REPORT

Waikato District Council

Draft Catchment Management Plan
Tuakau Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

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Draft Catchment Management Plan
Tuakau Structure Plan Area

Report prepared for:

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Executive summary

This Catchment Management Plan has broadly considered the background issues and potential constraints with regard to freshwater ecology and flood hazard to urban growth within the Tuakau Structure Plan Area.

The streams and tributaries within the Structure Plan Area are potentially subject to significant flood hazard (deep and or fast flowing flood waters) and this hazard extends well beyond the nominal stream channels and impacts the broader floodplains on many streams. Minor and potential flood hazards associated with overland flow paths also exist in urbanised parts of the Structure Plan Area.

The proposed land uses within the Structure Plan Area include significant areas of open space around stream corridors and this includes large areas where a significant flood hazard has been estimated to occur. Therefore there is often low constraint to the proposed development. Notwithstanding there are still proposed growth parcels which do not have adequate open space provisions and future development of those parcels would be significantly constrained by the estimated flood hazard.

A number of culverts and bridges are considered to be either exacerbating flood issues or limiting the upstream migration of fish and therefore require further assessment.

The status of the freshwater streams is generally considered degraded but there is significant potential for stream value enhancement throughout the Structure Plan Area. The proposed open space areas, and any additional open space areas included after a review of flood issues, could include riparian planting.

Overall, outside of significant flood hazard areas and the proposed industrial land use areas, we consider that there is generally a low to medium constraint to growth within the Structure Plan Area assuming that good practice measures are employed. Some specific mitigation measures (over and above good practice) are recommended for some parcels (i.e. proposed industrial land use areas).

The open space areas should be re-considered with regard to the flood hazard maps and ecological issues presented in this report.

Waikato District Council hold a Comprehensive Stormwater Discharge Consent for urban areas within the Structure Plan Area and this resource consent in effect sets the standard for good practice planning and design.

1 Introduction

1.1 Background

Waikato District Council (WDC) engaged Tonkin & Taylor Ltd (T&T) to prepare a Catchment Management Plan (CMP) for the Tuakau Structure Plan Area (SPA). This CMP has been produced to support and inform WDC's planning decisions relating to urban growth at Tuakau.

WDC has progressed high level planning for growth and consulted with the community to develop preliminary growth areas and the SPA used herein. The SPA extent is shown in Figure 1.

WDC has drawn on earlier reports prepared by both GHD Ltd (GHD, 2006) and Harrison Grierson Consultants Ltd (HG, 2008). These reports were produced for smaller areas within the larger Tuakau SPA. The reports have focused primarily on the Tuakau Township (HG, 2008) and the Whangarata industrial development area (GHD, 2006) to the east of the township.

This CMP builds on the earlier reports, and encompasses the wider Tuakau SPA. WDC has provided the future staging for Tuakau to 2051, showing the proposed extent of future land use including: commercial, light industrial, heavy industrial, large lot, low density residential, medium density residential and open space.

This CMP should be read in conjunction with a number of other reports commissioned by WDC for the Tuakau SPA covering issues related to:

- Contaminated land
- Built heritage
- Archaeology
- Tangata whenua matters
- Landscape and amenity
- Geotechnical matters
- Transport
- Water
- Wastewater
- Urban design
- Property economics
- Aquatic ecology

This CMP is limited to an assessment of ecological issues and flooding hazards within the defined Tuakau SPA.

1.2 Purpose

With respect to ecological and flood issues, the purpose of the CMP is to:

- Provide baseline information within the SPA.
- Broadly identify potential environmental effects on riparian and aquatic ecology from urban development within the nominated growth areas.
- Broadly identify potential flooding hazards in the nominated growth areas.
- Summarise the potential limitations to growth within the nominated growth areas.
- Identify means to address potential adverse environmental effects.

1.3 Scope

The following tasks have been undertaken and are outlined in this CMP:

i. A Rapid Flood Hazard Assessment (RHFA) using available LiDAR to map flood hazards.

ii. Identification and review of critical structures to help inform the RFHA results interpretation.

iii. Review and assessment of the ecological status of water resources in the catchment, concentrating on obtaining information for those parts of the catchment not covered by the HG, 2008 and GHD 2006 reports.

iv. Site walkovers at critical (and publicly accessible) locations to identify and map the key hydrological features of the catchment including; floodplain extents and levels of development, in-stream structures and visually assess barriers to fish passage and riparian and freshwater habitat condition.

v. Preparation of GIS layers (shape files) that show the extent of potential flooding and ecological attributes.

vi. Preparation of GIS layers that show the key stormwater features.

vii. Identification of gaps or areas where further data collection is required.

viii. Identification of stormwater management issues and potential adverse effects from growth and presentation of options for management of these issues.

1.4 Data obtained from councils

The following data has been supplied by WDC:

- Aerial photographs.
- Raw LiDAR data of the Tuakau area.
- Stormwater asset data (this generally excludes culverts as these are "road" assets).
- The Tuakau SPA boundary.
- Previous relevant reports:
    - GHD, May 2006. "*Report for Engineering Assessment of Proposed Business Land, Tuakau*" (GHD Ltd, 2006)
    - Harrison Grierson Consultants Ltd, 1999. "*An ecological assessment of Tuakau watercourses.*" (HG Ltd, 1999)
    - Brian T. Coffey & Associates Ltd, 2008. "Tuakau Structure Plan Aquatic Ecological Assessment." (Coffey Ltd, 2008)
    - Harrison Grierson Consultants Ltd, 2009. "*Tuakau District Growth Strategy 2051: Catchment Management Plan*." (HG Ltd, 2009)
    - Brian T. Coffey & Associates Ltd, 2014. "*Aquatic Ecological Assessment Update for the Tuakau Structure Plan Area*." (Coffey Ltd, 2014)
- Tuakau growth and staging sketches.

Waikato Regional Council (WRC) has provided:

- Waikato River 1D flood model (MIKE 11) cross sections including 1% AEP flood levels from the Karapiro Dam to Port Waikato.

We note that the 1D modelling carried out by WRC was undertaken in 2009 with no allowance for Climate Change.

Auckland Council (AC) has provided:

- Raw LiDAR data of the South Pukekohe area.

2 Catchment description

2.1 Location

The Tuakau SPA surrounds the North Waikato township of Tuakau, and is located on the northern side of the Waikato River, approximately 8 km south west of Pukekohe and approximately 7 km west of State Highway 1. The location of the Tuakau SPA is presented in Figure 1. The SPA (red outline) covers approximately 1,353 ha of the broader 6873 ha catchment (green outline).

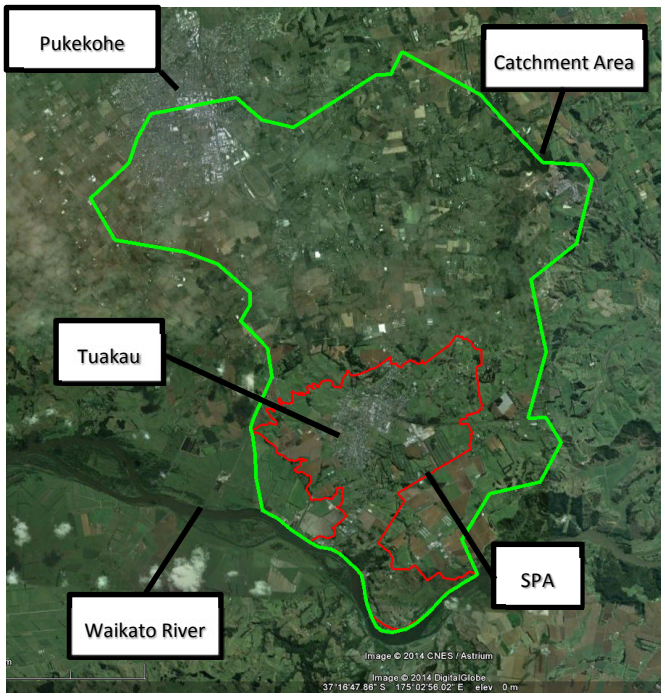


Figure 1. Tuakau SPA and catchment location (Image sourced from Google Earth, 2014)

2.2 Topography

The topography of the catchment and SPA is typically gently undulating with relatively flat terraces incised by natural water courses. Some hills are present in the northern and north eastern part of the SPA. The area generally slopes down towards the west and southwest, with low lying plains present beyond the south western boundary of the SPA. The south eastern part of the SPA, is steep and hilly. The Waikato River bounds the SPA in the south.

2.3 Geology and hydrogeology

The published geology of the area indicates that the majority of the Tuakau SPA is underlain by basaltic lava flows and scoria and air fall deposits of the Kerikeri Volcanic Group (Edbrooke, 2001) as shown in the Geological map in Figure 2 below. The area forms part of the South Auckland Volcanic Field. In the southern part of the SPA small pockets of alluvial deposits are present along the Waikato River. These deposits are part of the Puketoka Formation which comprises pumiceous mud, sand and gravel with muddy peat and lignite; rhyolite pumice, including non-welded ignimbrite, tephra and alluvial pumice deposits; massive micaceous sand.

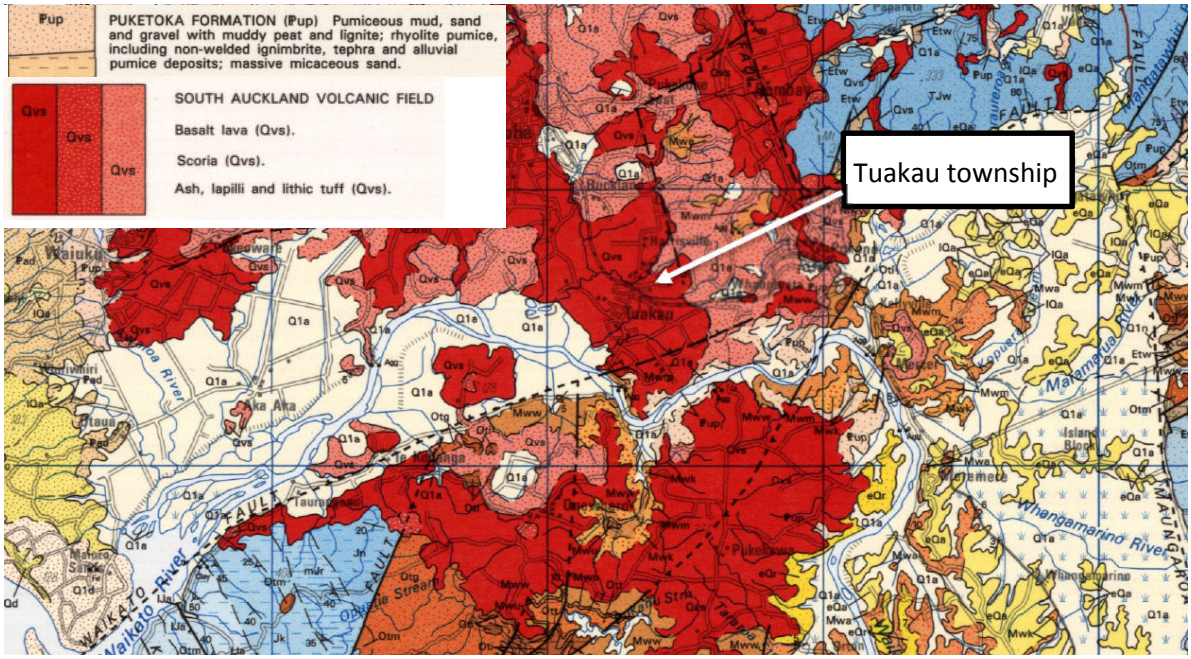


Figure 2. Geological map of Tuakau structure plan area

The hydrogeology is dominated by the presence of the volcanic rocks of the South Auckland Volcanic Field overlying a continuous Pliocene marine Kaawa Formation. The coarser members of the Puketoka Formation (sands and gravel) are likely to provide groundwater from aquifers that are limited in their lateral extent.

The hydraulic properties of basalt aquifers vary depending on their composition and degree of fracturing (White & Rosen, 2001) with hydraulic conductivities ranging over four orders of magnitude. The Kaawa Formation aquifer on the other hand is of moderate permeability but its hydraulic properties are more consistent. The Kaawa Formation is not present at the surface, but provides a source of recharge to the shallow basalt aquifers in the southern part of the SPA, as discussed below.

Recharge across the Pukekohe and Tuakau area is via infiltration of rainwater (and possibly surface water) into the shallow basalt and scoria aquifers, with leakage from these aquifers providing a source of recharge to the Kaawa Formation aquifer. Groundwater movement follows the topography with groundwater moving in a south to southwest direction towards the Waikato Fault and Waikato River.

In the lower part of the catchment, groundwater flows in the basalt and scoria aquifers arise to recharge surface water bodies through discharge points and springs and the hydraulic gradient between the volcanic aquifers and the Kaawa Formation reverses and the Kaawa Formation recharges the shallower aquifers (White & Rosen, 2001).

As a result many of the zero and first order streams have high specific discharges, as these flows are fed by groundwater rather than surface water runoff.

2.4 Watercourses

There are two main watercourses flowing through the existing Tuakau Township; the Kairoa Stream and the Whakapipi Stream. A third stream, Tutaenui Stream, is located west of the township and follows the western boundary of the SPA. The three streams are described below and shown (light blue) in Figure 3 below.

