Advisory Note.

Waikato District Council adopted the Ngaaruawaahia, Hopuhopu, & Taupiri Structure Plan / Ngaaruawaahia Town Centre Plan on the 21st of October 2024. Information contained in this report from the "Ngaaruawaahia Structure Plan – 2017" relating to **Ngaaruawaahia, Hopuhopu, & Taupiri** has been superseded by a more recent technical report.

You can find the updated report here.

If you are after information pertaining to **Glen Massey**, **Horotiu** or **Te Kowhai** this report still applies.

REPORT

Waikato District Council

Catchment Management Plan
Ngaruawahia & Surrounds Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Catchment Management Plan
Ngaruawahia & Surrounds Structure Plan Area

Report prepared for:

Waikato District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2

Table of contents

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 Ngaruawahia and Surrounds Structure Plan Area.

A draft Catchment Management Plan was prepared and issued to Council in August 2014. In February 2015, Council advised that no changes were required to the draft plan. This final version has been released with no new work completed since the draft version was issued.

The Structure Plan Area includes the towns of:

- Taupiri.
- Horotiu.
- Ngaruawahia.
- Glen Massey.
- Te Kowhai.

Flood hazard associated with the Waikato River affects the towns of:

- Taupiri.
- Horotiu.
- Ngaruawahia.

Flood hazard associated with the Waipa River affects the towns of:

- Ngaruawahia.
- Te Kowhai.

The streams and tributaries within all towns are potentially subject to flood ponding which extends well beyond the nominal stream channels and impacts the broader floodplains of many of these streams. Potential flood hazards associated with ponding areas and overland flow paths exist in urbanised parts of all of the towns within the Structure Plan Area.

The streams and tributaries within the Te Kowhai 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.

Ponding as a result of culvert capacity issues with Glen Massey results in adverse flood effects on some properties but no detailed topographic information was available to fully assess the extent of the issues.

The proposed growth area land uses within the Structure Plan Area include residential development around stream corridors and overland flow paths and this includes areas where flood hazard has been estimated to occur. Overall the nominated growth areas are relatively large compared to the extent of flood and ponding hazard and therefore there is an overall low constraint to the proposed development. Notwithstanding there are still parts of proposed growth areas which do not have adequate open space provisions and future development of those areas 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 potential for stream value enhancement throughout the Structure Plan Area. At this stage no open space areas and have been identified by WDC but it is expected that these will likely be included after a review of flood issues, and could include riparian planting.

Overall, outside of flood and ponding hazard areas, we consider that there is generally a low constraint to growth within the Structure Plan Area assuming that good practice stormwater management measures are employed. Some specific mitigation measures (over and above good practice) are recommended for some areas or land parcels.

The identification and use of open spaces areas can be used as a tool to help manage the flooding hazard maps and ecological issues presented in this report.

Waikato District Council holds 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 draft Catchment Management Plan (CMP) for the Ngaruawahia and Surrounds Structure Plan Area (SPA).

The Structure Plan Area (shown in Figure 1 below) includes the towns of:

- Taupiri.
- Horotiu.
- Ngaruawahia.
- Glen Massey.
- Te Kowhai.

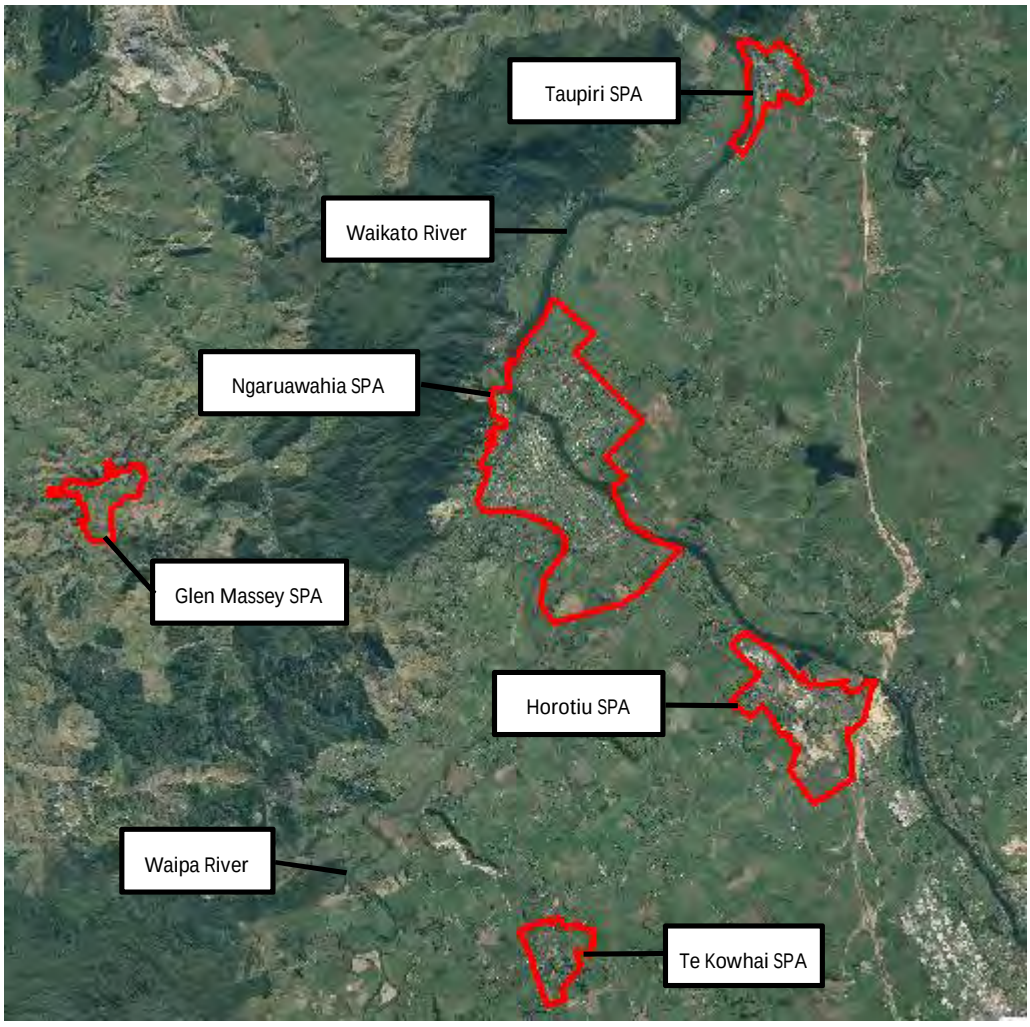


Figure 1. Location plan

This CMP has been produced to support and inform WDC's planning decisions relating to urban growth for each of these towns.

WDC has progressed high level planning for growth in the towns to develop preliminary growth areas and the SPAs used herein. The SPA extents are shown in the following sections.

This CMP focuses individually on each of the towns surrounding and including Ngaruawahia. WDC has provided indicative plans for each town (except Glen Massey) showing the proposed extent of future (exclusively residential) land use.

This CMP should be read in conjunction with a number of other reports commissioned by WDC for the each 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 Taupiri, Horotiu, Ngaruawahia, Glen Massey, and Te Kowhai SPAs.

1.2 Purpose

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

- Provide baseline information within each 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) for Te Kowhai using available LiDAR to map flood hazards.
ii. An engineering survey and culvert capacity analysis for Glen Massey.
iii. An assessment of potential ponding areas for Taupiri, Horotiu and Ngaruawahia.
iv. A review of flood extents from the Waikato River and Waipa River for all towns except Glen Massey.
v. Identification and review of critical structures to help inform the RFHA, culvert capacity and ponding assessment results interpretation.
vi. Review and assessment of the ecological status of water resources in the catchment.
vii. 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.

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

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

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

xi. 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 for the Taupiri, Horotiu, Ngaruawahia and Te Kowhai areas.
- Stormwater asset data (this generally excludes culverts as these are "road" assets).
- The SPA boundaries.
- Previous relevant reports.
- Basic residential growth areas for Taupiri, Horotiu, Ngaruawahia and Te Kowhai.

Waikato Regional Council (WRC) has provided:

- Waikato River 1D[1] flood model (MIKE 11) cross sections including 1% AEP (with no climate change) flood levels from the Karapiro Dam to Port Waikato as well as an interpolated 2D flood extent.
- 2D interpolated[2] flood levels for the Waipa River (1% AEP with no climate change).
- Additional raw LiDAR data for the Te Kowhai area.

1.5 Report structure

This CMP has been structured so that the main report body includes a high level overview, summary and conclusions relating to each of the towns and villages only.

Separate reports for each town addressing more specific background, issues, and assessments have been included in the appendices.

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

[2] 1D flood levels interpolated by WRC using 2007/2008 LiDAR data.

2 Ecological assessment overview

2.1 Introduction

This section provides an overview of the issues considered when undertaking the assessment of the potential effects on surface water resources as a result of development of the five SPAs.

This section:

- Outlines the types of stressors on surface water environments from urban development.
- Outlines the issues considered when determining the significance of potential environmental effects from urban development.
- Identifies areas of uncertainty, where further information may need to be gathered to more fully assess and understand these effects (common to all five SPAs).

Specific assessments for each SPA are presented in appendices to this report

2.2 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.

2.2.1 Catchment land uses and effects on water quality

All of the main streams passing through the five SPAs drain areas of agricultural and/or urban land use in their catchments. These streams are influenced to varying degrees as a result of these land uses. 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 significantly improve water and habitat quality in these water bodies.

2.2.2 Effects on water and sediment quality

Existing water quality issues for streams in the SPA 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 from agricultural land use in the catchment.
- 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.

2.2.3 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 in the SPA 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, and destabilising stream channels, resulting in habitat loss or severe degradation of habitat quality. Sediment runoff from large urban developments is usually managed through controls put in place by 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.

2.2.4 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 permanently flowing reaches of streams.

2.2.5 Changes in hydrology

Increases in impervious surface area as a result of development and associated 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 reduce contributions 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 surfaces which increase the rate of stormwater runoff into streams. This in turn can cause stream erosion, or more subtly can impact on aquatic resources, through the frequent disturbance of habitat during high flow events.

2.2.6 Fish species, habitats and passage

The streams within the SPA retain some fish habitat values despite being characterised by generally reduced habitat quality. Development has the potential to impact on native fish populations and habitats in the short term during construction works and in the long term if in-stream structures form a barrier to their migration. Many native fish species 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.

2.1 Assessment of effects

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 i.e. zero and first order streams located within growth areas are considered to be more vulnerable to the effects of development than if development was adjacent to larger streams or rivers.

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 result in 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 low density residential land use has been proposed by WDC within the SPA. For this assessment, we have assumed that 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).

The main ecological issues associated with future urban development in the five SPAs are described in detail in the appendices to this report.

2.2 Information gaps

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

- Site specific ecological information on streams within the SPA – No specific ecological information was available for streams inside the SPA. A site walkover of all stream and tributaries is required to gain a comprehensive understanding of these environments.
- Comprehensive fish passage information – At present the diversity of native fish in the catchment sites is low but it is not clear if this is due to poor water and habitat quality or the presence of barriers downstream. A comprehensive fish passage assessment would be required and could be undertaken in conjunction with stream walkovers.
- Base flow information – No readily available information on the hydrological regime of streams within the SPA has been found. Flow gauging data collected on an *ad hoc* basis by WRC might be available for some streams, but this would require further analysis in order to quantify base flows and determine site specific flow conditions that are necessary to sustain aquatic ecosystems.
- Water quality information – There is no readily available information on the nutrient status of the streams within the SPA, although some data may be available from WRC for some streams.
- 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 growth 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 ecological properties, base flows and water and possibly sediment quality.

3 Flooding review method summary

The information and methods used to review flood information within the five SPA's has included:

- Waikato and Waipa River Flood extents provided by WRC.
- Culvert analysis (hydrology and hydraulics).
- Rapid Flood Hazard Assessment (RFHA).
- Depression (ponding) mapping.

A detailed description of the information and methodology used to review flooding for each SPA is included within the relevant appendix for each town. The information and methods used are summarised in Table 1 below:

Table 1. Flood Review Information and Method Summary

Information/Method Town	River Flooding (WRC)	Culvert Analysis	RFHA	Ponding Maps
Taupiri	✓			✓
Horotiu	✓			✓
Ngaruawahia	✓			✓
Glen Massey		✓		
Te Kowhai	✓		✓	

4 Constraints to growth

In terms of fresh water ecology and flood hazard, the most significant constraint to growth is generally limited to the flood plains and riparian margins of the rivers, streams and tributaries within the five SPAs.

Development of land subject to flooding or ponding would need to be avoided and in the most part can been achieved through the identification of open space areas.

Rivers, streams, tributaries and drains are also the main ecological corridors within the five SPAs 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 riparian areas, there are localised constraints to growth as a result of potential flood hazards. These are most significant in Growth Sectors B (Taupiri), E (Ngaruawahia), G & F (Te Kowhai) where overall there are medium to high constraints to development.

In terms of ecological constraints to development Growth Sector F (Ngaruawahia) poses a slightly elevated (low to medium) constraint to development.

Overall and considering both ecological and flood issues, the Te Kowhai Growth Sectors (G and H) have medium to high constraint to growth with Taupiri Growth Sector B having medium constraint. All other growth sectors have low or low to medium constraint.

A summary of constraints to growth sectors in each town is presented in Table 2 below.

4.1 Mitigation

Flood risk to growth areas may be addressed in many areas by the inclusion of open space zones around streams, tributaries and drains. The extent of the open space zones should be reviewed in light of the flooding maps presented in appendices to this report 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 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 provided in Section 5.

Table 2. Growth constraint summary.

Town/SPA	Taupiri	Taupiri	Horotiu	Ngaruawahia	Ngaruawahia	Ngaruawahia	Glen Massey	Te Kowhai	Te Kowhai
Growth Sector	A	B	C	D	E	F	-	G	H
Ecological constraint	Low	Low	Low	Low	Low	Low to Medium	Low	Low	Low
Flooding constraint	Low	Medium to High	Low	Low	Medium	Low	Low	High	High
Overall constraint to development	Low	Medium	Low	Low	Low to Medium	Low	Low	Medium to High	Medium to High

5 Stormwater management

5.1 Resource consent requirements

Waikato District Council holds Resource Consents, being a Comprehensive Stormwater Discharge Consents (CSDC), associated with the existing urban areas of:

- Taupiri: Resource Consent No. 105651
- Horotiu: Resource Consent No. 105653
- Ngaruawahia: Resource Consent No. 105645
- Glen Massey: Resource Consent No. 105655
- Te Kowhai: Resource Consent No. 105656

The CSDC has a number of conditions which in effect sets out the stormwater management measures that should be considered and/or adopted for all (existing and new) council stormwater diversions and discharges to avoid or mitigate adverse effects on surface water resources[3].

Consents will normally be needed to facilitate the 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 following vesting.

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 effects of the activity in the normal manner. WDC would be considered an affected party to the consent, and would 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. At that point WDC would need to satisfy itself that the activity is consistent with its CSDC.
iv. Once WDC becomes the consent holder, it would seek to surrender the consent to WRC in favour of the comprehensive consent. WRC will also need to satisfy itself in a technical

[3] In some situations it is possible that stormwater management for new areas within existing urban settings may be able to remedy some adverse effects.

capacity that the surrender is consistent with the CSDC, and that there are no outstanding matters that would need to be addressed.

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.

5.2 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:

1. WRC approved Structure Plans.
2. WRC approved Catchment Management Plans.
3. WRC approved Stormwater Management Plans.
4. WDC's Comprehensive Stormwater Discharge Consent.
5. Waikato District Plan and Waikato Regional Plan.
6. HCC Development Manual (or its approved successor)
7. WRC's Sustainable Subdivision Development – An Environment Waikato Perspective.
8. AC's Technical Publication 124: Low Impact Design.
9. AC' Technical Publication 108: Guidelines for stormwater runoff modelling in the Auckland Region.
10. AC's Technical Publication 10: Stormwater Management Devices, Design Guidelines Manual.
11. NZTA Bridge manual (for bridge and culvert design).
12. 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.

5.3 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.

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.

5.4 Specific issues mitigation

5.4.1 Ecological matters

Low to medium significance ecological issues have been noted in Growth Sector F (Ngaruawahia) as receiving waters are likely sensitive to:

- Contaminant runoff including elevated temperature
- Reduced stream base flows and changes in flow variability

The above issues are not necessarily managed under the framework set out in Section 5.2 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.

5.5 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.

5.5.1 Potential barriers to upstream fish passage:

- Culvert cGM103 located on a tributary of Firewood Creek underneath Wilton-Colleries Road.

It is anticipated that the barrier to fish passage could be removed/remedied as part of or separate to development within the SPA.

The above culvert appears to be within the Glen Massey 'urban area' in terms of Resource Consent No. 105655, being a Comprehensive Stormwater Discharge Consent. As such we consider that WDC are required to consider fish passage improvement at the culvert in accordance with Resource Consent No. 105655 Condition number eight (refer extract below):

Fish passage

8. *With the exception of ephemeral watercourses, all structures that have been placed in natural and modified watercourses to enable municipal stormwater diversion and discharge activities shall allow, or be modified where possible to allow, for the safe upstream and downstream movement of fish. When acting on this condition, all stormwater system modifications and fish passage devices shall be designed and constructed to the satisfaction of the Waikato Regional Council.*

   Note: When acting on this condition the consent holder shall also consult with the Department of Conservation, in accordance with Part VI of the Freshwater Fisheries Regulations 1983.

5.5.2 Culverts

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

Taupiri

i. cTAU101 – Taupiri
ii. cTAU100 – Taupiri

Horotiu

i. cHOR100 – Horotiu

Ngaruwahia

i. cNGA103 – Ngaruawahia
ii. cNGA102 – Ngaruawahia
iii. cNGA106 – Ngaruawahia
iv. cNGA104 – Ngaruawahia
v. cNGA105 – Ngaruawahia
vi. cNGA100 – Ngaruawahia
vii. cNGA101 – Ngaruawahia

Glen Massey

i. cGM100 – Glen Massey
ii. cGM103 – Glen Massey
iii. cGM102 – Glen Massey
iv. cGM101 – Glen Massey

Te Kowhai

i. cNGA101 – Te Kowhai
ii. cNGA101 – Te Kowhai

6 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 Ngaruawahia and Surrounds SPA.

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

There is 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.

If appropriate open space and riparian buffers within the proposed growth sectors are 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 environmental constraint to development within the SPA.

One engineered barrier to fish passage in Glen Massey has been identified and this could be removed or retrofitted.

In terms of flood issues, the most significant constraint to growth is generally limited to Growth Sectors within Te Kowhai, Taupiri and Ngaruawahia (in descending order of significance) and in general the modelled flood plain and riparian margins of the Waikato and Waipa Rivers. Areas of significant constraint are associated with moderate flood hazard or ponding depth within tributaries and drains, particularly at road and access way embankments with culverts. It is anticipated that the significance of the constraint in terms of flood extent would reduce if the culverts 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.

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 to minimise actual and potential adverse effects resulting from the operation and maintenance of the municipal stormwater system.

7 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
Project Manager	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 ngaruawahia & surrounds cmp final.docx

Appendix A: Taupiri CMP Assessment

REPORT

Waikato District Council

Appendix **A**

Catchment Management Plan
Taupiri Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Appendix **A**

Catchment Management Plan
Taupiri Structure Plan Area

Report prepared for:

Waikato District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2000

Table of contents

1 Catchment description

1.1 Location

The Taupiri SPA surrounds the North Waikato township of Taupiri. The SPA is located adjacent the east bank of the Waikato River, approximately 7 km North East of Ngaruawahia. The location of the Taupiri SPA is presented in Figure 1. The SPA covers approximately 94 ha. The SPA is bordered by the Waikato River to the west, the Managawara Stream to the north and generally by rural land to the east and south punctuated by incised stream channels. The North Island Main Trunk railway line runs through the centre of the structure plan area, following Great South Road through the centre of Taupiri Township.

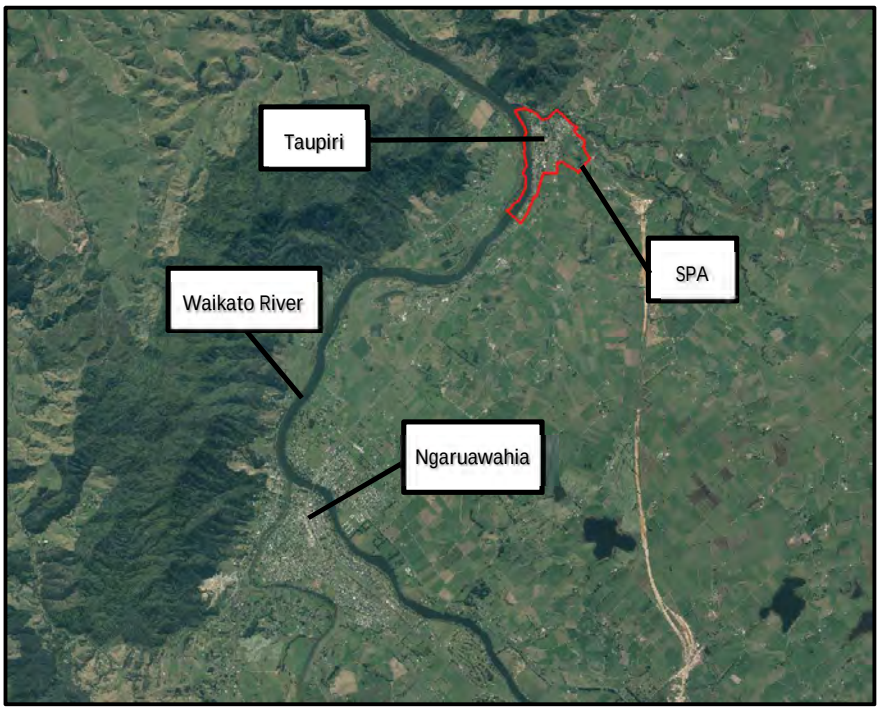


Figure 1. Taupiri SPA locations (Aerial sourced from WDC)

1.2 Topography

The topography of the catchment and SPA is typically gently undulating with relatively flat terraces with incised gullies which drain natural water courses. The SPA encompasses the Taupiri Township and some agricultural land to the south and the east. The area generally slopes to the north, towards the confluence of the Waikato River and the Mangawara Stream.

The upper catchment to the east is largely flat punctuated by managed farm drainage channels.

1.3 Geology and hydrogeology

The published geology of the area indicates that the majority of the Taupiri SPA is underlain by interbedded alluvial sands, silts and peats of the Hinuera Formation of the Piako Subgroup, overlying in places older sands, silts of the Walton Subgroup. Both the Pleistocene Age Walton Subgroup and the younger Holocene age Piako Subgroup are mapped as belonging to the Tauranga Group.

Recent alluvial sediments comprising sands, silts and peats are present in the bases of gullies or stream beds (Edbrooke S. W., 2005) as shown in the Geological map in Figure 2 below.

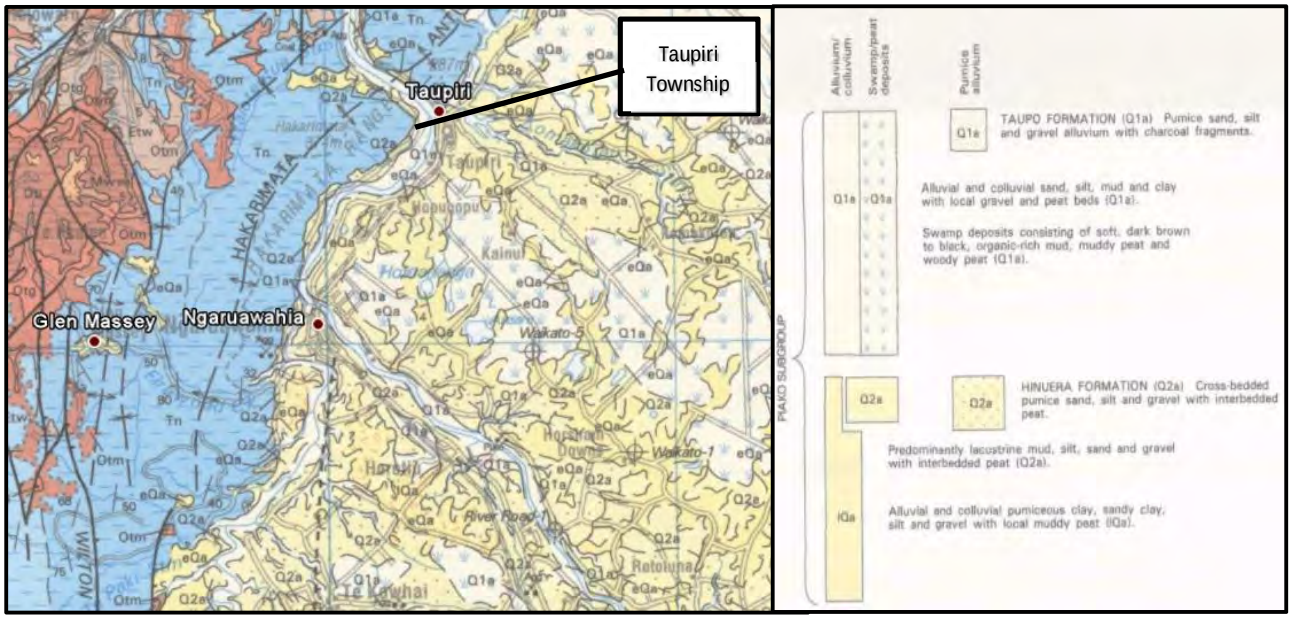


Figure 2. Geological map of Taupiri SPA

The SPA sits in northwest corner of the Hamilton Basin, where the basin abuts much older and much less permeable greywacke rocks of the Newcastle Group, and the Waikato River drains through the Taupiri Gap.

The hydrogeology of the Tauranga Group is characterised by a series of shallow unconfined and deeper semi-confined aquifers, which are variable in their horizontal and vertical distributions, and show varying degrees of connectivity with one another.

Groundwater is recharged from rainfall infiltration and a significant proportion of groundwater discharges to streams through the incised gullies. Marshall and Petch (1985) estimated that up to 85% of mean annual stream flow is sustained by groundwater discharges.

