UPPER HUNTER SHIRE COUNCIL

ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY AND DRAFT PLAN

(Adopted By Upper Hunter Shire Council on 23 November 2015)

November 2015

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FOREWORD

The NSW Government's Flood Policy recognises that flood-liable land is a valuable resource and should not be sterilised by unnecessarily precluding its development. The Policy also recognises the benefits flowing from the use, occupation and development of floodprone land. Accordingly, the Policy requires that all development proposals be treated on their merits.

The merit approach requires that flooding issues be considered along with other planning and environmental factors. Specifically, the merit approach seeks to balance social, economic, environmental and flood risk parameters to ascertain whether a particular development or use of the floodplain is appropriate and sustainable.

The prime responsibility for local planning and land management rests with local government. The study area falls under the administrative responsibility of Upper Hunter Shire Council.

The first Floodplain Management Manual (Ref 1) was released in 1986 and introduced the merit based approach. The first Floodplain Development Manual created a floodplain management process similar to that shown on Figure C1 in Appendix C, with a number of subtle differences. Revised versions of the Floodplain Development Manual in 2001 and 2003 led to the current Floodplain Development Manual (Ref. 2). Broad changes to the Manual between 1986 and 2005 covered:

- explicit consideration of the full range of floods up to and including the Probable Maximum Flood (PMF);

- recognition of existing future and continuing flood risks on a strategic basis rather than an ad-hoc individual basis;

- enabling local Councils to obtain State support to manage local overland flooding in a manner similar to riverine flooding;

- promotion of the preparation and adoption of local flood plans to address flood readiness, response and recovery;

More subtle changes in the progression from the 1986 Manual to the 2005 Manual were:

- the introduction of risk management concepts;
- the deletion of "Interim Flood Policies";
- deletion of an encompassing Flood Standard;
- adoption of Flood Planning Levels (FPLs);
- changes to reflect structural changes in the NSW Government departments with responsibility for administration of government policy.

The New South Wales Floodplain Development Manual (Ref. 2) has been prepared to assist councils in the development of management plans for flood-liable lands. The principal objective of the floodplain

management process is to reduce the impact of flooding and flood liability on individual owners and occupiers and to reduce private and public losses resulting from floods.

The Floodplain Risk Management process comprises the following activities:

- establishment of a Floodplain Management Committee;
- data collection;
- completion of a Flood Study;
- preparation of a Floodplain Risk Management Study;
- adoption of a Floodplain Risk Management Plan; and
- implementation of the Floodplain Risk Management Plan.

The Floodplain Risk Management process is presented schematically on Figure C1 in Appendix C, which has been derived from the Manual.

Upper Hunter Shire Council has progressed on the Floodplain Management Process above for Aberdeen, with the object of updating their management practices. The first three steps of the Floodplain Management process (establishment of Committee, data collection, and Flood Study) have been completed.

This report has been prepared to address the fourth and fifth steps in the process, namely, the Floodplain Risk Management Study and preparation of a Floodplain Risk Management Plan.

This report has been prepared by Paterson Consultants Pty Ltd under the direction of the Aberdeen Floodplain Risk Management Committee, following a formal brief from Upper Hunter Shire Council.

Funding of this report has been provided jointly by Upper Hunter Shire Council and NSW State Government.

GLOSSARY – Terms and Abbreviations

Note: A more extensive glossary is available in the 2005 Floodplain Development Manual. An extract from the Glossary of the Floodplain Development Manual, giving a fuller description of floodways, flood storages and flood fringe, appears in Appendix B.

Floodplain Management

Manual or *Floodplain Management Manual*: The New South Wales Government publication "Floodplain Management Manual", 2005.

Australian Height Datum (AHD): a common notional plane of level corresponding approximately to mean sea level.

Reduced Level (RL): a measured height above Australian Height Datum.

Full Supply Level (FSL): The level of a water supply storage which corresponds to the full storage capacity.

Flood Probability

Annual Exceedence Probability (AEP): the probability of an event (say a flood) occurring or being exceeded in any one year.

Average Recurrence Interval (ARI): the long-term average number of years between the occurrence of a flood as big as or larger than the selected event.

Probable Maximum Precipitation (PMP): the rainfall calculated to be the maximum which is likely to occur.

Probable Maximum Flood (PMF): the flood resulting from the PMP storm.

Flood Damages

Direct Damage: damage caused by contact with floodwater eg. Structural damage to building, water damage to furniture or house contents or damage caused by silt and debris.

Indirect Damage: damage caused by flooding though not directly eg. Loss of trade, cost of alternative accommodation or loss of wages.

Tangible Damage: damage that can be quantified in monetary terms, includes direct and indirect damages.

Intangible Damage: damage that occurs but is difficult to quantify eg. Increased stress in the community or disruption to community life.

Potential Damages: an estimate of the flood damage that represents the maximum damage loss if no action is taken to reduce the damage.

Actual Damage: an estimate of the flood damage that makes allowance for any action taken to reduce the damage.

Mean Annual Damage: an estimate of the annual average damage from the full range of floods. It is obtained by summation of the product of damage and probability over the full range of flooding.

Economic Factors

Capital Cost: total construction cost of project, including land acquisition, survey, investigation and design.

Amortization: annual interest and redemption payments over the economic life of the project.

Economic Life: period during which a works item remains in a satisfactory working condition before being replaced.

Recurrent Cost: annual cost for maintenance and operation eg. Power, fuel, repairs.

Annual Cost: sum of amortization, operation and maintenance cost for a year.

Net Present Value: the annualised value of a project at a point in time comprising of the sum of project benefits less the sum of project costs.
+
Recurrent Cost /Capital Cost Ratio: reflecting the relativities of capital and recurrent costs of a project.

Benefit-Cost Ratio: ratio of the monetary benefits of a project to the cost of a project. This ratio is usually determined on an annual cost basis.

Relative Cost Effectiveness: the ratio of the benefit-cost ratio for a project to the benefit-cost ratio for the reference project so that a variety of projects which provide different benefits to be compared.

Emergency Management

emergency management: a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare far, respond to and recover from flooding.

Disaster plan (DISPLAN): a step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

Flood plan (local): A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.

Flood awareness: Awareness is an appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood readiness: Readiness is an ability to react within the effective warning time.

Minor, moderate and major flooding: both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

Moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

Major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

Flood Behaviour

flood prone land: land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.

Flood risk: potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in the Floodplain Management Manual is divided into 3 types, existing, future and continuing risks as below:
existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented.

Floodway areas: those areas of the floodplain where a significant discharge of water occurs during floods.

Flood storage areas: those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

Flood fringe areas: the remaining area of flood prone land after floodway and flood storage areas have been defined.

Discharge: the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (cu m/sec).

probable maximum precipitation: the PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

Probable maximum flood: the PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions.

Stage: equivalent to water level (both measured with reference to a specified datum).

Stage hydrograph: a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

Development

Development: is defined in Part 4 of the EP&A Act.

Development Type for This Plan

Infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land.

New development: refers to development of a completely different nature to that associated with the former land use.

Redevelopment: refers to rebuilding in an area as urban areas age.

Flood planning levels: are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual.

Freeboard: provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided.

flood planning area: the area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual.

Government Agencies:

DECCW	Department of Environment Climate Change and Water
DLWC	Department of Land and Water Conservation
DWE	Department of Water and Energy *DWR*
	Department of Water Resources OEH
	Office of Environment and Heritage
SES	State Emergency Service
WC&IC	Water Conservation and Irrigation Commission
WRC	Water Resources Commission

Legislation

DCP	Development Control Plan
EP&A Act	Environmental Protection and Assessment Act
LEP	Local Environment Plan
LGA	Local Government Area

SUMMARY

This report outlines the work undertaken to complete the Aberdeen Floodplain Risk Management Study and the preparation of a draft Floodplain Risk Management Plan for Aberdeen.

The Floodplain Risk Management Plan represents the fourth step in a six step process that is outlined in the New South Wales Government's Floodplain Development Manual. The process, historically, has been shown to produce achievable outcomes for floodplain management.

The NSW Local Government Act provides protection for Councils and their agents with regard to floodplain management, provided the processes in the Floodplain Management Manual are followed.

Upper Hunter Shire Council has recently published the Aberdeen Flood Study which was adopted by Council on its meeting of 22 July 2013. The Flood Study predicts flood behavior, flood levels and flood extents over a range of various sized floods from a once in 10 year average recurrence interval (ARI) up to the probable maximum flood (PMF).

Upper Hunter Shire Council has gazetted the Local Environmental Plan (LEP) which provides a statutory backdrop to the land-use zoning through their local government area. The Council has recently adopted a Development Control Plan (DCP) which provides guidance for appropriate development and development standards within the land-use zoning as designated in the LEP.

The Aberdeen Flood Study indicates that parts of Aberdeen are flood liable, as well as a large area around Aberdeen, where the land lies on the floodplains of the Hunter River and a number of smaller tributaries to the Hunter River (Kingdon Ponds, Middle Brook and Dart Brook) which join the Hunter River near Aberdeen.

Figure 1 of this report shows the approximate extent of the once in 100 year ARI flood on the Hunter River and its floodplain in relation to Aberdeen, while Figure 2 shows the predicted flood extents for the once in 100 year ARI flood in Aberdeen itself. The principal area of concern for floodplain risk management relates to residential development sited on flood liable land to the east of the New England Highway crossing of the Hunter River and its floodplain.

The bulk of Aberdeen itself is sited on high land above the PMF. There is, however, residential development sited on the Hunter River floodplain, between the higher land in Aberdeen and the Hunter River itself. Thus, the floodplain management issues can be seen as arising from:

- very old subdivision of flood liable land beside the Hunter River;
- residential development on that land;
- the changed community perception, which now treats flooding as a significant risk and the cause of substantial damage to both the individuals and the community.

Major floods have occurred at Aberdeen in the past, notably in 1955, 1971, 1976 and 2000.

Some protection from flooding on the Hunter River at Aberdeen is provided by Glenbawn Dam, which controls about 38% of the Hunter River catchment at Aberdeen. The dam was completed in 1958. The occurrence of significant floods in 1971, 1976 and 2000 (which all had very small outflows from Glenbawn Dam) show that the other tributaries to the Hunter River at Aberdeen, namely Pages River, Isis River, Rouchel Brook, Kingdon Ponds, Mill Brook and Dart Brook, have the potential to create significant floods at Aberdeen without any contribution from the Hunter River at Glenbawn Dam.

Flood level records at Aberdeen are sparse, given that the OEH gauge, titled "Station 210056, "Hunter River @ Aberdeen", was installed in 1959 but was not operational over the period 1978 to 1998. Some flood level information has been derived by research into old WC&IC records.

The adopted ranking of historical flood levels at Station 210056, "Hunter River @ Aberdeen" for use in this study is:

- 1955 Peak level RL 169.3 m AHD
- 1971 Peak level RL 168.75 m AHD
- 2000 Peak level RL 160.35 m AHD
- 1976 Peak level RL 167.8 m AHD

The 1955 flood has been generally accepted as the highest flood in recent memory within the Hunter River at Aberdeen.

In response to the 1955 and 1971 floods, the WC&IC constructed a levee along the Hunter River bank at Aberdeen to protect the low lying areas. The levee was constructed circa 1976 and has been quoted as having a design crest level set at the recorded 1971 flood levels plus approximately 900 millimetres (3 feet imperial).

The Aberdeen Flood Study, given the lack of extensive historical records at Aberdeen, approached its brief to identify flood behaviour at Aberdeen by:

- use of an hydrologic model to convert "design" rainfall to create "design" flood hydrographs;
- use of a two-dimensional hydrodynamic model to predict design flood behaviour (including flood levels and flow velocities) from design flood hydrographs within the area of interest.

The Flood Study indicates:

- design once in 100 year ARI (1% AEP) flood levels that are in excess of the 1955 flood levels adjacent to the constructed levee;
- that the existing levee does not provide protection up to the design 1% AEP flood level with 0.5 m freeboard, which would be the minimum level generally currently applying for the levee construction;
- the levee provides protection up to approximately the once in 50 year ARI level with no freeboard.

Considerable effort in this study has been expended to identify historical flood levels and to compare historical flood levels against the design once in 100 year ARI flood levels as predicted in the Aberdeen Flood Study.

Throughout the general rural area around or downstream of Aberdeen, the Flood Study gives a reasonable comparison between the design once in 100 year ARI event and the 1955 flood levels. The exceptions are:

- upstream of the New England Highway and adjacent to the areas protected by the levee;
- at the downstream end of the flood study model area where a relationship between flood level and flood discharge has been adopted. This assumption represents current practice; given the flood study was directed essentially to Aberdeen itself.

The increased levels upstream of the New England Highway are seen as possibly:

- a function of construction of the levee itself, which has closed off an important floodway on the Hunter River floodplain;
- works to raise the embankments and pavements of the New England Highway and the probable raising of rail levels along the Main Northern Railway, as compared to the levels that existed before these important hydraulic controls in 1955.

The issues at the downstream end of the Flood Study model can be easily rectified by using data from the recently completed Muswellbrook Flood Model. Until an update of the Aberdeen Flood Model is completed, it is recommended that the 1955 recorded flood levels should be used (in the downstream end of the Aberdeen Flood Study model only).

Changes to design flood levels do occur with advances in:

- definition of topography (for example, LIDAR aerial survey);
- changes in flood models (for example, the move from one dimensional hydraulic models to two dimensional hydraulic models);
- the availability of more flood data (which occurs as floods occur).

On balance, addressing the question of the fitness for purpose of the Aberdeen Flood Study for use in the Aberdeen floodplain management plan, it is considered that:

- the Aberdeen flood study is adequate for setting house floor levels through the rural areas around Aberdeen with the exception of the area within 3 km of the downstream extent of the model;
- immediately upstream of the New England highway, the model might predict flood levels greater than the "true" value; and
- if the "true" design flood levels for the once in 100 year flood levels (1% AEP flood) are higher than the 1955 flood but lower than the 1% AEP flood levels indicated in flood study, the net effect will be similar to setting a higher design flood level, thus requiring larger mitigation measures and consequently attracting larger benefits by reduction of flood damages.

The Aberdeen Flood Study also estimated potential flood damages at Aberdeen using a standard technique involving:

- survey of floor levels of each building;
- assessment of inundation above floor level for the range of floods tested;
- estimation of the damage for each building using inundation depths;
- summation of the flood damage for each recurrence interval at each building to provide an estimated average annual damage.

The Aberdeen Flood Study deals with estimates of damage caused by flood waters directly to buildings (including contents). It does not include:

- indirect damage that occurs but not as a result of contact with floodwater;
- intangible damages (such as social costs);
- public sector damage (such as post flood cleanup).

The floor level survey of the buildings is provided through a floor level database comprising 143 dwellings, which includes 43 dwellings as "manufactured homes" within the "Willow Grove" development. The floor level data base does not include all the dwellings in the flood liable rural areas around Aberdeen.

In a once in 100 year ARI flood, 85 dwelling units are predicted to be flooded above floor level, while an additional 27 properties will be inundated but not above floor level. Seven dwellings of the 85 inundated above floor level are located on rural land outside of Aberdeen (that is, north of the Hunter River).

The average annual flood damage for Aberdeen is $216,000 which includes the seven dwellings located north of the Hunter River. The manufactured homes within the "Willow Grove" development contribute 19% of the total flood damages at Aberdeen.

The de-facto floodplain risk management measures in place in Aberdeen relate to:

- the existing levee;
- the floor level controls;
- flood emergency management planning and flood warning.

It was noted above that the existing levee was constructed circa 1976 and provides protection up to the once in 50 year flood level without freeboard. A levee inspection was undertaken as part of this study (see Appendix A of this report) and a number of issues identified, which should be rectified if full confidence is to be had in the levee for floods up to its crest height. The deficiencies indicated by the levee inspection were:

- inadequate crest width and crest surface to allow wet weather access;
- a general lack of adequate grass cover;
- trees have been allowed to grow in the levee which creates a long-term risks of levee failure;
- fences across the levee which limit access along the levee;
- the degree of compaction within the existing levee material has been raised as an issue with the local residents.

It is noted that the levee easements were not taken over the land where the levee has been constructed, though securing of easements was not common practice at the time of levee construction. The lack of easements has created issues such as the residents planting trees and shrubs on the levee or placing various "developments" (such as garden sheds and the like) directly adjacent to the levee.

Upper Hunter Shire Council was formed by amalgamation of Scone Shire Council with the adjacent Murrurundi Shire and Merriwa Shire. It appears that floor level controls based on the 1955 flood level have been used in some instances to fix floor levels for new buildings. However, within the flood liable area of Aberdeen, the presence of new buildings with a variety of floor levels suggests that the floor level controls have not been rigidly applied.

Emergency management and appropriate evacuation measures are important issues, given the number of properties that are flood liable at Aberdeen. If the evacuation of the flood liable areas in Aberdeen is required, it is expected that up to 240 people may well require evacuation.

However, the high set nature of many of the buildings suggests that the residents would probably opt to remain in place rather than evacuate, even if warned to evacuate by the SES.

The SES, under the Emergency Services Act, has a statutory role of coordination of the New South Wales government agencies in response to flooding. The SES has extensive flood plans for NSW. The SES flood plans are very general in nature and tend to cover broad command structure for the SES and include a series of tasks to be undertaken by various government agencies. Aberdeen is identified under the SES Local Sub Plan. The Sub Plan addresses the flood hazard issues at Aberdeen, which are generally consistent with the information provided in the Aberdeen Flood Study.

The issue of flood evacuation at Aberdeen gives rise to significant and immediate concerns. It appears that there is no dedicated flash flood warning system for Aberdeen and the local SES endeavour to use an ad- hoc review of water level gauges on Pages River, Rouchel Brook and Kingdon Ponds to identify if major flooding is imminent.

The potential evacuation in Aberdeen is a major concern, given the total number of persons involved (possibly 250), the "high hazard" potential of the floodways that cross the evacuation routes to flood free land, and "high hazard" flooding through the area that is partly protected by the Aberdeen levee.

The "Willow Grove" development creates concern, given it appears to be partly directed to "retirement living" and thus the residents can be expected to have health, mobility and other age related issues, should evacuation be required. The evacuation paths from "Willow Grove" (and the surrounding areas of Hall Street, Nandowra Street and Gundebri Street) pass through "high hazard floodways" before high ground is reached in Aberdeen itself.

The New South Wales floodplain development manual outlines a range of measures that might be used for a floodplain risk management plan. Strategies involve:

- "structural measures" that is, physical works; and
- "nonstructural measures", such as land use planning and provision of emergency services.

This study has concentrated on measures considered as "practical" for Aberdeen to reduce existing flood risk, future flood risk and any residual flood risk remaining after implementation of floodplain management measures.

The management options considered "practical" within the Aberdeen scenario are:

- maintenance of the status quo, implying existing flood damages and costs will continue to accrue;
- modifications to the existing levee system; and
- house raising program.

A voluntary purchase system has also been included to demonstrate the cost of such measures. The management options have been prepared on the basis of:

- financial tests that can be quantified;
- non-financial tests that are based on a qualitative assessment; and
- environmental impact based on a qualitative assessment.

In the financial test, scheme costs have been derived for various works on the basis of the estimated quantities involved and unit cost rates for those quantities. Benefits from works are derived from a reduction in flood damages, which are totaled over a project life span to provide a total value of flood damages saved (treated as the benefit).

Within the floodplain management plan, in the consultants view, it is self-evident that land use planning (through the LEP and DCP) and emergency management measures (chiefly improvement of flood warning for evacuation) need to be included in any floodplain management plan, irrespective of whether other works and measures are included.

The available works and measures are compared in Chapter 8 of this report. The minor levee works ("McAdam levee") show very high benefit/cost ratio (2.7) demonstrating cost efficiency in the works.

Conversely, house raising and voluntary purchase have a very low economic efficiency, represented by a low benefit cost ratio.

Increasing the height of the existing levee also shows a reasonable economic efficiency. Although the benefit cost ratio is shown as less than one, it would be normal to consider these works as "attractive" given the benefits assessed are probably an underestimate in that they do not include some direct flood damages, indirect flood damages and intangible benefits.

The option of a complete ring levee system has not been fully explored because there is insufficient volume within the protected area to store local run-off from a storm if such a storm should occur during a flood.

A draft floodplain management plan is included in this report. The intent is that the draft floodplain management plan will remain as part of the Floodplain Risk Management Study and that the final Floodplain Management Plan will be published as a separate document once it has been adopted by Upper Hunter Shire Council.

1. INTRODUCTION

The Aberdeen Floodplain Risk Management Study and Plan have been prepared by the Upper Hunter Shire Council with the expressed purpose of managing flood risk at Aberdeen.

The management of flood risk uses a merit approach that seeks to balance social, economic, environmental and flood risk parameters to determine whether a particular use of the floodplain is appropriate and sustainable.

The Study and Plan have been prepared following the principles outlined in the New South Wales Government's Floodplain Development Manual (Reference 1) which outlines the policy and the process to be followed in the management of flood prone land.

The primary objectives of the New South Wales flood prone land policy are:

- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land and property;
- to reduce private and public losses resulting from floods using ecologically positive methods wherever possible.

The management of flood prone land is primarily the responsibility of local councils. At Aberdeen, the appropriate Council is the Upper Hunter Shire Council.

The Floodplain Development Manual outlines a process for moving towards an acceptable floodplain management system. Essentially the process covers:

- establishment of a floodplain risk management committee;
- compilation of a flood study;
- compilation of a flood risk management study;
- completion of the floodplain risk management plan;
- implementation of the floodplain risk management plan;
- periodic review of the above inputs to the floodplain risk management plan.

The Upper Hunter Shire Council has completed the flood study at Aberdeen, which has been published as the "Aberdeen Flood Study" (Reference 2). The study was formally adopted by the Upper Hunter Shire Council at its meeting on 22 July 2013.

The Aberdeen Flood Study (Reference 2) has illustrated the flood extents for a range of flood sizes in Aberdeen and its surrounding areas. Figure 1 illustrates the flood extent of flood liable land near Aberdeen. Figure 2 illustrates the extent of flood liable land within Aberdeen itself, and the location of the existing earth levee.

It is interesting to note that the topography along the Hunter River changes at Aberdeen. The area west of Aberdeen is dominated by a very large floodplain created at the confluence of the Hunter River at

Aberdeen (which flows from east to west) and a series of smaller watercourses flowing from north to south (Dart Brook, Middle Brook and Kingdon Ponds). The catchment of the Hunter River at Aberdeen (measured at the New England Highway crossing) is significantly larger than the combined catchments of Dart Brook, Middle Brook and Kingdon Ponds to the north.

The current study, as detailed in this report, covers:

- the completion of a floodplain management study;
- preparation of a draft floodplain management plan on the basis of the results of the floodplain management study.

The final Floodplain Management Plan will need adoption by the Upper Hunter Shire Council after a community consultation process.

The Aberdeen Floodplain Risk Management Study and Plan has been prepared as a two volume set. The first volume (Volume One) covers the floodplain risk management study and details the investigations and conclusions leading to Volume Two, the draft Floodplain Risk Management Plan. This approach then allows for readers, who are solely interested in the contents of the Plan, to concentrate on Volume Two while those persons seeking to clarify why particular decisions were taken and inclusions made to the Plan can reference Volume One.

A Scope of Work (the Brief) for the Aberdeen Floodplain Risk Management Study and Plan has been prepared by Upper Hunter Shire Council. The floodplain management study is directed to flood issues in two principal areas namely:

- the area of Aberdeen that is flood liable and is partially protected by an earthen levee along the Hunter River bank;
- the general rural areas surrounding Aberdeen, which are affected by flooding from the Hunter River.

The Aberdeen Floodplain Risk Management Study and Plan has been prepared under the auspices of the Upper Hunter Shire floodplain management committee. The Study and Plan for Aberdeen have been funded by the Upper Hunter Shire Council with financial and technical assistance from the NSW Office of Environment and Heritage.

2. FLOODING AT ABERDEEN

2.1 Overview

The Hunter River at Aberdeen suffers flooding at somewhat irregular intervals, similar to most NSW coastal and inland rivers.

Official water level records for the Hunter River at Aberdeen with regard to flooding are sparse.

The WC & IC installed a staff gauge (Station No. 210056, "Hunter River at Aberdeen") in 1959 and the station is still current. The staff gauge is sited on the northern bank (right-hand bank) of the Hunter River, some 450 metres downstream of the New England Highway crossing of the Hunter River.

With respect to the flood records available from Station No. 210056, "Hunter River at Aberdeen", it should be noted that:

- the gauge was installed originally as a daily read staff gauge;
- the station was converted to an instrumented station in 1998;
- although the period of record available for the site, as reported in "Pinneena" (Ref. 4), stretches from 1959 to current day, the period of record is not continuous, as noted below;
- The gauge was lowered in 1970 by 5 feet, and thus some care is required in converting historical records to current day flood levels.

Whilst Pinneena implies that Station 210056 was continuous from 1959 to current date, Station 210056 has two separate periods of record, namely:

- March 1959 to October 1978;
- March 1998 to current day.

The station documentation file is available for the post 1998 period, though the documentation file is "missing" for the period 1959 to 1978. Searches of both DPI hydrography offices and State Archives have not revealed the missing file.

The station documentation file indicates that significant survey was undertaken in 1998, which showed that the bench mark near the site had moved (rendering its elevation to m AHD as incorrect). It should be noted that the changes in bench mark value did not change the gauge zero.

Care is required in conversion of gauge readings to flood levels (in m AHD) given:

- the difference between WC & IC datum and AHD datum;
- the lowering of the gauge zero in 1970;
- implied changes to the record given the incorrect bench mark values near the gauge.

The preliminary listing of the highest recorded floods at Aberdeen, for the period since 1950, is given in Table 1 below.

Table 1

Preliminary Listing of High Floods, Hunter River at Aberdeen
Station: 210056 "Hunter River @ Aberdeen"

Year	Peak Gauge Height (m)	Peak Water Height (m AHD)	Comment on Source
1955	nr	169.3	WC&IC, Flood Study
1971	9.94	168.75	Reliable record, Gauge Reader Card
1976	8.99	167.8	
1992	9.20		Backwater?, DLWC
1996	8.20	167.01	Reliable, DLWC
1998	8.17	166.98	Reliable record, Pinneena
2000	9.54	168.35	Reliable record, Pinneena

Note: Current gauge zero RL 158.81 m AHD

With respect to the historical flood levels quoted in Table 1, it is noted:

- the 1955 flood level to m AHD is derived from OEH information. The original field survey (which would have been in imperial measure to WC&IC datum) has not been able to be located;
- the 1971 flood level is derived from the actual gauge readers card;
- the 1976 flood was not recorded on the gauge reader's card, which contains the notation "gauge washed away".

Comparison against the flood record at Station 210002, "Hunter River at Muswellbrook" suggests that the possible peak floods occurring at Aberdeen during the period of missing record for Station 210056 would be January 1984 and February 1992.