The Kairoa Stream drains the eastern side of the catchment. The upper reach north east of the SPA drains mainly agricultural lands with the middle reach draining the industrial and commercial areas to the east of Tuakau Township and the residential areas in the central and southern parts of the SPA. The lower reach drain mainly agricultural lands with the Kairoa Stream discharging into the Waikato River south of Tuakau just outside the SPA.

The Whakapipi Stream drains the central-eastern part of the catchment. The upper and middle reach north east of the SPA drains mainly agricultural lands with the lower to middle reach draining the urbanised areas in the northern portion of the Tuakau Township. The lower reach drains agricultural land west of Tuakau township before discharging into the Tutaenui Stream west of Tuakau near the SPA boundary.

The Tutaenui Stream drains the western part of the catchment. The upper north west reach drains urbanised parts of Pukekohe and Bucklands. The upper north east reach as well as the middle reach drains mainly agricultural land before the confluence with the Whakapipi Stream west of Tuakau near the SPA boundary. Below the confluence with the Whakapipi Stream, the Tutaenui Stream borders the western boundary of the SPA and receives runoff from mainly agricultural land and a small area of urbanised Tuakau before discharging into the Waikato River to the southeast of the SPA.

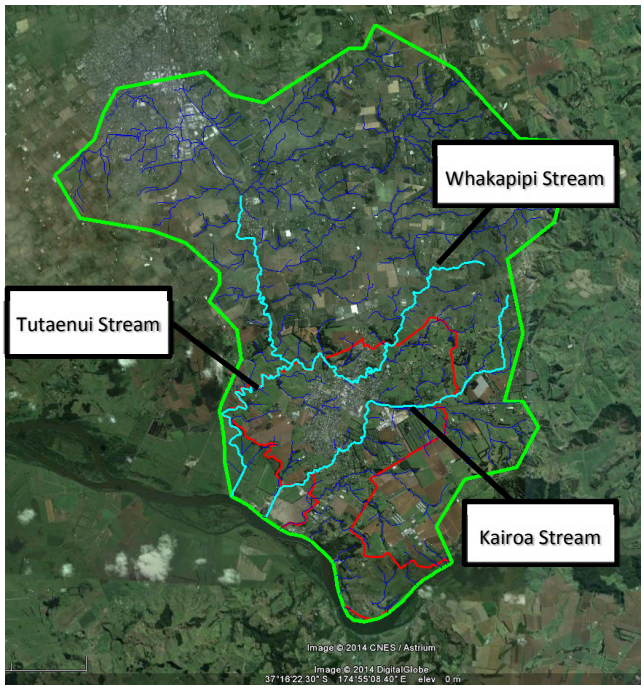


Figure 3. Main water courses (light blue) and tributaries (dark blue) within the catchment.

There are a number of unnamed tributaries within the Tuakau SPA that feed the three main streams. The unnamed tributaries drain a mixture of residential, rural, commercial and industrial land and are shown in Figure 3 above.

There are also a series of small unnamed tributaries which drain directly to the Waikato River within the south of the Tuakau SPA. The land use within these stream catchments is generally agricultural with small areas of lifestyle properties. These streams also include the lower flood plain areas of the Waikato River.

Figure 112 in Appendix A shows the locations of these streams, and their proximity to the Waikato River south of Tuakau.

2.5 Receiving environments

The identified surface water receiving environments within or adjacent to the Tuakau SPA include:

- Kairoa Stream.
- Whakapipi Stream.
- Tutaenui Stream.
- Waikato River.
- Unnamed tributaries of all of the above.

2.6 Existing WRC resource consents

2.6.1 General

WRC's online database has been used to broadly identify the types of resource consents held within the SPA and these are summarised in Table 1 below.

Table 1. WRC Resource Consents

Resource Consent Type	Number	Growth Sector
Discharge - Air	3	E
Discharge - Land	4	B, D, E, I
Discharge - Water	5	A, F(2), B, D
Land Use – Bore/Well	3	C, D(2)
Land Use – Other	8	B(3), H(3), K, J
Water Take - Ground	7	D, E(2), G92), I(2)
Water Take - Surface	6	A, G(4), H
Water Take - Other	3	E, G(2)

2.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105051, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Tuakau.

Relevant extracts from the resource consent are reproduced below:

Consent Type:	Discharge permit
Consent Subtype:	Discharge to water
Activity authorised:	Divert and discharge urban stormwater runoff and associated contaminants at multiple locations to land, the Whakapipi Stream, Tutaenui Stream and Kairoa Stream, and use discharge structures in the general vicinity of Tuakau Urban Area that is reticulated by the Tuakau municipal stormwater system.
Consent duration:	Granted for a period expiring on 14 November 2028

It is noted that the extent of the above consent (reticulated urban area of Tuakau) is significantly smaller than the extent of the SPA.

3 Land use in Tuakau

3.1 Current land use

Land within the SPA is dominated by horticultural and agricultural land uses, with the residential and commercial areas of Tuakau Township also occupying a significant portion of the central area. Other land uses currently occurring within the SPA include rural residential, light industrial and heavy industrial land uses.

The North Island Main Truck Line (NMTL) railway line runs through the northern part of the SPA and the centre of Tuakau Township. Key arterial routes to the north west (Buckland's Road), north (George Street and Harrisville Road), east (Whangarata Road) and to the south (River Road) are notable transport corridors.

The commercial/retail area of the Tuakau Township is located in the northern & central part of the SPA with predominantly residential land surrounding it to the south, west, north and northeast. Industrial land is located immediately east of the town centre. Outside of the township, the SPA is dominated by horticultural and agricultural land including market gardens, orchards and pasture land with small clusters of rural residential land use. Two clusters of industrial land are located beyond the township; on Bollard Road in the eastern part of the SPA, and on River Road, in the south-western part of the SPA.

Information on land use within the township of Tuakau is also contained within the Tuakau District Growth Strategy report (HG Ltd, 2009).

3.2 Future land use

Future growth within the SPA, staged to 2021, 2051 and beyond has been provided by WDC and is shown in Figure 4 below. Staging has been planned in three phases; 2021, 2051 and beyond.

For reporting purposes, the growth areas defined by WDC have been categorised into "Growth Sectors" A to K tabulated in Table 2 and presented in Figure 4.

It is noted that the staging plan provided by WDC and presented in Figure 4 extends beyond the SPA boundary provided by WDC.

For each growth area WDC has provided proposed land parcels with a specific attribute values including an ID (i.e. PLID_xxxx) and these ID's have been used for reporting purposes.

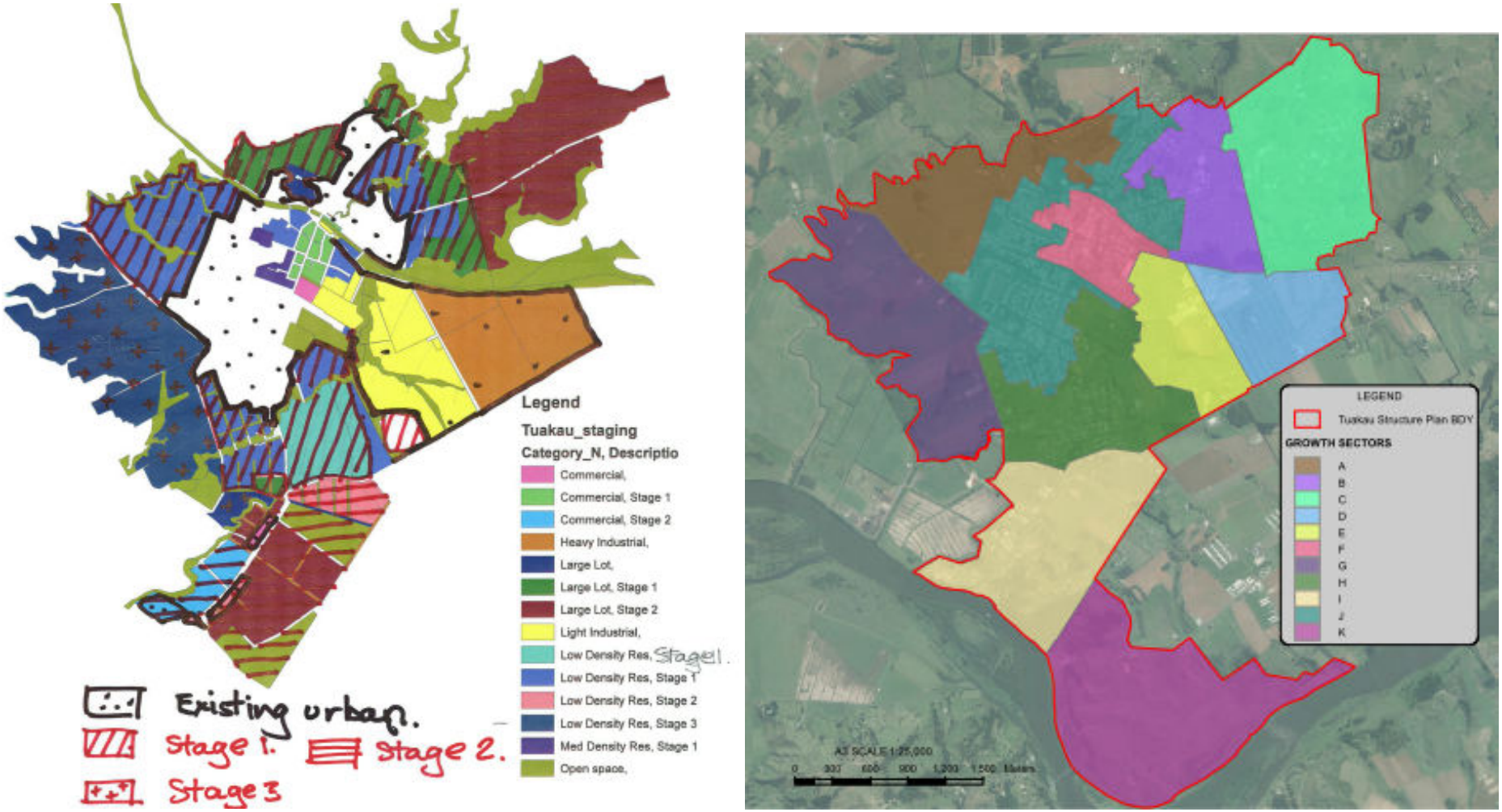


Figure 4. Staging plan provided by WDC (left) and Growth Sectors used for reporting (right).

Table 2. Growth Sectors

Growth Sector	Proposed use (excluding Open Space)
A	Stage 1 Large Lot north of NMTL and Stage 1 Low Density Residential south of NMTL.
B	Stage 1 Large Lot and Stage 1 Low Density Residential
C	Stage 2 Large Lot
D	Heavy industrial (partially developed already)
E	Light industrial (partially developed already)
F	Infill development in existing town centre with Commercial, Medium Density Residential, Low density residential, Light Industrial. Some greenfield expansion to south east includes Stage 1 Commercial and Light Industrial.
G	Stage 3 Low Density Residential
H	Stage 1 Low Density Residential
I	Stage 1 Large Lot and Commercial, Stage 2 Large Lot, Low Density Residential and Commercial
J	Existing Urban
K	Existing Rural

4 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Tuakau SPA. The assessment is based on a review of existing ecological studies with a brief walkover site visit to publicly accessible parts of the SPA not previously covered. Important terrestrial and wetland values recorded in the district plan are also briefly described.

4.1 SPA overview

4.2 Assessment methods

Three ecological assessments [(HG Ltd, 1999), (Coffey Ltd, 2008) and (Coffey Ltd, 2014)] and a CMP (HG Ltd, 2009) have previously been completed for Tuakau and its surrounds. Our assessment has reviewed the information contained in these documents.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 10 April 2014 to confirm levels of development, observe in stream structures, assess fish passage conditions and visually assess habitat condition. The sites assessed during the field assessment are shown on Figure 112 in Appendix A.

4.3 Summary of existing ecological information

4.3.1 Ecological assessment of Tuakau watercourses (HG Ltd, 1999)

The purpose of the 1999 study was to assess the relative impacts of contamination on stream habitat quality from the upstream rural catchments and from within Tuakau Township at the various stormwater discharge points. The study comprised a semi-quantitative assessment of physical habitat and macroinvertebrate at twelve sites distributed over the Tutaenui Stream, Whakapipi Stream and Kairoa Stream catchments. Fish population surveys were carried out at six representative sites.

The assessment concluded that physical habitat was low or moderate at the majority of sites sampled. This was supported by the low numbers of sensitive macroinvertebrate taxa being present (Ephemeroptera, Plecoptera, and Trichoptera (EPT)) and the low diversity of fish populations (shortfin eels (*Anguilla australis*) and gambusia only).

The 1999 report concluded that in-stream community structures were likely to be compromised by factors external to the Tuakau urban area, with degraded water quality from the upstream agricultural catchment the most likely cause. These results are somewhat dated and should only be used to help assess change in the ecological state of the streams between that survey and the more recent 2008 (Coffey Ltd, 2008) and 2014 (Coffey Ltd, 2014) reports which are summarised below.

