GREATER WELLINGTON REGIONAL COUNCIL

WAINUIOMATA RIVER

RIVER CORRIDOR

ASSESSMENT OF DESIGN CHANNEL
& EDGE BUFFER ZONES
BASED ON RIVER CHARACTER

Report prepared by

Gary Williams

APRIL

2007

WAINUIOMATA RIVER — RIVER CORRIDOR

ASSESSMENT OF DESIGN CHANNEL & BUFFER ZONES

1 INTRODUCTION

An assessment of appropriate design channels and vegetation buffer zones has been undertaken for the management scheme length of the Wainuiomata River. This assessment was based on the natural character of the river, taking account of variations along the study reach, and both natural and artificial controls on the alignment and form of the river. The aim is to determine a river corridor made up of a design channel and buffer zones of vegetation on each side. The river corridor then defines the boundaries of the river, and allows a more effective and efficient management of the river.

An empirical approach has been used, based on aerial photography taken over time, and the changes this shows, backed up by a semi-theoretical analysis based on the main river forming influences of flood flows, channel grade and bed material size. This approach has been used on a wide range of rivers in New Zealand, from flat-graded single channel meandering rivers within wide floodplains, to steep coarse gravel bed streams in confined valleys. Design channels have been determined for rivers with well-defined channels, including gravel bearing rivers with alternating beaches and a more mobile semi-braided form. Wider fairways have been determined for semi-braided to braiding rivers, which allow a meandering of major channels and braids within a clear gravel bed area.

The Wainuiomata River along the study reach — through the Town of Wainuiomata — has a narrow channel within a small alluvial floodplain, consisting of relatively coarse gravel material. Along the upper part, upstream of Black Stream, the channel is relatively entrenched, with only minor gravel beaches exposed during low flow periods. There has also been some channel degradation, probably as a response to the trapping of the gravel bed load of the river in the water supply dams upstream. Downstream of Black Stream the channel is less entrenched, and there are some longer bends, with a wider active channel of exposed gravel.

This report briefly outlines the basis of the design channel and buffer zones. It refers to the general approach taken, as well as the method of determining the river corridor for this reach of the Wainuiomata River.

The earliest aerial photography of the river reach was taken in 1941, and repeat aerial photography taken in 1969 and 1995 was available, along with the latest photography of 2004. Cross sections were surveyed along the river in the 1970s, as part of flood mitigation investigations. Another set of cross sections were surveyed in 1999, as part of a flood hazard study. The two sets of cross sections are not, however, directly comparable, as different cross section lines were used. An assessment of the flood hydrology of the river was also carried out in 1998, by Opus International Consultants, as part of the flood hazard study. The results of this study were published in a Greater Wellington report, of August 2000.

A few plans were available of past works proposals, including a channel diversion (just upstream of the Wood Hatton school) and of the Coast Road bridge. At the downstream end of the study reach, a river diversion was carried out, and the 2004 plans of this diversion were obtained. A few brief memoranda or reports on the river and the water supply dams was also obtained.

There was no information on the bed material of the river, and three samples were taken of the surface armouring layer, and grading curves developed, to obtain data on the median size of the armour bed material.

An inspection of the river reach was first carried out in June 2006, with inspections of the channel, buffer vegetation and river works along the study reach. A further inspection was carried out, in December 2006, after an initial assessment of a design channel for the reach, to check its practicality, and to obtain the bed material samples.

The assessment of a river corridor for the study reach is based on this information and the field inspections.

2 DESIGN PRINCIPLES

The nature of any river or stream, and the size and form of its channel, depends on the channel forming forces of its catchment and climatic regime, and the constraints of the surrounding landscape. The environment of any river and its channel form also varies down its course from the headwaters to the sea.

The natural meander form of a river, and the way it varies down its length, can be assessed from a study of aerial photography and from formulae for channel widths and meander relationships that have been derived empirically from experimental and theoretical research. Repeated aerial photography taken over a long period of time shows the type of changes that take place along rivers, and the rate at which these changes occur. The formulae give channel widths for the different types of channel meandering that occurs in rivers and streams, while simple wave form relationships relate width to the radius of curvature and wavelength of meanders. The formulae use different combinations of the main channel forming characteristics of flood flow, channel slope and the size of the channel bed material.

Developing a consistent channel along a river reach, based on these natural meander forms, decreases localised variations in sediment transport and flood capacity. This reduces the amount of bank erosion and flood damage, and hence the repairs and maintenance effort required to maintain protection works. Flood capacity, channel form and sediment transport are all inter-related, with changes in one affecting the others. There are then real channel management benefits from channel consistency, with less variation in the erosion and deposition activity of the river as it transports its gravel bed load, and less localised variation in flood capacity.