Perusal of the flood flow estimates for the recorded floods at both Aberdeen and Muswellbrook suggests that a good correlation between these two stations does not exist and thus the gauge correlation approach has not been pursued to complete the flood record at Aberdeen. Similarly, there are longer periods of record available for the lower Hunter River; however these are of minimal use, given that the major tributaries of the Goulburn River and Wollombi Brook join the Hunter River downstream of Denman.

The catchment area of the Hunter River at Aberdeen (Station 21056) is approximately 3089 sq. km with the major sub catchments as:

- Hunter River at Glenbawn Dam: 1307 sq. km
- Pages River at its confluence with the Hunter River: 1177 sq. km

- Rouchel Brook at its confluence with the Hunter River: 433 sq. km
- Inter-station areas below the above sub catchments: 82 sq. km

The above sub-catchments are shown on Figure 4.

Glenbawn Dam was completed in 1958 (Source: Aberdeen Flood Study, Section 2.2.1). The dam controls only 38 percent of the Hunter River catchment at Aberdeen. The occurrence of major floods at Aberdeen in 1971, 1976, 1996 and 2000 (all of which exhibited major flood flows down the Pages River), shows that Glenbawn Dam, in itself, does not prevent flooding at Aberdeen.

Several residents have indicated to the consultant that flood levels in the Hunter River at Aberdeen rise and fall quickly and that flooding only exists for some 24 hours. This flood behaviour is demonstrated on Figure 5 which illustrates the water levels recorded at Station 210056 for the 1971, 1976, 1998 and 2000 flood events.

With respect to Figure 5, it is noted that:

- the 1971 and 1976 flood events indicate the record is from Pinneena. Figure 5 also shows the record from the gauge readers' cards, which is slightly different to the Pinneena record. The reason for this discrepancy is unknown.
- the 1998 and 2000 flood plans were derived from the current instrument at Station 210056;
- Rates of rise and fall of 0.4 and 0.3 metres per hour respectively.

The reliable records of historical flood heights for Station 210056 are considered "sparse" and have insufficient flood records to enable an adequate statistical analysis to be completed.

Table 2 shows a ranking (from highest to lowest) of the four largest floods using flood data from Table 1.

Table 2

Ranking of Floods, Station 210056, "Hunter River @ Aberdeen"

Rank	Year	Peak Level (m AHD)
1	1955	169.3
2	1971	168.75
3	2000	168.35
4	1976	167.8

It is generally accepted in the community that the 1955 flood was the largest event since, say, 1900.

Further, the ranking is expected to include all major floods over the period 1959 to 2015. A crude analysis suggests therefore that the ranking given in Table 2 is applicable over the past 55 years and possibly the last 105 years. A plot of the four ranked floods (in Table 2) against return period is given on Figure 6.

Figure 6 suggests that Aberdeen Flood Study (which was based on a computer modelling approach) appears to reproduce the 1% AEP flood levels at Station 210056 "Hunter River @ Aberdeen" quite well. However, the Flood Study appears to over-estimate flood levels for lesser magnitude floods.

2.2 Aberdeen Flood Study

Flood Behaviour

The Aberdeen Flood Study was completed for Upper Hunter Shire Council by WMA Water (Consulting Engineers) and published in July 2013. The study was funded jointly by NSW Government (through OEH) and by Upper Hunter Shire Council.

The object of the Aberdeen Flood Study was to identify flood behaviour for a variety of floods with return periods of:

- once in five year Average Recurrence Interval (ARI)
- once in ten year ARI
- once in 20 year ARI
- once in 50 year ARI
- once in 100 year ARI
- once in 200 year ARI
- once in 500 year ARI
- probable maximum flood (PMF)

The flood study addresses the sparse flood record by adopting an approach to prediction of flood levels by:

- use of an hydrologic model (Watershed Bounded Network Model, WBNM) using design rainfall to predict design flood hydrographs;
- use of a two-dimensional hydrodynamic model (TUFLOW) to predict design flood levels from design hydrographs from the hydrologic model.

The results of the flood study are presented in the forms of:

- a water surface profile along the Hunter river;
- a water surface profile along the Dart Brook representing the combined floodplain of Dart Brook, Kingdon Ponds and Middle Brook;
- overlays to the aerial photographs indicating flood depths and flood surface contours for the once in five year, 10 year, 20 year, 50 year, 100 year, 200 year and 500 year ARI flood events plus the PMF;
- provisional flood hazards into categories of "low hazard" and "high hazard" for the design events listed above;

- categorisation of the floodplain into categories of "floodway", "flood storage" and "flood fringe" for the once in 20 year and once in 100 year ARI floods plus the PMF.

Table 3 below shows peak flood level at Station 210056 "Hunter River at Aberdeen" versus return period. The peak flood levels were derived from the Flood Study model data files. Table 3 shows that, once overbank flooding occurs, there are only small differences in flood height over the frequency range of 5% AEP to 0.2% AEP.

Table 3

Flood Height vs Frequency

Frequency		Level (m AHD)
%AEP	ARI	
10	10	168.45
5	20	169.00
2	50	169.15
1	100	169.25
0.5	200	169.39
0.2	500	169.47
NA	PMF	171.39

It is noted that the "top of bank" at Station 210056 "Hunter River @ Aberdeen" is approximately RL 169.4 m AHD and, given the range of flood levels given in Table 3 above, "top of bank" is not a useful measure of the magnitude.

The flood study indicates flood behaviour in Aberdeen as featuring:

- backwater flooding moving into Aberdeen from the Hunter River over the New England Highway in a once in 10 year ARI flood;
- backwater flooding and some overtopping at the most northern end of the Aberdeen levee in a once in 20 year event;
- the general overtopping of the Aberdeen levee between the Main Northern Rail Line and McAdam Street in a once in 50 year event with some overtopping immediately downstream of the Main Northern Railway Line;
- overtopping of the Aberdeen levee over the whole of its length in the once in 100 year flood. This indicates that the levee does not provide a once in 100 year protection within the so-called protected area;
- 100 properties are listed on the floor level data base;
- 7 included properties lie north of the Hunter River and thus are not strictly within Aberdeen;

- 72 properties are noted as "protected by Aberdeen levee" with the balance (28) either in Aberdeen itself or north of the Hunter River.

A number of aspects of the Flood Study have been examined to determine the "fitness for purpose" for the use of the Flood Study in preparation of this Floodplain Management Plan. The review is detailed in Section 2.3 of this report.

Figures 1 and 2 of the Aberdeen Flood Study show the predicted once in 100 year flood extent. Figure 1 illustrates the general Aberdeen area while Figure 2 is directed specifically to Aberdeen itself. Appendix D reproduces the diagrams from the Aberdeen Flood Study for the design 1% AEP flood in terms of flood levels, flood hazard and flood categories.

This report deals chiefly with the once in 100 year ARI flood (1% AEP flood) given that Upper Hunter Shire Council have adopted a Flood Planning Level of the once in 100 year ARI flood plus 0.5 m.

Flood Damages

The Aberdeen Flood Study estimated potential flood damages for the Aberdeen area, principally within the developed area of Aberdeen, using standard techniques endorsed by OEH.

Flood damages were estimated by a process utilising:

- survey of the floor levels of buildings that have the potential for flood inundation;
- assessment of flood levels over a range of floods with recurrence intervals between once in five year ARI and once in 500 year ARI events and the PMF flood level at each surveyed building;
- estimation of the damage for each flood at each building using a standardised inundation depths (above floor level) versus flood damage in monetary terms;
- summation of the flood damage for each recurrence interval flood to provide an estimated Average Annual Damage (AAD).

In assessment of flood damages, normal practice is to divide flood damage into:

- tangible flood damage;
- intangible flood damage.

Tangible flood damage represents the flood damage that can be quantified in financial terms (that is, a monetary value can be assigned to the damage suffered). Typical items for tangible flood damage are:

- structural damage to buildings, particularly building linings and foundations;
- damage to possessions;
- damage to furniture;
- damage to fittings and fixtures in the building;
- damage external to the individual dwelling such as motor vehicles, garages, workshops and the like;

- loss of wages and income because of the disruption caused by flooding;
- emergency accommodation costs;
- other items such as clean-up costs.

Intangible damage represents damage that occurs but which cannot easily be quantified to a monetary value. Such damages include the cost of community disruption, health costs through additional stress and the anxiety caused by the flood, increased risk to loss of life and the like.

The tangible damages can be further divided into:

- direct damage, that is where the damage is caused by flood water being in contact with a particular building. Such direct damages are listed above.

- indirect damage that occurs but not as the result of contact with floodwaters. Such indirect damages include:

    - loss of wages and income during a cleanup;
    - the cost of alternative accommodation and support services after a flood;
    - general cleanup activities after a flood.

Analysis of flood damage is an important criterion in the evaluation of any floodplain management plan. Floodplain management issues need to be compared against a variety of criteria including economic performance (that is to say, are the project works and measures justified in terms of costs and benefits) and financial capacity of the proponents to fund the floodplain management plan.

It should be noted, in the assessment of floodplain management programs, that:

- benefits received from a program are usually measured by flood damages saved and accrue to the community in general;
- costs of the program accrue to the proponent of the Floodplain Management Plan, usually government (Federal, State or local) with occasional resident contribution.

Within the Aberdeen Flood Study the principal conclusions were:

- 143 dwellings were listed on the floor level database, noting there are some properties with multiple dwelling units, notably “Willow Grove”;
- in a once in 100 year flood, 85 dwelling units were inundated above floor level, while an additional 27 properties were inundated but not above floor level;
- the total 85 dwelling units inundated in the once in 100 year event include 43 manufactured homes within the “Willow Grove” development;
- 7 dwelling units within the 85 buildings inundated above floor level are located outside of Aberdeen (north of the Hunter River);
- the number of commercial buildings within the flood prone areas is quite small and accordingly a simple approach of treating the commercial activities as a residential damage relationship was adopted for simplicity;

- the average annual flood damage for Aberdeen was $216,000;
- the average annual flood damage at "Willow Grove" ($41,161) comprises 19 percent of the total flood damage at Aberdeen;
- the flood damages indicated within the Flood Study are potential direct damages to residential and commercial buildings;
- the Flood Study does not include indirect damages, intangible damages or direct flood damage to public infrastructure.

Figure 7 shows design flood level, number of buildings flooded and predicted flood damages for various magnitude floods, identified by return period. Figure 7 shows how flood damages increase with flood magnitude, though the more frequent floods contribute a proportionally greater amount to the average annual flood damage because of their increased chance of occurrence.

In situations where a reasonable period of flood warning is available, residents, on receipt of the flood warning, can move goods and possessions to high ground (such as moving motor vehicles) and lift high valued possessions to above flood level (for example, placing high-value items on the tops of cupboards or bench tops/ tabletops), subject to the likely inundation of buildings. However, this activity needs a reaction time created by the flood warning and creates a situation where potential flood damages can be reduced to a lower value (identified by the term, "actual flood damage"). In the Aberdeen situation, floods rise relatively quickly in the Hunter River and hence limited flood warning time would be available. No reduction in "potential flood damages" is warranted as part of further consideration of "actual flood damages".

2.3 Fitness for Purpose

Examination of the results of the Aberdeen Flood Study for the Hunter River in the vicinity of Aberdeen has raised the issue of the "fitness for purpose" for use of the Flood Study results to complete the Floodplain Risk Management Study and Plan.

Figure 8 illustrates a long section of the Hunter River at Aberdeen, upstream of the New England Highway, for:

- the design once in 20 year, once in 50 year, and once in 100 year ARI floods;
- the existing levee profile, as defined by ground survey;
- the recorded 1955 flood levels, as reproduced in the Flood Study;
- estimated flood levels for the design once in 100 year ARI floods prior to construction of the Aberdeen Levee;
- the levee height required to satisfy a condition such that the crest level is at the design once in 100 year ARI flood level plus 0.5 m freeboard.

The Flood Study model topography was modified to simulate the situation prior to construction of the Aberdeen levee. The approach taken was simply to remove the levee embankment as created within the model. However, other areas that could critically affect the model results (namely the New England Highway and the Main Northern Railway) were not modified and no attempt has been made to create a topography set where these two features are set at the best estimate of their level as existed in 1955.

With respect to Figure 8, it is noted that:

- the design once in 50 year and once in 100 year ARI floods exceed the recorded 1955 levels over the length of Hunter River plotted;
- the design once in 20 year ARI flood exceeds the recorded 1955 levels upstream of the Main Northern Railway and is less than the recorded 1955 flood levels downstream of the Main Northern Railway;
- the railway openings and bridges at the time of the 1955 flood event would have been essentially as currently exist;
- an increase in the height of the existing levee of up to 900 mm will be required to meet the likely design crest level for any new levee matching the Flood Planning Level within Upper Hunter Shire;
- the model results for the current topography, but without the Aberdeen levee (as an estimate of the 1955 conditions), produces flood levels that are in excess of the recorded 1955 flood levels;
- the recorded 1955 flood levels would appear not to have recorded any head loss through the Main Northern Railway openings or the bridging for the New England Highway. There are also some issues raised regarding:
- the flood height versus frequency plot shown in Figure 6, which shows the Flood Study results versus an approximate flood frequency derived from available records. Figure 6 indicates the flood study results are considerably higher than the estimated historical events for the frequent floods, though the results approach the recorded events for the once in 100 year ARI event.
- discrepancies in the estimated total flood flows in Hunter River between the Aberdeen Flood Study and the more downstream Muswellbrook Flood Study.

In this study, additional data from the 1971 and 1955 floods have been sought from:

- Hydrography Branch, Department of Primary Industries for the original gauge reader cards for Station 210056 “Hunter River @ Aberdeen”;
- Office of Environment and Heritage for the original survey of the 1955 flood levels, which were plotted on the cadastral maps as existed at that time;
- Roads and Maritime Services for any flood levels noted during investigations for the bridge crossing of the Hunter River;
- Australian Rail & Track Corporation, as the lessee of the New South Wales railway network for the original flood levels noted for the rail crossings. It appears that, through the number of changes of office and responsibility, the original Working Plans for the railway have been lost.

The Aberdeen Levee was reportedly constructed to the 1971 flood levels plus a freeboard. The freeboard was presumably 3 foot (910 mm) given the general standard applied by WC&IC at that time. Comparison between the available 1971 flood levels and the surveyed crest shows that the actual levee crest is at or higher than the level specified for construction.

Comparison between the model results for the pre-levee conditions and current day conditions shows:

- The pre-levee predicted flood levels show as:
  - 350 mm above the 1955 flood levels and 250 mm above the recorded 1955 flood levels upstream of the Main Northern Railway and downstream of the Main Northern Railway respectively;
  - Differences between the pre-levee design once in 100 year flood and the current design once in 100 year flood of up to 350 mm upstream of the Railway Line and 110 mm downstream of the Railway Line.
- The levee has increased flood levels by up to 350 mm.
- The most significant increase in flood levels is upstream of the Main Northern Railway Line where the levee has closed a floodway that would have passed from the north eastern corner of the currently protected area to the south western corner of the protected area.
- The increase in flood levels downstream of the Main Northern Railway Line may in fact be masked because the design flood levels are higher than the recorded flood levels.

The "Top of Bank" at Station 210056 "Hunter River @ Aberdeen" is approximately RL 169.4 m AHD and hence the bank at this point has not been overtopped in any of the recorded floods but may have been close to overtopping in the 1955 event. Consequently, "Top of Bank" at Station 210056 is not an appropriate measure for the magnitude of flood events.

Figure 9 shows a comparison between the model results for the 1% AEP flood as predicted by the Aberdeen Flood Study and the 1955 flood levels as recorded by the WC&IC survey after the 1955 flood. Review of Figure 9 illustrates:

- In the area within 3 km upstream of the downstream limit of the model, the model predicts flood levels in the order of 0.7 m above the 1955 flood levels. This result is not unexpected given the model flood levels are controlled by an assumed flood level versus discharge relationship at its downstream level. This approach is standard practice given that the model was essentially established for prediction of flood levels at Aberdeen.
- Upstream of the New England Highway at Aberdeen, in the area influenced by the Aberdeen levee, the model results are about 0.5 m above the 1955 flood levels;
- In the remainder of the model area, the average of the differences between the recorded 1955 flood levels and the model results is approximately zero. There is, however, a scatter between the model and recorded 1955 levels.
- there is not a consistent height difference between the model and the 1955 flood levels.

The scatter of results is expected given the uncertainty of the nature of the 1955 flood levels that were surveyed. No records exist that give a description of the flood marks that were surveyed after the 1955 flood. The passage of time since 1955 means that it is virtually impossible to trace back to review the veracity of those flood levels. Accordingly, some scatter between the 1955 and model results should be expected.

In addressing the question of fitness of purpose for the use of the Aberdeen Flood Study for a floodplain management plan and given the information above, it is concluded that:

- the Aberdeen Flood Study is generally adequate for setting of house floor levels through the rural areas around Aberdeen;
- the exception to the general statement is in the area within 3 km of the downstream extent of the model, where model flood levels are controlled by an assumed relationship between flood level and flood discharge;
- the assumed relationship at the downstream end of the model can be adjusted to examine if a better comparison can be made regarding the design 1% AEP flood and the historical 1955 flood.
- the general increase in flood levels along the Hunter River immediately upstream of the New England Highway could be a function of the construction of the Aberdeen Levee combined with increases in height of both the New England Highway and the Main Northern Railway across the Hunter River floodplain at Aberdeen;
- if the true situation for design flood levels at Aberdeen is higher than the 1955 flood but lower than the 1% AEP flood levels as indicated by the Flood Study, the net effect, from a floodplain management perspective, will be similar to setting of a higher design flood level and thus dictate larger than required mitigation measures, which will attract a larger benefits by reduction in flooding.

2.4 Flood Hazard

The NSW Floodplain Development Manual requires an assessment of "flood hazard". The concept of "flood hazard" is based on the numerical product of flood depth and velocity.

FigureL1 and L2 of the Floodplain Manual divide flood hazard at a site into categories of Low Hazard, High Hazard, and a transition zone (identified as "medium" hazard in this report) between high hazard and low hazard. In reality, the boundaries between the flood hazard categories are not precise and relate to general safety of able bodied adults for wading in flood waters and limited damage to typical building construction types. Aberdeen Flood Study has produced a "provisional flood hazard" in map form for the 5% AEP and 1% AEP events. Figure 3 of this report, Flood Hazard, presents "provisional flood hazard" for the 1% AEP flood at Aberdeen.

Figure 3 indicates the residential areas, north of the New England Highway and west of Hall Street, as "provisional low hazard". The area covered includes the Willow Grove" development. The "low hazard" area does present significant flood evacuation issues, given that evacuation will be required along the New England Highway to reach high ground (and any evacuee reception centres). The New England Highway will be overtopped with "high hazard" areas either side of it. In this instance, given the evacuation difficulties and the likelihood of levee overtopping, the "low hazard" area should be changed to a "high hazard" area".

The changed flood hazard categories are shown on Figure 3 as "Adopted Flood Hazard".

2.5 Climate Change

Climate change and associated impacts of increased sea levels and changes to rainfall patterns is a vexed question for Floodplain Management Plans.

The general consensus is that sea levels will rise, but the possible changes in rainfall patterns, particularly short duration intense rainfall, is less clear.

The NSW Government does not offer any guidance to local government on this matter and suggests local government sets "local" standards. Aberdeen is simply too high above mean sea level to be affected by predicted sea level changes

The most recent publication dealing with changes to rainfall as a result of climate change appears to be a presentation by Bates et alia (Reference 5) at the 2015 Floodplain Management Association National Conference in Brisbane. The presentation includes a number of broad statements indicating the lack of research and lack of information on possible changes to intense rainfall events. Such statements are:

> "*Across Australia there has been little detailed analysis of the implications of climate change for the intensity, frequency and duration characteristics of heavy rainfall events."*
>
> "*In the absence of robust research results or national guidance, a number of states and organisations have developed approaches for assessment of the impacts of climate change on "extreme" rainfall."*

It is noted that the CSIRO and Bureau of Meteorology investigations on simulated increases in the magnitude of the wettest day rainfall suggested that increases were present even when there was a strong simulated decrease in the mean rainfall. The projected changes for these rainfall statistics, is a 2% to 8% increase in intense rainfall per degree centigrade rise in global average temperature.

The CSIRO and Bureau of Meteorology have prepared a website tool for assessing climate change, although the website appears to have little data on projected changes to extreme rainfall for the general area of the Upper Hunter region.

The consensus of the global climate models (identified by the CSIRO website) suggests that the Upper Hunter region will display temperature increases up to 3 degrees in maximum average temperature. The change in maximum average temperatures will produce little change in rainfall. It is noted that the past increases in average temperatures appear to be on average 0.11 degrees per decade. On the basis of the information provided by the Bates presentation (Reference 5), it is concluded that the best estimate of increases in heavy rainfall due to climate change over the next 100 years is likely to be about 5 percent increase on current values.

The Aberdeen Flood Study has addressed the potential increase in flood levels at Aberdeen by addressing:

- potential flood level changes resulting from increases in the design rainfall of 10, 20 and 30%;
- the differences in flood levels between the Flood Planning Level (based on the design 1% AEP flood) and flood levels from the 0.5% AEP flood and 0.2% AEP flood (once in 200 year and once in 500 year ARI events respectively).

In this instance, guidance is taken from the difference in flood levels at Aberdeen between the design 1% AEP flood and the sensitivity testing using a 10% increase in rainfall. It is noted that the adopted 10% increase in rainfall is above the average 5% increase in rainfall projected by the Bates presentation. The Aberdeen flood model indicates the increases in flood levels along the Hunter River channel at Aberdeen are in the

range of 0.1 to 0.2 m. Such increases in flood levels along the Hunter River will overtop the levee and cause flood level increases up to between 0.2 and 0.3 m within the protected area.

Given that the Flood Planning Level is based on the design 1% AEP flood level plus 0.5 m freeboard, the impact of climate change can be seen as causing a gradual continuing reduction in the freeboard available each year such that, in 100 years, the freeboard will have effectively reduced from 0.5 m to 0.2 m within the protected area. The change in design flood levels is expected to be relatively slow.

At New South Wales statute level, it is noted, that if Council wished to vary the Flood Planning Level from the design 1% AEP flood level plus 0.5 m, Council will need to apply to the Department of Planning for a special exemption to be incorporated into their LEP to allow for this variation to the New South Wales template LEP.

Given that the Bates paper identifies that climate change science is currently dynamic and that "the most up-to-date data" is being varied frequently, an appropriate response is:

- to adopt the current design 1% AEP flood levels as applying within a time window of the next five years;

- at the end of the initial five year window, to review climate change and rainfall data projections available at that time and to modify the Flood Planning Levels if required by projected intense rainfall changes.

This approach is viewed as an adaptive management technique and is appropriate, given the anticipated development is principally seen as replacement of existing housing stock and limited new dwellings in the rural floodplain areas.

3. CURRENT FLOODPLAIN MANAGEMENT PRACTICES

Following the 1955 flood, a variety of floodplain risk management measures have been gradually developed for Aberdeen.

The four broad areas of risk management measures cover:

- physical works;
- land use and development controls;
- flood emergency management;
- flood warning.

Each broad area of risk management is outlined below and has been developed by a variety of government agencies as:

- Physical Works: Department of Environment, Climate Change and Water (DECCW) principally its predecessors WRC, DWR and DNR), Upper Hunter Council and Roads and Traffic Authority;
- Land use planning and development controls: Upper Hunter Council;
- Flood emergency management: local SES committee;
- Flood warning, Planning and Provision: Bureau of Meteorology and NSW Flood Warning Consultative Committee.

3.1 Physical Works

The flood liable area of Aberdeen is partially protected by a levee along the left hand bank (looking downstream) of the Hunter River.

The levee location is shown on Figure 10 together with chainages (distances) that are used solely for reference purposes.

The levee prevents the breakout of water from the Hunter River running across the floodplain to the south west and through parts of Aberdeen, including Nandowra Street, Gundebri Street, Hall Street, McAdam Street and the New England Highway. It also partly protects the manufactured home site known as "Willow Grove". The levee does not prevent floodwater "backing up" over the New England Highway.

The levee was constructed circa 1976 by the then Water Resources Commission and Soil Conservation Service.

The levee is a compacted earth levee with dimensions as:

- crest width: approximately 2 m
- side slopes on the river side of the levee: 3 to 1 (horizontal to vertical)
- side slopes on the protected side: 2.5 to 1 (horizontal to vertical)
- the average height of the levee is about 1.4 to 1.5 m.

As noted, the levee is compacted earth and it is thought that the material for the levee was sourced from the floodplain adjacent to the Hunter River at the site.

There are three sets of drainage pipes beneath the levee, which drain from the protected side of the levee to the river side of the levee. Each pipe drainage pipe has a flap gate fitted to prevent backflow up the pipe during floods. The drainage pipes are located at (refer Figure 10):

- Chainage : 252 m
- Chainage: 573 m
- Chainage: 636 m

Given that the levee was constructed by NSW Government agencies using government funds, the logical conclusion is that the asset (the levee) is owned by the New South Wales Government.

Maintenance on the levee appears to be split. Mowing and repair of damage is undertaken by the New South Wales Government using funding through the Hunter River Flood Mitigation program. However, this maintenance work appears to occur only on the river side of the levee. There appears to be no maintenance on the protected side of the levee between the Main Northern Railway (Chainage: 371 m) to the New England Highway (Chainage: 718).

The Aberdeen Flood Study indicates that the levee provides only partial protection to Aberdeen. In the design 1% flood at Aberdeen (equivalent to the once in 100 year ARI event for the purpose of this study), the levee is predicted to be overtopped, while backwater flooding crossing the New England Highway into Hall Street and the surrounding areas is expected.

The levee has been inspected at regular intervals and it is interesting to note that all the inspections have noted the same issues with the levee. The last levee inspection was undertaken by Paterson Consultants in October 2014. The levee inspection was a visual inspection of the levee, partly as familiarisation exercise for the Aberdeen Floodplain Management Study. There were a number of issues related to the levee noted during the inspection. The issues were classified as:

- the crest width and crest surface was considered inadequate to allow wet weather access along the crest of the levee for inspection and emergency works;
- the levee was generally lacking adequate grass cover;
- trees and fences within the levee were viewed as a major concern between the Main Northern Railway Line and the New England Highway;
- The degree of compaction of the material in the levee was also raised by the residents as a concern; however these concerns can easily be addressed by a series of geotechnical tests to indicate the level of compaction actually achieved during construction.

It appears that easements were not taken over the levee route during or after construction. Thus, the levee is sited on privately owned land, which has the potential to restrict access should maintenance or emergency works to the levee be required.

The failure to take easements for levees is not uncommon in that:

- levees are quite often constructed soon after major floods and, as a consequence, landowners are happy for the levee works to proceed, given the flood protection they will receive;
- the acquisition of easements can be a long and very expensive process and, as such, government agencies seek to avoid taking easements unless absolutely necessary.
- local government seeks, where possible, to avoid compulsory acquisition process given the disruption, anxiousness and ill-feeling that compulsory acquisition process creates within the community.