4.3.2 Tuakau structure plan aquatic ecological assessment (Coffey, 2008)

The 2008 report provides an assessment of stream ecological health and a description of community structure for a small part of Kairoa Stream that drains the industrial area to the east of Tuakau. The assessment was undertaken to support the development of a catchment management plan for the eastern Tuakau urban area and comprised semi-quantitative habitat assessment, periphyton and macrophyte assessment, macroinvertebrate sampling and fish survey at nine sites.

The assessment concluded that Kairoa Stream has poor physical in-stream habitat quality associated with excessive macrophyte and periphyton growth. Poor habitat quality was considered to be due to a lack of or low tributary inflows during dry summer months, and probable degraded water quality associated with the agricultural and horticultural land use in the upper catchment.

Shortfin eel and koura (classified as 'At Risk: Declining', (Goodman, 2014)) were the only species captured during the fish survey, with a natural barrier (waterfall below Geraghtys Road) and two manmade weirs (one downstream and one upstream of George Street) likely to obstruct upstream migration of all non-climbing native and exotic fish species. Macroinvertebrate results showed low numbers of sensitive EPT taxa and macroinvertebrate community index (MCI) scores at the majority of the sampling sites indicating severe pollution and poor habitat within the Kairoa Stream.

4.3.3 Tuakau CMP (HG, 2009)

The 2009 Tuakau CMP includes brief comments on the source and ecological conditions of unclassified streams within growth areas of Tuakau. These comments are summarised below.

Two unnamed tributaries to Tutaenui Stream are present to the west of Tuakau. The northern watercourse initially flows through open pasture for a short distance before entering an incised channel. At the time of the assessment the channel was densely vegetated throughout its length entering a series of natural wetlands to the north of the proposed 2009 rezoning boundary.

The southern watercourse originates within the residential area between Gibson Road and Jellicoe Avenue. The watercourse includes a natural ponding area immediately upstream of Gibson Road with some natural vegetation and manmade landscaping on its banks. Downstream from that point the watercourse comprises a mixture of open channels and culverts, constructed to facilitate residential development.

The report recommended that the two watercourses should not be incorporated into the reticulated stormwater system but should undergo riparian restoration (protection of riparian margins and re-vegetation with native species) to improve stream health and be incorporated into a community reserve.

An unnamed tributary of the Kairoa Stream is present to the east of Tuakau. The watercourse channel is characterised by a wide shallow dish with slow moving sheet flow and localised wetlands. The report also recommended that this watercourse should be retained as an open stream if possible.

4.3.4 2014 Tuakau structure plan aquatic ecological assessment update (Coffey, 2014)

This assessment was specifically undertaken to support the Tuakau Structure Plan project outlined in this report. The ecological assessment included periphyton and macrophyte assessments, field water quality measurements and macroinvertebrate and fish survey at two sites within each of the Tutaenui, Whakapipi and Kairoa streams.

The ecological assessment concluded habitat quality was poor to suboptimal at all sites. All hard-bottom sites were dominated by filamentous periphyton. Within soft bottom sites exotic and emergent macrophytes were dominant with over 30% stream coverage within the Whakapipi and Kairoa streams. Emergent macrophyte cover was dominated by reed sweet grass (*Glyceria maxima*) while submerged macrophyte cover in unshaded reaches was generally dominated by the exotic oxygen weeds *Egeria densa* and *Elodea canadensis.* Overall habitat assessment concluded that all sites were highly eutrophic (nutrient rich). Agricultural land uses in the upper

catchment were considered the likely source of plant available nutrients (nitrogen and phosphorus) to the stream.

Macroinvertebrate communities were consistent with the eutrophic state of the stream and were characterised by low numbers of sensitive ETP taxa. Average MCI scores for all sites were indicative of poor habitat quality and likely severe pollution.

Results from the fish survey show that longfin eel (*Anguilla dieffenbachii*), shortfin eel, common bully (*Gobiomorphus cotidianus*), *Gambusia affinis,* Koura and freshwater shrimp (*Paratya curvirostris*) are present within all three streams. Inanga (*Galaxias maculatus*) and goldfish (*Carassius auratus*) were present in the lower reaches of the Tutaenui and Kairoa streams. Longfin eel, inanga and koura are classified as At Risk with declining populations, the remaining species are classified not threatened or introduced (Goodman, 2014).

4.3.5 Trends in stream ecological health

Comparisons of habitat assessment data and macroinvertebrate community index scores between the 1999 and 2014 ecological assessments indicate that conditions have remained similar in all three of the streams assessed. All three streams are influenced by agricultural land uses in upper catchment areas, have been subject to riparian modifications and support macroinvertebrate communities typical of reduced habitat quality conditions.

Conditions in the Kairoa Stream reported in 2014 (Coffey Ltd 2014) were also similar to that reported in the 2008 ecological assessment (Coffey Ltd, 2008). The stream is characterised by excessive growth of aquatic plants and filamentous algae which result in reduced aquatic habitat quality.

A comparison of fishing survey results show an increase in species diversity for all SPA streams in 2014 when compared to 1999. However, this is likely due to locations fished and survey methods rather than reflecting any improvement in aquatic habitat quality.

4.3.6 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Tuakau area is included on Planning Map 7. Two of the ecological features identified on Map 7 are located within the SPA. These are described as follows.

- Identified Significant Natural Feature 5 – Waikato River and Wetlands. This covers several specific wetland vegetation patches, all of which are protected by the District Plan conservation zoning (Wetland Conservation Zone). These patches are present within and immediately adjacent to the SPA. Tutaenui Stream passes through one particular area as shown on District Plan Map 7. Potential adverse effects or threats noted in the DP schedule include vegetation clearance, loss of threatened species, weed invasion, reclamation, siltation, degradation in water quality and modification or damage to wetland habitats.
- Identified Significant Natural Feature 29 – Alexandra Redoubt Bush (DP Map 7). This includes a reserve status and an area of bush on private land that is protected by Council Covenant. Potential adverse effects and threats noted in the DP include modification, damage of the native bush and wildlife habitats; vegetation clearance and fragmentation; reduction in naturalness and quality by pests and weeds; reduction in regeneration ability through stock grazing, weed invasion, browsing; loss of threatened species.

4.3.7 Waikato Regional Plan maps

Waikato Regional Plan (WRP) water management and stock exclusion maps were reviewed to check for any specific values that apply to SPA streams. All watercourses within the area are

classified as Waikato Surface Water (Map R12) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

The lower reaches of several streams near the Waikato River and the Waikato River itself are classified as Priority 1 Stock Exclusion areas (Stock Exclusion Map 4). This classification is applied to significant habitats or areas that are characterised by high water quality. It is not clear why the WRP applies this classification to SPA streams.

4.4 T&T's 2014 field assessment

A site inspection of publicly accessible locations on the Tutaenui, Whakapipi and Kairoa Streams and unnamed tributaries within the Tuakau SPA was conducted on 10 April, 2014. Locations inspected are shown on Figure 112 in Appendix A.

Observations from site inspections concluded that there was excessive macrophyte and periphyton growth within streams. The likely factors contributing to excessive macrophyte growth are the lack of significant areas of riparian vegetation providing shade to the stream channel and the presence of nutrients in the stream due to the agricultural and horticultural land use in the upper catchment.

In-stream habitat at the sites inspected was generally limited to slow moving runs and pools with undercut banks, root mats and overhanging vegetation present at limited locations. Within the soft bottom sections there was a lack of large woody debris providing hard substrate habitat for macroinvertebrate species. Within the sections of hard bottom streams riffle sections were observed on the Tutaenui Stream downstream from the Buckland road bridge and the within Kairoa Stream upstream from the Bollard Road Bridge.

Barriers to upstream fish passage were identified on the Tutaenui, Whakapipi and Kairoa streams. These consisted of weirs downstream of Buckland Road Bridge on the Tutaenui stream, downstream of the Harrisville Road Bridge on the Whakapipi Stream and downstream of the North Island Main Trunk Line Bridge on the Kairoa Streams. It is likely that migration of non-climbing fish species such as inanga, would be impeded by these barriers. It is anticipated that these barriers could be removed or retrofitted as part of developments within the Tuakau area.

Public access to much of the upper catchment of the Tutaenui, Whakapipi and Kairoa streams is limited and therefore condition of streams in these areas were not able to be assessed as part of the stream walkover.

5 Ecological assessment

5.1 Introduction

This section provides an assessment of the potential effects of development of the Tuakau SPA on surface water resources. This section:

- Outlines the types of stressors on surface water environments from urban development.
- Provides an assessment of the significance of these for each of the growth areas identified by WDC.
- Identifies areas of uncertainty, where further information may need to be gathered to more fully assess and understand these effects.
- Provides recommendations on measures to avoid or mitigate these adverse effects.

5.2 Effects of urban development on surface water resources

This section summarises the potential adverse effects of urban development on surface water resources within and downstream of the SPA.

5.2.1 Upper catchment land uses and effects on water quality

All three of the main streams passing through the SPA drain areas of agricultural and/or horticultural land use in upper catchment areas. These streams are influenced to varying degrees as a result of these land uses.

From the Waikato River to its headwaters, the Kairoa Stream is approximately 9.5km long with approximately 3.5km (37%) upstream of the SPA boundary.

From the Waikato River to its headwaters, the Tutaenui Stream is approximately 16.5km long with approximately 11km (67%) upstream of the SPA boundary.

From its confluence with the Tutaenui Stream, the Whakapipi Stream is approximately 12.5km long with approximately 8.2km (66%) upstream of the SPA boundary.

The management of urban stream reaches cannot be undertaken effectively without consideration of these influences on water and habitat quality, and in some instances the measures that may be carried out to manage potential adverse effects on water and habitat quality from urban development may not necessarily improve water and habitat quality.

5.2.2 Effects on water and sediment quality

Existing water quality issues for streams in the area and potential issues associated with development are described as follows:

- Physical and chemical water quality – Key potential stressors for aquatic fauna include water temperature, dissolved oxygen and water clarity. Elevated water temperature is a direct stressor to aquatic fauna as well as affecting dissolved oxygen concentrations. Water temperature elevations can occur as a result of loss of stream riparian cover and shade as well as introduction of sources of heat, such as on-line stormwater ponds, that discharge to streams. Decreased levels of dissolved oxygen and water clarity are stressful to aquatic organisms and reduce habitat quality. Reduced dissolved oxygen and water clarity conditions often occur as a result of organic pollution and reductions in base flows that are typically associated with urban development.
- Nutrients – Elevated concentrations of nitrogen and phosphorous contribute to excessive and nuisance growth of aquatic plants including algae and macrophytes, particularly where

little riparian shade is present and this reduces stream habitat quality. Urban stormwater runoff can contribute to nutrient concentrations in streams but the main source in the subject streams is likely to be the upper catchment agricultural land use.

- Stormwater contaminants – Typical contaminants include metals and hydrocarbons. These toxic substances can impact on in-stream biota and can accumulate in stream sediments potentially affecting sediment biota as well. Current practices in the management of stormwater can reduce impacts on receiving waters but existing developed catchments can be difficult to successfully retro-fit improvement measures and the receiving environments may already be compromised by historical land uses and land use practices. The existing contamination status of streams (in terms of water and sediment quality) in these areas is unknown.
- Urban development increases the chance of accidental spills of contaminants occurring. This is particularly the case for industrial areas where storage and transport of hazardous materials is concentrated and spills are more likely to occur. Development and associated expansion of the sewer network introduces a potential for overflow events to a wider range of aquatic receiving environments.

5.2.3 Effects on in-stream habitat quality

A range of habitat types are required to support diverse and healthy aquatic communities. Habitat quality is impacted by the water and sediment quality issues described above as well as physical habitat characteristics that can be modified and adversely affected as a result of urban development. Physical habitat issues for the streams of the area are described as follows:

- Reduction in habitat diversity – Streams in both rural and urban catchments can be affected by sedimentation that smothers stream beds, riparian vegetation removal that reduces bankside cover and woody debris input, and results in uniform flow conditions that affect the ability of plants and animals to become established in these reaches. These activities can collectively result in significant reduction and disruption of habitat and habitat diversity through loss or reduction of physical habitat and reduction in food sources and/or food source substrates.
- Exacerbation of nuisance aquatic plant growth – Excessive periphyton and macrophyte biomass is currently an issue in the catchment streams and reduces habitat quality for macroinvertebrates and fish.
- Introduction of aquatic pests – Aquatic plant and fish pest species area already present in the streams in the area. Fish pests such as Gambusia can displace native species and aquatic weeds such as the various oxygen weeds can clog streams, reduce habitat quality and are difficult to eradicate.
- Erosion and sedimentation – Stream bank erosion and the movement of sediment is a natural process, but acceleration of this process through earthworks in riparian margins, poor earthworks and construction practices, or the concentration of stormwater flows into streams can lead to a disproportionate sediment supply smothering existing substrates, stream channel instability, resulting in habitat loss or severe degradation of habitat quality. Sediment runoff from large urban developments is usually managed through resource consents. However, sediment loss from smaller developments can be also be significant and is often more difficult to manage as it may not be captured via a resource consent process.
- Removal of riparian vegetation – many of the streams in the study area lack vegetated riparian margins. Riparian margins provide a range of ecological services including filtering of contaminants, providing shade and temperature control in streams and providing habitat and food for aquatic and terrestrial fauna.

