

Waikato Regional Council Technical Publication No 1992/15

**HUNTLY FLOOD
MANAGEMENT PLAN**

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PREFACE

This plan has been prepared in conjunction with the Waikato District Council. It shows how regional and district councils can successfully work together. The regional council assessed the extent, depth and velocity of flood waters. The two councils then worked together to determine ways of dealing with the problem.

A draft plan was released in 1991. Comment was gained through a public workshop and a written submission from the Waikato District Council on behalf of the Huntly Community Board.

The major issue raised was the floor level requirement for new buildings in the Industrial Estate. Local calls were made for lower floor levels to promote development in the area.

After carefully considering this request, the regional council has decided not to change floor level requirements. Hazard avoidance is better than repairing damage. Allowing low floor levels in a flood prone area will simply increase the amount of damage that will inevitably occur.

Long term prosperity of the town requires development which will withstand floods. With the flood hazard clearly identified, controls on development have been carefully targeted and hence minimised. Adoption of this plan will, therefore, benefit the community.

Mr M Black
Chairman
Waikato Regional Council

SUMMARY

This plan assesses the flood hazard in Huntly and the adjacent rural area, and identifies management options. It has been prepared jointly by the Waikato Regional Council (WRC) and the Waikato District Council. Implementation of this plan will primarily be through the district plan.

The main objective is:

To identify, mitigate and avoid the flood hazard pertaining to the Huntly area to the fullest extent practicable, without placing unnecessary restrictions on the rights of individual property owners.

The Huntly area is prone to flooding from three sources. The first is the Waikato River, from which the town is protected by the Lower Waikato and Waipa Flood Control Scheme stopbanks. Secondly, localised flooding can occur from ponded stormwater, particularly when drainage is restricted by high river levels. Thirdly, the numerous lakes in the area tend to rise in response to localised rainfall events.

These three potential sources of flooding have been the subject of previous studies, and in 1989 a flood hazard map and associated ordinances were inserted into the Huntly Borough District Scheme. The boundaries of this map have been extended and the potential flood information has been refined through using revised ground survey data and improved hydrological information.

Flood hazard maps have been prepared that show the spatial extent of flooding for the 1% flood event (likely to occur once in a hundred years). Also, an indication of the hazard potential based on the combination of depth and velocity has been made. High risk areas are those where the combination of depth and water velocity are such that it would be difficult to escape the area on foot, and structural damage to buildings could occur. Low risk areas are those where people could wade through without the risk of being swept away.

A range of avoidance and mitigation options are proposed. Several possible physical works are identified including additional stormwater pumping stations, upgrading the Huntly College embankment and placing a floodgate on an outlet to Lake Waahi. Due to the lack of central government subsidies, the cost of these works would have to be largely borne by local residents.

The proposed development controls are based on existing provisions of the district plan. Open Space Zoning, which prevents further building development, is applicable to high risk areas not currently zoned residential, commercial or industrial.

Minimum floor levels requirements, aimed at ensuring property remains above flood levels, apply to high and low risk areas. The design flood is the 1% event; minimum floor levels for residential and commercial buildings shall be 0.3 m above this level, and minimum floor levels for industrial buildings shall be the 1% level. For areas protected by the Lower Waikato and Waipa Flood Control Scheme, the local pond level is used (Map 1). For areas

unprotected by the Scheme, the river flood level is used (Map 2). This policy presupposes continued maintenance of the Scheme to design standards by the district council.

Existing district plan restrictions relating to the infilling of areas prone to ponding are to be retained. The intention of these restrictions is to ensure that ponding levels are not raised by future development. Controls on earthworks adjacent to stopbanks are introduced to ensure stopbank strength is maintained.

It is recommended that the Waikato District Council considers preparing an information kit on how buildings can be flood proofed.

The flood warning system for the Waikato River is summarised. WRC staff monitor weather reports and river levels, and advise district council staff of potential flood situations. Should a major flood event occur, then the Civil Defence organisation would become involved in warning and evacuating people in the at risk areas. Detailed Civil Defence procedures are described elsewhere.

Other avoidance and mitigation measures are briefly considered. These include catchment management, public land purchase, and asset relocation.

Responsibility for the implementation of each of the above mitigation options has been assigned to either the district council or WRC. This will provide a means of monitoring the effectiveness of the plan and the appropriateness of the mitigation options.

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1 INTRODUCTION

1.1 Purpose of Plan

This plan assesses the flood hazard in Huntly and the adjacent rural area, and identifies management options. These options include building controls in at risk areas, and minor physical works to mitigate the flood potential from ponded stormwater.

It is primarily a support document for the district plan, through which the building controls will be implemented. These are based on existing district plan provisions and in many cases confirms the status quo.

1.2 Regional and District Council Responsibilities

The Waikato Regional Council (WRC) has a responsibility under the Soil Conservation and Rivers Control Act 1941 to minimise and prevent damage by floods. The WRC and the Waikato District Council both have responsibilities under the Resource Management Act 1991 to avoid or mitigate natural hazards. Under the Building Act 1991 the district council must consider flood hazards when deciding on building consents.

In view of these complementary roles, this document has been prepared with the assistance of the Waikato District Council.

The primary role of the WRC is to provide the community and the district council with sufficient information so that informed decisions on development can be made. It has assessed the flood hazard and possible physical works. The district council is responsible for developing management measures such as planning controls.

1.3 Objectives and Policies

In the past, flood management has mainly involved physical works such as stopbanks and channel clearance. These works were designed to either protect property and assets from flood waters, or else modify the nature of the flood itself. Funding assistance by central government encouraged communities to undertake such works.

Central government subsidies have reduced greatly in recent years, and so increasing emphasis is being placed on non-structural solutions. This approach is reflected here.

Objectives

- (1) To document the flood hazard for the Huntly urban area and adjacent rural areas.

- (2) To avoid or mitigate the flood hazard to the fullest extent practicable, without placing unnecessary restrictions on the rights of individual property owners.
- (3) To implement mitigation and avoidance measures through the district plan.
- (4) To identify minor structural works to reduce the potential damage from ponded stormwater.
- (5) To monitor the effectiveness of this plan in an ongoing manner and review it as required.

Policies

Information to the Public

- (1) The flood hazard maps shall be included in the Waikato District Council's hazard register. The associated management measures shall be included in the district plan.
- (2) Guidelines on non-compulsory flood mitigation measures may be made available to property owners in flood prone areas and potential developers of those areas.

Land Use in High Risk Areas

- (3) New subdivisions shall be discouraged.
- (4) The further zoning of urban land shall be discouraged.
- (5) Intensification of infrastructure in rurally zoned land shall be discouraged.

New Developments in High and Low Risk Areas

- (6) New buildings or alterations to existing buildings shall conform to the following standards:
 - (a) For any new residential or commercial building, or alteration to an existing building, the minimum floor level shall be 0.3 metres above the 1% (100 year return period event) flood level.
 - (b) For any new industrial building, or alteration to an existing building, the minimum floor level shall be at the 1% (100 year return period event) flood level.

Note: For areas protected by the Lower Waikato and Waipa Flood Control Scheme, the local pond level is used (Map 1). For areas unprotected by the Scheme, the river flood level is used (Map 2). This policy presupposes

continued maintenance of the Scheme to design standards by the district council.

- (c) Any infilling shall be restricted to that necessary to provide a foundation for, and access to, a building.

For high risk areas, additional mitigation measures such as flood proofing buildings should be considered.

- (7) Land uses must not lessen the strength of the Lower Waikato and Waipa Flood Control Scheme stopbanks.

2 FLOOD POTENTIAL AND EXISTING PROTECTION WORKS

Huntly and the adjacent rural land could be flooded from three distinct but inter-related sources. These are the Waikato River, stormwater ponding, and adjacent lakes.

