subcatchment would therefore be 10 to 20% of the total for the aquifer.

Total Aquifer Storage

In addition to the annual aquifer recharge and throughflow estimated above, there is a considerable volume of stored groundwater in the aquifer at any one time.

Assuming an average aquifer thickness of 50 metres and aquifer conditions as set out in Appendix 3, total aquifer storage is probably of the order of 1 to 5 x 10^7 m^3.

However, use of any significant volume of this stored water could result in significant reductions in spring and stream flows.

2.4 STREAM FLOWS

2.4.1 General

Runoff and flow from the Kaikohe basalts drains to subcatchments of the Punakitere River which flows west to the Hokianga Harbour. The basalt flows are bounded to the north and east by the Wairoro Stream, to the north west by the Otangaroa Stream tributaries and to the south by the Punakitere River. The tributaries of the Omaunu and Tokakopura Streams drain the central areas of the basalt flows towards the southwest.

Stream locations can be seen in Figure 1.

There are numerous springs and seepages of groundwater that naturally sustain the flows of these streams during dry spells.

2.4.2 Groundwater Level-Spring Flow Relationships

A typical relationship between spring flow rates and nearby groundwater levels is shown in Figure 2.14. Peak weir flows occur immediately after heavy rainfall, as quickflow occurs. Stream flows after that time result largely from groundwater seepage. As groundwater levels decline, spring flows reduce, shown by the similar forms of the spring flow and groundwater recession curves. The relationship between the two records in Figure 2.14 is represented in a different way in the upper part of Figure 2.15. This relationship illustrates that it is possible to estimate spring flow at Windmill Spring with an error of less than 2%, using groundwater levels at the nearby Rangihamama monitoring well and an equation derived from recorded data.

Similar relationships occur throughout the Kaikohe basalts: a second typical relationship is shown in the lower part of Figure 2.15. **Clearly spring flow is very much determined by groundwater levels, and the relationship between spring flow and groundwater levels varies from place to place.** This is because of the varying nature of the springs, which occur at different levels and in different hydrogeological conditions. It is possible to predict spring flows at any point quite accurately. But first there must be a number of spring flow measurements to establish the spring flow/groundwater level relationship for the particular spring.

2.4.3 Low Flow Resource

A map showing low flow gauging sites and a list of low flow gaugings is contained in Appendix 4.

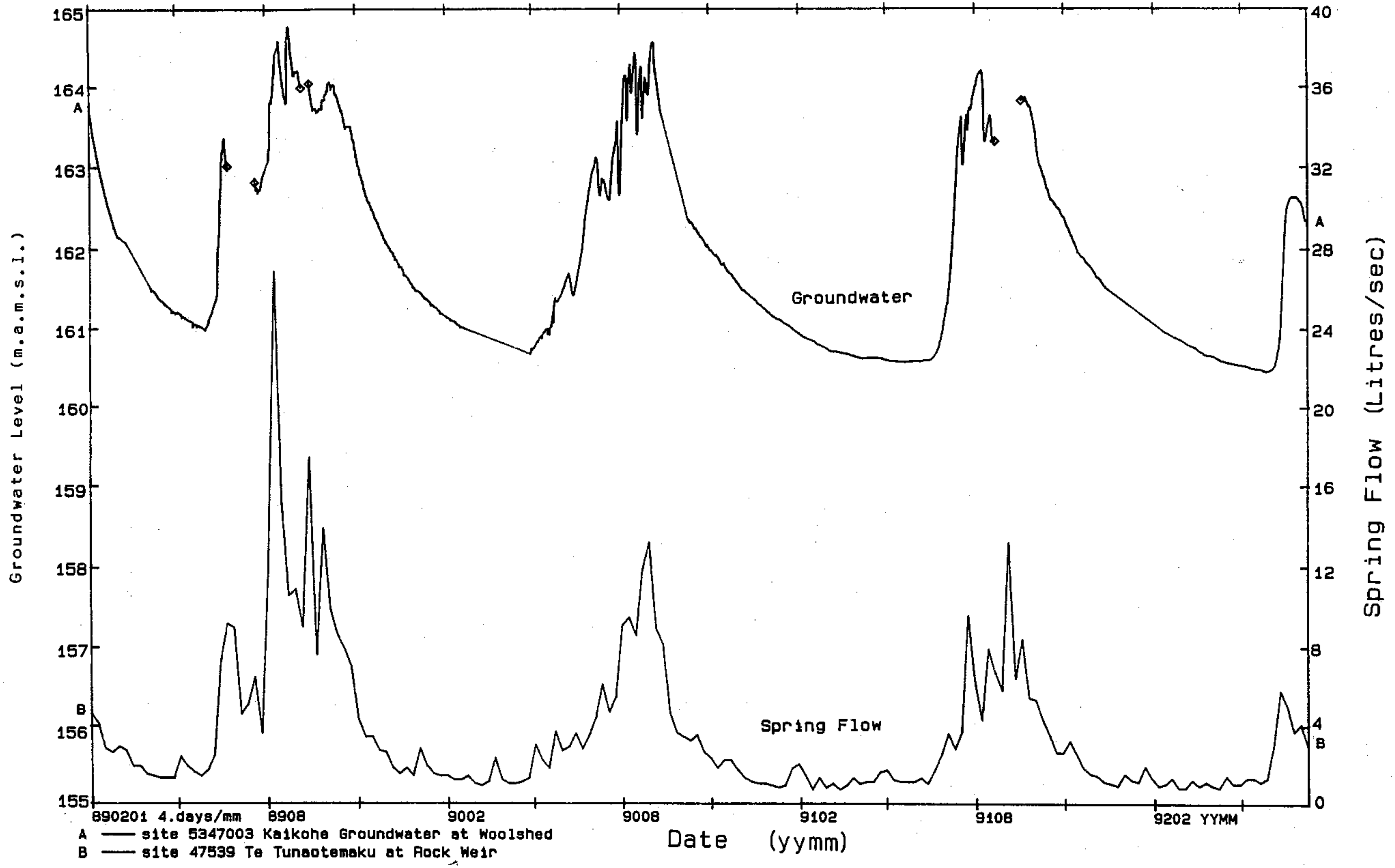

Figure 2.14 : Comparative Plot
Spring Flow (weekly average) and adjacent Groundwater Level
(Jan 1989 - Aug 1992)

