REPORT

MANGAKOTUKUTUKU STREAM CARE GROUP

Mangakotukutuku Stream Erosion Control and Aquatic Habitat Restoration

Report prepared for:

MANGAKOTUKUTUKU STREAM CARE GROUP

Report prepared by:

TONKIN & TAYLOR LTD

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1 Introduction

1.1 Background

The Mangakotukutuku Stream Care Group (MSCG) was established in 2006. The focus of the MSCG is on the stream ecosystem and its associated freshwater habitats (such as springs and seepages) and complementing other initiatives that promote terrestrial values of Hamilton City's gully systems. The MSCG's visions for the Mangakotukutuku Stream include: diverse and abundant stream life; low weed and pest numbers; improved habitat diversity; stable stream banks; less sediment in the stream and improved water clarity.

Enhancement work undertaken along the Mangakotukutuku Stream by volunteers to date has included several rubbish clean ups and the clearing and planting of a small tributary on the true right bank of the main stream in Sandford Park. The MSCG is proposing a further enhancement project on the main stream through Sandford Park that will include clearing and planting work. The enhancement project is to focus on a 500 m trial reach of the main stream upstream of the Peacockes Road tributary. The project has the following objectives:

- To enhance in-stream habitat diversity and the ecological environment for fish and invertebrates;
- To stabilise stream banks and reduce bank erosion utilising appropriate low impact (soft engineering) methods;
- To create a demonstration and/or trial site to test the success of various habitat enhancement methods and to publically showcase the positive results of waterway restoration.

Tonkin & Taylor was engaged by the MSCG to assist in the development of ecologically appropriate erosion control, bank stability and habitat enhancement options within the trial reach. The project is to be undertaken in two stages:

i. Scoping of information requirements, evaluation of engineering options and preparation of concept designs;

ii. Confirmation of preferred options and detailed design preparation.

This report covers ecological and engineering services for the first stage of the overall project. Our approach has been to develop 'natural', ecologically sensitive engineering options to address stream erosion and enhance habitat values. We have focussed on options that are cost effective, could be constructed with volunteer labour (or minimal machinery) and options that minimise resource consent requirements.

Although this report refers to and recommends stream riparian planting, no detailed information on stream planting is provided. We understand that advice on appropriate riparian planting is being provided separately to the MSCG by the National Institute of Water and Atmospheric Research (NIWA).

1.2 Report layout

Our report layout is summarised as follows:

- **Section 1** – introduction;
- **Section 2** – provides a general description of the Mangakotukutuku Stream catchment and its ecological values;

- **Section 3** - presents our comments regarding stream sedimentation issues within the trial reach;
- **Section 4** - presents a stream erosion assessment for the trial reach and an evaluation of remedial and erosion control options;
- **Section 5** - outlines habitat enhancement options for the trial reach based on the habitat requirements of key native fish species;
- **Section 6** - provides a brief assessment of the construction methodologies and costs for a range of stream restoration options;
- **Section 7** - provides a suggested priority ranking of stream restoration works for the trial reach;
- **Section 8** - provides an overview of statuatory requirements for works within a watercourse;
- **Section 9** - summarises our recommendations for the stream enhancement project and provides comment on Stage 2 tasks;
- **Section 10** - report closure;
- **Section 11** - references.

This report has been prepared in accordance with the T&T proposal dated 26 March 2008.

2 Mangakotukutuku Stream

2.1 General description

The Mangakotukutuku Stream catchment represents one of Hamilton city's larger incised gully systems and is located on the south western side of the Hamilton urban area (see Figure 1 in Appendix C for location plan). The upper part of the Mangakotukutuku catchment is drained by two main tributary systems. The upstream reaches of each of these tributaries drain mainly agricultural land uses with the mid to lower reaches flowing through residential land use areas. The two tributaries join near the upstream end of Sandford Park.

The main Mangakotukutuku Stream and its tributaries upstream of the Hamilton urban area drain the Rukahia peat bog (mainly under pastoral agriculture) in the western part of the catchment. Flows in this tributary are generally tannin stained and darker in colour than other inflows. The other main tributary (known as the Te Anau branch) drains the central area of the catchment and has similar proportions of urban and rural land use as the main Mangakotukutuku Stream tributary.

The Mangakotukutuku Stream flows in a more or less easterly direction through Sandford Park from the confluence of the main tributaries to Peacockes Road. The stream channel generally flows along the southern gully bank. A minor tributary joins the main stream a short distance upstream of Peacockes Road. The Peacockes Road tributary has the lowest proportion of urban land use within its catchment although further residential development is in progress. The MSCG has undertaken some riparian enhancement planting around the Peacockes Road tributary immediately upstream of its confluence with the main stream. The Mangakotukutuku Stream discharges to the Waikato River approximately 1.5km downstream of the Peacockes Road culvert.

The trial reach is located on the lower reach of the main Mangakotukutuku Stream within Sandford Park. The trial reach covers a distance of some 500m upstream of Peacockes Road culvert (see Figure 1 in Appendix C). Riparian vegetation along the trial reach comprises mainly rank grasses and weeds on both banks with the occasional willow tree. The flood plain on the left bank comprises the open grassed area of Sandford Park. Stream substrates are soft within the trial reach, comprising mainly sandy silt, and accumulations of woody debris are common.