An initial assessment of the flood hazard was included in the April 1989 Review of the Huntly Borough District Scheme. The map was based on a limited amount of reliable survey data and provided only a general indication of the flood hazard.

The hazard has been reassessed to cover areas outside the former Borough Council boundaries, and to provide more accurate information.

2.1 Waikato River

Flooding by the Waikato River has occurred several times. A major flood occurred in 1958, and resulted in considerable damage and community calls for a comprehensive protection scheme. The Lower Waikato and Waipa Flood Control Scheme (LWWCS) was designed in the early 1960s and construction was completed in 1983. The scheme consists of three main elements: stopbanks, floodgates, and pump stations. The floodgates allow water to flow from tributary channels into the main river but prevent flood waters in the main river flowing back up these side valleys. The pump stations remove water ponding behind the stopbanks. Scheme details are given in Waikato Valley Authority (1959).

The LWWCS provides a relatively high level of protection to the Huntly East urban area. Some development has occurred on the eastern side of the river where there is no stopbank protection. The western part of the town is unprotected but most buildings are above the flood level.

The stopbanks are capable of containing a major flood having an annual probability of occurrence between 0.2 and 0.5% (likely to occur once every 200 to 500 years). This compares very favourably with the design standard used by many agencies in NZ and the USA of a 1% flood (likely to occur once every 100 years - a smaller flood than a 0.5% event).

It remains possible that the stopbanks will be overtopped by a very large flood. There is between a 10% and 30% chance of the stopbanks being overtopped during a 70 year period, which is the average person's lifespan. The "protected" area could also be flooded if the stopbank was breached. This type of risk is hard to quantify, but it should be planned for.

Ongoing maintenance is essential for the continued integrity of the Scheme works. This is a district council responsibility. The district council is also responsible for operating the floodgates and pumping stations.

A private stopbank exists along the river edge of the Huntly College grounds. It

provides a lower standard of protection than the Scheme stopbanks. Significant seepage through the stopbank can occur and a sizable portion of the school grounds can be flooded. The Department of Education is responsible for maintenance of the structure.

2.1.1 Karapiro Dam Break

The implications of a dam break at Karapiro occurring during normal river flow conditions have been investigated (Webby 1989). The predicted resulting flood at the Huntly power station would be approximately 0.7 metres higher than the present design flood levels associated with a 1.0% flood. This dam break flood level would be below the crest level of the existing LWWCS stopbanks that protect areas of Huntly.

2.1.2 Probable Maximum Flood

The Probable Maximum Flood is the largest flood that could theoretically ever occur, given the worst case combinations of storm events and antecedent catchment conditions. Flood levels at Huntly resulting from this theoretical event are shown in Appendix 1.

2.2 Stormwater

The second potential source of flood waters is runoff from local catchments. At Huntly, stormwater would naturally drain into the Waikato River. However, the stopbanks and floodgates can impede this natural pattern. When the river is in flood, its surface water level may be higher than the ground level of the area protected by the stopbanks. Stormwater ponds behind the stopbanks while the floodgates remain closed by the high river levels.

Several stormwater pumps have been installed to hasten pond drainage. The pumps and the catchment areas they drain are located on Map 1. The pumps will not significantly reduce peak flood levels; rather they drain the ponds over a period of days.

Prolonged flooding may result from pump failure. The possibility also remains of the pumps being switched off to reduce pressure on the stopbanks from high river levels. In addition, some areas behind the stopbanks are not fitted with pumps, and so any ponded water remains until it soaks into the ground or drains through floodgates when the river level drops.

Floods can reach higher levels in urban areas than in similar sized rural areas. This is because rain is unable to soak into paved surfaces and so runs off more quickly than it would on natural surfaces. This is a contributing factor to flooding in the Huntly North ponding area.

2.3 Lakes

Three large lakes are situated near the Huntly urban area (Map 1). These are Lake Hakanoa and Lake Kimihia on the eastern side of the river and Lake Waahi on the western side. These lakes are fed by several small streams and their levels rise during significant rainstorms. Lake catchments are shown in Appendix 1.

The level of Lake Hakanoa is controlled by the ability of the lake waters to drain into the Waikato River. The outlet culvert beneath SH 1 is floodgated (the Hakanoa floodgate) so that there is less than a 1% chance of Lake Hakanoa rising above 10.1 m (Moturiki datum).

Lake Waahi has its level controlled by floodgates at the lower end of Waahi Stream. The floodgates and associated works are designed to ensure that there is less than a 1% chance of Lake Waahi rising above 10.5 m (Moturiki datum).

Lake Kimihia lies north of Huntly and drains to the Waikato River near Fosters Landing. Floodgates provide a less than 1% chance of Lake Kimihia rising above 10.3 m (Moturiki datum). East Mine Road, and an adjacent embankment constructed to counter the effects of mining-induced ground subsidence, form a barrier between the Lake Kimihia pond and the Huntly North pump ponds.