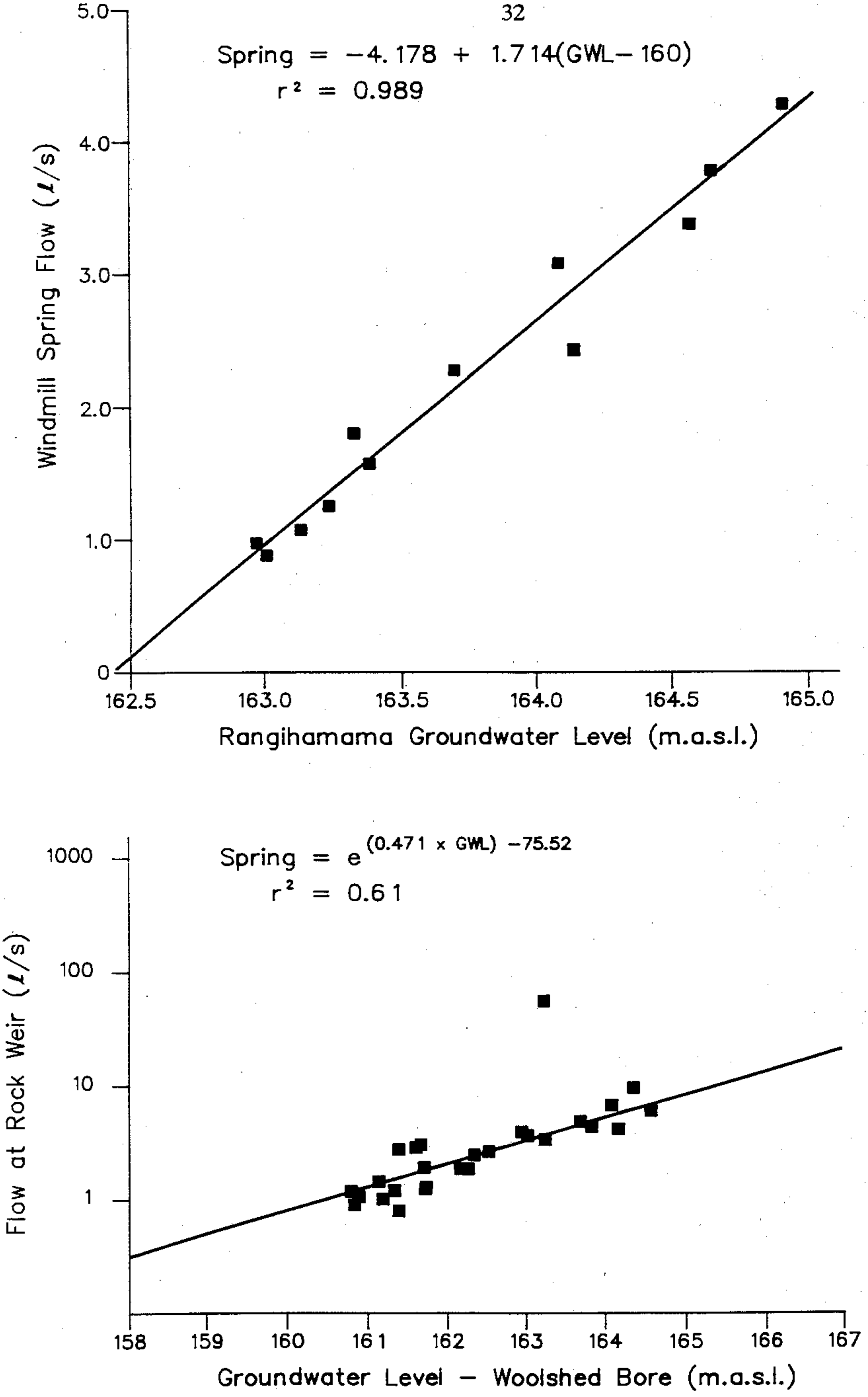

Figure 2.15: Relationship Between Groundwater Level and Spring Flow: Regression Analyses

There is no suitable long term flow recording site in or near the study catchment on which estimates of low flow frequency, return periods, could be based. However, analysis of the long term rainfall records indicate that the dry spells experienced during the study period, (1990/91 and 1991/92), were quite severe, as was the 1986/87 prolonged dry spell.

The 1987, 1990 and 1991 winters were relatively dry resulting in only a short period of groundwater recharge.

That combined with the following dry summers resulted in long periods without recharge and extreme low flows, particularly in small spring fed streams. Gaugings of flow in late summer of 1991 and 1992 are therefore a good measure of extreme low flows.

Heavy pumping of the Far North District Council Kaikohe Hill bores and Squires Springs would have further reduced flows, particularly in the upper Otangaroa Stream catchment, Waikaka and Mangamutu Streams. Over the 1990/91 summer, the Far North District Council was pumping 7 to 9 litres per second (700 to 800 m^3/day) on average from the Kaikohe Hill bores, about 125000 cubic metres was taken from the hill from October 1990 to March 1991. This resulted in the flow from Squires Spring almost stopping and the neighbouring spring dried.

Extreme low flows for the streams of the area are shown in Figure 2.16 The flows shown could be equated with about a 1 in 10 year return period low flow. However, if the rainfall pattern of the 1980's and early 90's continues, such low flows could be experienced more frequently. Some of the flows gauged and listed in Appendix 4 are likely to have been affected by water being taken from the streams at the time of gauging, particularly some of the smaller streams. In some of the small streams, flow may decrease going downstream due not only to pumping but also to natural loss, by evaporation from the stream and wetlands and seepage out of the stream. This is evident in the Omaunu Stream and Ohuka Stream.

Average and wetter summer flows will, of course, be significantly greater than those shown in Figure 2.16, as can be seen from the gaugings listed.

Otaua Stream and Upper Punakitere

It has been suggested that the headwaters of the Otaua Stream or the upper Punakitere River could be used for community water supply. Two sites on the upper Otaua Stream, at the end of Ranwick Road, were gauged, as was the Punakitere River at the falls adjacent to Mangakahia Road and just downstream of the Mangakahia Road bridge.

Some details on those sites are given in Table 2.4. The gauging results are listed in Appendix 4.

TABLE 2.4 OTAUA STREAM & UPPER PUNAKITERE RIVER FLOW GAUGING SITES & ESTIMATED LOW FLOWS

Site No.	Stream	Map Reference	Elevation (m.a.m.s.l.)	Approximate Distance to Kaikohe	Estimated Low Flow
47555	Otaua	P06:733-292	160	20 km +	70 l/sec
47559	Punakitere	P06:861-374	100	7 km	45 l/sec
4755	Punakitere	P06:859.374	100	7 km	80 l/sec

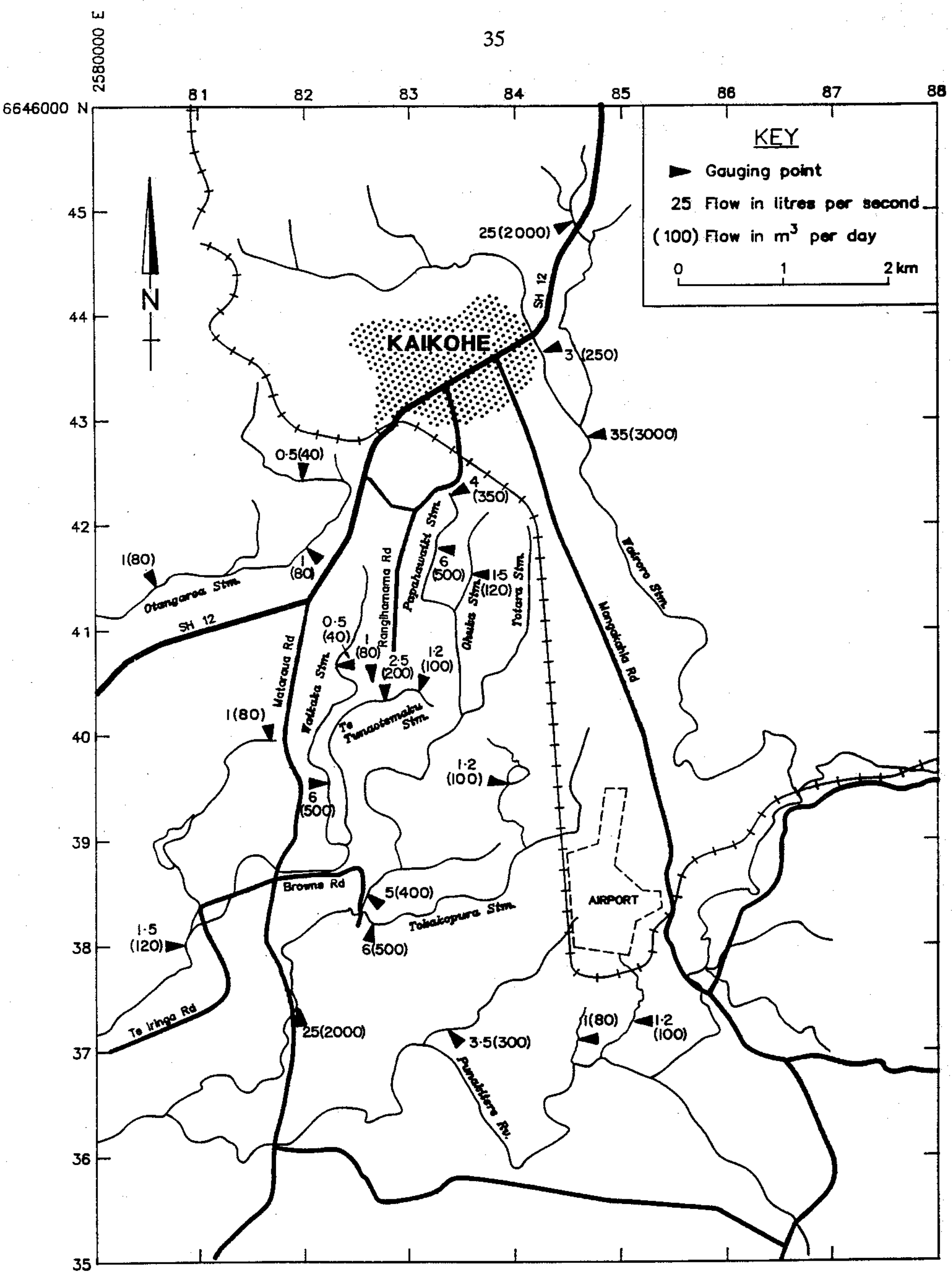

Figure 2.16: Estimates of Extreme Low Flows

2.5 WATER QUALITY

2.5.1 Stream Water Quality

Stream water was sampled at a number of sites in the study area during late summer low flows and at some sites once during higher flows in late spring. The sampling sites are shown in Figure 2.17 and the water quality analysis results are given in Table 2.5.

In general, the results are typical of small streams in predominantly agricultural areas.

The following are some notable features of the water quality results:

(i) There were some low dissolved oxygen levels, less than 6 g/m^3 and as low as 1 g/m^3, at some of the small stream sites downstream of wetlands (sites 1170, 1171 and 1174) when flows were low.

(ii) Samples from those same sites and sites 1172, 1173 and 1180 also had fairly high iron concentrations (0.6 to 3.2 g/m^3).