1.4 Watercourses

The village of Taupiri is situated on a low lying river terrace, lying south of the confluence of the Mangawara Stream with the Waikato River and southwest of the Komakorau stream and the Mangawara Stream.

The Mangawara and Komakorau Steams (and their tributaries) drain significant catchments to the east of the Taupiri Township.

An unnamed tributary of the Waikato River passes through the SPA including Growth Sectors A and B. The tributary receives runoff from farmland south of the SPA and is approximately 10km in length. The unnamed tributary runs south to north through the SPA and is conveyed under Te Putu Street via a 1300 mm diameter culvert and then under the NMTL via another culvert. It then passes under the Gordonton Road Bridge alongside the NMTL and discharges to the Mangawara Stream just upstream of the Waikato River confluence.

Another unnamed tributary of the Waikato River passes beneath the North Island Main Trunk Line and Great South Road to discharge to the river in the southern part of the SPA. The tributary receives runoff from rural land.

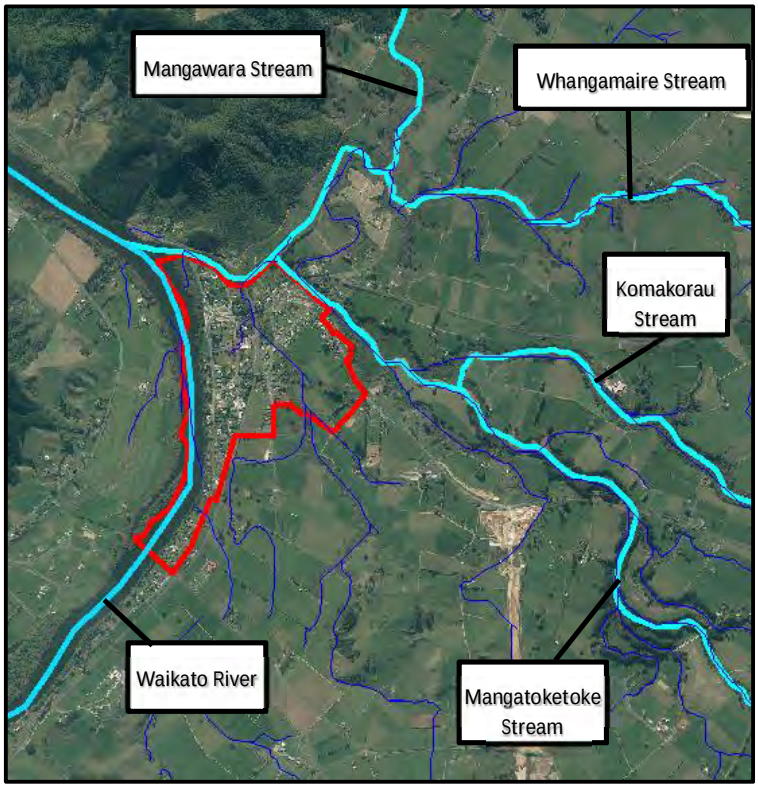


Figure 3. Main water courses (light blue) and tributaries (dark blue) surrounding the SPA.

1.5 Receiving environments

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

- An unnamed tributary of the Mangawara River.
- Mangawara Stream.
- Komakorau Stream.
- Mangatoketoke Stream.
- Waikato River.
- Unnamed tributaries of all of the above.

1.6 Existing WRC resource consents

1.6.1 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	0	-
Discharge - Land	4	-
Discharge - Water	3	-
Land Use – Bore/Well	0	-
Land Use – Other	3	-
Water Take - Ground	0	-
Water Take - Surface	2	-
Water Take - Other	2	-

1.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105651, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Taupiri.

Relevant extracts from the resource consent are reproduced below:

Consent Type: Discharge permit

Consent Subtype: Discharge to land and water

Activity authorised: To divert and discharge urban stormwater and associated contaminants at multiple locations to land and an unnamed tributary of the Waikato River, and use discharge structures, within the Taupiri urban area.

Consent duration: Granted for a period expiring on 22 September 2028

It is noted that the extent of the above consent (reticulated urban area of Taupiri) is somewhat smaller than the extent of the SPA, with the SPA extending further south and northeast.

2 Land use in Taupiri

2.1 Current land use

Land use within the SPA is dominated by residential areas and agricultural land uses. Other land uses currently occurring within the SPA include rural residential and a small urban (rural town) area.

The North Island Main Trunk Line (NMTL) railway line runs through the middle of the SPA and the centre of Taupiri Township. Key arterial routes run through the SPA, including state highway 1 (SH1) and Great South Road.

Outside of the township, the SPA is dominated by pastoral land with some rural residential development. Individual blocks of horticultural land use are present within the rural parts of the SPA.

2.2 Future land use

Future growth within the SPA has been provided by WDC and is shown in Figure 4 below. The figure shows that the future land use is anticipated to be only residential zones.

For reporting purposes, the growth areas defined by WDC have been categorised into “Growth Sectors” A and B. These are also presented in Figure 4.

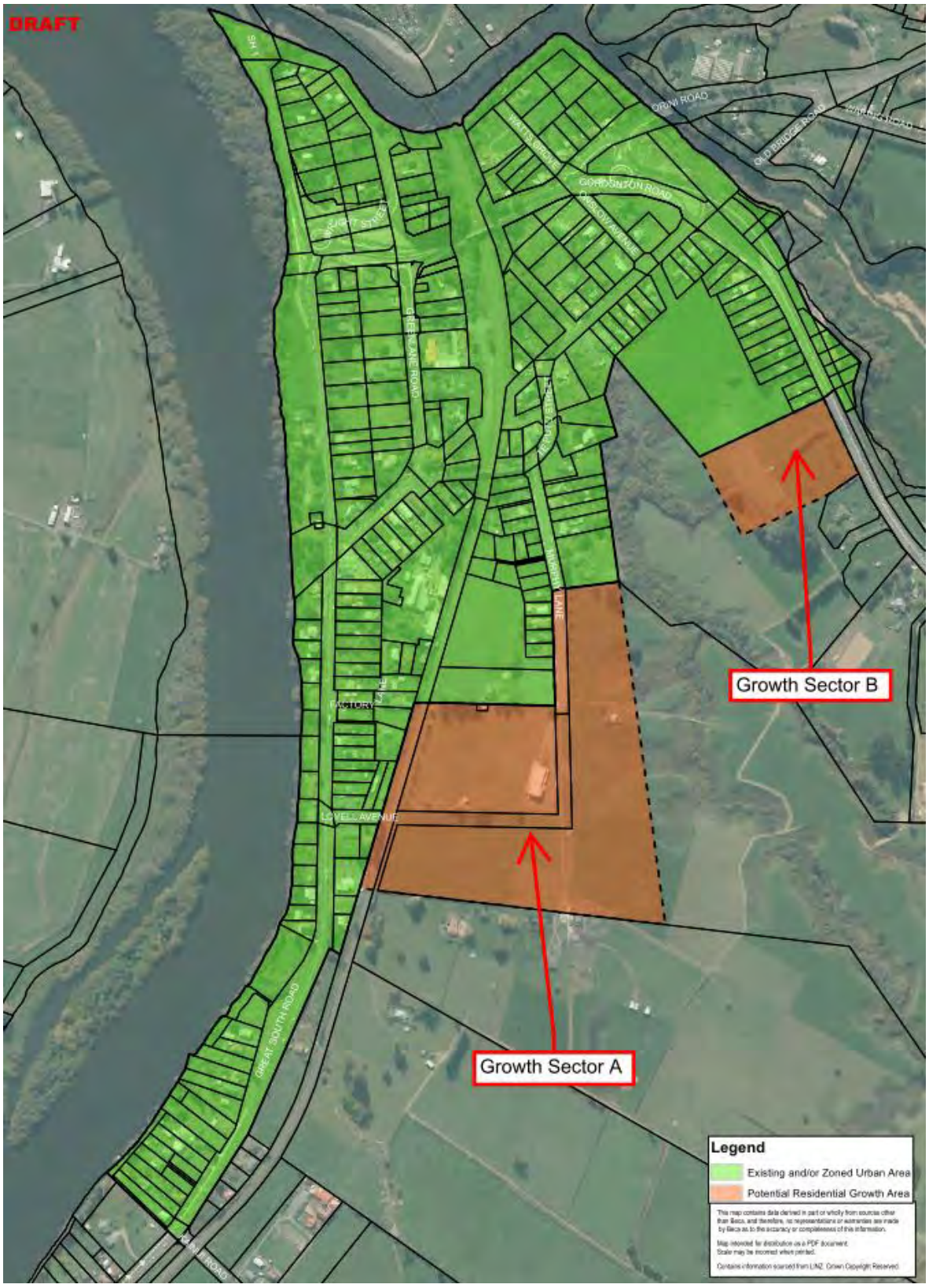


Figure 4. Taupiri growth plan provided by WDC and Growth Sectors used for reporting.

3 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Taupiri SPA. The assessment is based on a review of existing ecological information with a walkover site visit to publicly accessible parts of the SPA. Important terrestrial and wetland values recorded in the district plan are also briefly described.

3.1 SPA overview

3.2 Assessment methods

There has been no ecological assessments of Taupiri and its surrounds provided by Waikato District Council. Our assessment has reviewed the information available within national and regional ecological databases.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 9 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 232 in Appendix AA.

3.3 Summary of existing ecological information

3.3.1 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Taupiri SPA is included on Planning Map 20.5. There were no ecological features of note within the Taupiri SPA.

3.3.2 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.

The Waikato River, Mangawara Stream and Whangamarie Stream are classified as Indigenous Fish Habitat Areas (Map S14). This classification is applied to significant habitats or areas that are characterised by high water quality. The Waikato River is also designated as Trout Habitat and Contact Recreation.

All other permanent watercourses within the area are classified as Waikato Surface Water (Map S14) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

3.4 T&T's 2014 field assessment

A site inspection of publicly accessible locations on the streams within the SPA was conducted on 9 April, 2014. Locations inspected are shown on Figure 232 in Appendix AA. Observations from site inspections concluded that the unnamed stream within the Taupiri SPA was a small stream with flow attenuated by excessive infestation of Crack Willow (*Salix fragilis*) throughout the entire observed length of stream. Stream habitat at the sites inspected was generally limited to slow moving runs and pools with undercut banks, root mats and overhanging vegetation present. No barriers to upstream fish habitat were identified although due to difficulties with access, the culvert under the North Island Main Trunk line was not inspected.

The Waikato River and Komakorau Stream run along the boundary of the Taupari SPA. Both these water courses provided aquatic habitat.

4 Ecological assessment

4.1 Introduction

This section provides an assessment of the potential effects of development of the Taupiri SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report. This section provides an assessment of the significance of these issues for each of the growth areas identified by WDC.

4.2 Assessment of effects

The main ecological issues associated with future urban development in the Taupiri SPA are described below and the significance of proposed development to a range of issues for each growth area is presented in Table 2.

Table 2. Significance of potential adverse effects from proposed development

Growth Sector / Issue	A - Low density residential	B - Low density residential
Stormwater		
Contaminants	Low	Low
Increase in peak flows leading to stream bed/bank erosion	Low	Low
Hydrological		
Reductions in base flow	Low	Low
Reduction in flow variability leading to reduced habitat quality	Low	Low
Habitat		
Culverting or infilling of perennial streams reducing habitat	Low	Low
Protection of riparian margins	Low to medium	Low to medium
Barriers to fish movement	Low	Low
Overall potential adverse effect on surface water	Low	Low

5 Flooding assessment

5.1 Introduction

A ponding map of the Taupiri SPA has been produced. The purpose of the ponding map is to determine the areas which may be inundated if no pipe network is available. The ponding map is a valuable tool to provide an indication of where potential flooding hazards may occur and where future modelling efforts should be concentrated. This approach assumes that the reticulated network (pipes, culverts and catchpits) are blocked but does include rainfall-runoff analysis.

5.2 Methodology

To create the ponding maps, a GIS tool has been used to infill and map all topographic depressions based on the LiDAR survey provided. We note that LiDAR provided was collected in 2007 and 2008 so is considered somewhat out of date. The mapped depressions represent all areas where stormwater could *potentially* pond.

A key issue 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 caused by road embankments, bridges or culverts.

From the ponding maps, critical areas have been identified and a field assessment has been undertaken to identify sub-surface drainage features that could significantly affect the ponding areas shown.

The key culverts that may influence the ponding areas have been identified on the Figure 222 in Appendix AA and also in Table 3.

5.3 Information provided by WDC

5.3.1 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.

5.3.2 Buildings

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

5.3.3 Drainage operational issues

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

The town is located within the Lower Waikato Waipa Control Scheme, Section B (Waikato River Channel) administered by Waikato Regional Council.

5.3.4 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 as well as an interpolated 2D flood extent.

The interpolated 2D extent of 1% AEP flooding for both rivers was undertaken by WRC by interpolating the 2009 MIKE 11 1D models on to a LiDAR derived topography using WaterRide Software.

The WRC cross sections indicate that the Waikato River 1% AEP (with no climate change) flood level ranges between approximately 12.9 m RL and 13.2 m RL within the Taupiri SPA. The WRC interpolated 1% AEP river flood extent (with no allowance for climate change) has been presented in Figure 222 in Appendix AA.

WRC were not able to provide any flood level or extent information for the Mangawara River.

5.4 Reporting

For reporting purposes, the areas of potential growth has been broken up into "Growth Sectors". Within the Taupiri SPA, there are two Growth Sectors – A and B. The locations of the Growth Sectors are shown in Figure 222 in Appendix AA and also Figure 4. Both Growth Sectors contain only proposed residential land.

Growth Sector A is outside the SPA. The SPA boundary may need to be extended to encompass this area. Growth Sector A has an approximate area of 13 ha. It is bound by the railway line to the west, and generally rural farmland to the north, east and south. There currently appears to be two buildings in Growth Sector A.

Growth Sector B is smaller than A, with an approximate area of 1.3 ha. It is bordered to the east by the Waikato Expressway and to the north, west and south by farmland. There appear to be no existing buildings within Growth Sector B, and it looks to be currently used as farmland.

5.5 Results

The results from the ponding assessment are presented in Figure 222 in Appendix AA. The ponding assessment entails a high level overview of the ponding extent shown in these figures and reviews the constraints to the proposed residential area.

Flooding of each Growth Sector has been reviewed separately and discussed in the following sections. The areas within the SPA but outside of the proposed growth areas have not been specifically considered as no growth has been proposed.

The ponding map does not account for culverts, road embankments or bridges. There is seen to be extensive and significant ponding upstream of where the unnamed tributary appears to be conveyed under the NMTL (which coincides with the location of the Gordonton Road Bridge). The LiDAR data has been reviewed, and the contour information for Gordonton Road Bridge, directly above the NMTL railway line has been excluded to give a more accurate flood map. However, the NMTL railway line has an approximately 3.5 m high embankment and there is expected to be a culvert (cTAU101 on Figure 222 in Appendix AA) underneath the railway line at the location of the Gordonton Road Bridge, but this was not identified in our site visits.

This appears to have an effect on the upstream overland flow paths which demonstrate significant ponding up to 1.8 km south of the bridge. Some of these overland flow paths are within the boundaries of both Growth Sectors A and B. This should be considered when assessing the ponding in these areas.

5.5.1 Growth Sector **A**

There is localised ponding within Growth Sector A, as seen in Figure 222 in Appendix AA. There is an overland flow path running east through the middle of Growth Sector A. Further downstream, this joins with other overland flow paths and is conveyed under Te Putu Street via a 1300 mm diameter concrete culvert (cTAU100). The flow path is then assumed to pass under the NMTL railway before the Gordonton Road Bridge via a culvert (cTAU101) and discharges to the Mangawara Stream.

The overland flow path running through Growth Sector A is affected by the downstream culverts cTAU100 and cTAU101, and therefore the ponding shown on the eastern side of Growth Sector A may be less significant if the bridge and culvert were included in a detailed flood model.

However, is also important to note that if Growth Sector A is developed, the area will become more impermeable and result in greater runoff flows to both cTAU100 and cTAU101. Both of these culverts should be investigated further to ensure they have adequate capacity for the 1% AEP storm event in the future, including development of Growth Sector A.

5.5.2 Growth Sector **B**

The potential ponding within Growth Sector B is extensive as shown in Figure 222 in Appendix AA, and covers approximately 40% of the Growth Sector. As discussed, there are two culverts downstream of Growth Sector A that may be causing an unfair representation of the extent of flooding. A more detailed analysis should be produced, including the bridges and culverts within the Taupiri SPA, to further assess whether Growth Sector B will be affected by flooding.

5.5.2.1 Infrastructure

Table 3 below summarises the existing critical infrastructure within the Taupiri SPA which is considered a potential restriction on the flow of major overland flow paths, watercourses or streams. Refer to Figure 222 in Appendix AA which shows the locations of these restrictions. The ponding model was used to determine which infrastructure assets were considered 'restrictions'. WDC have provided stormwater asset details but unfortunately this did not include the majority of culverts identified as constrictions.

Table 3. Summary of critical infrastructure

Infrastructure ID	Length (m)	Diameter (mm)	IL's – US/DS	Capacity check required?	Other notes
cTAU100	No data	1300	No data	Yes	-
cTAU101	No data	No data	No data	Yes	-

5.6 Summary of flooding issues

This section provides an assessment of the potential effects of flooding on the Taupiri SPA. The assessment includes an evaluation of ponding areas on 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 4.

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

- Low constraint to development have been categorised as Growth Sectors with large areas not affected by flooding, and overall no significant flood mitigation required.
- 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 and/or causing upstream flooding) would likely pose a significant constraint to development.

Table 4. Summary of flooding issues

Flooding Assessment	Growth Sector A - Residential	Growth Sector B - Residential
Existing buildings affected by ponding?	Yes	Yes
Existing potentially critical infrastructure	cTAU100, cTAU101	cTAU100, cTAU101
Overall constraint[1]	Low	Medium to High

1. Based on area affected by ponding and ability of the land use type to avoid or mitigate the adverse effects of flood hazards on the built environment.

5.7 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.
- Existing building floor levels to clarify potential flood vulnerability.
- More detailed information on future growth areas including road layout and waterway crossings.

6 References

Edbrooke, S. W. (2005). *Geology of the Waikato area. 1:250000 geological map 4. .* Lower Hutt: Institute of Geological and Nuclear Sciences.

Edbrooke, S. W., & Begg, J. G. (2005). *Geology of the Waikato area .* Lower Hutt: Institute of Geological & Nuclear Sciences.

Goodman, J. (2014). *Conservation status of New Zealand freshwater fish, New Zealand Threat Classification Series 7 .* Wellington: Department of Conservation .

Marshall, T. W., & Petch, R. A. (1985). *A Study of Groundwater and Surface Water Resources in the Hamilton Basin.* Waikato Valley Authority Technical Publication 30.

White, P. A., & Rosen, M. R. (2001). *Groundwaters of New Zealand.* Wellington: New Zealand Hyrological Society.

WRC. (2014, July 18). *Waikato Regional Council - Environment - Waikato River*. Retrieved from Waikato Regional Council: http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/Waikato-River/

7 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

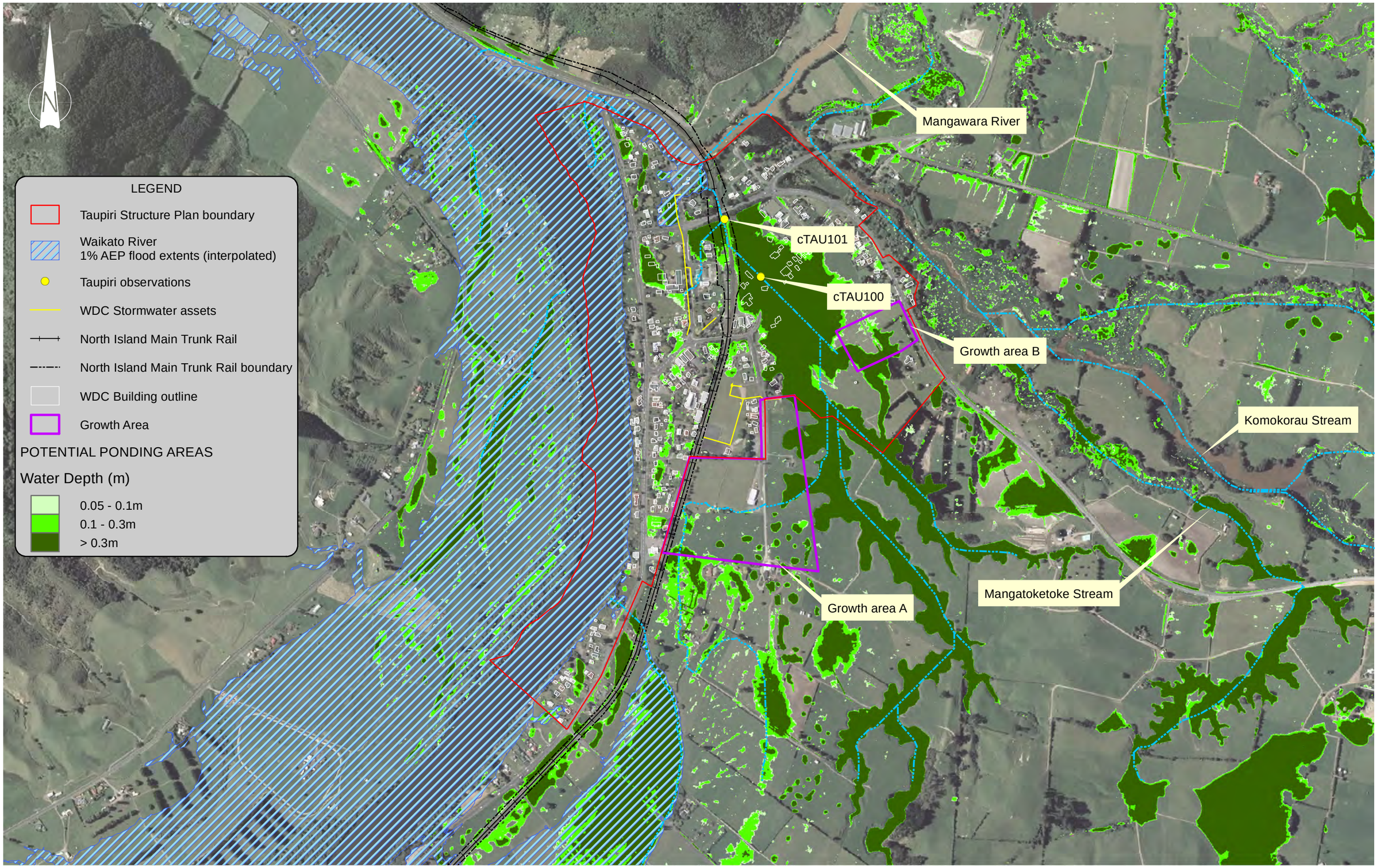
Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Elliot Smith/Bryn Quilter	Peter Cochrane
Civil Engineer/Project Manager	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 appendix a - taupiri final.docx

Appendix AA: Figures

- Figure 222 Flooding Map
- Figure 232 Ecological Map



Notes: Aerial photograph supplied by Waikato District Council

A3 SCALE 1:10,000

0 120 240 360 480 600 Meters

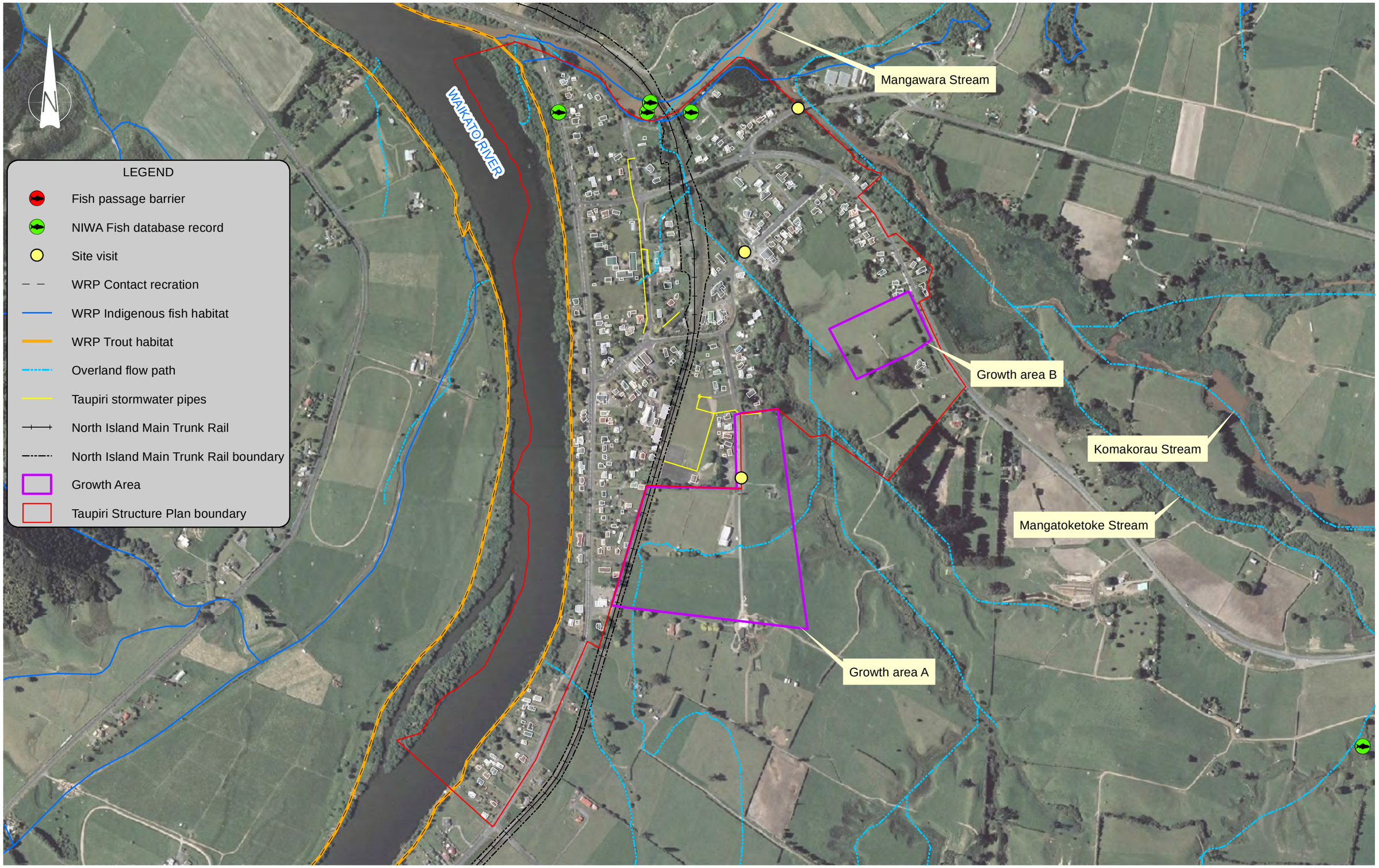
Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F222.mxd Date: 21/08/2014 Time: 11:25:37 a.m.