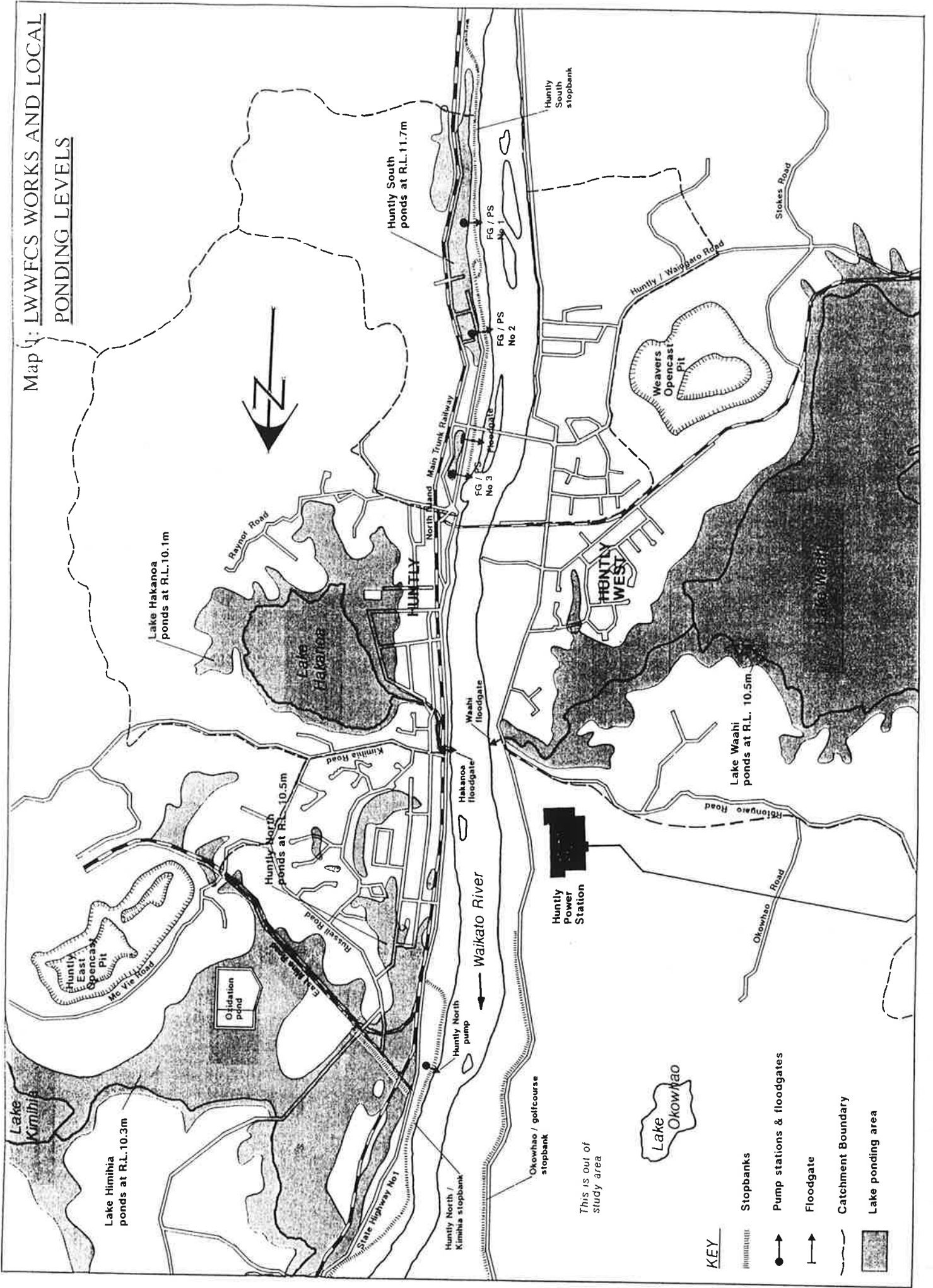
2.4 Flood Hazard Maps

Flood hazard maps have been produced for the Huntly area that denote:

- the areas flooded by the 1% probability (100 year) flood resulting from local runoff and lake level rises (Map 1)
- the areas below a 1% probability (100 year) flood in the Waikato River and the hazard potential based on the combination of depth and velocity (Map 2)

Flood prone areas have been designated as either high risk or low risk. High risk areas are those where the combination of depth and water velocity are such that it would be difficult to escape the area on foot, and structural damage to buildings could occur. Low risk areas are those where people could wade through without the risk of being swept away.

Map 1: LWWFCS WORKS AND LOCAL PONDING LEVELS






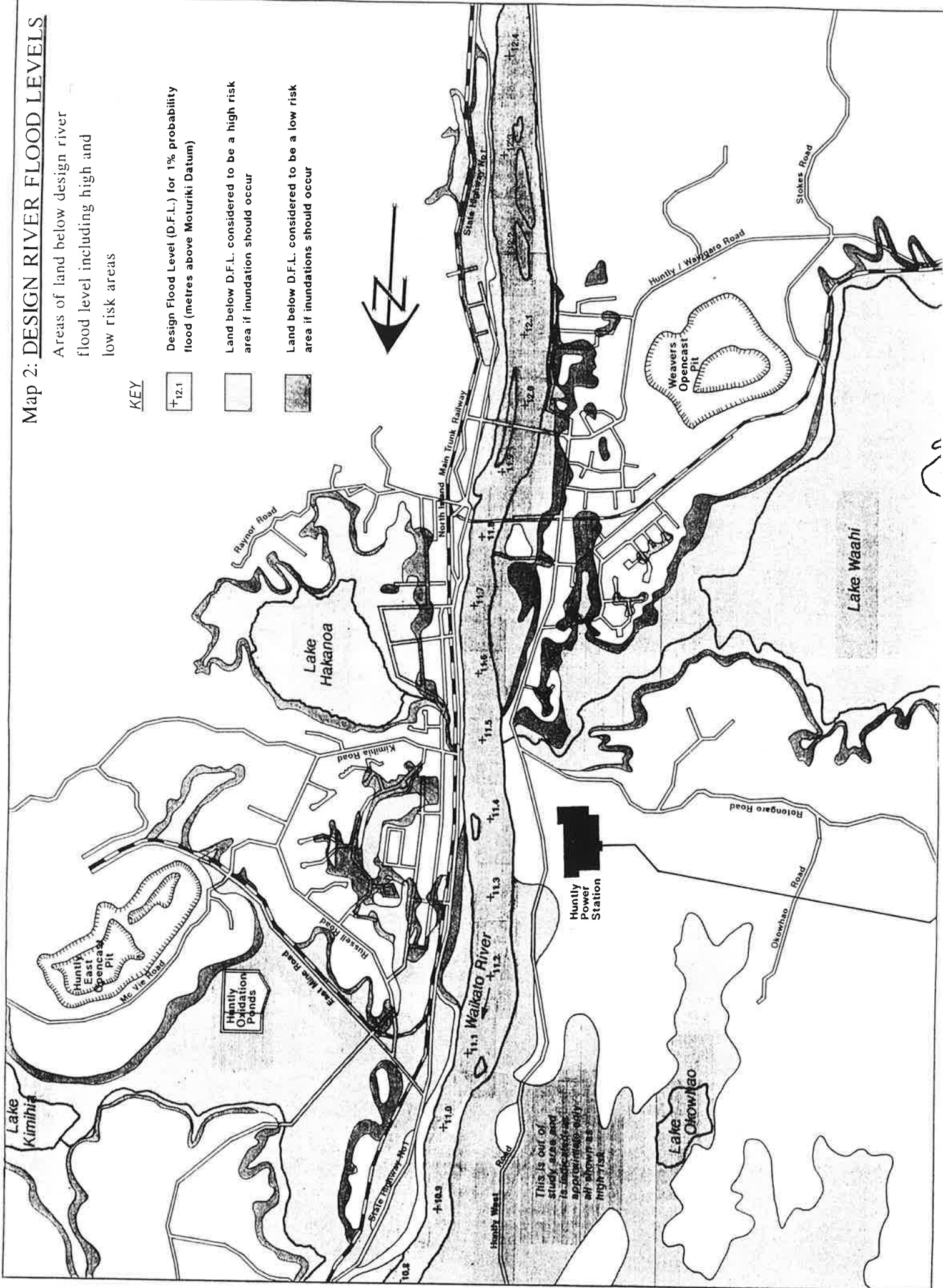
- KEY**
- Stopbanks
 - Pump stations & floodgates
 - Floodgate
 - Catchment Boundary
 - Lake ponding area

Map 2: DESIGN RIVER FLOOD LEVELS

Areas of land below design river flood level including high and low risk areas

KEY

-  +12.1
-  Land below D.F.L. considered to be a high risk area if inundation should occur
-  Land below D.F.L. considered to be a low risk area if inundations should occur



3 MITIGATION OPTIONS

Flood management measures have tended to focus on physical works aimed at keeping flood waters away from people and property. This is one of three general flood management options that have been documented in various flood management reports (Erickson 1986, Bewick 1988). These three general options are:

- (i) **Modifying the flood event.** This can be achieved by modifying the catchment of a watercourse, or containing a flood within a preselected area. Techniques commonly used are:
 - ground cover management,
 - channel modifications,
 - stopbanks,
 - dams or reservoirs,
 - drainage works.

- (ii) **Modifying flood loss susceptibility,** which essentially involves either avoiding the area prone to flooding or modifying the infrastructure within the flood prone area so that it is less susceptible to flood damage. Commonly used techniques include:
 - district plan zonings,
 - development controls through sub-division and building permit provisions,
 - flood proofing of structures,
 - infilling ponding areas,
 - public education,
 - land purchase,
 - relocation of infrastructure,
 - flood forecasting and flood warning,
 - orderly evacuation during floods.

- (iii) **Modifying flood losses** through post disaster relief and insurance. These options are not addressed here as they are the responsibility of other agencies such as central government and the insurance companies. This plan describes the potential risk and enables insurance companies to make commercial decisions on what course of action to take.

The mitigation options relevant to Huntly are now discussed.

3.1 Protection Works

This section discusses in general terms possible works to further mitigate the potential flood hazard. Initial rough order costs are listed in Table 1.

3.1.1 Possible Physical Works

Huntly East

As discussed above, the east side of the Waikato River at Huntly is bordered by stopbanks providing protection from a 0.2% to 0.5% flood event. These stop banked areas are drained by floodgated culverts and stormwater pumps. Areas not protected by stopbanks are generally above the design flood level.