(iii) The pH of most of the small stream samples was generally acidic and at the low end of the natural range.

(iv) A couple of the small stream samples showed elevated nitrate concentrations (sites 1170, 1171, 1172, 1175 and 1176).

(v) The low flow sample from site 1171 had an elevated ammonia concentration and BOD5 (oxygen demand of decomposable organic material).

(vi) Several samples had elevated Faecal Coliform bacteria counts of 1000 to > 6000 per 100 mls, these included the November sample of the larger Punakitere River.

The low dissolved oxygens, low pHs and high iron concentrations are likely to be a result of the combination of low flows, upstream wetlands and basalt geology and are likely to occur naturally. However, reduced flows due to heavy use of stream flow and groundwater could increase the effect.

The raised nitrate, ammonia, BOD5 and bacteria levels are likely due to runoff from pasture and grazing of stream banks ie. from stock dung, urine and fertiliser entering the streams.

TABLE 2.6 BORE AND SPRING WATER SAMPLE ANALYSIS RESULTS (Sample and site numbers as per NRC water quality data base)

SITE NO	SAMPLE	DATE	TIME	PH pH	COND mS/m	TEMP Deg.C	ALKT g/m3	ALKB g/m3	CL g/m3	SO4 g/m3	CA g/m3	MG g/m3	NA g/m3	FET g/m3	MNT g/m3	K g/m3
Kaikohe Hill Town Supply Bore				P05:820-432												
001922	NLD910730	910221	1030	6.9	16.1	18.0	49	60	11	2	11.0	4.9	12.8	<0.04	<0.02	1.36
Squires Spring				P05:821-426												
001921	NLD910731	910221	1015	6.6	9.2	16.5	22	27	9	2	5.4	3.3	8.9	<0.04	<0.02	0.80
Windmill, Pioneer Village				P05:835-428												
001919	NLD910732	910221	1100	7.1	14.4	19.0	65	79	10	3	5.6	11.2	9.3	5.3	0.02	0.90
Kairangi Orchard				P05:827-412												
001917	NLD910733	910221	1130	7.5	17.8	18.0	66	80	13	1	12.2	9.0	12.2	<0.04	<0.02	0.80
Johnson No.3				P05:823-411												
001918	NLD910734	910221	1200	6.6	15.9	17.5	27	33	14	2	10.5	5.1	12.3	<0.04	<0.02	1.11
Johnson No.1				P05:828-434												
001920	NLD910735	910221	1215	7.2	18.0	18.5	60	73	11	2	12.6	6.1	14.6	0.07	<0.02	1.53

Key:

DO	dissolved oxygen
COND	conductivity
ALKT	total alkalinity
ALKB	bicarbonate alkalinity
SS	suspended solids
BOD5	biochemical oxygen demand (5 day)
NNN	nitrite/nitrate nitrogen
NH4	ammoniacal nitrogen
DRP	dissolved reactive phosphorus
SO4	sulphate
CA	calcium
MG	magnesium
NA	sodium
FED	iron dissolved
FET	iron total
MNT	manganese total
K	potassium
FC	Faecal coliforms
CL	chloride

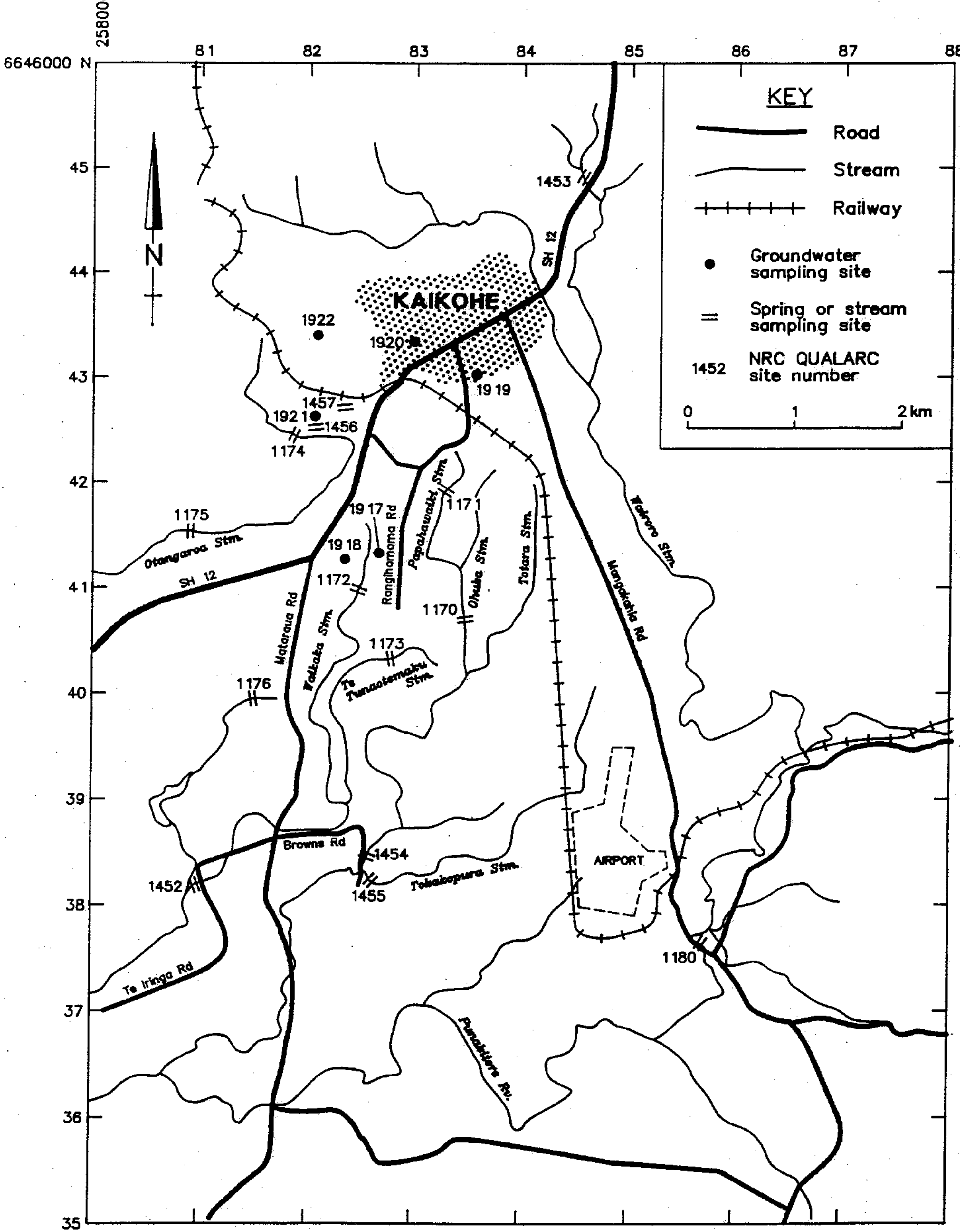

Figure 2.17: Water Quality Sampling Sites

The stream waters sampled are not suitable for domestic water supply without prior treatment, primarily because of the bacterial counts which indicate the possible presence of disease causing organisms. The relatively low pH and high iron concentrations may give the water an unpleasant taste, and cause staining and corrosion of plumbing.

The stream water quality would be generally acceptable for stockwater and irrigation use. Although the pH and iron could cause corrosion and blockages of plumbing.

2.5.2 Groundwater Quality

Five bores and one spring were sampled. The site locations are shown on Figure 2.17 and analysis results given in Table 2.6.

The groundwater quality sampled was generally good and suitable for most uses. The sample from site 1919 had a high iron concentration of 5.3 g/m^3, which would likely give the water a bad taste and cause staining. High iron concentrations are not uncommon in bore water from basalt aquifers and in that particular case may have been related to corroded pipes.

2.5.3 Discharges of Contaminants

There are a number of sources of contaminants that could have a significant adverse impact on groundwater and stream water quality in Kaikohe basalt catchment area.

Groundwater and stream flow are closely linked and contamination of groundwater is likely to flow through to springs and streams.

Potential sources of groundwater contamination in the area include nitrate from stock wastes and nitrogen fertilisers, leachate from the Kaikohe tip, the closed sawmill and timber treatment site, infiltration of urban stormwater soakage, leakages from sewer lines and service station inground storage tanks, and rural septic tank effluent soakage. The limited sampling of groundwater from some of the most heavily used bores showed the groundwater quality to be generally good. However, having the Kaikohe urban area and an intensively farmed rural area on top of the basalt aquifers means that the potential for significant contamination exists. If the water quality of the resource is to be preserved, significant discharges of contaminants onto or into the ground must be avoided.

The major source of contaminants in the streams is runoff from farm land, particularly grazed stream margins. Runoff from farm races where they cross streams may also contribute significantly. Stock crossing, drinking and grazing in streams will reduce water quality during low flows. Urban stormwater discharges and runoff from roads may also contribute significant contaminants directly to streams.