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMB	8/14
ARCFILE	61814.200-F222.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN OF TAUPIRI STRUCTURE PLAN AREA
Flooding Map

FIGURE No. Figure 222 | Rev. 0



Notes: Aerial photograph Copyright 2002-2005 Terralink International Limited

A3 SCALE 1:8,000

0 80 160 240 320 400 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMB	8/14
ARCFILE	61814.200-F232.mxd	
SCALE (AT A3 SIZE)	1:8,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN OF TAUPIRI STRUCTURE PLAN AREA
Ecological Map

FIGURE No. Figure 232 Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F232.mxd Date: 21/08/2014 Time: 11:32:01 a.m.

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

Appendix B: Horotiu CMP Assessment

REPORT

Waikato District Council

Appendix **B**

Catchment Management Plan
Horotiu Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Appendix **B**

Catchment Management Plan
Horotiu Structure Plan Area

Report prepared for:

Waikato District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2000

Table of contents

1 Catchment description

1.1 Location

The Horotiu SPA surrounds the township of Horotiu, and is located on the western side of the Waikato River, approximately 13 km north of Hamilton City. The Waikato Expressway and interchange with Great North Road is adjacent to the southeast boundary of the SPA. The North Island Main Trunk Line railway line runs through Horotiu. The location of the Horotiu SPA is presented in Figure 1. The SPA (red outline) covers approximately 258 ha.

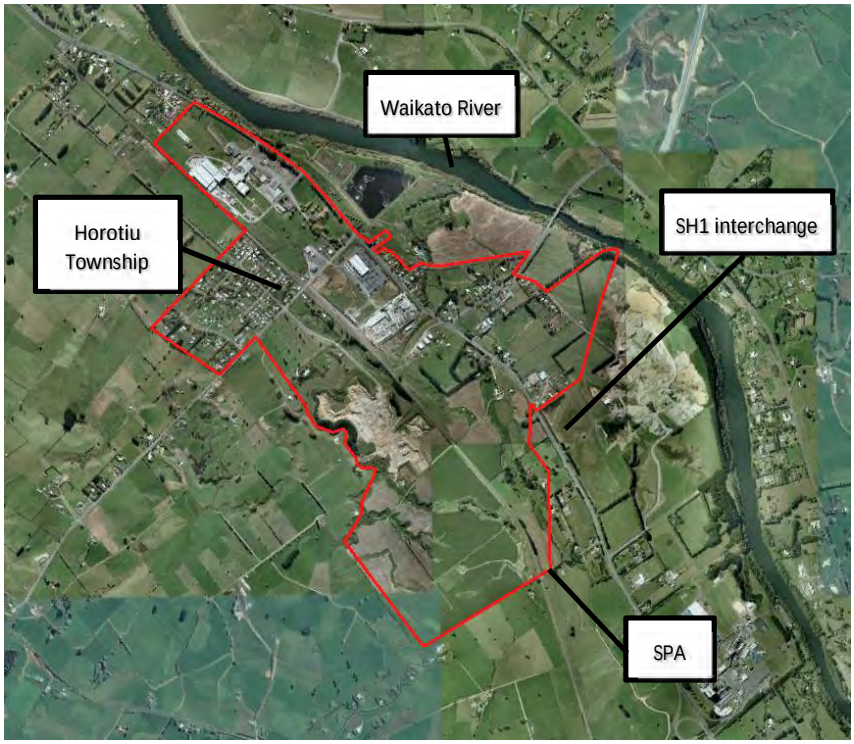


Figure 1. Horotiu SPA location (Image sourced from Google Earth, 2014)

1.2 Topography

The topography of the catchment and SPA comprises a relatively flat terrace incised by natural water courses including the Waikato River. The area generally falls to the northeast towards the Waikato River. There are low lying plains present beyond the southern and western boundaries of the SPA.

1.3 Geology and hydrogeology

The published geology of the area indicates that the majority of the Horotiu SPA is underlain by interbedded alluvial sands, silts and peats of the Hinuera Formation of the Piako Subgroup, overlying in places older sands and silts of the Walton Subgroup. Both the Pleistocene Age Walton Subgroup and the younger Holocene age Piako Subgroup are mapped as belonging to the Tauranga Group.

Recent alluvial sediments comprising sands, silts and peats are present in the bases of gullies or stream beds (Edbrooke, 2005) as shown in the Geological map in Figure 2 below.

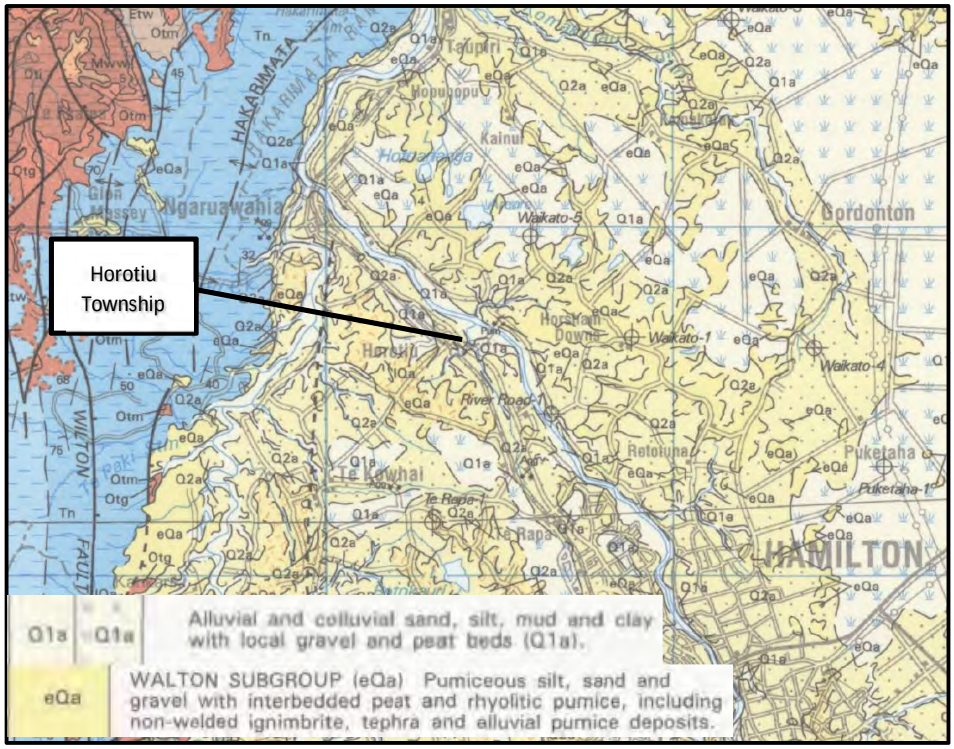


Figure 2. Geological map of Horotiu structure plan area

The hydrogeology of the Tauranga Group is characterised by a series of shallow unconfined and deeper semi-confined aquifers, which are variable in their horizontal and vertical distributions, and show varying degrees of connectivity with one another.

Groundwater is recharged from rainfall infiltration and a significant proportion of groundwater discharges to streams through the incised gullies. Marshall and Petch (1985) estimated that up to 85% of mean annual stream flow is sustained by groundwater discharges.

1.4 Watercourses

There are two main watercourses flowing through the existing Horotiu Township; the Te Rapa Stream and an unnamed tributary of Te Rapa Stream labelled tribHOR01. These streams are described below and shown (light blue) in Figure 3 below.

The Te Rapa Stream drains a portion of land in the east SPA and significant areas of rural land and industrial land in the north of Hamilton City. The upper and middle reaches south of the SPA receive runoff from Hamilton City and agricultural lands with the lower reach (the majority of which is within the SPA) receiving runoff from a mix of industrial and agricultural land. Only a small section of the land currently discharging to the unnamed tributary is residential land. Te Rapa Stream discharges into the Waikato River northeast of Horotiu just outside the SPA. From the Waikato River to its headwaters, the Te Rapa Stream is approximately 8.3 km long with approximately 6 km upstream of the SPA boundary.

The unnamed tributary drains the majority of the SPA and a significant portion of rural land to the southwest of the SPA. The upper reach southwest of the SPA receives runoff from mainly agricultural lands with the middle and lower reaches (the majority of which are within the SPA) receives runoff from a mix of industrial and agricultural land. As per the Te Rapa Stream, only a small section of the land currently discharging to the unnamed tributary is residential land. The unnamed tributary discharges into the Te Rapa Stream within the SPA.

The Waikato River runs adjacent to a small section of the SPA, with the remaining portion of the SPA separated from the Waikato River by agricultural land uses.

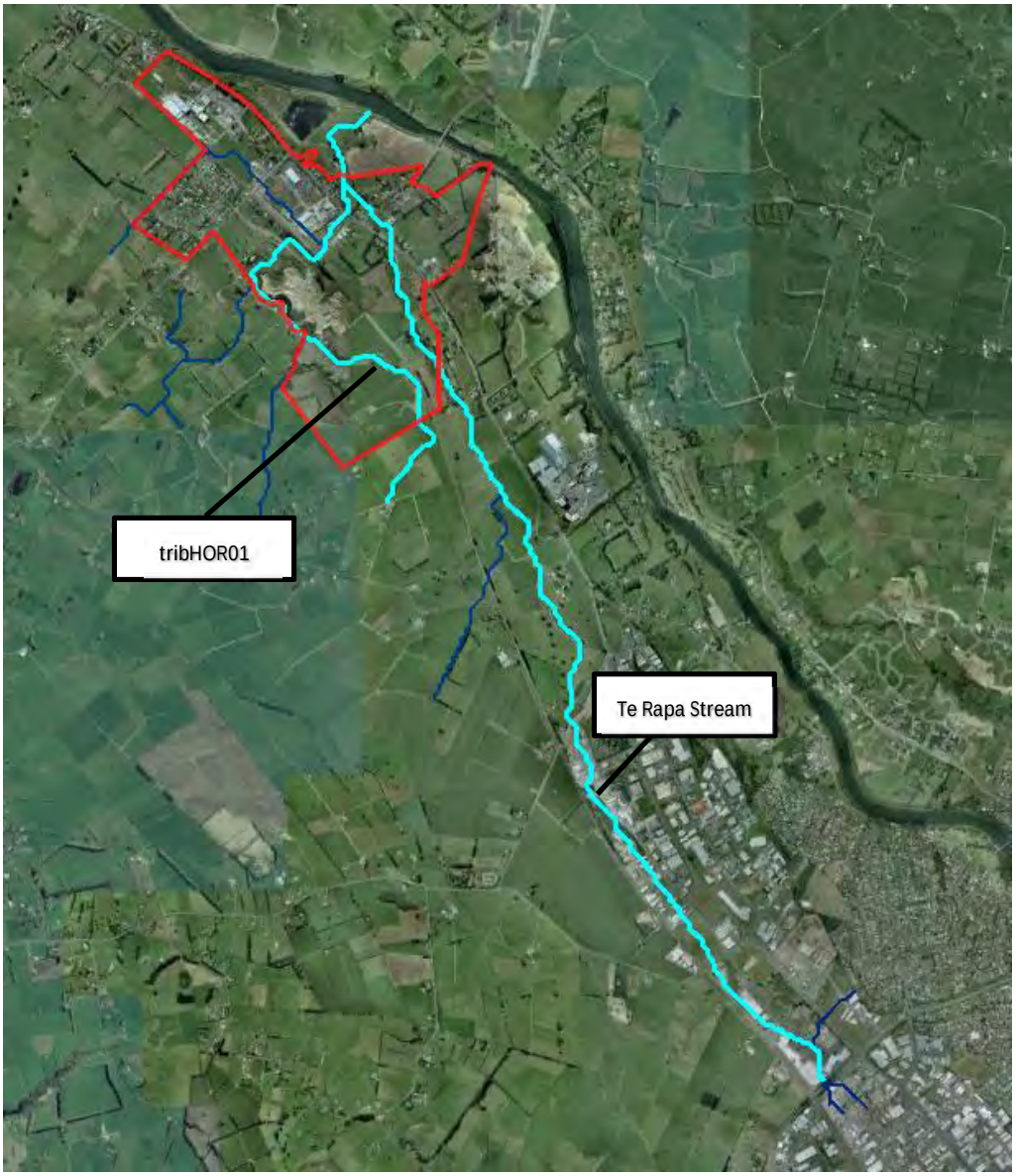


Figure 3. Main water courses (light blue) and tributaries (dark blue) within the catchment.

There are a number of smaller unnamed tributaries within the Horotiu SPA that feed into the Te Rapa Stream and tribHOR01. The unnamed tributaries drain a mixture of industrial, agricultural and residential land. These unnamed tributaries are shown in Figure 3 above.

There are also a number of small unnamed tributaries within and bordering the Horotiu SPA which drain directly to the Waikato River. The unnamed tributaries generally drain industrial and agricultural land. These tributaries also include the lower flood plain areas of the Waikato River.

Figures 242 to 243 in Appendix BA shows the locations of these streams, and their proximity to the Waikato River northeast of Horotiu.

1.5 Receiving environments

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

- Te Rapa Stream.
- Waikato River.
- Unnamed tributaries of the Waikato River.

1.6 Existing WRC resource consents

1.6.1 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	1	-
Discharge - Land	4	C(2)
Discharge - Water	5	-
Land Use – Bore/Well	1	-
Land Use – Other	4	-
Water Take - Ground	1	-
Water Take - Surface	0	-
Water Take - Other	2	-

1.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105653, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Horotiu.

Relevant extracts from the resource consent are reproduced below:

Consent Type:	Discharge permit
Consent Subtype:	Discharge to land and water
Activity authorised:	To divert and discharge urban stormwater and associated contaminants at multiple locations to land and a tributary of the Waikato River, and use discharge structures, within the Horotiu urban area.
Consent duration:	Granted for a period expiring on 22 September 2028

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

2 Land use in Horotiu

2.1 Current land use

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

The North Island Main Trunk Line (NMTL) railway line runs through the centre of the SPA and the centre of Horotiu. Key arterial routes to the north and south (SH 1 Waikato Expressway) and to the west and east (Horotiu Road) are notable transport corridors.

Horotiu is dominated by industrial land across the SPA. This industrial land includes AFFCO meatworks to the north, Waikato aggregates in the centre and the newly developed Northgate business park to the south. The residential areas of Horotiu Township are located in blocks in the western and eastern parts of the SPA. The remainder of land within the SPA is made up of agricultural land, within minimal commercial land.

2.2 Future land use

Future growth within the SPA has been provided by WDC and is shown in Figure 4 below. The figure shows that the future land use is anticipated to be only residential.

For reporting purposes, the growth area defined by WDC have been categorised into "Growth Sector" C. This is also presented in Figure 4. It is noted that the growth area provided by WDC and presented in Figure 4 extends beyond the SPA boundary provided by WDC.

Figure 4. Horotiu growth plan provided by WDC and Growth Sector used for reporting

3 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Horotiu SPA. The assessment is based on a review of existing ecological information with a brief site visit to publicly accessible parts of the SPA.

3.1 Assessment methods

There has been no ecological assessments of Horotiu and its surrounds provided by Waikato District Council. Our assessment has reviewed the information available within national and regional ecological databases.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 9 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 252 in Appendix BA.

3.2 Summary of existing ecological information

3.2.1 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Horotiu SPA is included on Planning Map 20 and 26. There was no ecological features of note within the Horotiu SPA.

3.2.2 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.

The Waikato River is classified as Indigenous Fish Habitat Area (Map S14). This classification is applied to significant habitats or areas that are characterised by high water quality.

The Waikato River is also designated as Trout Habitat and Contact Recreation.

All permanent watercourses within the area are classified as Waikato Surface Water (Map S14) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

3.3 T&T's 2014 field assessment

A site inspection of publicly accessible locations on the Te Rapa stream and its unnamed tributaries within the SPA was conducted on 9 April, 2014. Locations inspected are shown on Figure 252 in Appendix BA.

Observations from site inspections concluded that majority of the stream channel was open and in places had large areas of macrophyte growth within stream channel. 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 land use in the catchment. In places along the main stream channel macrophyte growth had been sprayed to increase the drainage capacity.

In-stream habitat at the sites inspected was generally limited to slow moving runs and pools with undercut banks, and overhanging vegetation present at limited locations. There was a lack of large woody debris providing hard substrate habitat for macroinvertebrate species. Schools of the At Risk species inanga (*Galaxias maculatus*) were observed upstream and downstream of the

culvert under Horotiu Bridge Rd (Goodman et al., 2014). It is noted that inanga are present within the catchment and are classified as nationally vulnerable (Goodman et al, 2014).

No barriers to upstream fish passage were identified within the SPA. The culvert under Horotiu Bridge Rd had been retrofitted with baffles and riprap to attenuate flow. The culvert under Washer Rd has recently been replaced with fish passage provided. Culverts under the state highway and the North Island Main Trunk Line were not able to be assessed due to no access being available. The ability of fish to migrate upstream of these points is unknown.

4 Ecological assessment

4.1 Introduction

This section provides an assessment of the potential effects of development of the Horotiu SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report. This section provides an assessment of the significance of these issues for each of the growth areas identified by WDC.

4.2 Assessment of effects

The main ecological issues associated with future urban development in the Horotiu SPA are described below and the significance of proposed development to a range of issues for each growth area is presented in Table 2.

Table 2. Significance of potential adverse effects from proposed development

Growth Sector	C - Low density residential
Issue	
Stormwater	
Contaminants	Low
Increase in peak flows leading to stream bed/bank erosion	Low
Hydrological	
Reductions in base flow	Low
Reduction in flow variability leading to reduced habitat quality	Low
Habitat	
Culverting or infilling of perennial streams reducing habitat	Low
Protection of riparian margins	Low to medium
Barriers to fish movement	Low
Overall potential adverse effect on surface water	Low

5 Flood assessment

5.1 Introduction

A ponding map of the Horotiu SPA has been produced. The purpose of the ponding map is to determine the areas which may be inundated if no pipe network is available. The ponding map is a valuable tool to provide an indication of where potential flooding hazards may occur and where future modelling efforts should be concentrated. This approach assumes that the reticulated network (pipes, culverts and catchpits) are blocked but does include rainfall-runoff analysis.

5.2 Methodology

To create the ponding maps, a GIS tool has been used to infill and map all topographic depressions based on the LiDAR survey provided. We note that LiDAR provided was collected in 2007 and 2008 so is considered somewhat out of date. The mapped depressions represent all areas where stormwater could *potentially* pond.

A key issue 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 caused by road embankments, bridges or culverts.

From the ponding maps, critical areas have been identified and a field assessment has been undertaken to identify sub-surface drainage features that could significantly affect the ponding areas shown.

The key culverts that may influence the ponding areas have been identified on Figures 242 and 243 in Appendix BA and also in Table 3.

5.3 Information provided by WDC

5.3.1 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.

Stormwater from the village is generally collected via open drains and is eventually discharged into the Waikato River to the northeast, or its tributaries to the west of the village. There is limited stormwater reticulation within Horotiu.

5.3.2 Buildings

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

5.3.3 Drainage operational issues

No drainage issues or flood reports were noted or provided by WDC. Land drainage around Horotiu is part of the Te Rapa Drainage Scheme.

5.3.4 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 as well as an interpolated 2D flood extent.

The WRC cross sections indicate that the Waikato River 1% AEP (with no climate change) flood level ranges from approximately 15 mRL to 14.8 mRL within the Horotiu SPA. The interpolated 1% AEP river flood extents (with no allowance for climate change) are presented in Figures 242 to 243 in Appendix BA.

5.4 Reporting

For reporting purposes, the area of potential growth has been labelled a "Growth Sector". Within the Horotiu SPA, there is one Growth Sector – C. The location of this Growth Sector can be seen in Figure 4 above and Figures 242 to 243 in Appendix BA. The Growth Sector contains only proposed residential land.

5.5 Results

The results from the ponding assessment are presented in Figures 242 and 243 in Appendix BA. The ponding assessment entails a high level overview of the model provided in these figures and reviews the feasibility of the proposed residential area.

Flooding of the Growth Sector has been reviewed in the following sections. The areas within the SPA but outside of the proposed growth area have not been considered as they are existing and not anticipated to change.

5.5.1.1 Growth Sector C

Growth Sector C is generally bounded by the Waikato Expressway to the southeast, agricultural land to the northwest and northeast and rural land to the southeast. The Thermal Explorer Highway (formerly SH1) passes north south through the SPA.

The unnamed tributary tribHOR01 flows through the western section of the growth sector from underneath the Thermal Explorer Highway (cHOR101), while the Te Rapa Stream flows into the growth sector from beneath Horotiu Bridge Road (cHOR102). The confluence of these two streams is upstream of a culvert under Washer Road (cHOR100) within the growth sector. Both tribHOR01 and the Te Rapa Stream above are incised channels and subject to backwater flooding from the Waikato River. These channels will also be prone to flooding during large storm events.

Key waterway structures in the area of the growth sector have the potential to restrict flow and/or block and create localised flooding or overland flow paths. Culverts on tribHOR01 may restrict flow and cause flooding upstream and/or create an alternative overland flow path, most likely over the road. Culverts cHOR101 and cHOR102 are on the edge of the growth sector and have the potential to create overland flow paths into the growth sector.

As these streams have localised restrictions which are subject to flooding, these areas will need to be managed accordingly with any development or the border or the growth sector may need to be altered to exclude these streams.

There is a potential overland flow path flowing over Horotiu Bridge Road and into the growth sector as identified as olfHOR01. No culvert has been identified at this location and there is no incised channel to indicate a culvert.

Within the growth sector there are isolated low areas subject to flooding which will need to be managed with any development in the growth sector through local contouring and/or drainage systems.

The area is not significantly affected by flooding from the Waikato River although there are some backwater effects within the Te Rapa Stream up to the Thermal Explorer Highway.

5.5.1.2 Infrastructure

Table 3 below summarises the existing critical infrastructure within the Horotiu SPA which is considered a potential restriction on the flow of major overland flow paths, watercourses or streams. Refer to Figure 242 and 243 in Appendix BA which shows the locations of these restrictions. The ponding map was used to determine which infrastructure assets were considered 'restrictions'. WDC have provided stormwater asset details but unfortunately this did not include the majority of culverts and bridges identified herein as constrictions.

Table 3. Summary of critical infrastructure

Infrastructure ID	Length (m)	Diameter (mm)	IL's – US/DS	Capacity check required?	Other notes
cHOR100	No data	4000 high, 3000 wide box	No data	Yes	New culvert
cHOR101	No data	No data	No data	Yes	-
cHOR102	No data	2400	No data	Yes	-

5.6 Summary of flooding issues

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

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

- Low constraint to development has been categorised as a growth sector with large areas not affected by flooding, and overall no significant flood mitigation required.
- 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 and/or causing upstream flooding) would likely pose a significant constraint to development.

Table 4. Summary of flooding issues

Flooding Assessment	Growth Sector C - Residential
Existing buildings affected by ponding?	Yes
Existing potentially critical infrastructure	cHOR100
Overall constraint[1]	Low

1. Based on area affected by ponding and ability of the land use type to avoid or mitigate the adverse effects of flood hazards on the built environment.

5.7 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.
- Existing building floor levels to clarify potential flood vulnerability.
- More detailed information on future growth areas including road layout and waterway crossings.

6 References

Edbrooke, S. W. (2005). *Geology of the Waikato area. 1:250000 geological map 4.* Lower Hutt: Institute of Geological and Nuclear Sciences.

Goodman, J. (2014). *Conservation status of New Zealand freshwater fish, New Zealand Threat Classification Series 7 .* Wellington: Department of Conservation .

Marshall, T. W., & Petch, R. A. (1985). *A Study of Groundwater and Surface Water Resources in the Hamilton Basin.* Waikato Valley Authority Technical Publication 30.

NIWA. (2004). *New Zealand River Environment Classification.* Wellington: Ministry for the Environement.

T&T Ltd. (2009). *Waikato District council Stormwater Management Plan.* Hamilton: Tonkin & Taylor Ltd. .

T&T Ltd. (2014). *Waikato District Council Ngaruawahia Structure Plan area Preliminary contaminated land assessment.* Hamilton : Tonkin & Taylor Ltd.

White, P. A., & Rosen, M. R. (2001). *Groundwaters of New Zealand.* Wellington: New Zealand Hyrological Society.