The only physical works that could be undertaken to further protect Huntly east would be the installation of pumping stations for Lake Hakanoa or Lake Kimihia. These would remove ponding lake waters and discharge them to the Waikato River. Pumps would not significantly lower the peak pond level but would remove the ponded waters at a faster rate than would occur naturally. Pumps are normally designed to remove ponded water within 2-3 days in order to minimise damage to pasture.

These works were considered as part of the LWWCS, but were uneconomic. This situation is not likely to have changed. In addition, the maximum ponding level of Lake Kimihia is decreasing due to ground subsidence associated with mining.

Huntly West

The only physical protection works on the west side of the river at Huntly are a floodgate on an outlet to Lake Waahi and a private embankment in front of Huntly College. Additional floodgates on stormwater outlets to Lake Waahi would prevent back flow and reduce flooding in some low lying areas. Upgrading the college embankment would require a pump to be installed, but would be the responsibility of the Department of Education.

The remainder of the Huntly West urban area is prone to flooding from high river levels. While some of the older houses have floor levels below the design flood level, more recent subdivisions have utilised building platforms above the design level.

3.1.2 Cost Benefit Analysis

Historically, flood control works were significantly subsidised by central government. The future of central government subsidies is unclear, but they have reduced considerably in recent years and are unlikely to increase. Future funding for flood control works will most likely come from the local beneficiaries. Any cost-benefit analysis should thus be undertaken from a local viewpoint. This has not been done

for this report as:

- cost benefit analysis provides a useful tool for ranking alternative projects, rather than justifying individual works.
- no historical flood damage costs are held by the WRC, the Waikato District Council or insurance companies covering the Huntly area. As flood control benefits are largely "saved flood damage costs", the quantification of tangible benefits directly applicable to the Huntly area was not possible.
- the social disruption is perhaps the most significant "cost" of flooding. Social costs include:
 - inconvenience,
 - isolation,
 - disruption,
 - loss of personal items,
 - anxiety and trauma,
 - ill-health.

Such social costs can not be quantified.

Any cost-benefit analysis would thus provide an inadequate basis for decision-making. Given that local residents would largely pay for any further physical works, it is appropriate that they should provide a clear mandate that such works are desired.

Table 1 **Possible Physical Works**

Item	Rough Order Cost (June 1992 Terms) \$
1 Pumping Stations	
Lake Hakanoa 2.0 m ³ s ⁻¹	250,000
Lake Kimihia 4.0 m ³ s ⁻¹	500,000
2 Upgrade Huntly College Embankment	300,000
3 Floodgates on stormwater outlets to Lake Waahi	10,000

3.2 Development Controls

Having identified areas at risk from flooding, it is possible to develop controls to avoid or mitigate the hazard. One approach is to prohibit further building development through designating areas as Open Space Zones (Section 3.2.1). This approach is generally not favoured by landholders as they limit future development options and can lead to a reduction in land value.

Another approach is to specify development standards for areas where further buildings are allowed (Sections 3.2.2 and 3.2.3). Such standards may include minimum floor levels and earthworks restrictions.

3.2.1 Open Space Zoning

This approach may be applicable only to the high risk areas which are not currently zoned residential, commercial or industrial. In high risk areas, the combination of water velocity and depth would make walking difficult during a flood, and in an extreme case structural damage to buildings could occur. Some high risk areas have had bulk services provided in an effort to attract development. The use of stringent development standards is preferable to preventing any development in these areas.

Low risk rural areas could also be zoned as Open Space. However it is more equitable to control additional buildings through development standards as the underlying Rural Zone provisions already limit development.

3.2.2 Minimum floor levels

Minimum floor levels are an attempt to avoid the hazard by simply ensuring that the floor levels of buildings are above the expected level that the flood waters will rise to. The minimum floor level is usually based on the calculated design flood level, plus a freeboard allowance. The freeboard allows for waves and errors in the calculation of the flood.

For areas protected by the Lower Waikato and Waipa Flood Control Scheme, the 1% local pond level is used as the design flood (Map 1). For areas not protected by the Scheme, the design flood is the 1% river flood level (Map 2). This presupposes continued maintenance of the Scheme to design standards by the district council.

The freeboard requirement of the transitional district plan is retained. The minimum floor level for residential and commercial buildings is 0.3 m above the design flood level, with no freeboard for industrial buildings. Although a more common specification is 0.5 m, it is considered that for the sake of continuity, and to avoid confusion amongst community members, the existing 0.3 m requirement should be retained.

In response to local community requests, consideration was given to using the 2% (50 year) design flood level for the areas protected by the Scheme. This would enable floor levels to be 0.1 m lower in the Huntly North and the Huntly South ponding areas. The 1% flood has been retained as only minor building cost savings would result from using the 2% event. More significant cost savings would result from using the 10% (10 year) event. Floor levels would be 0.2 m lower in the Huntly North and 0.3 m lower in the Huntly South ponding areas, where the industrial subdivision is located. However possible construction savings are more than outweighed by greatly increased likelihood of flood damage costs.

3.2.3 Earthworks

Several of the at risk areas in Huntly are prone to flooding from the ponding of stormwater. In theory, the level to which the ponded water will rise is dependant on the volume of storage available for flood waters. If that volume is reduced through the construction of additional buildings (especially if those buildings are located on raised earth foundations) then the ponding level for a given flood will rise.

In practical terms, the impact of any new individual buildings (or alterations to existing buildings) on the ponding level will be almost imperceptible and extremely difficult to accurately predict. This is an especially relevant consideration in view of the margin of error associated with flood level calculations. The site filling restriction contained in Section 10.7 of the existing transitional district plan is adequate: filling of a site to implement the Floor Level standard may not exceed that which is reasonably necessary to provide a building platform appropriate to any building planned for the site, and access to it.

The impact of infilling may be more severe for entirely new subdivisions that involve significant earthworks, contouring or new roads. However, the Building Act 1991 and the Resource Management Act 1991 would normally preclude such subdivisions.

Stopbanks could be weakened by adjacent earthworks. It is important to maintain the strength of these structures and so limits on site development earthworks are needed in some areas. For instance, the stopbank batters in the industrial estate should not be excavated.

3.3 Flood Proofing

Flood proofing involves undertaking various measures which render property less vulnerable to flood damage. Implementation is best achieved through public education rather than through a district plan requirement. It is recommended that the district council consider preparing an information kit outlining possible measures.

3.4 Flood Warning and Evacuation

The NZ Meteorological Service warns of incoming storms or likely heavy rainfall

events. This alerts WRC staff to the possibility of a flood occurring. The WRC operates a flood warning system for the Waikato River and monitors levels using a radio link to water level recorders. Local stream and lake levels are not monitored by the WRC.

The Waikato District Council is notified of rainfall warnings and rising river levels. When a formal flood warning is received, district council staff carry out the following actions:

- notify the Civil Defence organisation of the potential flood hazard,
- warn people working in known problem areas such as construction sites adjacent to the river,
- warn farmers to move stock to higher ground,
- patrol the river stopbanks to check for damage,
- make sure that heavy machinery is available should it have to be used in an emergency.

As the river level continues to rise, other parties such as the police and radio stations are notified. Commercial radio stations are generally the most effective way of warning people that a flood is on the way.

If flooding of houses is likely, evacuation procedures or flood proofing measures (*eg* placing sandbags) are used. The district Civil Defence Plan (WDC 1991) sets out the functions, responsibilities, priorities and procedures to be followed during major emergencies. Civil Defence measures are legally enforceable in a declared emergency.