The only major point source discharge is that from the Kaikohe sewage treatment pond and wetland to the Wairoro Stream.

2.6 WETLAND AND STREAM HABITATS

As part of this investigation, a brief survey was undertaken of 12 stream and wetland sites to the south and southwest of Kaikohe to evaluate their habitat value and the general ecological state of the streams and wetlands of the area.

General instream and ecological values were found to be low due to agricultural activity, particularly due to grazing of stream banks and wetlands. Fishery values were considered low with short fin eels being the only species commonly present.

There are, however, a number of wetlands that, if fenced, would create good potential habitats, especially for wetland birds.

The wetland adjacent to Browns Road and the lake created by the man-made 'Mawhitu Dam' on the Waikaka Stream are registered by the Department of Conservation as 'Sites of Special Biological Interest'. The Browns Road wetland has an SSBI ranking as a potentially valuable habitat and Mawhitu Dam has a moderate ranking.

More complete details of the survey can be found in the reports in Appendix 5.

3.0 GROUNDWATER/STREAMFLOW - CONJUNCTIVE USE

3.1 INTRODUCTION

The resource descriptions presented above have demonstrated the interdependence of groundwater and surface water (stream and spring) resources. It is necessary to recognise the relationship, and to plan resources use in a conjunctive way. This section discusses the availability of groundwater and surface water, the effects of groundwater use on surface water availability, and ways of managing both resources to best effect.

3.2 EFFECTS OF GROUNDWATER ABSTRACTION ON STREAM FLOW

3.2.1 General

Abstraction of groundwater at one point will lower groundwater levels in the surrounding area. Section 2.4 discussed the effects of groundwater levels in the Kaikohe basalts on spring flows.

The quantitative effect of well abstractions on spring flows will vary according to the distance between well and spring, distances to aquifer boundaries, the elevation of the spring, season (ie. whether groundwater levels and hence spring flows are naturally high or low) the rate and timing of pumping and many other factors. To illustrate the general nature of these effects, an example is presented below of the likely effect of pumping at one well on one spring, assuming most of these variables are constant.

3.2.2 Rangihamama Example

The example considered here is that of the effects of a well at the Rangihamama site, previously investigated for Kaikohe Borough Council (KBC) as a possible water supply source (Thompson, 1987; Roberts, 1987), on the spring catchment monitored at Rock weir (refer Figure 3.1).

Abstraction of groundwater from a well results in lowering of groundwater levels, which can be predicted using standard equations (eg. Freeze and Cherry, 1981) and pumptest results. The results of previous testing at the Rangihamama site (Thompson, 1987) have been used to predict groundwater levels in the surrounding area after pumping at different rates for a period of 3 months (see Figure 3.2).

The relationship illustrated in Figure 2.15 shows that groundwater levels at the Woolshed well can be used to predict spring flows at the Rock Weir Site. By calculating drawdown at the Woolshed well from Figure

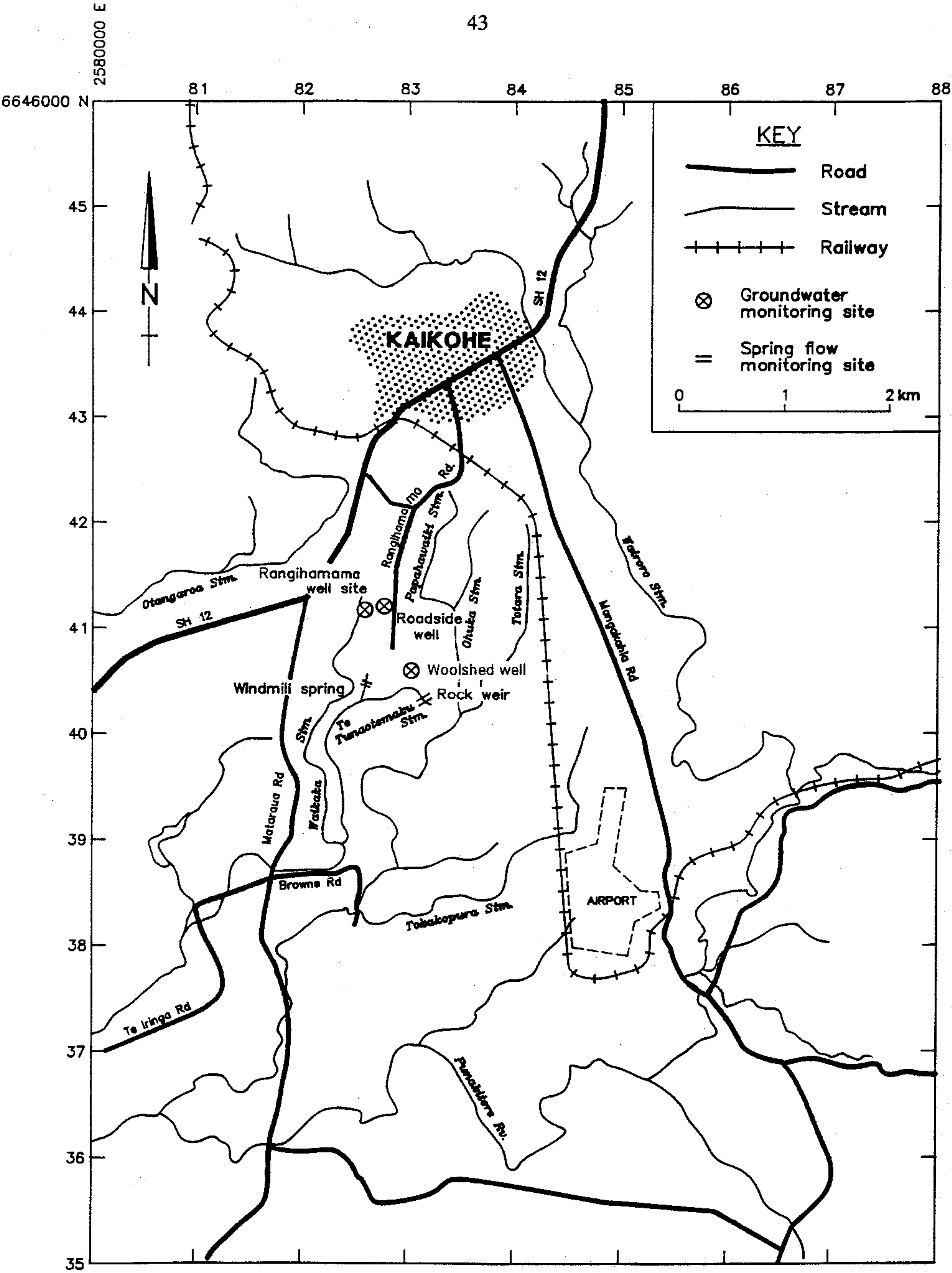

Figure 3.1: Location Plan, Rangihamama Area Monitoring Wells and Springs

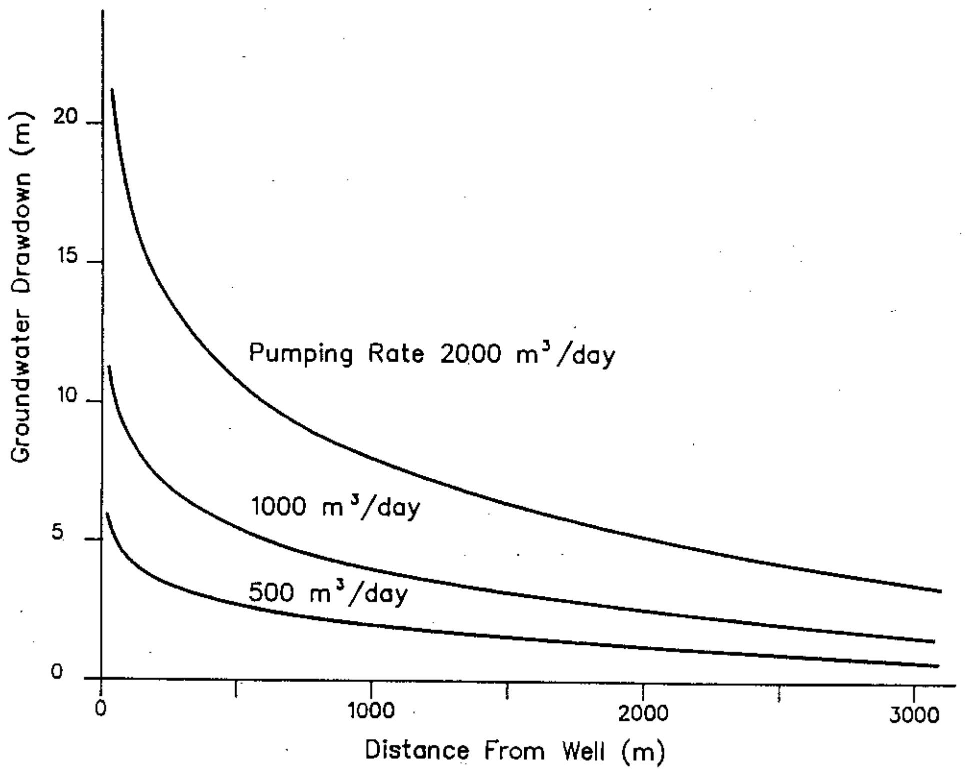

Figure 3.2: Distance – Drawdown Relationship For a Well at Rangihamama After 100 Days Pumping