WRC. (2014, July 18). *Waikato Regional Council - Environment - Waikato River*. Retrieved from Waikato Regional Council: http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/Waikato-River/

7 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:
.....	.....
Regan Robinson/Bryn Quilter	Peter Cochrane
Civil Engineer/Project Manager	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 appendix b - horotiu final.docx

Appendix BA: Figures

- **Figures 242 & 243 Flooding Maps Sheets 1 & 2**
- **Figure 252 Ecological Map**

LEGEND

- Horotiu Structure Plan boundary
- Waikato River 1% AEP Flood Extents (interpolated)
- Horotiu observations
- WDC Stormwater assets
- WDC Building outlines
- Growth area
- State Highway 1 designation
- North Island Main Trunk Rail boundary
- North Island Main Trunk Railway

POTENTIAL PONDING AREAS

Water Depth (m)

- 0.05 - 0.1m
- 0.1 - 0.3m
- > 0.3m

cHOR100

olfHOR01

Growth area C

cHOR101

cHOR102

Horotiu sand quarry

Notes: Aerial photograph supplied by Waikato District Council
State Highway 1 designation supplied by: NZ Transport Agency.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

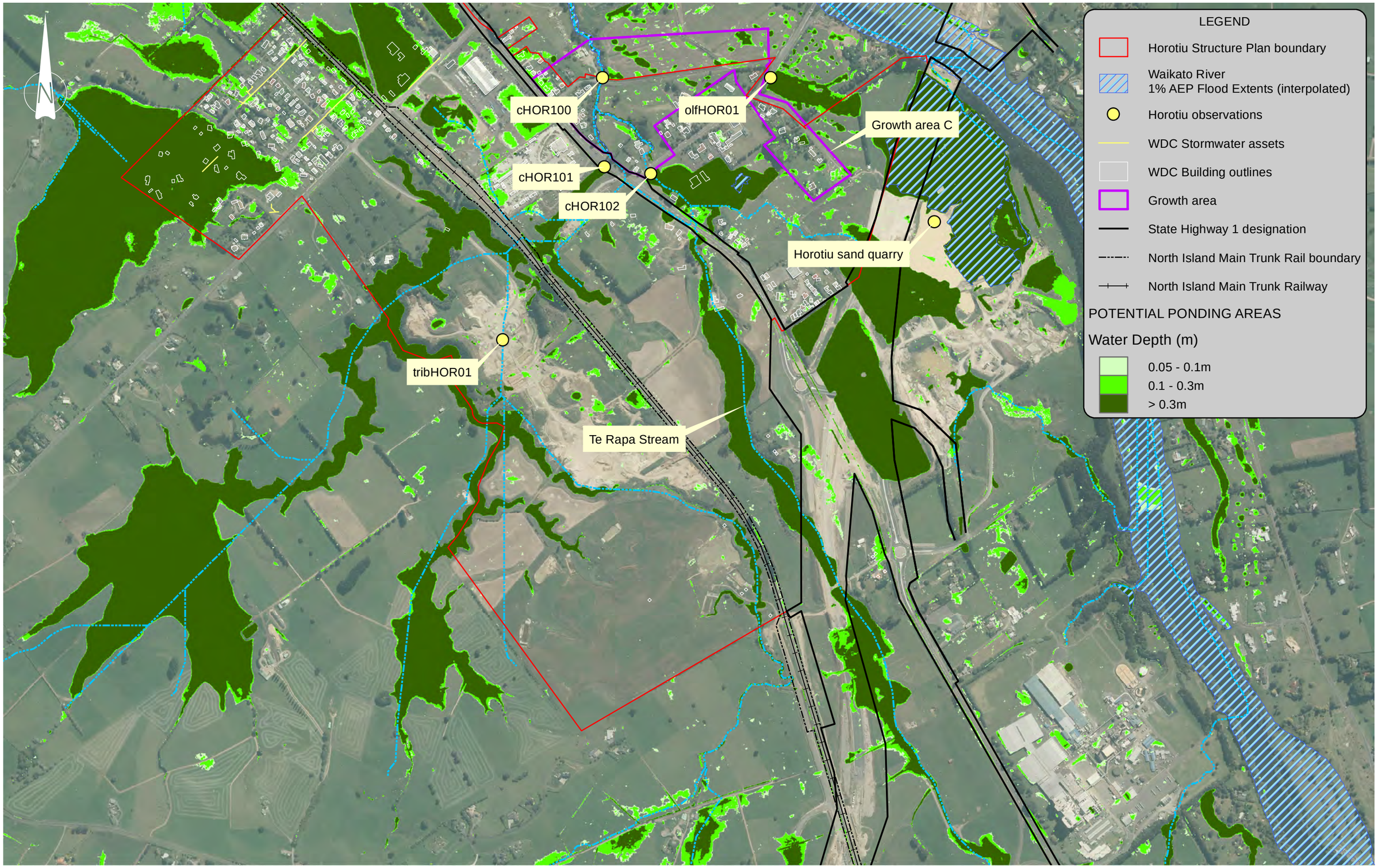
DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMB	8/14
ARCFILE	61814.200-F242_243.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
HOROTIU STRUCTURE PLAN AREA
Flooding Map - Sheet 1 of 2

FIGURE No. Figure 242

Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F242_243.mxd Date: 21/08/2014 Time: 11:36:44 a.m.



Notes: Aerial photograph supplied by Waikato District Council
State Highway 1 designation supplied by: NZ Transport Agency.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

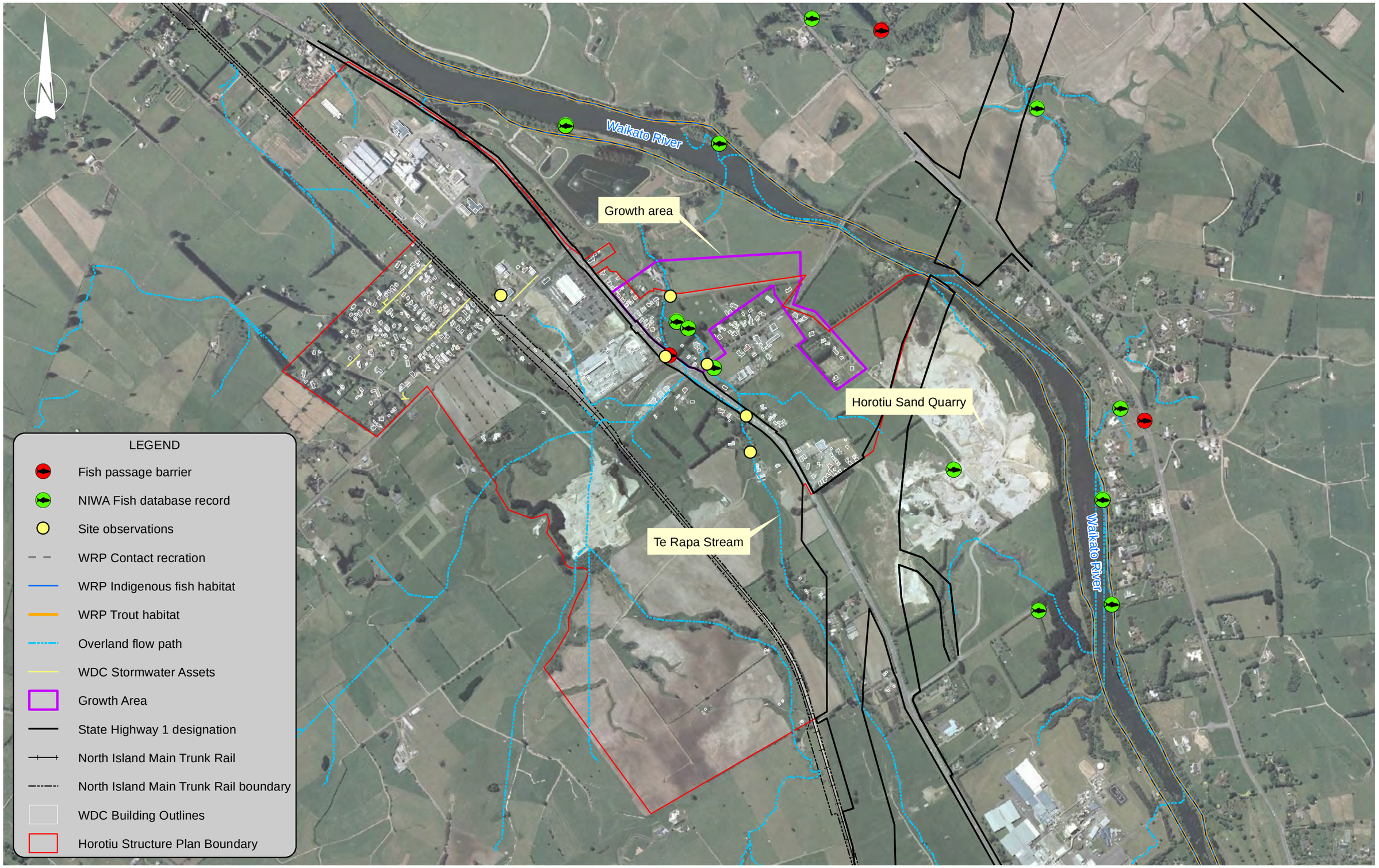
DRAWN	DWM	Aug.14
CHECKED	PRC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F242_243.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

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

FIGURE No. Figure 243

Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F242_243.mxd Date: 21/08/2014 Time: 11:36:49 a.m.



Notes: Aerial photograph Copyright 2002-2005 Terralink International Limited

A3 SCALE 1:12,500

0 150 300 450 600 750 Meters

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F252.mxd Date: 21/08/2014 Time: 11:49:22 a.m.

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F252.mxd	
SCALE (AT A3 SIZE)	1:12,500	
PROJECT No.	61814.200	

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

FIGURE No. Figure 252

Rev. 0

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

Appendix C: Ngaruawahia CMP Assessment

REPORT

Waikato District Council

Appendix C

Catchment Management Plan
Ngaruawahia Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Appendix **C**
Catchment Management Plan
Ngaruawahia Structure Plan Area

Report prepared for:
Waikato District Council

Report prepared by:
Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2000

Table of contents

1 Catchment description

1.1 Location

The Ngaruawahia Structure Plan Area (SPA) surrounds the central Waikato township of Ngaruawahia, located approximately 17 km northwest of Hamilton City. Ngaruawahia is located at the confluence of the Waipa and Waikato Rivers. The location of the Ngaruawahia SPA is presented in Figure 1. The SPA (red outline) covers approximately 780 ha. The structure plan area is bounded by the Hakarimata Ranges to the west, and by rural land to the north, east and south. The North Island Main Truck railway line runs through the centre of the structure plan area, following Great South Road through the centre of Ngaruawahia Township.

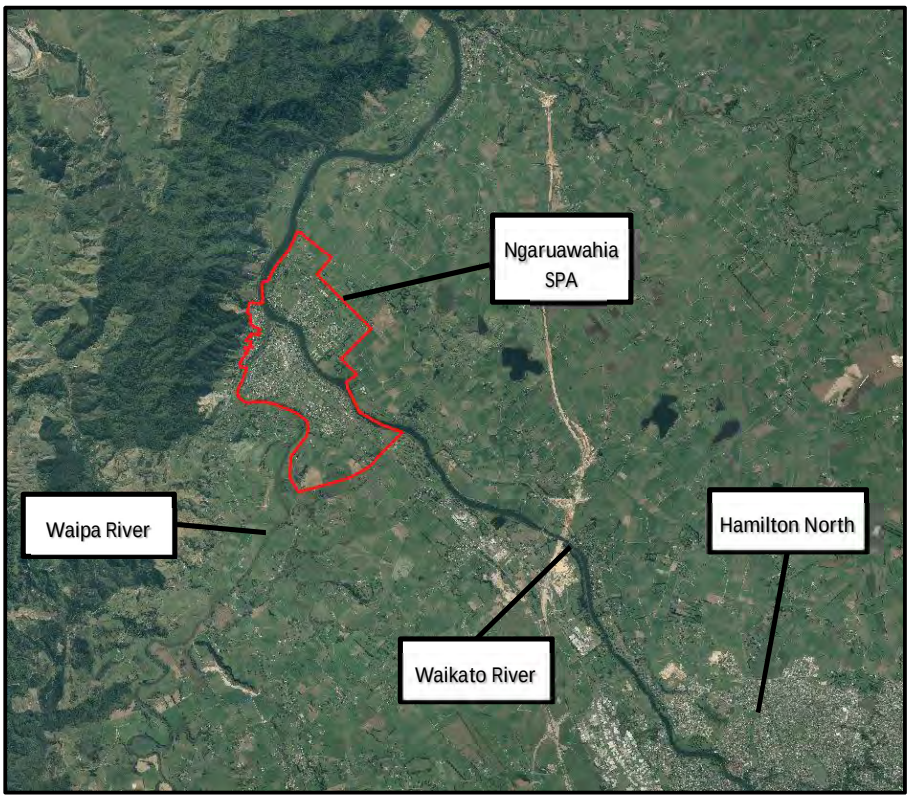


Figure 1. Ngaruawahia SPA (Image sourced from WDC)

1.2 Topography

The topography of the SPA is mainly flat and the area is dominated by the incised channels of the Waikato and Waipa Rivers. Near these features, the land generally slopes down gently to meet river levels. The southern part of the structure plan area is more undulating. Immediately beyond the western boundary lies the Hakarimata Ranges which rise steeply above the surrounding river terraces.

1.3 Geology and hydrogeology

The published geology of the area shows that the majority of the Ngaruawahia structure plan area is underlain alluvial and colluvial deposits of the Piako Subgroup (Edbrooke S. , 2005) as shown in the geological map below. The Ngaruawahia Township is underlain by the Hinuera Formation which comprises cross-bedded pumice sand, silt and gravel with interbedded peat. Along the river

channels, Taupo Formation pumice alluvium is present which comprises pumice sands and gravels. In the eastern part of the structure plan area, north of the Waikato River, swamp deposits consisting of soft, dark brown to black, organic-rich mud, muddy peat and woody peat are present.

The low hills in the southern part of the structure plan area are underlain by older Walton Subgroup deposits comprising pumiceous alluvium and colluvium dominated by primary and reworked, non-welded ignimbrite.

The SPA abuts the Hakarimata Range which comprise older greywacke rocks of the Newcastle Group.

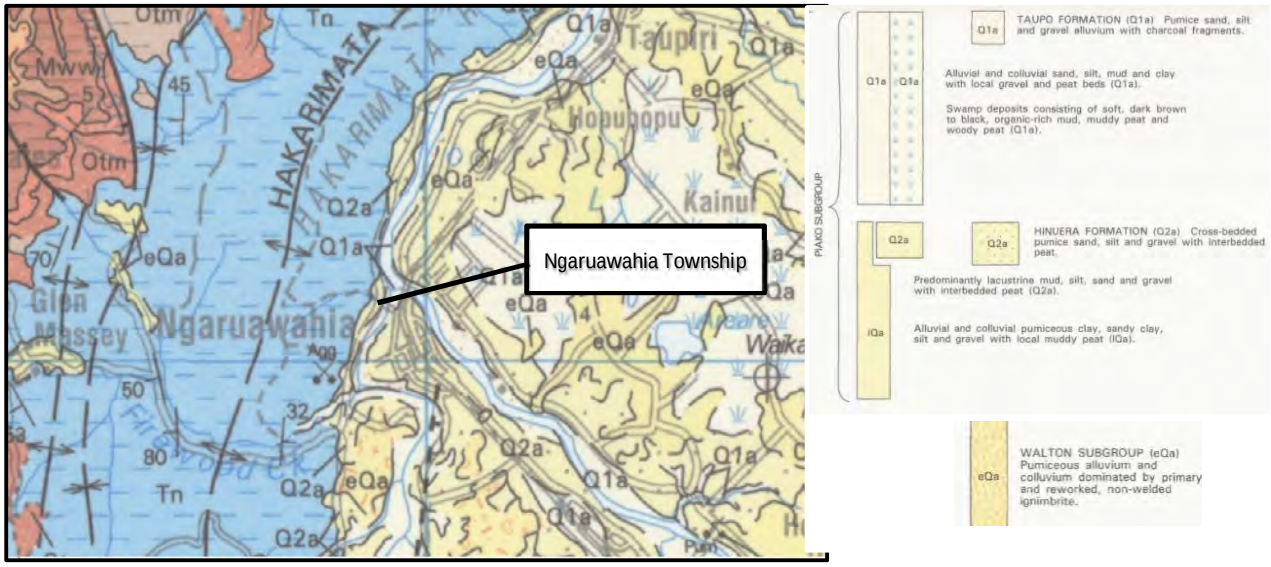


Figure 2. Geological map of Ngaruawahia structure plan area.

The hydrogeology of the Tauranga Group is characterised by a series of shallow unconfined and deeper semi-confined aquifers, which are variable in their horizontal and vertical distributions, and show varying degrees of connectivity with one another.

Groundwater is recharged from rainfall infiltration (and on the western side of the SPA some recharge from the Hakarimata Range) and a significant proportion of groundwater discharges to streams through the incised gullies. Marshall and Petch (1985) estimated that up to 85% of mean annual stream flow is sustained by groundwater discharges.

1.4 Watercourses

Two main watercourses dominate the existing Ngaruawahia Township and the SPA; the Waikato River and the Waipa River. The Mangaheka Stream is also a significant tributary stream within the southern SPA. The Mangarata Stream receives runoff from the Hakarimata Range to the west of the township but only 150m of the stream is actually within the SPA before is discharges into the Waipa River just upstream of the confluence with the Waikato. There are also multiple overland flow paths running through the Ngaruawahia SPA which feed into these water courses.

The rivers and streams are described in more detail and shown in Figure 3 below.

The Waipa River is the largest tributary of the Waikato River (Waikato Regional Council, 2014). The river generally follows the western side of the SPA. At approximately 71B Waingaro Road, the SPA extends west and encompasses the Waipa River until the river discharges to the Waikato

River. The catchment of the Waikato and Waipa Rivers is dominated by agricultural land uses, but also comprises multiple towns, villages and all manner of other land uses.

The Mangaheka Stream, located to the south of the SPA, drains mainly agricultural land and discharges into the Waipa River.

The Mangarata Stream, located to the west of the SPA, drain the Hakarimata ranges and discharges into the Waipa River, just upstream of the confluence of the Waipa and Waikato Rivers.

There are a number of tributaries within the Ngaruawahia SPA that feed into the above water courses. The unnamed tributaries generally drain residential and farmland, and can be seen in Figure 3.

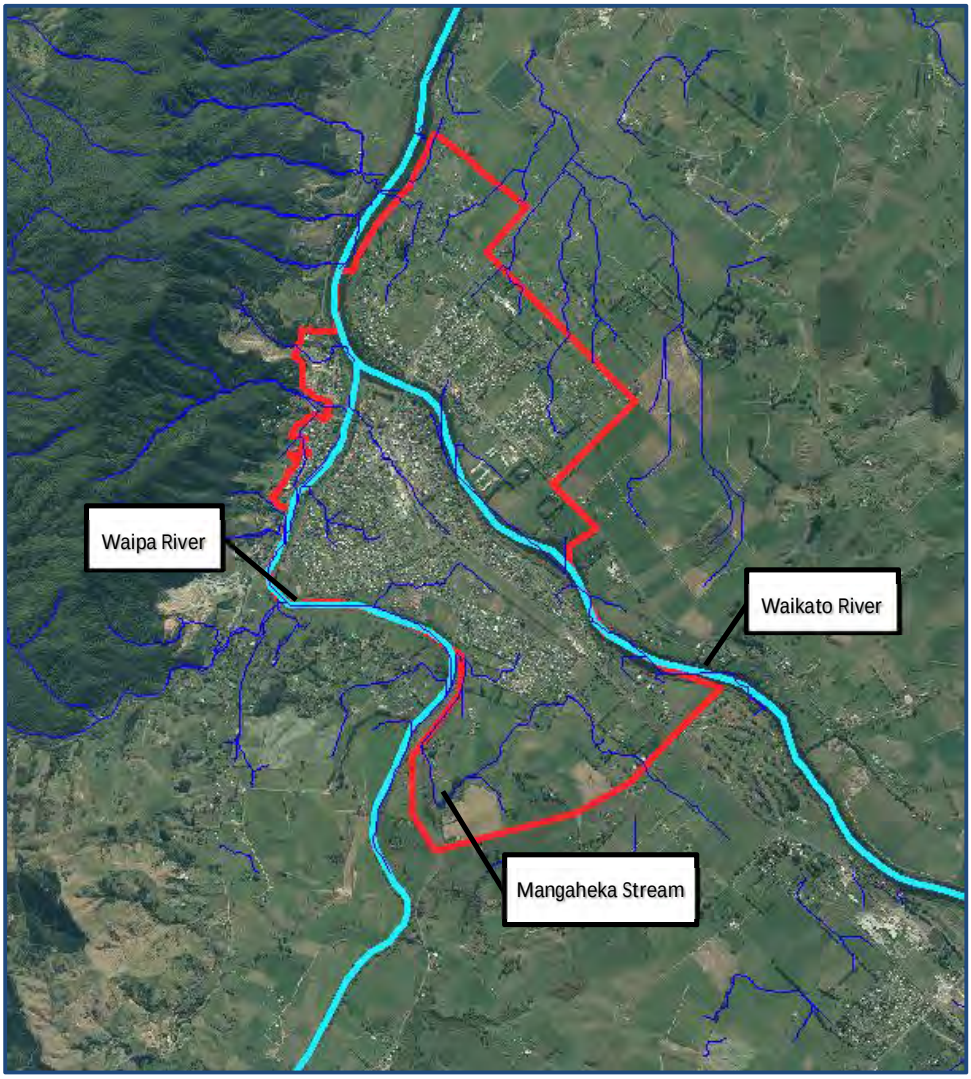


Figure 3. Main water courses (light blue) and tributaries (dark blue) surrounding the SPA.

1.5 Receiving environments

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

- Waikato River.
- Waipa River.

- Mangaheka Stream.
- Mangarata Stream
- Unnamed tributaries of all of the above.

1.6 Existing WRC resource consents

1.6.1 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	0	-
Discharge - Land	1	-
Discharge - Water	1	-
Land Use – Bore/Well	2	-
Land Use – Other	3	-
Water Take - Ground	1	F
Water Take - Surface	1	-
Water Take - Other	1	D

1.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105645, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Ngaruawahia.

Relevant extracts from the resource consent are reproduced below:

Consent Type:	Discharge permit
Consent Subtype:	Discharge to land and water
Activity authorised:	Divert & discharge urban stormwater & associated contaminants at multiple locations to the Waikato River, Waipa River & land, & use discharge structures, within the vicinity of Ngaruawahia urban area
Consent Duration:	Granted for a period expiring on 22 September 2028

It is noted that the extent of the above consent (reticulated urban area of Ngaruawahia) is somewhat smaller than the extent of the SPA, with the SPA extending further north and south.

2 Land use in Ngaruawahia

2.1 Current land use

The land within the SPA is dominated by Ngaruawahia which includes residential, commercial and industrial land used. Agricultural land dominates the remainder of the SPA, beyond the current urban boundary. Other land uses currently occurring within the SPA include rural residential and limited horticultural land use. The North Island Main Trunk railway line runs through the centre of the SPA, following State Highway 1 through the centre of Ngaruawahia Township.

The main commercial/retail area of Ngaruawahia is located in the centre of the SPA, between State Highway 1 and the Waikato River. Established industrial areas are located to the west of the town centre, and further south, adjacent to the rail corridor. Residential areas make up the bulk of the Ngaruawahia urban area which surrounds the town centre, and extend to the western boundary of the SPA.

Outside of the township, the SPA is dominated by pastoral land with some rural residential development. Individual blocks of horticultural and industrial land use are present within the rural parts of the SPA.

Immediately west of the SPA, on the slopes of the Hakirimata Range, there is also hard rock (aggregate) quarry activities.

2.2 Future land use

Future growth within the SPA has been provided by WDC and is shown in Figure 4 below. The figure shows that the future land use is anticipated to be only residential zones.

For reporting purposes, the growth areas defined by WDC have been categorised into “Growth Sectors” D, E and F. These are also presented in Figure 4.

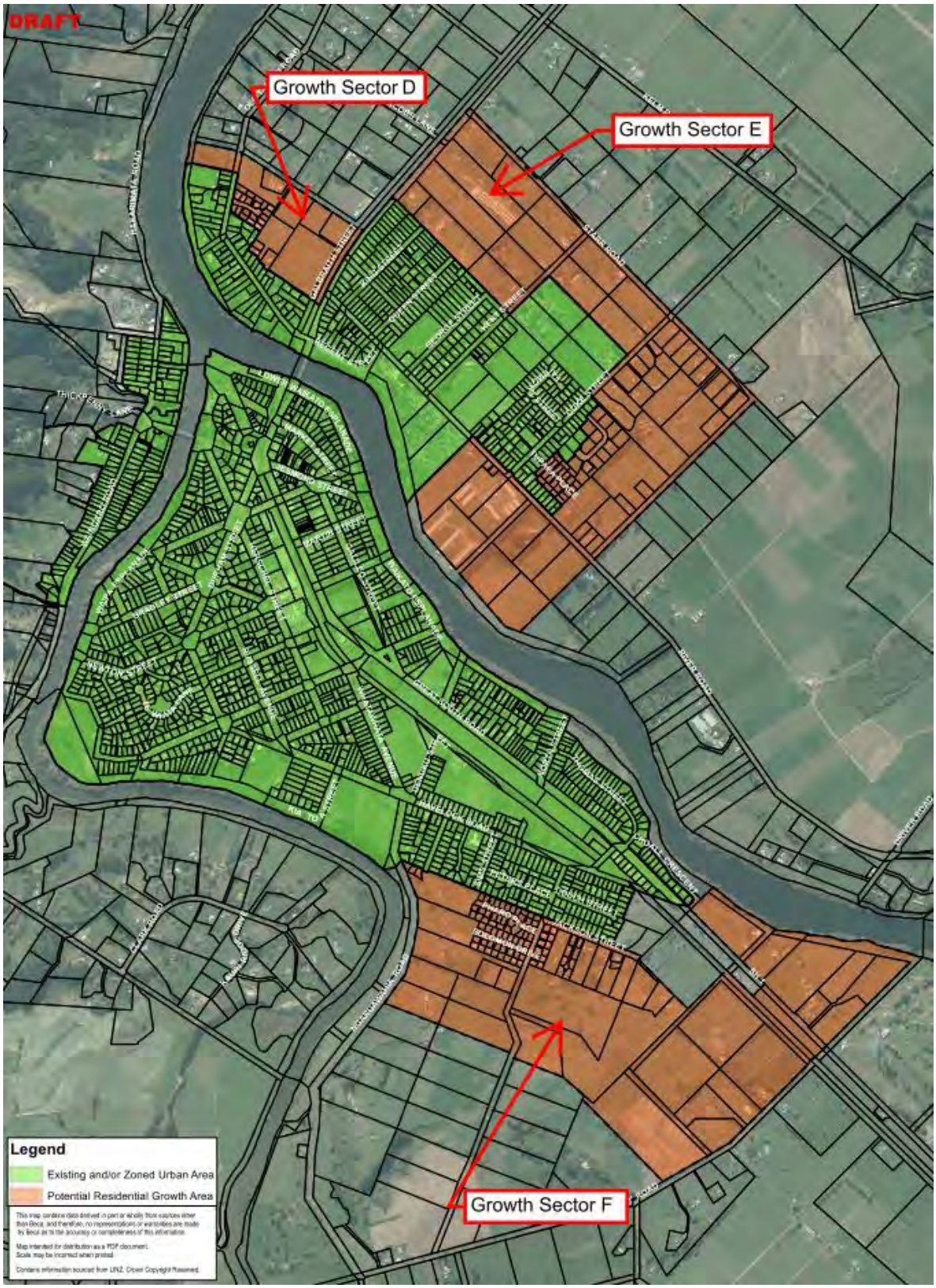


Figure 4. Ngaruawahia growth plan provided by WDC and Growth Sectors used for reporting.