The Mangakotukutuku Stream is classified as Waikato *Surface Water Class* in the Waikato Regional Plan.

2.2 In-stream habitat

The Mangakotukutuku Stream through the trial reach is characterised by relatively uniform flow conditions with long, slow to moderate flowing runs predominating. Some deeper pool/run areas are also present. Bed gradients are low within the trial reach and are controlled by the upstream end of the Peacockes Road culvert. For this reason and given the ongoing sediment supply from the contributing catchment, the lower Mangakotukutuku Stream through Sandford Park is likely to remain soft bottomed in the long term.

In-stream habitat diversity over the trial reach is relatively low and the dominant substrate comprises the soft sediments described above. Other elements adding some diversity to the available in-stream habitat include the occasional accumulation of woody debris, bank overhangs, eroded bank slumps, overhanging vegetation and to some extent, urban debris. Woody debris is likely to be the key hard substrate providing physical habitat in the stream.

Some of the accumulations of woody debris in the stream appear to be relatively stable and associated with willow roots or larger branches either growing in or lodged in the stream. Other accumulations are less stable and are likely to be flushed out during flood flows, or possibly removed by HCC in order to maintain flood conveyance capacity. The natural input of wood to the stream from riparian margins is likely to be currently limited due to the lack of larger trees (other than willows) adjacent to the trial reach.

Key measures for enhancing in-stream habitat conditions in the trial reach will include the installation of stable hard substrates (woody debris) and stream margin cover.

2.3 Aquatic ecology

Several records of native fish within the Mangakotukutuku Catchment are included on the New Zealand freshwater fish database (administered by NIWA). Fish records for sites upstream and downstream of Peacockes Road are summarised in Table 1. Of the species listed in Table 1, giant kokopu and longfin eel are considered threatened (gradual decline) within the Waikato Region by the Department of Conservation (Hitchmough, 2005).

Table 1 – Summary of Mangakotukutuku Stream fish database records (from the freshwater fish database administered by NIWA)

Location	Species	Year/s recorded
Mangakotukutuku Stream downstream of Peacockes Road	Longfin eel (*Anguilla australis*)	1992, 2005
	Shortfin eel (*Anguilla dieffenbachii*)	1992
	Common smelt (*Retropinna retropinna*)	1992, 2005
	Common bully (*Gobiomorphus cotidianus*)	1992
	Torrentfish (*Cheimarrichthys fosteri*)	1992, 2005
	Koi carp (*Cyprinis carpio*)	2005
Mangakotukutuku Stream and tributaries upstream of Peacockes Road	Longfin eel (*Anguilla australis*)	1997, 2003, 2006, 2005, 2007
	Shortfin eel (*Anguilla dieffenbachii*)	1992, 1997, 2003, 2005, 2006, 2007
	Common smelt (*Retropinna retropinna*)	1997, 2003, 2005
	Common bully (*Gobiomorphus cotidianus*)	1997, 2003
	Torrentfish (*Cheimarrichthys fosteri*)	2006, 2007
	Inanga (*Galaxias maculatus*)	2003, 2005, 2006
	Banded kokopu (*Galaxias fasciatus*)	2003, 2005
	Giant kokopu (*Galaxias argenteus*)	2005
	Mosquitofish (*Gambusia affinis*)	2003, 2005, 2007

Macroinvertebrate diversity is currently limited within the main reach of the Mangakotukutuku Stream and mainly dominated by species that are tolerant of reduced habitat conditions (e.g. snails, worms and midges) (Collier *et. al.* 2008). One of the most commonly used metrics for the assessment of stream habitat quality is the

Macroinvertebrate Community Index or MCI. When MCI scores drop below 80, streams are generally considered to have poor water or habitat quality. From 1997 to 2004, MCI scores have averaged 81 for a site on the mainstream at Peacockes Road (MSCG website, 2008).

2.4 Flood issues

The Mangakotukutuku Stream is known to break its banks within Sandford Park on the true left bank of the stream. The large diameter corrugated steel culvert under Peacockes Road would act as a flow constriction under very large storm events and backwater effects would extend some distance upstream.

No records regarding calculated or recorded flood levels have been obtained. However, Environmental Protection Overlay maps shown in the Proposed District Plan indicate that the trial reach is within a *Flood susceptibility Zone (given a 7m rise in river levels)* and also a *Culvert Block and Associated Flooding Zone.*

We note that all restoration works will require that the stream's flood capacity be maintained. We consider that it is unlikely that any adverse flood effects would result from the works proposed in this report. However, flooding effects would need to be further assessed as part of Stage 2 (detailed design phase) of the restoration project.

3 Sedimentation assessment

3.1 Background

Approximately 70% of suspended sediment carried by the Mangakotukutuku is estimated to be derived from rural areas in the catchment (Williamson, 2001). The streambed is currently characterised by fine sediment build-up on the streambed. Observed accretion of sediments within the trial reach is likely due to the Peacockes Road culvert which is expected to be the controlling factor on the stream bed gradient within the area.

3.2 Site assessment

We consider that the trial reach is likely to remain characterised by fine bed sediments in the long term and reflects the nature of soils in the catchment. Fine bed sediments are likely due to the ongoing input of fine sediments from the contributing catchment and accumulation of those sediments due to the fixed inlet level at the Peacockes Road culvert which controls upstream bed gradients.

3.3 Options

Options for flushing sediments from the trial reach would generally require increasing water velocities to mobilise bed sediments and would be contrary to the erosion control and habitat restoration measures proposed. Engineered sediment flushing could also have negative impacts on downstream water quality due to the suspension of fine sediments.

Overall, we recommend that restoration efforts focus on erosion control and mitigation and habitat enhancement. Some localised sediment flushing (scour) may occur around any structures placed on the stream banks or bed for these purposes.

4 Erosion assessment

4.1 Background

Poor streambed stability has been identified as the major ecological stressor in the Mangakotukutuku Stream, followed by lack of habitat cover and metal contamination (Williamson, 2001). Peak flows from urban stormwater along with rural runoff contribute to streambed instability and poor habitat quality. The main part of Mangakotukutuku Stream running through Sandford Park has severe bank erosion and fine sediment build-up on the streambed.

4.2 Site assessment

Site inspections have been conducted by T & T staff on a number of occasions from March through to October 2008. In general, a number of bank erosion features were noted within the trial reach and included slumping and bank undercutting.

Figure 1 shown in Appendix C provides an overview of the observed erosion and stream features within the trial reach. No new erosion sites were noted between the first site inspection in March 2008 and the most recent inspection in October 2008.

Slumping has occurred in various locations over the trial reach and is most likely caused by high velocity flows that undermine the toe of the bank.

Stream bank undercutting was observed at the outside of a number of bends over the trial reach and is most likely caused by increased velocities and turbulence that naturally occurs at the outside of bends.

One site in particular is worthy specific mention and is shown as BRO4 on Figure 2 in Appendix C. Bank erosion at this site is shown in Photos 1 to 4 provided in Appendix B. Bank undercutting at BRO4 is likely to move towards the existing maintenance track and has the potential undermine the track in the short to medium term.

It is important to note that erosion and deposition processes are natural and whilst erosion may be a problem in urban streams, it is a natural feature of a meandering stream and helps create a heterogeneous stream habitat.

4.3 Erosion control options

A number of methods may be considered for stream bank erosion protection. Each has varying degrees of disturbance to the stream environment. Erosion protection methods, in order of least cost to most cost, include:

- **Maintain the status quo** – as noted above, erosion and deposition processes are natural and assist in maintaining a heterogeneous stream habitat;
- **Riparian planting** – where the consequences of continued natural erosion are not significant, riparian planting is an appropriate control tool;
- **Soft engineering works** – measures include minor bank regrading, the placement of rock or woody debris, riparian planting or a combination of these;
- **Hard Engineering works** – measures include major bank regrading, stream bed protection using gabions, cemented rock, timber or concrete walls and full waterway structural lining, or a combination of these.

4.3.1 Options for improving bank stability and erosion control

Options for improving bank stability and controlling erosion include:

- Bank re-grading - reshaping of the bank profile to a more gradual slope will help to prevent erosion (BRO 1 Figure 5);
- Bank terracing - usually used in situations where there is little riparian width although it may be appropriate on the outsides of bends or in local areas to create habitat diversity (BRO 2 & 3 Figure 5). Soil socks, timber or rock bank protection may be used and could be screened by vegetation once established;
- Waterway structural lining - reinforced earth and geotextiles to support banks particularly while vegetation is establishing;
- Toe protection - incorporating support for the wetted toe from the bed to slightly above normal water level to protect from undercutting (BRO 3 and 4 Figure 5):
  - Stone or rock revetment - slows water down by increasing the roughness of the stream banks;
  - Log revetment - logs secured to the bank or stream bed and may include a geotextile roll and mat;
  - Root wads - dead logs with root wads facing upstream to reduce flow velocities;
  - Log, rootwad, boulder revetment;
  - Coir geotextile roll and emergent macrophytes.
- Splash zone protection - the splash zone is the zone between the normal low and high water levels i.e. exposed to wave wash, erosive river currents and wet-dry cycles. Splash zone protection options include (refer BRO 3 & 4 Figure 5):
  - Coir fibre mats keyed the toe protection and staked down, may be pre-vegetated;
  - Geotextile keyed into the toe protection and planted;
  - Vegetative geogrid (fabric encapsulated soil) - successive walls of several lifts of fabric reinforcement. Would be masked by vegetation.
- Bank zone - exposed to periodic flooding. Measures for splash zone can be extended up the bank although the type of plants will differ (BRO 4 Figure 5).
- Terrace zone -planting should be sufficient in this zone including tree species with deeply penetrating roots.

4.3.2 Discussion of bank stability and erosion control options

No structures are affected by the observed erosion other than the existing walking track adjacent to erosion site BRO4 (see Figure 2 in Appendix C). It is therefore considered that either maintaining the status quo, riparian planting or minor bank regrading be undertaken to stabilise all the other non-critical slumped or undercut areas identified. Soft engineering measures may also be used at these sites.

It is considered that the erosion occurring closest to the existing track has the potential to undermine the track and therefore more significant works are likely to be required. Soft engineering measures are preferred to hard measures in this instance with bank regrading works preferred as it involves the least engineering and could be done by hand. Riparian planting would be an essential component of these works with woody debris, soil socks or placed rock used if required.

Hamilton City Council would need to be consulted regarding any bank regrading works as this may impinge upon the existing track. Any regrading works would need to be designed to suit Council's requirements for the width and location of the track.

5 Habitat enhancement

This section presents options for the enhancement of aquatic habitat over the project reach. Habitat enhancement components of the project will aim to increase local habitat diversity and abundance for key native fish species while also providing a substrate for macroinvertebrates.

5.1 Target species

The diversity and distribution of fish species recorded within the Mangakotukutuku Stream catchment are presented in Section 2.3. Habitat enhancement should focus on those species that are likely to inhabit the trial reach given the predominating habitat types (see Section 2.2) and access constraints. Priority should also be given to species with higher conservation value.

The Peacockes Road culvert on the main stream is considered to be a barrier to upstream fish passage under most flow conditions (Aldridge & Hicks, 2006). However, the diversity of species previously recorded above this culvert suggests that native species can negotiate this culvert by climbing wetted margins (e.g. eels and banded kokopu) and occasionally by swimming (e.g. inanga and smelt). Species with only moderate climbing ability such as giant kokopu and common bullies appear to have been able to pass upstream.

Giant kokopu and longfin eel are considered threatened (gradual decline) within the Waikato Region by the Department of Conservation (Hitchmough, 2005). Longfin eels and giant kokopu are also likely to favour the habitat types already present within the trial area (see Section 5.2 below). Giant kokopu and longfin eel are therefore considered to be key target species for the restoration trial.

Aquatic habitat enhancement works should also consider the other native fish that are likely to frequent the soft-bottomed habitat through the project reach such as inanga, shortfin eels. The project reach is unlikely to be suitable for other native species recorded in the upper catchment such as banded kokopu and torrentfish that prefer higher elevation, smaller stream habitats (Baker & Smith, 2007) and higher water velocities respectively.

In-stream habitat enhancement measures aimed at fish species also has the potential to improve local macroinvertebrate diversity through the introduction of new stable hard substrates.

Overall, suggested target species for habitat restoration are as follows:

- **Priority 1** - giant kokopu and longfin eels
- **Priority 2** - inanga and shortfin eels

5.2 Habitat preferences

5.2.1 Giant kokopu

The giant kokopu is the largest of the galaxiid fishes and is endemic to New Zealand. They are normally diadromous (spend part of their life at sea and part in freshwater) and the juveniles form a small proportion of the annual whitebait harvest (Bonnett & Sykes, 2002).

Habitat preferences and critical habitats for the conservation of the giant kokopu are detailed in Bonnett and Sykes (2002). That study assessed habitat requirements for giant kokopu based on a review of data on the New Zealand Freshwater Fish Database (administered by NIWA) and specific habitat surveys of Westland and Southland streams. Five critical habitat features were identified as follows (Bonnett and Sykes, 2002):

iii. **In-stream cover** – the presence of in-stream cover is indicated to be more important than its composition. Cover included woody debris and logs, in-stream vegetation and bridge and culvert structures.

iv. **Low water velocity** – the water velocity preference curve generated from the microhabitat survey indicated that giant kokopu favour slow moving or still water (< 0.1 m/s).

v. **Shade** – the presence of riparian cover and shade was indicated to be more important than its composition.

vi. **Inland penetration** – giant kokopu are found mainly at low elevation and close to the sea. However, they are capable of significant upstream migration, particularly in low gradient rivers like the Waikato River.

vii. **Water depth** – the habitat preference curve generated from the microhabitat survey indicated that giant kokopu favour deep water (> 0.5 m), characterised by softer substrates.

Habitat use by giant kokopu in some Waikato Streams (tributaries of the Waikato River draining the Hakarimata Range) was more recently studied by Baker and Smith (2007). Giant kokopu were generally found in pool habitats that had a relatively high proportion of mud in bottom substrates and grasses and flax on riparian margins. Woody debris dams and undercut banks were also strongly selected as in-stream cover.

Two studies have assessed the effectiveness of artificial habitat structures specifically targeting giant kokopu.

Bonnett *et al.* (2002) noted that giant kokopu were almost exclusively found under dense accumulations of logs and debris in Westland streams. To determine if this type of habitat was key to giant kokopu occurrence the authors constructed six artificial habitats in a 200 m reach of the Viaduct Creek, Westland. These artificial habitats comprised logs attached to warratahs driven into the stream bed with some logs placed close to the stream bed. These structures were left for a period of three months to accumulate debris and were then surveyed by electrofishing on two occasions. A total of eight giant kokopu were found in the reach with four specifically occupying the artificial habitats.

Aldridge *et al.* (2007) conducted a similar experiment at several urban stream sites in Hamilton using clay pipes and ponga logs attached to stream banks as artificial habitat. Tagged giant kokopu specimens were released into several stream reaches that included enhanced zones and control zones. Stream reaches were then monitored over a period of eight months. Monitoring data suggested that, as fish became larger, they preferred to reside in sections of the stream enhanced with ponga logs, particularly in pools and amongst the organic matter associated with the logs.

5.2.2 Longfin and shortfin eels

Longfin and shortfin eels are probably the most widespread freshwater fish in New Zealand and are encountered in almost all habitats with access to the sea. In general, shortfin eels prefer lowland lakes, swamps and sluggish streams and rivers whereas longfin eels prefer faster flowing water (Glova *et. al.* 1998). Fish records suggest that both species are relatively widespread throughout the Mangakotukutuku catchment. Longfin eels appear to penetrate slightly further inland compared to shortfin eels and have been identified in tributaries upstream of State Highway 3.

Jowett & Richardson (1995) investigated habitat preferences for several common native fish species. Habitat preference curves generated in their study indicated that both shortfin and longfin eels prefer water depths of less than 0.2 m. Velocity preferences were less clear with eels having broad velocity preferences. In terms of substrate longfin eels preferred coarse gravels and cobbles while shortfin eels preferred fine gravels. However, the authors suggest that this could have been related to the larger mean size of longfin eels and a preference for substrates with larger interstitial space in the substrate (Jowett & Richardson, 1995).

Glova *et. al.* (1998) investigated factors associated with the distribution of small and medium-large eels in three lowland streams. The authors found that juvenile longfin biomass was highest in riffle and run habitats. In contrast juvenile shortfin eels were evenly distributed across all habitat types. The distribution of medium to large (>300 mm total length) eels of both species was strongly associated with cover. Longfin eels used a greater variety of large cover types including macrophytes, banks and in-stream debris whereas shortfin eels preferred riparian vegetation bank cover.

Glova *et.al.* (1998) concluded that longfins are a more generalist species occurring in virtually all habitat types, other than swamps, and utilising a diverse range of cover types. In contrast, shortfin eels have a more restricted distribution, occurring largely in lowland lakes, swamps and the slow flowing areas of lowland rivers and streams.

Glova (1999) conducted cover preference tests on three size classes (small = <100 mm, medium = 100-199 mm and large = 200-299 mm total length) of longfin and shortfin eels in replicate artificial channels. When species were unmixed, small and medium sized eels of both species preferred watercress, cobbles and woody debris. Large eels preferred watercress. When mixed, longfin eels of all size classes preferred cobbles and shortfineels preferred macrophytes and woody debris. Watercress use appeared to increase in use with increasing eel size when species were unmixed. Woody debris use increased with increasing eel size when species were mixed.

5.2.3 Inanga

Inanga are the most common and widespread of New Zealand's galaxiid fishes and forms the bulk of the whitebait catch in most New Zealand Rivers. Many inanga habitats have been affected by urban and rural development and this has contributed to the gradual decline in the size of whitebait runs.

While natural migration upstream of the Peacockes Road culvert may be limited, we understand that the MSCG has previously obtained permits for manually transferring upstream migrants past the culvert. Inanga have been found in the Mangakotukutuku Stream as far upstream as SH3 (NIWA Freshwater Fish Database).

Jowett (2002) investigated the in-stream habitat suitability for feeding inanga. He found that inanga favoured pools or slow moving runs with a depth preference of >0.3 m. Feeding occurred mainly where currents concentrated food (downstream of where flows impinged against a bank or a constriction) or near the surface of pools. Water velocities used by feeding inanga ranged from 0.03 to 0.07 m/s (Jowett, 2002).

The importance of in-stream cover for inanga has been demonstrated through the experimental removal of cover in various reaches of a stream known to provide good cover for inanga (Richardson, 2002). Reaches where cover (bank-side vegetation, bank overhangs and woody debris) was removed became shallower, swifter and wider compared to control areas that were unchanged. Inanga densities were significantly greater in the control reaches.

Overall, inanga generally favour pool habitats in lowland rivers and streams that have good levels of cover ((Richardson & Taylor, 2004)). In small waterways good cover can be provided by vegetation that overhangs the stream banks. Slightly overhanging banks covered with vegetation also provides good cover for inanga (Richardson & Taylor, 2004). Wood accumulation in streams also appears to be important for creating habitat diversity and encouraging the development of deeper pool areas (Richardson, 2002).

5.2.4 Macroinvertebrates

The introduction of stable in-stream habitat will likely enhance local macroinvertebrate diversity within the project reach.

5.3 Key habitat features

While there will likely be some overlap in the actual distribution of fish species along the trial reach it is apparent that key forms of habitat for target species will include:

- Areas of low water velocity (< 0.1 m/s) in deeper pool areas (>0.5m deep) with features that provide in-stream cover for giant kokopu.
- Features that provide in-stream cover for eel species in shallower run areas including bank overhangs, in-stream woody debris and overhanging riparian vegetation.
- Areas of low water velocity (< 0.1 m/s) downstream of flow constrictions with features that provide good bank cover (overhanging banks or vegetation) for feeding inanga.
- Overhead riparian cover and shade.

Therefore, the design approach to habitat enhancement through the project reach focuses on stabilising, enhancing or restoring these features. Other important design considerations include:

- Sympathetic, nature based engineering design - working with the existing physical and ecological features of the stream system.
- Maintainability of works - recognition that works may require periodic maintenance over time, hence ensuring that designs facilitate this.
- Cost minimisation - overall design concepts are kept simple and materials utilised for construction are minimised. Ideally works will be able to be constructed by hand by volunteers.
- Stability - engineered habitats are likely to be more stable than natural woody debris that could be dislodged by stormwater flows.

5.4 In-stream habitat enhancement options

Design concepts for habitat enhancement in the project reach are presented in Figures 2 to 5 presented in Appendix C and are summarised below. We note that the detailed design of habitat enhancement structures (woody debris weirs and a log overhang) would address design considerations such as stability, buoyancy, frictional and drag forces and any undesirable scour around the structures. An analysis of the effects of the structures on stream flooding will also be required.

5.4.1 Woody debris weirs

Concept designs for woody debris weirs are presented in Figure 3 in Appendix C. Photographs of a natural and constructed woody debris weirs are included in Appendix B (Photo 5 and Photo 6 respectively).

The weir installation would generally comprise a wood log structure keyed into the banks of the stream. The structure would extend across the full width of the stream and be designed to act as a low weir under base flow conditions. The placement of the weir will lead to the development of a scour pool and low velocity zone on the downstream side while forming a riffle feature as flow passes over the weir. Under higher flows the structure would be submerged and would have negligible impact on flood flows.

The woody debris structure itself would comprise durable native or exotic hardwood, sourced locally from windfall or tree maintenance activities. The ends of the structure would be keyed into the stream bank with the base of the structure at bed level.

It is anticipated that up to three weir structures could be constructed within the trial reach as shown in Figure 2 (Appendix C).

Bank keyed woody debris weirs are preferred as they have good stability and are less expensive and easier to construct that boulder anchored woody debris weirs.

Table E1 in Appendix E provides a summary of issues associated with various woody weir structures.

5.4.2 Log overhang

This habitat feature would comprise either a log bundle (or a single log) anchored to rocks placed on the stream bed as shown in Figure 4 (Appendix C). The feature would create a bank overhang in a deeper/lower velocity section of the stream providing cover. A relatively straight and stable reach of the stream would be suitable for such a structure. It is anticipated that two such structures could be installed in the project reach. This structure would be constructed using durable native or exotic hardwood, sourced locally from windfall or tree maintenance activities.

Boulder anchored log overhangs are preferred over soil anchored or freely placed log overhangs.

Table E2 in Appendix E provides a summary of issues associated with various log overhang structures. Photo 7 in Appendix B shows a recently constructed boulder anchored log overhang under low flow conditions.

5.4.3 Overhanging bank-side vegetation and riparian cover

Grasses planted directly adjacent the stream channel would overhang channel banks, including constructed log overhangs, as they matured.

We understand that advice on appropriate riparian planting is being provided to the MSCG by NIWA.

5.5 Maintenance

Habitat structures would be designed using relatively durable materials (i.e. native hardwoods or similar) and would not be expected to require significant maintenance (The life of the structures would be expected to last beyond the point at which riparian vegetation is naturally contributing woody debris to the stream). However, we would recommend that structures are inspected annually. For example, it may be necessary to tighten steel cable fastenings on boulder anchored structures in the event of woody debris shifting during flooding.

It should be expected that scour will occur around and downstream of in-stream habitat enhancement features - this is desirable as it will lead to the formation of additional habitat features (i.e. pools and undercut banks), but it will need to be monitored and any excessive scour or erosion will need to be addressed.

We would expect the in-stream structures to capture further debris over time. This is generally desirable where the debris adds to the complexity of the habitat. However, it may be necessary to clear the structures of any trapped litter or to remove excess debris if this is affecting the conveyance of flood flows.

6 Stream restoration options

A number of stream restoration options have been considered and these are generally discussed above. Stream restoration options include bank stabilisation via riparian planting, bank regarding works and habitat enhancement via woody debris weirs, log overhangs and riparian planting.

Preliminary stream restoration options are presented in Appendix C with preliminary cost estimates provided in Appendix D.

Additional investigations and liaison with both EW and HCC will be required to determine the extent of existing flood levels and how restoration works may affect adjacent land owners.

6.1 Erosion protection works

Three construction methodologies have been considered for this project and are discussed below.

6.1.1 Construction Option A - Contractor

Construction Option A provides construction costs where all work would be let under a typical construction contract with no involvement from MSCG volunteers. Major items include:

- The use of long length machine filled soil socks filled and installed by the supplier;
- Machine excavated banks; and
- All works undertaken by contractor.

6.1.2 Construction Option B – Contractor and MSCG

Construction Option B provides construction costs where some work would be let under a typical construction contract and some labour from MSCG volunteers would be used. Major items include:

- Short length soil socks filled by hand and placed via excavator;
- Machine excavated banks; and
- Riparian planting undertaken by MSCG volunteers.

6.1.3 Construction Option C - MSCG

Construction Option C provides construction costs where all works would be undertaken by MSCG volunteers. Major items include:

- Short length soil socks filled by hand and placed via excavator;
- Hand excavated banks; and
- All erosion mat placement and riparian planting undertaken by MSCG volunteers.

6.1.4 Construction methodology comparison

The comparative advantages and disadvantages of the three approaches to implementing restoration works are shown in Table 2 below.

Table 2 - Comparison of construction methods for erosion protection works

Construction Option	Advantage	Disadvantage
A	• Surety of installation quality • Fastest implementation	• Highest cost • Highest impact by machinery • Least community involvement
B	• Medium cost	• Less surety of installation quality
C	• Lowest cost • Least impact by machinery • Most community involvement	• Least surety of installation • Slowest implementation

6.1.5 Erosion protection work costs

Erosion protection at critical locations have been identified and Bank Regrading Options (BRO) presented in Figure 5 (Appendix C). Preliminary cost estimates have been developed for the four options under three different construction methodologies and are shown in Tables 3 and 4 below.

Table 3 - Cost comparison ($/m) for bank regarding options (excl. GST)

Bank Regrading Option (BRO)	Construction Option ($/m)		
	A	B	C
1	220	200	165
2	185	169	135
3	300	244	180
4	331	243	160

Table 4 – Cost comparison ($) for erosion protection works (excl. GST)

Construction Option ($)		
A	B	C
12,743	8,073	4,992

In general we recommend riparian planting along the entire stream bank and corridor to assist in bank stabilisation and habitat enhancement. Only limited planting has been included within the preliminary cost estimates. Preliminary cost estimates are presented in Appendix D.

6.2 Habitat enhancement

Bank keyed woody weirs have been selected as a preferred option at this stage as they have good stability and are less expensive and easier to construct that boulder anchored woody debris weirs. They are capable of being constructed by volunteers without the aid of large machinery.

Boulder anchored log overhangs have been selected as a preferred option at this stage as they have better stability than other options with similar costs and construction implications.

Habitat Enhancement measures have been identified and presented in Figures 2, 3 and 4 in Appendix C.

Indicative cost estimates (from a recently completed stream restoration project) for the nominated habitat structures are shown in Table 5 below. Costs are for all construction works undertaken by a contractor.

Table 5 – Indicative costs for habitat enhancement works

Item	Cost ($)
Bank Keyed Woody Weir	3,000-5,000
Boulder Anchored Log Overhang	2,000-4,000

7 Restoration prioritisation

The works nominated within the trial reach can be implemented in one stage or split into multiple stages if required. To aid in decision the making and funding process we have prioritised the restoration items shown on Figure 2 (Appendix C). A priority ranking is presented in Table 6 below.

Table 6 - Priority schedule for stream restoration measures

Priority Ranking	Restoration Measure
1	BRO4
2	BRO3
3	KW2
4	LO2
5	KW1
6	KW2
7	KW3
8	BRO2

8 Statutory considerations

The Hamilton City Council has a key role in managing the effects of land use activities that could adversely impact on water quality or increase local flood hazards. The Waikato Regional Council's (Environment Waikato) has a key role in managing the water quality and ecology of streams within the city.

8.1 Waikato Regional Council

Erosion control and habitat rehabilitation works may be considered under Section 4, River and Lake Bed Module, of the Waikato Regional Plan. This module of the Regional Plan addresses river and lake bed management issues

Our discussions with Environment Waikato staff suggest that the works proposed in this report are likely to be considered under Section 4.2.15.1 *Permitted Activity Rule - Erosion Control Structures* of the Regional Plan. This rule is set out as follows:

The use, erection, reconstruction, placement, alteration or extension of a:

1. *revetment or erosion control structure, and*
2. *associated bed disturbance, and*
3. *necessary deposition of construction material, and*
4. *any discharge of sediment associated with construction activities,*

in, on or over the bed of a lake or river, for the purposes of erosion control are permitted activities subject to the following conditions:

a *The structure and the floodway in the immediate vicinity of the structure shall be maintained clear of debris.*

b *The structure shall not decrease the cross sectional area of the river.*

c *For any stretch of river or lake bank measuring up to one bank kilometre in length, the combined length or erosion control structures shall not exceed 50 metres in length.*

d *The structure shall not be constructed of, or contain, vehicle bodies or demolition rubble other than clean concrete, placed such that there is no visible steel in the finished work.*

e *The construction works shall comply with the suspended solids discharge standards as set out in Section 4.2.21.*

f *All construction materials and equipment shall be removed from the river or lake bed and the floodplain on the completion of that activity.*

g *No contaminants (including, but not limited to, oil, hydraulic fluids, petrol, diesel, other fuels, paint or solvents, but excluding sediment) shall be discharged to water from the activity.*

h *Where the weight of the structure is insufficient to keep it in place it shall be anchored to the bed and bank of the river.*

i *The structure shall be maintained in a structurally sound condition at all times.*

j *The owner of the structure shall inform the Waikato Regional Council in writing of the location of the structure at least 10 works days prior to work commencing.*

k *The structure shall not be located in a water body identified as a Natural State water body in the Water Management Class Maps.*

l *The activity shall not disturb any archaeological site or waahi tapu as identified at the date of notification of this Plan, in any district plan, in the NZ Archaeological Association's Site Recording Scheme, or by the Historic Places Trust except where Historic Places Trust approval has been obtained.*

m *In the event of any waahi tapu that is not subject to condition l) being identified by the Waikato Regional Council to the person undertaking the use, erection, reconstruction, placement, extension or alteration, the activity shall cease insofar as it may affect the waahi tapu. The activity shall not be recommenced without the approval of the Waikato Regional Council.*

n *Any erosion occurring as a result of the structure shall be remedied as soon as practicable.*

o *This Rule shall not apply to activities located in, on, under or over the bed of a river or lake that is a Significant Geothermal Feature.*

p *The structure shall provide for the safe passage of fish both upstream and downstream.*

Our assessment of the above rule suggests that the proposed restoration measures would most likely be able to meet all of the permitted activity requirements. Erosion control measures suggested in this report cover a combined linear distance of approximately 28 m and therefore comply with condition 4.2.15.1 (c). Condition 4.2.15.1 (e) relating to suspended solids discharge during construction will need to be addressed at the detailed design stage. We note that Environment Waikato requires 10 days written notice of the locations of any structures prior to work commencing.

8.2 Hamilton City Council

The proposed restoration works are consistent with the Hamilton City Proposed District Plan, Objective 3.1.1 *Waikato River Corridor and Gullies,* to protect the natural character, bank stability and water quality of the river corridor and gully system for their visual, wildlife, cultural, historical, and recreational values and enhance these significant natural features and their associated ecological processes.

Environmental Protection Overlay maps shown in the Proposed District Plan indicate that the trial reach is subject to the following overlays:

- Flood susceptibility zone (given a 7m rise in river levels);
- Culvert block and associated flooding zone;
- Gully Slopes >25° (and 10m Buffer Zone);
- Gully Slopes <25°.

The overlay maps identify restrictions on development in areas that are adjacent to the Waikato River, or are a part of, or adjacent to the gully systems, peat lakes and wetlands. The Environmental Protection Overlay does not preclude developments that can meet the performance standards and assessment criteria. Two critical conditions under Rule 2.1 of the district plan have been identified; Vegetation Removal and Earthworks (Including Clean Fill).

Rule 2.1.2 b) iii) and c) iii) requires that any area of vegetation removed within 5m of the banks of the Waikato River, or any natural watercourse, shall be replanted with an equivalent area (or covered with an impermeable surface) within one calendar month of removal.

Rule 2.1.2 b) iv) and c) iv) requires that the maximum volume of earthworks shall not exceed $40m^3$ per site per calendar year and that earthworks shall not take place within 5m of the edge of the banks of the Waikato River or any natural watercourse, or on slopes > 25°.

As earthworks may exceed $40m^3$ per site per calendar year and earthworks shall take place within 5m of the natural watercourse, the restoration works are likely to be considered a Restricted Discretionary Activity and will also likely to require that a Site Management Plan be prepared.

In addition to the District Plan controls, Reserve Management Plans prepared under the Reserves Act 1977 guide and control the day to day management and use of land that is held as Council Reserve land.

It is recommended that Council should be consulted to confirm the activity status of the proposed works and the likely requirements under the District Plan and the Gully Reserves Management Plan.

9 Restoration summary and next steps

9.1 Restoration summary

This report presents the first stage (concept design) of a two stage project to implement stream restoration measures over a trial reach of the lower Mangakotuku Stream. The MSCG considers that habitat diversity, stream erosion and stream sedimentation are the key issues limiting the overall quality of habitat in the lower reach of the stream.

Our assessment suggests that the trial reach is likely to remain characterised by fine bed sediments in the long term. This is due to bed gradients being controlled by the level of the Peacockes Road culvert and the likely ongoing input of fine sediments from the surrounding catchment. Overall, we recommend that restoration efforts focus on erosion control and mitigation and habitat enhancement.

A range of options are available that will provide low impact solutions for erosion protection and enhance in-stream habitat values. We have focussed on 'natural' and more cost effective engineering options that could be constructed by volunteer labour (under appropriate supervision) if desired and have considered the Permitted Activity requirements of the Regional Plan.

No structures are affected by the observed stream bank erosion other than the existing walking track at one site. Also, whilst erosion may be a problem in urban streams, it is a natural feature of a meandering stream and helps create a heterogeneous stream habitat. We therefore recommend that either the status quo is maintained or riparian planting be undertaken to stabilise the non-critical slumped or undercut areas identified. Soft engineering measures may also be used at these sites if desired.

The erosion occurring closest to the existing track has the potential to undermine the track and therefore more significant works at this location should be prioritised. Bank regrading is the preferred option at this site as it involves the least engineering and could possibly be done by hand. Riparian planting would be an essential component of these works with soil socks or placed rock used if required.

Habitat enhancement options focus on the habitat types favoured by key native fish species which include giant kokopu, eel species and inanga. Riparian planting, log overhangs and constructed woody weirs are recommended to enhance in-stream cover for these species. The placement of wood structures would aim to increase the diversity in water velocities and depths and provide relatively stable hard substrates within the soft bottomed stream environment. The introduction of stable in-stream habitat is also likely to enhance local macroinvertebrate diversity within the project reach.

As the trial reach is located within a Council reserve, it is recommended that consultation with Council is undertaken as early as possible.

9.2 Next steps

Stage 2 of the project will comprise the development of concept designs through to detailed designs for construction. Key items for the MSCG to confirm in order to progress concept designs to a detailed design stage include:

- The desired extent and location of restoration works, noting any other planned developments for the site;
- The available budget for design and construction components of the project;
- The preferred construction methodology including the likely inputs from volunteers.

We note that depending on the nature of the restoration options chosen for implementation that there may also be consenting, contract and works supervision requirements.

10 Applicability

This report has been prepared for the benefit of Mangakotutuku Stream Care Group 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 by:
....	....
Jodi Earwaker,	Peter Cochrane
Dean Miller, &	SENIOR ENVIRONMENTAL SCIENTIST
Bryn Quilter	
ENVIRONMENTAL CONSULTANTS	

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