5.2.4 Habitat modification and loss

Ideally urban development planning works with the stream resources present, does not alter natural stream channels and allows for sufficient riparian buffers. However, in some cases modifications to streams cannot be avoided and diversion, piping and in some cases filling are required. In general these activities will require mitigation works to offset habitat modification or loss and this will apply to both intermittent and permanent reaches of streams.

5.2.5 Changes in hydrology

Increases in impervious surface area as a result of development and associate stormwater discharges and management can affect both base and peak flow conditions in streams.

- Decreases in base flows – increases in impervious area can reduce water infiltration to groundwater and subsequently the contribution to base flows in streams. This is particularly important in headwater areas or areas that have a high proportion of impervious cover and may impact on the amount of aquatic habitat available during dry conditions.
- Increases in peak flows – also occur with increasing impervious surface and can cause stream erosion.

5.2.6 Fish species, habitats and passage

The streams within the SPA retain some fish habitat values despite being characterised by generally reduced habitat quality.

In particular, inanga and longfin eel are present in all catchment streams and are classified as At Risk: Declining (Goodman, 2014). Development has the potential to impact on native fish and habitats in the short term during construction works and in the long term if in-stream structures form a barrier to their migration. Specific issues are as follows:

- Fish spawning habitat availability and quality – inanga spawning sites are potentially present in the lower reaches of the streams near the Waikato River. The quality of the spawning habitat will be affected by local land use as well as upstream influences on water quality.
- Barriers to fish passage and migration timing– many native fish species, including longfin eels and inanga, migrate between freshwater habitats and the sea as part of their lifecycle. Development that includes in-stream works and structures will need to consider the migration timing and requirements of fish present in the catchment.

5.3 Assessment of effects

The main ecological issues associated with future urban development in the Tuakau SPA are described below and the significance of proposed development to a range of issues for each growth area is presented in Table 3.

In determining the significance (high, medium and low) of effects, we have considered the general potential effects discussed above with respect to the types of land uses proposed by WDC with specific issues as outlined below.

Stormwater runoff from developed urban land will likely include elevated concentrations of total suspended solids (TSS), have on occasions elevated temperature, contain litter and have elevated concentrations of metals, hydrocarbons and nutrients (nitrogen and phosphorus). All of these have the potential to adversely affect water quality and place stresses on flora and fauna living in receiving waters. While runoff from residential land is considered to represent a low risk to water quality, stormwater runoff from industrial and commercial land represents a higher risk to water

quality. Also for these types of land uses, there is the potential for industrial site activities to result in spills of contaminants to the stormwater network.

The effects of urban development on stream base flows will depend on the nature of development (i.e. commercial and industrial development is more likely to require the formation of flat building platforms, resulting in the infilling of zero and first order stream channels than large lot rural developments) and location of the development within a stream's catchment. For the Tuakau SPA, many of the zero and first order streams are located to the east, and therefore this area is considered to be more vulnerable to effects of development on hydrological issues.

Urban development has the potential to adversely affect stream riparian margins through the removal of tall and woody vegetation, and/or regular herbicide spraying to reduce urban flooding risks, planting of species that provide limited shading or other habitat, or neglect leading to weed infestation. Urban development has the potential to adversely affect stream water temperature directly through removal of vegetation (often to reduce urban flooding risks) that provides shade or indirectly as stormwater runoff from impervious areas can also have elevated temperatures. These effects can be further exacerbated through the construction of stormwater treatment devices that provide for thermal gain and in particular the use of on-line ponds. Riparian planting can reduce potential adverse effects of elevated temperatures from stormwater discharges through shading of waterways. The land uses proposed by WDC within the SPA include significant open space areas which are often associated with water courses. These open spaces provide an opportunity for maintenance of existing or improved riparian planting to manage potential temperature effects. For the purposes of this assessment, we have assumed that some form of riparian management will take place within the open space areas and therefore the constraint to adjacent development is low.

For this assessment, we have assumed that:

- Open space and riparian margins will remain as shown within the SPA growth plans prepared by WDC.
- Planning, design and construction of new growth areas will occur in accordance with best practice guidance including riparian enhancement and the provision for fish passage.

Our assessment is based on fully developed urban areas, and does not take account of effects during construction (such as erosion and sedimentation).

For the growth areas where potential adverse effects on surface water bodies are medium to high in Table 3 some additional measures will be need to be implemented to mitigate these potential effects. These additional measures are set out in Section 9.3.

Table 3. Significance of potential adverse effects from proposed development

Growth Sector Issue	A - Large lot and stage 1 low density residential	B - Large lot and stage 1 low density residential	C - Stage 2 large lot	D - Heavy industrial	E - Light industrial	F - Commercial, medium density residential, low density residential, light industrial	G - Stage 3 low density residential	H - Low density residential	I - Commercial, stage 2 large lot, open space	J- Existing urban (assumed in-filled)	K – Existing rural (assumed future large lot)
Stormwater											
Contaminants[1]	Low	Low	Low	High	High	Low to Medium	Low	Low	Low to Medium	Low	Low
Increase in peak flows leading to stream bed/bank erosion	Low	Low	Low	High	High	Low to Medium	Low	Low	Low to Medium	Low	Low
Hydrological											
Reductions in base flow[2]	Low	Low	Low	High	High	Low	Low to Medium	Medium	Low to Medium	Low	Low
Reduction in flow variability leading to reduced habitat quality	Low	Low to Medium	Low	High	High	Medium	Medium	Medium	Low to Medium	Medium	Low

Growth Sector Issue	A - Large lot and stage 1 low density residential	B - Large lot and stage 1 low density residential	C - Stage 2 large lot	D - Heavy industrial	E - Light industrial	F - Commercial, medium density residential, low density residential, light industrial	G - Stage 3 low density residential	H - Low density residential	I - Commercial, stage 2 large lot, open space	J- Existing urban (assumed in-filled)	K – Existing rural (assumed future large lot)
Habitat											
Culverting or infilling of perennial streams reducing habitat	Low	Low to Medium	Medium	High	High	Low	Medium	Medium to High	Low to Medium	Low	Low
Protection of riparian margins[3]	Low to medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Barriers to fish movement	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Overall potential adverse effect on surface water	Low	Low	Low	High	High	Medium	Low	Low	Medium	Low	Low

5.4 Information gaps

Through our review of available information and our assessment of issues and constraints, we have identified the following information gaps.

- **Site specific ecological information on small unnamed tributaries** – several unnamed tributaries of the Waikato River and two small streams to the south of Tuakau have not been assessed due to access restrictions and examination of these areas were outside of the scope of these investigations. Site walkover of all stream and tributaries is required to gain a comprehensive understanding of the issues. This is particularly important in the east of the SPA where industrial land use is planned.
- **Comprehensive fish passage information** – At present the diversity of native fish in the upper catchment sites is low but it is not clear if this is due to poor water and habitat quality or the presence of existing barriers downstream. A comprehensive fish passage assessment would be required and could be undertaken in conjunction with stream walkovers.
- **Base flow information** – No data on the hydrological regime of streams within the SPA has been found. This information is required to set appropriate minimum flow conditions that are necessary to sustain aquatic ecosystems.
- **Water quality information** – water quality information for catchment streams is currently limited comprising spot measurements using field meters only. There is no information on the nutrient status of the streams, although agricultural land use is indicated to be the likely cause of nuisance aquatic plant growth. There is also no baseline information on suspended solids, turbidity or typical stormwater contaminants such as heavy metals and polycyclic aromatic hydrocarbons (PAHs).
- **Existing stream contamination status** – We have not found any sediment sampling and analysis data for the SPA streams and this is required to clarify issues and establish baseline conditions. This is particularly important for infill areas and expansion of industrial areas, where stream values may be compromised from previous land uses.

Development will likely require resource consent(s) from WRC. Both WRC and WDC will likely want to ensure that the effects of any land use changes are monitored. For some areas this will require data gathering to provide a baseline from which changes can be measured and assessed. This could include gathering data on base flows and water and sediment quality.

6 Flood modelling

6.1 Introduction

A Rapid Flood Hazard Assessment (RFHA) has been undertaken. The purpose of a RFHA is to determine the areas which would be inundated if no pipe network is available. An RFHA is a valuable tool to provide an indication of where flooding hazards may occur and where future modelling efforts should be concentrated. An RFHA provides a conservative estimate of flooding as it assumes that the reticulated network (pipes, culverts and catchpits) are blocked. It defines the level of worst risk of property flooding issues within the catchment (Auckland Council, 2011)

The RFHA methodology adopted is generally in accordance with Auckland Council's Stormwater Flood Modelling Specification (SFMS) Version 4, November 2011.

6.2 Methodology

6.2.1 Model bathymetry

6.2.1.1 Digital elevation model (DEM)

A digital elevation model (DEM) for the Tuakau region extending as far north as South Pukekohe was developed by T&T based on LiDAR data.

LiDAR was provided by WDC and Auckland Council (AC). Approximately 90% of the model extent has utilised WDC LiDAR with the remaining area (north western extent around Pukekohe South) supplied by AC.

The WDC Northern Waikato LiDAR data was collected between 3rd October 2010 and 30th June 2011. Vertical accuracy for all point and grid data is within 0.15m RMS at 68% confidence relative to Moturiki 1953 and NZVD2009 datum. Horizontal accuracy is within 0.5 metre RMS (at 68% confidence). Accuracy estimates for terrain modelling refer to the terrain definition on clear ground. Ground definition in vegetated terrain may contain localised areas with systematic errors or outliers which fall outside of this accuracy estimate

The source of the Auckland Council LiDAR data originated from 2010 LiDAR survey that was carried out to an urban specification (as opposed to rural). The accuracy for the urban LiDAR is +/- 0.25m @ 95% confidence. It is noted by AC that not all areas meet this specification and LiDAR is known to be less accurate in areas covered by dense vegetation. The horizontal accuracy was not specified in the LiDAR metadata but is expected to be around +/-0.3m (Auckland Council, per communication GIS team 4 April, 2012). Auckland Council used the LiDAR data to create a DTM (Digital Terrain Model), and then smoothed with 0.5m contours (with non-ground features removed) to define the DEM. Non ground features includes buildings, vegetation and water bodies were removed from the DEM. Despite non ground features being removed from the DEM, the method of interpolating ground levels beneath the non-ground features can significantly affect the topographic representation. We understand that LiDAR of the area was re-flown in 2013 and may be available for future assessments.

A DEM with a grid size of 2m x 2m and 5m x 5m was generated for the Rapid Flood Hazard Assessment.

6.2.2 Catchment boundary

The initial catchment boundary was adopted based on REC (NIWA, 2004) database 1st Order catchments.

The 2m x 2m DEM was used to create ponding and overland flow paths and the catchment reviewed.

We have used a GIS tool to infill and map all topographic depressions based on the LiDAR survey provided. The mapped depressions represent all areas where stormwater could *potentially* pond. A key issue here is that the mapping does not allow for culverts or other sub-surface drainage features which could convey stormwater and reduce or eliminate ponding. Overall the largest ponding areas are generally associated with road and rail embankments and bridges.

The catchment boundary was then modified to encompass areas where overland flow paths were observed outside the REC catchment extent. The modified catchment boundary (indicative only) is shown in Figure 5 below.

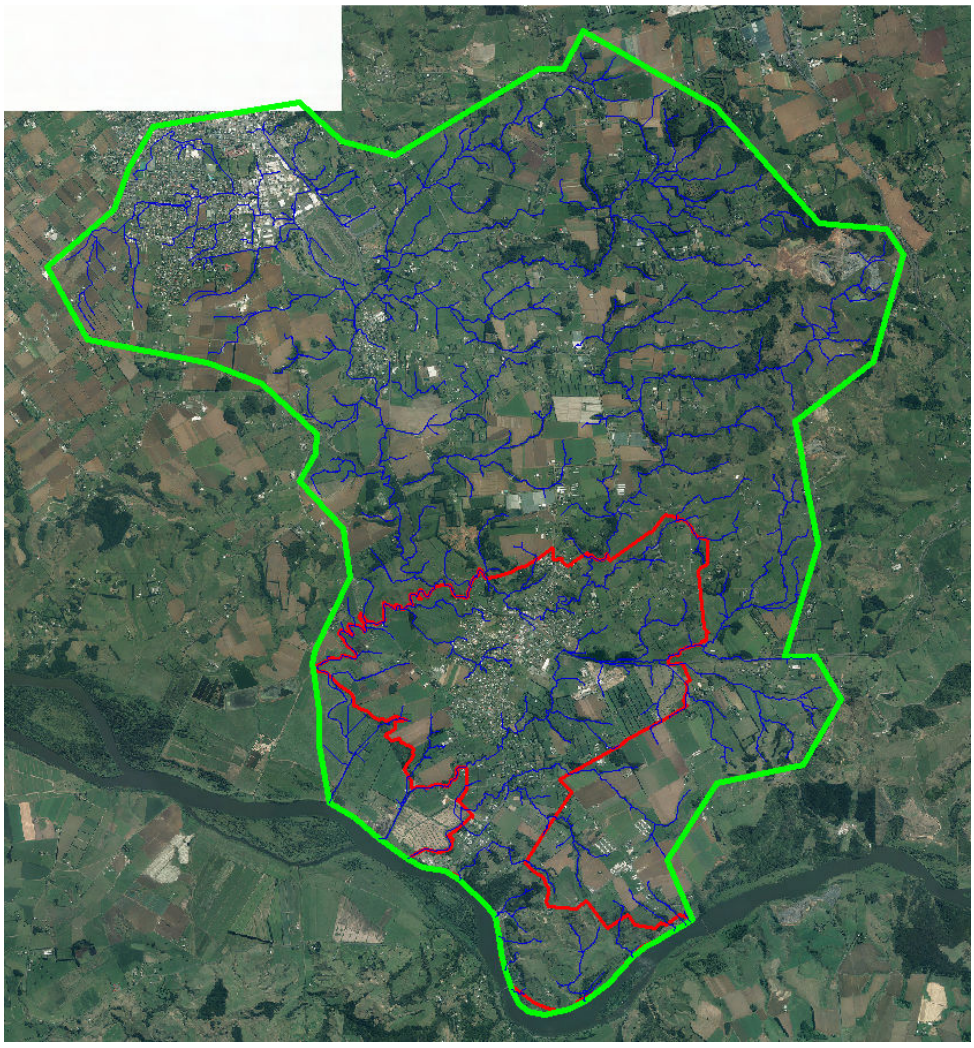


Figure 5. Indicative catchment boundary

The extent of the hydrological model is larger than the catchment boundary. It is noted that the RFHA model results indicate that a small pocket of flooding may extend outside the model extent in the north western sector but this is not considered to be significant at this stage.