3 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Ngaruawahia SPA. The assessment is based on a review of existing ecological information with a brief site visit to publicly accessible parts of the SPA.

3.1 SPA overview

3.2 Assessment methods

There has been no ecological assessments of Ngaruawahia and its surrounds provided by Waikato District Council. Our assessment has reviewed the information available within national and regional ecological databases.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 9 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 212 in Appendix CA.

3.3 Summary of existing ecological information

3.3.1 Waikato District Council Stormwater Management Plan (Tonkin & Taylor, 2009)

The 2009 SMP summarised the results of thirteen random samples of Ngaruawahia stormwater collected and analysed from several outlet points and several different storm events between 2000 and 2004. The report concluded that the stormwater quality was generally similar to average concentrations of contaminants in urban stormwater contained in published literature.

3.3.2 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Ngaruawahia SPA is included on Planning Map 20 and 26. There was no ecological features of note within the Ngaruawahia SPA.

3.3.3 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.

The Waikato and Waipa Rivers and unnamed streams draining the Hakarimata Range on the western side of the SPA are classified as Indigenous Fish Habitat Areas (Map S14). This classification is applied to significant habitats or areas that are characterised by high water quality.

The Waikato and Waipa Rivers are also designated as Trout Habitat and Contact Recreation.

Some reaches of the unnamed streams that are within the Hakarimata Range have also been classified as Natural State and Priority 1 Stock Exclusion areas (Stock Exclusion Map 4)

All permanent watercourses within the area are classified as Waikato Surface Water (Map S14) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

3.4 T&T's 2014 field assessment

A site inspection of publicly accessible locations on the unnamed tributaries within the SPA was conducted on 9 April, 2014. Locations inspected are shown on Figure 212 in Appendix CA.

Observations from site inspections concluded that streams were in range of conditions based on catchment size and land use.

The unnamed streams that drain the Hakarimata Range were typically of high quality due to the high percentage of native vegetation cover. The lower reaches of theses streams had been negatively affected by development due to a reduction in riparian cover allowing excessive macrophyte growth. Instream habitat was generally run type habitat with small sections of shallow pools or riffles. Barriers to upstream fish passage were identified under the Waingaro Rd and Hakarimata Rd. These consisted of perched culverts, it is likely that the migration of fish species will be impeded by these culverts under normal flow conditions. At times where water level within the Waikato River are high these culverts may become passable.

Streams draining the central urban area were intermittent and had no flow on the day of the site visit. Streams within the area were highly modified with large sections culverted or have undergone channel straightening. Perched culverts or flood protection devices restricted upstream fish passage.

The watercourses to the east of Waikato River, including growth areas D and E, have been modified into farm and roadside drains that have little ecological value. These watercourses are intermittent/ephemeral and were dry at the time of site inspection.

The Mangaheka Stream to the south of the Ngaruawahia SPA, within growth area F, is a permanent stream that has undergone significant modification. Large sections of the stream channel have been straightened (presumably to increase drainage capacity) reducing the availability of some habitat types. There was excessive macrophyte and periphyton growth within the lower stream reaches. 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 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. There was also lack of large woody debris providing hard substrate habitat for macroinvertebrate species. Upstream from Ngaruawahia Rd there is a large area of wetland that is possible habitat for the At Risk black mudfish (*Neochanna apoda*) (Goodman et al, 2014). Perched culverts under Ngaruawahia Rd and Saulbery Rd were identified as barriers to upstream fish passage. It is likely that migration of non-climbing fish species such as inanga, would be impeded by these barriers. It is noted that lampery (*Geotria australis*) are present with in SPA and are classified as nationally vulnerable (Goodman et al, 2014).

4 Ecological assessment

4.1 Introduction

This section provides an assessment of the potential effects of development of the Ngaruawahia SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report. This section provides an assessment of the significance of these issues for each of the growth areas identified by WDC.

4.2 Assessment of effects

The main ecological issues associated with future urban development in the SPA are described in Section 2 of the main report. The significance of proposed development to a range of issues for each growth area is presented in Table 2.

For the Ngaruawahia SPA, zero and first order streams are located within growth areas and therefore are considered to be more vulnerable to effects of development on hydrological issues.

Table 2. Significance of potential adverse effects from proposed development

Growth Sector / Issue	D - Low density residential	E - Low density residential	F - Low density residential
Stormwater			
Contaminants[1]	Low	Low	Low
Increase in peak flows leading to stream bed/bank erosion	Low	Low	Low
Hydrological			
Reductions in base flow[2]	Low	Low	Low
Reduction in flow variability leading to reduced habitat quality	Low	Low	Low to Medium
Habitat			
Culverting or infilling of perennial streams reducing habitat	Low	Low	Low to medium
Protection of riparian margins[3]	Low	Low	Low to medium
Barriers to fish movement	Low	Low	Low
Overall potential adverse effect on surface water	Low	Low	Low to Medium

5 Flooding assessment

5.1 Introduction

A ponding map of the Ngaruawahia SPA has been produced. The purpose of the ponding map is to determine the areas which may be inundated if no pipe network is available. The ponding map is a valuable tool to provide an indication of where potential flooding hazards may occur and where future modelling efforts should be concentrated. This approach assumes that the reticulated network (pipes, culverts and catchpits) are blocked but does include rainfall-runoff analysis.

5.2 Methodology

To create the ponding maps, a GIS tool has been used to infill and map all topographic depressions based on the LiDAR survey provided. We note that LiDAR provided was collected in 2007 and 2008 so is considered somewhat out of date. The mapped depressions represent all areas where stormwater could *potentially* pond.

A key issue 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 caused by road embankments, bridges or culverts.

From the ponding maps, critical areas have been identified and a field assessment has been undertaken to identify sub-surface drainage features that could significantly affect the ponding areas shown.

The key culverts that may influence the ponding areas have been identified on Figures 202-204 in Appendix CA and also in Table 3.

5.3 Information provided by WDC

5.3.1 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.

The stormwater network in Ngaruawahia consists of a network of pipes and open drains which discharge stormwater into either the Waipa or Waikato Rivers. There are an estimated 33 stormwater outlets from Ngaruawahia Township.

A visual inspection of several outlet structures was undertaken in 2009 by T&T and showed that many of the 33 stormwater outlets are small pipe outlets (<300mm diameter) discharging above the river level. Discharges from larger outlets commonly flow over riprap or concrete erosion protection structures before entering the river. Some steeper sections of the reticulated network are fitted with energy dissipaters to reduce the risk of scour at the outlet. Some flap gates have been installed in flood prone areas to prevent upstream flooding in the catchments. Most entry points to the stormwater network are fitted with catchpits for the removal of litter and sediments.

5.3.2 Buildings

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

5.3.3 Drainage operational issues

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

The town is located within the Lower Waikato Waipa Control Scheme, Section B (Waikato River Channel) and Section C (Waipa River Channel) administered by Waikato Regional Council.

5.3.4 Waikato and Waipa River flooding, 2009.

T&T has liaised with WRC to obtain flood model data for the Waikato and Waipa Rivers.

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 as well as an interpolated 2D flood extent.

Only 2D interpolated flood levels for the Waipa River (1% AEP with no climate change) were available.

The interpolated 2D extent of 1% AEP flooding for both rivers was undertaken by WRC by interpolating the 2009 MIKE 11 1D models on to a LiDAR derived topography using WaterRide Software.

The WRC cross sections indicate that the Waikato River 1% AEP (with no climate change) flood level ranges from approximately 14.0 m RL to 14.6 m RL within the Ngaruawahia SPA.

The WRC flood extents indicate that the Waipa River 1% AEP (with no climate change) flood level ranges from approximately 15.0 m RL to 14.3 m RL within the Ngaruawahia SPA.

The interpolated 1% AEP river flood extents (with no allowance for climate change) are presented in Figures 202 to 204 in Appendix CA.

5.4 Reporting

For reporting purposes, each area of potential growth has been broken up into “Growth Sectors”. Within the Ngaruawahia SPA, there are three Growth Sectors – D, E and F. The locations of the Growth Sectors are shown in Figure 4 above and Figures 202 to 204 in Appendix CA. All three Growth Sectors contain only proposed residential land.

Growth Sector D is the smallest of the three, with an approximate area of 14.3 ha. It is bound by the Waikato River to the west and SH1 to the east. The current land use in Growth Sector D appears to be primarily farmland.

Growth Sector E has an approximate area of 91 ha. The general land use of Growth Sector E appears to be industrial, rural residential and farmland. Growth sector E is located northeast of the Waikato River and has what appear to be overland flow paths/minor tributaries feeding the river.

Growth Sector F is the southernmost sector within the SPA, and has an approximate area of 98 ha. It is bound by the Waipa River to the west, the Waikato River to the east, existing residential land to the north and farmland to the south. Growth Sector F appears to consist of mainly farmland, with a small area of existing residential.

5.5 Results

The results from the ponding assessment are presented in Figures 202 to 204 in Appendix CA. The ponding assessment entails a high level overview of the model provided in these figures and reviews the feasibility of the proposed residential area.

Flooding of each Growth Sector has been reviewed separately in the following sections. The areas within the SPA but outside of the proposed growth areas have not been considered as they are existing and not anticipated to change.

5.5.1.1 Growth Sector **D**

Generally, Growth Sector D appears to have relatively low extent of significant ponding. Figure 202 in Appendix CA shows localised areas of ponding only, scattered throughout the Growth Sector.

The 1% AEP flood extent of the Waikato River slightly encroaches on the western edge of the growth sector. The edge of the Growth Sector may need to be slightly adjusted to account for this.

There appears to be an overland flow path through the middle of the Growth Sector which runs north and is conveyed under Old Taupiri Road through a culvert (cNGA100). A site visit was undertaken in Ngaruawahia which found this culvert to be a 750 mm diameter culvert.

To the south of Growth Sector D there is known to be a 300 mm diameter culvert (cNGA101) which discharges to the Waikato River.

It is also important to note that if Growth Sector D is developed, the area will become more impermeable and result in greater runoff flows to both cNGA100 and cNGA101.

No assessment has been undertaken on whether or not these culverts have sufficient capacity as there was no available information about the upstream or downstream invert levels of the pipes.

5.5.1.2 Growth Sector **E**

There are three unnamed tributaries running through Growth Sector E, which result in significant extensive ponding as shown in Figure 202-204 in Appendix CA. Approximately 20% of the area is covered by ponding greater than 0.1 m deep. Development within this areas may be significantly constrained.

The overland flow path (ofpNGA01), presented in Figure 202 in Appendix CA runs parallel with Great South Road to the north. There is extensive ponding (greater than 0.3 m deep) at the property on the corner of Starr Road and Great South Road. This appears to be mainly confined to farmland.

There is a culvert (cNGA 102) conveying the tributary under Starr Road which was seen at the site inspection. The size of the culvert was not able to be measured. The culvert was seen to be half filled with debris.

An overland flow path (ofpNGA02) presented in Figure 202 runs parallel with ofpNGA01. There is extensive flooding around the flow path on the southern side of Starr Road. The flood map shows that three existing buildings are affected by the flooding of this flow path, with flood depths between 0.1 m and 0.3 m.

There is also a culvert (cNGA103) conveying this tributary under Starr Road. Similar to cNGA102, the size was unable to be determined and the culvert was half filled with debris.

At the Starr Road/Duke Street intersection, there are two culverts (cNGA104 & cNGA105) which have been estimated to have a 300 mm diameter. The culverts convey an overland flow path under Duke Street and then Starr Road. The flooding map shows that two existing buildings are at risk of flooding if either culvert is under capacity to take the 1% AEP rainfall event.

There is potential flooding (see Figure 203 in Appendix CA) to the southeast of Herangi Crescent, which appears to affect one existing building. The majority of the flooding currently appears to be contained within farmland.

Culvert cNGA106 was identified during the site visit to the south of Growth Sector E. The flooding map shows flooding greater than 0.3 m around the culvert. It appears to be in poor condition, with branches covering the entrance and one end of the culvert broken.

No assessment has been undertaken on whether or not these culverts or the stormwater network at Herangi Crescent have sufficient capacity as there was insufficient asset information available.

The south of Growth Sector E is bounded by the Waikato River. The 1% AEP flood extent of the Waikato River encroaches into growth sector E covering approximately 14 ha and would constrain growth in the area. We note that this flooding affects approximately six existing buildings. The edge of the Growth Sector may need to be adjusted to account for this flooding.

5.5.1.3 Growth Sector F

Overland flowpath (ofpNGA03) flows through the middle of Growth Sector F and feeds into the Mangaheke Stream. In a 1% AEP storm, the Waipa River flood extent backs up this flow path into Growth Sector F. The flood extent appears not to affect any existing buildings.

The west of Growth Sector F is bordered by the Waipa River. Some of the northern border of Growth Sector follows the Waikato River. The interpolated 1% AEP flood extents show that that the rivers encroach into Growth Sector F at both of these locations and may constrain development of these areas.

Throughout Growth Sector F, there are areas of flooding greater than 0.3 m depth. Some of these areas appear to be caused by road embankments, and some appear to be natural low points. The flooding is mainly contained within farmland, except for one existing building. If Growth Sector F is to be developed into residential area, the natural low points and the overland flow path running through it will need to be considered.

5.5.1.4 Infrastructure

Table 3 below summarises the existing critical infrastructure within the Ngaruawahia SPA which is considered a potential restriction on the flow of major overland flow paths, watercourses or streams. Refer to Figure 202 to 204 in Appendix CA which shows the locations of these restrictions. The ponding map was used to determine which infrastructure assets were considered ‘restrictions’. WDC have provided stormwater asset details but unfortunately this did not include the majority of culverts identified as constrictions.

Table 3. Summary of critical infrastructure

Infrastructure ID	Length (m)	Diameter (mm)	IL's – US/DS	Capacity check required?	Other notes
cNGA100	No data	750	No data	Yes	
cNGA101	No data	300	No data	Yes	
cNGA102	No data	No data	No data	Yes	Half filled with debris
cNGA103	No data	No data	No data	Yes	Half filled with debris
cNGA104	No data	300	No data	Yes	
cNGA105	No data	300	No data	Yes	
cNGA106	No data	No data	No data	Yes	Culvert covered in branches and broken at one end

5.6 Summary of flooding issues

This section provides an assessment of the potential effects of flooding on the Ngaruawahia SPA. The assessment includes an evaluation of potential ponding areas on 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 4.

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

- Low constraint to development have been categorised as Growth Sectors with large areas not affected by flooding, and overall no significant flood mitigation required.
- 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 4. Summary of flooding issues

Flooding Assessment	Growth Sector D - Residential	Growth Sector E - Residential	Growth Sector F - Residential
Existing buildings affected by ponding?	Yes	Yes	Yes
Existing potentially critical infrastructure	cNGA100 cNGA101	cNGA102 cNGA103 cNGA104 cNGA105 cNGA106	-
Overall constraint[1]	Low	Medium	Low

1. Based on area affected by ponding and ability of the land use type to avoid or mitigate the adverse effects of flood hazards on the built environment.

5.7 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.
- Existing building floor levels to clarify potential flood vulnerability.
- More detailed information on future growth areas including road layout and waterway crossings.

6 References

Edbrooke, S. (2005). *Geology of the Waikato area. 1:250000 geological map 4.* Lower Hutt: Institute of Geological and Nuclear Sciences.

Edbrooke, S., & Begg, J. (2005). *Geology of the Waikato area.* Waikato: Institute of Geological and Nuclear Sciences.

Goodman, J. (2014). *Conservation status of New Zealand freshwater fish, New Zealand Threat Classification Series 7 .* Wellington: Department of Conservation .

Marshall, T. W., & Petch, R. A. (1985). *A Study of Groundwater and Surface Water Resources in the Hamilton Basin.* Waikato Valley Authority Technical Publication 30.

T&T Ltd. (2009). *Waikato District council Stormwater Management Plan.* Hamilton: Tonkin & Taylor Ltd. .

T&T Ltd. (2014). *Waikato District Council Ngaruawahia Structure Plan area Preliminary contaminated land assessment.* Hamilton : Tonkin & Taylor Ltd.

Tonkin & Taylor. (2009). *Waikato District Council Stormwater Management Plan.*

Waikato Regional Council. (2014, July 18). *Waikato Regional Council - Environment - Waikato River*. Retrieved from Waikato Regional Council: http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/Waikato-River/

7 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

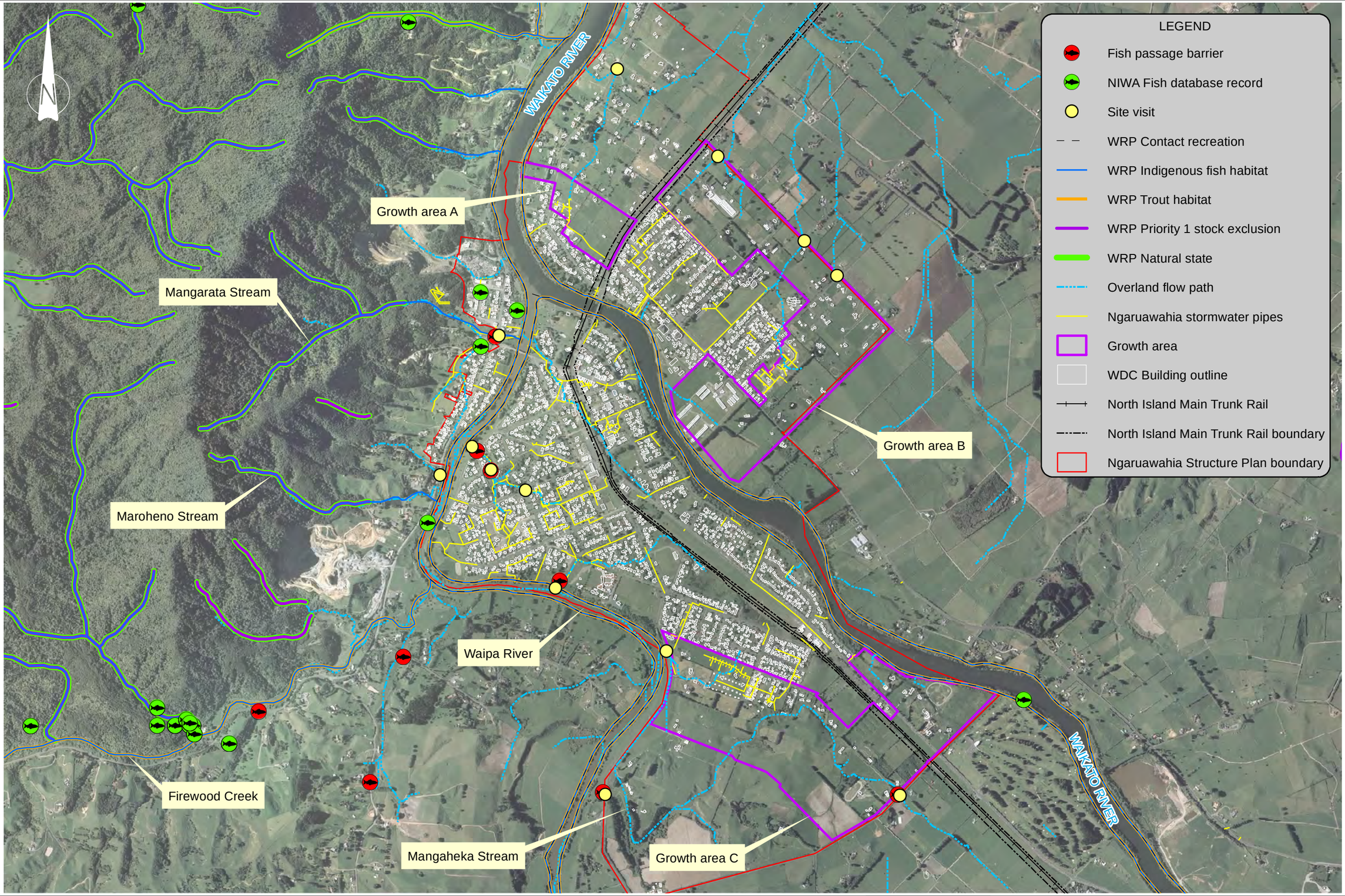
Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Elliot Smith/Bryn Quilter	Peter Cochrane
Civil Engineer/Project Manager	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 appendix c - ngaruawahia final.docx

Appendix CA: Figures

- **Figure 212 Ecological Map**
- **Figures 202 to 204 Flooding Maps Sheets 1 to 3**



Notes: Aerial photograph Supplied by Waikato District Council.

A3 SCALE 1:20,000

0 200 400 600 800 1,000 Meters

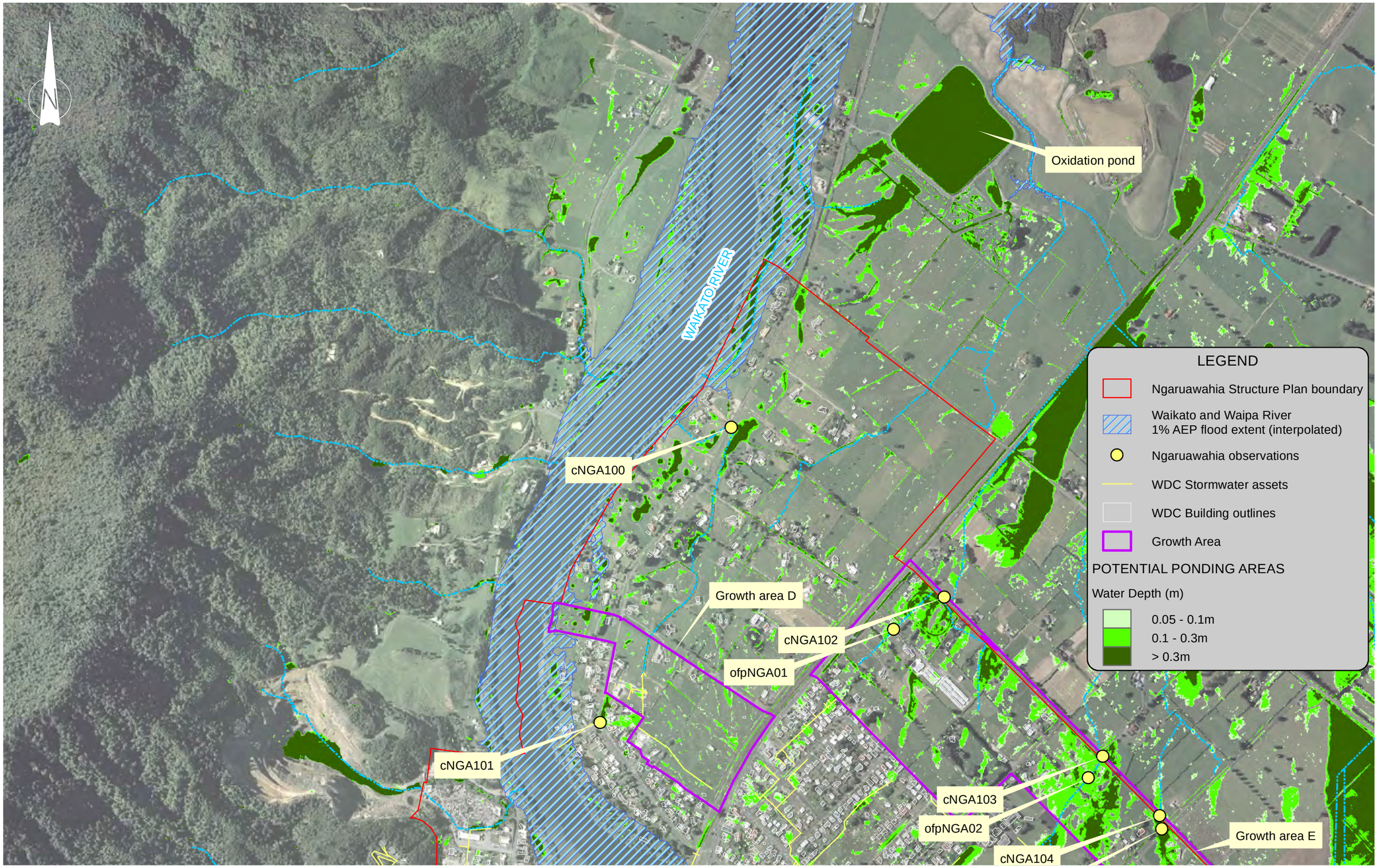
Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMB	8/14
ARCFILE	61814.200-F212.mxd	
SCALE (AT A3 SIZE)	1:20,000	
PROJECT No.	61814.200	

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

FIGURE No. Figure 212 | Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F212.mxd Date: 11/08/2014 Time: 12:39:17 p.m.