A design channel based on the natural meander patterns of a river can, then, be used to develop a consistent channel that reduces management efforts and generally enhances the effectiveness of management measures. The meander patterns can also guide the layout and spacing of bank protection and river training works. As well, the width of the natural meanders can be used as a guide to the thickness of vegetation buffer zones, as the size of erosion embayments is related to these meander shapes.

The smallest meandering channels are formed as threshold of motion meanders, and become fixed on flood recessions, as sediment transport stops. They are seen as low flow channels in gravel bed rivers, and there are two forms, a narrower meander based on the regime slope for the reach, and a wider meander based on the actual slope of the reach. Where the river has formed a single channel, and is being relatively tightly managed, then the smallest design channel, based on the wider of the threshold of motion meanders, can be applied. This gives a well defined channel which can have a consistent meander amplitude and wavelength, generally using a radius of curvature of 4 to 6 times the width. The design channel is lined by a buffer zone around the outer bank (erosion) side, with the buffer width taken as half of the narrower meander width.

This design channel requires the highest level of management, as a particular channel meandering (of many possible channel positions) is defined and has to be maintained. Downstream migration will continue to occur, and an important part of river management under this regime is to minimise the generation of distortions, by considering what is happening along a series of bends, and the downstream response from management interventions at a given bend. This **threshold of motion** meander form is applicable to narrow and well-defined single channels.

Where there is a less defined and more mobile main channel within a wider channel area, then a wider design channel can be applied, based on the dominant flow meander width. This channel width provides sufficient space for the active main flow channels to migrate, within a channel defined by buffer zones. The threshold of motion meanders associated with bed material movement can then migrate within this channel, with adequate curvature, but with not so much curvature that they tend to split up or form sharp cross-overs that directly attack the bank and buffer vegetation. In this case the radius of curvature of the meanders is taken as 4 times the width. The buffer zones on each side contain the channel meanders, with a width based on a full width incursion of the narrower threshold of motion channel, and thus with sufficient width to accommodate some channel migration and its associated erosion, and then be able to be re-planted as deposition occurs with further channel migration.

Under this management regime the buffer zones do not have to be repaired so promptly, following erosion damage, and reinstatement can take place over a period of time. Thus wider buffer zones are used, but repairs are less expensive as more gradual reclamation of eroded areas can be achieved using mainly vegetative means. The wider channel is, though, more prone to re-vegetation, especially by vigorous exotic species, and some regular channel clearing may be necessary as part of this approach. This **dominant flow** meander form is applicable to channels with gravel beaches and a low flow channel which is relatively mobile.

Where there is sufficient space available, and the river tends towards a wider semi-braided to braided form, then an even wider design channel, or fairway, can be applied. In this case the fairway is about 1.7 times the dominant flow meander width, which provides sufficient space for this meander form to migrate along the channel with a minimum of restraint (at a meander sinuosity of 1.1 to 1.2), but is sufficiently narrow to inhibit channel splitting. For wide gravel rivers this width is a good compromise between the conflicting requirements of minimised bank attack, low flow rise, efficient sediment transport and reduced channel area.

The management approach is one of quite frequent but low level interventions, mainly of channel clearing and re-vegetation of eroded areas within the buffer zones. For a mainly vegetation approach to river management, the buffer zones have to be correspondingly wider, and can be taken as the width of the wider threshold of motion meander. Some strengthening of the channel edge may, though, still be necessary, to reduce buffer zone losses and assist in re-establishment after loss. This **fairway** applies to wider channels with a braided form.

3 CHANNEL CHANGES

A comparison of the available aerial photography shows that there have been substantial changes in the river channel since the 1941 photography.

Along the upper part of the study reach, there has been less change, with less movement of the more entrenched channel. However, across Richard Prouse Park the river had a split channel (and presumably was shallower) in 1941, and the present channel follows a very different alignment. In the 1969 photography the river generally followed the present course, but the channel was somewhat wider and more meandering, especially around the pipe bridge. Upstream of the Black Stream confluence, the river was diverted into a straight channel, where the river had a wider channel and a significant bend within lower river bed land — in the 1941 photography, and as shown by the cadastral plan river boundaries, which are derived from early surveys. The straight channel is present on the 1969 photography. Weirs across the river channel have had to be placed upstream of this diversion at the old sewer crossing and below the Coast Road bridge to maintain bed levels, as upstream migrating channel degradation occurred in response to the diversion.