3.2 Land Use Planning

Upper Hunter Shire Council was formed in 2004 by amalgamation of Scone Shire with Murrurundi Shire and Merriwa Shire. Recent developments within the flood liable areas appear to be above the 1955 flood levels. However, corporate knowledge of floor level controls applied to new building appears to have been lost in the amalgamation and subsequent staff changes. The loss of such corporate knowledge is not seen as a significant issue, given that Upper Hunter Shire Council are actively developing a DCP with specific reference to flooding, while adequate flood behaviour data is given in the Aberdeen Flood Study.

3.3 Emergency Management

Emergency management is an integral part of current floodplain risk management practice.

The State Emergency Service (SES) has a statutory role for coordination of New South Wales government agencies in response to flooding. The statutory role is defined by the State Emergency Service Act, 1989.

The SES, in fulfilling their statutory obligations, relies on:

- a headquarters/head office based in Wollongong;
- division of the state into 17 regions with separate regional headquarters;
- local emergency committees based in each local government area;
- individual units reporting to the local emergency committee. Aberdeen falls within the SES Hunter region.

The SES documents their expectations in response to flooding for various New South Wales agencies in the Upper Hunter Shire via a public document titled “Upper Hunter Shire Flood Emergency Sub-plan”, which forms part of the “Upper Hunter Shire Emergency Management Plan”.

The Upper Hunter Shire Flood Emergency Sub-Plan has two volumes. Volume 1 identifies the various New South Wales agencies that are affected or required to contribute, while Volume 2 details known and proven flood risk at various centres in the Upper Hunter Shire.

In general, SES practice is to divide the flood emergency response into three phases, paraphrased as:

- preparedness for flood events;
- response to flood events;
- recovery from flood events. Under the Sub-plan:
- the SES maintain an SES unit at Aberdeen under a unit controller;
- the unit activities are as directed by the SES Upper Hunter Local Incident Controller, who is based in Scone;
- the identified tasks of the SES Aberdeen unit relate to flood response tasks including:
    - collection of flood information;
    - flood rescue and evacuation;
    - provision of immediate welfare for evacuated persons;
    - delivery of warnings and flood information;
    - levee monitoring;
    - sandbagging;
    - lifting and removal of possessions and commercial stock;
    - assistance for repair and improvement of levees;
    - assistance in road closures;
    - assistance in flood event preparedness activities;
    - undertaking training for flood and storm response and operations.

Within the Sub-plan, tasks that are identified for the New South Wales government agencies cover, inter alia:

- Office of Environment and Heritage relate to:
    - provision of specialist policy, engineering and scientific advice to Upper Hunter Shire Councils at
    - provision of specialist advice regarding flooding to the SES;
    - provision of relevant flood studies to the SES;
    - collection of flood data after the event.

- Office of Water is tasked essentially with:
    - collection of the hydrographic information;
    - provision of the hydrographic data to the SES and to the Bureau of Meteorology.

The responsibilities of the Upper Hunter Shire Council are identified, and those tasks related to "Preparedness for flooding" and "Response to Flooding" are summarised as:

- "Preparedness for flooding":
    - establish and maintain floodplain risk management committees;
    - provide flood studies, levee studies and the like to the SES;
    - provide information on the consequences of dam failure to the SES.

- "Response to Flooding":
    - deploy personnel and resources as requested by the Upper Hunter Shire Local Incident Controller;
    - open and close roads;
    - provide sandbags;
    - assist removal of caravans;
    - provide backup radio communications;
    - assist in making facilities available for companion animals.

Under the sub-section of Volume 2, "Part2 - Preparedness" SES contributions are identified, and among other things, include:

- the SES may establish a total flood warning system in the areas affected by flooding requiring:
    - identification of potential users of such a flood warning system;
    - presentation of available information of estimated impacts of flooding;
    - identification of required actions and time available for such action;
    - appropriate means for dissemination of warnings.

Under the sub-section of Volume 2, "Part3 - Response", the Flood Sub-plan notes:

- flood response operations within the SES will begin:
    - on receipt of a Preliminary Flood Warning, Flood Warning, Flood Watch, Severe Thunderstorm Warning or Severe Weather Warning from the Bureau of Meteorology; or
    - on receipt of a dam failure alert; or
    - when other evidence indicates an expectation of flooding.

- floods in the Upper Hunter Shire are initially to be managed by the Upper Shire Incident Controller in Scone.

Volume 2 of the Upper Hunter Shire Local Flood Sub-plan addresses known flood hazard and risk in various areas of the Upper Hunter Shire. With respect to Aberdeen, the flood hazard clauses in Volume 2 are generally consistent with the information provided in the Aberdeen Flood Study.

It should be noted that the above presents an overview of the Upper Hunter Shire Flood Emergency Sub- plan and that readers should consult the original document (Reference 3) for further detail.

Given that the Upper Hunter Shire Flood Emergency Sub-plan details their interpretation of their statutory obligations, it is apparent that the objectives of a Floodplain Risk Management Plan lie within the SES "Preparedness for Flooding" phase.

The Aberdeen Flood Study provides available flood data, both from known events and predicted flood events, by way of computer model.

It is clear from comparison of the objectives of the Floodplain Risk Management Plan (broadly to reduce public and private losses from flooding) and the statutory obligations for the SES, as enunciated through their Upper Hunter Shire Flood Emergency Sub-plan, there is an expectation that the floodplain management plan is directed towards providing information for the SES's "Phase 1, Preparedness of flooding". It is also interpreted that the Floodplain Risk Management Plan can contain a series of works and measures that not only reduce public and private losses from flooding but also reduce the requirements on the SES for evacuation and accommodation of evacuees who are affected by flooding.

Discussions between the consultant and the SES Unit controller at Aberdeen indicate:

- there is no flood warning system for Aberdeen;
- the Bureau of Meteorology has advised that the catchment response to rainfall is too fast to allow an effective flood warning system;
- The Aberdeen SES Unit is thus forced to use volunteers to monitor flood gauges on Pages River, Glenbawn Dam and Rouchel Brook plus Kingdon Ponds to assess likely flood height at Aberdeen;
- there are no gauges on the Hunter River downstream of its confluence with Pages River;
- the principal station at Aberdeen (Station 210056, "Hunter River @ Aberdeen") is located on the steep outer bank, slightly downstream of the New England Highway. Thus the gauge is sited such that it is virtually impossible to obtain manual gauge readings in floods up to "top of bank" and access is cut once overbank flooding occurs.

Analysis of the house floor level data used in the Aberdeen flood study indicates that at least 105 houses within Aberdeen would be identified for evacuation of their residents in a once in 100 year ARI flood event.

The manufactured home facility known as "Willow Grove", located immediately upstream of the New England Highway and partly protected by the Aberdeen levee, contains some 48 individual units. Accordingly, it can be expected that some 60 to 90 people would need to be evacuated from this facility.

The conversion of the "Willow Grove" facility from a caravan park to a manufactured home park has created considerable issues for the SES in that:

- the residents have changed from a partly transient population to a fixed resident population;
- although manufactured homes are transportable, they would not be able to be moved as quickly as caravans would have been able to be evacuated.
- the creation of a manufactured home area has probably increased the average age of the residents and thus health, mobility and other age-related issues would be more apparent during a flood evacuation.

The evacuation of residents from the area protected by the Aberdeen levee is problematic.

The residents in Nandowra Street, Gundebri Street, Hall Street and the "Willow Grove" facility (refer Figure 10 for street locations) need to pass through a High Hazard Flood way to reach higher ground within Aberdeen itself. The floodway is created by the depression that runs from the Hunter River, south of Hall Street.

The residents in Macadam Street do have access to high ground directly, although they would need to pass through flood water if they sought to access Aberdeen where emergency accommodation is planned to be available.

The SES Local Flood Sub plan indicates that there could be some 80 residents requiring flood evacuation from the rural areas surrounding Aberdeen.

In assessment of house raising (a potential measure in the rural areas), the number of likely houses affected has been quantified as 72 residences (requiring raising to satisfy minimum floor levels at or above the Flood Planning Level). It is suspected that the number of residents requiring evacuation from the rural areas could exceed the 80 residents listed in the SES Local Flood Sub Plan.

It is clear that a better flood warning system is required for Aberdeen to ensure that evacuations can be adequately planned and executed. The need for a flash flood warning system is exacerbated by the historically recorded rapid rise of flood levels in the Hunter River at Aberdeen.

Given the above:

- the Floodplain Risk Management Plan should make the Bureau of Meteorology aware of the magnitude of flood evacuation issues that exist in Aberdeen and should press for a flash flood warning system as has been undertaken for scone;

- a procedure manual should be developed so that the local SES can interpret Bureau of Meteorology flood warnings such that the local emergency management measures can be implemented in a timely fashion.

4. LANDUSE PLANNING AND DEVELOPMENT CONTROL

4.1 Overview

Within New South Wales, land use planning and development follows a hierarchy, in decreasing order, as:

- Environmental Planning and Assessment Act (EPA Act)
- State Environmental Planning Policies (SEPP)
- Local Environmental Plans (LEPs)
- Development Control Plans (DCPs)

Broadly, LEPs deal with land use zoning with permissible and prohibited development, while DCPs deal with more specific detail for particular areas.

The documents of specific interest to this study are:

- Upper Hunter Local Environmental Plan (2013), currently in force;
- Upper Hunter Draft DCP (2014).

The specific provisions of these documents are addressed below, together with the practical consequences of past implementation of these planning documents.

4.2 Upper Hunter Local Environment Plan (2013)

The Upper Hunter LEP, gazetted in 2013, applies to the whole Upper Hunter administrative area (including Aberdeen). The LEP follows the NSW Government standard template for LEP applying to Local Government.

Flooding issues and development of floodplain land is addressed in:

- Clause 2(e) of "Aims of Plan";
- Clause 6.2 under Part 6 "Additional Local Provisions".

The relevant clauses are reproduced below. The LEP provisions are:

1.2 Aims of Plan

(1) This Plan aims to make local environmental planning provisions for land in the Upper Hunter in accordance with the relevant standard environmental planning instrument under section 33A of the Act.

(2) The particular aims of this Plan are as follows:
(a) to encourage the proper management, development and conservation of natural and human- made resources in the Upper Hunter by protecting, enhancing and conserving the following:
(i) important agricultural resources,
(ii) timber, minerals, soil, water and other natural resources,
(iii) the environmental, scenic and cultural heritage of the Upper Hunter,

(b) to protect and conserve:
(i) soil stability by controlling development in accordance with land capability, and
(ii) remnant native vegetation, and
(iii) water resources, water quality and wetland areas, natural flow patterns and their catchments and buffer areas,
(c) to establish a pattern of broad development zones as a means of: (i) separating incompatible uses, and
(ii) minimising the cost and environmental impact of a development, and
(iii) maximising efficiency in the provision of utility, transport, retail and other services, (d) to manage the urban areas of the Upper Hunter by strengthening retail centres and employment opportunities, promoting appropriate tourism development, guiding affordable urban form and providing for the protection of heritage items and precincts,
(e) to promote ecologically sustainable urban and rural development and control the development of flood liable land,
(f) to secure a future for agriculture by expanding the Upper Hunter's economic base and minimising the loss or fragmentation of productive agricultural land,
(g) to protect, enhance and provide for biological diversity, including native threatened species, populations and ecological communities, by long-term management and by identifying and protecting habitat corridors and links throughout the Upper Hunter.

Part 6 Additional Local Provisions

6.2 Flood planning
(1) The objectives of this clause are as follows:
(a) to minimise the flood risk to life and property associated with the use of land,
(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,
(c) to avoid significant adverse impacts on flood behaviour and the environment. (2) This clause applies to

land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
(a) is compatible with the flood hazard of the land, and
(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
(c) incorporates appropriate measures to manage risk to life from flood, and
(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

(5) In this clause:
***flood planning level** means the level of a 1:100 year ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*

The LEP contains clauses relating to minimum lot sizes for subdivision of rural areas. In the consultant's interpretation, the LEP allows for subdivision and lot sizes less than 40 ha however the LEP precludes subdivision less than 40 ha for either development of a residential building or creation of a housing entitlement.

Figure 11 reproduces the land use zoning map from the Upper Hunter LEP 2013, which covers Aberdeen. Figure 11 also shows (as an overlay), the extent of the inundation of the design 1% AEP flood and the extent of land where the Flood Planning Level (the design 1% AEP flood level plus 0.5 m freeboard) should be applied.

The zoning of Aberdeen is consistent with its flood liability, with the exception of the area of residential land (Zone RU1) and land zoned as "private recreation" for the "Willow Grove" development (Zoned RE2).

In Aberdeen, there is not a substantial difference between the inundation extent and the land where the flood planning levels should be applied. The small difference between the area of application of building controls (through the Flood Planning Levels) and the inundation extent for the design 1% flood at Aberdeen is a function of the topography. The topography of Aberdeen features a relatively flat floodplain while, outside the floodplain, land rises quite steeply to the higher parts in the centre of Aberdeen. Accordingly, the land between the inundation extents and the area of application for building controls through the Flood Planning Levels is quite small.

In other parts of the flood liable area of the rural land surrounding Aberdeen, the differences between the inundation extent for the design 1% AEP flood and the flood planning level application area flood planning level may be substantial if there is a gentle topographical rise between the two extents.

4.3 Upper Hunter Development Control Plan (Draft, August 2014)

Upper Hunter Council is developing a development control plan (DCP) for their local administrative area. Flooding is addressed under "Part 10 Natural Hazards". The DCP indicates that the intent of Part 10 is to specify outcomes, design guidelines and other requirements relating to the management of natural hazards. Flooding is addressed within Part 10 under a separate section ("Section 10A").

Under Section 10A, flooding and development is addressed as a sequence following:

- Types of development requiring consent and land to which those types of development are applicable
- The requirements for the supporting plans and documentation
- The outcomes to be achieved with regard to general flood considerations
- The requirements for supporting documentation (such as survey requirements, flood reports)

- The outcomes to be achieved, principally:
    - compatibility of development with flood hazard
    - habitable (residential) buildings
        - electrical and mechanical equipment
        - heating and air conditioning
        - alterations and additions to habitable buildings
    - non-residential development
    - rural development
    - flood proofing requirements for buildings on flood liable land

The draft DCP follows the common format used in New South Wales and covers most of the flood related issues with individual developments. In the consultant's view, items that need further consideration in the draft DCP relate to:

- the quotation of flood levels on the plan of flood prone land at Aberdeen;
- the allowable afflux caused by individual developments at the property boundaries.

4.4 Concluding Comments

The LEP, through its minimum lot sizes, is expected to limit further growth of residential housing or commercial/industrial development on the flood liable land in the rural areas around Aberdeen.

The draft DCP can be improved by:

- inclusion of a plan showing the extent of the Flood Planning Level as opposed to the extent of the design 1% AEP flood;

- quantification of the allowable afflux (an increase in the design flood level) caused by development on the properties surrounding that development.

A plan showing the extent of the Flood Planning Level is required because there will be areas that are outside the design 1% AEP flood extent but which will be below the Flood Planning Level. In these areas, flood planning levels will need to be applied and thus the plan is required to avoid confusion on the part of the community as to why flood planning controls are applied outside the extent of the design 1% AEP flood.

5. DEVELOPMENT OF A FLOODPLAIN RISK MANAGEMENT PLAN

5.1 Overview

The New South Wales Government has published the Floodplain Development Manual with the objective of the management of flood liable land. Whilst the government's flood prone land policy is outlined in the Manual, it is expected that local government councils will be the lead agency for the management of flood prone land through their primary responsibilities of land use planning.

The New South Wales Government provides financial assistance to local government for works and measures and technical assistance to assist responsible floodplain management decisions within local government.

The primary objective of the New South Wales Floodprone Land Policy is directed to reduction of the impact of flooding and flood liability on individual owners and occupiers of flood prone land and to reduce private and public losses resulting from floods.

In the formulation of the Floodplain Development Manual, the government has recognised that flood prone land is a resource that should not be unnecessarily sterilised and that development applications and proposals for flood prone land should not be measured against rigid and prescriptive criteria. Accordingly the Floodplain Development Manual outlines a set of steps leading to the creation of a floodplain management plan for an area. A "merit" approach is envisaged such that a variety of factors are considered during development of a floodplain management plan, including the economic and social and ecological factors as well as assessment of flooding behaviour.

The Local Government Act (Section 733) provides a legal indemnity for councils, government agencies and their staff against claims relating to flooding, providing that the steps within the Floodplain Development Manual have been followed.

5.2 Broad Floodplain Risk Management Principles for Aberdeen

The Aberdeen Flood Study has indicated the nature of flood risk at Aberdeen and its immediate surrounds. The flood liable areas of Aberdeen are partly protected by a constructed levee along the left bank of the Hunter River, upstream of the New England Highway.

The Floodplain Development Manual identifies possible floodplain management strategies as:

- "structural measures" (that is physical works);
- "non-structural measures" (such as application of land use planning principles, provision of emergency services).

The Floodplain Development Manual outlines a series of possible floodplain development works and measures that might be implemented as part as a of a floodplain management plan.

However, given the nature of flooding at Aberdeen and the flood damages accruing at Aberdeen, it is clear that not all of the options quoted in the Floodplain Development Manual are "practical" in addressing the flood issues at Aberdeen.

This report concentrates on the "practical" measures that might be applied at Aberdeen and the surrounding area for the development of a suitable floodplain management plan for the area.

An overview of the existing development at Aberdeen in relation to flood behaviour and flood risks suggests the area can be divided into two broad-scale areas of focus, namely:

- the existing residential and commercial development within Aberdeen itself, where the development is concentrated over a small area as a function of the urban subdivision;
- the area surrounding Aberdeen, which is characterised as a general rural area and noting that there are a significant number of dwellings in the rural area that serve as either dwellings associated with an agricultural enterprise or dwellings for those residents seeking a rural lifestyle.

In development of a floodplain risk management plan, it is worthwhile noting that the overall floodplain risk can be divided into the categories of:

- "existing flood risk", which flows from existing development within flood liable areas;
- "future flood risk" flowing from flood risk that would be created by new development, changes to existing development or possible future changes to climate affecting rainfall;
- "residual flood risk", identified as the risk (principally from existing risk) which will continue following implementation of floodplain management works and measures that would reduce but not totally eliminate existing flood risk.

Within the Aberdeen scenario, the "practical" floodplain risk management options available for a floodplain risk management plan are:

- maintenance of the status quo (implying existing flood damages will continue to accrue);
- a general house raising program;
- implementation of land use planning measures providing explicit recognition of the flood issues;
- modification of the existing levee system;
- complete upgrading of the existing levee system.

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One object of this study is to proceed on the basis of:

- proposal of practical floodplain management options;
- comparison of available options;
- selection of appropriate works and measures to comprise the floodplain risk management plan.

Given the nature of flooding at Aberdeen and the practical floodplain risk management works and measures, the appropriate criteria for the comparison of various floodplain risk management initiatives are:

- financial tests (which can be quantified);

- non-financial tests, which need to be addressed on the basis of a qualitative assessment. Under financial tests, the items for consideration have been identified as:
- the cost of works;
- the benefits of works (as measured by flood damages saved);
- the benefit cost ratio (as a measure of economic efficiency of works or measures).

Other numerical measures (that are not financial) for consideration are:

- number of properties affected;
- the population affected, by implication, directly related to the number of properties affected.

Under non-financial tests, items for consideration are:

- general community acceptance of works and measures;
- environmental improvement opportunities;
- environmental cost implications.

With respect to the financial tests, it should be noted that:

- the benefits of works or measures (as measured by a reduction in flood damages) accrue generally to individuals and enterprises in flood liable areas;
- costs of works or measures, giving general government financial assistance (with some personal contributions in particular cases) accrue to the community as represented by government;
- the total benefits created are measured as an accrual of the damages saved each year;
- the present value of benefits is discounted for future years using the compound interest formula.
- the total benefits (identified as Net Present Value) are a summation of the stream of yearly benefits accruing;
- one result of the application of the compound interest formula is that the current value of future benefits decreases as the number of years into the future increases;
- the total value of benefits depends on the discount rate (similar to interest rate) used and the number of years used for the summation of benefits.

In this study, a discount rate of 4% per annum has been used over a duration of 30 years for the summation of the total Net Present Value of benefits.

The net present value of the annual benefit accruing in 30 years time (at a discount rate of 4% per annum) is only 4% of the current value. Thus, extension of the period of accruing benefits does not significantly increase the net present value of the benefit stream.

6. FLOODPLAIN RISK MANAGEMENT – RURAL AREAS

6.1 Overview

The flood liable rural areas surrounding Aberdeen are quite extensive. The area liable in the design 1% AEP flood, as defined by the Aberdeen Flood Study, covers some 32.5 sq. kilometres and is indicated on Figure 9.

The rural areas are identified as flood-liable on Figure 9 include:

- the Hunter River floodplain;
- the floodplain of Dart Brook, Middle Brook and Kingdon Ponds.

It should be noted that there will be other areas of flood liable land outside the area covered by the Aberdeen Flood Study.

The topography of the floodplain areas is quite flat and features wide floodplain with several incised waterways.

The floodplain appears to have been sub-divided into quite small land holdings and as a consequence, there are a considerable number of residences scattered over the floodplain areas. Historically, the number of residences is seen as being tied to the small scale agricultural enterprise on fertile floodplain soils.

Clearly, works such as levees or bypass channels are not appropriate, given the high cost of such works to protect the widespread distribution of the existing residences.

6.2 Existing Development

In relation to protection of the existing development, there are realistically only three options available namely:

- maintain the status quo, which essentially means existing flood damages will continue to accrue;
- undertaking a house raising program to elevate the floor levels of individual residences;
- provision of emergency services.

With regard to future development, the realistic options relate to:

- subdivision control to limit the number of future buildings that may be constructed on the floodplain;
- building controls to specify minimum floor levels for new buildings and to specify flood compatible materials to be used for building below a Flood Planning Level.

With regard to future development, it is noted that Upper Hunter Shire's latest DCP for development includes items covering minimum floor levels and the use of flood compatible materials in buildings.

Site inspection indicates that:

- there are some 72 residential buildings within the flood liable rural area;
- the bulk of the residences have their floor levels elevated between 0.5 m to 1 m above the ground level. This is most probably a response to historically recorded floods.
- Two of the 72 residences are elevated and thus not candidates for house raising;
- Fifteen (15) residences were classed as "not raisable" because of their construction (for example, having brick cladding, slab on ground construction or numerous brick chimneys);
- Fifty-five (55) residences were classed as "raisable".

At this point, floor level data and building type data for the residences within the rural areas are not available and hence the normal method of calculating flood damages as the basis of inundation above floor level over a range of flood magnitudes is not possible.

However, the flood damages estimates within the Aberdeen Flood Study provide average annual flood damages for eight residences located north of the Hunter River in the rural area. The floor levels to these buildings range from the order of "slab on ground" to 1 m above ground level. The average annual damage per building is $1927 which includes an average annual damage of $418 for damage created by inundation of the property below floor levels.

A simplified financial analysis of a house raising program within the rural areas can be undertaken as follows:

- Benefits
  - Annual Flood Damage saved: 55 residences at $1509 per building $ 83,000
  - Net present value of benefits: $969,400
- Cost
  - Cost of raising: 55 residences at $80,000 per residence $4,400,000
- Benefit Cost Ratio 0.22

It is noted that house raising does have some adverse impacts which are covered in further detail in the following chapter dealing with house raising within Aberdeen itself.

Given the low benefit cost ratio of the house raising proposal for the rural areas, there is little to be gained by further exploration of this option.

6.3 Future Development

It can be anticipated that there will be a continuing pressure on Upper Hunter Shire Council to allow further residential development on the flood liable rural land surrounding Aberdeen, as community members seek residences with a rural outlook, or a hobby farm, or a small-scale agricultural operation or simply children wishing to build residences adjacent to their parents or family home.

Such forms of development simply exacerbates the issues of floodplain management and is not consistent with the view that appropriate development on flood liable lands are developments that limit or reduce the flood damages and flood risk to both the community and individuals.

Construction of dwellings with elevated floor levels does not provide a complete solution in that:

- ancillary buildings are usually not elevated and thus the building and contents can suffer significant flood damage;
- elevated dwellings only increase the evacuation and other service issues faced by the SES, even though the affected dwellings were well elevated above design flood levels;
- often the land holdings are not large enough to have adequate refuges for livestock and thus evacuation of livestock becomes a significant issue. Evacuation of livestock can become a trauma issue for stockowners, particularly if there are small livestock numbers that are treated as family pets.

Appropriate floodplain management measures for future development on the flood liable rural lands are available through the Council's LEP and DCP provisions.

The clauses of the gazetted LEP restrict:

- the creation of new lots by subdivision by way of a 40 ha minimum lot size;
- the ability to create new dwelling entitlements on existing lots;
- the creation of "rural workers" housing by way of a narrow definition of the object of "rural workers" housing as housing associated with and necessary to an adjacent agricultural enterprise.

7. FLOODPLAIN MANAGEMENT – ABERDEEN

7.1 Overview

This section addresses a number of "practical options" of floodplain management within the urban areas of Aberdeen. As noted earlier in this report, effort has been concentrated on measures identified as "practical" rather than expended on measures identified as "not practical".

The work and measures considered "practical" at Aberdeen comprise:

- a house raising program;
- levee works involving:
    - minor levee works to the existing levee;
    - major levee works to the existing levee system;
    - completion of a complete ring levee system for Aberdeen.
- a voluntary purchase scheme for flood affected properties.

This section examines the above works and measures as options in further detail.

Two measures that are considered as "self-evident" for a floodplain risk management plan at Aberdeen are:

- improvement to emergency management measures; and
- use of land use controls to ensure only appropriate development occurs on flood liable lands.

Accordingly, these self-evident measures have not been addressed as options and have been transferred directly to the draft Floodplain Management Plan.

7.2 House Raising

"House raising" can be an effective way of reducing risk of flood damages potential for flood liable properties.

Literally the process of house raising involves:

- placing beams underneath the house to support the structure;
- elevating the whole house structure evenly;
- replacing the footings and support structure under the house.

Clearly, house raising is not practical for all buildings. Buildings considered impractical to raise include:

- slab on ground construction;
- full brick and/or masonry buildings;
- brick clad or masonry clad buildings;
- buildings with a brick or masonry attachment such as a fireplace.