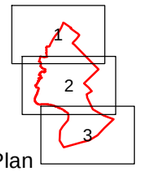


Notes: Aerial photograph supplire by Waikato Regional Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F202_204.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
NGARUAWAHIA STRUCTURE PLAN AREA
Flooding Map - Sheet 1 of 3

FIGURE No. Figure 202

Rev. 0

Path: P:\61814\61814.2000\WorkingMaterialGIS\61814.200-F202_204.mxd Date: 11/08/2014 Time: 12:03:34 p.m.

cNGA103
ofpNGA02
cNGA104
cNGA105
Growth area E
ofpNGA02
cNGA106
WAIPA RIVER
WAIKATO RIVER

LEGEND

- Ngaruawahia Structure Plan boundary
- Waikato and Waipa River 1% AEP flood extent (interpolated)
- Ngaruawahia observations
- WDC Stormwater assets
- WDC Building outlines
- Growth Area

POTENTIAL PONDING AREAS

Water Depth (m)

- 0.05 - 0.1m
- 0.1 - 0.3m
- > 0.3m

Notes: Aerial photograph supplire by Waikato Regional Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan

1
2
3

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

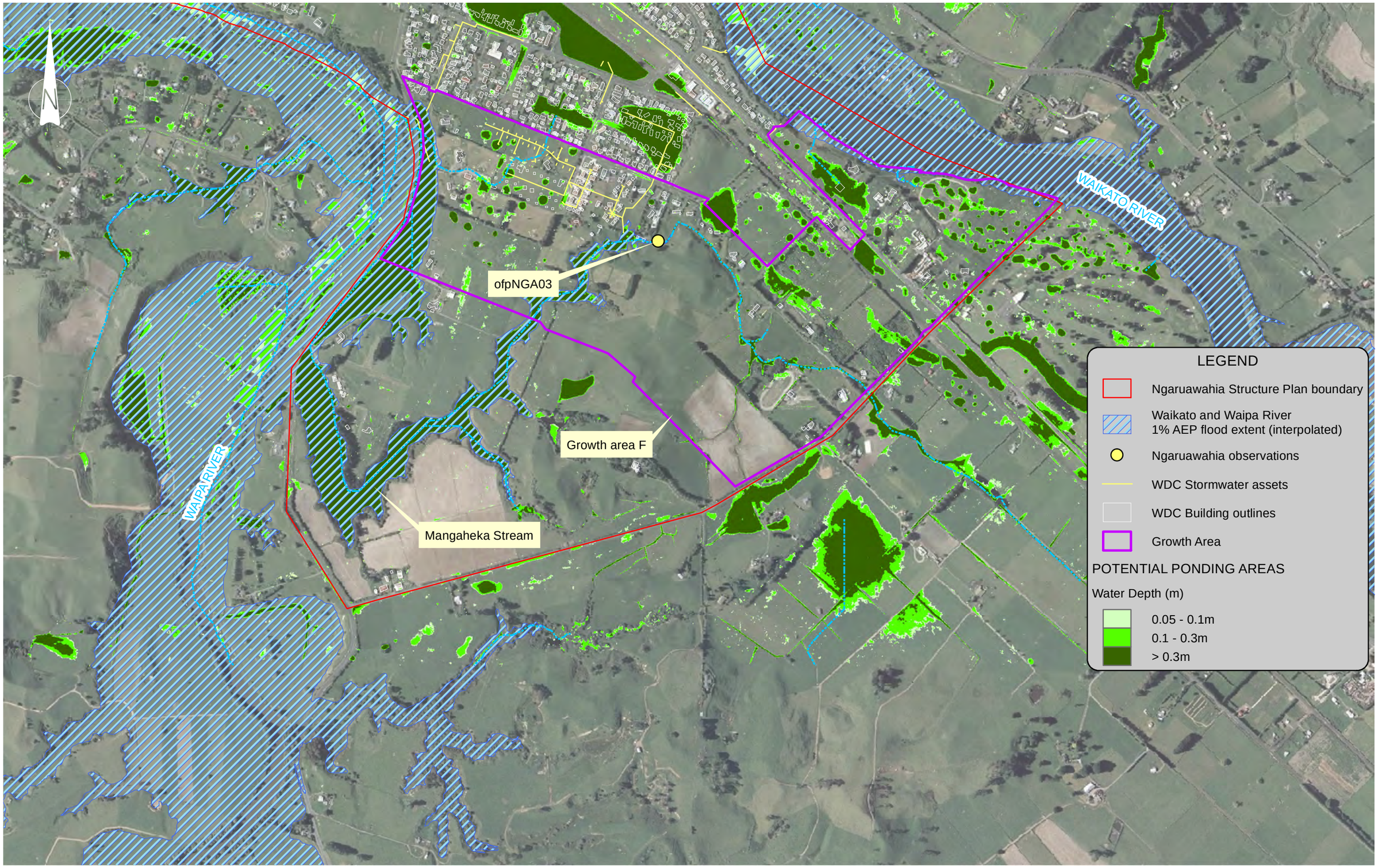
DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F202_204.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
NGARUAWAHIA STRUCTURE PLAN AREA
Flooding Map - Sheet 2 of 3

FIGURE No. Figure 203

Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F202_204.mxd Date: 11/08/2014 Time: 12:03:37 p.m.

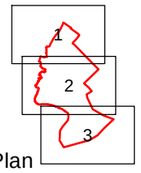


Notes: Aerial photograph supplire by Waikato Regional Council.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

Location Plan



Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F202_204.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

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

FIGURE No. Figure 204

Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F202_204.mxd Date: 11/08/2014 Time: 12:03:40 p.m.

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

Appendix D: Glen Massey CMP Assessment

REPORT

Waikato District Council

Appendix **D**
Catchment Management Plan
Glen Massey Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Appendix **D**
Catchment Management Plan
Glen Massey Structure Plan Area

Report prepared for:

Waikato District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2000

Table of contents

1 Catchment description

1.1 Location

The Glen Massey Structure Plan Area (SPA) surrounds the North Waikato township of Glen Massey, and is located approximately 10 km west of Ngaruawahia. The location of the Glen Massey SPA is presented in Figure 1. The SPA (red outline) covers approximately 74 ha of the broader 580 ha catchment (green outline).

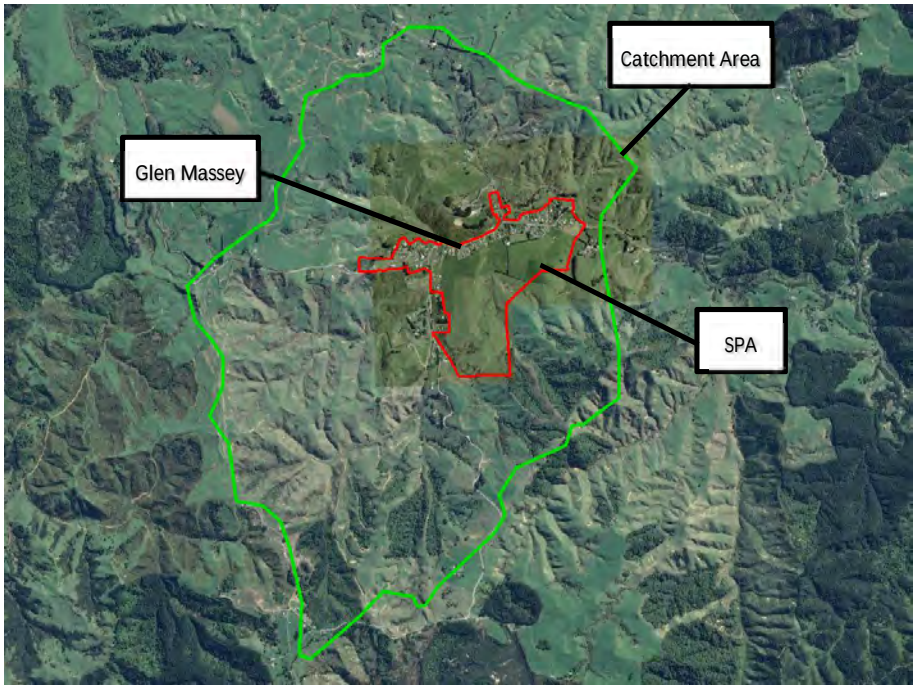


Figure 1. Glen Massey SPA and catchment location (Image sourced from Google Earth, 2014)

1.2 Topography

The topography of the catchment and SPA is typically rolling to steep hills divided by ridges and valleys with natural water courses. The SPA is located adjacent to Firewood Creek in the upper reaches of this catchment. The majority of the SPA is on the floodplain and hillside to the south of the creek. Firewood Creek generally flows from west to east through the SPA.

1.3 Geology and hydrogeology

The published geology of the area indicates that the majority of the Glen Massey SPA is underlain by hard siltstone with fine to coarse-grained sandstone (commonly referred to as greywacke) of the Newcastle Group (Edbrooke S. W., 2005) as shown in the geological map in Figure 2 below. This is overlain by Oligocene age fine to medium-grained sandstone overlying siltstones of the Glen Massey Formation, which outcrops in the elevated parts of the catchment generally to the north of Glen Massey. In the low lying (north) area of the SPA there is a small pocket of alluvial sediments of the Pleistocene age Walton Subgroup (Edbrooke S. W., 2005).

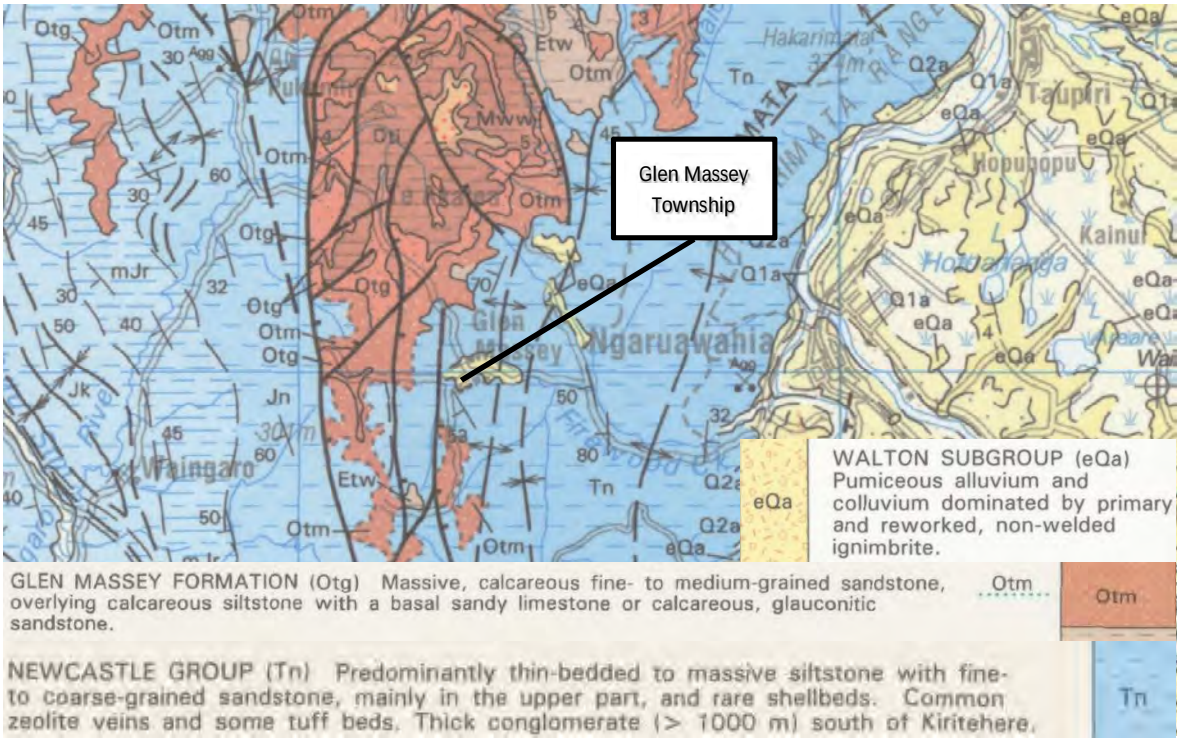


Figure 2. Geological map of Tuakau structure plan area

The hydrogeology of the area is characterised by the presence of limited quantities of groundwater in either the greywacke rocks of the Newcastle Group or calcareous siltstones, sandstones and occasional limestones of the Glen Massey Formation. Marshall and Petch (1985) consider that the rocks of the Newcastle Group and have low porosity and permeability, except in localised areas where these rocks have been fractured, resulting in moderate secondary porosity. The rocks of the Glen Massey formation similarly contain limited quantities of groundwater. This indicates that groundwater flows are likely to be limited and form a small proportion of the overall water balance for the area.

Recharge of groundwater is likely to be limited to infiltration of rainwater onto relatively steep land, where surface runoff is more dominant.

1.4 Watercourses

There is one main watercourse flowing through the existing Glen Massey Township; Firewood Creek. Firewood Creek runs through the Township within an incised channel receiving runoff from the north, south and west, before discharging to the east. The creek drains both agricultural and residential land that make up the SPA. The middle reach of Firewood Creek runs through the low lying areas of the SPA. After exiting the SPA Firewood Creek drains to the east before discharge to the Waipa River some 10km downstream.

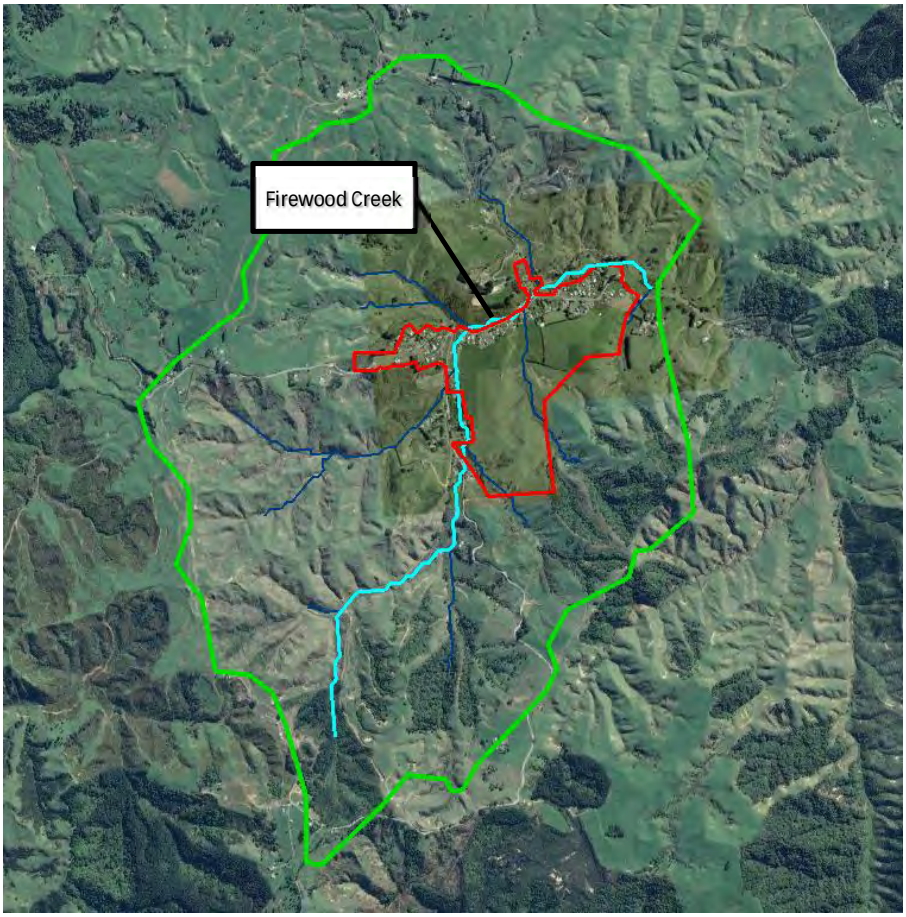


Figure 3. Firewood Creek (light blue) and tributaries (dark blue) within the catchment.

There are a number of unnamed tributaries within the Glen Massey SPA that discharge to Firewood Creek. The unnamed tributaries drain predominantly agricultural and a small amount of residential land and are shown in Figure 3.

1.5 Receiving environments

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

- Firewood Creek
- Unnamed tributaries of Firewood Creek

1.6 Existing WRC resource consents

1.6.1 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
Discharge - Air	Nil
Discharge - Land	Nil
Discharge - Water	Nil
Land Use – Bore/Well	Nil
Land Use – Other	2
Water Take - Ground	Nil
Water Take - Surface	Nil
Water Take - Other	Nil

1.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105655, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Glen Massey.

Relevant extracts from the resource consent are reproduced below:

Consent Type: Discharge permit

Consent Subtype: Discharge to land and water

Activity authorised: To divert and discharge urban stormwater and associated contaminants at multiple locations to land and Firewood Creek, the Waipa River, and use discharge structures, within the Glen Massey urban area.

Consent duration: Granted for a period expiring on 22 September 2028

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

2 Land use in Glen Massey

2.1 Current land use

Land within the SPA is dominated by agricultural land uses, with the residential Glen Massey Township and rural residential outskirts also occupying a significant portion of the total area. There are negligible other land uses currently occurring within the SPA. The residential area of the Glen Massey Township is located in the northern part of the SPA with predominantly agricultural land surrounding it to the south.

A key arterial route to the north and south is Waingaro Road, which is the only transport corridor giving access to the township.

2.2 Future land use

The future growth in Glen Massey has not been specified by WDC. This CMP therefore only generally assesses the areas within the SPA and highlights areas that are not suitable for future growth.

3 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Glen Massey SPA. The assessment is based on a review of existing ecological information with a brief site visit to publicly accessible parts of the SPA.

3.1 SPA overview

3.2 Assessment methods

There has been no ecological assessments of Glen Massey and its surrounds provided by Waikato District Council. Our assessment has reviewed the information available in national and regional ecological databases.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 9 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 292 in Appendix DA.

3.3 Summary of existing ecological information

3.3.1 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Glen Massey SPA is included on Planning Map 19.3. There was no ecological features of note within the Glen Massey SPA.

3.3.2 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 S14) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

Firewood creek directly downstream from Glen Massy is classified as Indigenous Fisheries and Fish Habitat, and Trout Fisheries and Trout Spawning Habitat. This classification is applied to significant habitats or areas that are characterised by high water quality.

From the downstream end of the SPA to its headwaters, the unnamed tributaries of Firewood Creek are approximately 13.0km long with approximately 11.0km (85%) upstream of the SPA boundary.

3.3.3 T&T's 2014 field assessment

A site inspection of publicly accessible locations on Firewood creek and its unnamed tributaries in the Glen Massy SPA was conducted on 9 April, 2014. Locations inspected are shown on Figure 292 in Appendix DA.

Observations from site inspections concluded that streams where typically open with limited areas of riparian vegetation providing shade to the stream bed. The stream bed was dominated by gravels and small cobble sized sediments embedded in fine silts and sands. There was excessive periphyton growth in unshaded areas. Upper catchment land use is a mix of agriculture and regenerating vegetation which likely contributed to the excessive periphyton growth.

In-stream habitat at the sites inspected was generally diverse with a range of habitats including riffles, runs and shallow pools, with good connectivity to the flood plain in upstream areas of the SPA. A short section of stream along Wilton Collieries Rd has undergone channel modification and is now a straightened U shaped channel.

A barrier to upstream fish passage was identified at the culvert under Wilton Collieries Rd east of the intersection with Kereru Rd. This culvert has previously been retrofitted for fish passage but a small concreate lip on the downstream end would prevent the migration of non-climbing fish species such as inanga during low flows. It is noted that inanga and longfin eel are present in all catchment streams and are classified as At Risk: Declining (Goodman, 2014).

4 Ecological assessment

4.1 Introduction

This section provides an assessment of the potential effects of development of the Glen Massey SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report and provides an assessment of the significance of these issues for growth.

We note that WDC has not provided any indication of the types of future land use within Glen Massey, so for the purposes of this assessment, we have assumed that any growth in Glen Massey would be low density residential.

4.2 Assessment of effects

The main ecological issues associated with future urban development in the Glen Massey SPA are described below and the significance of possible future development to a range of issues for each is presented in Table 2.

Table 2. Significance of potential adverse effects from proposed development

Future development	Low density residential
Issue	
Stormwater	
Contaminants[1]	Low
Increase in peak flows leading to stream bed/bank erosion	Low
Hydrological	
Reductions in base flow[2]	Low
Reduction in flow variability leading to reduced habitat quality	Low
Habitat	
Culverting or infilling of perennial streams reducing habitat	Medium
Protection of riparian margins	Low
Barriers to fish movement	Low
Overall potential adverse effect on surface water	Low

5 Flood analysis

5.1 Introduction

A Culvert Capacity Analysis (CCA) has been undertaken. The purpose of the CCA was to determine culvert capacity and also to approximate levels of inundation within and surrounding the incised stream due to the culvert obstructions. An engineering survey to determine key levels and CCA was performed due to the absence of LiDAR making it impossible to undertake the previously proposed Rapid Flood Hazard Assessment. The CCA provides information to indicate where flooding hazards may occur and is considered a 'rough order' estimate of flood extents only.

5.2 Methodology

5.2.1 Waterways and culverts

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

Stormwater from the township is generally directed via open drains to tributaries of Firewood Creek, or directly into the creek itself. As there was no ground level or asset data available, two site visits were undertaken to establish critical stormwater asset level and approximate ground levels at some locations. These site visits were undertaken on 9 April 2014 and 15 May 2014.The culvert information gathered during site visits is outlined below.

In total four culverts were identified that have the potential to influence the stream and cause flooding to adjacent property within the SPA. The location of these culverts is shown on Figure 4.

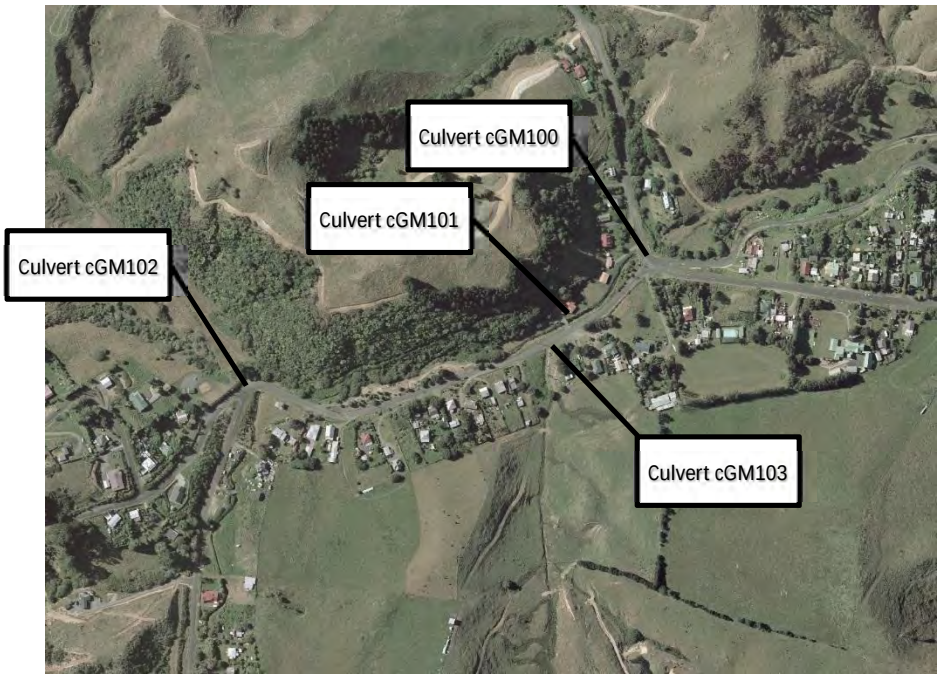


Figure 4: Culvert locations

Culverts cGM100 to cGM102 are located on Firewood Creek, while Culvert cGM103 is located on an unnamed tributary of Firewood Creek.

Culvert cGM100 is located under Waingaro Road and has the largest catchment.

Culvert cGM101 is located just upstream of cGM100 under a private access way.

Culvert cGM102 is located upstream of cGM101 underneath Wilton-Colleries Road.

Culvert cGM103 is located on a tributary of Firewood Creek underneath Wilton-Colleries Road, the culvert discharges directly to Firewood Creek above cGM101.

Culvert details were obtained using a GPS and dumpy survey. All measurements and levels obtained are approximate only with a likely margin of error of +/- 0.3m in the vertical and +/-1.0m in the horizontal. Vertical datum is approximates Moturiki Vertical Datum based on GPS survey only as no suitable LINZ survey benchmarks were available. The culvert information is summarised in Table 3 .

Table 3: Culvert properties

Culvert	Type	Diameter/ width (m)	Upstream invert (mRL)	Downstream invert (mRL)	Length (m)	Road overtopping level (mRL)
cCGM100	Corrugated iron with concrete base	4.25	126.20	125.98	21	129.30
cCGM101	Corrugated iron	2.2	126.74	126.66	8	129.67
cCGM102	Concrete	0.75	128.17	128.17	18	129.62
cCGM103	Corrugated iron with concrete base	3.45	129.85	129.76	14	132.46

We understand that culvert information may be available on WDC's RAMM database but these were not available at the time of this assessment.

5.2.2 Hydrology

Hydrologic modelling of the catchment areas has been carried out using the SCS curve number method as prescribed in Technical Publication 108 (Auckland Regional Council, 1999).

5.2.2.1 Catchments

Culvert catchment boundaries and flow paths were adopted based on REC (NIWA, 2004) database 1st Order catchments and classifications. The catchment boundary for cGM100 (indicative only) is shown in Figure 5 below. This catchment is the largest of the four and encompasses the other three culvert catchments.