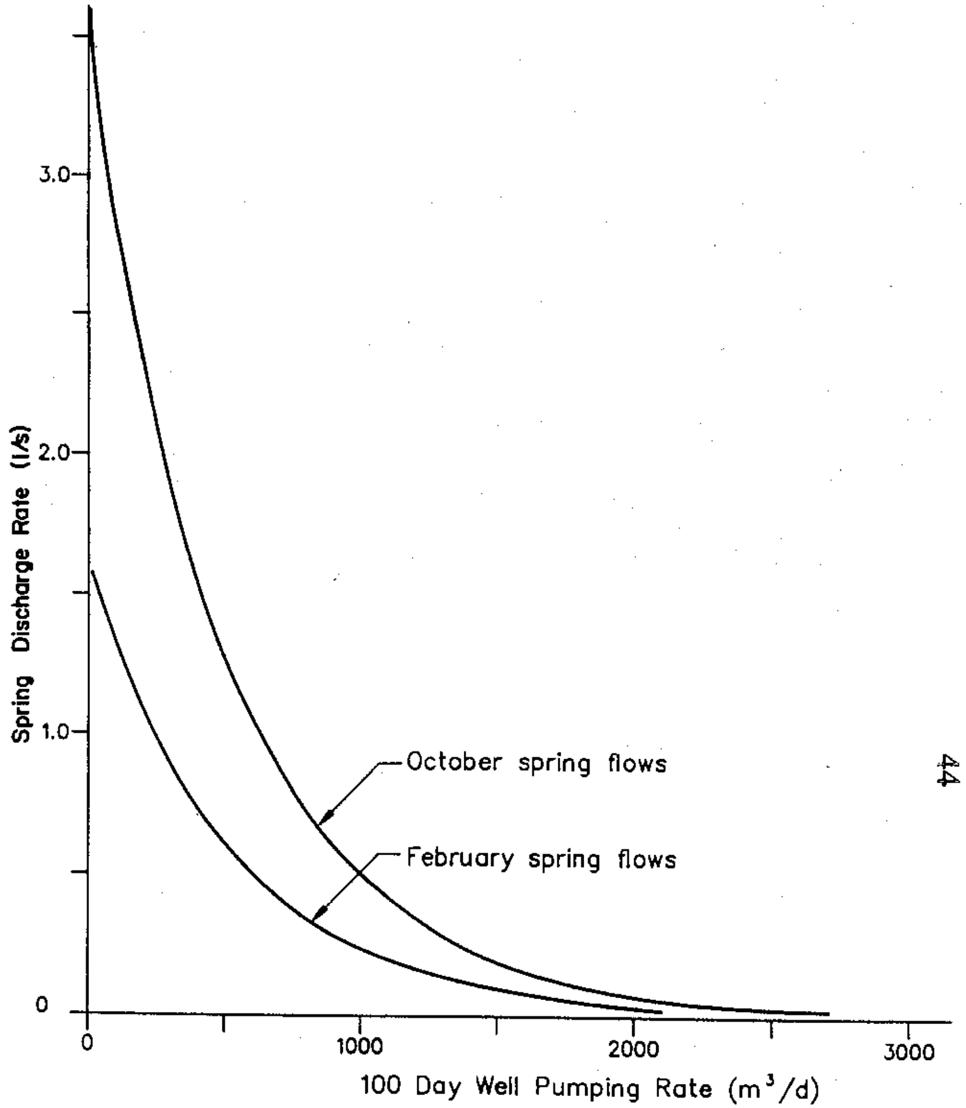

Figure 3.3: Effect of 100 Days Abstraction at Rangihamama on Spring Flows at Rock Weir

3.2, reductions in springflows at Rock weir have been estimated, as shown in Figure 3.3. Because the relationship between groundwater level and spring flow is not linear, the effect on spring flow will depend on "undisturbed" groundwater levels ie. flow reduction effects will be different at different times of the year. This is shown by estimating the effect of different Rangihamama well abstraction rates on spring flows in February (summer low flow) and October (late winter flow) in Figure 3.3. For example average October spring flow is approximately 3.5 litres per second. Abstracting groundwater from a Rangihamama well at 200 m^3 per day from July to September would reduce this flow to 2.25 litres per second, a reduction of approximately 1.2 litres per second (100 m^3 per day). Figure 3.4 illustrates the likely effects of such an abstraction in terms of changes to typical pumping, groundwater and spring flow records.

It is clear from this example that substantial effects on spring and stream flows can result from groundwater abstractions. If minimum stream flows are to be maintained, in order to supply existing downstream users, then strict constraints on the rate, timing and location of groundwater abstractions maybe required. For example, if a minimum flow of 1 litre per second is required in the example case, then a long term Rangihamama abstraction rate of 100 m^3 per day to 200 m^3 per day may be sustainable, but a higher abstraction rate (which the well could certainly provide) would result in unacceptability low spring flows.

As discussed in Section 2.4, spring flow - groundwater level relationships are unique so prediction of impacts in detail must be carried out on a case by case basis. However, the principles illustrated by this example apply to all well/spring relationships in the Kaikohe basalt aquifer.

3.3 WELL & SPRING YIELD - 'EFFICIENCY'

The above example also shows that it is more efficient, in simple water supply terms, to abstract at a higher rate from groundwater, than to reduce groundwater abstractions to maintain spring flows. For example, higher overall production could be achieved by pumping the Kaikohe well than by reducing well yields to increase Squire's spring flows. This will, of course, depend on pump positioning and well efficiency.

This is because the groundwater flows affected by a well would probably discharge to more than one spring or stream reach, and because, through more complex aquifer storage effects, well abstractions create a an aquifer storage "deficit" which is replaced by recharge that would otherwise discharge to a stream or spring during late winter/early summer high flows (see Section 3.4 below).

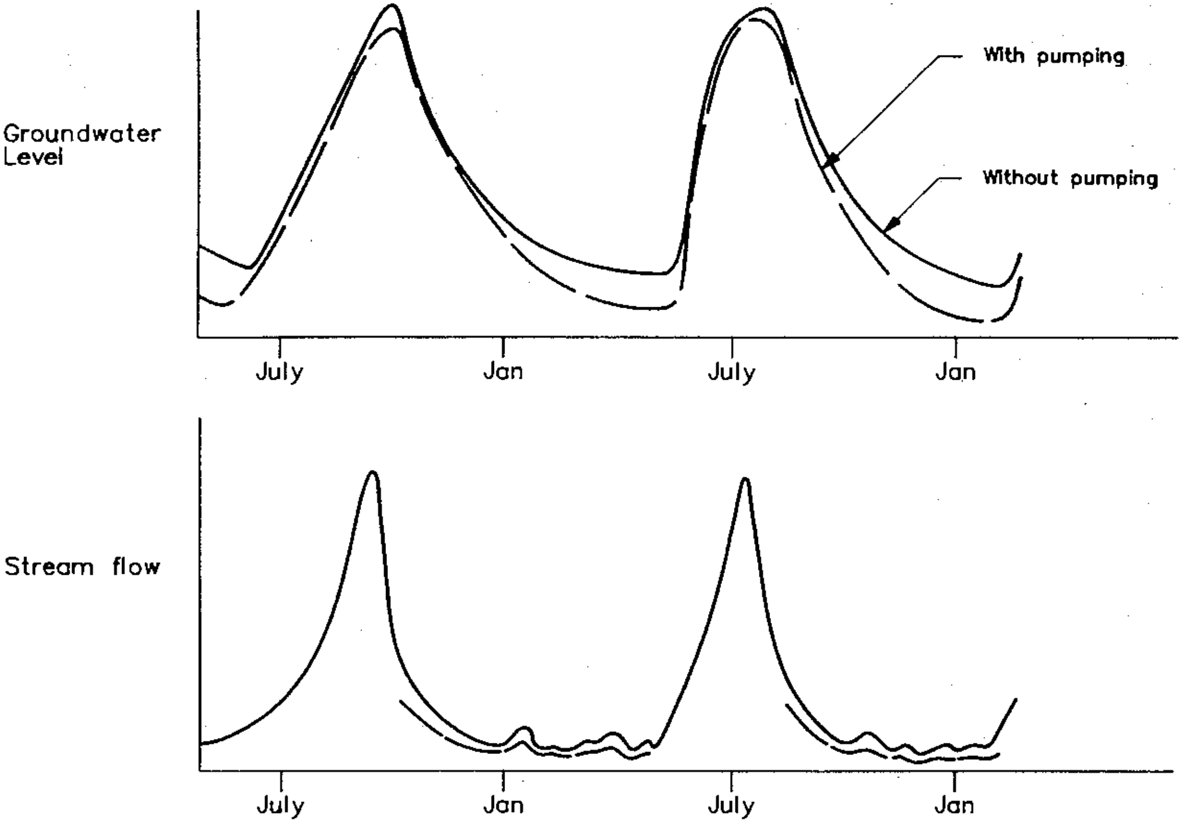

Figure 3.4: Indicative Effects of Rangihamama Abstractions on Groundwater Levels and Stream Flows