Floods in the Waikato River originate in the upper catchments and take one to two days to arrive at Huntly. This allows ample time for necessary evasive action to occur. Floods are managed to some extent through agreements with Electricorp over dam outflows.

3.5 Catchment Modification

Catchment land uses can affect flood levels. For instance, vegetation cover changes, channel siltation and channel diversions can influence the amount and speed of storm runoff. Careful land uses practices are needed to ensure the flood hazard is not made worse by catchment changes. This in part depends on the co-operation and goodwill of private landowners. A public relations exercise may be useful to raise the awareness of private landowners to the fact that their actions can affect downstream flood levels. The WRC is reviewing its land use controls. One of the purposes of the controls is to ensure flood hazards are not increased. Land uses must also be consistent with policies included in the district plan.

3.6 Other Measures

Flood prone land may be purchased and held in public ownership. The land can then be turned into parks, reserves, playing fields and other open space uses that benefit the community. Funding would have to come from local rates as no central government assistance is likely. This is unlikely to meet with community approval, given the recent calls on local authorities to limit rate increases and curtail non-essential expenditure.

Another mitigation measure involves the relocation of assets to areas not prone to flooding. High costs make this option unfeasible for local government agencies to finance. However, private landowners always have the option of relocating their assets at their own cost. This again is unlikely to occur, as the salvage value of the flood prone land would not be high.

4 IMPLEMENTATION, MONITORING AND REVIEW

The main mitigation options are listed in Table 2, together with information on implementation. This includes the identification of the agency responsible, any action required, realistic target dates to work towards and appropriate monitoring measures. Monitoring reveals the level of plan implementation and assess the effectiveness of specific mitigation measures.

New information on flooding levels, the advent of new mitigation techniques, or policy changes at a central or local government level may require changes to be made to the plan. The plan will be reviewed as the need arises. The review will involve public input, and submissions will be called on any proposed changes.

It should be noted that the Waikato District Council, upon whom many of the implementation responsibilities will fall, has been involved in the establishment of these implementation and monitoring measures.

TABLE TWO: IMPLEMENTATION MEASURES

Mitigation or Avoidance Measure	Agency Responsible	Action Required	Target Date	Monitoring Required	Monitoring Agency
Inform the public, residents and property owners of the flood hazard	WRC and WDC	Make flood plan publicly available	August 1992	-	-
Co-ordinate any physical works endorsed by the Huntly community	WDC	Arrange contractors Collect funding from ratepayers	-	Check effectiveness of works during next flood	WRC and WDC
Development controls	WDC	amend district plan enforce provisions	November 1992 Ongoing	Verify amendments consistent with flood plan field checks	WRC WDC
Flood proofing	WDC	Disseminate Advice Sheet to prospective builders	Ongoing	Record community response Field check any flood proofing measures adopted	WDC WDC
Flood warnings	WRC	Continue existing flood warning procedures	Ongoing	Record community response	WDC and WRC
Civil Defence and Evacuation procedures	WDC	Inform community of excavation procedures. Hold community evacuation drills or desktop	-	Record community response	WDC

10 REFERENCES

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Erickson, NJ; 1986: Creating Flood Disasters, NWASCA.

Waikato District Council (1991) Civil Defence Plan.

Waikato Valley Authority (1959) Report on Major Control Scheme for Flood Protection, Lower Waikato and Waipa Rivers. WVA, Hamilton.

Webby, G; 1989: Karapiro Dam - Report on Dam Break Analysis, Works and Development Services Corporation.

APPENDIX 1

Probable Maximum Flood

The Probable Maximum Flood (PMF) is the largest flood that could theoretically ever occur, given the worst case combinations of storm events and antecedent catchment conditions.

The PMF has been estimated for Huntly. The 0.2% flood event of 1800 cubic metres per second at Ngaruawahia (Mulholland 1983) was increased by range of scaling factors giving a PMF in the range of 2500 to 3000 cubic metres per second.

This theoretical PMF flood range was used in a river flow computer model (based on actual river bed cross sections) to derive flood levels at Huntly. The model has calculated flood levels based on cross section data only and takes no account of out of channel flow and reductions in flood peaks due to ponding, so the resulting levels may be considered conservatively high. Areas of Huntly that are below the 3000 cumec PMF flood levels are shown on Map A1. This map represents the worst possible degree of flooding that is ever likely to occur from a natural flood. The PMF levels are approximately 1.4 metres higher than the present design flood levels associated with the 1% flood, and consequently are above the crest level of the existing Scheme stopbanks protecting Huntly.

Works Corporation (Webby *et al* 1989) have also investigation the implications of a PMF. The modelling was extended downstream as far as Huntly Power Station and concluded that at this locality PMF levels are approximately 0.6 m higher than the present design flood levels associated with the 1% flood.

Lake Catchment Areas

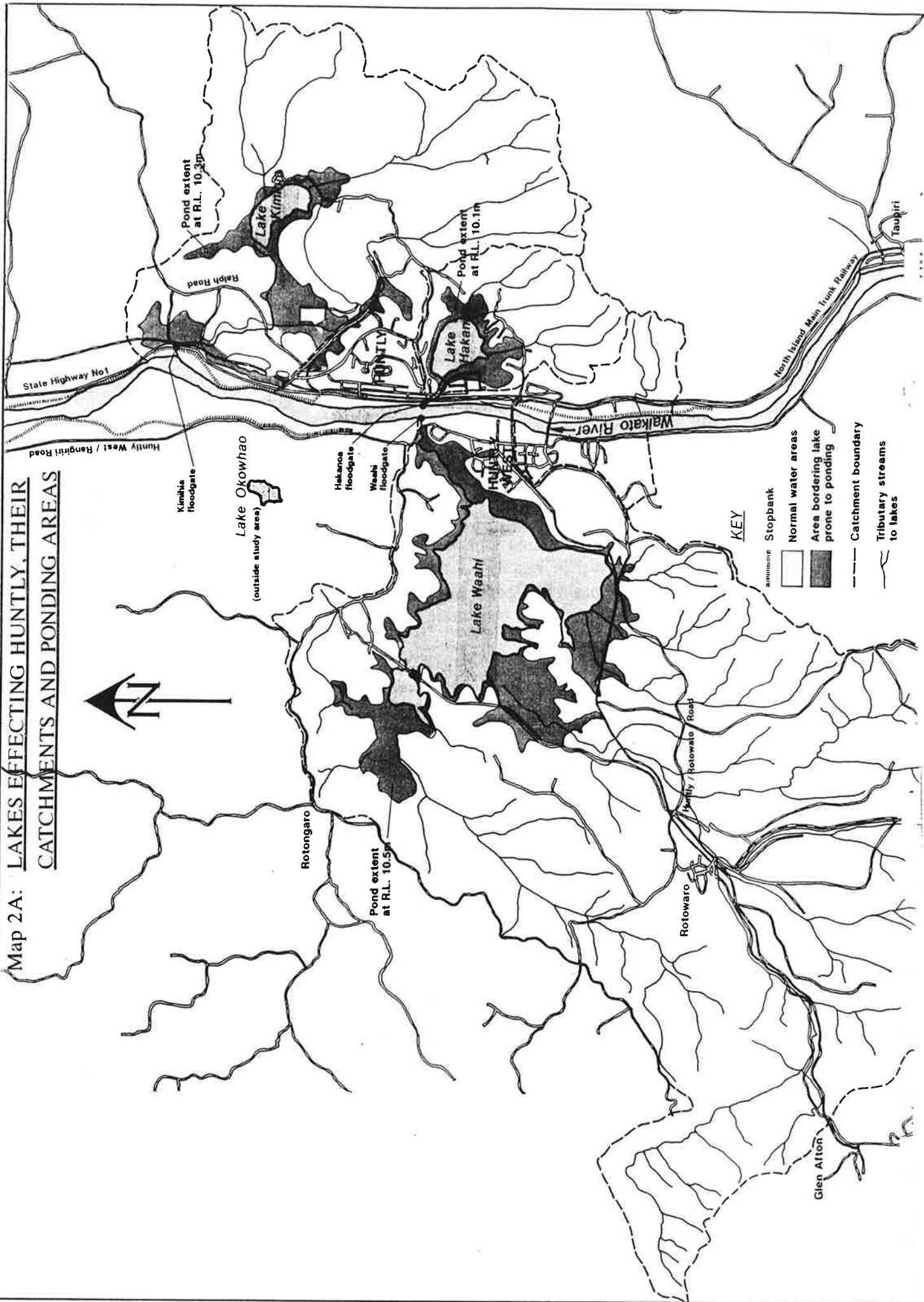
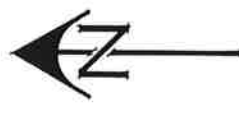
The catchment areas for the three lakes near Huntly are shown in Map A2.