Whilst house raising has some advantages, it also has a number of disadvantages namely:

- the raising, if substantial, can significantly increase the difficulty of accessing the building as well as creating inconvenience;
- the raising creates a requirement for additional stairs, ramps or lifts;
- the additional elevation to main living areas can be an almost insurmountable issue for the aged and those with physical disabilities;
- house raising affects the "streetscape" and this may be viewed as a significant negative environmental impact;
- house raising of individual buildings can create issues of overshadowing of adjacent buildings that have not been raised;
- depending on the height raised, owners, in the longer term, may turn the space created below the main floor level into habitable areas and thus negate the objectives of the house raising program;
- whilst building floor levels have been raised, residual flood damages will continue to exist as flood damages accrue once floodwaters enter a property but may not have exceeded the floor level.
- the creation of high-set houses may encourage the inhabitants to remain in place during a flood evacuation emergency rather than evacuation. This practice is generally frowned upon by emergency service providers.
- house raising will reduce the flood damage suffered on individual properties but does not completely exclude flood damages.

It should also be noted that, under current government financial guidelines, contribution to the house raising is expected from the property owner, given the benefit they are receiving from a government-sponsored program.

A major house raising program is possible within the residential areas of Aberdeen that are protected by the existing levee. An objective of the program would be to raise the lower floor level of all buildings where the lower floor level is less than the design 1% AEP flood level plus a 0.5 m freeboard (that is, to raise all floor levels that are currently below the Flood Planning Level to a new level equal to or above the Flood Planning Level).

Use of the house floor level database for Aberdeen indicates that, in the flood liable area, there 65 potential candidates for raising of floor levels. However within the total number of 65 candidates for house raising, it is noted that:

- Twenty one (21) houses are considered not "raisable" by virtue of their construction;
- Fifteen (15) houses are shown on Upper Hunter Shire's databases as "heritage listed" and thus could not be raised whilst maintaining their heritage status;
- accordingly, thirty two (32) houses only are considered as "raisable".

The house raising candidates above do not include the manufactured homes within "Willow Grove". "Willow Grove" is listed variously as a manufactured home park, a self-contained community for permanent residents only or as on option for "retirement living". The 45 dwellings in "Willow Grove" have not been considered for house raising principally on the basis that, whilst the buildings themselves may be

raised, raising of the buildings would cause significant access difficulties considering the apparently older age distribution of the population of "Willow Grove".

Current (2014) costs for house raising are in the order of $70,000 to $80,000 per house. The financial cost of a house raising program can be itemised as:

Cost

Raising Houses: 32 houses at $80,000 per house	$2.56 million
Benefits	
Current, Average Annual Flood Damage (AAD)	$200,842
After House raising, Average Annual Flood Damage	$163,600
Benefit (Damages saved as AAD)	$ 37,219
NPV of Benefits	$434,700
Benefit Cost Ratio	0.17

It is noted that the benefit cost ratio for the house raising program above is quite low, which follows from the low benefits that are achieved. The benefits achieved by the program follow the existing house floor levels of the 32 candidates for house raising. The house floor level database shows that 17 of the 32 house raising candidates have floor levels that are above the design 1% AEP flood level but below the Flood Planning Level. Further, two houses have floor levels within 200 mm of the design 1% AEP flood level. Accordingly, these 19 properties record low damages in the design 1% AEP flood or smaller magnitude events and hence the benefits from excluding floods from these buildings are not large.

7.3 Levee Works

The earlier work in this report has indicated that:

- the existing levee at Aberdeen has been constructed to the design level as specified at the time of construction.
- the Aberdeen Flood Study has indicated that the levee does not provide protection up to be design1% AEP flood level. Whilst the Flood Study levels may overestimate the design flood level, it is suitable to use flood levels for the consideration of various floodplain management options.

There is no inherent need identifying that the levee should be on constructed to the design 1% AEP flood plus freeboard other than a levee to this height would be consistent with the Flood Planning Level that has been set within the Upper Hunter Shire Council's draft DCP.

The Flood Study indicates that, for the design flood, the levee is expected to commence overtopping at its upstream end.. This breakout floods McAdam Street and contributes floodwater to a larger breakouts further downstream both upstream or downstream of the Main Northern Railway line.

The survey of the levee shows a number of small depressions in the crest of the levee, which will break out prior to the general overtopping of the levee. It is not clear whether these depressions exist in reality or are a reflection of the ground survey, which may not have been briefed to identify significant flood breakout points.

There are two major options dealing with the Aberdeen levee that would reduce flooding and thus create a benefit. The two options have been identified as:

- "minor levee" works which involve construction of a small levee to link the existing levee to McAdam Street and thus close off the initial breakout point; and

- "major levee" works as a complete upgrade of the levee to design levels as specified by the 1% AEP design flood level from the Aberdeen Flood Study plus 0.5 m freeboard.

Completion of a ring levee around the flood liable area of Aberdeen by undertaking the "major levee" works as identified above plus completion of a levee on the western side of the New England Highway would prevent backwater flooding entering the protected area from downstream.

The "minor levee" works would also create a consistent profile for the existing levee such that the crest matches the gradient demonstrated by a flood surface from the Aberdeen Flood Study.

Figure 12 illustrates the location of the works for both the "major" and "minor" levee works.

7.3.1 "Minor Levee" Works

The "minor levee" works identified above would essentially raise the existing levee to provide protection against the 2% AEP flood (a once in 50 year ARI flood) but with no freeboard.

The principal works are construction of the small levee at the northern end of McAdam Street to close a potential breakout around the north eastern end of the existing levee.

The levee works are noted in this report as the "McAdam Levee" which is used simply as an identification of the work.

The levee will reduce flooding within the area currently protected by the existing Aberdeen levee. It is emphasised that these works do not prevent flooding within the protected area because, in the design 1% AEP flood:

- overtopping of the levee will occur;
- backwater flooding across the New England Highway from further downstream will still occur.

Figure 13 illustrates the extent of flooding predicted for the design 1% AEP flood after construction of the McAdam levee

Comparison between Figure 13 and existing conditions (Figure 2) shows that the McAdam levee:

- prevents inundation of 20 properties along McAdam Street;
- prevents inundation of 7 properties within the Nandowra Street/Gundebri Street/Hall Street area.

The Aberdeen Flood Study model shows that the McAdam levee and topping up the low spots in the existing levee cause an increase in flood levels upstream of the Main Northern Railway of about 125 mm (12 cm). This increase in flood height extends north along the Main Northern Railway and is vindication of the importance of the flood way that existed through Aberdeen prior to construction of the existing levee.

The financial costs of "McAdam levee" program can be itemised as:

Cost

Cost of works (assessment as reproduced in Appendix B)	$309,000
Benefits	
Current average annual damage (AAD)	$200,842
After "McAdam levee", Average Annual Flood Damage	$129,339
Benefit (damages saved as AAD)	$ 71,503
NPV of benefits	$835,155
Benefit cost ratio	2.70

In consideration of the financial analysis above, pertinent points to be made are:

- the benefit cost ratio of 2.7 is very high and indicates an efficient financial investment given that, typically, the floodplain management works create a benefit cost ratio of less than one.
- the cost of works estimate includes a large contingency which essentially is derived from the consultants experience dealing with similar projects and given the level of detail, the lack of survey and the lack of a complete Schedule of Quantities available at this stage of project;
- within the "after McAdam levee" average annual flood damage, the "Willow Grove" development contributes some 30% of the damages for the whole area. This indicates the significance of adequate flood evacuation planning for this development will continue even after the works are constructed.
- the levee works themselves do not remove the existing flood way that passes east of Hall Street and thus the evacuation difficulties within the Gundebri Street to Hall Street areas will remain.
- The principal benefit from the work is the reduction of flooding along McAdam Street, where the bulk of the dwellings are heritage listed.
- the dis-benefits of the work relate to the increased flood levels on the Hunter River floodplain generally and the potential increase in flood risk at a number of dwellings. The dwellings and businesses affected do not appear on the floor level survey and accordingly it is not possible to develop an appreciation of the changes to flood liability that will affect these properties, given a predicted increase of 0.125 m.

7.3.2 "Major Levee" Works

The "major levee" works identified above would essentially raise the existing levee to provide protection against the 1% AEP flood (a once in 100 year ARI flood) plus 0.50m freeboard.

The levee works are noted in this report as the "Upgrade Levee" which is used simply as an identification of the work.

From a construction perspective, increasing the height of the existing levee between McAdam Street and the Main Northern Railway is a relatively simple project, assuming compacted earth is used. The existing levee passes over land that is used for grazing and which is un-encumbered by land owner improvements along its route. Thus, space is available to raise the levee.

Construction in upgrading the levee between the Main Northern Railway and the New England highway is significantly more difficult than upstream. The difficulties are created by:

- land ownership;
- limited available space for works;
- the lack of suitable crest width on the existing levee;
- landowners' improvements within their land on and adjacent to the levee itself;
- the proximity of houses to the existing levee.

In the section from the Main Northern Railway to the New England Highway, there are two options to increase the height of the levee, either:

- to increase the height of the levee by widening the levee on the river side of the existing levee such that the height is increased and that appropriate crest width is established along the top of the levee; or

- by use of a concrete block wall on the protected side of the levee to increase the height of the levee and provide additional crest width on the levee.

With either option for increasing the levee height between the Main Northern Railway and the New England Highway, good engineering practice dictates that the existing trees and vegetation be removed (including their root zones) and compacted material used to restore the levee.

The existing batter slope on the protected side of the levee is very steep and virtually impossible to mow as maintenance. It would be prudent to flatten the protected side levee slope to allow better maintenance if the option of increasing the height of the levee using earth fill on the river side of the levee is adopted.

It is expected that the concrete wall option on the protected side of the levee will be more expensive than earth fill on the river side of the levee. However it would create a clear dividing line between the levee and land in private ownership beside the levee.

The proposal to upgrade the existing levee to the design 1% AEP flood plus 0.5 m freeboard does not render all of the existing flood liable areas in Aberdeen to a flood free situation. Figure 14 shows the predicted inundation extents for the 1% AEP flood after upgrading of the levee. It will be noted that, in the upgraded levee situation, it is assumed that McAdam levee will be constructed between the north eastern end of the current levee and McAdam Street such that a breakout depression is closed.

Figure 14 illustrates that the upgrading of the levee will render:

- McAdam Street as protected (viz "not flooded") in a design 1% AEP flood;
- the land to the west of Hall Street (including Nandowra Street and Gundebri Street) and the Willow Grove development will become flood free;
- the land to the east of Hall Street generally remains flood liable;
- the existence of flooding along the old floodway east of Hall Street, (which is caused by backwater flooding over the New England Highway from downstream) means that the evacuation difficulties from Nandowra Street, Gundebri Street and the western side of Hall Street plus the Willow Grove development still face the same evacuation issues in that any evacuation route passes through flood waters to get to higher ground in the central part of Aberdeen. In this situation, it can be expected that the residents in Nandowra Street, Gundebri Street and the western side of Hall Street will expect to remain in the residences rather than evacuate, even though levee overtopping might be predicted and the New England Highway escape route is closed.

The financial costs of "Upgrade levee" program can be itemised as:

Option 1: Earthworks construction

Cost

Cost of works (assessment as reproduced in Appendix B) $1.446 million

Benefits

Current average annual damage (AAD)	$200,842
After "Upgrade" levee, Average Annual Flood Damage	$ 96,025
Benefit (damages saved as AAD)	$104,817
NPV of benefits	$1.26 million

Benefit cost ratio 0.87

Option 2: Earthworks and Concrete block-work construction

Cost

Cost of works (assessment as reproduced in Appendix B) $2.420 million

Benefits	
Current average annual damage (AAD)	$200,842
After "Upgrade" levee, Average Annual Flood Damage	$ 96,025
Benefit (damages saved as AAD)	$104,817
NPV of benefits	$1.26 million
Benefit cost ratio:	0.52

7.3.3 Ring Levee Construction

Figure 14 shows the inundation extent after an upgrade of the existing levee to provide a crest level at 0.5 m above the predicted design 1% AEP flood. It is noted (from Figure 14) that backwater flooding, from downstream, over the New England Highway will still occur even after the levee upgrade works.

The construction of a levee on the downstream side of the New England Highway could be used to prevent the backwater flooding however. The total cost of such works is expected to be in the order of the $2.2 million.

However, the current vertical profile of the New England Highway and the existing drainage beneath the Highway shows that there is not sufficient volume within the protected area to store local run-off from rainfall should sufficient rainfall occur during a flood similar to the design flood. The issues of drainage are also exacerbated by the shape of the actual flood. For example, the design flood hydrograph is a single peak event however double peak events can occur (as in the 2000 flood), which follow from the rainfall patterns over the catchment. A double peak flood would worsen the local drainage issues

It appears that the pavement of the New England Highway has been raised several times but without major improvement to the drainage underneath the highway. Simply, drainage from the eastern side of the highway (in the protected area) relies on pipe drainage below the New England Highway. There is no surcharge path available once the capacity of the drainage is reached. Accordingly, ponding will occur even in local rainfall events on the eastern side of the New England Highway.

Clearly, the drainage issues at the New England Highway need to be addressed before extension into a Floodplain Risk Management program for Aberdeen.

7.4 Future Development

The land use zoning at Aberdeen (as shown on Figure 11) indicates that land zoned for residential use which is also flood liable is essentially confined within the area bounded by the Hunter River, McAdam Street and the New England Highway (including streets such as McAdam Street, Hall Street, Gundebri Street, Nandowra Street and Dart Street plus the New England Highway).

The Aberdeen Flood Study shows the flood liable area as comprising low flood hazard along the bank of the Hunter River but with a High Hazard Floodway running from the north-east to the south-west across the flood liable land to the south of Hall Street.

The bulk of the existing subdivided lots in this area are approximately 1000 sq. m in area. There are, however, six lots whose areas range from 1.5 ha to 2.85 ha.

Upper Hunter Shire Council can anticipate applications for three forms of development within the flood liable area indicated above. These are:

- new building development as a replacement of existing building stock;
- extensions to existing building stock;
- new subdivisions.

The Upper Hunter LEP clause on minimum lot sizes for land zoned as R1 "Residential" allow a minimum area of 600 sq. m. However, the LEP also contains provision for dual occupancy housing and the like, which would allow subdivision of the lots down to 300 sq. m. Thus, the LEP provisions have the potential to allow further development within the flood liable area of Aberdeen.

The Upper Hunter Shire Council Development Control Plan (under Section 10a, "Natural Hazards") contains suggested development conditions for new buildings and extensions to existing buildings.

It is unrealistic to expect that replacement of existing building stock or extension to existing building stock can be prevented, given that the area has limited flood protection provided by the existing Aberdeen levee. The clauses in the DCP should ensure that future flood damages are reduced following new development, given that increased floor level heights and building material types should be able to be enforced. Nonetheless, the severe evacuation difficulties in the area will remain and, if new development provides significantly increased habitable space, such new development will create further evacuation and emergency accommodation difficulties for the SES.

In regard to the potential subdivision of the existing large lots within the flood liable area or the subdivision of the smaller lots for dual occupancy, such approvals would simply increase the population at risk of flooding, exacerbate the evacuation difficulties already faced by the SES and will lead to an increase in flood damages suffered by both the community and individual occupiers.

The opportunities to mitigate against future subdivision are:

- to back zone the existing large lots to rural land use zoning such that further subdivision is not permissible under the LEP;

- to utilise the clauses of the LEP and DCP relating to the flood hazard to limit the opportunities for future subdivision.

7.5 Voluntary Purchase

Voluntary purchase schemes are occasionally used for properties that are sited in "high hazard floodways" and thus create a significant risk of loss of life should major floods occur. Such programs are "voluntary" in that government funding may be available for the purchase and demolition of properties where the property owner or user of the property is willing to participate in the program.

Nonetheless, voluntary purchase schemes tend to show a very low economic efficiency and are usually undertaken only when the social needs (reduction of the threat to life) is considered to outweigh the economic efficiency.

The economic efficiency of voluntary purchase schemes is demonstrated below for potential schemes involving:

- Acquisition of the area protected by the Aberdeen levee;
- Acquisition of the flood liable area remaining after the upgrade of the Aberdeen levee (as illustrated on Figure 14) representing a "partial" voluntary purchase scheme.

In the cost estimates below, the values of properties are being assumed as:

- General overall properties $250,000 per property
- Dwellings within "Willow Grove" $ 85,000 per building
- Land at "Willow Grove" $ 2.5 million

The above values are solely used for the purposes of demonstrating the economic efficiency of a voluntary purchase scheme. They do not represent a "valuation" on the properties nor do they represent what sale prices might be achieved if the properties were available on the market.

The economic analysis of a total voluntary purchase scheme is:

Purchase of the properties	62 properties @ $250,000	$15.5 million
Purchase "Willow Grove" Dwellings	45 dwellings @ $85,000	$ 3.83 million
Development other than dwellings		$ 2.25 million
Demolition & clean-up	62 properties @ $50,000	$ 3.10 million
	Total Cost	$24.68 million

Benefits

Current Average Annual Flood Damage (AAD)	$200,842
After voluntary acquisition, Average Annual Flood Damage	Assume no damage
Benefits (Damages saved as AAD)	$200,842
NPV of Benefits	$2.41 million

Benefit/Cost Ratio 0.10

The economic analysis of a partial voluntary purchase scheme is:

Costs

Purchase of the properties	21 properties @ $250,000	$15.5 million
Demolitions	21 properties @ $ 50,000	$ 1.05 million
Levee works (See Section 7.3.2)		$ 1.45 million
	Total Cost	$18 million

Benefits

Current Average Annual Flood Damage (AAD)	$200,842
After voluntary acquisition, Average Annual Flood Damage	Assume no damage
Benefits (Damages saved as AAD)	$ 200,842
NPV of Benefits	$2.41 million

Benefit/Cost Ratio 0.13

With respect to voluntary purchase schemes, it should be noted that:

- voluntary purchase schemes are only effective if all the landowners within the affected area agreed to participate. Given the number of properties within the flood liable area of Aberdeen, agreement to participate over the full population of the area would seem unlikely;

- known flood liable house properties tend to have market values towards the lower end of values within the particular area. Thus, while a voluntary purchase arrangement may provide compensation to the market value of the property, there simply may not be replacement accommodation within the surrounding area that can be acquired at the paid compensation value.

- voluntary acquisition does cause disruption to the community, particularly for residents who have lived within the target area for a considerable period of time.

Within the "partial" voluntary purchase scheme outlined above (combined with levee works), the evacuation difficulties for "Willow Grove" and the general development in Gundebri Street, Nandowra Street and Hall Street will still have the same evacuation difficulties and risks. The levee works and voluntary purchase arrangements may create a false sense of security for persons living in the area, which the post-works inundation extents would indicate as flood free but would be at severe risk if the levee were to be overtopped

8. COMPARISON OF OPTIONS

8.1 Overview

The previous sections of this report have outlined a variety of options for improvement of floodplain risk management, both in Aberdeen itself and the surrounding areas. The object of floodplain risk management is to reduce potential flood liability and to reduce the damages accruing to both the community and individuals through flooding.

It is self-evident, from Chapter 3, Section 3.3, that the emergency management, in particular the flood warning system available for Aberdeen, needs improvement given:

- the lack of a flood warning system or even a rudimentary flood magnitude assessment system for Aberdeen;
- the limited protection provided by the Aberdeen levee;
- the number of dwellings that would require evacuation;
    - the occurrence of backwater flooding over the New England Highway into Aberdeen, which would possibly require evacuation;
    - the evacuation difficulties are created by the nature of flooding, which features a "high hazard floodway" between the lower hazard areas along the bank of the Hunter River and the flood free higher land to the south, where the bulk of Aberdeen is located and where emergency accommodation would be located.

Accordingly, the emergency management improvement has not been included in this comparison of options.

Similarly land-use planning has not been included in this comparison. The latest Upper Hunter Shire LEP and the recently adopted DCP address the bulk of the land use planning issues as they relate to floodplain risk management. In essence the land use planning documents seek to allow appropriate development on the flood liable areas and seek to discourage inappropriate development (that is residential housing and commercial and industrial development) on the flood liable areas in and around Aberdeen. Accordingly, land use planning documents have not been included in the comparison of options.

8.2 Available Options

The available floodplain management options (excluding emergency management and land use planning) are shown in a tabular format in Table 4 below. Table 4 includes:

- economic factors which are treated in dollar terms;
    - social factors that have been addressed in a numerical system ranging from "Best" as +5 to "Worst" as -5 and "Neutral" as 0. The assessment is based on the consultant's perception of the social factors.

- environmental factors are based on the consultant's perception of the importance of those factors using a numerical system from +5 "Best" to -5 "Worst".

It should be noted that, in the areas where physical works are envisaged, the natural environment has been highly modified from that which would have existed prior to European settlement. The land has been cleared, subdivided and utilised for residential building. Thus, the environmental factors addressed relate to the impact of the works on the surrounding land noting that natural environment features that require mitigating allowances would rate between "very limited" to "non-existent".

Review of the options given in Table 4 below suggests that house raising is not an effective means of reducing flood damages. Within the urban area, the environmental impact of the house raising has been shown as "–2" given that:

- house raising requires all of the buildings to be raised, thus requiring the acceptance of all the community;
- some buildings already have elevated floor levels, hence the process of raising only some of the houses will have an impact on the streetscapes through the area;
- current subsidy arrangements through government allow only a part subsidy of the house raising with the property owner expected to contribute the balance of the funds required.

The minor levee works (the "McAdam levee") show a very attractive benefit cost ratio. However the environmental issues have been shown as "–1" given that the Flood Study model predicts an increase in flood levels for surrounding properties, both adjacent to the levee and north of the Hunter River. These impacts require further quantification before proceeding with construction.

The "upgraded levee" option also shows a reasonable benefit cost ratio. However, it also shows increased flood levels north of the Hunter River. It has the additional disadvantage (by the "–2" ranking of environmental issues) that it will tend to promote a community expectation that the levee will render the areas flood free in all floods, and thus the community will be reluctant to undertake any evacuations even if the levee is threatened to overtop.

The "ring levee" option has not been pursued further because there does not appear to be sufficient volume available for the storage of local run-off (that could occur during a flood) in the protected area. Similarly, the New England Highway itself and provision for drainage under the roadway will promote ponding on the eastern side of the Highway. This issue needs to be resolved to ensure that a levee further downstream can be effective.

Both in the urban areas of Aberdeen and the rural areas surrounding Aberdeen, the land use zoning and building controls (as scheduled in the DCP) should act to limit the development of the flood liable areas to those developments considered as having "merit" under the Floodplain Management Manual. In those cases, the building controls in the DCP of set minimum floor levels and use of flood compatible building construction will not prevent all flood damage but will act to reduce potential flood damage.

Table 4

Comparison of Floodplain Management Options

Options	Financial				Non-Financial			Environmental
	Capital Cost ($)	Damage Cost ($AAD)	Benefit ($NPV)	Benefit/Cost	Properties Benefiting	People Benefiting	Community Support	
Existing – Urban Areas								
1. Status Quo	NA	$201,000	NA	NA	0	0	+ 0	+ 0
2 "McAdam" Levee	0.31 million	$129,500	835,250	2.7	85	210	+ 1	– 1
3. "Upgrade" Levee	$1.45 million	$96,000	$1.26 million	0.87	85	210	– 1	– 2
4. Ring Levee	$2.2 million							
5. House Raising	$2.56 million	$163,600	$434,700	0.17	32	190	– 1	– 2
6. Voluntary Purchase - Total	$24.7 million	Assume 0	$2.41 million	0.10	85	210	– 5	+ 1
Voluntary Purchase – Partial	$15.5 million	Assume 0	$2.41 million	0.13	85	210	– 5	+ 1
Existing – Rural Areas								
1. Status Quo	NA	$138,800	NA	NA	-	-	+ 0	+ 0
2. House Raising	$4.4 million	$55,800	969,400	0.22	55	135	+ 0	–1

Notes: AAD = Average annual flood damage
NPV = Net present value
NE = Not estimated
NA = Not applicable

9. DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

9.1 Overview

Low lying parts of Aberdeen and the surrounding rural areas are flood liable.

In the design once in 100 years Average Recurrence Interval (ARI) flood (equivalent to a 1% AEP flood), it is predicted that some 85 properties in Aberdeen will be inundated with some 69 houses inundated above floor levels.

The Aberdeen Flood Study has been completed (adopted by Council on 22 July 2013) and shows that areas of High Hazard Floodway will exist through the low lying areas of Aberdeen. Such floodways increase the flood risk to the persons and the properties within those floodways and severely hamper evacuation operations from other flood liable areas, even though those flood liable areas might have a lower flood hazard.

The object of the draft Aberdeen Floodplain Risk Management Plan is to provide Upper Hunter Shire Council with a pathway to achieving the New South Wales Government objectives in the floodplain risk management manual, that is:

- to creation of a reduction in flood damages accruing both to the community and to individuals occupying the floodplain;

- to promote sustainable development of floodplain.

This draft Floodplain Risk Management Plan is not intended to be a firmly fixed document, but one that can be reviewed at regular intervals and adjusted according to both the works and measures that have been implemented and the experience derived from such implementation.

Within the Aberdeen Floodplain Risk Management Study, improvements to the flood evacuation planning and the implementation of the Upper Hunter Local Environmental Plan (LEP) and the recently adopted Development Control Plan (DCP) are self-evident inclusions within any floodplain management plan for Aberdeen.

Similarly, the consultant's perception is that the general community within the low lying areas of Aberdeen may not be generally aware of the flood risk, nor are they prepared for any evacuations.

The draft Floodplain Risk Management Plan outlined below lists floodplain management issues and the actions to be taken. A table is included outlining priorities and costings.

9.2 Components of the Draft Floodplain Risk Management Plan

Issue: Flood warning and preparation for evacuation

It appears that there is no flash flood warning system for Aberdeen and, at this point, the SES rely on volunteers using the river level gauges on the Pages River, Rouchel Brook and Kingdon Ponds to estimate the magnitude of the flood.

Given the demonstrated rapid rise of Hunter River at Aberdeen and the number of people and properties likely to be affected, it is clear that there is a need for a better flood warning system, preferably a two-stage approach using:

- a flash flood warning system through the Bureau of Meteorology;
- a written procedure for the SES locally that can be followed as a backup to the Bureau of Meteorology system.

The "Willow Grove" development represents the largest concentration of persons within the areas that would require evacuation. A "temporary measure" to assist evacuation would be:

- topping of the levee with an all-weather surface between the north-eastern corner of "Willow Grove" and the existing New England Highway bridge over the Hunter River;
- creation of steps to give access from "Willow Grove" to the top of the levee;
- closure of the access to the New England Highway using a lockable gate with keys to be held by the SES and on-site management of "Willow Grove".

The object of these minor works is to provide an emergency access for the residents of "Willow Grove" to a higher area. Whilst this work is not ideal, it would be better than current arrangements.

Action:

Upper Hunter Shire Council to press the Bureau of Meteorology to develop a flash flood warning system for Aberdeen, given the magnitude of the flood issues and the rapid rate of rise of the Hunter River at Aberdeen, and noting that a flash flood warning system is already in place for Scone.

Upper Hunter Shire Council to work with the SES to investigate a simple procedure to using the available river gauges, to predict as an approximate predictor of likely flood height, and times of flood arrival, at Aberdeen.