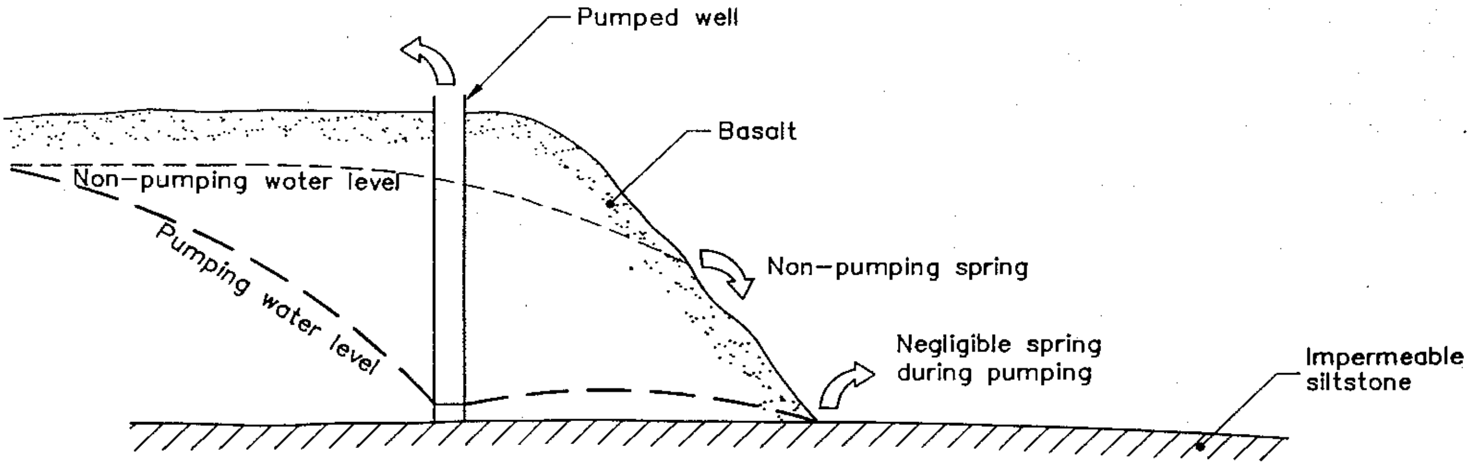

Figure 3.5: Pumping Effects Close to an Aquifer Boundary

The definition of "efficiency" used above ignores the need to provide supplies at a number of different locations, and does not consider other water uses or values, for example, the aesthetic, cultural, recreational and ecological values of a flowing stream. For example, heavy pumping of the Kaikohe Hill well reduced Otangoroa Stream flows to an undesirably low level.

3.4 EFFECTS OF WELL LOCATION ON RESOURCE AVAILABILITY

Groundwater drawdown and hence well performance and abstraction related impacts on spring/stream flows, may be strongly affected by the location of a well within the aquifer. Figure 3.5 shows that groundwater abstractions close to an aquifer boundary increase drawdowns and limit well performance. The locations of some aquifer boundaries, and the relationship between groundwater in the Kaikohe and older basalts is not known, but it is clear that wells close to the edge of the Kaikohe basalt will have a substantially greater effect on spring and stream flows than those at a greater distance.

The discussion in Section 3.2 showed that any well abstraction will affect spring flows, and that acceptable minimum spring flows need to be determined to define appropriate abstraction rates. It follows, that major abstractions, if they are not to cause unacceptable impacts on spring flows, should be spread over a number of locations, rather than concentrated in one part of the aquifer. For example, a limited quantity of the water now taken from Kaikohe Hill could be taken from the Rangihamama area, thus spreading the impact, but reducing the severity of the impact.

It is noted that the most efficient part of the aquifer for a major abstraction is the scoria cone of Kaikohe Hill. A combination of high permeability and, probably, high storage coefficient and high infiltration rates, means that this area is the part of the aquifer most capable of sustaining a long-term large scale abstraction. However, it is clear that over abstraction can (and has done so in the past) result in stream/spring flow impacts.

3.5 SEASONAL RESOURCE AVAILABILITY

Groundwater level records (see Figure 2.13) show that rapid recharge usually occurs during mid to late winter as the soil moisture deficit is satisfied. This recharge event apparently replaces any excess volumes taken out of the aquifer and elevates groundwater levels to a point where they are high relative to springs. Spring flow recession curves (spring flow over the time following recharge) have, in general, two parts with a relatively sharp division between: a period of high flow which occurs when groundwater levels are relatively high, and a period of low (or base) flow, when groundwater levels are close to spring elevation. Analysis of recharge events associated with single rainfall events (eg. Cyclone Bola) and longer winter rainfalls (months) indicates that, provided recharge events achieve a certain minimum raising of groundwater levels, the low flow recession curve is unaffected by the size of the recharge event.

This means that much of the groundwater rises resulting from normal winter recharge events, which produce high late winter/early summer spring flows, could be abstracted without affecting important late summer low flows. Groundwater abstracted from wells or springs at this time could be stored for use when groundwater levels are lower, or could be used in lieu of stored water which could therefore be conserved for later use, or used in lieu of more costly sources.

An alternative strategy suggested by this analysis is that groundwater could be used as storage buffer, provided that reduced spring and stream flows are acceptable. This would involve pumping all year including during late summer and early winter. If large quantities were pumped, this would result in drying up of springs and streams which would otherwise continue to flow. The winter recharge event would then replace the "overdraft" resulting only in a minor reduction in peak spring discharges, probably not observable against a background of high rainfall runoff (quick flow).

Such a strategy may require replacement of some of the spring/stream supplies currently relied upon by downstream users, presumably by reticulation from the well system, and acceptance of the loss of other values of those reaches of the stream which may be dried.

3.6 QUICKFLOW/RUNOFF UTILISATION

A proportion of rainfall onto the basalt aquifer runs off without infiltrating into the ground or evaporating. Little of this quickflow is utilised as a resource, and some potential exists for its use.

Quickflow could be retained in a storage dam for subsequent use. However, given relatively flat nature and high porosity of the basalt flow, and hence relatively high infiltration rates and dam construction costs, it would appear more appropriate to investigate dam options in steeper, less permeable catchments. Suitable catchments may exist in the surrounding Cretaceous siltstone hills.

A second option could be to use the quickflow to artificially recharge the basalt aquifer using leaky dam-like impoundments. Most such recharge would take place during times of high natural recharge and would simply contribute to higher late winter/early summer spring flows. Some potential does exist for artificial recharge using summer storm runoff. Further consideration of the economics of a summer recharge system may be worthwhile at some future time if demand for water increased dramatically.

3.7 FURTHER INVESTIGATIONS

The discussion, in general terms, of water resource availability presented above has been based on existing monitoring and aquifer testing information. In order to investigate the effects of specific major abstractions, additional investigations would be required. In this context, a major abstraction can be considered as any proposed take of greater than about 200 m^3 per day, or a smaller take close to an aquifer boundary or important spring.

Appropriate further work to determine the impacts of specific groundwater abstractions on surface water availability would include:

(i) longer, higher rate pump testing than previously carried out, to establish, at least on a local scale, the nature and extent of the aquifer system, effects on spring and stream flows, and any interactions with other aquifers;

(ii) mapping and gauging of springs and stream flows, and establishment of correlations with nearby groundwater levels, to allow estimation of abstraction related impacts; and

(iii) development of a groundwater model based on this data, which would enable quantitative prediction of abstraction impacts on surface water resources.

Currently, NRC is monitoring rainfall, spring flow and groundwater flow in the Kaikohe area. Existing data demonstrates a high degree of correlation between groundwater levels, so maintenance of more than one of these recorders does not appear necessary. Spring flow records show that good correlation with groundwater level records exists, but that the correlation is site-specific. Therefore it is recommended that spring flow monitoring be established in relation to specific abstraction proposals, and that current monitoring of spring flows only be continued if exercise of the right issued to FNDC is likely.