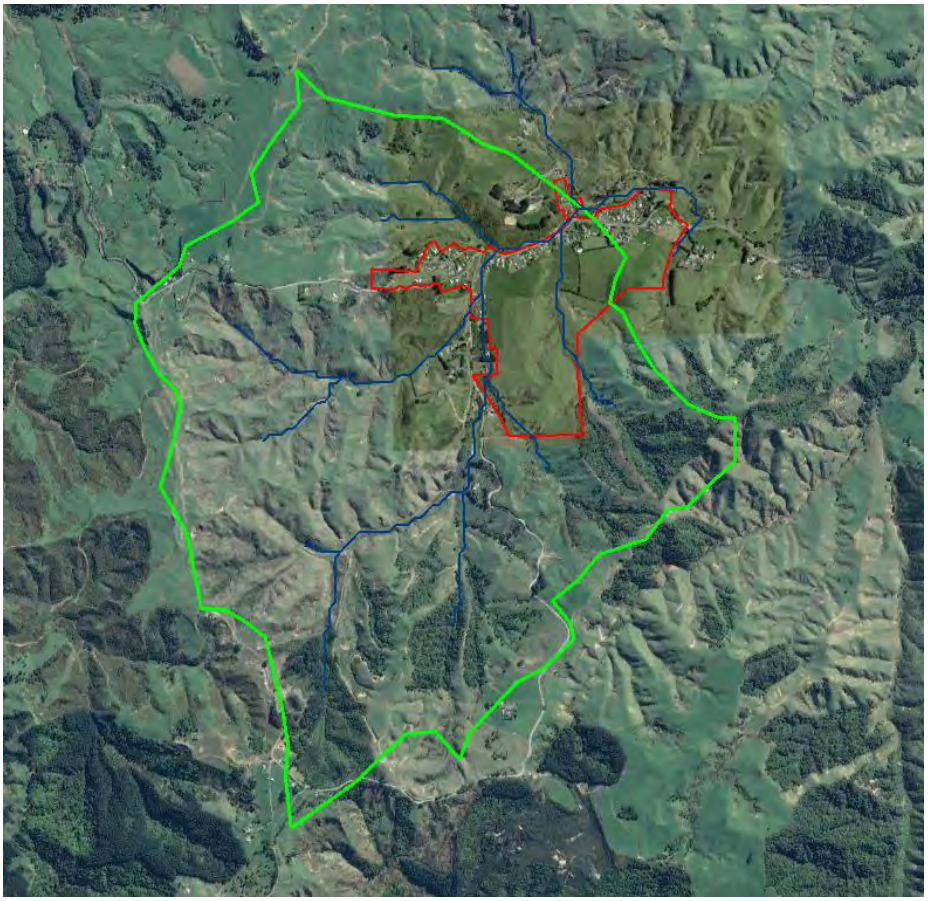


Figure 5. Indicative catchment boundary for CCA

The slope within each catchment was determined using the equal area method and 30 m contours obtained from Terraview software. The catchment properties for each culvert are shown in the table below.

Table 4: Catchment properties

Culvert catchment	Area (Ha)	Flowpath length (m)	Slope (m/m)
cGM100	580	3884	0.02
cGM101	573	3730	0.02
cGM102	407	3390	0.03
cGM103	69	1640	0.04

5.2.2.2 Underlying geology and land cover

Aerial photography and satellite imagery from Google Earth has been used to determine percentage land cover.

Land cover has been approximated at 90% pasture and 10% bush, with the hydrologic condition of this cover assumed as fair and good respectively. The underlying soil has been estimated at 5% group B soil (moderate-high soakage) and 95% group C soil (low-moderate soakage).

It was assumed that all catchment areas were pervious, and the presence of buildings and roads was negligible. An initial abstraction of 5mm was applied to all catchment areas.

5.2.2.3 Rainfall

The 24 hour rainfall depth for a 1%, 10% and 50% AEP design storms was obtained using NIWA's HIRDSv3 online rainfall inventory based on the approximate centroid of the catchment. Although the 1% AEP is the critical design storm, the other design storms were analysed for comparison. 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 24 hour rainfall depths are shown below:

- 1% AEP 218.7 mm
- 10% AEP 129.5 mm
- 50% AEP 83.5 mm

5.2.3 Hydraulics

The CCA involved hydraulic modelling of the culverts and overtopping of these culverts where applicable.

5.2.3.1 Culverts

The capacity of identified culverts was analysed using CulvertMaster software. Properties for the culverts were taken from the site visit as summarised in Table 3. Flows at each culvert were taken from the hydrologic analysis.

Tail water levels were assumed to be defined by the culvert obvert at the downstream end. Where the required headwater for a culvert to pass a flow was above road or access way overtopping levels at that culvert, flow through the culvert was limited and excess flow was assumed to be flowing over the above road or access way.

5.2.3.2 Road overtopping

Headwater levels of flows in excess of culvert capacity (above road or access way crown) were analysed as a weir using FlowMaster software. All weirs were assumed to be v-notch weirs with an angle of 176 degrees and a discharge coefficient of 0.57 and were also checked using a broad crested weir calculation. Road overtopping was analysed at all culverts. Tail water levels at cGM101 and cGM102 were assumed to be defined by the headwater level at cGM100 and cGM101 respectively.

5.2.3.3 Buildings

WDC provided building footprints in the district but no information on any floor levels.

5.3 Results and discussions

5.3.1 Analysis review

Results of the analysis are shown below in Table 5. Flow to the culverts is significantly higher than culvert capacity at road/access overtopping level. Indicative overtopping levels at each culvert are also provided in the summary table.

Table 5: Analysis results

Culvert	1% AEP Flow (m^3/s)	Culvert capacity at overtopping (m^3/s)	Overtopping water level (approximate mRL)
cGM100	72.9	26.3	130.5
cGM101	72.7	12.6	131.0
cGM102	55.2	1.2	131.1
cGM103	12.6	17.8	133.5

5.3.2 Rough order flood extent

The rough order flood extent has been approximated only based on the analysis results and site visits. Due to lack of a detailed ground elevation data, the accurate flood extent or flood hazard could not be quantified.

The rough order flood extent map has been produced using estimated flood levels, interpolation between surveyed ground levels and photo records. The flood extent is rough order only and should not be used for any building consent or detailed land planning purposes. The rough order flood extent is shown in Figure 282 in Appendix DA.

Building footprints supplied by WDC are shown on the flood maps presented in Appendix DA. Where the flood extent 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.

6 Flooding assessment

This section presents the results of our review and flooding assessment of the Glen Massey SPA. The assessment is based on results from a Culvert Capacity Analysis (CCA) and a brief site walkover of selected parts of the SPA.

6.1 Assessment methods

6.1.1 Existing documentation

No existing documentation was available.

6.1.2 CCA

A Culvert Capacity Analysis (CCA) was undertaken for the Glen Massey SPA for a 1% AEP (plus climate change) storm event to identify flood hazards.

6.1.3 Infrastructure

Critical infrastructure within or affecting the Glen Massey SPA is summarised in Table 3 of this report. This infrastructure will likely restrict the flow of major overland flow paths, watercourses or streams. Refer to Figure 282 in Appendix DA which shows the locations of these restrictions.

6.1.4 Drainage operational issues and flooding

No drainage issues or flood reports were noted or provided by WDC. WDC have not indicated any properties effected by flooding.

6.2 Summary of flooding issues

This section provides an assessment of the potential effects of flooding on the Glen Massey SPA. The assessment includes an evaluation of flood hazards on existing 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 6.

Table 6. Summary of flooding issues

Flooding Assessment	Upstream of culvert CGM100	Upstream of culvert CGM101	Upstream of culvert CGM102	Upstream of culvert CGM103
Existing buildings within significant flood hazard?	Yes	No	No	Yes
Growth area affected	N/A	N/A	N/A	N/A
Existing critical infrastructure	CGM100	CGM100, CGM101	CGM100, CGM101, CGM102	CGM103
Overall constraint[1]	Low	Low	Low	Low

1. Based on area estimated to be affected by flooding compared to the SPA area.

6.3 Information gaps

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

- Historical flooding information for Glen Massey.
- A detailed ground elevation model or topographic survey so that flood extents could be more accurately determined.
- Similar to above, information on waterway dimensions is required to enable more detailed modelling.
- Existing building floor levels to clarify potential flood vulnerability.
- Any information on future growth areas including road layout and waterway crossings.

7 References

Auckland Regional Council. (1999). *Technical Publication 108 Guidelines for stormwater runoff modelling in the Auckland Region.* Auckland: Auckland Regional Council.

Edbrooke, S. W. (2005). *Geology of the Waikato area.* Lower Hutt: Institute of Geological & Nuclear Sciences.

Goodman, J. (2014). *Conservation status of New Zealand freshwater fish, New Zealand Threat Classification Series 7 .* Wellington: Department of Conservation .

NIWA. (2004). *New Zealand River Environment Classification.* Wellington: Ministry for the Environement.

White, P. A., & Rosen, M. R. (2001). *Groundwaters of New Zealand.* Wellington: New Zealand Hyrological Society.

8 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

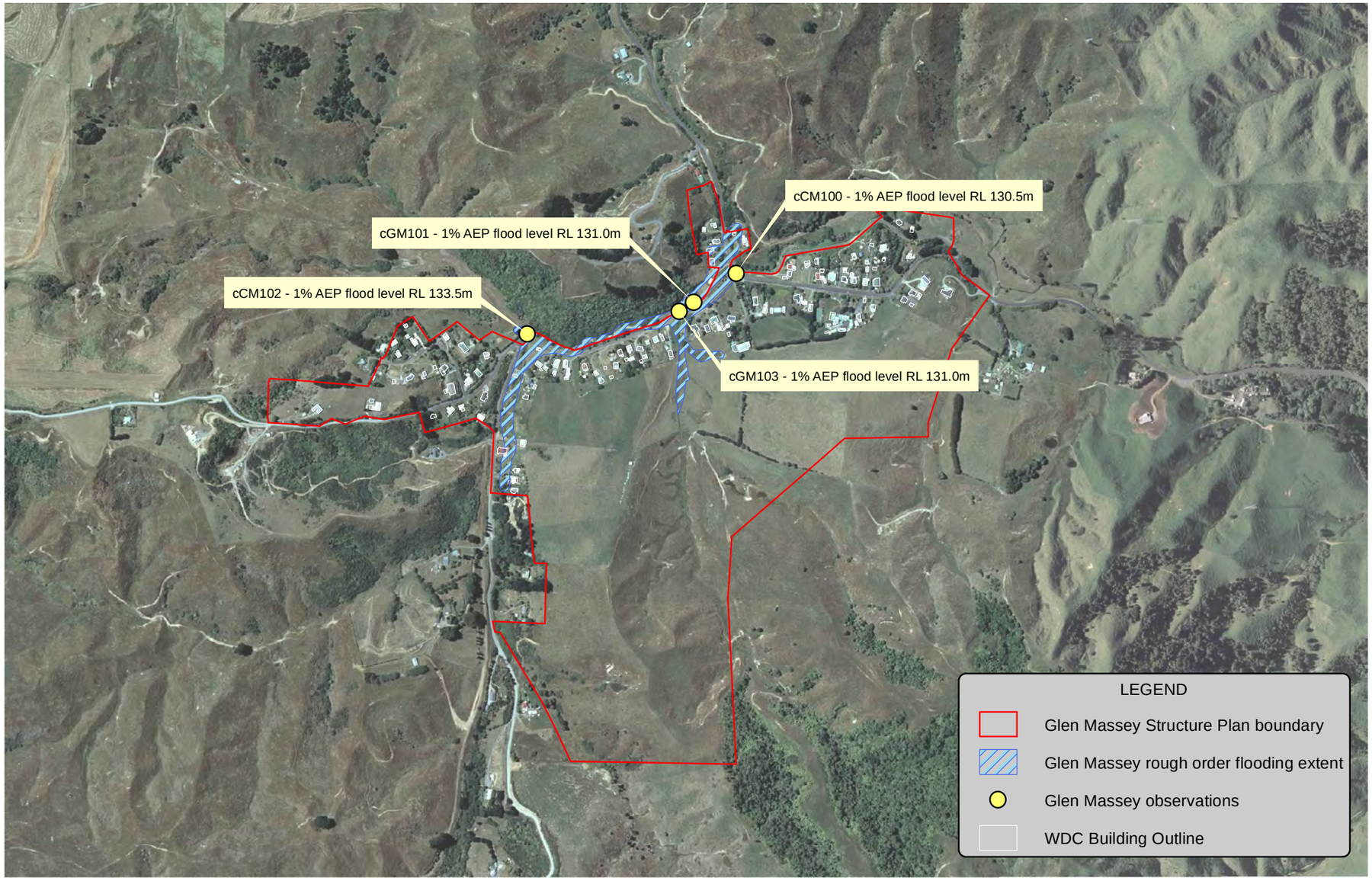
Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Regan Robinson/Bryn Quilter	Peter Cochrane
Civil Engineer/Project Manger	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 appendix d - glen massey final.docx

Appendix DA: Figures

- **Figure 282 Flooding**
- **Figure 292 Ecological Map**



Notes: Aerial photograph supplied by Waikato District Council

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

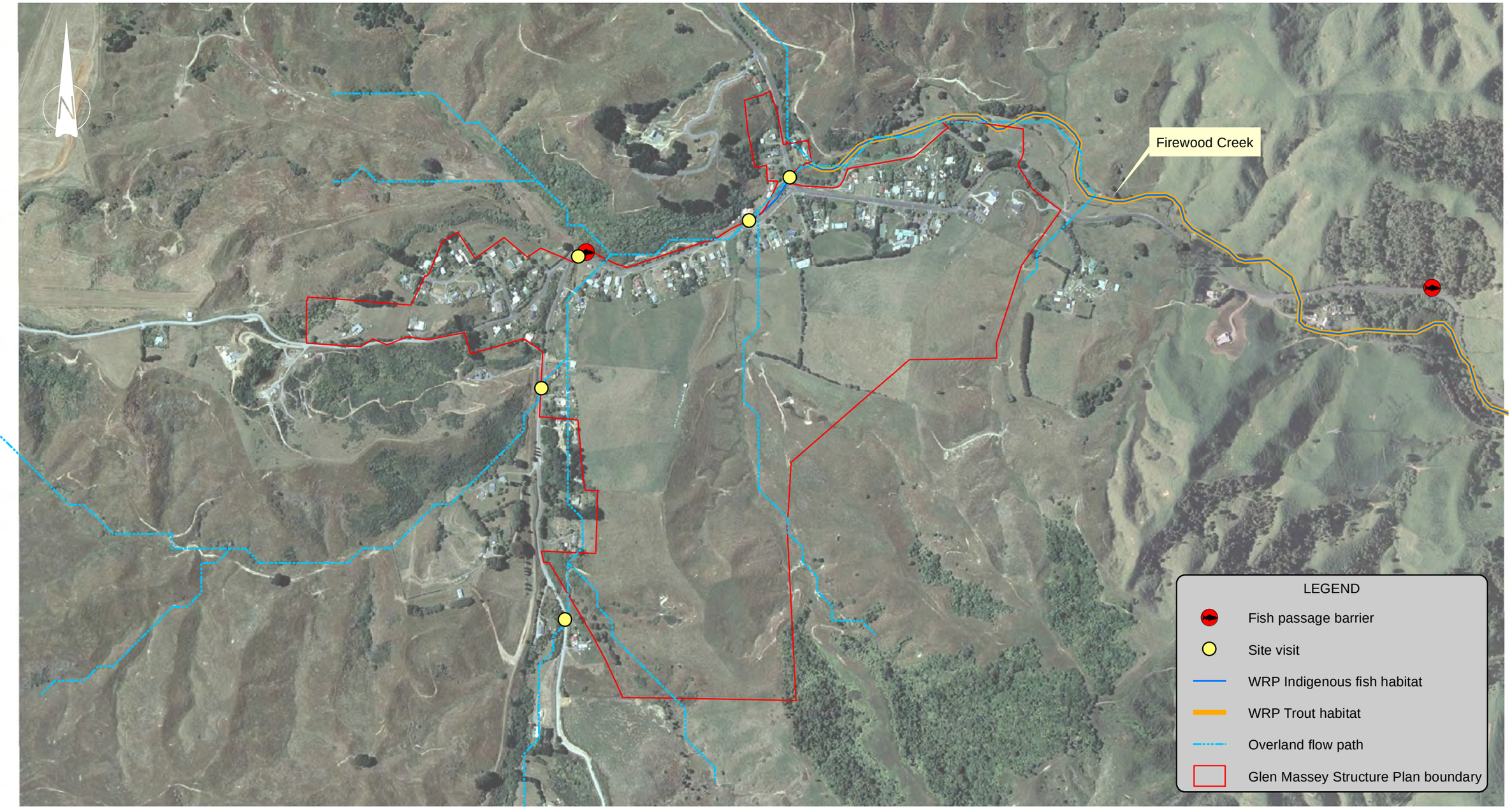
Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F282.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
GLEN MASSEY STRUCTURE PLAN AREA
Flooding Map

FIGURE No. Figure 282 Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F282.mxd Date: 21/08/2014 Time: 12:05:56 p.m.



Notes: Aerial photograph supplied by Waikato District Council

A3 SCALE 1:8,000

0 90 180 270 360 450 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMD	8/14
ARCFILE	61814.200-F292.mxd	
SCALE (AT A3 SIZE)	1:8,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN OF GLEN MASSEY STRUCTURE PLAN AREA
Ecological Map

FIGURE No. Figure 292 | Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F292.mxd Date: 22/08/2014 Time: 2:25:03 p.m.

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

Appendix E: Te Kowhai CMP Assessment

REPORT

Waikato District Council

Appendix **E**
Catchment Management Plan
Te Kowhai Structure Plan Area

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Waikato District Council

Appendix **E**
Catchment Management Plan
Te Kowhai Structure Plan Area

Report prepared for:

Waikato District Council

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waikato District Council	PDF
Tonkin & Taylor Ltd (FILE)	1 copy

March 2015

T&T Ref: 61814.2000

Table of contents

1 Catchment description

1.1 Location

The Te Kowhai Structure Plan Area (SPA) surrounds the central Waikato township of Te Kowhai, located approximately 12 km northwest of Hamilton City and 8 km south of Ngaruawahia. The location of the Te Kowhai SPA is presented in Figure 1. The SPA (red outline) covers approximately 90 ha. The SPA is surrounded by rural land, and is located at the upper reach of an unnamed tributary discharging to the Waipa River.

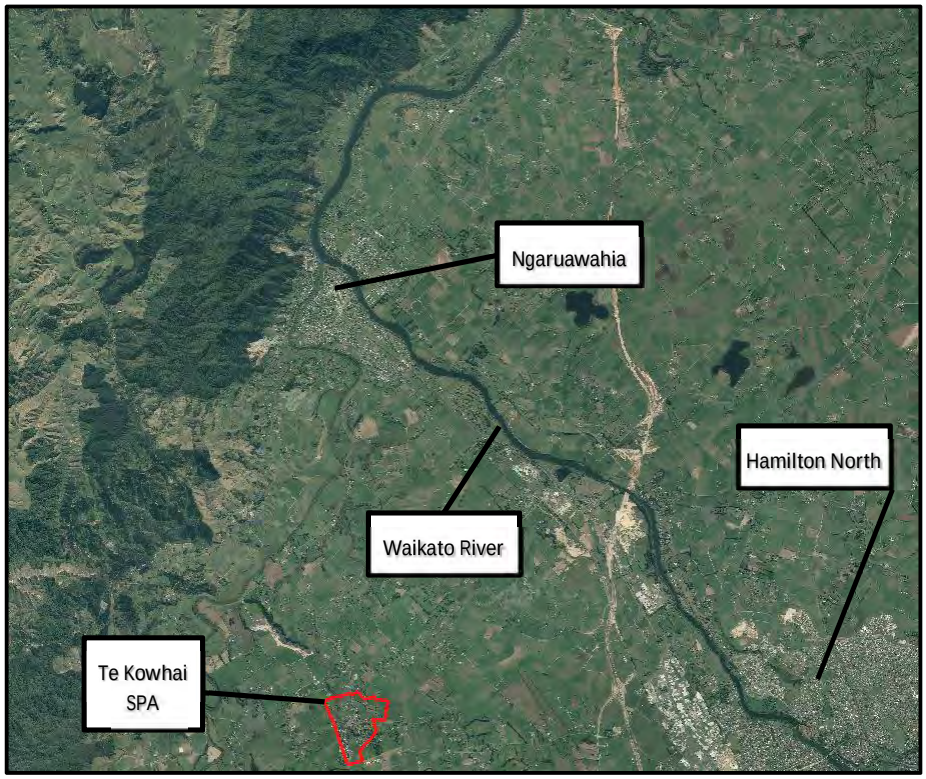


Figure 1. Te Kowhai SPA (Image sourced from WDC, 2014)

1.2 Topography

The topography of the Te Kowhai SPA is mainly flat, with a deep gully an an unnamed watercourse running through the centre of the SPA.

1.3 Geology and hydrogeology

The published geology of the area shows that the majority of the Te Kowhai structure plan area is underlain alluvial and colluvial deposits of the Piako Subgroup of the Tauranga Group (Edbrooke S. , 2005) as shown in the geological map below. The Te Kowhai Township is underlain by the Hinuera Formation which comprises cross-bedded pumice sand, silt and gravel with interbedded peat.

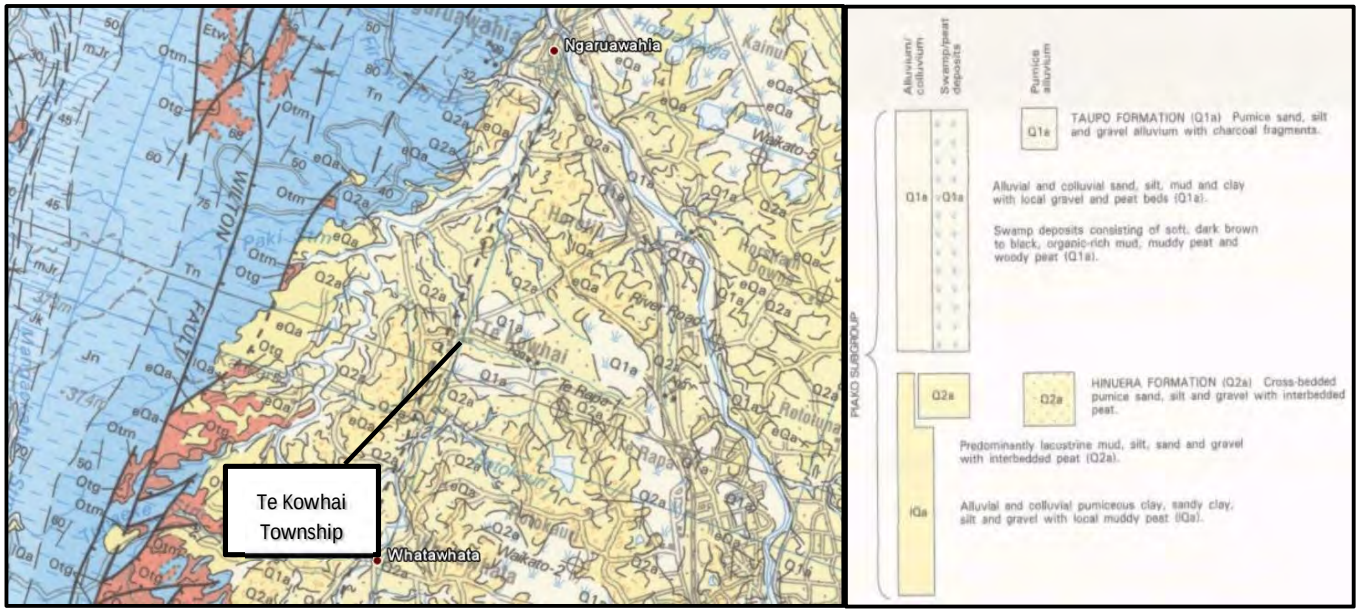


Figure 2. Geological map of Te Kowhai structure plan area

The hydrogeology of the Tauranga Group is characterised by a series of shallow unconfined and deeper semi-confined aquifers, which are variable in their horizontal and vertical distributions, and show varying degrees of connectivity with one another.

Groundwater is recharged from rainfall infiltration (and on the western side of the SPA some recharge from the Hakarimata Range) and a significant proportion of groundwater discharges to streams through the incised gullies. Marshall and Petch (1985) estimated that up to 85% of mean annual stream flow is sustained by groundwater discharges.

1.4 Watercourses

The nearest major watercourse to Te Kowhai is the Waipa River, located approximately 2.5 km west of the town centre. There is a significant unnamed tributary which flows through the Te Kowhai SPA and discharges to the Waipa River in the north. The northern and southern parts of the SPA drain to other unnamed tributaries of the Waipa River.

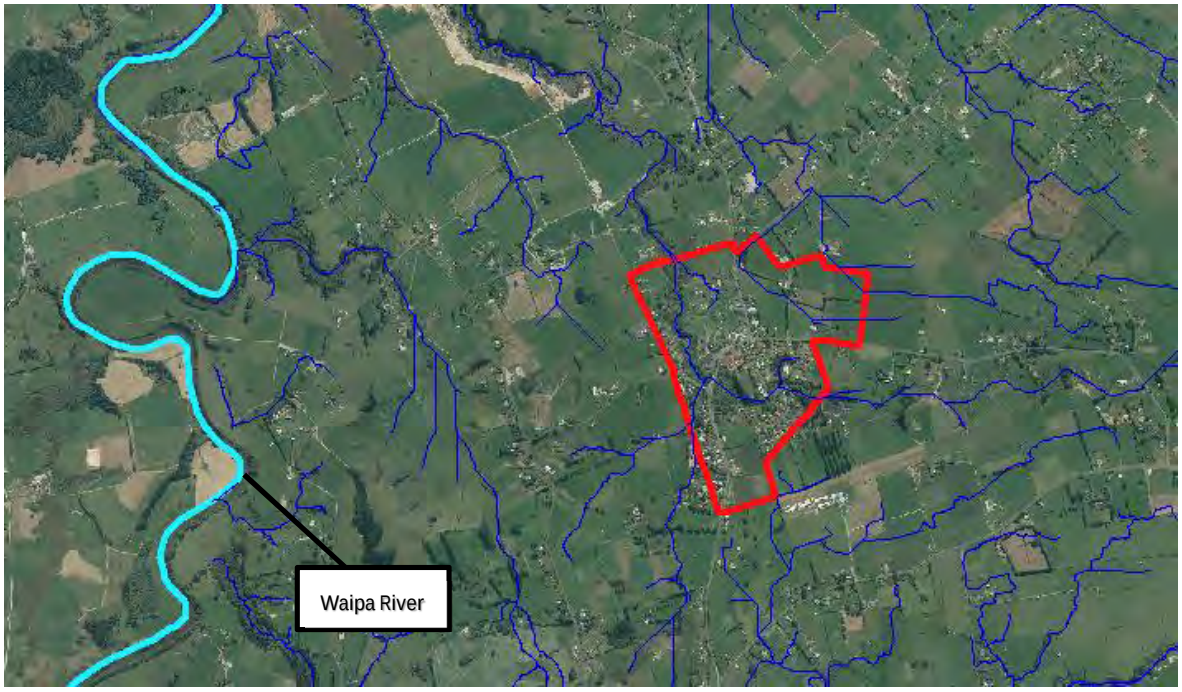


Figure 3. Main water courses (light blue) and tributaries (dark blue) around the SPA (red).