Downstream of about Faulke Avenue, the river channel was wider in the 1941 and 1969 photography, with larger beaches to an alternating bar pattern. There was a sharp bend close to Wood Street at the time of the 1941 photography, which developed into a very sharp bend up against harder terrace material by the time of the 1969 photography. This was where the river was diverted as shown on old plans, and in the 1995 photography there was a uniform narrow channel along this reach of the river. Recent flood events have opened up the channel in this area again, with a wider area of exposed gravel bed.

Below this bend the river runs over rock outcrops, and has remained relatively straight. However the channel has become narrower, with denser tree vegetation alongside this channel. In the Leonard Wood Park area the river has retained a similar alignment and form, but with a progressive shift in the position of deflection by the bluff at the recorder site — where the stopbank around Orewa Grove has excluded all the natural floodplain from the river corridor.

Along the Ngaturi Park area, upstream of the old sewage treatment plant, the river has followed a straight alignment, but channel break outs have occurred across the park, which show in the 1969 and 2004 photography. The cadastral boundaries indicate a river channel on the left side of the lower land of the park — up against the present stopbank.

Below the old sewage treatment plant, the river channel was much wider, with large gravel beaches as the river meandered around a long bend, as shown on both the 1941 and 1969 photography. The channel then became much narrow and congested with (mostly) willow vegetation, before being diverted after the 2004 flood events.

4 CHANNEL WIDTHS

Design channel widths, for different regime conditions, have been determined for the Wainuiomata River, using the empirical formulae.

The channel slope is generally constant along the study reach, within normal channel variations, with a change in grade downstream of the Wainuiomataiti Stream confluence, where the river is deflected by the confining hills. The mean bed level data at cross sections has been used to determine the channel slope, which is around 0.006 below the change in grade and 0.008 above.

Grading curves of the bed material of the river channel were obtained from the three samples taken of the surface armour layer. The grading curves were relatively consistent, with a median size of around 100 mm. The make up of the samples did, though, vary in a significant and progressive way down the river, with a mixed bi-modal distribution (of coarse gravel and a finer gravel material) at the upstream end, and a more uniform well sorted material at the lower end.

The specific diameters for the sample (in terms of percentage passing by weight) is given in the table below, and plots of the grading curves are attached.

CROSS SECTION	d_{25}	d_{50}	d_{75}
XS 1070	65	120	170
XS 1220	45	85	110
XS 1460	75	95	135

Flood flow frequencies have been estimated for the Wainuiomata River using catchment runoff modelling, regional estimation methods and at-site analyses of flood records. There were considerable discrepancies in the estimates, even for frequent flood flows, such as for a 2 year return period, particularly at the Leonard Wood Park recorder site. The attenuating effect of the water supply dams on flood flows may have been a contributing factor, affecting the recorded flood peaks. The dominant flood flow has been taken as the 2 year return period peak flow, and at the LWP recorder site different values were used to check the sensitivity of the regime channel widths to these flow differences.

Using this data, the natural widths of channel meanders, as given by empirically derived formulae, were determined, and they are given in the attached Table 1. The formulae relate to different natural meander forms, covering both threshold of motion conditions, where the bed material has a high resistance to the imposed forces of flood flows, and flow dominant live bed conditions, where the flood flows fully mobilise the bed material.

5 RIVER CORRIDOR

The threshold of motion meander is clearly present in the river channel, as shown by the aerial photography and the channel cross sections. A minimum design channel based on this meander pattern has then been drawn up for the study reach of the river. For the lower part of the reach a dominant flow meander form could be used, and a design channel based on this meander form has also been drawn up. These design channels are shown on the attached plans.

A design channel width of 20 m has been taken for all of the study reach, for the threshold of motion meander channel, except upstream of the Wainuiomataiti Stream, where a width of 17 m has been used. The minimum buffer zone width is then 5 m, based on half the width of the minor threshold of motion meander. This buffer is not required on the inside of bends, as the intended river management is to (generally) retain the river bends where they are at present. There are also natural controls at some bends. An overall river corridor has, however, been drawn around this minimum width, to provide some accommodation of channel migration, especially along the relatively straight (and hence less well-defined) reaches.

This design channel has a narrow buffer zone, but high maintenance requirements, as it fixes the channel and does not allow for channel migration, and stronger works will be required, especially at the tighter bends. The design channel does, though, provide overall guidelines for the positioning and layout of these works.

The wider design channel based on the dominant flow meander does allow for the migration of the flow channels than form around gravel beaches, and has a greater flood capacity. The entrenchment of the river and its confinement within a narrow valley and by natural bluffs and terrace faces, restricts the use of this channel. However, it would reduce the repair and maintenance costs of river management, allowing a greater reliance on vegetation and less need for stronger works.

At Ngaturi Park either design option would involve substantial channel re-forming and bank and buffer re-establishment costs, which may or may not be worthwhile in terms of saved maintenance costs in the future. The diverted channel downstream still has an over long bend, which does not fit in well with either of the main natural meander patterns of the river. Given the existing channel, re-aligning the river here may, however, not be warranted as well.

6 CONCLUSIONS

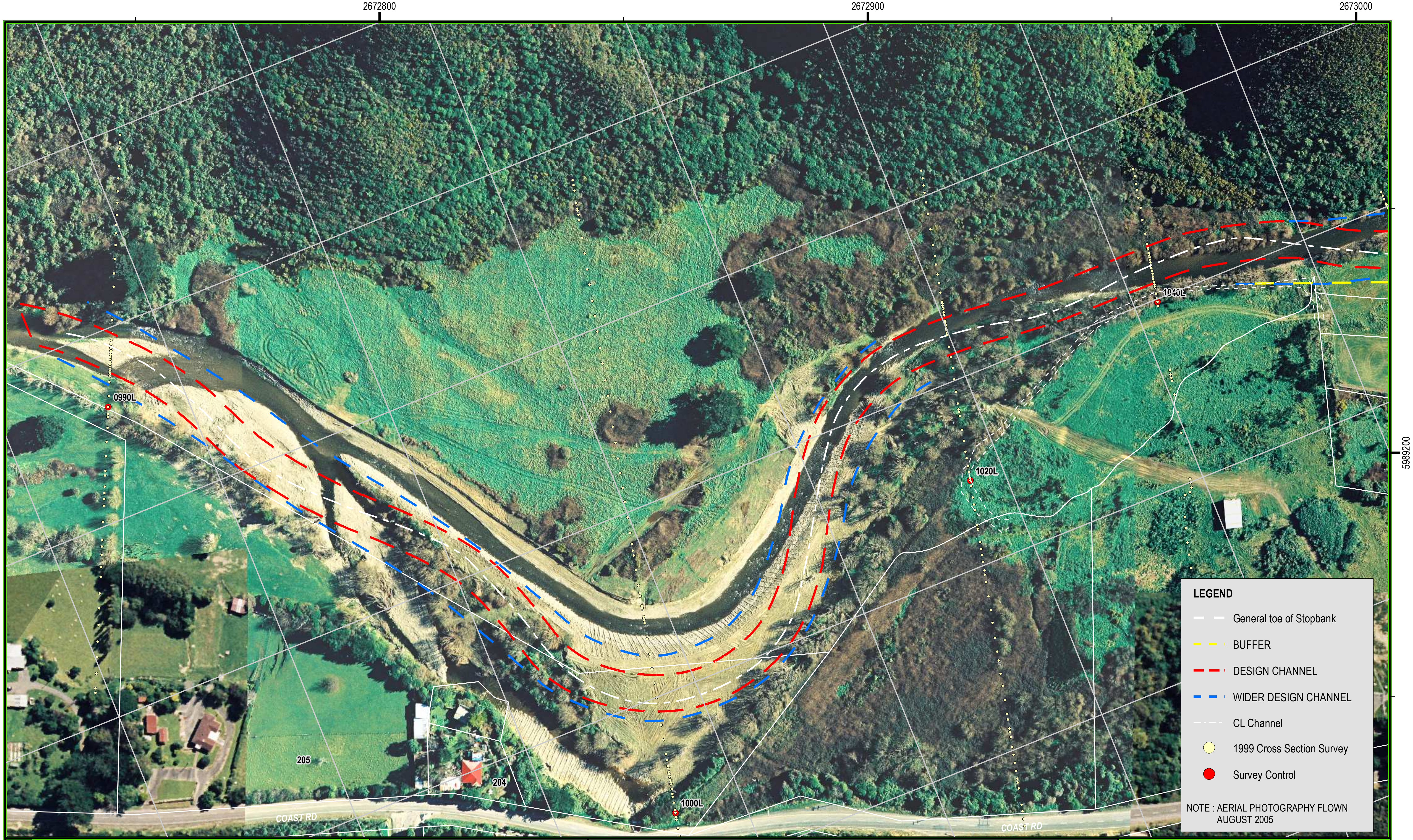
A river corridor has been defined for the Wainuiomata River from Richard Prouse Park to Ngaturi Park. Over most of this reach of the river the choice of design channel is obvious from the present character and form of the river, and a natural meander form can be fitted to the existing channel, with some variation in meander wavelength and especially amplitude. Along the lower part of the study reach there is somewhat more choice, and some mixing of the meander patterns could be used.