Continued maintenance of rainfall monitoring and one groundwater recorder would provide the long term records necessary for the evaluation of long term trends as part of any impact assessment. It may also be appropriate, if abstractions in the area are considered likely, to consider establishing a groundwater monitoring well in the basalt's southern lobe, to establish baseline groundwater conditions in this relatively separate area

4.0 WATER USE

4.1 COMMUNITY WATER SUPPLY

The Kaikohe urban area, with a population of about 4000 and only light service industry, has current water usage of approximately 1650 m^3/day on average, giving an annual usage of about 600,000 m^3. Peak summer time usage is about 2400 m^3/day with winter usage being closer to 1300 m^3/day.

The Far North District Council (FNDC) currently supplies this usage from four sources. A summary of the current water permits and water availability from these sources is given in Table 4.1 and their locations are shown on Figure A6.1 in Appendix 6.

4.1.1 Rangihamama

The FNDC holds a permit (No. 4393 - see Table 4.1) to take from groundwater adjacent to the southern end of Rangihamama Road. The permit has conditions restricting the quantity that can be taken depending on the flow in the adjacent Waikaka and Papahawaiki Streams. However, FNDC has not yet made use of the permit as it cannot gain access to the bore site. In any case, the FNDC would not have been able to take any water from the proposed Rangihamama bore for 25% of the time since the permit was issued in 1989 because the flow in the upper Waikaka Stream was less than the 1.0 l/sec cut off. They could have taken up to 550 m^3/day for 15% of that time and greater than 550 m^3/day for just over 60% of the time.

The District Council's predecessor, the Kaikohe Borough Council applied to take up to 2300 m^3/day from groundwater in the Rangihamama area.

4.1.2 Wairoro Stream

The Wairoro Stream supply water permit (No. 4109) allows FNDC to take up to 1800 m^3/day from May to November and 1300 m^3/day for the rest of the year. The permit requires that a flow of at least 8.4 l/sec is left in the stream, but even in recent prolonged dry spells this has not prevented FNDC from taking 1300 m^3/day when required.

4.1.3 Kaikohe Hill

During the period November 1990 to March 1991, FNDC pumped heavily from Kaikohe Hill up to the limit of their permit. This resulted in Squires Spring almost drying and the drying of a neighbouring spring. However, a report on Kaikohe Hill groundwater levels, pumping records

TABLE 4.1 CURRENT WATER SUPPLY SOURCES AND PERMITS HELD BY FAR NORTH DISTRICT COUNCIL FOR KAIKOHE WATER SUPPLY

(All figures in m^3/day)

Water Permit No.	Source	Permit Maximum		Average	Available During Prolonged Dry Spell	Permit Expires
		per day	per year			
4046	Taraire Dam	not restricted		300	100	1998
4109	Wairoro Stream	1800 (1300^+)	566000	1550	1300	2002
1862	Kaikohe Hill bores and Squires Spring	1100	total 288000 (bores 180000)	790 (500 from bores)	500-1100*	1998
4393	Rangihamama Bore + +	1600	218000	600	0**	1995

+ Quantity restricted to 1300 m^3/day from November through to May.

* Depends on Far North District Council pumping strategy (see text).

+ + Far North District Council cannot currently exercise this permit as it cannot get access to bore site.

** Current permit restrictions based on flow of Waikaka Stream would have severely restricted use of this source, refer to text.

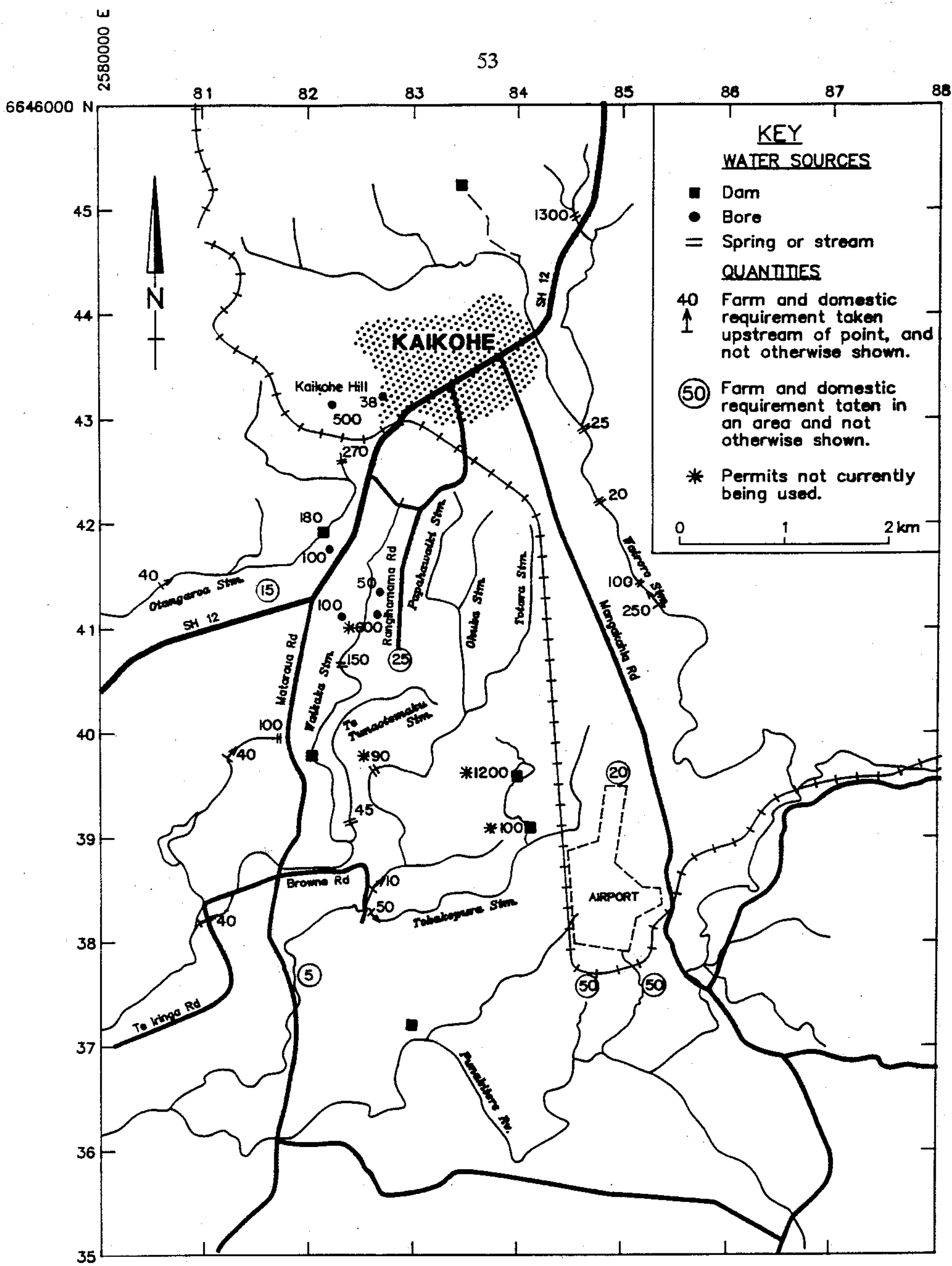

Figure 4.1: Summer Water Use
Current permit allocations and farm and domestic water supply requirements
(refer to Table 4.2)

TABLE 4.2

EXISTING WATER DEMAND AND PERMIT ALLOCATIONS

(All Figures in m³/day)

Water Use	Sub-Catchments Otangaroa Stream u/s of Jordan Rd	Omaunu S.tribs u/s of Te Iringa Rd Confluence	Tokakopura u/s of Browns Rd	Punakitere River Tributaries	Wairoro Stream u/s of quarry
Farm and Domestic					
Surface water	41	92	50	100	250
Groundwater	17(a)	15	19		
Community Water Supply (FNDC)					
Surface Water	270(c)				1300
Groundwater	500(b)	*600			
Irrigation					
Surface Water	180 (dam, d)	295(e)	90 *1200 (dam)		510
Groundwater	100	150			
Industrial					
Surface Water			*100		
Groundwater					

*not currently being used

(a) Based on half the properties using bores.

(b) Far North District Council Kaikohe Hill bore abstraction, an average figure, the impact of this is spread over several sub-catchments.

(c) At times of prolonged dry spells, 1 l/sec must be left to flow in the stream and little water may be able to be taken.

(d) At times of prolonged dry spells, 1.1 l/sec must be left to flow in the stream.

(e) 150 m³ of this only permitted to be taken for a two week period in November-December each year, from Waikaka Stream.

u/s: upstream

and spring flows for that period (P Jacobson, FNDC per. con., 1992) concludes that FNDC should be able to pump up to 1100 m^3/day from the Kaikohe Hill sources during summer without drying the springs. That is, provided the groundwater level in the hill is above a certain level (approximately 206 masl) in early December.