References






Mulholland M (1983) Lower Waikato, Waipa Flood Control Scheme Review - Part A Hydraulic/Hydrological Evaluation. Waikato Valley Authority Technical Report 25.

Webby, G; Freestone, N; Ong, K; 1989: Kapapiro Dam - Comparison of Dam Break and Probable Maximum Flood Levels in the Waikato River Downstream of Kapapiro Dam, Works and Development Services Corporation.

Map 2A: LAKES EFFECTING HUNTLY, THEIR CATCHMENTS AND PONDING AREAS



KEY

-  Stopbank
-  Normal water areas
-  Area bordering lake prone to ponding
-  Catchment boundary
-  Tributary streams to lakes

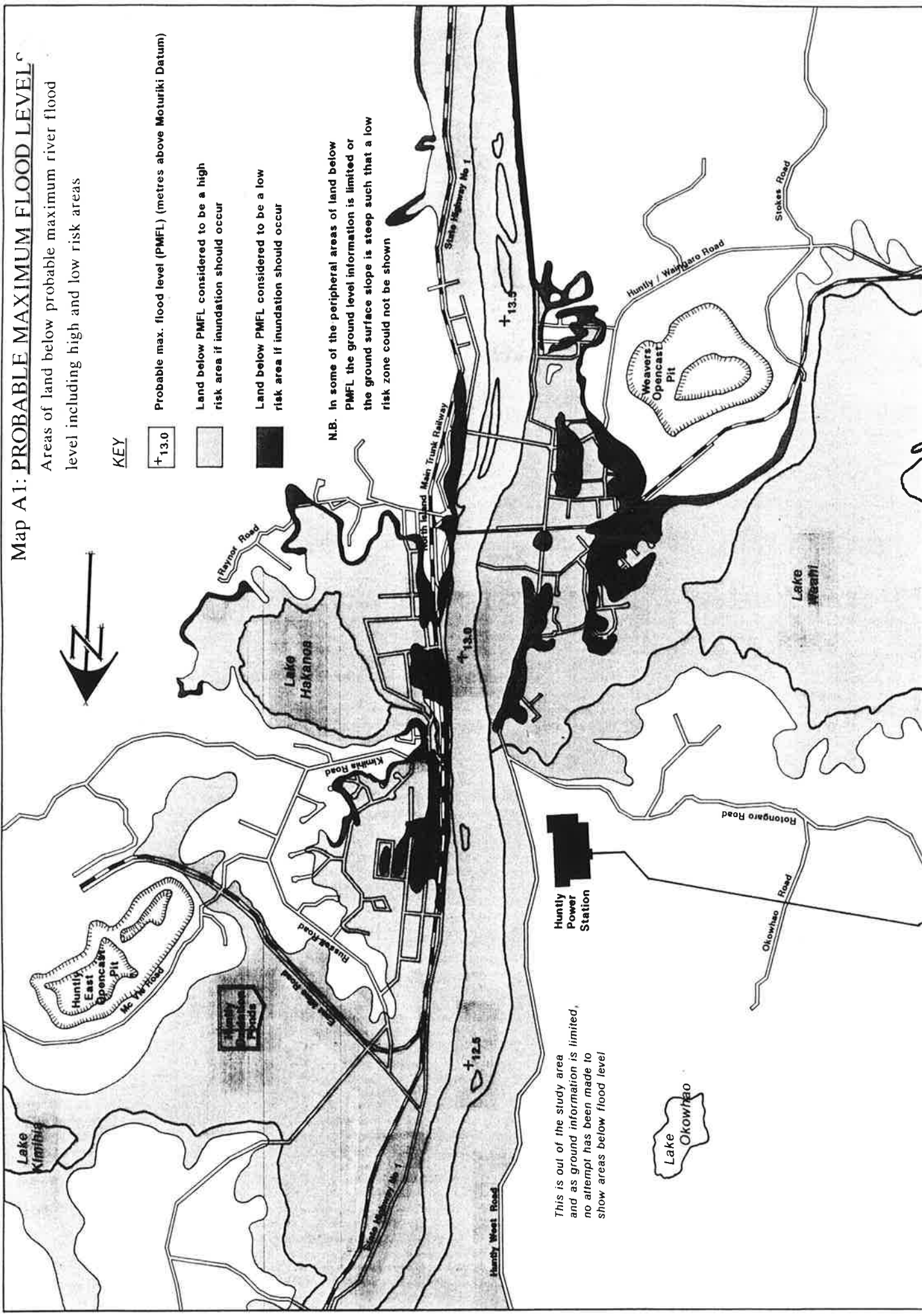
Map A1: PROBABLE MAXIMUM FLOOD LEVEL

Areas of land below probable maximum river flood level including high and low risk areas

KEY

- Probable max. flood level (PMFL) (metres above Moturiki Datum)
- Land below PMFL considered to be a high risk area if inundation should occur
- Land below PMFL considered to be a low risk area if inundation should occur