6.2.2.1 Waterway and reticulated assets

WDC did not provide any information on any bridges or significant culverts within the catchment.

Some stormwater reticulation data was provided but in general layout information only was provided and infrastructure elements such as pipe sizes, lengths, and invert levels were generally not provided. It is also noted that road culverts were generally not shown on the stormwater asset layer provided and we understand that culvert information may be available on WDC's RAMM database but these were not available at the time of this assessment.

6.2.2.2 Buildings

WDC provided building footprints within the Waikato but no information on any floor levels.

Building footprints within the Auckland City part of the catchment (extreme north) were not available.

6.2.3 Drainage operational issues

No drainage issues or flood reports were noted or provided by WDC.

6.2.4 Model & parameters

TuFLOW (flood and coastal simulation software) was used to undertake the RFHA.

TuFLOW is a powerful computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions of the free-surface flow equations to simulate flood propagation.

Key model parameters were as follows:

- The grid size initially used was 2m x 2m but was subsequently increased to 5m x 5m to enable data processing.
- A time step of 0.2 sec was set however TuFLOW uses as adaptive time step function to adopt the best time step during the simulation run.
- Eddy viscosity was calculated based on 0.02 $dx^2/dt = 0.4$.
- A constant Manning's roughness coefficient of 0.050 was used except for buildings and roads. Buildings were represented by high roughness (Manning's n= 0.300) with roads represented by low roughness (Manning's n= 0.014).
- No structures (culverts and bridges) were represented in this model.
- No hydrological losses were applied in this model.

6.2.5 Initial conditions

The initial conditions for the RFHA model were developed based on ponding areas in the DEM. The ponding areas were identified from all depressions in the DEM which were filled to create the initial condition (water depth) i.e. all topographic depressions including those created by road embankments etc were filled with water prior to rainfall being applied.

6.2.6 Boundary conditions

The 24 hour rainfall depth for a 1% AEP design storm was obtained using NIWA's HIRDSv3 online rainfall inventory based on the approximate centroid of the catchment. To incorporate climate change, the rainfall depth was then increased by applying a 3 degree Celsius temperature increase within the HIRDSv3 inventory. An increase of 3 degree Celsius has been adopted in accordance with unpublished guidance from WRC. The climate change adjust 24 hour rainfall depth used was 246mm.

The rainfall distribution was developed using the embedded storm hyetograph method, which was developed using the Intensity-Duration-Frequency (IDF) curve from HIRDSv3 up to 24

hours. The embedded storm hyetograph method is sometimes known as the Chicago method and is based on the work of (Keifer, (1957). For the purposes of this study the time of peak rainfall to rainfall duration ratio was assumed to be 0.5.

A downstream boundary condition was determined from the 1% AEP (no climate change) flood levels in the Waikato River provided by WRC. A single water level of 3.8mRL within the Waikato River (at cross section ID Waikato_121427) was taken as the downstream boundary condition. This cross section is approximately halfway between the outlets of the Kairoa and Tutaenui Streams. It is noted that the 1% AEP (no climate change) flood levels in the Waikato River provided by WRC vary from approximately 4.5mRL in the extreme east of the SPA to approximately 3.6mRL in the extreme west of the SPA.

6.3 Results and discussions

6.3.1 Model review

The model and results have been reviewed by a Senior Modeller. Mass balance checks were carried out. The mass balance continuity error is approximately 1% which is considered acceptable for flood modelling purposes.

It is noted that the model results are not considered appropriate at the downstream model boundary (Waikato River) as the results are affected by the Waikato River flood levels. The Waikato River flood extent plotted on the Flood Maps presented in Appendix A are considered more appropriate in this area. As such the RFHA results have been cropped where they intersect with the interpolated Waikato River flood extent.

6.3.2 Post processing of model results

TuFLOW results files were processed, reviewed and plotted using WaterRide software.

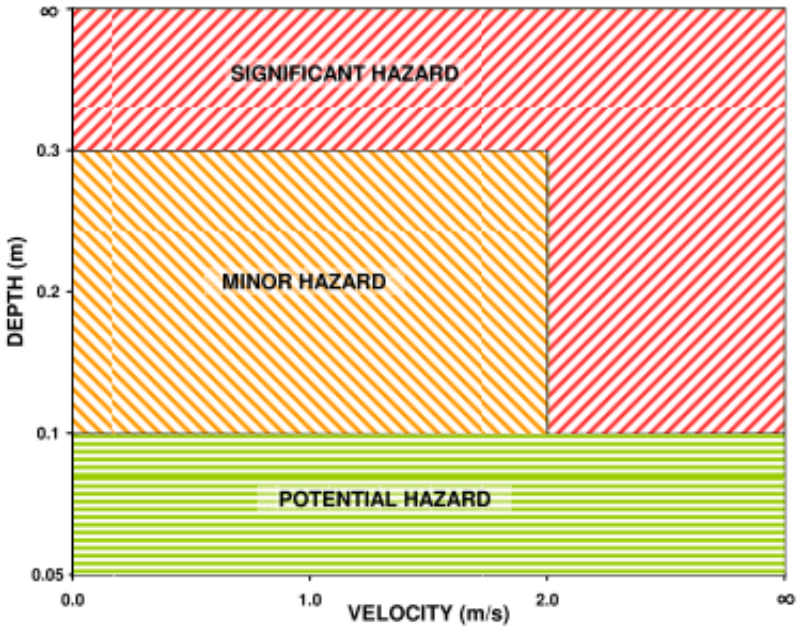
Results files for the 2m x 2m grid were unable to be opened within WaterRide due to the very large file size so the model was re-run using a 5m x 5m grid size. The 5m x 5m grid size was able to be processed using WaterRide. Model outputs calculated using the 5m x 5m grid have been projected onto a 2.5m x 2.5m grid resolution for plotting purposes.

The flood extent plots using 2m x 2m and 5m x 5m model grids were compared and no significant differences were noted.

Flood hazard has been categorised in accordance with the methodology set out in AC (SFMS), 2011. Table 7.5 and Figure 8 from the SFMS summarising the categorisation methodology has been reproduced below.

Table7.5 Flood Hazard Classification Category

Hazard Classification	Description	Depth – Velocity Criteria
1	Potential Hazard	0.05 m < Depth < 0.1 m
2	Minor Hazard	0.1 m ≤ Depth < 0.3 m and Velocity < 2.0 m/s
3	Significant Hazard	Depth ≥ 0.3 m and Depth ≥ 0.1 m & Velocity ≥ 2.0 m/s



Flood hazard plots using the 5m x 5m model grid results were generated from model results and are shown in Figures 102 to 105 in Appendix A.

Building footprints supplied by WDC are shown on the Flood Maps presented in Appendix A. Where a flood hazard layer encroaches on a building footprint we consider that the buildings are potentially flood prone, however building floor levels are unknown and therefore the number of buildings actually affected by flooding cannot be determined.

Additionally, we would expect modelled flood levels to be reduced after detailed flood modelling and therefore the number of flood prone buildings may be overestimated.

7 Flooding assessment

This section presents the results of our review and flooding assessment of the Tuakau SPA. The assessment is based on a review of existing studies as well as results from a Rapid Flood Hazard Assessment (RFHA) model and a brief site walkover of selected parts of the SPA.

7.1 Assessment methods

7.1.1 Existing documentation

Two previous reports (H&G 2009 and GHD 2006) have been undertaken for areas within the Tuakau Township to support development and expansion of the town. Our assessment has reviewed the information contained in these documents.

The H&G CMP was produced specifically for the Tuakau Township and included modelling of the urban stormwater network.

The GHD report focuses specifically on the Whangarata business development area, which is "approximately 110 hectares and comprises 18 parcels of land" across Growth Sectors D and E.

Waikato River 1D flood model (MIKE 11) cross sections including 1% AEP flood levels from the Karapiro Dam to Port Waikato have also been used to inform this assessment.

Our assessment reviews the conclusions made in these documents.

7.1.2 RFHA

A RFHA was undertaken for the Tuakau SPA for a 1% AEP (plus climate change) storm event to map flood hazard. The results from the RFHA are presented in Figures 102 to 105 in Appendix A.

The RFHA results have been cropped to the SPA boundary where they intersect with the interpolated Waikato River flood extent.

Insufficient asset data has been provided to allow a review of identified critical culverts but the 2009 CMP (HG, 2009) included a 1D hydraulic model over a limited extent which has been used to compare the RFHA results.

The RFHA model has used an embedded storm hyetograph method (sometimes known as the Chicago method) with a climate change adjusted 24 hour rainfall depth of 246mm.

The HG Mike Urban Model has used the TP108 (Auckland Regional Council, 1999) method with a climate change adjusted 24 hour rainfall depth of 281mm

The difference in rainfall depth and temporal patterns limits the direct comparison of the results of the two models. Notwithstanding we have considered the general conclusions of the HG report with regard to infrastructure capacity issues.

7.2 Summary of existing information

7.2.1 Tuakau catchment management plan, HG 2009

Catchment areas for the HG CMP hydraulic modelling were decided based on a "1999 Stormwater Management Plan, LiDAR contour data, data collected from site walkovers and aerial photography." (HG Ltd, 2009). The catchment area used was measured to be 2,600 hectares, which included the town of Tuakau, and upstream catchments of the Whakapipi and Kairoa Streams.

Future residential areas were assumed to be 70% impervious.

Rainfall data was taken from TP 108 (Auckland Regional Council, 1999). The 1% AEP rainfall was increased by 28% to account for the potential effects of climate change to give a 24 hour rainfall depth of 281mm.

Hydrologic modelling of the catchment areas was undertaken using HEC-HMS modelling software, as well as Mike Urban hydraulic software to model the watercourses and determine the floodplains.

From the modelling, "existing hydraulics restrictions within the main channels" were identified and included:

- Geraghtys Road ford – twin 600 mm diameter pipes with a weir at road crest level.
- Bollard Road culvert – Irregular culvert section.
- George Street Culvert/State Highway 22 – Irregular culvert section.
- Harrisville Road culvert – 6 m wide by 2.8 m deep box section.
- George Street/River Road culvert – 900 mm diameter pipe.
- Various culverts on the Gibson Road watercourse.

From the above, it was confirmed through hydraulic modelling, that the following infrastructure "does not have the capacity to convey the 100 year [1% AEP] flow and could impact upon upstream flood levels":

- Geraghtys Road ford.
- George Street/River Road culvert.

Upgrade options/recommendations have been provided in the HG report to accommodate the estimated flood flows including:

- To upgrade Geraghtys Road ford. HG have recommended a 3.6 m wide by 3.6 m deep box culvert with headwalls at entrance and exit points.
- To upgrade the George Street/River Road culvert. HG have recommended a 3.0 m wide by 2.0 m deep box culvert with headwalls at entrance and exit points.

The HG report also highlighted a number of properties at risk of flooding, if the finished floor level was to be constructed at ground level. HG has outlined the properties as:

- Numbers 5E and 5D Dominion Road, including possible marooning by flood waters covering the right of way.
- Number 3 Dominion Road, towards the rear of the site. Development to the front of the lot would be removed from the floodplain.
- Land in the proposed business zone immediately to the north of Bollard Road and Tuakau Salesyard Road junction.
- Numbers 197, 195B, 191C and 193 George Street.
- Number 3 Cole Street, access to George Street is likely to be affected.

The report has stated that "most of the above properties are located on the edges of the floodplain and therefore the depth of flooding is likely to be shallow and develop over a relatively long period of time allowing for safe egress if required".

HG have proposed stormwater ponds for larger catchments to provide attenuation of the 34.5 mm storm event. It is known that there are existing ponds in Tuakau, some of which are natural and some of which are manmade. For smaller catchments, HG have highlighted the possibility of "using proprietary devices to treat runoff."

7.2.2 Engineering assessment of proposed business land, GHD 2006.

The site studied in the GHD report covered approximately 110 ha and 18 parcels of land and is show in Figure 6. The development areas includes T&T Growth Sectors D (east of Bollard Road) and E (west of Bollard Road).

Figure 6. Business development area - Whangarata. (GHD Ltd, 2006)

The report highlighted unnamed streams which run through the site that would need to be considered in future development. Generally, bridges or large culverts were proposed to overcome any problems involved in developing around these streams. To the east, an option "to divert the stream along the eastern boundary of the development area" was considered.

Limited information was available about the history of flooding and the capacity of the existing watercourses but after discussion with Franklin District Council (FDC), GHD determined that "From the information obtained, there are a number of constrictions imposed by bridges or crossing and one road crossing by means of a ford. No serious issues were reported and provided that detention is used to restrict stormwater run-off at or below current levels then the downstream conditions should not restrict development."

The report goes on to discuss potential stormwater management devices for post-development run-off, including rain gardens, sand filters, swales, porous pavement, ponds, and wetlands etc.

7.2.3 Waikato River flooding, 2009.

T&T has liaised with WRC to obtain flood model data for the Waikato River. Waikato River 1D flood model (MIKE 11) cross sections including 1% AEP (with no climate change) flood levels from the Karapiro Dam to Port Waikato were available.

The WRC cross sections indicate that river flood levels vary from approximately 4.5m RL at the SPA's eastern boundary to approximately 3.6m RL at the SPA's western boundary which is set some way back from the normal river edge.

1D water levels have been interpolated using 0.5m LiDAR contours to estimate the extent of river flooding across the southern extent of the SPA. The interpolated 1% AEP river flood extent (with no allowance for climate change) has been presented in Figures 102 to 105 in Appendix A.

The southern boundary of Growth Sector K is affected by the interpolated Waikato River Flood levels but the WDC growth plan does not indicate any planned growth in this area. There are some small, insignificant areas in the south of Growth Sectors G and I that are also affected.

7.2.3.1 Infrastructure

Table 4**Error! Reference source not found.** below summarises the existing critical infrastructure within the Tuakau SPA which is considered a potential restriction on the flow of major overland flow paths, watercourses or streams. Refer to Figure 102 to 105 in Appendix A which shows the locations of these restrictions. The RFHA model was used to determine which infrastructure assets were considered 'restrictions'. Generally, the constrictions identified in the HG report are all consistent with those found in the most recent RFHA model (where the model extents were coincident). WDC have provided stormwater asset details but unfortunately this did not include the majority of culverts and bridges identified herein as constrictions.

Table 4. Summary of critical infrastructure

Infrastructure ID	Length (m)	Diameter (m)	IL's – US/DS	Identified in HG report?	Capacity check in HG report?
cTUA100	Nil	Nil	Nil	No	No
cTUA101	Nil	Nil	Nil	No	NO
cTUA102	Nil	0.9	Nil	George Street/River Road Culvert	Under capacity
cTUA103	Nil	Nil	Nil	No	No
cTUA104	Nil	Nil	Nil	No	No
cTUA105	Nil	Nil	Nil	No	No
cTUA106	Nil	Nil	Nil	No	No
cTUA107	Nil	Nil	Nil	Bollard Road	OK
cTUA108	Nil	Nil	Nil	Gibson Road	OK
cTUA109	Nil	Nil	Nil	Gibson Road	OK
cTUA110	Nil	Nil	Nil	George Street	OK
cTUA111	Nil	0.6m twin culverts	Nil	Geraghtys Road culvert/ford	Under capacity
cTUA112	Nil	6m wide by 2.8m deep	Nil	Harrisville Road culvert (bridge)	OK
cTUA113	Nil	Nil	Nil	No	No

7.2.3.2 Properties effected by flooding

HG have indicated a number of properties at risk of flooding, which are all generally consistent with what is seen in this study. However, more extensive flooding is shown in the RFHA model, covering a larger range of properties that may be effected by the 1% AEP storm event.

7.2.4 Flood issues by growth sector

For each growth area WDC has provided proposed land parcels with a specific attribute values including an ID (i.e. PLID_xxxx) and these ID's have been used for reporting purposes.

7.2.4.1 Growth Sector A

The Whakapipi Stream and Tutaenui Stream generally define the northeast and western borders respectively of the Tuakau SPA within Growth Sector A. As these streams are prone to flooding, these areas will need to be managed accordingly or the border of the SPA may need to be altered.

There is significant flooding within the open space areas in Growth Sector A. This is particularly prominent along the two streams and the tributaries draining Growth Sector A. As these are areas are generally designated as open spaces, flooding is not seen as a significant constraint to the proposed growth.

The proposed large lots in the north of Growth Sector A (PLID_581 on 32 Ryder Road and PLID_582 north of Johnson Street) also appear to have significant flooding that may constrain growth as planned.

Within the proposed low density residential area to the west of Growth Sector A (PLID_358), the two major tributaries have been provisioned with an open space land use and therefore there is no real constraint to the proposed growth. However there appears to be overland flow paths and flood plain issues between these two tributaries (west of 63 Jellicoe Street) that would constrain full development of the area.

Key waterway structures in this area include a culvert (cTUA104) under the NMTL railway and two bridges (cTUA112 and cTUA113 on Harrisville Road and Buckland Roads respectively. These structures may cause flooding problems if they are undersized, or if they become blocked.

7.2.4.2 Growth Sector B

Generally, the open space areas within Growth Sector B tend to follow the Whakapipi Stream and the Kairoa Stream running through the area.

The RFHA model shows that the Whakapipi Stream floods and then encroaches into the low density residential area (PLID_616) over 29 Dominion Road and near Whakapipi Way and Westland Road.

Culvert cTUA105 under the NMTL rail line on the Kairoa Stream is a potential significant cause of flooding if blocked or if it has inadequate flow capacity. However, the majority of flood hazard area upstream of this culvert is within proposed open space land use and therefore does not pose a significant constraint to development.

Feature cTUA105 also appears to influence an overland flow path to the Kairoa Stream in the south of Growth Sector B between the NMTL and Dominion Road. Flood hazard associated with this overland flow path may constrain low density residential (PLID_614) and large lot (PLID_611) development as planned.

7.2.4.3 Growth Sector C

Growth Sector C appears to contain flooding predominantly in open space areas and is therefore not considered a significant constraint to the proposed growth.

There is some flooding in the large lot areas to the north east (PLID_620 around 221 and 241 Dominion Road). This appears to be because of an overland flow path feeding the stream to the north. This land type may have to be rezoned as 'open space' instead of ‘large lot’ or other remedial measures considered to avoid this potential flooding hazard.

There is some land to the east of Growth Sector C, which is classified as a large lot, but appears to be outside of the SPA. There is also some designated open space areas outside of the SPA. This open space has flow paths running through it and feeding the Kairoa Stream. The SPA needs be

adjusted to account for these additional areas, or alternatively not included in the future staging proposals.

7.2.4.4 Growth Sector D

Growth Sector D contains mainly proposed heavy industrial areas. There are existing stormwater ponds in this area.

The main area of flooding is to the east of Growth Sector D (PLID_609 around 235 Whangarata Road) with a minor area in PLID_376 where there is a tributary feeding into the Kairoa Stream. The flooding in this area and the eastern part of Growth Sector D will be controlled in large part by the capacity of the culvert (cTUA106) underneath the NMTL rail. An assessment of the capacity and structural integrity of this culvert would be warranted prior to development of this area.

7.2.4.5 Growth Sector E

The Kairoa Stream runs along the western boundary of Growth Sector E. The modelled flood extent appears to be mostly contained within designated open space areas. However the open space areas may need to be altered slightly too fully encompass the modelled flood extent.

To the north of Growth Sector E, there is an existing culvert (cTUA107), conveying the Kairoa Stream underneath Bollard Road. Because of this culvert, the RFHA model has picked up some flooding in the area upstream. This extent of flooding only effects land classified as 'open space'.

7.2.4.6 Growth Sector F

The RFHA model is predicting significant flood hazard areas in the north of Growth Sector F, particularly in PLID_561 north of the NMTL railway over 2 Dominion Road and PLID_559 south of the NMTL over 10 and 12 Liverpool Street.

There also appears to be culverts under Gibson Road (cTUA108 & cTUA109), which result in some potential and minor flooding hazards along the western boundary of Growth Sector F extending north to Jellicoe Avenue and West Street.

7.2.4.7 Growth Sector G

Flood hazard associated with the Tutaenui Stream and to a lesser extent the Kairoa Stream and their tributaries effect the potential for development in Growth Sector G. However the majority of significant flood hazard areas are within proposed open space areas. As such flooding is not considered to pose a significant constraint to proposed growth.

There is some flooding from the Tutaenui Stream in the northwest of Growth Sector G which effects a proposed low density residential area (PLID_608). This may require the SPA or open space designations to be altered to account for this flooding hazard.

7.2.4.8 Growth Sector H

Flood hazard associated with the Kairoa Stream and an unnamed tributary of the Waikato River which runs parallel to the southern boundary of Growth Sector H) potentially effect development within the area.

Along the Kairoa Stream, it appears that culverts cTUA110 and cTUA111 under George Street and Geraghtys Road respectively are potential flood flow restrictions. These culverts need to be checked for capacity. As discussed in Section 7.2.1, HG have also indicated that cTUA111 appears to be under capacity.

Significant flood hazard potentially effects development on the south side of the Kairoa Stream north of Coles Road and east (upstream) of George Street and in particular proposed low density residential development in PLID_452, 453, 489 and 497.

Along the unnamed tributary of the Waikato River, it appears that culvert cTUA102 under George Street is a potential flood flow restriction.

Significant flood hazard potentially effects development either side of the unnamed tributary north of Whangarata Road and east (upstream) of George Street and in particular proposed low density residential development in PLID_491, 498, 505 and 506. The HG report has not identified this culvert as being under capacity, but given the potential extent of flooding, confirmation of its capacity is warranted.

Much of the remaining estimated flood hazard is contained within proposed open space areas.

7.2.4.9 Growth Sector I

Growth Sector I contains various proposed land uses which may be affected by flooding, including open space, low density residential, large lo', heavy industrial and commercial.

There is significant flood hazard associated with an unnamed tributary of the Waikato River and a culvert under River Road (cTUA101) in the north of Growth Sector I which may effect low density residential development in PLID_507, 508 and 511.

There is significant flood hazard associated with an unnamed tributary of the Waikato River and a culvert under River Road (cTUA100) in the southwest of Growth Sector I which may effect large lot development in PLID_566 and low density residential development in PLID_569.

Culverts cTUA100 and cTUA101 will need to be further investigated prior to development to ensure that it will have sufficient capacity to adequately manage flood flows.

7.2.4.10 Growth Sector J

The RFHA model is predicting some areas of flooding associated with overland flow paths draining to the Whakapipi Stream. These areas are west of George Street between Elizabeth Street and Jellicoe Avenue. The model shows that if the local drainage network is blocked or under capacity, flood flows may effect some of the existing properties in the area.

To the north of Growth Sector J, there appears to be significant flood hazard which will effect a broad area north of the NMTL railway, particularly west of Johnson Street and Oak Street.

The Harrisville Road bridge (cTUA112) over the Whakapipi Stream is a significant waterway feature and would cause significant flood hazard west of Harrisville Road and north of the NMTL if it is blocked or under capacity.

The RFHA model is also predicting potential flood hazard in the vicinity of Cherry Grove, Martindale Lane and McGowan Rise.

7.2.4.11 Growth Sector K

No new land uses have been proposed in this Growth Area.

Flood hazard in this area is associated with a number of unnamed tributaries of the Waikato River and from the Waikato River itself.

7.3 Summary of flooding issues

This section provides an assessment of the potential effects of flooding on the Tuakau SPA. The assessment includes an evaluation of flood hazards on existing and potential future residential development, and on the capacity of infrastructure critical to managing flood hazard within the SPA.

A summary evaluation of the issues is presented in Table 5.

In this table we have made the following assumptions on the constraint that flooding might pose to development in each growth sector:

- A potential flood hazard as identified in the RFHA can be managed via the building consent process to avoid ingress of surface water into buildings and this is considered a low constraint to growth.
- A minor flood hazard represents a medium constraint to growth, because this hazard may able to be managed under certain land uses, such as large lot developments where building platforms, access and egress locations can be identified and located away from these hazard areas. However, the ability to manage this hazard is reduced for higher density land uses, where the ability of configure a development to avoid this hazard is reduced. For residential land uses this represents a medium constraint to growth. For commercial and industrial land uses this hazard represents a medium to high constraint to growth as development of this nature may need to rely on significant earthworks and reticulated drainage to manage this hazard, and this in turn may result in exacerbating downstream flooding effects.
- A significant flood hazard as identified in the RFHA can only be managed by way of avoiding development within these areas or upgrading drainage infrastructure. In the context of this assessment, this is regarded as a high constraint to growth as it will likely control the location of development and built form within each growth sector and development yield that can be sustainably achieved within each area. It may also restrict the function of reserve land/open space identified alongside watercourses, due to the hazard it may pose to reserve users. The provisions for open space should be reviewed with regard to the estimated flood hazard and growth in significant hazard areas may need to be managed in the future.
- Medium and high constraints to development would probably need to be managed through land use policies, and/or rules in the District Plan, or modifications to the Development Manual.
- For critical infrastructure, those structures that are unable to pass the 1% AEP (peak flow) without heading up to above road crown level would likely pose a significant constraint to development.

Table 5. Summary of flooding issues

Flooding Assessment	Growth Sector A - Large lot and stage 1 low density residential	Growth Sector B - Large lot and stage 1 low density residential	Growth Sector C - Stage 2 large lot	Growth Sector D - Heavy industrial	Growth Sector E - Light industrial	Growth Sector F - Commercial, medium density residential, low density residential, light industrial	Growth Sector G - Stage 3 low density residential	Growth Sector H - Low density residential	Growth Sector I - Commercial, stage 2 large lot, open space	Growth Sector J – Existing Urban	Growth Sector K – Existing Rural
Existing buildings within significant flood hazard?	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Growth parcels with significant flood hazard (PLID_xxx)	358, 581, 582	611, 614, 616	620	609, 376	nil	561, 569	608	452, 453, 489, 497, 491, 498, 505, 506	507, 508, 511, 566, 599	nil	nil
Existing critical infrastructure	cTUA104 cTUA113	cTUA105 cTUA112	cTUA105	cTUA105 cTUA106	cTUA107 cTUA110	cTUA108 cTUA109	None	cTUA102 cTUA110 cTUA111	cTUA100 cTUA101	cTUA108 cTUA109	None
Overall constraint[1]	Low	Medium	Low	Medium to High	Low	Low	Low	Medium to High	Medium	Low	Low

1. Based on area covered by minor and significant flood hazards, and ability of the land use type to avoid or mitigate the adverse effects of flood hazards on the built environment.

7.4 Information gaps

Through our review of available information and our assessment of issues and constraints we have identified the following information gaps:

- Information about existing culvert levels, diameters, lengths and materials. This information would be useful in verifying the capacity of existing culverts that are of concern and is essential for more detailed modelling efforts. We note that WDC could request that HG supply the 2009 Mike Urban model (or at minimum the asset data bases) and this could be used to inform/update WDC's own asset data base.
- Similar to above, information on bridge waterway dimensions is required for more detailed modelling efforts.
- Existing building floor levels to clarify potential flood vulnerability.
- More detailed information on future growth areas including road layout and waterway crossings.

8 Constraints to growth

In terms of fresh water ecology and flood hazard, the most significant constraint to growth is generally limited to the modelled flood plain and riparian margins of the Whakapipi, Kairoa and Tutaenui Streams and their tributaries. For these streams and tributaries, the estimated flood hazard category is generally 'significant' with either deep or fast flowing flood waters. Development of land subject to this degree of hazard would need to be avoided and in the most part can been achieved through the identification of open space areas.

These streams are also the main ecological corridors within the catchment and although somewhat degraded already, development within their catchments would need to consider protecting and/or enhancing these natural features, whilst avoiding further degradation as a result of development.

Outside of these areas, there are localised constraints to growth as a result of potential flood hazards. These are most significant in Growth Sectors B, D, H & I where overall there are medium to high constraints to development. In terms of ecological constraints to development Growth Sectors D, E pose a high constraint to development and Sectors F and I present a medium constraint to development.

Significant Natural Feature 29 – Alexandra Redoubt Bush is an important natural feature and is considered a significant constraint to growth in Growth Sectors I and K.

Growth Sector D (Heavy Industrial) is partially developed already but represent the highest overall constraint to develop from both a flood hazard and ecological effects perspective. This area includes stream tributaries headwaters which are likely to be sensitive to changes in water quality as a result of runoff, reduced base flows and changes in flow variability. This catchment is at greater risk of contamination from spills which may occur on industrial sites from time to time.

8.1 Mitigation

Flood hazard risk to growth areas has already been addressed in many areas by the inclusion of open space zones around streams and tributaries but the extent of the open space zones should be reviewed in light of this or future flood modelling efforts.

Similarly the key ecological mitigation for freshwater streams is the inclusion of riparian buffers (open space zones around streams and tributaries). Ideally the riparian margins should be planted (to improve riparian habitat and provide shading) with maintained open space areas being set back from the streams.

Approaches to stormwater quantity and quality management to mitigate the effects of the proposed growth are contained in Section 9.

9 Stormwater management

9.1 Resource consent requirements

Waikato District Council holds (from the former Franklin District Council) Resource Consent No. 105051, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with the existing urban area of Tuakau. The CSDC has a number of conditions and in effect sets out the stormwater management measures that should be considered and/or adopted for all (existing and new) council stormwater infrastructure (including pipes and open drains) to avoid or mitigate adverse effects on surface water resources.

It is expected that for all new urban development, individual resource consents to divert and discharge water will be required.

A range of consents will normally be needed to facilitate construction of any urban development (earthworks, temporary stormwater diversion and the discharge of stormwater from earth worked areas), and consideration of these consents is outside the scope of this report.

Other consents will be required following construction to allow for the ongoing diversion and discharge of stormwater to land and water, and for the placement of structures on or over water bodies. In this instance the consent applicant would normally be the land developer but may on occasions it may be WDC.

In situations where development progresses with a Structure Plan in place, the development would need to take account of the requirements of the Structure Plan generally and any particular requirements for stormwater management set out in either the Structure Plan, a relevant catchment management plan and/or District Plan.

For developments where assets are vested with WDC, it is expected that the Council will take responsibility for any consents related to these assets, including stormwater discharges and structures.

The CSDC provides a mechanism for the transfer and where appropriate the surrender of individual consents for new development in favour of a comprehensive consent for the district. The general process for incorporating new consents into the CSDC will generally be as follows:

i. Anyone seeking to develop land will need to seek separate stormwater resource consents (and consent for structures if applicable) from WRC.
ii. WRC will assess the effect of the activity in the normal manner. WDC would be considered an affected party to the consent, and is therefore able to participate in the consideration of the consent applications.
iii. At completion of the development, the developer will seek to transfer the individual consent to WDC and WDC will need to satisfy itself that the activity is consistent with its CSDC.
iv. Once WDC becomes consent holder, it will seek to surrender the consent to WRC in favour of the comprehensive consent. WRC will also need to satisfy itself in a technical capacity that the consent is consistent with the CSDC.

A separate but related process would be expected to occur with the WDC, in that anyone seeking to develop land will most likely need to obtain either a land use or subdivision consent from WDC, and that the WDC would assess this application against its District Plan, any other relevant plan or strategy and infrastructure development standards set out in the HCC Development Manual.

We understand that WDC intends to prepare a Structure Plan that includes stormwater infrastructure to be developed to manage effects in accordance with the conditions of the CSDC.

We expect that individual developers would likely implement elements of the Structure Plan pertinent to the development of their land, and would typically need to demonstrate compliance with the WDC's final CMP and Structure Plan for the area with any consent application made to council. Compliance may also be via rules in the District Plan.

9.2 General design approach

The CSDC has a number of conditions and in effect sets out the stormwater management measures that should be considered and/or adopted for all (existing and new) stormwater infrastructure development. The key issues for each development include:

i. Stormwater quantity management.
ii. Stormwater quantity management.
iii. Aquatic resource and erosion protection.
iv. Flood hazard management.
v. Use of a Best Practicable Option approach.

In addition to the above, a significant issue for development over a large area such as the SPA is the scale and timing of individual developments and how the first developments cater for those that come after.

Relevant guidelines documents (from planning through to design) to assist in achieving the desired outcomes of the CSDC include but are not limited to:

- WRC approved Structure Plans.
- WRC approved Catchment Management Plans.
- WRC approved Stormwater Management Plans.
- WDC's Comprehensive Stormwater Discharge Consent.
- Waikato District Plan and Waikato Regional Plan.
- HCC Development Manual (or its approved successor)
- WRC's Sustainable Subdivision Development – An Environment Waikato Perspective.
- AC's Technical Publication 124: Low Impact Design
- AC' Technical Publication 108: Guidelines for stormwater runoff modelling in the Auckland Region
- AC's Technical Publication 10: Stormwater Management Devices, Design Guidelines Manual
- NZTA Bridge manual (for bridge and culvert design)
- NZTA Fish Passage Guidance For State Highways

Of the key issues identified above, issues 1, 2, 3 and 4 (in part) are addressed by the provisions contained in TP10. In particular, the requirements for peak flow attenuation in the 50% and 10% AEP storm events and the requirement to store and release (via extended detention) of the first 34.5mm of rain are considered standard practice and we have assumed that these measures will be adopted for most stormwater design.

Flood hazard management is addressed in part herein by providing preliminary modelling results to inform high level planning. The next step is to undertake more detailed modelling including the reticulated network and various development scenarios.

Flood hazard management (Issue 4) would also be exercised in part though the District Plan and SP, where areas vulnerable to flood hazards are excluded from urban development.

9.2.1 Best practicable option

All stormwater management matters should considered under a Best Practicable Option (BPO) approach. In relation to stormwater discharges, a BPO approach refers to the best method for preventing or minimising the adverse effects on the environment having regard to:

- The nature of the discharge
- The sensitivity of the receiving environment to adverse effects
- Up-to-date technical knowledge
- Implementation compared to other options
- Comparative environmental effects compared to other options
- Financial implications compared to other options

WDC's Stormwater Management Plan (T&T, 2009) sets out a comprehensive procedure for identifying and implementing Best Practicable Options (BPOs) to minimise actual and potential adverse effects resulting from the operation and maintenance of the municipal stormwater system.

It is noted that the HG 2009 CMP proposes stormwater ponds as a universal solution to mitigate the effects of stormwater discharges. We generally disagree with this universal approach. The use of TP10 and other documents noted above within a BPO framework for each sub-catchment is likely to yield a variety of solutions that are appropriate to each location and environmental setting.

9.3 Specific issues mitigation

9.3.1 Ecological matters

High significance ecological issues have been noted in Growth Sectors D (Heavy Industrial) and E (Light Industrial) with medium significance ecological issues noted in Growth Sector F (existing urbanised area) and Growth Sector I (partially urbanised) for similar reasons including:

- Receiving waters are likely sensitive to:
- Contaminant runoff including elevated temperature
- Reduced stream base flows and changes in flow variability
- Risk of contamination from non-routine spills within industrial areas.

The above issues are not necessarily managed under the framework set out in Section 9.2 above.

Specific management measures that WDC could consider include:

- Adding Open Space land use around identified tributaries and providing an opportunity to provide vegetative cover to assist with managing temperatures.
- Restricting infilling of perennial and/or ephemeral streams.
- Specific directives in terms of stormwater treatment to specifically manage contaminant loads from industrial sites.
- Land use controls to prevent or manage spills i.e. bunding, dual drainage systems, spill kits etc.
- Improving fish passage (Refer Section 9.4.1).

9.4 Flooding and infrastructure matters

Some existing infrastructure has been identified to be significantly contributing to the estimated flood hazard and/or are barriers to the upstream migration of native fish species. The following water way features have been highlighted for investigation and analysis.

9.4.1 Potential barriers to upstream fish passage:

- A weir downstream of Buckland Road Bridge on the Tutaenui stream.
- A weir downstream of Harrisville Road Bridge on the Whakapipi stream.
- A significant natural barrier (waterfall) downstream of Geraghtys Road on the Kairoa Stream, noting that this feature would likely limit the fish species that would need to be considered in terms of fish passage further upstream (i.e. at the two sites below).
- A weir downstream of the North Island Main Trunk Line Bridge on the Kairoa Stream.
- A water supply intake weir upstream of George Street on the Kairoa Stream.

With the exception of the Geraghtys Road waterfall, it is anticipated that the barriers to fish passage could be removed as part of development within the Tuakau SPA.

9.4.2 Culverts

The following culverts (in order of priority) require further investigation, analysis and possibly upgrading to improve flood conveyance:

i. cTUA106 - Culvert under NMTL railway.
ii. cTUA105 - Culvert under NMTL railway.
iii. cTUA102 – George Street/River Road culvert.
iv. cTUA111 – Geraghtys Road twin culvert and ford.
v. cTUA100 – River Road South Culvert.
vi. cTUA101 – River Road North Culvert.
vii. cTUA104 – Culvert under NMTL railway.
viii. cTUA113 – Buckland Road Bridge.
ix. cTUA110 - George Street Culvert.
x. cTUA112 – Harrisville Road Bridge.
xi. cTUA107 – Bollard Road Culvert
xii. cTUA108 – Gibson Road culvert
xiii. cTUA109 – Gibson Road culvert

Priority iii and iv culverts were determined to have inadequate capacity and preliminary upgrade details were provided in HG LTD 2009.

Priorities ix to xiii have been identified in the 2009 CMP report (HG Ltd, 2009) as having adequate capacity but may be re-checked to confirm

10 Conclusions

This assessment has broadly considered the background issues and potential constraints to urban development with regard to ecology and flood hazard to urban growth within the Tuakau SPA.

There is a dearth of ecological and environmental information on which to base a robust analysis but in general terms the streams and tributaries are considered to be compromised as a result of catchment land use activities and lack of riparian cover.

There is significant potential for improvements in water quality by way of providing riparian buffer zones (open spaces near streams) and planting of the riparian margins of those zones.