Upper Hunter Shire Council work conjointly with SES and "Willow Grove" to develop an evacuation plan for "Willow Grove" and incorporate an all-weather access for pedestrian evacuation from "Willow Grove" to the New England Highway bridge.

Issue: Community flood awareness

The low lying areas of Aberdeen were flooded in 1955 and 1971 and possibly in 1976 (subject to the precise construction completion of the Aberdeen levee at the time of the 1976 flood).

The Aberdeen Flood Study indicates that the Aberdeen levee does not provide protection up to the design once in 100 year flood event, or larger events, and only provides protection up to the once in 50 year ARI event but with no freeboard.

The consultant's perception is that the general community within the low lying areas of Aberdeen may not be generally aware of the flood risk, nor are they prepared for any evacuations.

Action:

Upper Hunter Shire Council and the SES will need to undertake a locally specific public information program to inform the residents of:

- the flood liability of the lower lying areas of Aberdeen and the hazard attendant to flooding;
- the potential need for evacuations from the area.

Issue: Land use planning

The latest Upper Hunter Shire LEP and the recently adopted DCP include a variety of clauses and measures which will act to attain the objectives of any floodplain risk management plan in reduction of flood damages.

There are minor amendments that can be made to the DCP and it is suggested that an annual review of the DCP be undertaken, rather than Council seeking to occlude amendments as soon as the need of those amendments becomes evident.

Action:

Upper Hunter Shire Council undertake annual review of the DCP to incorporate amendments as required.

Issue: Future Development

There are areas of low lying, flood-liable land within Aberdeen and around Aberdeen that have the potential to attract interest for residential or commercial /industrial development. Such uses of floodplains are discouraged generally under the merit approach as enunciated by the New South Wales Floodplain Development Manual.

The provisions of the LEP and the DCP should act to:

- direct development of flood liable lands away from residential, commercial and industrial development;

- provide a level of flood protection to dwellings by enforcement of minimum floor levels (at the Flood Planning Level or above) and by enforcement of the use of flood compatible materials below the Flood Planning Level in buildings.

Additional residential development on the flood liable lands will only exacerbate the flood risk to properties and life and will only exacerbate the issues facing the SES in terms of emergency management in the area.

There are a number of vacant large blocks within the lower parts of Aberdeen that are zoned as "R1 General Residential" which potentially could attract interest for further development. It is suggested that these large lots be "back zoned" to rural zoning such as "RU1 Primary Production" or "RU4 Primary Production, Small Lots" such that the provisions for the rural land development would then apply to these.

Action:

"Back zone" the large vacant lots currently zoned as "R1 General Residential" in the lower parts of Aberdeen as "RU1 Primary Production" or "RU4 Primary Production, Small Lots".

Issue: Levee works

The minor levee works ("McAdam levee") have useful economic return on the works costs.

There are, however, several issues that should be addressed prior to a decision to proceed with construction. These issues are:

- the impact of the levee works on the surrounding properties needs better quantification (such as via a Review of Environmental Factors) to identify the precise impact of any changes to flood levels;

- survey and design of the proposed levee works is required with the object of accurately quantifying the works cost.

The Aberdeen Flood Study hydrodynamic model does require some additional work to identify if the increases in design flood levels above the 1955 flood levels, upstream of the New England Highway are due to:

- changes in the road and rail embankments post 1955;
- the model assumptions used to generate head losses through the bridges (verification that the model does not overestimated such losses).

Preparation of a Review of Environmental Factors (REF) is required to quantify the actual impact of any increased flood levels on the properties surrounding the flood liable area of Aberdeen. The object of the REF would be provision of sufficient information such that Upper Hunter Shire Council can make a considered decision on whether to proceed with the works.

A more detailed cost estimate needs to be derived from a Schedule of Quantities, which would be produced by the design process. Given the design process should cost less than 10% of the total works cost, it is prudent to complete an accurate cost estimate before a decision to proceed with construction is made.

Action:

Further detailed review of parts of the hydrodynamic model used in the Aberdeen Flood Study to confirm its veracity in prediction of increased flood levels.

Preparation of an REF for the minor levee works to quantify the actual impact of any increased flood levels on the properties surrounding the flood liable area of Aberdeen.

Subject to the results of the REF, proceed with survey and design of the minor levee works with the object of producing a refined cost estimate for the works.

Issue: New England Highway

It appears that the raised carriageways on the New England Highway will create ponding in local run-off on the eastern side of the Highway itself. Rectification will probably require further drainage works underneath the Highway to resolve the situation.

Nonetheless, it appears that there is insufficient storage volume for local run-off within the protected area, such that a ring levee system (comprising upgrades of the existing levee plus closure levee along the western side of the New England Highway) may not provide the flood protection expected.

The provision of additional drainage beneath the New England Highway will also probably require fitting floodgates to the new drainage structures such that backwater flooding from downstream of the New England Highway does not enter into the protected area.

Action:

Upper Hunter Shire Council approach RMS regarding the joint investigation to rectify the drainage beneath the New England Highway at Aberdeen.

Issue: Limited voluntary acquisition or house raising

It is noted that there are 11 dwellings located on the eastern side of the New England Highway in the flood liable area of Aberdeen that have floor levels that are less than the once in 20 year flood event.

Eight of the buildings are suitable to be raised, however heritage considerations may prevent such works on three buildings.

Following resolution of the drainage issues created by the New England Highway, consideration should be given to either raising these houses or a voluntary acquisition program to provide a better level of protection. It is unlikely that these works will show a reasonable benefit cost ratio and thus the program would need to be undertaken under a “social obligation” consideration.

Action:

Consideration of a limited voluntary acquisition or house raising program for the 5 houses that currently have floor levels below once in 20 year flood level.

Table 5

Draft Floodplain Risk Management Plan Summary

Issue	Action	Priority	Cost
Flood warning and preparation for evacuation	1. Press Bureau of Meteorology for flash flood warning	Immediate	-
	2. With SES develop a local flood warning check	Short term	$20,000
	3. Provide all-weather pedestrian access from "Willow Grove" to the New England Highway with a lockable gate closure of the route. Gate keys to be held by SES and "Willow Grove" on-site management.	Immediate	$10,000
Community flood awareness	1. Undertake a community awareness program for flood liable areas of Aberdeen	Immediate	$15,000
Land use planning	1. Complete an annual review of DCP to incorporate amendments	On-going	$5,000
Future development	1. Back zone large vacant lots in flood liable areas	Medium	-
Levee works	1. Review impact of increased flood levels	Short term	$25,000
	2. REF for minor levee works	Short term	$25,000
	3. Design of minor levee works	Medium	$35,000
	4. REF for major levee works	Long term	$30,000
New England Highway	1. Liaise with RMS re upgrade of drainage under New England Highway	Medium	$30,000
	2. Fit gate to drains under New England Highway	Medium	$30,000
Limited voluntary Acquisition or house raising	1. Raise 5 lowest houses in Aberdeen	Long term	$400,000

REFERENCES

1. New South Wales Government, "Floodplain Development Manual, the Management of Flood Liable Land", April 2005

2. Upper Hunter Shire Council, "Aberdeen Flood Study", July 2013, prepared by WMA Water

3. State Emergency Service, "Upper Hunter Shire Emergency Sub-plan",

4. NSW Office of Water, "Pinneena", (Water Archives)

5. Bates, Bryson C. et alia, "Revision of Australian Rainfall and Runoff – The Interim Climate Change Guideline" (2015 Floodplain Management Association National Conference)

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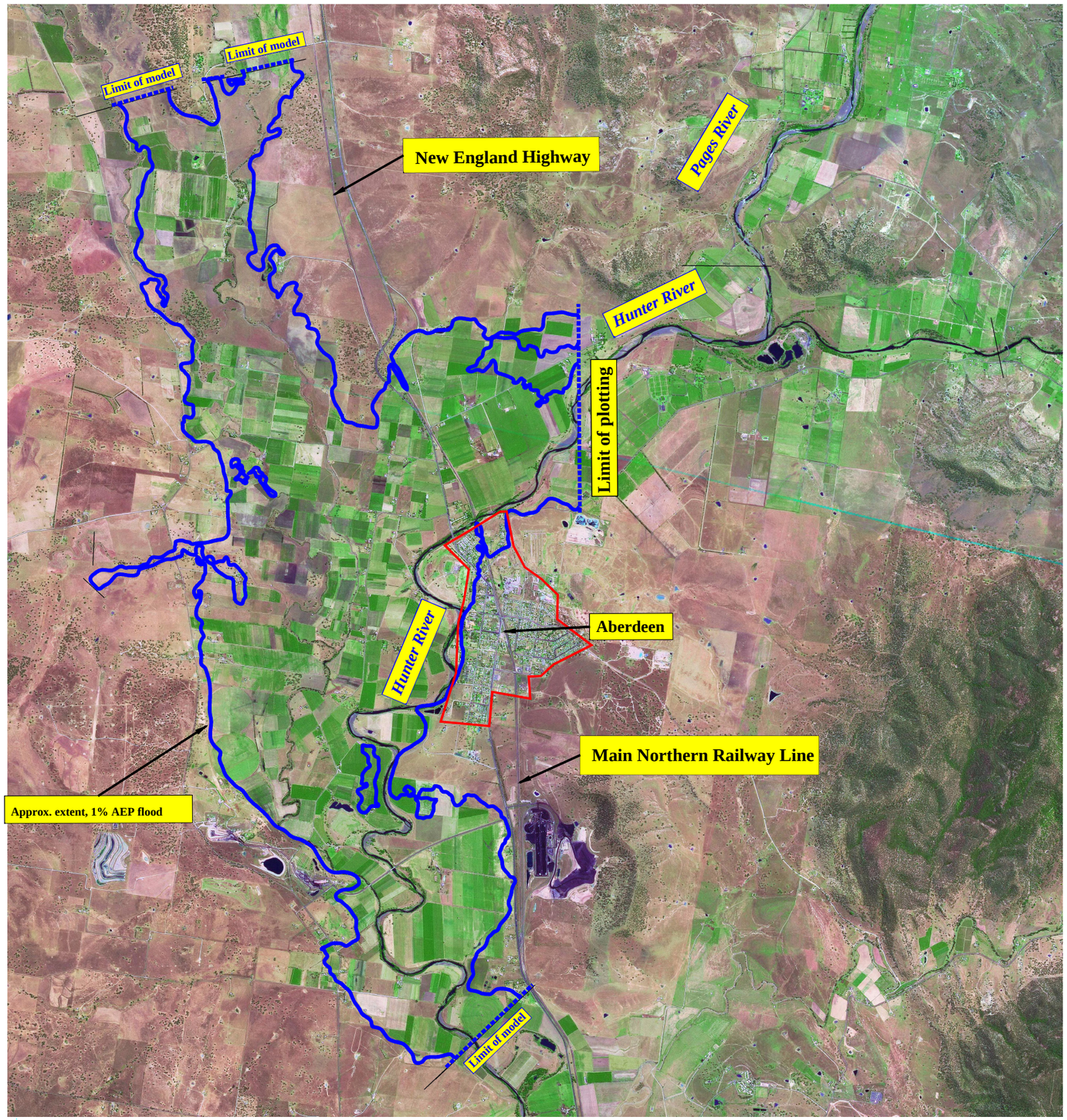
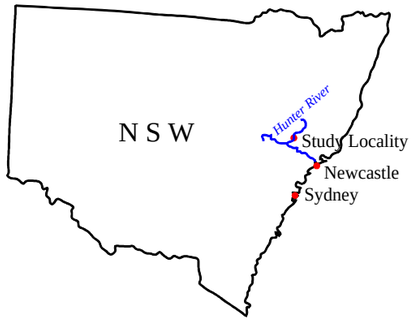
FIGURES

UPPER HUNTER SHIRE COUNCIL
ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY



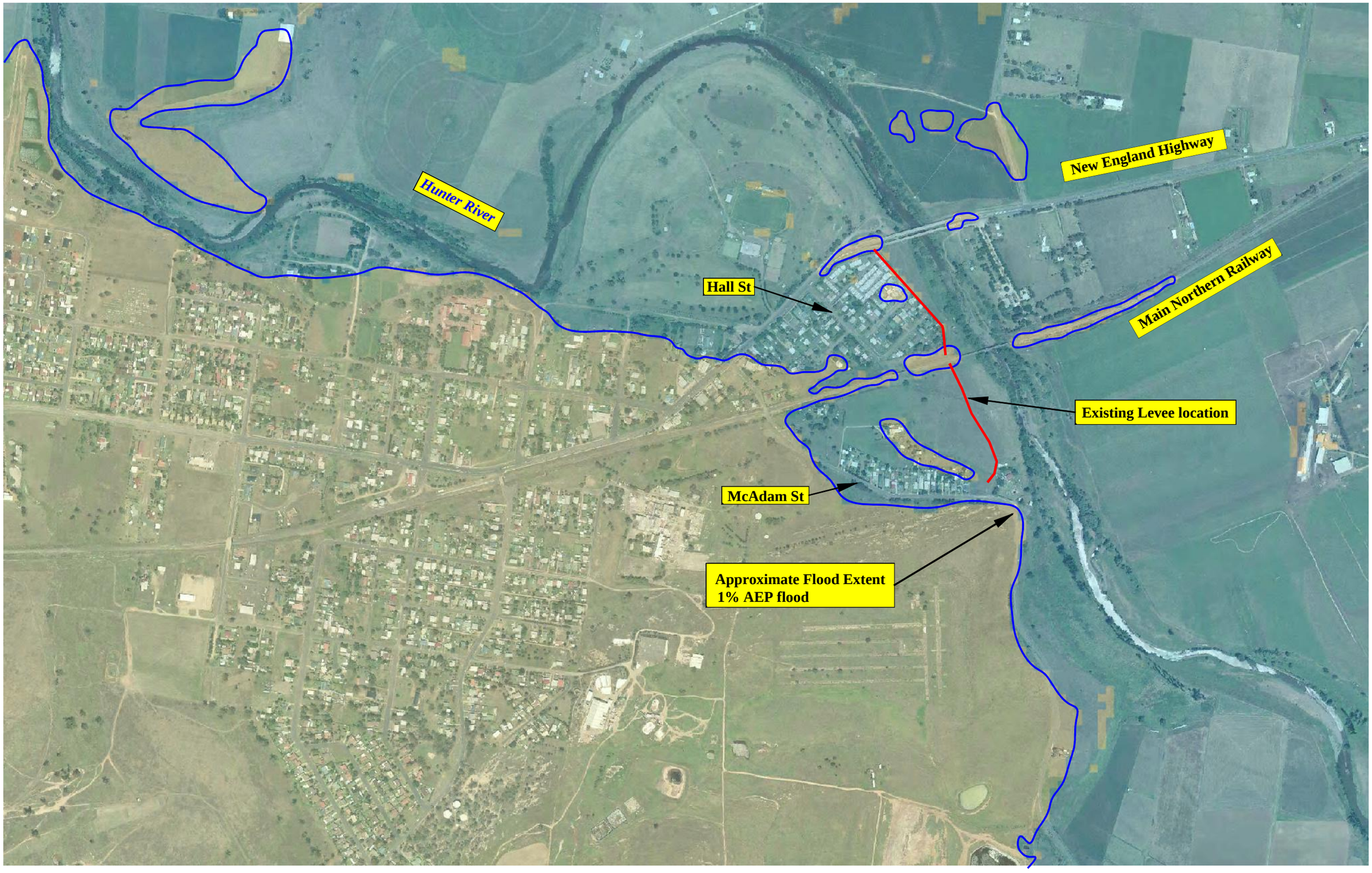


0 2000
Metres

25 May 2014
DISC REF: 14016
FILE REF: 14016_1_LOCALITY PLAN_V2

FIGURE 1
LOCALITY PLAN

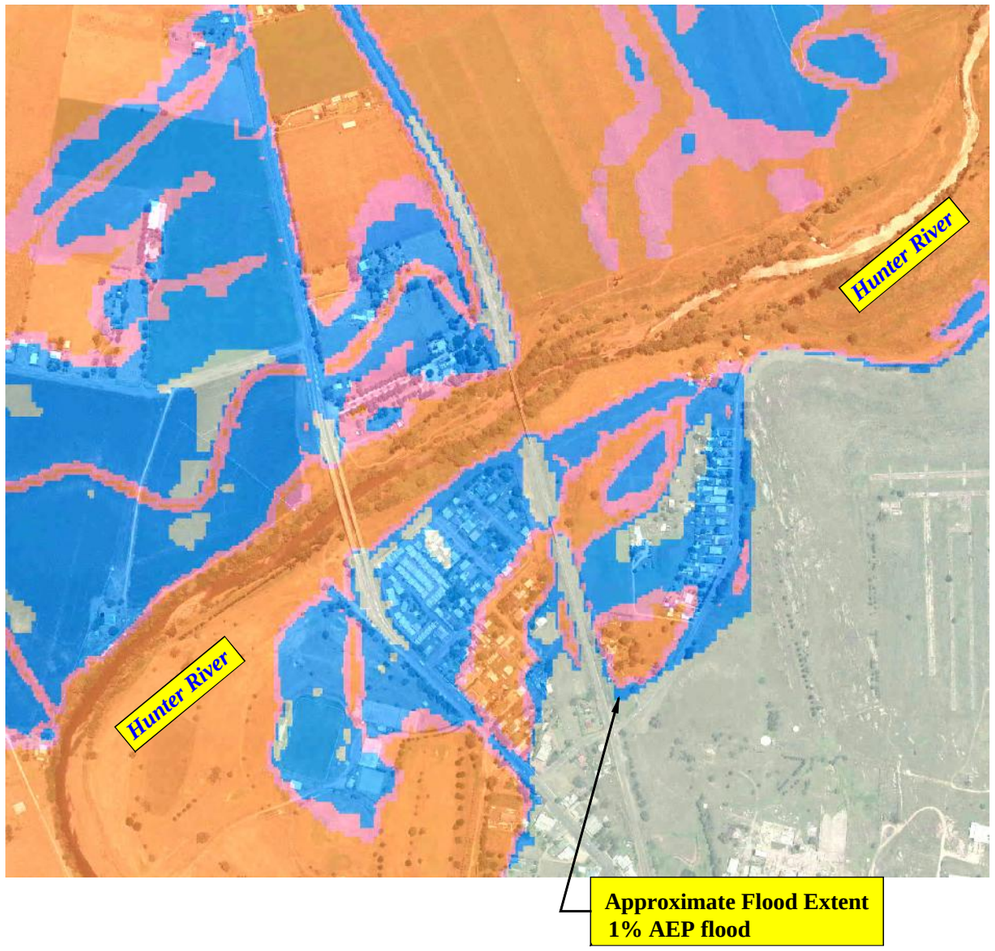
UPPER HUNTER SHIRE COUNCIL
ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY



0 500
Metres

27 May 2015
DISC REF: 14016
FILE REF: 14016_2_INUNDATION_EXTENTS_ABERDEEN_V1

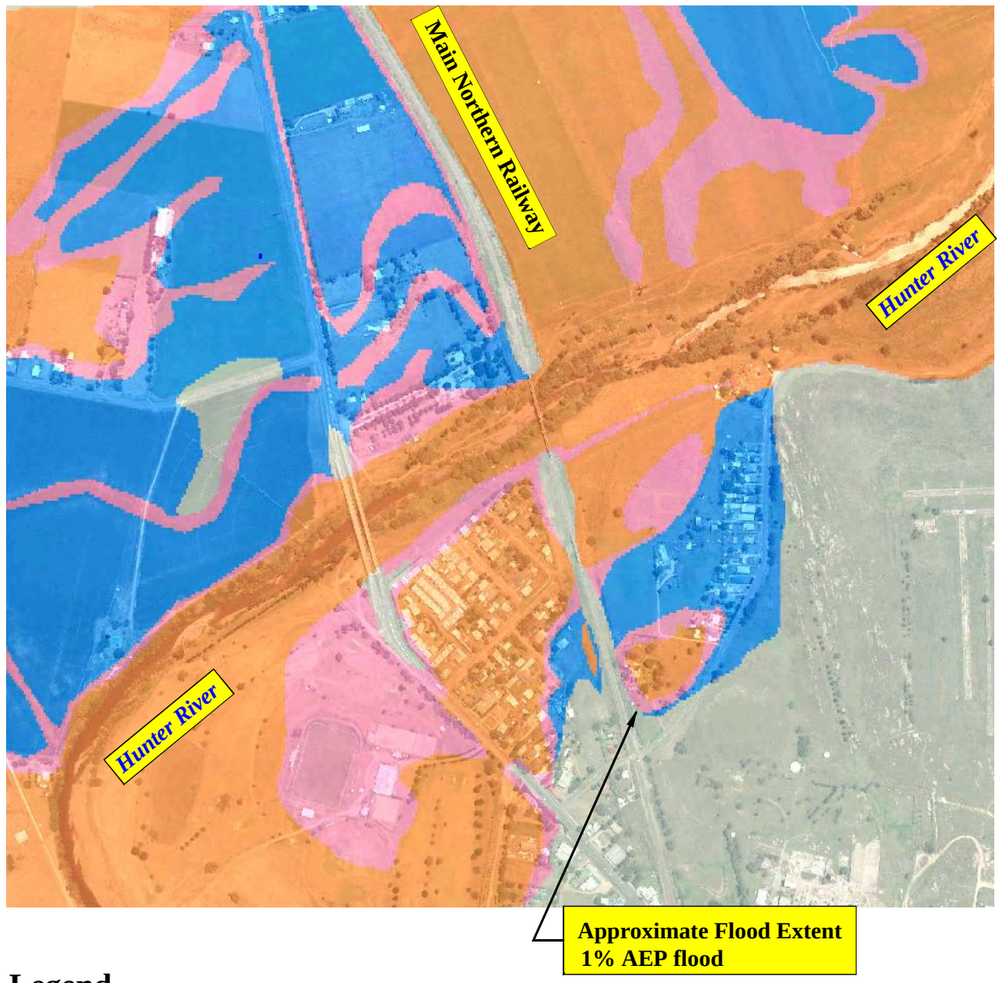
FIGURE 2
INUNDATION EXTENT, ABERDEEN



Legend

- Not innundated (in 1% AEP flood)
- Low Hazard
- Medium Hazard
- HighHazard

Provisional Flood Hazard



Legend

- Not innundated (in 1% AEP flood)
- Low Hazard
- Medium Hazard
- HighHazard

Adopted Flood Hazard

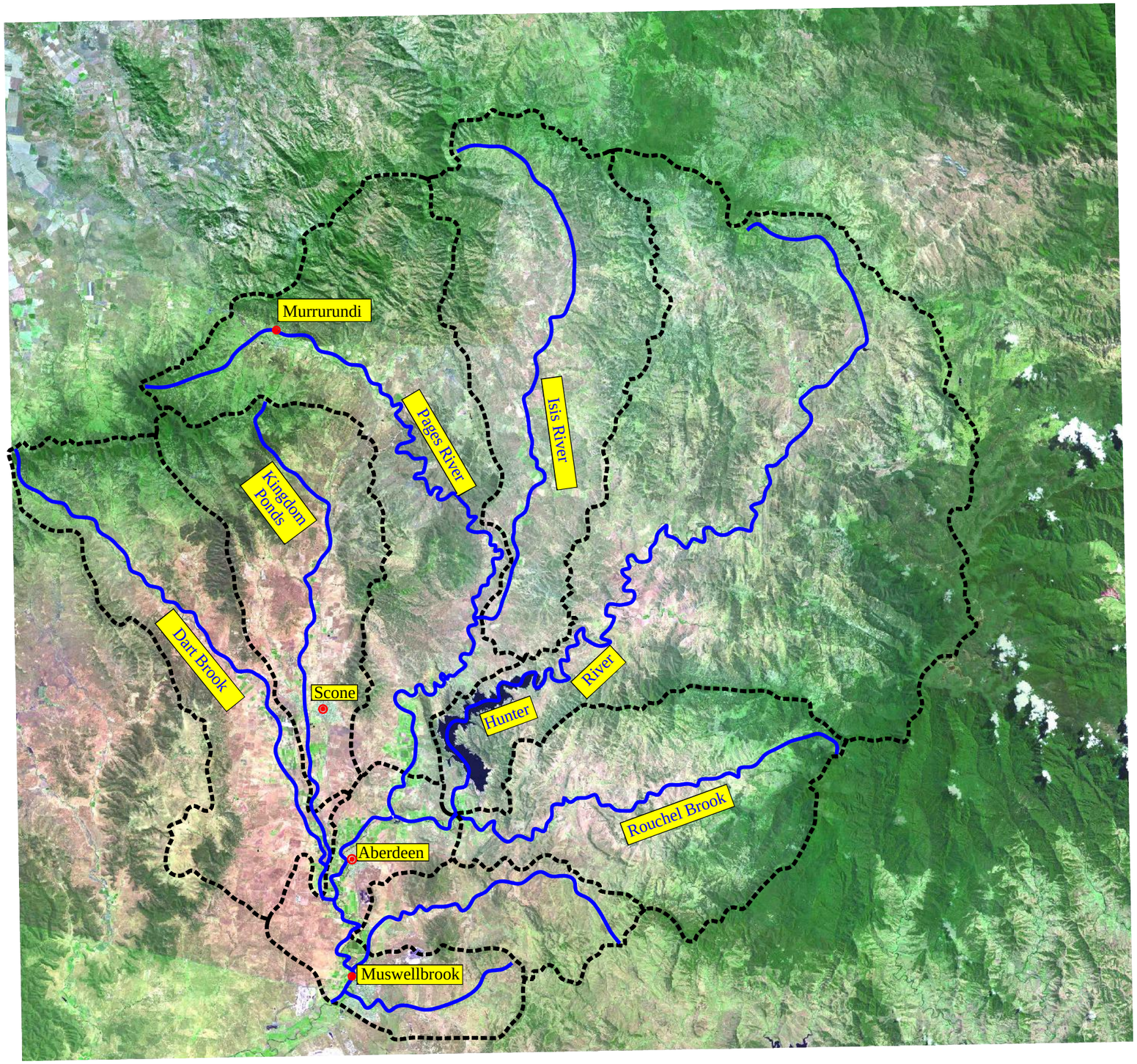
0 250
Metres

10 AUGUST 2015
DISC REF: 14016
FILE REF: 14016_3_Flood hazard Assessment_V1

FIGURE 3
FLOOD HAZARD ASSESSMENT, ABERDEEN

UPPER HUNTER SHIRE COUNCIL

ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY



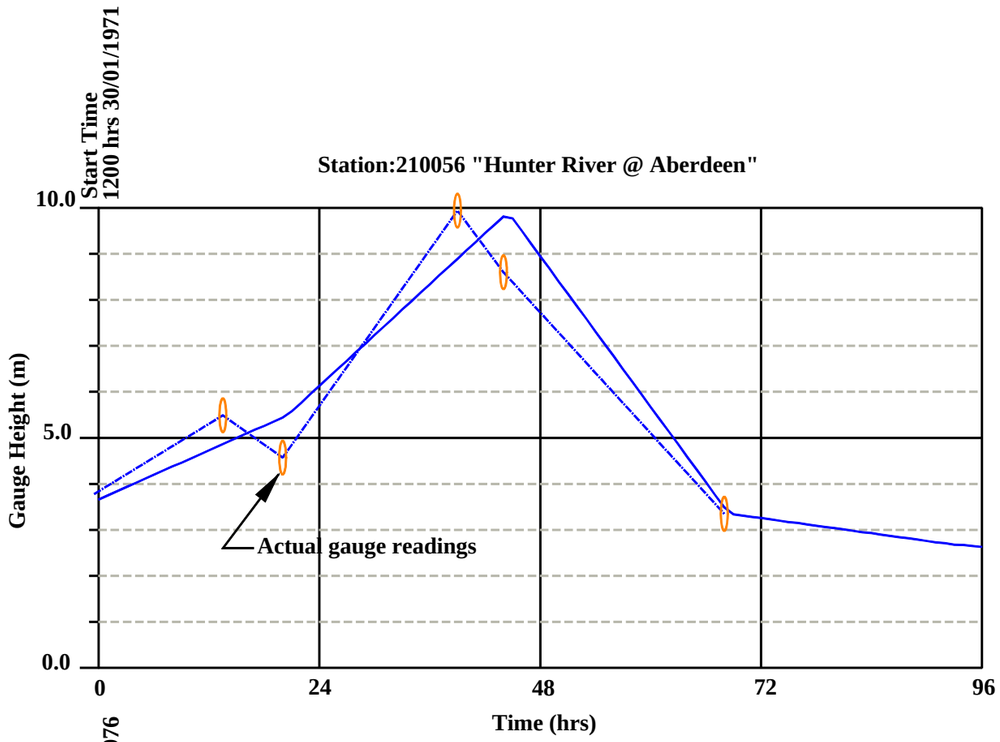
0 10 20

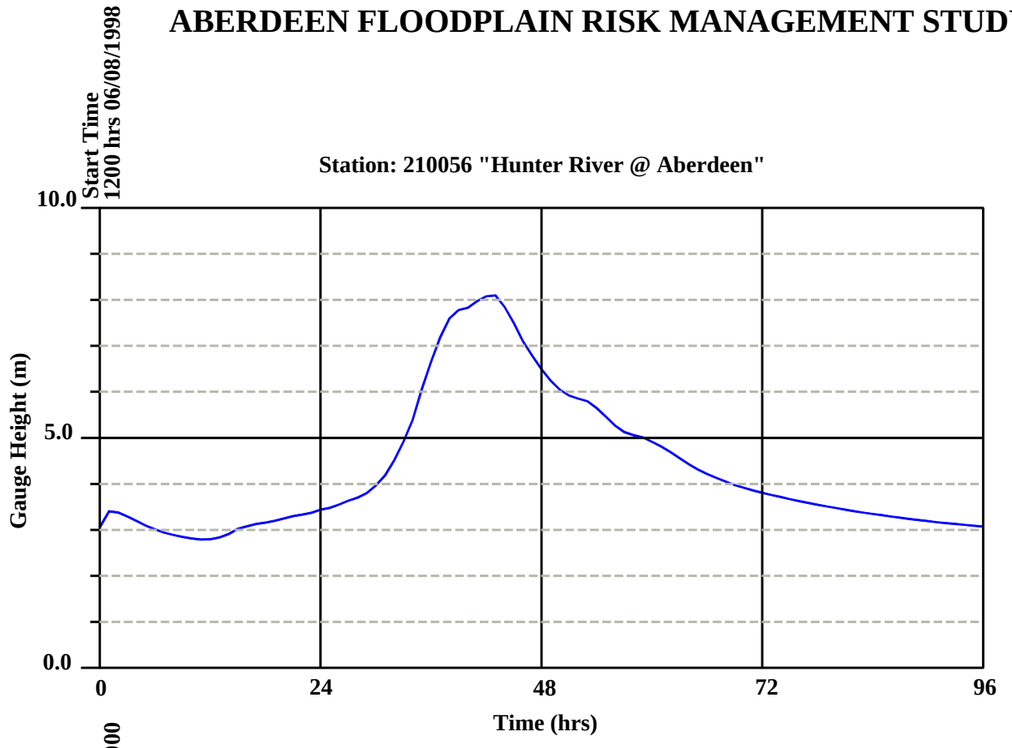
Kilometres

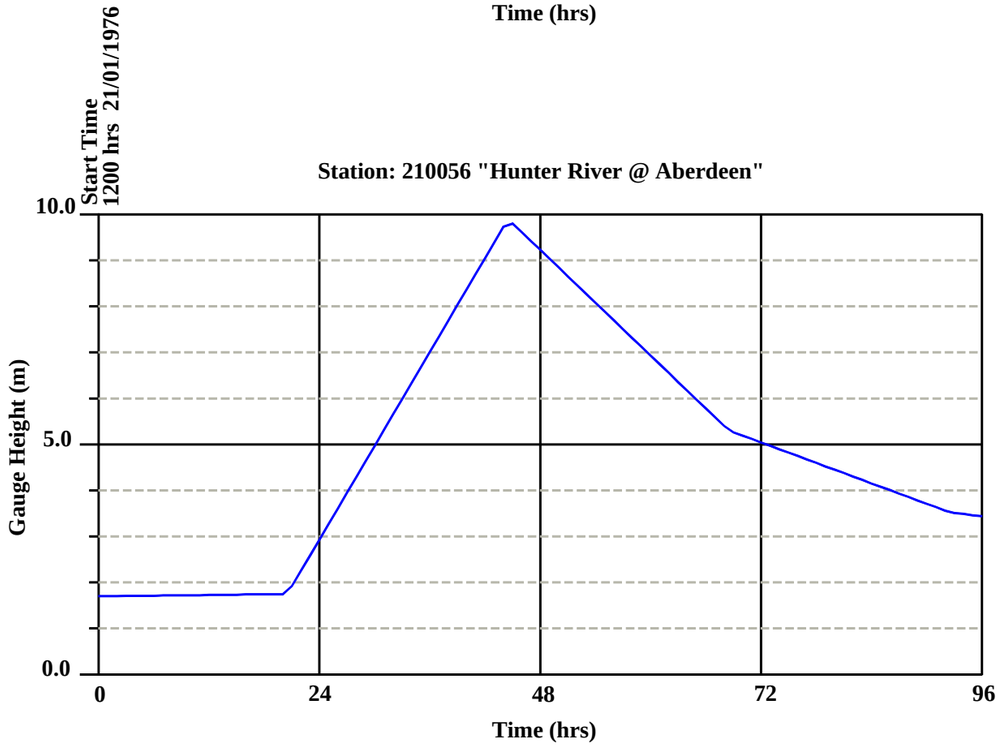
24 July 2015
DISC REF: 14016
FILE REF: 14016_4_SUB_CATCHMENT_PLAN_V3

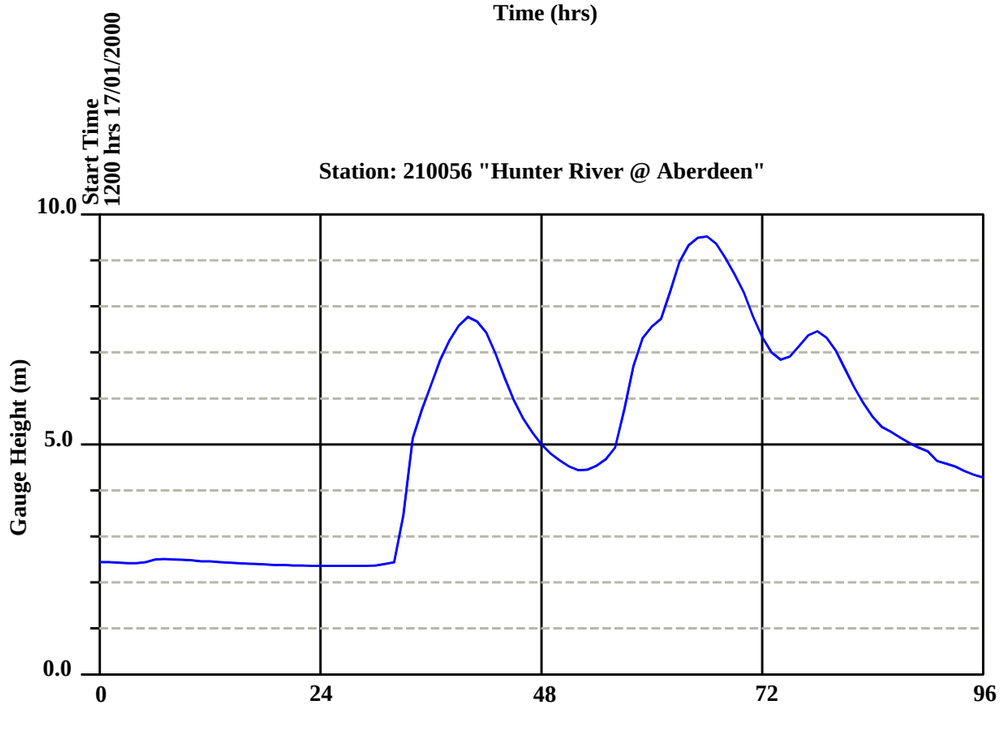
FIGURE 4
SUB-CATCHMENTS PLAN

UPPER HUNTER SHIRE COUNCIL
ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY







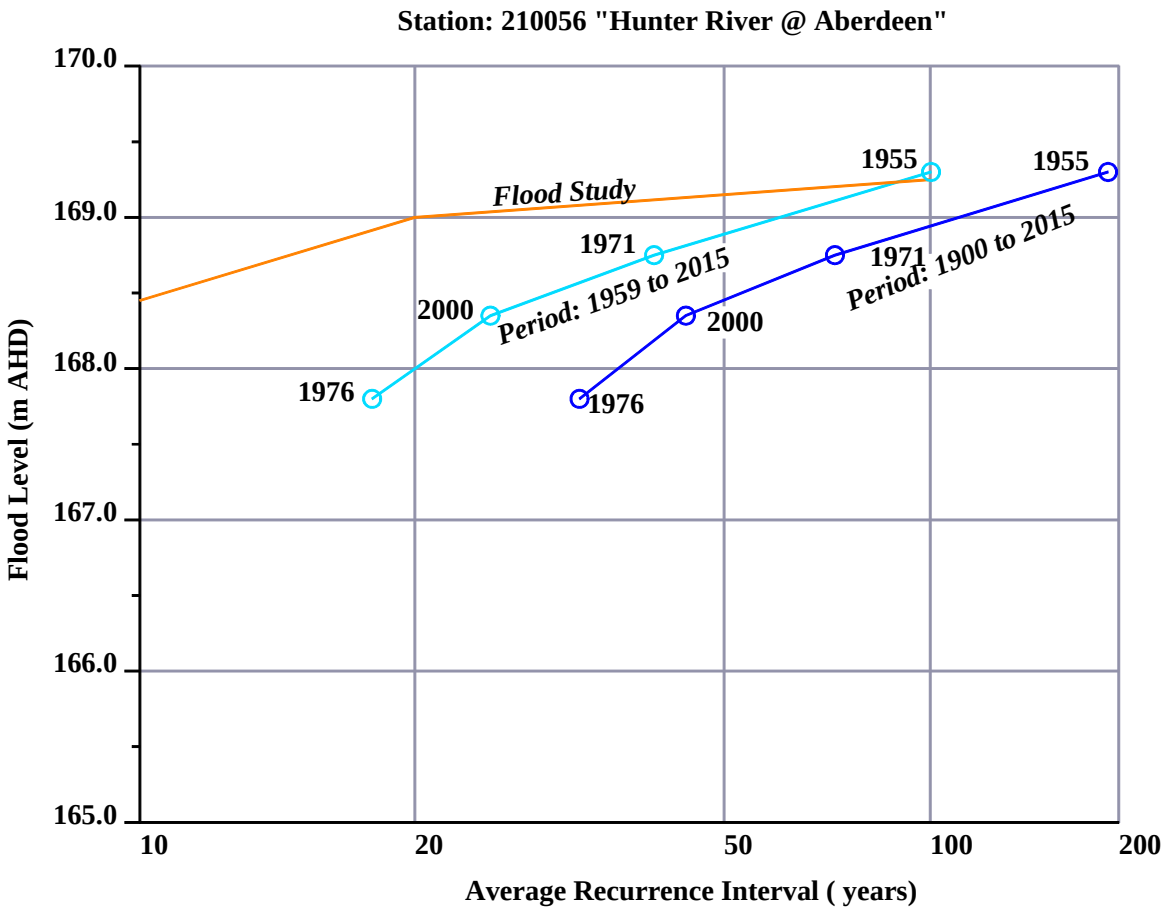


24 JULY 2015
DISC REF: 14016
FILE REF: 14016_5_RECORDED_HYDROGRAPHS_V3

Station: 210056 "Hunter River @ Aberdeen" : Gauge zero 158.808 m AHD post 1970

FIGURE 5
RECORDED HYDROGRAPHS

UPPER HUNTER SHIRE COUNCIL
ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY



Notes

1. This figure presents an approximate flood frequency based on sparse historical records

2. Floods recorded in 1955, 1971, 1976 and 2000 were ranked by peak level

3. Average recurrence intervals were derived assuming a 55 and 105 year period of record

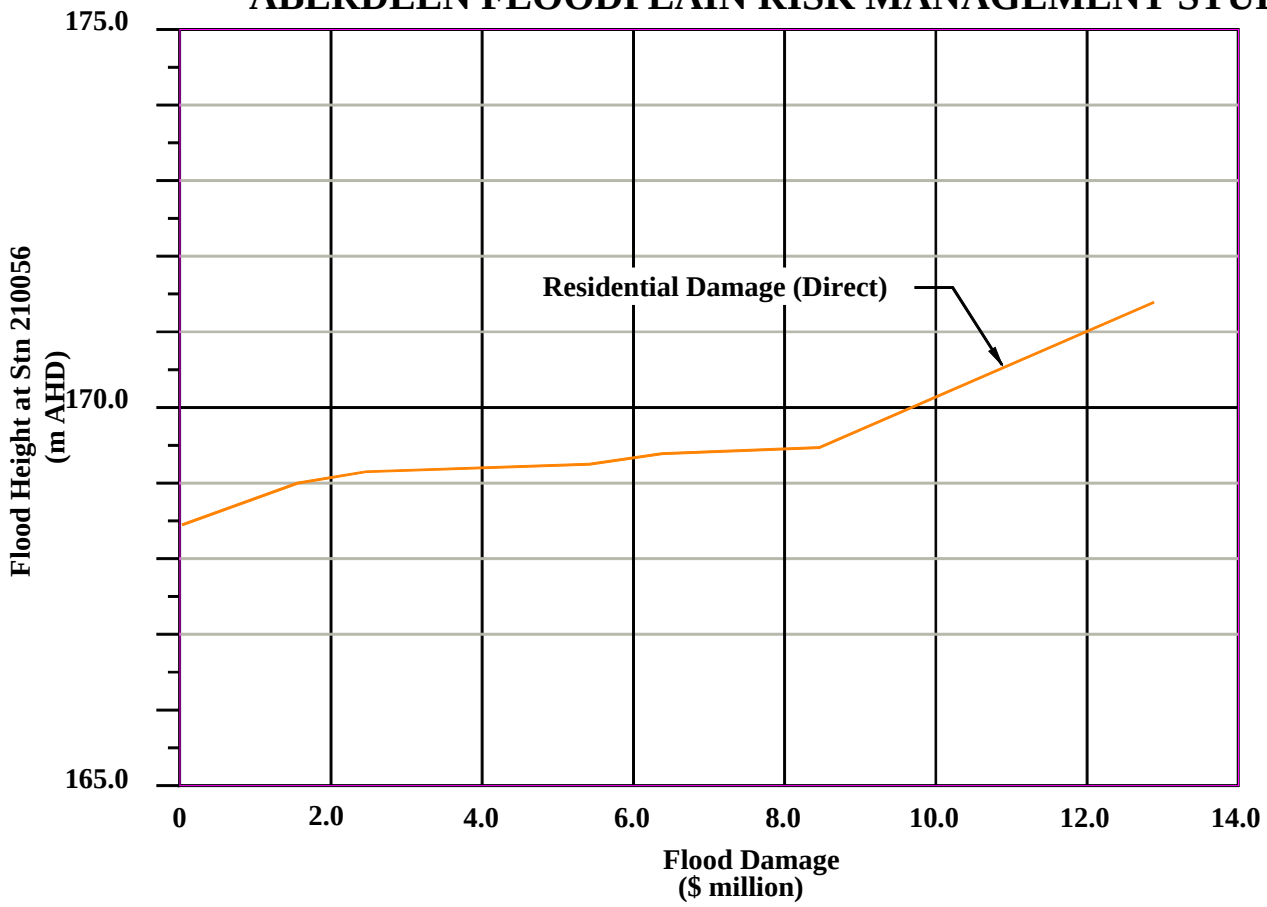
4. Flood frequency from the Aberdeen Flood Study is provided for comparison

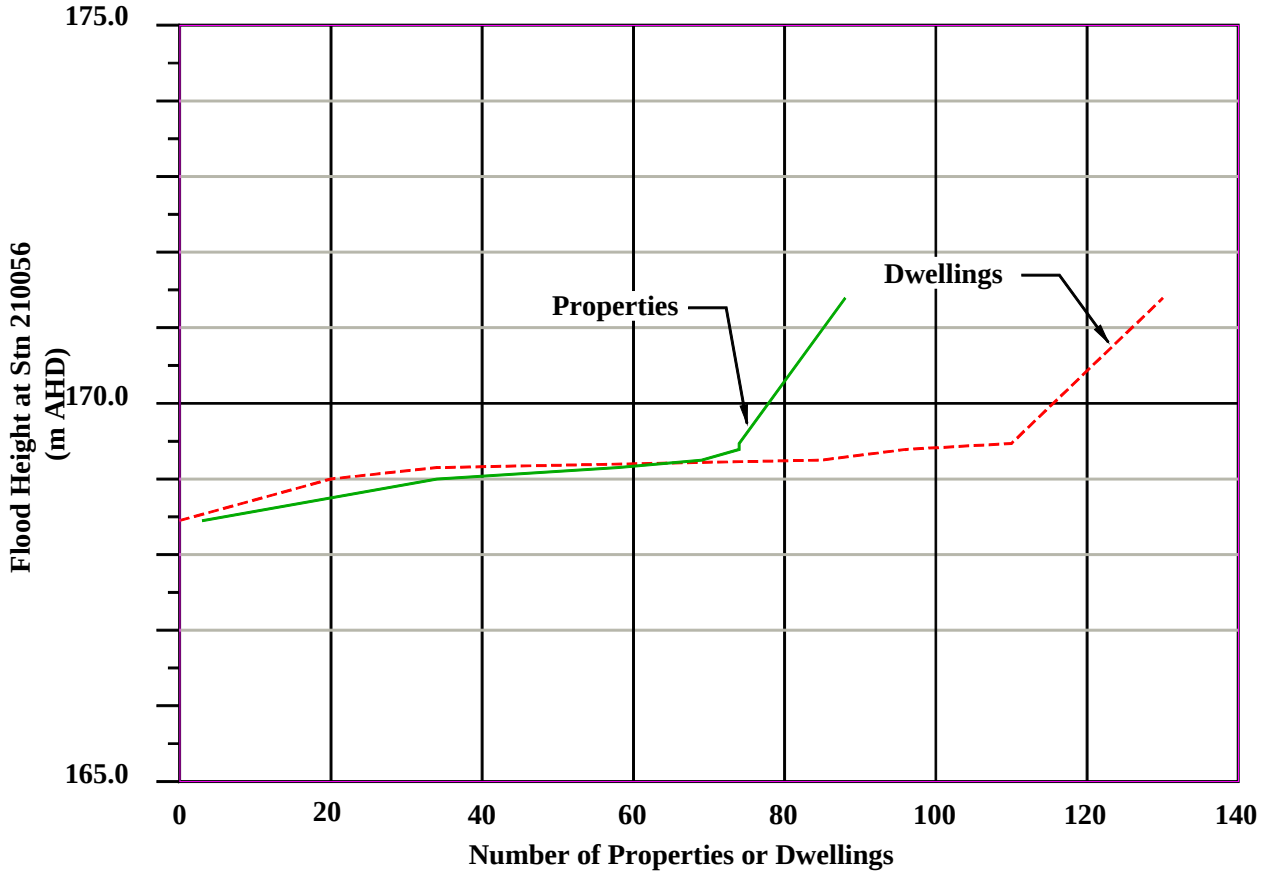
24 July 2015
DISC REF: 14016
FILE REF: 14016_6_Approx_Flood_frequency_V2

FIGURE 6
APPROX. FLOOD FREQUENCY

UPPER HUNTER SHIRE COUNCIL

ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY

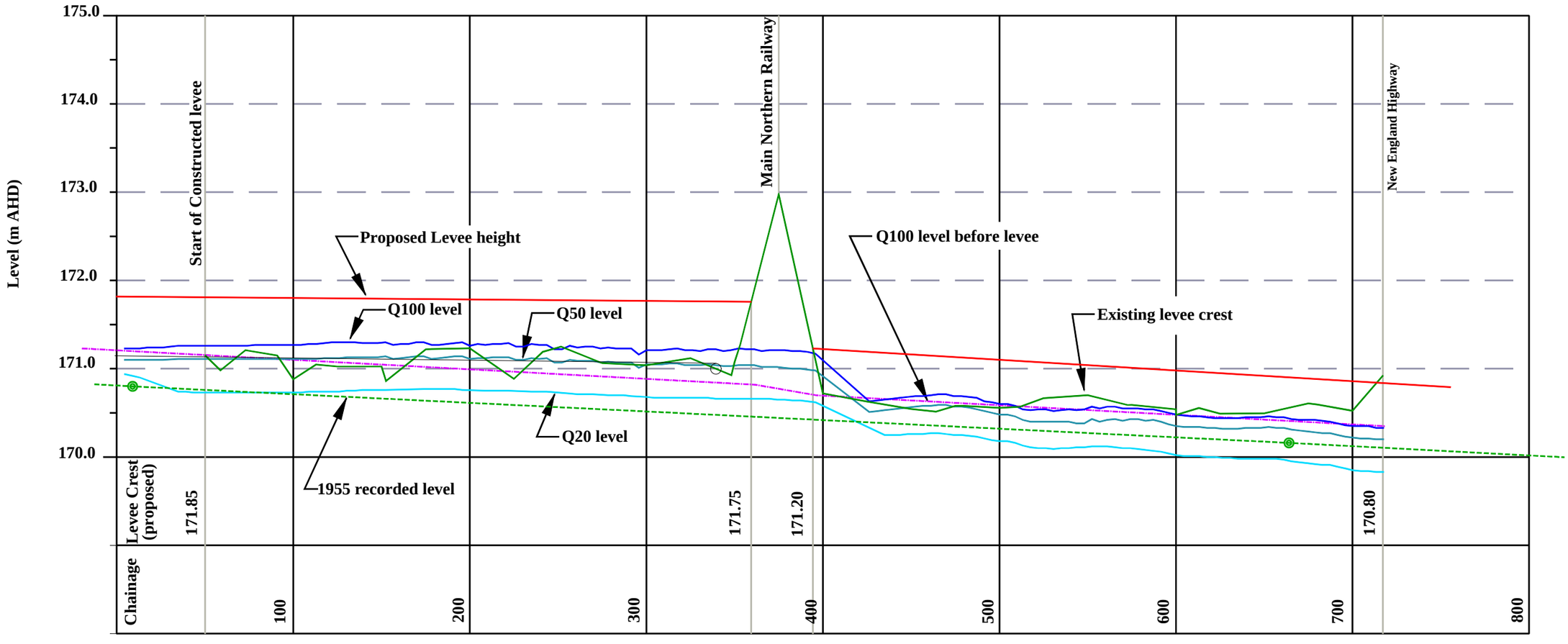




24 July 2015
DISC REF: 14016
FILE REF: 14016_7_Flood_damage_vs_height_V2

FIGURE 7

FLOOD DAMAGE VS HEIGHT



Notes:

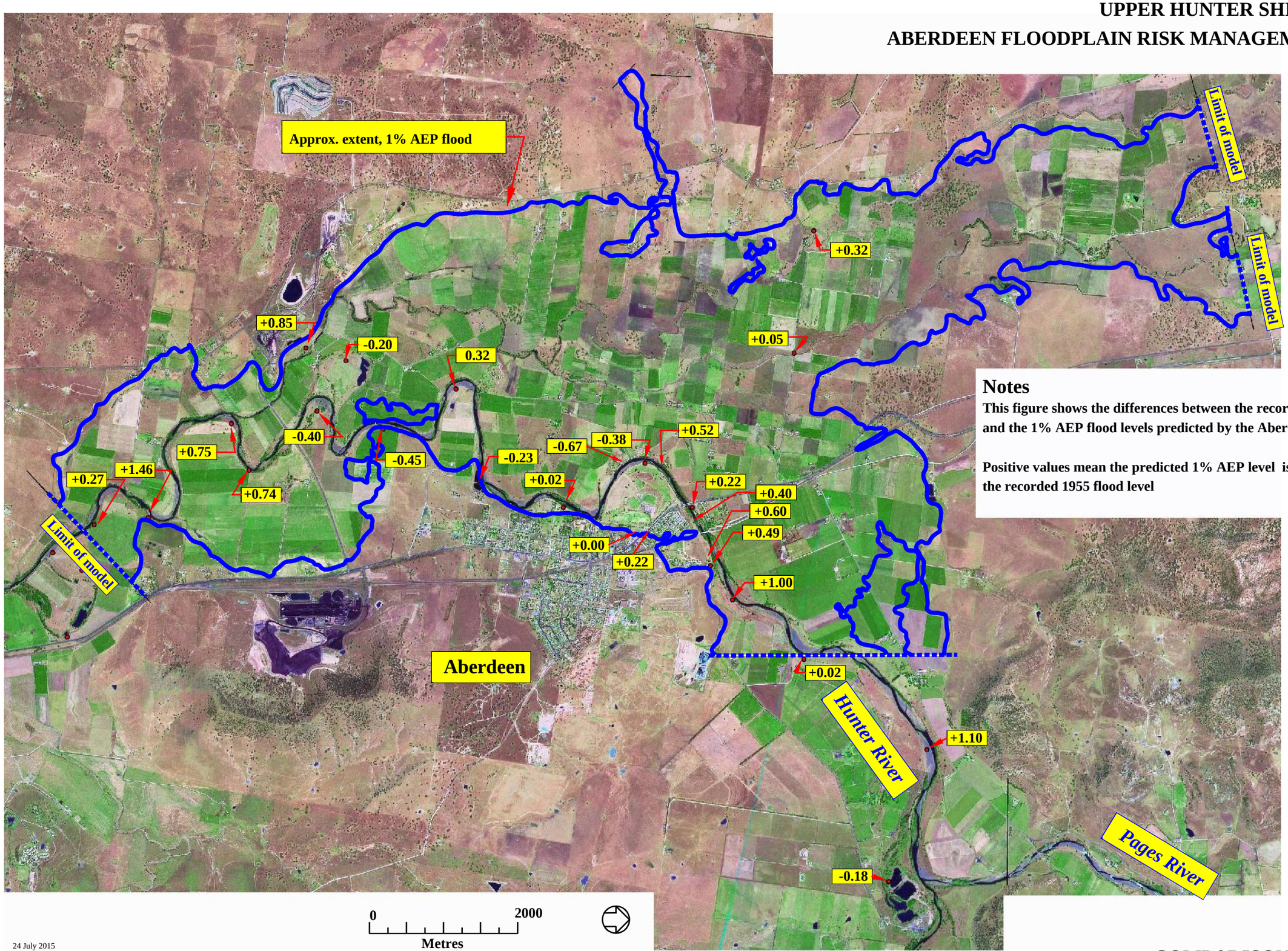
1. Design flood levels for Q100, Q50 & Q20 (100, 50 & 20 yr ARI) derived from Aberdeen Flood Study
2. Levee crest derived from Boardman & Peasley surveys (Feb 2007)
3. 1955 flood levels derived from WC&IC survey, as digitised by OEH
4. Proposed levee height as Q100 level plus 0.5m freeboard