1.5 Receiving environments

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

- Waipa River.
- Unnamed tributaries of the Waipa River.

An unknown proportion of surface water within the SPA discharges to groundwater via natural and engineered ground soakage.

1.6 Existing WRC resource consents

1.6.1 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	0	-
Discharge - Land	3	-
Discharge - Water	0	-
Land Use – Bore/Well	1	-
Land Use – Other	0	-
Water Take - Ground	1	-
Water Take - Surface	0	-
Water Take - Other	0	-

1.6.2 Comprehensive stormwater discharge consent

Waikato District Council holds Resource Consent No. 105656, being a Comprehensive Stormwater Discharge Consent (CSDC) associated with urban Te Kowhai.

Relevant extracts from the resource consent are reproduced below:

Consent Type: Discharge permit

Consent Subtype: Discharge to land and water

Activity authorised: To divert and discharge urban stormwater and associated contaminants at multiple locations to land and the Waipa River, and use discharge structures, within the [Te Kowhai] urban area.

Consent duration: Granted for a period expiring on 22 September 2028

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

2 Land use in Te Kowhai

2.1 Current land use

Land within the SPA is dominated by urban and rural areas, with commercial industrial areas and council reserves also occupying a small portion of the SPA. Horotiu Road (State Highway 39) and Te Kowhai Road are notable arterial routes that run through the SPA.

2.2 Future land use

Future growth within the SPA has been provided by WDC and is shown in Figure 4 below. The figure shows that the future land use is anticipated to be residential only.

For reporting purposes, the growth areas defined by WDC have been categorised into "Growth Sectors" G and H. These are also presented in Figure 4.

Figure 4. Te Kowhai growth plan provided by WDC and Growth Sectors used for reporting.

3 Ecological review

This section presents the results of our review and assessment of the ecological status of stream resources in the Te Kowhai SPA. The assessment is based on a review of existing ecological information with a brief site visit to publicly accessible parts of the SPA.

3.1 SPA overview

3.2 Assessment methods

There has been no ecological assessments of Te Kowhai and its surrounds provided by Waikato District Council. Our assessment has reviewed the information available within national and regional ecological databases.

In addition, a site walk over of streams at publicly accessible locations was conducted by a T&T ecologist on 9 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 272 in Appendix EA.

3.3 Summary of existing ecological information

3.3.1 Operative District Plan

The Operative Waikato District Plan and associated maps were reviewed for any ecological features of note. The Te Kowhai SPA is included on Planning Map 20 and 26. There was no ecological features of note within the Te Kowhai SPA.

3.3.2 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 permanent watercourses within the area are classified as Waikato Surface Water (Map S14) and will be subject to the relevant standards in Section 3.2 of the WRP in regard to discharges of contaminants.

3.4 T&T's 2014 field assessment

A site inspection of publicly accessible locations on the unnamed tributaries within the SPA was conducted on 9 April, 2014. Locations inspected are shown on Figure 272 in Appendix EA.

Observations from site inspections concluded that the unnamed tributary to the Waipa River that flows north through Te Kowhai, was characterised by slow flow flowing open channel with excessive macrophyte growth. 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. 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 some locations. Within the soft bottom sections there was a lack of large woody debris providing hard substrate habitat for macroinvertebrate species. No barriers to fish passage were identified within the Te Kowhai SPA. Stream Bank vegetation had been recently sprayed.

The National Freshwater Fish Database has a record of the At Risk, black mudfish (*Neochanna diversus*) within the SPA, in the wetland area upstream from the Horotiu Rd culvert (Goodman et al., 2014). Crack willow (*Salix fragilis*) is the dominant vegetation within this area with small strands of kahikatea (Dacrycarpus dacrydioides) and Cabbage tree (*Cordyline australis*) also present.

4 Ecological assessment

4.1 Introduction

This section provides an assessment of the potential effects of development of the Te Kowhai SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report. This section provides an assessment of the significance of these issues for each of the growth area identified by WDC.

4.2 Assessment of effects

This section provides an assessment of the potential effects of development of the Te Kowhai SPA on surface water resources. The assessment has considered the general issues outlined within Section 2 of the main report. This section provides an assessment of the significance of these for each of the growth areas identified by WDC.

The main ecological issues associated with future urban development in the SPA are described in Section 2 of the main report. The significance of proposed development to a range of issues for each growth area is presented in Table 2.

Table 2. Significance of potential adverse effects from proposed development

Growth Sector / Issue	G - Residential	H - Residential
Stormwater		
Contaminants[1]	Low	Low
Increase in peak flows leading to stream bed/bank erosion	Low to Medium	Low
Hydrological		
Reductions in base flow[2]	Low to Medium	Low
Reduction in flow variability leading to reduced habitat quality	Low to Medium	Low
Habitat		
Culverting or infilling of perennial streams reducing habitat	Low	Low
Protection of riparian margins[3]	Low	Low
Barriers to fish movement	Low	Low
Overall potential adverse effect on surface water	Low	Low

5 Flood modelling and assessment

5.1 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.

5.2 Methodology

5.2.1 Model bathymetry

5.2.1.1 Digital elevation model (DEM)

A digital elevation model (DEM) for Te Kowhai was developed by T&T based on LiDAR data.

LiDAR was provided by WDC and WRC.

The WDC Waikato LiDAR data was collected between 22nd of November 2007 to 5th of February 2008 . 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 0.45 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

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

5.2.2 Catchment boundary

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

A 2m x 2m DEM was used to create ponding and overland flow paths for catchment delineation only. This 2m x 2m DEM was used to account for the farm drains within the catchment. For the rest of model, a DEM of 5m x 5m was used.

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.

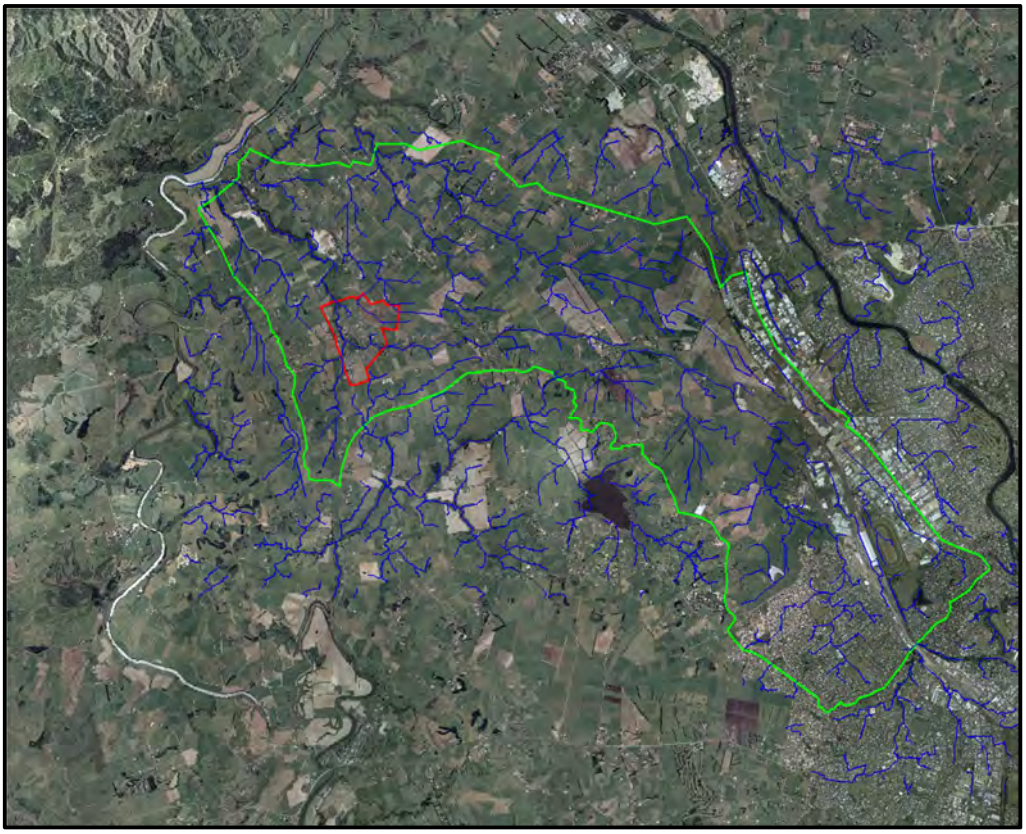


Figure 5. Indicative catchment boundary

The extent of the hydrological model is larger than the catchment boundary.

5.2.3 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.

5.2.4 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 adjusted 24 hour rainfall depth used was 180mm.

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.

5.3 Information provided by WDC

5.3.1.1 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.

5.3.1.2 Buildings

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

5.3.2 Drainage operational issues

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

5.3.3 Waipa River flooding, 2009.

T&T has liaised with WRC to obtain flood model data for the Waipa Rivers.

WRC have a Waipa River 1D flood model (MIKE 11) using the 1% AEP (with no climate change) event. The interpolated 2D extent of 1% AEP flooding was undertaken by WRC by interpolating the 2009 MIKE 11 1D models on to a LiDAR derived topography using WaterRide Software.

The interpolated 1% AEP river flood extents (with no allowance for climate change) are presented in Figures 262 in Appendix EA.

5.3.4 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 used was 5m x 5m.
- 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.

5.4 Results and discussions

5.4.1 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 -3.7% which is considered acceptable for flood modelling purposes.

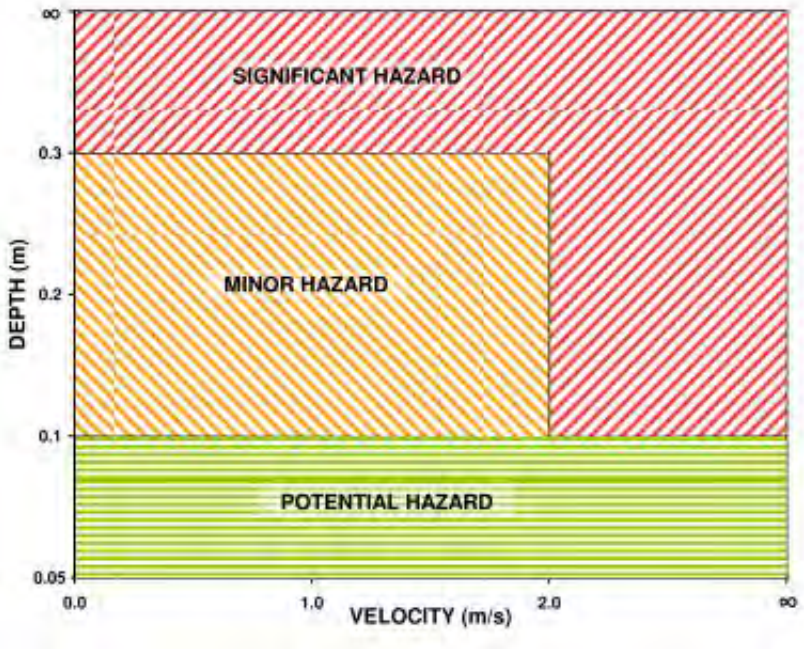
5.4.2 Post processing of model results

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

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 Figure 262 in Appendix EA.

Building footprints supplied by WDC are shown on the Flood Maps presented in Appendix EA. 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.

5.5 Reporting

For reporting purposes, each area of potential growth has been broken up into "Growth Sectors". Within the Te Kowhai SPA, there are two Growth Sectors – G and H. The locations of the Growth Sectors are shown in Figure 4 and Figure 262 in Appendix EA. Figure 4 shows that both Growth Sectors contain only proposed residential land.

Growth Sector G is the larger area, with an approximate area of 9.8 ha. The current land use in Growth Sector G appears to be primarily farmland.

Growth Sector H has an approximate area of 6.0 ha. The general land use of Growth Sector F also appears to be farmland.

5.6 Results

The results from the RFHA are presented in Figure 262 in Appendix EA. The RFHA entails a high level overview of the model provided in these figures and reviews the feasibility of the proposed residential area.

Flooding of each Growth Sector has been reviewed separately in the following sections. The areas within the SPA but outside of the proposed growth areas have not been considered as they are existing and not anticipated to change.

5.6.1.1 Growth Sector G

Generally, Growth Sector G has relatively extensive significant and minor flood hazard, covering approximately 50% of the area. Flood hazard is generally associated with of an overland flow path (ofpTKO100) running through the centre of Growth Sector G as well as another overland flow path just north of the SPA boundary.

During the site visit, a 600 mm diameter culvert (cTKO100) was observed under Te Kowhai Road, with an approximate location shown on Figure 262 in Appendix EA. No other culverts were noted under Te Kowhai Road. The RFHA model does not allow for culverts or road embankments, which may make the flooding upstream of culverts appear more significant or extensive than if culverts were included in the model.

Using the information provided by WDC regarding building footprints, it appears from the RFHA model that no existing building within the Growth Sector are affected by this flooding.

It is also important to note that if Growth Sector G is developed, the area will become more impermeable and result in greater runoff flows to the downstream culverts.

No assessment has been undertaken on whether or not the culverts downstream have sufficient capacity as there was no available information about the upstream or downstream invert levels of the pipes.

5.6.1.2 Growth Sector **H**

The RFHA model shows that there is extensive flooding within Growth Sector H. The area appears to currently be used as farmland, and there is a farm drain through the centre, running east to west, dividing the area in two. The farm drain appears to discharge via a culvert (cTKO101) under SH39 and to the unnamed watercourse which flows to the Waipa River.

The capacity of culvert cTKO101 has not been assessed due to insufficient information about the culvert size and the upstream and downstream invert levels.

If the area is to be developed, the area will become more impervious, and the culvert will have to be sized adequately to convey the increased flow rate. This should be investigated further if the area is developed.

The flooding shown in the RFHA and Figure 262 in Appendix EA shows that several existing buildings are affected by the estimated flooding.

5.6.1.3 Infrastructure

Table 3 below summarises the existing critical infrastructure within the Te Kowhai SPA which is considered a potential restriction on the flow of major overland flow paths, watercourses or streams. Refer to Figure 262 in Appendix EA which shows the locations of these restrictions. The flooding map was used to determine which infrastructure assets were considered 'restrictions'. WDC have provided stormwater asset details but unfortunately this did not include the culverts that have been identified as constrictions.

Table 3. Summary of critical infrastructure

Infrastructure ID	Length (m)	Diameter (mm)	IL's – US/DS	Capacity check required?	Other notes
cTKO100	No data	600	No data	Yes	RCRRJ
cTKO101	No data	No data	No data	Yes	

5.7 Summary of flooding issues

This section provides an assessment of the potential effects of flooding on the Te Kowhai SPA. The assessment includes an evaluation of potential ponding areas on 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 4. For critical infrastructure, those structures that are unable to pass the 1% AEP peak flow (without heading up to above road crown level and/or causing upstream flooding) would likely pose a significant constraint to development.

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

- Low constraints to development has been categorised as growth sectors with large areas not affected by flooding, and overall not a great amount of mitigation required.
- 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 and/or causing upstream flooding) would likely pose a significant constraint to development.

Table 4. Summary of flooding issues

Flooding Assessment	Growth Sector G - Residential	Growth Sector H - Residential
Existing buildings affected by ponding?	No	Yes
Existing potentially critical infrastructure	cTKO100	cTKO101
Overall constraint[1]	High	High

1. Based on area affected by ponding and ability of the land use type to avoid or mitigate the adverse effects of flood hazards on the built environment.

5.8 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.
- Existing building floor levels to clarify potential flood vulnerability.
- More detailed information on future growth areas including road layout and waterway crossings.

6 References

Auckland Council. (2011). *Stormwater Flood Modelling Specifications.* Auckland: Auckland Council.

Edbrooke, S. (2005). *Geology of the Waikato area. 1:250000 geological map 4. .* Lower Hutt: Institute of Geological and Nuclear Sciences.

Edbrooke, S., & Begg, J. (2005). *Geology of the Waikato area.* Waikato: Institute of Geological and Nuclear Sciences.

Goodman, J. (2014). *Conservation status of New Zealand freshwater fish, New Zealand Threat Classification Series 7 .* Wellington: Department of Conservation .

Keifer, C. J. ((1957). Synthetic storm pattern for drainage design. *ASCE Journal of the Hydraulics Division 83 (HY4)*, 1-25.

Marshall, T. W., & Petch, R. A. (1985). *A Study of Groundwater and Surface Water Resources in the Hamilton Basin.* Waikato Valley Authority Technical Publication 30.

NIWA. (2004). *New Zealand River Environment Classification.* Wellington: Ministry for the Environement.

White, P. A., & Rosen, M. R. (2001). *Groundwaters of New Zealand.* Wellington: New Zealand Hyrological Society.

7 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

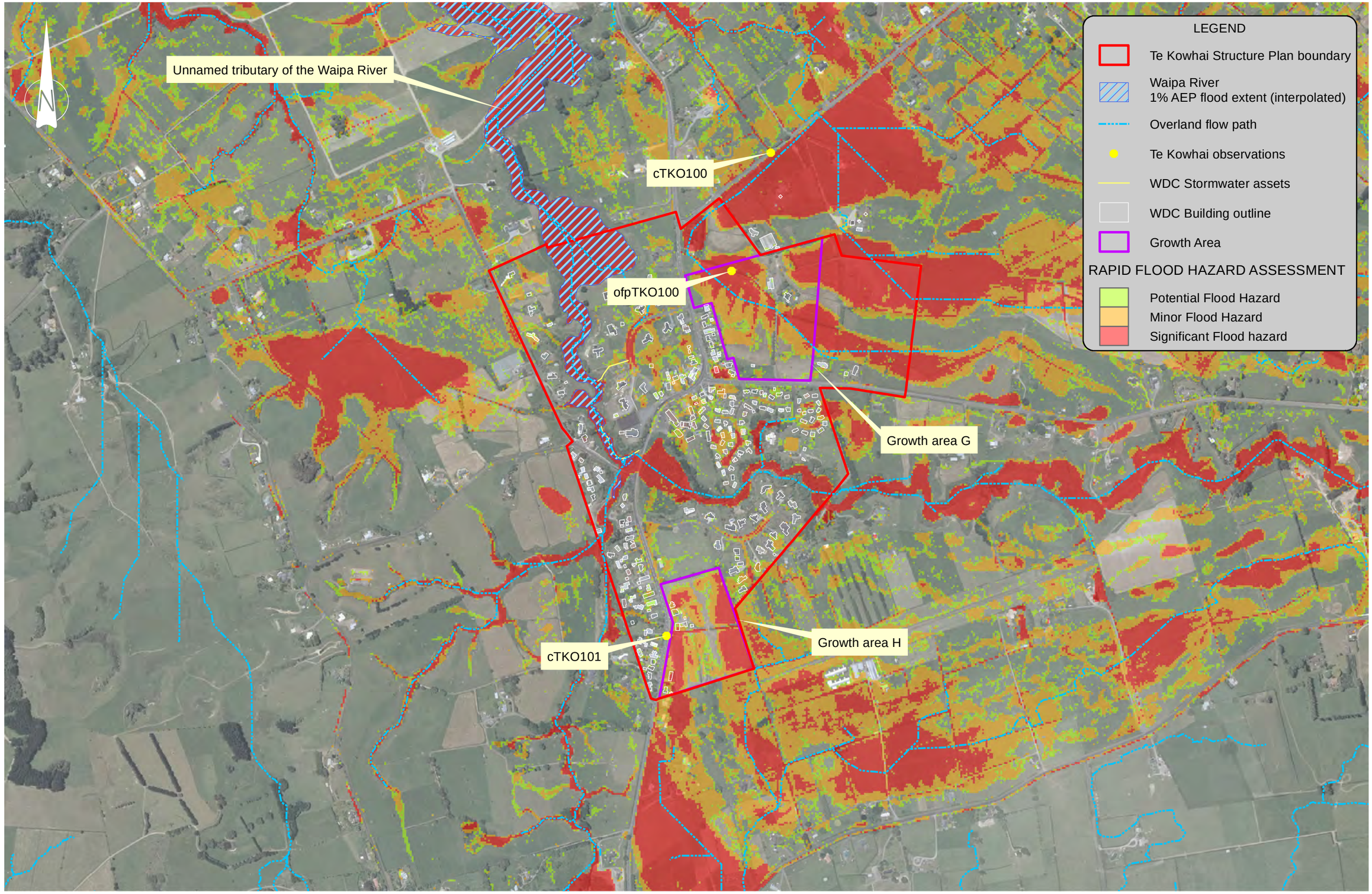
Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Elliot Smith/Bryn Quilter	Peter Cochrane
Civil Engineer/Project Manager	Project Director

BMQ

p:\61814\61814.2000\workingmaterial\catchment management plan\final\150323 appendix e - te kowhai final.docx

Appendix EA: Figures

- **Figure 262 Flooding Maps**
- **Figure 272 Ecological Map**



Notes: Aerial photograph supplied by Waikato District Council

A3 SCALE 1:10,000

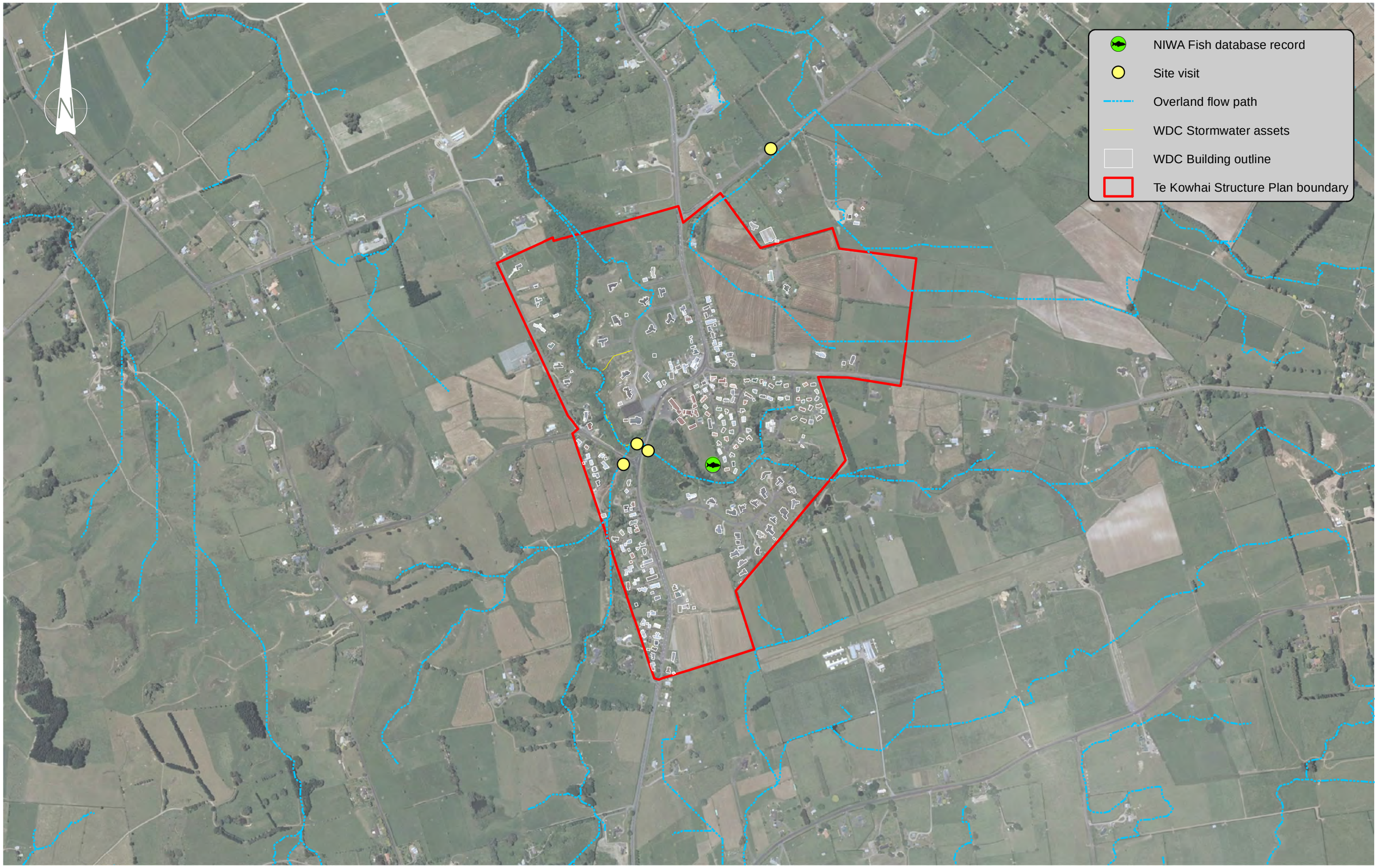
0 100 200 300 400 500 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMS	8/14
ARCFILE	61814.200-F262.mxd	
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	61814.200	

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TE KOWHAI STRUCTURE PLAN AREA
Flooding Plan

FIGURE No. Figure 262 Rev. 0



Notes: Aerial photograph supplied by Waikato District Council

A3 SCALE 1:10,000

0 120 240 360 480 600 Meters

Tonkin & Taylor
Environmental and Engineering Consultants
Level 1, 9 CliftonRoad, Hamilton
www.tonkin.co.nz

DRAWN	DWM	Aug.14
CHECKED	PMC	8/14
APPROVED	BMB	8/14

ARCFILE 61814.200-F272.mxd
SCALE (AT A3 SIZE) 1:10,000
PROJECT No. 61814.200

WAIKATO DISTRICT COUNCIL
CATCHMENT MANAGEMENT PLAN
TE KOWHAI STRUCTURE PLAN AREA
Ecological Map

FIGURE No. Figure 272
Rev. 0

Path: P:\61814\61814.2000\WorkingMaterial\GIS\61814.200-F272.mxd Date: 21/08/2014 Time: 10:58:26 a.m.

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS