Assessment of the stream conditions associated with the Hudson Street Gully erosion control works

CBER Contract Report Number 9

Prepared for the Hamilton City Council

by

Dr Brendan J. Hicks

Gavin B. Reynolds

Paul M. Jamieson

Centre for Biodiversity and Ecology Research
Department of Biological Sciences
School of Science and Technology
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

2 July 2001

Email: b.hicks@waikato.ac.nz

The University of Waikato
Te Whare Wānanga o Waikato

CBER
University of Waikato
Centre for Biodiversity and Ecology Research

Assessment of the stream conditions associated with the Hudson Street Gully erosion control works

EXECUTIVE SUMMARY

Before the commencement of the Hudson Street Gully erosion control works there were two waterfalls and a 58–m long culvert on the Hudson Street Gully Stream. The works have replaced the 3-m waterfall at the confluence of the stream with the Waikato River with a 75-m concrete pipe culvert with a fall of 3.45 m, and a 10-m long culvert between the new, 75-m long culvert and the original culvert. The 2.6-m waterfall with its overhanging lip that is 9 m upstream of the original Hudson Street Gully culvert remains unaltered.

Channel works associated with the erosion control, and the tracks required for machinery movement, have culverted about 85 m of the 134 m of the original stream channel below the Hudson Street culvert. The stream channel was aquatic habitat of moderate quality before the erosion and recent culvert construction, and had been channelised to stabilise the stream bed. The stream before culvert installation was shallow (maximum depth about 0.25 m) with a mud and rock bed, and had no bank undercuts suitable for fish cover. However, as no baseline survey was conducted, the precise value of this lost habitat cannot be quantified.

Despite the original barriers to upstream fish migration, shortfinned eels inhabited the Hudson Street Gully stream above the original Hudson Street Gully culvert. The stream habitat above the original culvert was of high quality for fish, though realistically eels were the only species with the ability to migrate into it naturally. This is an interesting little stream and reasonable efforts should be made to maintain passage for eels.

The addition of the two further culverts and removal of the downstream waterfall as part of the Hudson Street Gully erosion control works should not seriously impede the continued upstream migration of juvenile eels provided that flow is maintained in the culverts and that the eels can negotiate the drop structure between the downstream end of the longest culvert and the Waikato River. Natural high flow events will drown the drop structure, but these will be sporadic and unpredictable.

We recommend:

1. That if the inlet and culvert joints do not quickly seal naturally with fine sediment to limit water loss in the long culvert or at its inlet, they should be sealed artificially to maintain flow through the entire length of the culvert.

2. That the drop structure at the end of the 75-m long culvert should incorporate a ramp with a roughened surface to enable juvenile eels to climb into the culvert regardless of the level of the Waikato River.

INTRODUCTION

On 25 June 2000 the Hamilton City Council requested an evaluation of the environmental impacts of the emergency culverting associated with the Hudson Street Gully erosion control works. These works include the installation of two concrete culverts through which the stream below Hudson Street passes (Figure 1). The study objective was to determine the fish assemblage upstream of the Hudson Street culvert, and to report on any possible effects of the works.