24 July 2015
DISC REF: 14016
FILE REF: 14016_8_ABERDEEN_LEVEE_PROFILE_V3

FIGURE 8
ABERDEEN LEVEE PROFILE

UPPER HUNTER SHIRE COUNCIL

ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY



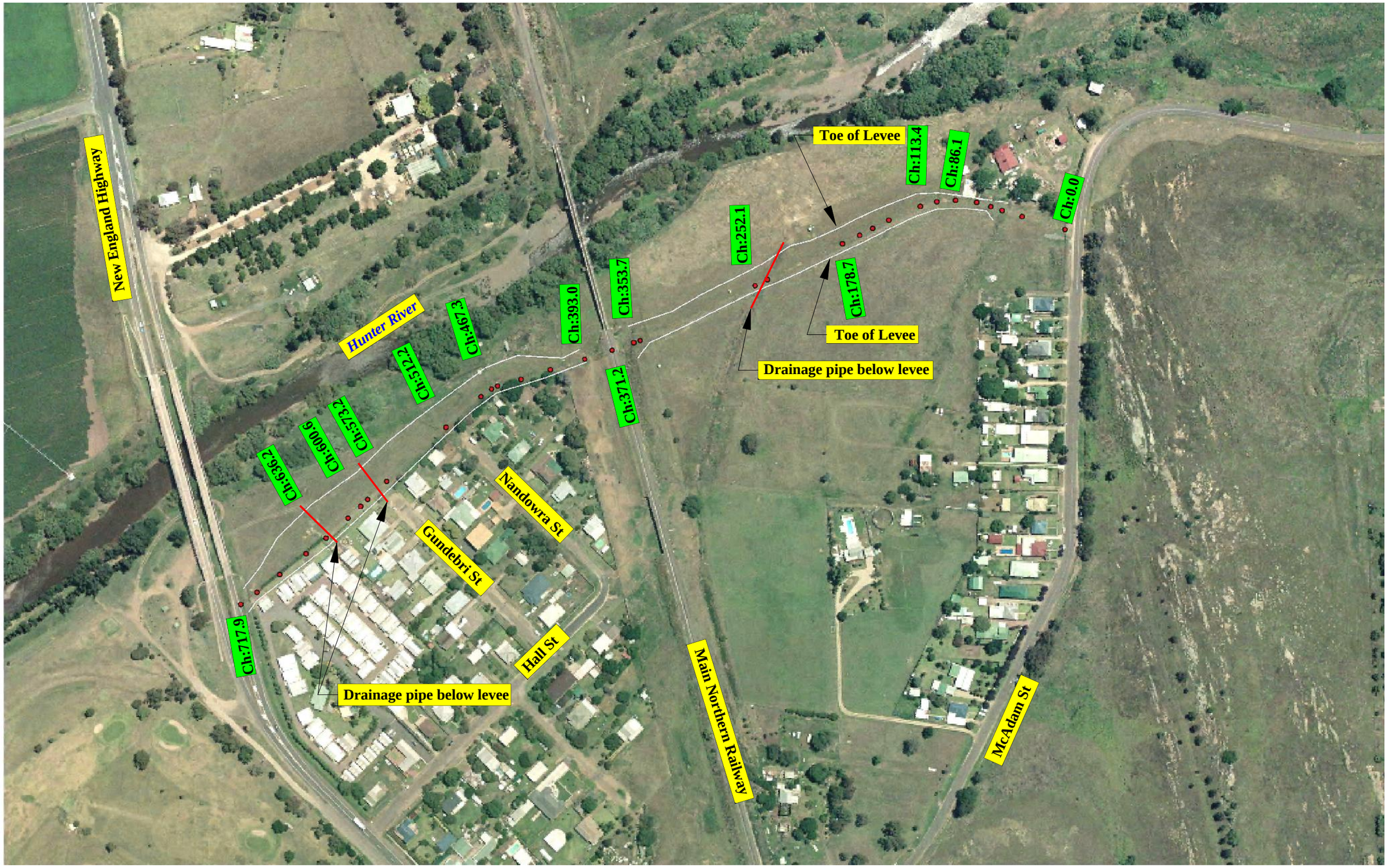
Notes

This figure shows the differences between the recorded 1955 flood levels and the 1% AEP flood levels predicted by the Aberdeen Flood Study

Positive values mean the predicted 1% AEP level is greater than the recorded 1955 flood level

24 July 2015
DISC REF: 14-016
FILE REF: 14016_9_COMPARISON 1955 FLOOD_V2

FIGURE 9
COMPARISON - 1955 FLOOD



0 100
Metres

24 July 2015
DISC REF: 14016
FILE REF: 14016_10_ABERDEEN_LEVEE_LOCATION_V2

FIGURE 10
ABERDEEN LEVEE LOCATION PLAN

UPPER HUNTER SHIRE COUNCIL

ABERDEEN FLOODPLAIN RISK MANAGEMENT STUDY

Upper Hunter Local Environmental Plan 2013

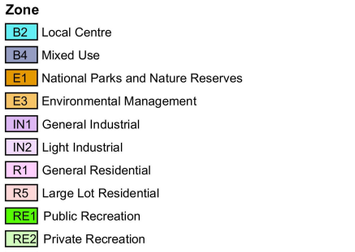
Land Zoning Map - Sheet LZN_008D

Zone

- B2 Local Centre
- B4 Mixed Use
- E1 National Parks and Nature Reserves
- E3 Environmental Management
- IN1 General Industrial
- IN2 Light Industrial
- R1 General Residential
- R5 Large Lot Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU1 Primary Production
- RU3 Forestry
- RU4 Primary Production Small Lots
- RU5 Village
- SP1 Special Activities
- SP2 Infrastructure

Cadastre

Cadastre 15/10/2012 © Land and Property Information (LPI)



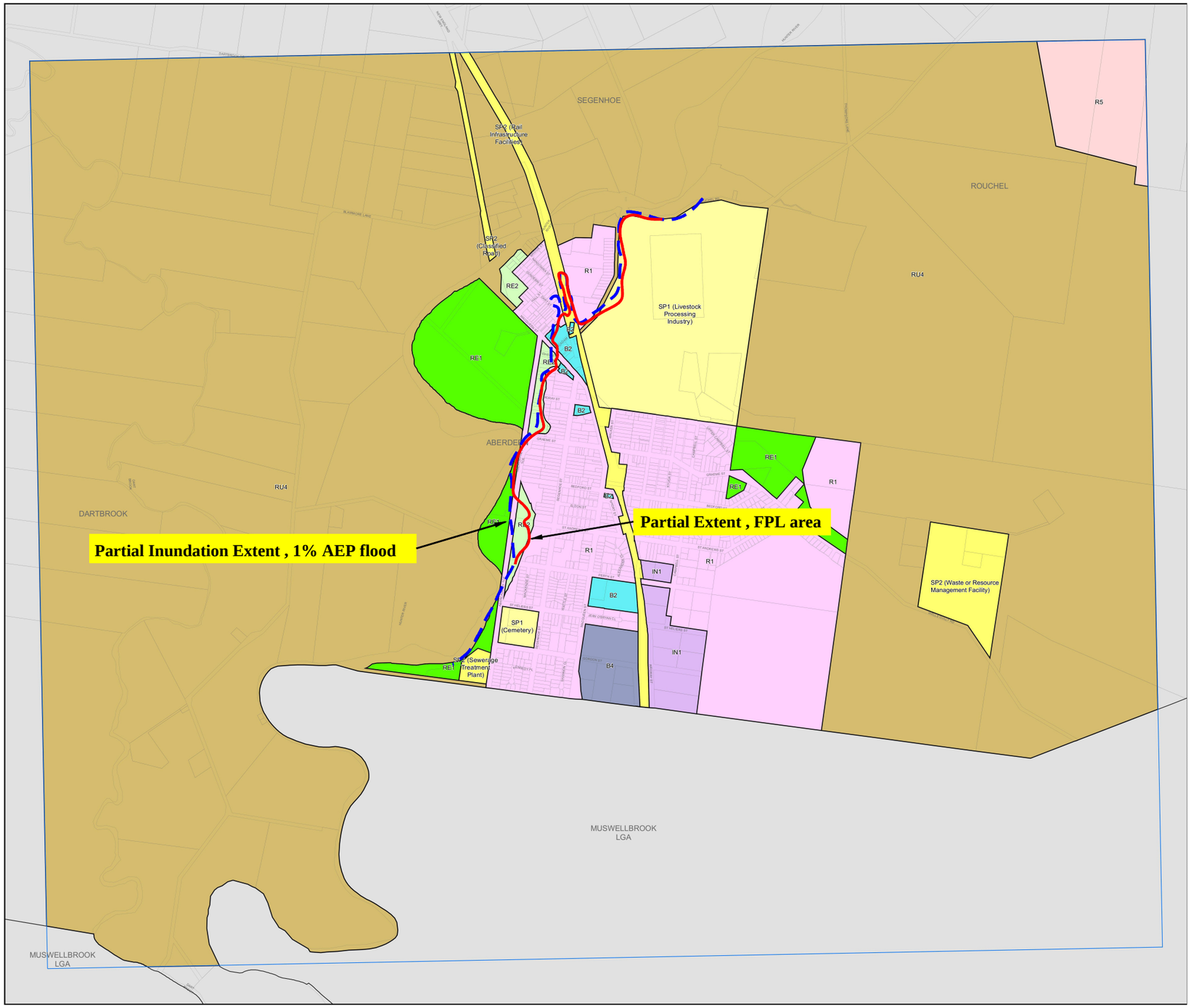
N

0 0.75 Kilometres

Scale:1:20,000 @ A3

Projection: GDA 1994 MGA Zone 56

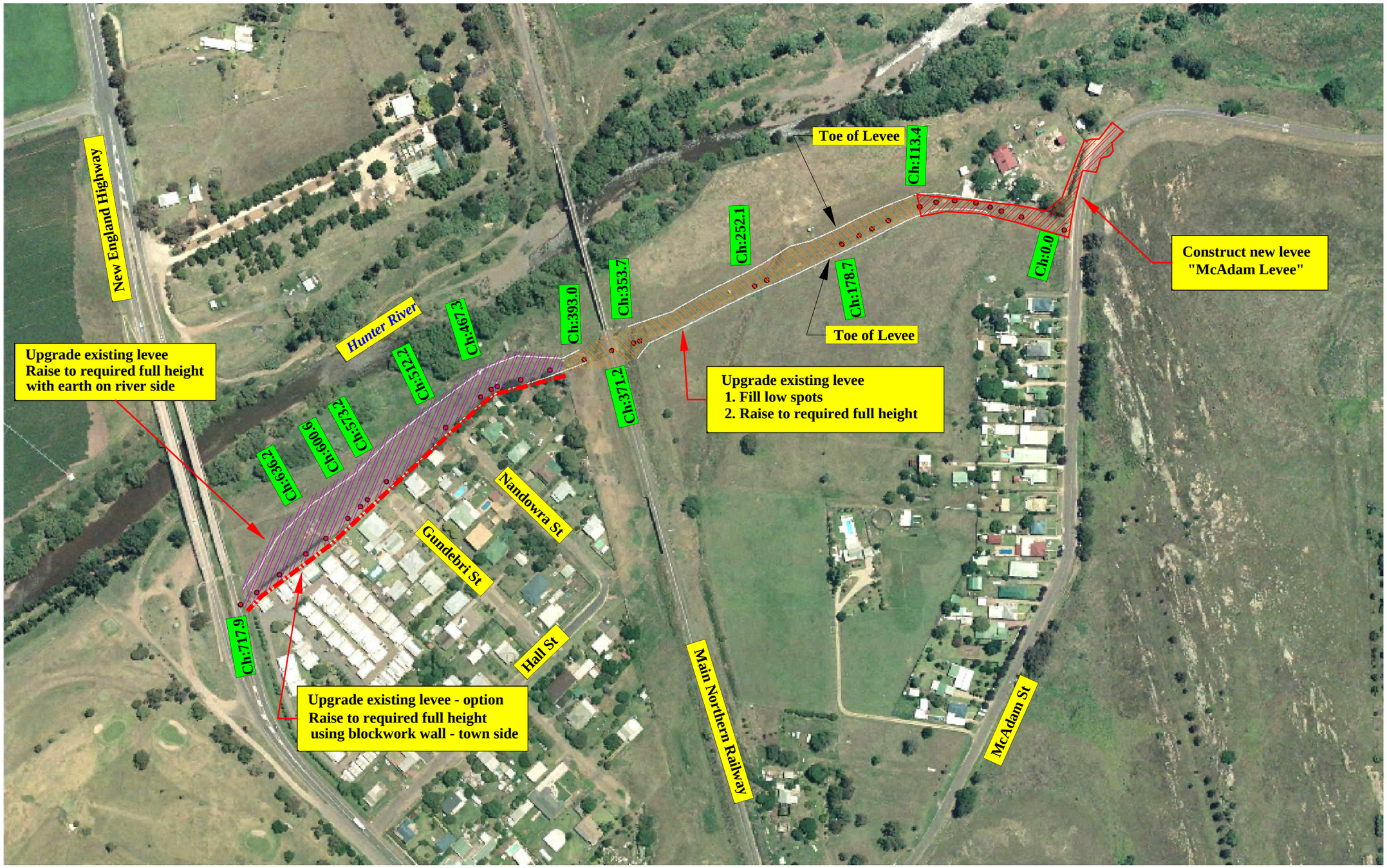
Map identification number: 7620_COM_LZN_008D_020_20131204



Note: **This drawing is a reproduction of Upper Hunter Shire Council zoning map from the Upper Hunter LEP (2013)**
The drawing is reproduced soley as reference for the Aberdeen Floodplain Management Study & Plan
Persons seeking detailed land use zoning data should consult Upper Hunter Shire Council

24 July 2014
DISC REF: 14016
FILE REF: 14016_11_Land use zoning_V2

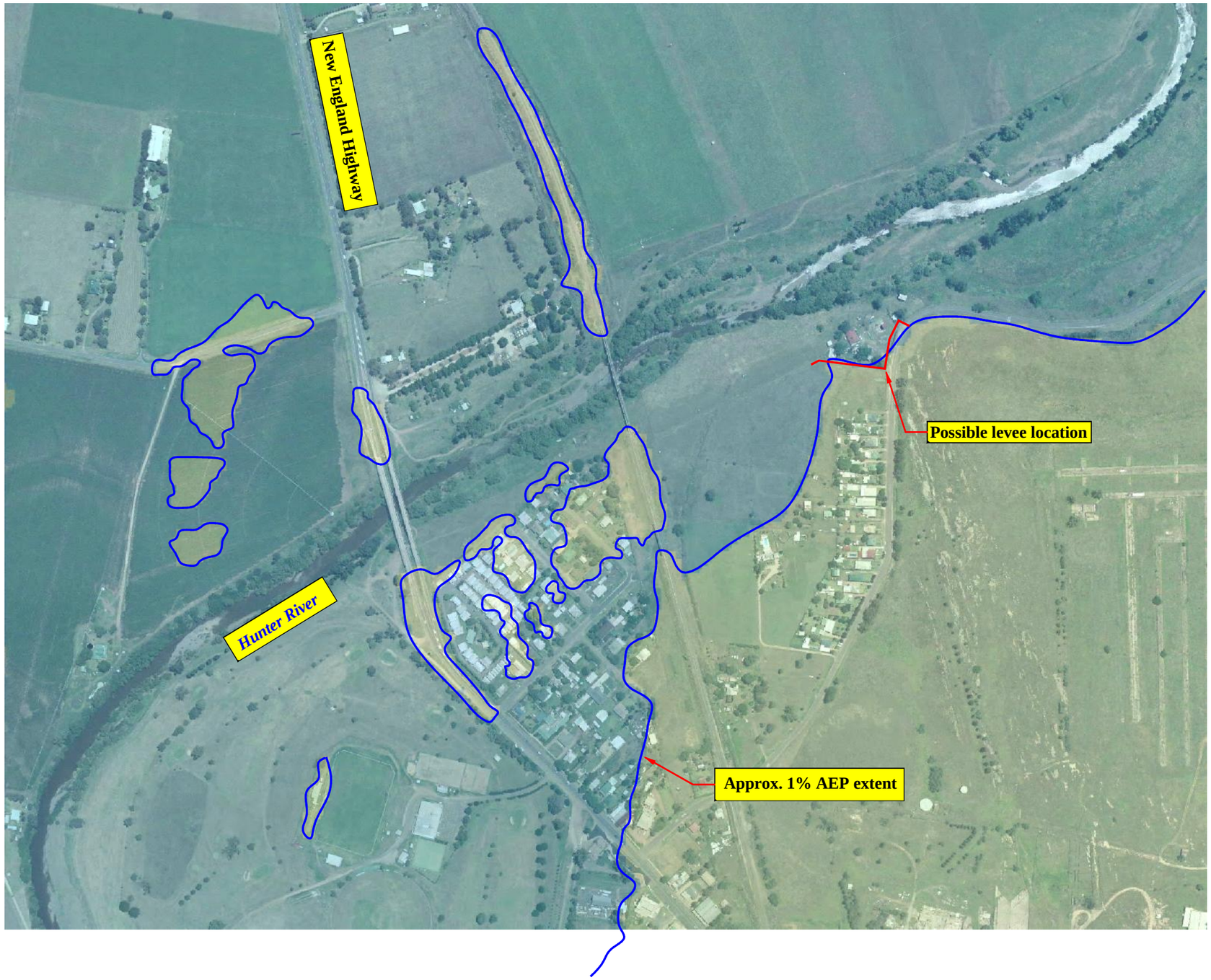
FIGURE 11
LAND USE ZONING



0 100
Metres

24 July 2015
DISC REF: 14016
FILE REF: 14016_12_Possible levee options_V3

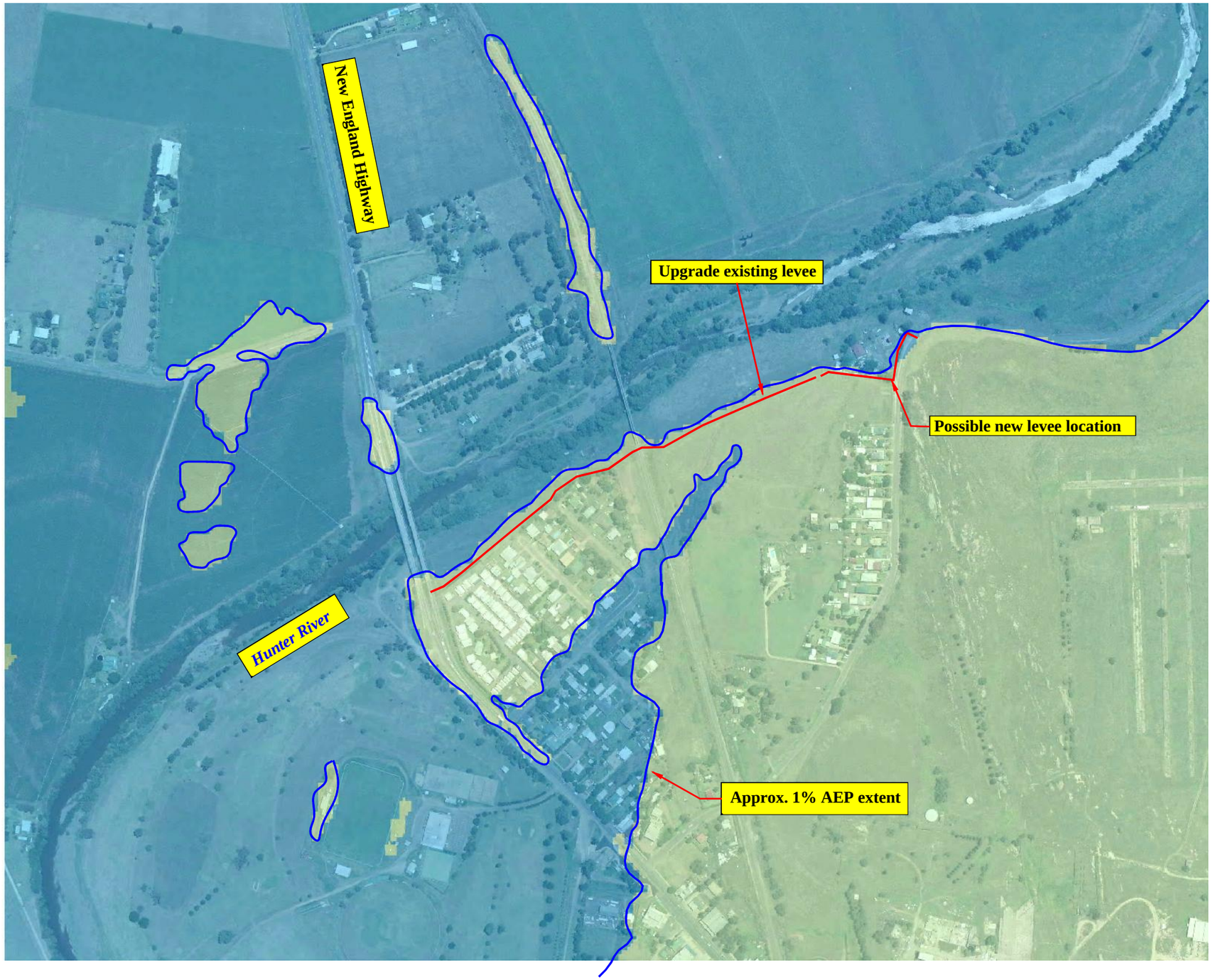
FIGURE 12
POSSIBLE LEVEE OPTIONS



0 200
Metres

24 July 2015
DISC REF: 14016
FILE REF: 14016_13_Inundation extents_post_McAdam_levee_V4

FIGURE 13
INUNDATION EXTENT - 1% AEP
(after construction - McAdam Levee)



0 200
Metres

24 July 2015
DISC REF: 14016
FILE REF: 14016_14_Inundation extents_post_"UPGRADE"_levee_V4

FIGURE 14
INUNDATION EXTENT - 1% AEP
(after construction - "Upgrade" Levee)

APPENDICES

APPENDIX A

LEVEE INSPECTION REPORT

APPENDIX A

LEVEE INSPECTION – OCTOBER 2014

1. Background, Aberdeen Levee

Parts of Aberdeen are protected by an earthen levee. The earth levee was reportedly constructed by the Water Resources Commission in 1976. The design crest level was set at the recorded 1971 flood levels plus 1 m freeboard, although some sources indicate the freeboard was 0.9 metres, which would be consistent with the WRC practice at the time of using 3 foot freeboard.

The levee comprises of a compacted earth bank with design side slopes of 3:1 (horizontal to vertical) on the riverside and 2 :1 (H:V) on the protected side.

A number of levee inspections have been undertaken in the past.

During the October 2014 levee inspection, discussions with the local landowners indicated their concerns regarding the degree of compaction in the levee and the foundation material. Whilst these items are somewhat technical in nature, it is queried whether such concerns have been raised by the residents through their own investigation or alternatively are merely a repetition issues raised in earlier levee reports.

2. Overview, October 2014 Levee Inspection

A visual inspection of the levee was undertaken by Mr K W Paterson on the 24 October 2014. The inspection comprised of a “walk-over” of the levee with a series of photographs taken to record the condition of the levee.

Figure 1 illustrates the location of the levee and a notional control line set near the crest of the levee with chainages. The object of the chainages used is to allow a correlation to be made between the levee photographs and their location on the ground.

Figures 2 to 6 inclusive illustrate the photographs taken on the levee inspection.

3. Levee Conditions, Ch 0.0 to Ch 371

The section of levee between Chainage 0 and Chainage 371, (McAdam Street to the Main Northern Railway Line), is unencumbered with structures.

A Council drainage pipe (with a flap gate) at Ch 240 serves a drainage channel from near the intersection of Nandowra Street and Hall Street to the Hunter River.

The levee appears to start approximately at Chainage 50 where it ties to a higher bank of land running from the north-east to the south-west. Between Ch. 0 and Ch. 50, the ground levels are lower

than the levee crest. However, the levee is contiguous with higher ground to the south-west of the control line. At this point, survey is not available to confirm the actual high point of ground from Ch 50 to the eastern side of McAdam Street, which would effectively form the levee.

In the section of levee between Chainage 0 and Chainage 371, there are no significant breaks in the levee.

There has been some repair of the levee at approximately Chainage 180. The levee has been repaired using a silt type material that has a small amount of angular gravel within it.

Over this section of the levee area (Chainage 0 and Chainage 371) there is inadequate topsoil to promote the growth of a healthy grass cover.

The levee appears to have been mown on the “River side” but not on the “Protected side”.

The flap gate on the Council drainage line at approximately Chainage219 has a considerable amount of grass and weed growth around it and thus it has the potential to become blocked “open” during a flood. The surrounds of the flap gate should be cleared and the vegetation removed so that the gate can swing freely from “closed” position to “open” position and from “open” position to “closed” position.

Some rabbit scrapings were observed around to Chainage150, though no burrows was seen close to the levee at this point. It was noted that rabbit burrows were in evidence near the outlet of the Council drainage line (approximately Chainage 219) but there did not appear to be evidence of recent activity. There is a risk that the rabbit burrows may go under the levee system. In this situation, the rabbit burrows should be “grubbed” out and replaced with compacted material.