Given the open space and riparian buffers within the proposed growth areas provided by WDC together with the assumption that good design practice will be implemented for all future growth areas, we consider that there is an overall low to medium environmental constraint to development within the SPA.

Some engineered barriers to fish passage have been identified but these could be removed or retrofitted as part of developments within the Tuakau SPA.

In terms of flood hazard, the most significant constraint to growth is generally limited to the modelled flood plain and riparian margins of the Whakapipi, Kairoa and Tutaenui Streams. In these stream channels the estimated flood hazard category is generally 'significant' with either deep or fast flowing flood waters. Some areas of significant constraint are associated with moderate flood hazard within tributaries of the above streams, particularly at road and rail embankments with culverts or bridges. It is anticipated that the significance of the constraint in terms of flood extent would reduce if the culverts and bridges were included within a more detailed flood model, and a series of prioritized recommendations to better understand the performance of these structures is provided herein. A number of specific growth parcels have been identified as significantly affected by the estimated flood hazard.

Stormwater management should be considered under a Best Practicable Option (BPO) approach, and WDC's Stormwater Management Plan (T&T, 2009) sets out a comprehensive procedure for identifying and implementing Best Practicable Options (BPOs) to minimise actual and potential adverse effects resulting from the operation and maintenance of the municipal stormwater system.

11 References

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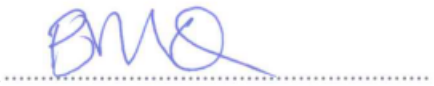
12 Applicability

This report has been prepared for the benefit of Waikato District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
Bryn Quilter	Peter Cochrane
Senior Civil & Environmental Engineer	Project Director

BMQ

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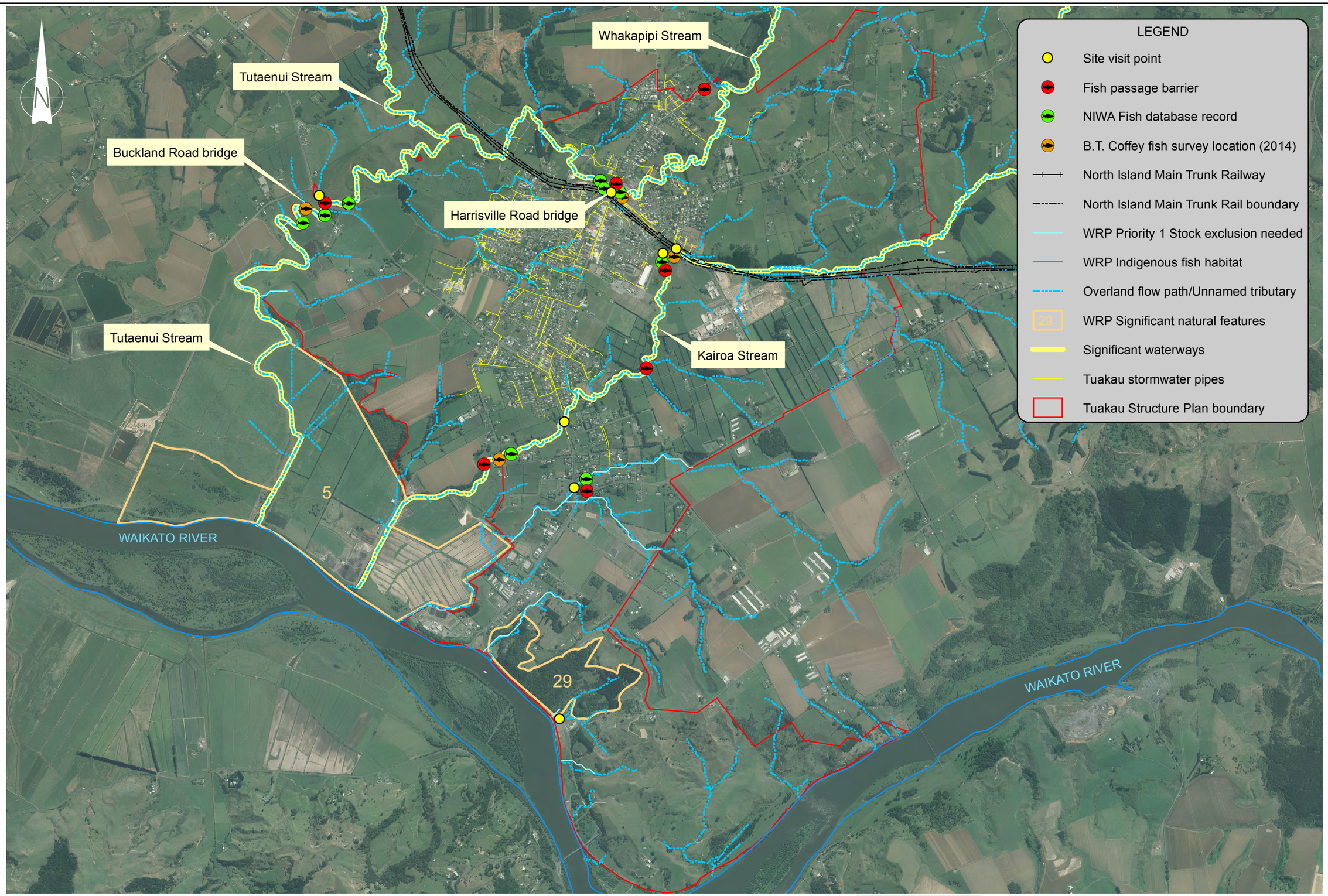
Appendix A: Figures

- **Figure 112 Ecological Map**
- **Figures 102 to 105 Flooding Maps Sheets 1 to 4**



Notes: Aerial photograph supplied by Waikato District Council.

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WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TUAKAU STRUCTURE PLAN AREA
Ecological Map

FIGURE No. Figure 112 | Rev. 0

Whakapipi Stream

Harrisville Road bridge

CTUA112

CTUA105

CTUA107

CTUA109

CTUA106

Kairoa Stream

Kairoa Stream

N

LEGEND

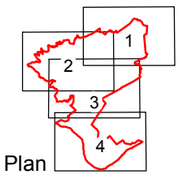
- Tuakau Structure Plan Boundary
- Critical culvert locations
- Existing pond locations
- Overland flow path/Unnamed tributary
- Significant waterways
- WDC Building outlines
- Waikato River 1% AEP flood extent (interpolated)
- WDC stormwater assets
- North Island Main Trunk Rail boundary
- North Island Main Trunk Railway
- Potential Flood Hazard
- Minor Flood Hazard
- Significant Flood Hazard

Notes: Aerial photograph supplied by Waikato District Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



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PROJECT No.	61814.000	
FIGURE No.	Figure 102	Rev. 0

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TUAKAU STRUCTURE PLAN AREA
Flooding Map - Sheet 1 of 4

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Whakapipi Stream

Tutaenui Stream

Harrisville Road bridge

Buckland Road bridge

CTUA104

CTUA112

CTUA113

CTUA103

CTUA108

CTUA109

CTUA105

CTUA107

Kairoa Stream

CTUA110

N

LEGEND

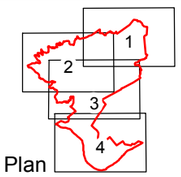
- Tuakau Structure Plan Boundary
- Critical culvert locations
- Existing pond locations
- Overland flow path/Unnamed tributary
- Significant waterways
- WDC Building outlines
- Waikato River 1% AEP flood extent (interpolated)
- WDC stormwater assets
- North Island Main Trunk Rail boundary
- North Island Main Trunk Railway
- Potential Flood Hazard
- Minor Flood Hazard
- Significant Flood Hazard

Notes: Aerial photograph supplied by Waikato District Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



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DRAWN	DWM	Jul.14
CHECKED	BMD	7/14
APPROVED	PRC	7/14
ARCFILE	61814.000-F102_F105.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.000	
FIGURE No.	Figure 103	Rev. 0

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TUAKAU STRUCTURE PLAN AREA
Flooding Map - Sheet 2 of 4

Path: P:\61814\61814.0000\WorkingMaterial\GIS\61814.000-F102_F105.mxd Date: 16/07/2014 Time: 9:15:52 a.m.

CTUA103
CTUA108
CTUA109
CTUA107
CTUA105
Kairoa Stream
CTUA106
Kairoa Stream
CTUA110
CTUA111
CTUA102
CTUA101

N

LEGEND

- Tuakau Structure Plan Boundary
- Critical culvert locations
- Existing pond locations
- Overland flow path/Unnamed tributary
- Significant waterways
- WDC Building outlines
- Waikato River 1% AEP flood extent (interpolated)
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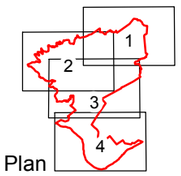
- Potential Flood Hazard
- Minor Flood Hazard
- Significant Flood Hazard

Notes: Aerial photograph supplied by Waikato District Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



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CHECKED	BMD	7/14
APPROVED	PR	7/14
ARCFILE	61814.000-F102_F105.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.000	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TUAKAU STRUCTURE PLAN AREA
Flooding Map - Sheet 3 of 4

FIGURE No. Figure 104 | Rev. 0

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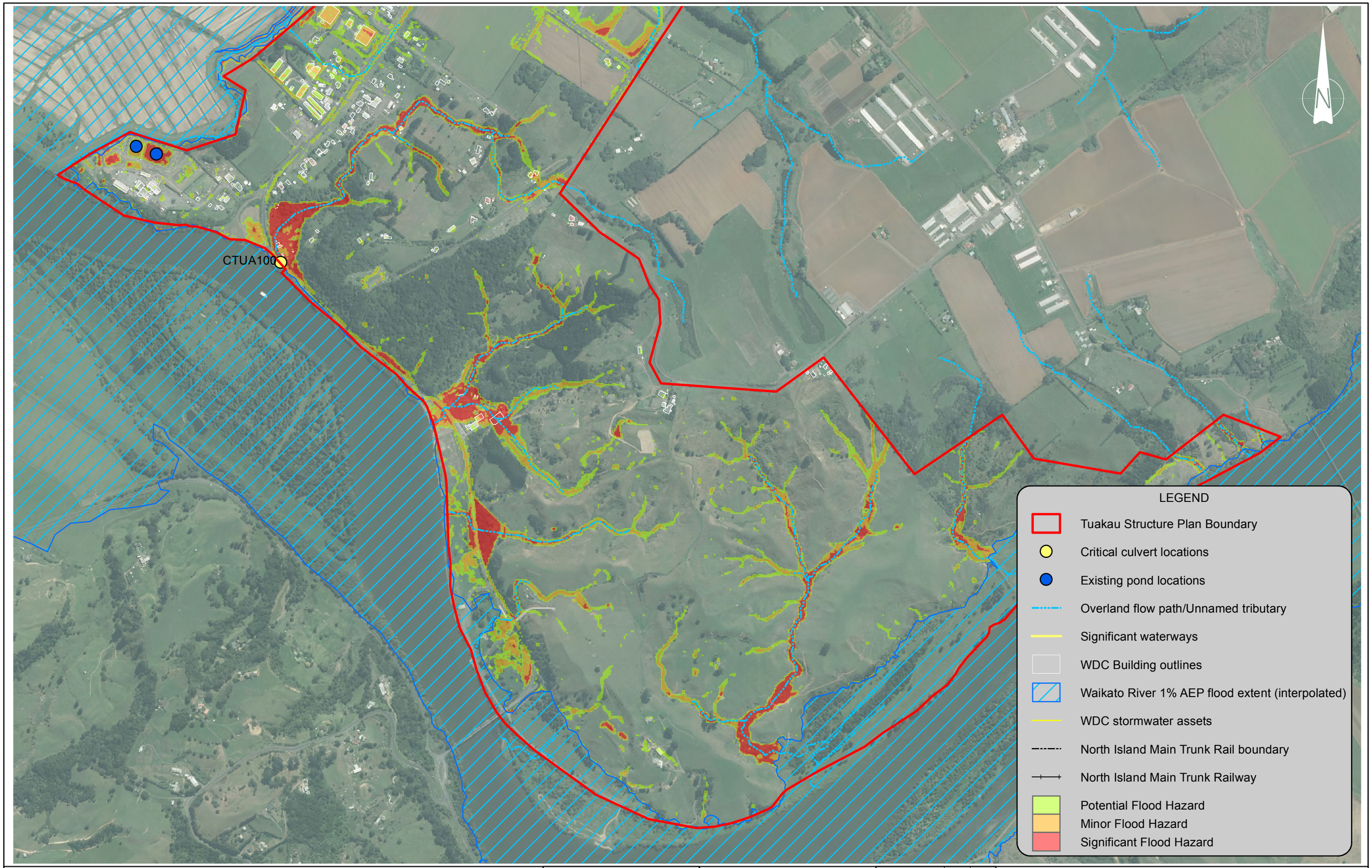
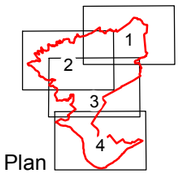


Notes: Aerial photograph supplied by Waikato District Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



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CHECKED	BnD	7/14
APPROVED	PR	7/14
ARCFILE	61814.000-F102_F105.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.000	
FIGURE No.	Figure 105	Rev. 0

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TUAKAU STRUCTURE PLAN AREA
Flooding Map - Sheet 4 of 4

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