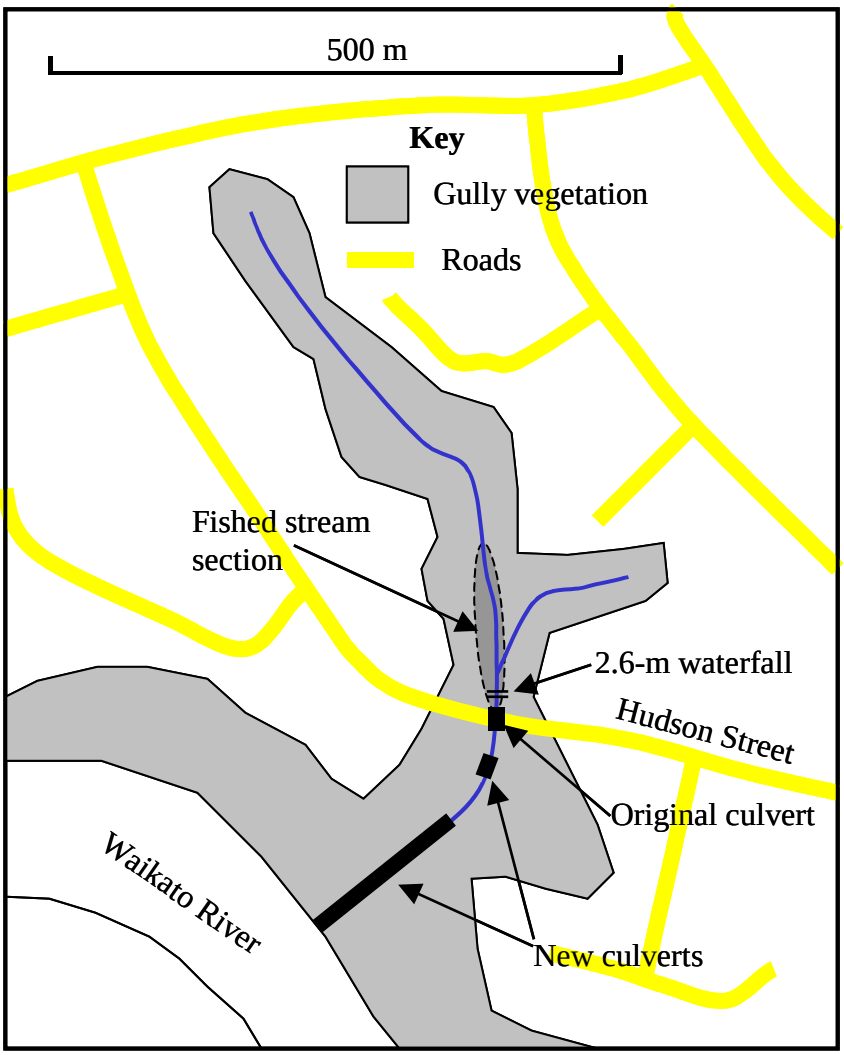

Figure 1. The location of the new and existing culverts on the Hudson Street Gully stream, showing their relation to the fished stream section and the gully vegetation.

METHODS

The stream that passes under Hudson Street was inspected on 25 June 2001, and then on 26 June 2001 a survey of the fish upstream of the existing Hudson Street Gully culvert was carried out by single-pass electroshocking, and the stream habitat was evaluated. The electroshocking was conducted using a generator-powered, 240-V electroshocker with a nominal power output of 300 W. This electroshocker was operated by a highly experienced electrofisher (BJH). The dissolved oxygen, pH, total dissolved solids, and water temperature were measured at the same time.

Two stream reaches were electroshocked (Table 1). One section was very short (8.2 m long), and was immediately upstream of the Hudson Street culvert, but downstream of a 2.6-m free-fall waterfall. The waterfall plunged onto a low tallus slope at the head of a pool. (Figure 2).

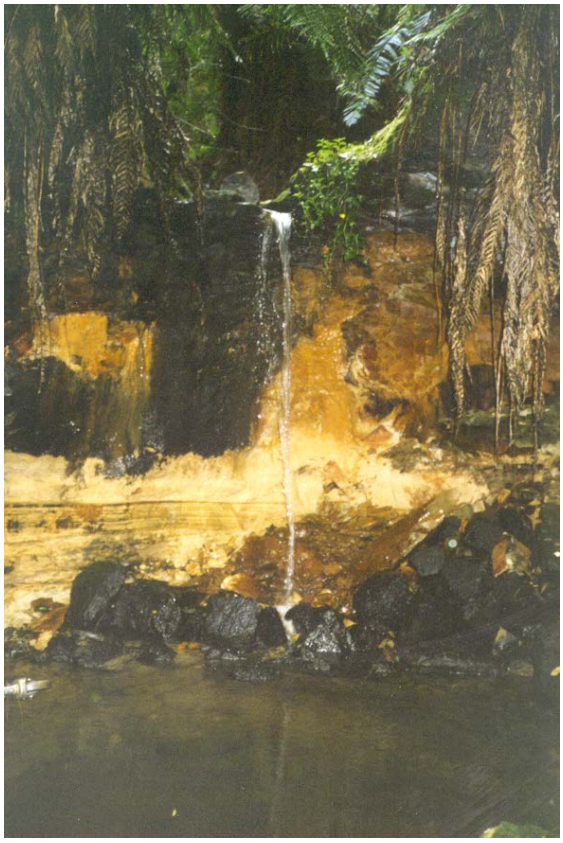

Figure 2. A 2.6-m free-fall waterfall that was 9 m upstream of the Hudson Street culvert. The discharge was 2.35 l s^{-1} when the picture was taken on 26 June 2001 (photo: Brendan J. Hicks).

Table 1. Length of stream electroshocked and stream dimensions at two sites upstream of the Hudson Street culvert surveyed on 26 June 2001.

Site	Length (m)	Water width (m)	Area (m^2)	Average depth (m)	Maximum depth (m)
Between Hudson Rd culvert and waterfall					
Riffle	5.2	1.2	6.2	0.05	0.22
Pool	3.0	4.1	12.3	0.50	0.72
Total area			18.5		
Above 2.6-m overhanging waterfall					
Pool-riffle section	34.5	1.5	52.4	0.25	0.72
Large pool	6.0	4.0	24.0	0.65	1.03
Total area			76.4		

The ages of the eels were estimated from the age-length regression for Waikato pastoral streams of Chisnall and Hayes (1991), where age in years = (length in mm – 155.7)/15.9 (N = 102, r^2 = 0.79). The weights were calculated from the weight-length regression for shortfinned eels from small pastoral and forested streams of Hicks and McCaughan (1999):

$$W = 8.47 \times 10^{-7} L^{3.102},$$

where W = weight in g and L = total length in mm. For this equation, N =261, and r^2 = 0.99.

Physical description of the fished stream section. Two stream sections were fished at about map reference NZMS 260 S14 27148 63747. These sections were divided by the 2.6-m waterfall. The upstream entrance to the culvert under Hudson Street was a round concrete pipe with an internal diameter of 1.05-m that had its invert set at stream-bed level (Figure 3). The stream bed between the Hudson Street culvert and the waterfall was angular cobbles and boulders. The stream banks were vertical and were composed of weak sedimentary strata on the waterfall face upstream, capped with a bedrock lip, and gabion baskets overgrown with wandering jew (*Tradescantia fluminensis*) at the sides.

Figure 3. The inlet to the 1.05-m internal-diameter culvert under Hudson Street (photo: Brendan J. Hicks).

The stream flow was about 2.35 l s^{-1} between the upstream end of the Hudson Street Gully culvert and the tributary that entered from the true left about 25 m upstream of the waterfall (Figure 1). This tributary flowed at 0.96 l s^{-1}, and by subtraction the main stem discharge upstream of this tributary was 1.39 l s^{-1}.

Above the waterfall the Hudson Street Gully Stream was 1-2 m wide with well vegetated margins that created moderate stream shading (Figure 4). The stream banks were mud and clay faces 0.5-1.0 m high that are stablilised by riparian vegetation of shrubs and trees. In places there were undercuts suitable for fish habitat, and tree roots in the stream created additional cover. The riparian vegetation was a mixture of native and exotic species, including a large poplar (*Populus* sp.) and a stand of bamboo (*Bambusa* sp.). The ground cover was mainly exotic weeds such as wandering jew. The stream bed was a mixture of bedrock (10%), sand (50%), mud (45%), and tree roots (5%). The channel was mainly

shallow pools up to about 0.35 m maximum depth, but between the pools were bedrock chutes 1-2 m long with an angle of about 30º. These chutes comprised about 10% of the channel length, and the water in them was 2-3 cm deep and swiftly flowing.

Figure 4. Hudson Street Gully Stream looking upstream immediately upstream of the 2.6-m waterfall where its discharge was 2.35 l s^{-1} (photo: Brendan J. Hicks).

Physical conditions in the upstream reaches. Though our fish survey did not extend more than about 50 m above the Hudson Road culvert, we did walk the stream section up to about 100 m from the waterfall. The stable banks and wooded riparian margins extended throughout this section, and for an unknown distance further upstream (Figure 5).

Figure 5. The Hudson Street Gully Stream beyond the reach in which the fish were surveyed, showing the stable wooded margin and in-stream woody debris (photo: Brendan J. Hicks).

We also walked up the small tributary that joins the main stream from the true left about 25 m upstream of the 2.6-m waterfall. This tributary had a 10-m slope at an angle of about 60^{o} composed of clay, rock, and concrete rubble about 10 m upstream from its confluence with the main stem. Above this slope the stream was about 0.3 m wide with stable grassy margins and a cobble bed (Figure 6).

Figure 6. The tributary on the true left that joins the main stem about 25 m upstream of the waterfall. The discharge on 26 June 2001 was 0.96 l s^{-1} (photo: Brendan J. Hicks).

RESULTS

Culverts and fish access

The original 1.05-m diameter culvert beneath Hudson Street was built about 27 years ago according to Hamilton City Council plans dated December 1972. This design was for a 58-m long culvert with a gradient of 0.0143 (1 in 70) as it passed through the base of the substantial fill supporting Hudson Street (Mark Dearlove, Hamilton City Council, pers. comm.). Before the bank slumping that prompted the Hudson Street Gully erosion control works, the stream also plunged over a 3-m waterfall at its confluence with the Waikato River most of the time (Brendan Hicks, personal observation).

A track was recently formed within the gully to give access for heavy earth-moving machinery to install the new culverts. This track crossed the stream about 30 m downstream of the original Hudson Street Gully culvert, and a new culvert of approximately 10 m in length and 1.2 m inside diameter was installed in June 2001 for the stream crossing (Figure 1). About 20 m downstream of this culvert an additional new culvert was also constructed in June 2001. This additional culvert is approximately 75-m long with a fall of about 3.45 m, which is a gradient of 0.0460 (Figure 1; Hamilton City Council draft plans), and is a round,

concrete pipe of the same 1.2-m inside-diameter as the shorter culvert upstream (Figure 7). The drop structure from the downstream end of the culvert into the Waikato River had yet to be built at the time of inspection, and was predicted to have a fall of about 1.5-2.0 m to the level of the Waikato River at low flows.

Figure 7. The inlet of the 75-m long culvert on the Hudson Street Gully Stream at a stream discharge of 2.35 l s^{-1} on 25 June 2001 (photo: Brendan J. Hicks).

Because the joints in the culvert pipes have not been sealed, at a flow of 2.35 l s^{-1} all of the water that entered the top of the culvert had leaked out before the culvert outlet, making the invert dry for the lower part of its length (Figure 8). The poorly sealed nature of the bed material around the inlet of the culvert may also have contributed to the water loss.

Figure 8. The outlet of the 75-m long culvert on the Hudson Street Gully Stream at a stream discharge of 2.35 l s^{-1} on 25 June 2001, showing complete water loss within the culvert (photo: Brendan J. Hicks).

Channel works associated with the erosion control, and the tracks required for machinery movement, have culverted about 85 m of the 134 m of the original stream channel below the Hudson Street culvert. The stream channel was aquatic habitat of moderate quality before the erosion and recent culvert construction, and had been channelised to stabilise the stream bed. The stream before culvert installation was shallow (maximum depth about 0.25 m) with a mud and rock bed, and had no bank undercuts suitable for fish cover (personal observation, BJH). However, as no baseline survey was conducted, the precise value of this lost habitat cannot be quantified.

Water quality

The water quality of the stream was very suitable for aquatic life. At 1100 h on 26 June 2001 the water temperature was 12^{o}C, and pH was 7.1, close to neutral. The specific conductance (temperature corrected) was 149.2 µS cm^{-1}, and the conductivity was 112.8 µS cm^{-1}. Such values are usual for small Waikato streams in ungrazed land, and are about half that of the Waikato River at this point. The dissolved oxygen was 8.72 g m^{-3} (81.3%), which was a little lower than we expected for a small, well-mixed stream.

Fish

A total of nine shortfinned eels (*Anguilla australis*) were found in the 49 m (95 m^2) of stream channel that was fished. Their estimated total biomass was 2082 g (Table 2). Thus fish diversity was low, with shortfinned eels the only fish species found, but fish biomass was moderate for a shaded stream. This was predictable given small size of the stream, and the restricted fish access caused by the waterfalls and the original Hudson Street culvert. The densities and biomasses of the eels were lower above the waterfall than below it, but were still within expectations for shaded streams with woody vegetation on the margins (Table 2). The estimated ages of the eels, especially the absence of eels less than 10 years of age, suggest that recruitment of juveniles is a sporadic event, and that most eels migrated to their present location after the construction of the original Hudson Street culvert (Table 2). One eel (shortfinned eel no. 9) might predate the construction of the original Hudson Street culvert.

DISCUSSION

In 2000 and in the previous 26 years, the Hudson Gully Stream had three significant barriers to fish migration:

1. An approximately 3-m waterfall at its confluence with the Waikato River;
2. The 58-m long Hudson Street culvert with its gradient of 0.0143; and
3. A 2.6-m high free-fall waterfall with an overhanging bedrock lip that was 9 m upstream of the Hudson Street culvert.

Despite these historic barriers to upstream fish migration, shortfinned eels inhabited the Hudson Street Gully stream above the original Hudson Street culvert. The stream habitat above the Hudson Street culvert is of high quality for fish, though realistically eels were the only species with the ability to migrate into it naturally. This is an interesting little stream and reasonable efforts should be made to maintain passage for eels. The stream is also close to the locally recognised Hammond Bush (Wall and Clarkson 2001).

Eels are adept climbers, and as juveniles are able to surmount most wetted surfaces, which may have been their method of entry to the Hudson Gully Stream. Alternatively, the waterfalls may have been drowned by high flow events that caused high levels in the Waikato River, and ponding of water between the Hudson Street culvert and the 2.6 m high waterfall.

The addition of two further culverts and removal of the downstream waterfall as part of the Hudson Street Gully erosion control works should not seriously impede the continued upstream migration of juvenile eels, provided that flow is maintained in the culverts and that the eels can negotiate the drop structure between the downstream end of the longest culvert and the Waikato River. Natural high flow events will drown the drop structure, but these will be sporadic and unpredictable, and may not coincide with the migratory periods of juvenile eels. No attempt has been made here to calculate through-culvert velocities (e.g., Boubée et al. 1999) because the culverts are probably less important as fish barriers than the remaining waterfall.

Table 2. Lengths and estimated ages and weights for the shortfinned eels captured in two stream sections of the Hudson Street Gully stream on 26 June 2001.

	Total length (mm)	Estimated age (years)	Calculated weight (g)
Between Hudson Road culvert and the waterfall			
Shortfinned eel no. 1	313	10	48.2
Shortfinned eel no. 2	316	10	49.6
Shortfinned eel no. 3	369	13	80.2
Shortfinned eel no. 4	405	16	107.1
Shortfinned eel no. 5	506	22	213.7
Shortfinned eel no. 6	582	27	329.8
Number of shortfinned eels	6		
Density (eels 100 m^{-2})	32.4		
Total eel biomass (g)			828.7
Areal eel biomass (g m^{-2})			44.8
Above the 2.6-m overhanging waterfall			
Shortfinned eel no. 7	425	17	124.4
Shortfinned eel no. 8	540	24	261.5
Shortfinned eel no. 9	795	40	867.9
Number of shortfinned eels	3		
Density (eels 100 m^{-2})	3.9		
Total eel biomass (g)			1253.7
Areal eel biomass (g m^{-2})			16.4

We recommend:

1. That if the inlet and culvert joints do not quickly seal naturally with fine sediment to limit water loss in the long culvert or at its inlet, they should be sealed artificially to maintain flow through the entire length of the culvert.

2. That the drop structure at the end of the 75-m long culvert should incorporate a ramp with a roughened surface to enable juvenile eels to climb into the culvert regardless of the level of the Waikato River.

ACKNOWLEDGEMENTS
We thank Bruce Clarkson of CBER for comments on the manuscript.

References

Boubée, J., I. Jowett, S. Nichols, and E. Williams. 1999. Fish passage at culverts: a review, with possible solutions for New Zealand indigenous species. Department of Conservation, Wellington. 63pp. plus appendices and computer programme.

Chisnall, B.L., and J.W. Hayes. 1991. Age and growth of shortfinned eels (*Anguilla australis*) in the lower Waikato basin, North Island, New Zealand. New Zealand Journal of Marine and Freshwater Research 25(1):71-80.

Hicks, B.J., and H.M.C. McCaughan. 1997. Land use, associated eel production, and abundance of fish and crayfish in streams in Waikato, New Zealand. New Zealand Journal of Marine and Freshwater Research 31:635-650.

Wall, K., and B. Clarkson. 2001. Gully restoration guide: a guide to assist in the ecological restoration of Hamilton's gully systems. Hamilton City Council, Hamilton. 52 p.