4. Levee Conditions, Chainage 371 to Chainage 718

This section of the levee is a compacted earth levee with the crest width of approximately 2.5 m or less with side slopes of approximately 3:1 (horizontal to vertical) on the “river” side and 2.5:1 (horizontal to vertical) on the “protected” side.

There is some grassing along the levee, though the grass cover is not good. The levee appears to lack topsoil to enable a healthy grass cover to be grown, while in other parts the levee has been grazed by stock up to the crest on the “river” side.

The major concern in this section of the levee is the planting of trees and growth of trees on and near the levee, plus fence lines being constructed along the levee over this section.

At the time of construction of the levee, the levee footprint had been subdivided into residential lots. It is also apparent that easements were not taken over the levee route and thus the residents have planted or allowed trees to grow in the levee. Similarly there are numerous fence posts and fences cut into the levee, which restricts easy maintenance of the levee

The failure to take easements over the levee footprint is not an uncommon practice, particularly when the levee has been constructed after recent floods. In general, the residents will tend to be in favour of the levee construction but are unwilling to relinquish any property rights with the construction of such a levee.

The successful operation of an earth levee requires a complete compacted fill volume below the levee surface. Trees threaten the structure of the levee through their roots both:

- in the growing stage, when the tree roots push through the compacted material and are likely to break up the fill structure; and
- on the death of the tree, the roots die leaving tunnels within the levee cross-section.

The trees and their root structures should be “grubbed” out of the levee and the void created replaced with select compacted material.

Access along the levee in this section is severely restricted by:

- fences across the levee;
- lack of crest width;
- poor surface material on the crest.

During wet periods, it would be virtually impossible to access the levee, should emergency works or repairs to the levee be required.

It is clear that easement acquisition may well be required. It is appreciated that this action will most probably not receive the approval of the local residents. Nonetheless achievement of the engineering requirements for the levee may necessitate acquisition of easements so that Council has control over the complete levee to ensure its ongoing structural efficiency.

5. Implications for the Aberdeen Floodplain Risk Management Plan

At this point, there appear to be three possible outcomes for Aberdeen levee within the Aberdeen Floodplain Risk Management Plan. These outcomes are:

- maintain the current conditions with ownership of the levee remaining in private ownership and maintenance being undertaken by the New South Wales State government and the

landowners. This implies acceptance of the current level of protection and acceptance of the current risk of failure;

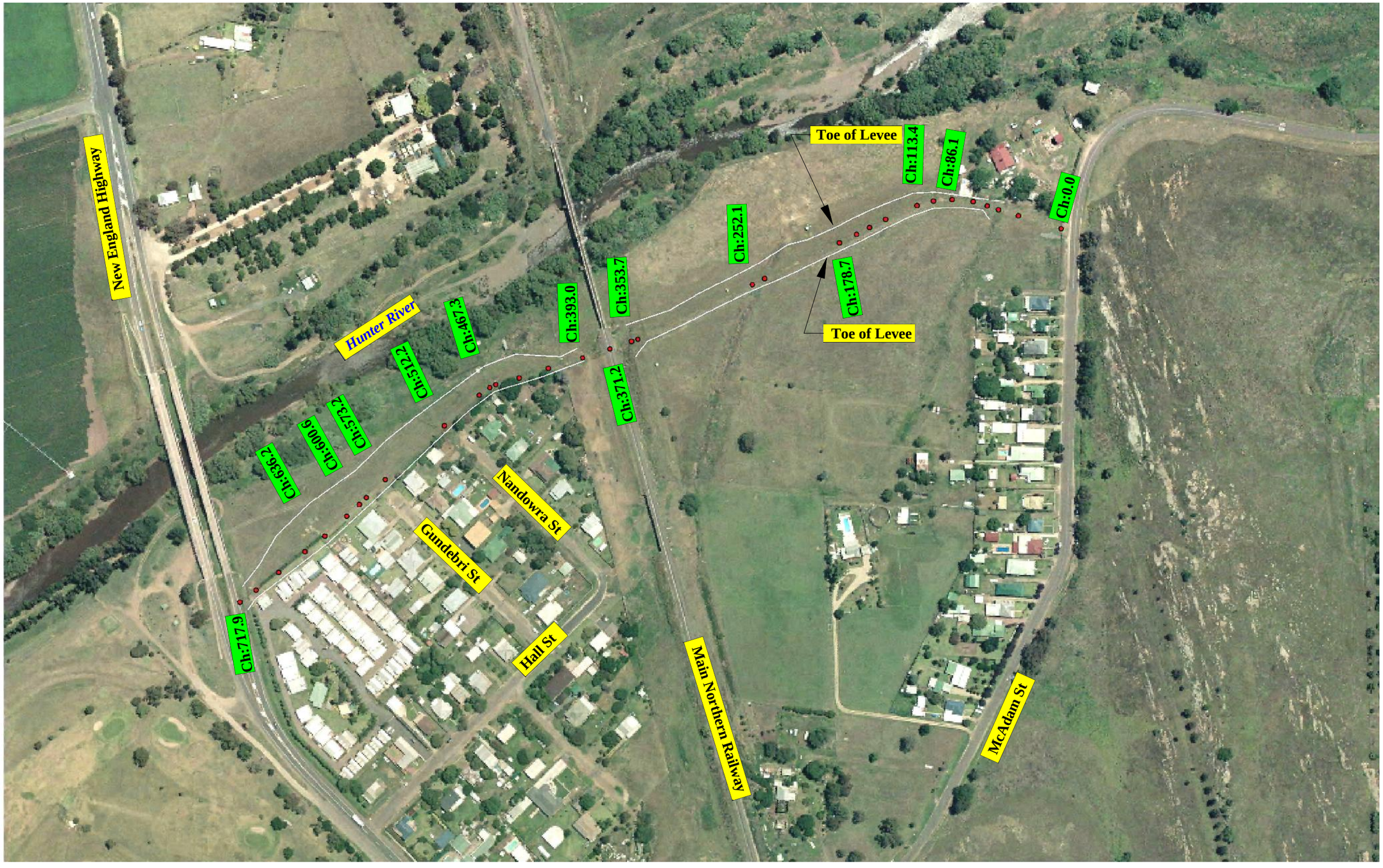
- removal of trees and vegetation from along the levee followed by topsoil and re-grassing with the levee at the same height. This action will probably require the acquisition of easements.
- Increasing the height of the levee to the level of protection consistent with the Aberdeen Flood Study, which will require raising of the crest, acquisition of easements, removal of vegetation followed by topsoil and re-grassing.

The issues of resident concerns relating to the materials used in the levee, the degree of compaction in the levee, and the foundations, can be addressed through a geotechnical investigation involving:

- a number of test bores through the levee down to the foundations and below to indicate the materials that are in the levee and below the levee
- a series of test pits to confirm the degree of compaction of the material in the levee.

It should be noted that, in general, levees are constructed to a compaction level of 95% Standard Compaction Test given that:

- flood levels tend to rise and fall relatively quickly;
- levees are not structures for retention of water in the long-term;
- the rate of rise and fall of flood levels does not create a situation where the pore water pressures within the levee have sufficient time to build up;
- provided adequate side slopes are used, slumping of the levee banks is quite rare.



0 100
Metres

14 November 2014
DISC REF: 14016
FILE REF: 14016A_1_LOCALITY PLAN_V1

FIGURE 1
LOCALITY PLAN

Ch 003 Looking downstream

Ch 034 Looking downstream

Ch 114 Looking downstream

Ch 114 Looking upstream

Ch 208 Looking upstream

Ch 252 Looking downstream

FIGURE 2
LEVEE PHOTOGRAPHS

Ch 272 Looking upstream

Ch 328 Looking upstream

Ch 242 Looking upstream

Ch 242 Looking downstream

Ch 393 Looking downstream

Ch 410 Looking downstream

FIGURE 3
LEVEE PHOTOGRAPHS

Ch 458 Looking downstream

Ch 462 Looking downstream

Ch 462 Looking upstream

Ch 462 Looking upstream

Ch 467 Looking downstream

Ch 477 Looking downstream

FIGURE 4
LEVEE PHOTOGRAPHS

Ch 512 Looking downstream

Ch 512 Looking upstream

Ch 522 Looking downstream

Ch 539 Looking downstream

Ch 573 Looking downstream

Ch 613 Looking downstream

FIGURE 5
LEVEE PHOTOGRAPHS

Ch 636 Looking upstream

Ch 655 Looking upstream

14 November 2014
DISC REF: 14016
FILE REF: 14016A_6_LEVEE PHOTOGRAPHS_V1

FIGURE 6
LEVEE PHOTOGRAPHS

APPENDIX B

COST ESTIMATES

Project:		Mcadam Levee adjustment				
Item no		Description	units	Qty	Rate ($)	Value ($)
1		Site Establishment	ls	1	7500.00	7500.00
2		Site Clearing	sq. m	1500	2.00	3000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	1500	2.50	3750.00
3.2		Transport, spread and compact fill	cu. m.	1600	25.00	40000.00
3.3		Spread topsoil	sq. m	1500	3.50	5250.00
3.4		Hydro-mulch and Grass	sq. m	1750	1.10	1925.00
3.5		Crest & access tracks	cu. m.	150	94.00	14100.00
3.6		Top up existing levee				
3.6.1		Strip & Stockpile topsoil	sq .m	1200	2.50	3000.00
3.6.2		Transport, spread and compact fill	cu. m.	500	25.00	12500.00
3.6.3		Spread topsoil	sq. m	1200	3.50	4200.00
3.6.4		Hydro-mulch and Grass	sq. m	1200	1.10	1320.00
3.6.5		Crest & access tracks	cu. m.	0	94.00	0.00
4		Road works				
4.1		Pavement	cu. M	45	94.00	4230.00
4.2		Bitumen seal	sq m	125	50.00	6250.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	25	175.00	4375.00
6.2		Install culverts	lin. M	25	20.00	500.00
6.2		Headwalls	no	2	500.00	1000.00
6.3		Flap gates	no	1	500.00	500.00
7		Grass maintenance	sq m	400	0.50	200.00
8		Dispersal	ls	1	5000.00	5000.00
					Sub_total	118600.00
9		Contratcors Profit				11860.00
					Sub_total	130460.00
10		Off site activities				
10.1		Survey, Investigation & Design				11860.00
10.2		Project management, testing				11860.00
					Sub_total	154180.00
11		Contingency		1		154180.00
					Total	308360.00
					say	309000.00

Project:		Upgrade_earth_levee				
Part 1		Extend Existing Levee				
Item no		Description	units	Qty	Rate	Value
					($)	($)
1		Site Establishment	ls	1	10000.00	10000.00
2		Site Clearing	sq. m	9500	2.00	19000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	9500	2.50	23750.00
3.2		Transport, spread and compact fill	cu. M	9000	30.00	270000.00
3.3		Spread topsoil	sq. m	9500	3.50	33250.00
3.4		Hydro-mulch and Grass	sq. m	10000	1.10	11000.00
3.5		Crest & access tracks	cu. m.	648	94.00	60912.00
4		Road works				
4.1		Pavement	cu. M	0	94.00	0.00
4.2		Bitumen seal	sq m	0	50.00	0.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	0	175.00	0.00
6.2		Install culverts	lin. M	0	20.00	0.00
6.2		Headwalls	no	0	500.00	0.00
6.3		Flap gates	no	0	500.00	0.00
7		Fencing				
7.1		Fence	m	675	20.00	13500.00
7.2		gates	no	9	690.00	6210.00
8		Grass maintenance	sq m	10000	1.00	10000.00
9		Dispersal	ls	1	5000.00	5000.00
					Sub_total	462622.00
Part 2		McAdam levee				
Item no		Description	units	Qty	Rate	Value
					($)	($)
1		Site Establishment	ls	0	7500.00	0.00
2		Site Clearing	sq. m	1500	2.00	3000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	1500	2.50	3750.00
3.2		Transport, spread and compact fill	cu. M	1600	25.00	40000.00
3.3		Spread topsoil	sq. m	1500	3.50	5250.00
3.4		Hydro-mulch and Grass	sq. m	1750	1.10	1925.00
3.5		Crest & access tracks	cu. m.	150	94.00	14100.00

4		Road works				
4.1		Pavement	cu. M	45	94.00	4230.00
4.2		Bitumen seal	sq m	125	50.00	6250.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	25	175.00	4375.00
6.2		Install culverts	lin. M	25	20.00	500.00
6.2		Headwalls	no	2	500.00	1000.00
6.3		Flap gates	no	1	500.00	500.00
7		Grass maintenance	sq m	400	0.50	200.00
8		Dispersal	ls		5000.00	0.00
					Sub_total	85080.00
		Parts 1 & 2			Sub_total	547702.00
9		Contratcors Profit				54770.20
					Sub_total	602472.20
10		Off site activities				
10.1		Survey, Investigation & Design				60247.22
10.2		Project management, testing				60247.22
					Sub_total	722966.64
11		Contingency		1		722966.64
					Total	1445933.28
					say	1446000.00

Project:		Upgrade_earth_levee				
Part 1		Extend Existing Levee				
Item no		Description	units	Qty	Rate	Value
					($)	($)
1		Site Establishment	ls	1	10000.00	10000.00
2		Site Clearing	sq. m	9500	2.00	19000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	5200	2.50	13000.00
3.2		Transport, spread and compact fill	cu m	5500	30.00	165000.00
3.3		Spread topsoil	sq. m	9500	3.50	33250.00
3.4		Hydro-mulch and Grass	sq. m	6000	1.10	6600.00
3.5		Crest & access tracks	cu. m.	270	94.00	25380.00
4		Road works				
4.1		Pavement	cu m	0	94.00	0.00
4.2		Bitumen seal	sq m	0	50.00	0.00
5		Concrete works				
5.1		Blinding stabs	cu m	30	360.00	10800.00
5.2		In-situ foundations	cu m	250	586.00	146500.00
5.3		In-situ walls	cu m	0		0.00
5.4		Blockwork	sq m	469	610.00	286090.00
5.5		Cut_off walls			949.00	0.00
5.6		Backfill by hand	cu m	450	90.00	40500.00
6		Landscaping				
6.1		Turf	sq. m	1200	21.00	25200.00
6.2		Handrail	lin. M	320	91.00	29120.00
7		Fencing				
7.1		Fence	m	225	20.00	4500.00
7.2		gates	no	9	690.00	6210.00
8		Grass maintenance	sq m	5200	1.00	5200.00
9		Dispersal	ls	1	5000.00	5000.00
					Sub_total	831350.00
Part 2		McAdam levee				
Item no		Description	units	Qty	Rate	Value
					($)	($)
1		Site Establishment	ls	0	7500.00	0.00
2		Site Clearing	sq. m	1500	2.00	3000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	1500	2.50	3750.00
3.2		Transport, spread and compact fill	cu. M	1600	25.00	40000.00
3.3		Spread topsoil	sq. m	1500	3.50	5250.00
3.4		Hydro-mulch and Grass	sq. m	1750	1.10	1925.00
3.5		Crest & access tracks	cu. m.	150	94.00	14100.00

4		Road works				
4.1		Pavement	cu. M	45	94.00	4230.00
4.2		Bitumen seal	sq m	125	50.00	6250.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	25	175.00	4375.00
6.2		Install culverts	lin. M	25	20.00	500.00
6.2		Headwalls	no	2	500.00	1000.00
6.3		Flap gates	no	1	500.00	500.00
7		Grass maintenance	sq m	400	0.50	200.00
8		Dispersal	ls		5000.00	0.00
					Sub_total	85080.00
		Parts 1 & 2			Sub_total	916430.00
9		Contratcors Profit				91643.00
					Sub_total	1008073.00
10		Off site activities				
10.1		Survey, Investigation & Design				100807.30
10.2		Project management, testing				100807.30
					Sub_total	1209687.60
11		Contingency		1		1209687.60
					Total	2419375.20
					say	2420000.00

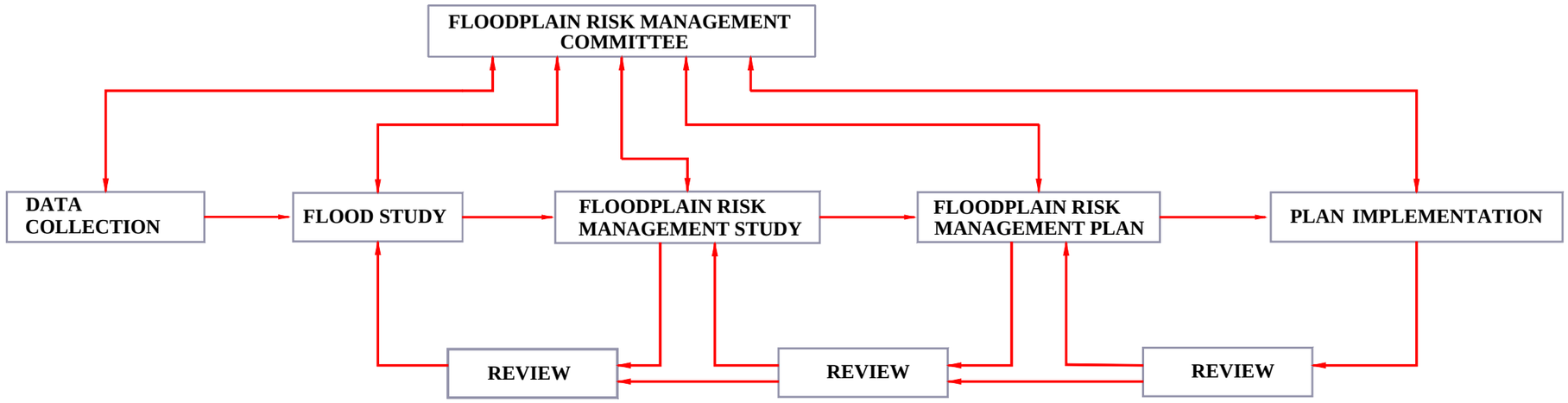
Project:		Upgrade_earth_levee plus New England				
Part 1		**Extend Existing Levee**				
Item no		**Description**	**units**	**Qty**	**Rate ($)**	**Value ($)**
1		Site Establishment	ls	1	10000.00	10000.00
2		Site Clearing	sq. m	9500	2.00	19000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	9500	2.50	23750.00
3.2		Transport, spread and compact fill	cu. M	9000	30.00	270000.00
3.3		Spread topsoil	sq. m	9500	3.50	33250.00
3.4		Hydro-mulch and Grass	sq. m	10000	1.10	11000.00
3.5		Crest & access tracks	cu. m.	648	94.00	60912.00
4		Road works				
4.1		Pavement	cu. M	0	94.00	0.00
4.2		Bitumen seal	sq m	0	50.00	0.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	0	175.00	0.00
6.2		Install culverts	lin. M	0	20.00	0.00
6.2		Headwalls	no	0	500.00	0.00
6.3		Flap gates	no	0	500.00	0.00
7		Fencing				
7.1		Fence	m	675	20.00	13500.00
7.2		gates	no	9	690.00	6210.00
8		Grass maintenance	sq m	10000	1.00	10000.00
9		Dispersal	ls	1	5000.00	5000.00
					Sub_total	462622.00
Part 2		**McAdam levee**				
Item no		**Description**	**units**	**Qty**	**Rate ($)**	**Value ($)**
1		Site Establishment	ls	0	7500.00	0.00
2		Site Clearing	sq. m	1500	2.00	3000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	1500	2.50	3750.00
3.2		Transport, spread and compact fill	cu. M	1600	25.00	40000.00
3.3		Spread topsoil	sq. m	1500	3.50	5250.00
3.4		Hydro-mulch and Grass	sq. m	1750	1.10	1925.00
3.5		Crest & access tracks	cu. m.	150	94.00	14100.00

4		Road works				
4.1		Pavement	cu. M	45	94.00	4230.00
4.2		Bitumen seal	sq m	125	50.00	6250.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	25	175.00	4375.00
6.2		Install culverts	lin. M	25	20.00	500.00
6.2		Headwalls	no	2	500.00	1000.00
6.3		Flap gates	no	1	500.00	500.00
7		Grass maintenance	sq m	400	0.50	200.00
8		Dispersal	ls		5000.00	0.00
					Sub_total	85080.00
Part 3		**New England Levee**				
Item no		**Description**	**units**	**Qty**	**Rate**	**Value**
					($)	**($)**
1		Site Establishment	ls	1	5000.00	5000.00
2		Site Clearing	sq. m	3000	2.00	6000.00
3		Earth works				
3.1		Strip & Stockpile topsoil	sq .m	2950	2.50	7375.00
3.2		Transport, spread and compact fill	cu. M	2600	35.00	91000.00
3.3		Spread topsoil	sq. m	2950	3.50	10325.00
3.4		Hydro-mulch and Grass	sq. m	3000	1.10	3300.00
3.5		Crest & access tracks	cu. m.	189	94.00	17766.00
4		Road works				
4.1		Pavement	cu. M	110	94.00	10340.00
4.2		Bitumen seal	sq m	360	50.00	18000.00
5		Concrete works				
5.1		Blinding stabs		na		
5.2		In-situ foundations		na		
5.3		In-situ walls		na		
5.4		Blockwork		na		
5.5		Cut_off walls		na		
6		Culvert				
6.1		Supply & install culverts	lin. M	0	175.00	0.00
6.2		Install culverts	lin. M	0	20.00	0.00
6.2		Headwalls	no	0	500.00	0.00
6.3		Flap gates	no	0	500.00	0.00

7		Fencing				
7.1		Fence	m	500	20.00	10000.00
7.2		gates	no	3	690.00	2070.00
8		Grass maintenance	sq m	3000	1.00	3000.00
9		Dispersal	ls	1	5000.00	5000.00
					Sub_total	189176.00
		Parts 1 & 2 & 3			Sub_total	836878.00
10		Contratcors Profit				83687.80
					Sub_total	920565.80
11		Off site activities				
11.1		Survey, Investigation & Design				92056.58
11.2		Project management, testing				92056.58
					Sub_total	1104678.96
12		Contingency		1		1104678.96
					Total	2209357.92
					say	2210000.00

APPENDIX C

FLOODPLAIN MANAGEMENT PROCESS



FLOODPLAIN RISK MANAGEMENT PROCESS

27 May 2014
DISC REF: 14016
FILE REF: 14016_C1_FLOODPLAIN_MANAGEMENT_PROCESS_V1

FIGURE C1
FLOODPLAIN RISK MANAGEMENT PROCESS

APPENDIX D

ABERDEEN FLOOD STUDY, 1% AEP DESIGN FLOOD LEVELS AND FLOOD HAZARD

FIGURE 25

1% AEP (100 YR ARI)

FLOOD DEPTHS AND CONTOURS

Height Contours (mAHD)

Major Contour (1m)

Minor Contour (0.2m)

Peak Flood Depth (m)

0 - 0.5

0.5 - 1

1 - 2

2 - 5

> 5

N

0 0.25 0.5 1 1.5 2 km

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FIGURE 30
1% AEP (100 YR ARI)
PROVISIONAL HAZARD

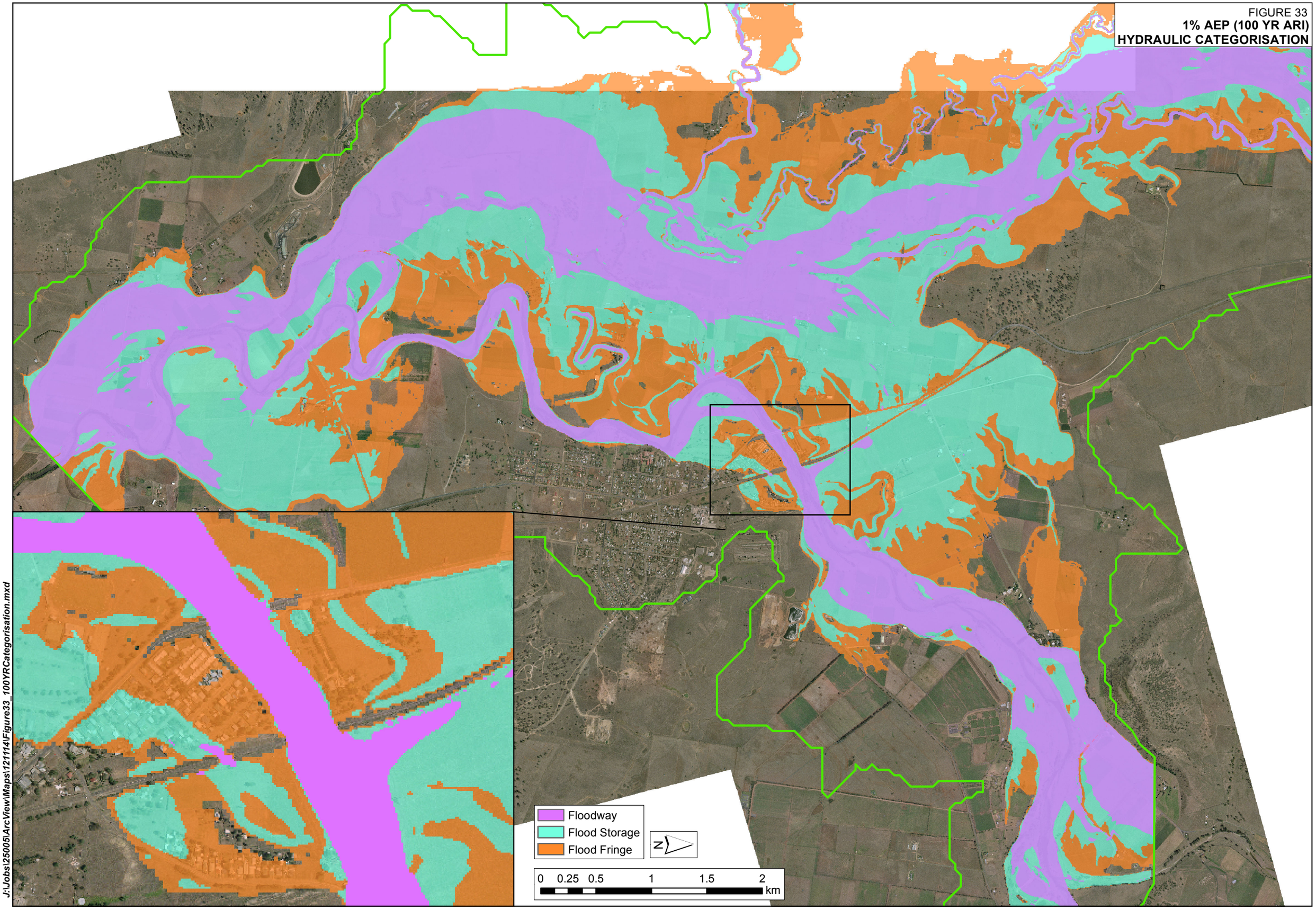
Low Provisional Hazard
High Provisional Hazard

N

0 0.25 0.5 1 1.5 2
km

J:\Jobs\25005\ArcView\Maps\121114\Figure30_100y_Hazard.mxd

FIGURE 33
1% AEP (100 YR ARI)
HYDRAULIC CATEGORISATION



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