To achieve this, FNDC has suggested a strategy of restricting its winter pumping. However, it is during the normal recharge months of winter that the most groundwater can be pumped with least effect, both at the time of pumping and as far as late summer spring flows are concerned. Restricting pumping in late spring and early summer would be more effective at protecting late summer spring flows and allowing mid to late summer use of the bores.

FNDC staff have also suggested the use of a minimum groundwater level (at 202.7 masl) as a "lowest normal operating level" at which pumping would be stopped to prevent springs from drying.

If spring flow is to be protected, and the Kaikohe Hill resource used efficiently, then close monitoring of abstractions, spring flow and groundwater level should continue.

4.2 RURAL DOMESTIC AND FARM WATER SUPPLIES

Farm water needs are mostly taken from small springs, streams, and shallow bores with storage dams being used in a few cases. Stock also have direct access to streams for drinking.

Estimating the farm water supply requirements and usage of the area that relies on the basalt groundwater and streamflow resource is difficult because of the variety and number of sources used by some farms, and lack of measurements of actual use. For example, farms often use different sources depending on where the stock are on the farm.
The following estimates have been based on evidence presented at the hearing of the Kaikohe Borough Council water right applications in 1988 and a water use survey undertaken by landowners from area to the south of Kaikohe in January 1989. The estimates of water volumes needed are based on stock and house numbers given and on a water requirement of 145 l/day for milking cows, 50 l/day for dry cattle, 4.5 l/day for sheep, and 1000 l/day per house.

The estimated farm water supply demand is summarised by sub catchment in Table 4.2. The locations of the abstractions are summarised in Figure 4.1, small individual water supply takes are not shown separately but have been grouped.

The rural domestic and farm water supply needs of the area which relies on the Kaikohe basalt resource is estimated at approximately 350 m^3/day and 125000 cubic metres per year. That does not include the uses of the Wairoro and Kopenui stream catchments.

4.3 IRRIGATION

Currently there are water permits issued for up to 2015 m^3/day for irrigation from the Kaikohe basalt resource, with a further 510 m^3/day from the Wairoro Stream catchment. However, a major proportion of that allocation is not being used primarily the 1200 m^3/day from the dam on the Rangihamama block (Permit No. 2452).

Although the area currently used for horticulture is only about 20 to 25 hectares, there is a large area, approximately 2000 hectares of soil associated with the Kaikohe basalts that is suitable for intensive horticultural use (Harmsworth, 1990). Most crops require irrigating on those soils even if only for a few weeks per year. The irrigation requirements of such an area could be tens of thousands of cubic metres per day.

The NZ Land Resource Inventory (Harmsworth, 1990) map for the study area showing the Land Use Capability Units, soil and rock types and land cover is given in Appendix 7.

A list of current and expired water permits for the study area and the Wairoro Stream catchment is given in Appendix 6.

It is not possible to say if any increase in the demand for irrigation water is likely. The trend over the last few years has been a decrease in irrigation water demand in the Kaikohe area with a number of people surrendering their water permits and not proceeding with planned horticultural developments. This can be seen from the expired and surrendered permits shown in Appendix 6.

5.0 WATER AVAILABILITY VERSUS CONSUMPTIVE DEMAND

5.1 OBJECTIVE

This section relates to the demand for water for consumptive uses outlined in Section 4 to the groundwater and streamflow resources identified in Section 2.

5.2 EXISTING PROBLEM AREAS

5.2.1 Otangaroa Stream - Kaikohe Hill

The tributary of the Otangaroa Stream which runs along the NW edge of the Kaikohe basalt aquifer, NW of SH12, is heavily used to the extent where there is little more than 1 l/sec left flowing at Jordan Road during a prolonged dry spell. The existing water permits are restricted by a small, 1 l/sec continuation flow requirement. NRC has received a number of complaints over recent years, from those using the stream for stock and domestic water, that there is insufficient flow and poor water quality during prolonged dry spells.

Heavy pumping of Kaikohe Hill bores caused the Te Kotahitanga Marae spring on the lower southern side of the hill to dry up in March 1991. Those relying on that spring were added to the FNDC community supply. Now that it is known at what groundwater level the spring flow becomes inadequate, pumping could be managed to maintain the flow if necessary.

There is little doubt that the FNDC abstractions of groundwater from Kaikohe Hill bores and Squires Spring significantly reduce the low flow of this stream. If this situation is not to get worse then current restrictions on water permits must be retained. For the situation to improve, there would have to be further restrictions on the existing permits. Alternatively the users of the stream could be added to the community water supply.

5.2.2 Omaunu Stream Tributary

This is the northern Omaunu Stream tributary that runs from the Te Iringa Road confluence north to springs below Mataraua Road (at about P05:815-402). The upper part of this small stream and springs are heavily used and relied on for farm water supply and irrigation. Current demand likely exceeds flow in a severe prolonged dry spell, zero flows have been recorded.

It is not yet known what, if any, effect abstraction of groundwater from the Rangihamama area would have on these springs as the groundwater level flow relationship has not been determined yet.

5.2.3 Waikaka Stream

The Waikaka Stream upstream of the dam adjacent to Mataraua Road (P06:820-399) is another small spring fed stream where demand exceeds supply. The upper part of the stream stopped flowing for much of the first three months of 1990 and for short periods in March and April 1992.

There is one current permit to take irrigation water (4826; 150 m^3/day) which is severely restricted. Available information indicates that little domestic and stock water is required from this stream.

5.2.4 Rangihamama Groundwater

With regard to the application made by KBC and current permit held by FNDC, the following conclusions can now be made:

The taking of 2300 m^3/day applied for by the KBC would not be sustainable in terms of the total resource and would cause major reductions in streamflow.

* As the current permit conditions are worded, use of the proposed Rangihamama bore(s) would be significantly restricted by the Waikaka Stream low flow limitations, but not restricted by the Papahawaiki low stream flow condition.

* Between 100 and 200 m^3/day on average could be taken in most years, depending on the recharge events of the year, without having a major impact on stream and springflow users. In prolonged dry spells, with a long period since recharge, some further restriction would be needed if a substantial portion of local spring flows are to be maintained.

* The quantity of water that can be pumped from this area ultimately depends on the level of reduction of spring and streamflow that is acceptable.

* Larger quantities may be taken during periods of significant recharge, with little impact on surface flows.

5.2.5 Other High Use Streams

Other areas in which consumptive water demand is high in relation to summer flows are the small spring fed Punakitere River tributaries in the area immediately south of the aerodrome, the upper Tokokapura tributary just north west of the aerodrome and the upper Wairoro Stream catchment.

The two major permits (4540, 2452) for the upper Tokokapura tributary are not currently being exercised and so much of the demand is potential rather than actual.

The two small spring fed Punakitere River tributaries are used for farm water supplies with a demand equivalent to about half the low flow.

The upper Wairoro Stream is heavily used, primarily by FNDC for community water supply, with over 60% of the low flow allocated.

5.3 WATER AVAILABLE FOR FUTURE USES

5.3.1 Kaikohe Basalts - Groundwater and Streamflow

As stated previously, the groundwater and spring flow resources of the Kaikohe basalts must be considered together.

If summer spring and stream flows are to be largely preserved for instream and downstream uses, then further groundwater use must be restricted to modest quantities, generally less than 100 m^3/day from individual bores. With bores located away from aquifer boundaries, important springs, and well spaced to avoid interference and cumulative effects.

Greater quantities, several hundred cubic metres per day, could be taken from individual bores or well fields if some significant loss of local spring and stream flow is acceptable.

Larger quantities again could be taken during significant recharge periods, with little impact on summer spring stream flows.

Groundwater and direct use of stream and spring flow will only be able to provide for limited small scale developments, such as small (< 5 ha) horticultural developments or a small industrial uses, like the abattoir proposed for south Kaikohe. Any larger horticultural venture or major industry will have to look to other sources.

5.3.2 Stream Flow and Groundwater Harvesting

At times of high groundwater levels and medium to high spring and stream flows, relatively large quantities of water could be taken for storage for use during low flow periods.

5.3.3 Other Rivers and Streams

Other more distant rivers and streams have been suggested as possible water supply sources for the Kaikohe area and gauging of the upper Punakitere River and Otaua Stream are given in Section 2.4. Although those streams have potentially useful flows, pipeline, pumping and water treatment costs would need to be considered against those for other sources.

5.3.4 Runoff Collection Dams

Runoff collection and storage dams built on the steeper less permeable siltstones surrounding the basalts provide one of the best potential sources of water should larger quantities of water be required. Average surface runoff in such catchments should be about 7000 to 9000 m^3/year/ha.

Runoff and quickflow collection dams on the basalt flows have less potential because of its generally flat and relatively permeable nature. However, there are some potential sites for small volume low dams.

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