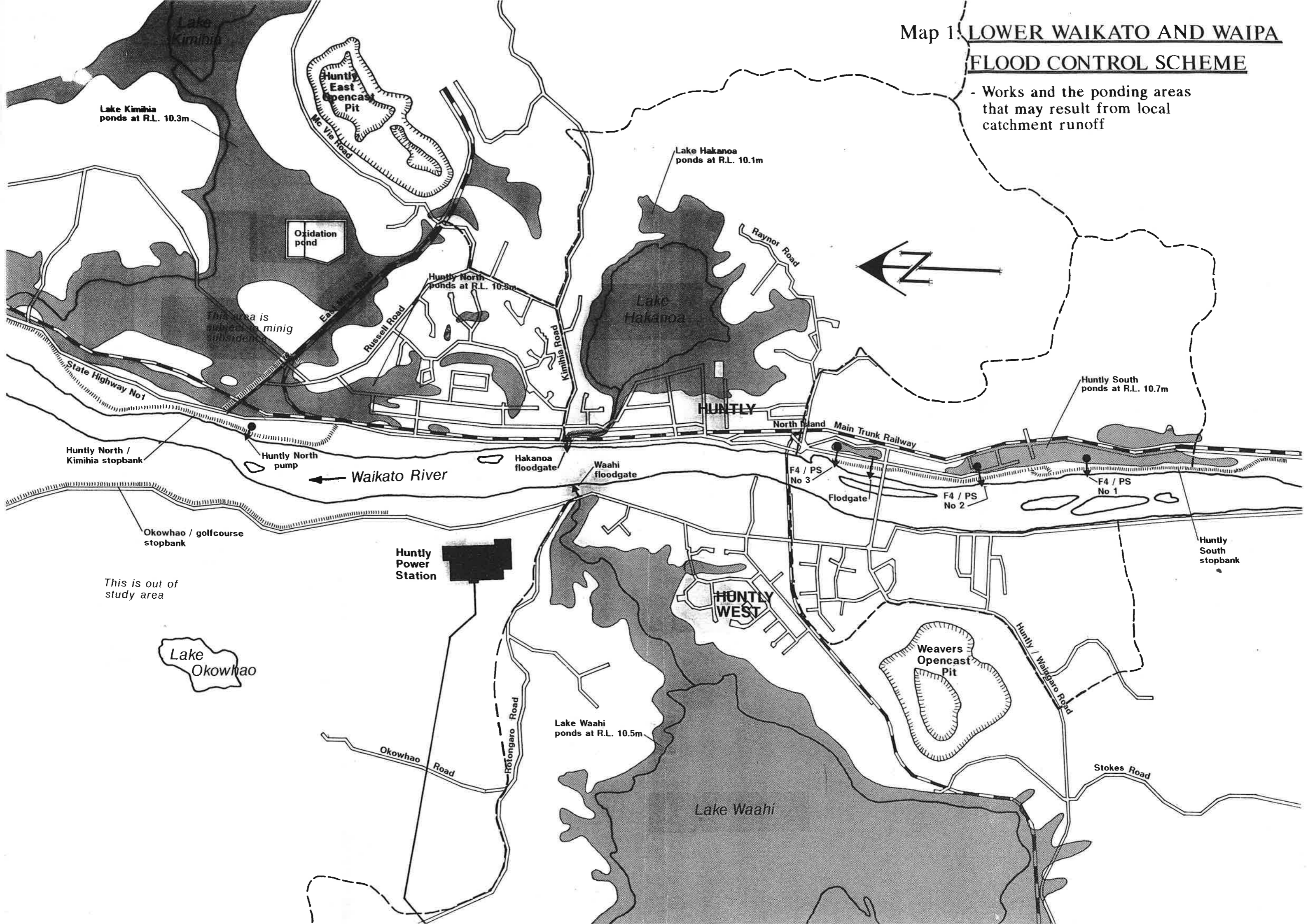
N.B. In some of the peripheral areas of land below PMFL the ground level information is limited or the ground surface slope is steep such that a low risk zone could not be shown



This is out of the study area and as ground information is limited, no attempt has been made to show areas below flood level

Map 1. LOWER WAIKATO AND WAIPA FLOOD CONTROL SCHEME




- Works and the ponding areas that may result from local catchment runoff

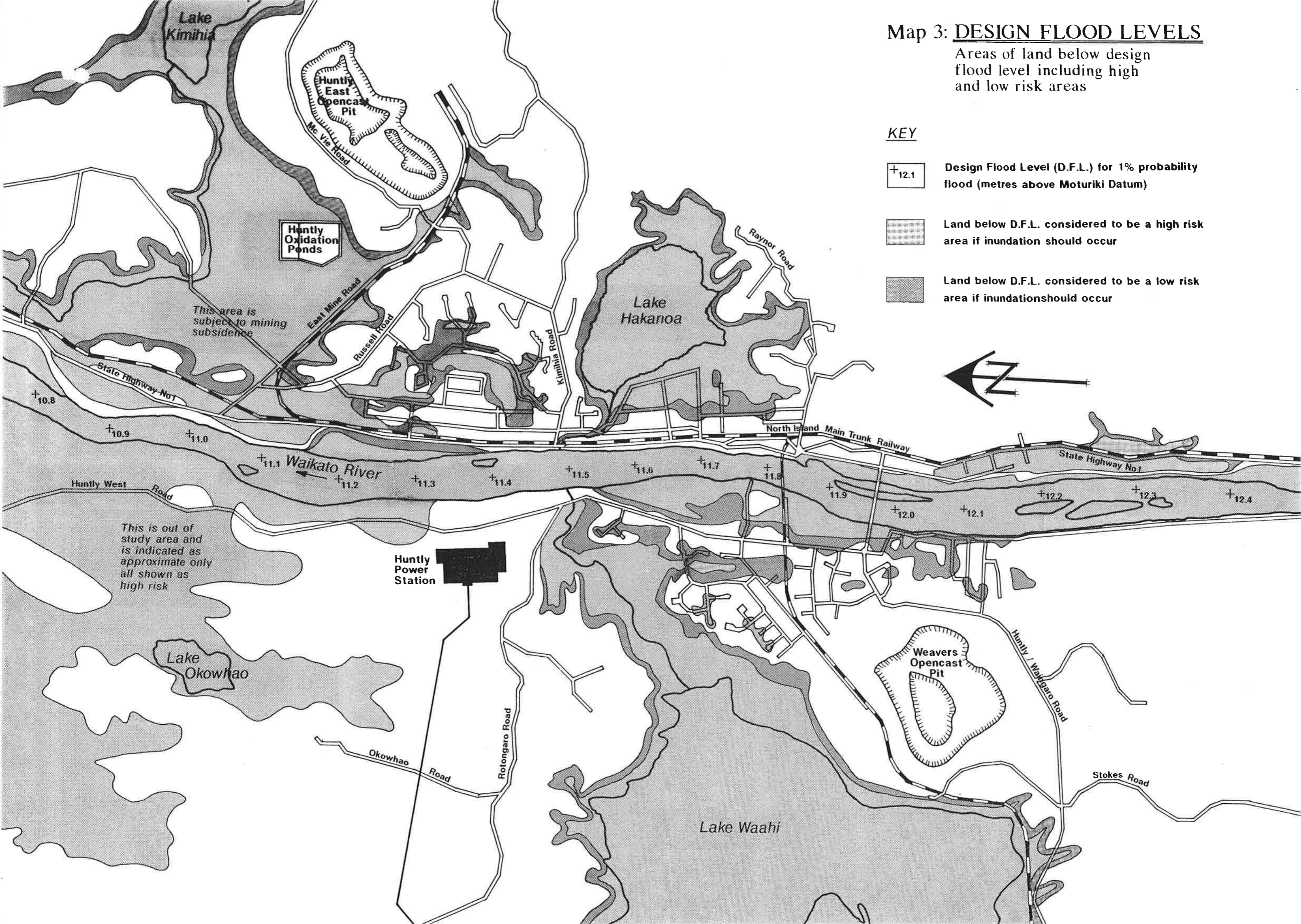


Map 3: DESIGN FLOOD LEVELS

Areas of land below design flood level including high and low risk areas

KEY

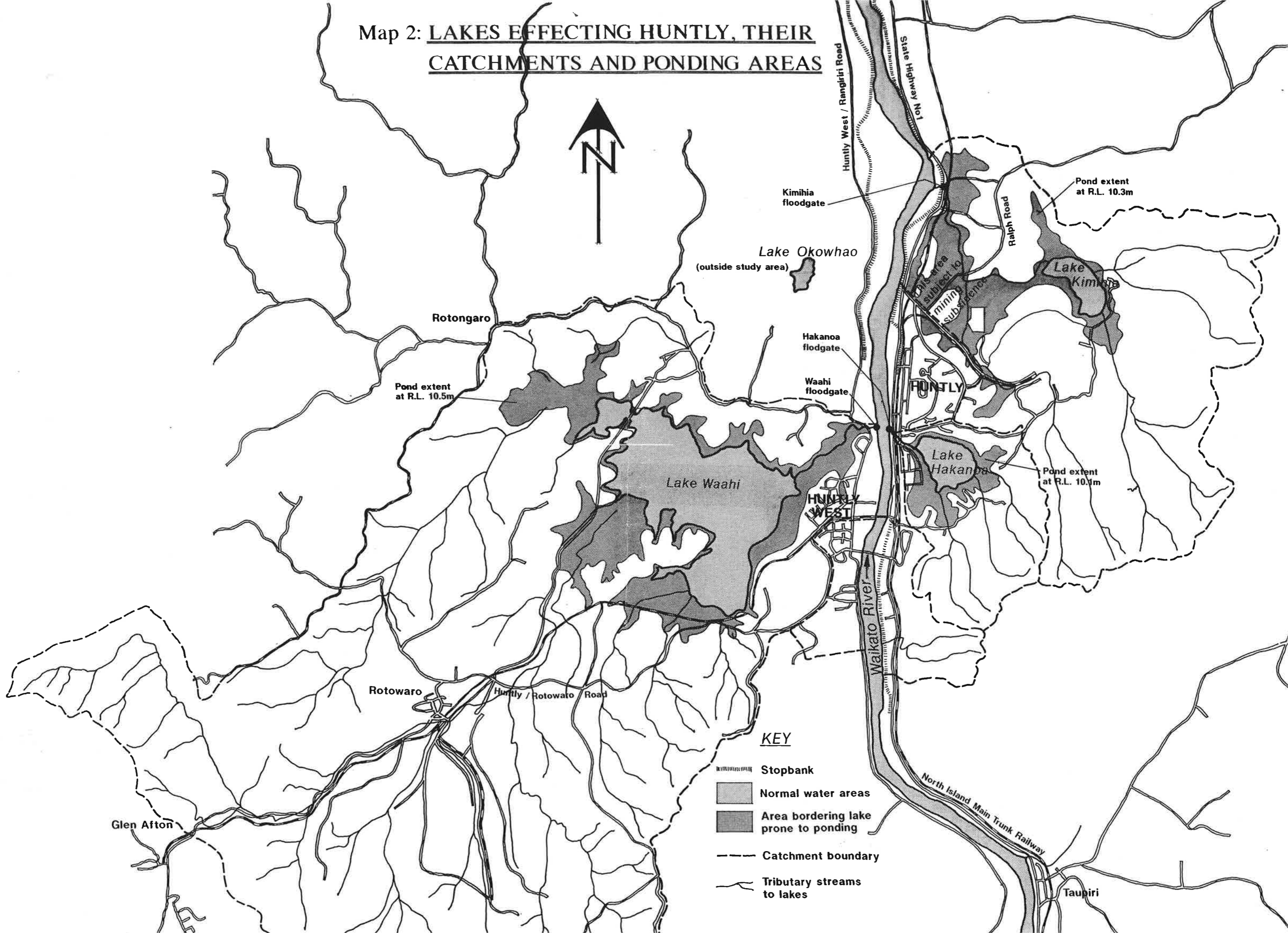
-  Design Flood Level (D.F.L.) for 1% probability flood (metres above Moturiki Datum)
-  Land below D.F.L. considered to be a high risk area if inundation should occur
-  Land below D.F.L. considered to be a low risk area if inundation should occur








This area is subject to mining subsidence

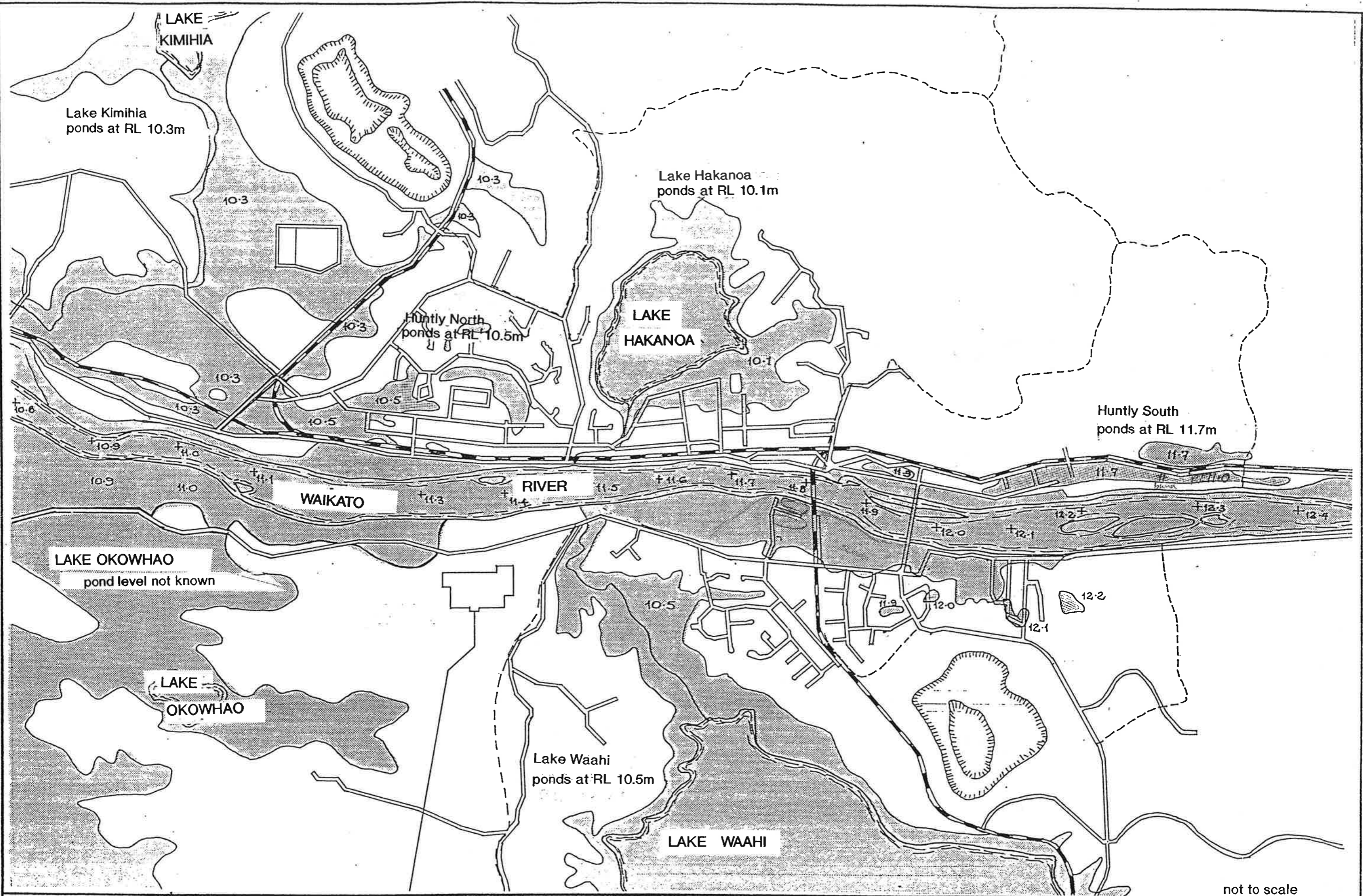
This is out of study area and is indicated as approximate only all shown as high risk

Map 2: LAKES EFFECTING HUNTLY, THEIR CATCHMENTS AND PONDING AREAS



KEY

-  Stopbank
-  Normal water areas
-  Area bordering lake prone to ponding
-  Catchment boundary
-  Tributary streams to lakes

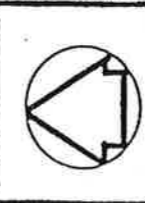


not to scale



**WAIKATO
DISTRICT
PLAN**

**HUNTLY FLOOD PLAIN
DESIGN RIVER FLOOD LEVELS
& LOCAL PONDING LEVELS**



Reference:
 Planning Maps 50-57
 Rule 41.5.2
 Huntly Flood Plain Management Plan
 Technical Publication 1992/15
 Environment Waikato