It is recommended that a river corridor be defined along the river, and that it encompass both design options along the lower part of the study reach, as shown on the attached plans.

April 2007

G J Williams
Water & Soil Engineer

G & E Williams Consultants Ltd,
R D 1,
OTAKI. (06) 3626684



AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 990 to 1040

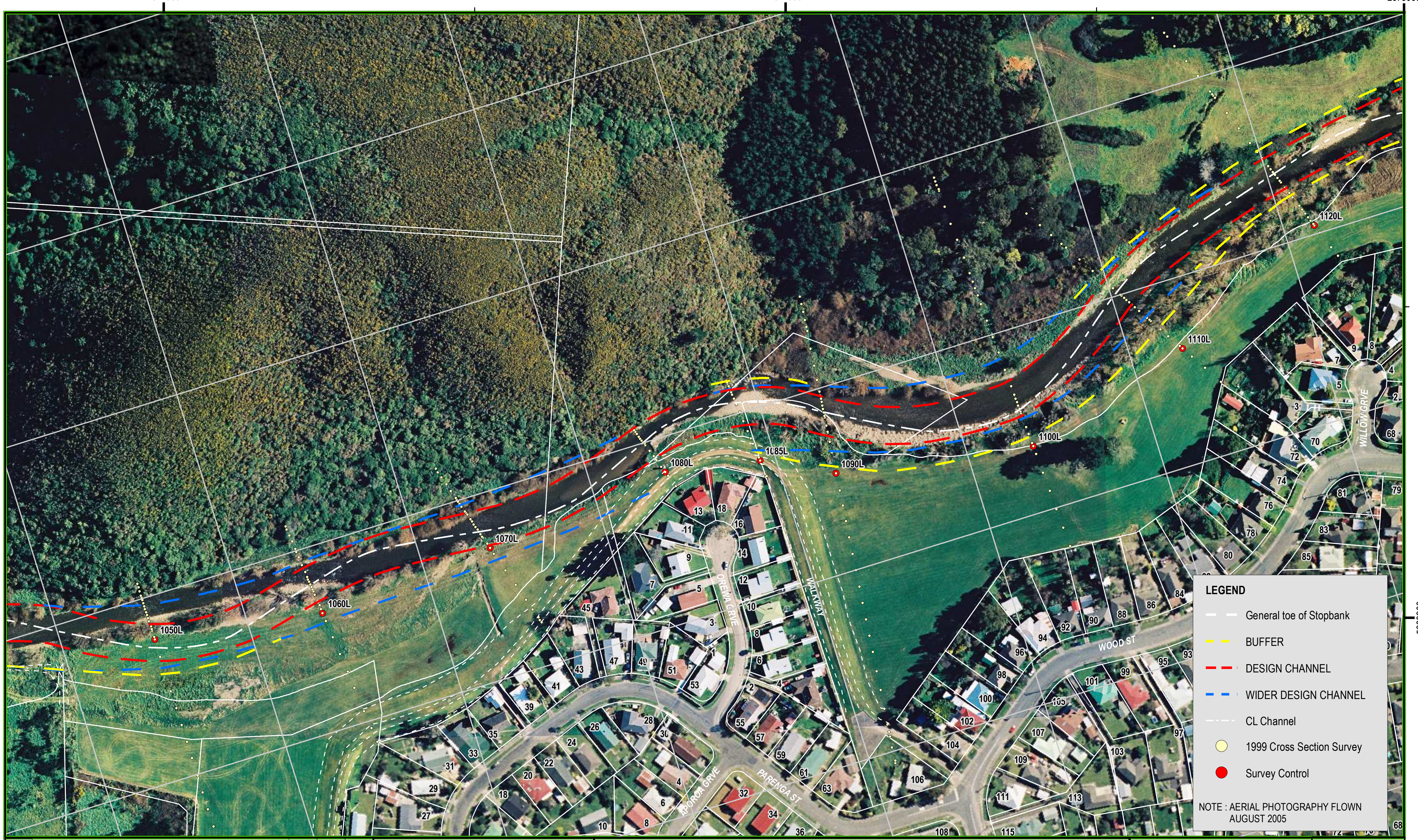
greater WELLINGTON
REGIONAL COUNCIL

FILE No. N/4/9/14
A3 SCALE 1 : 2,000
SHEET No. 01 OF 07 SHEETS

DRAWING No.
Wn-5269/01

Drawing Reference:
File Ref: Wn-5269-01.mxd

0 5 10 20 30 40 50 Metres



AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 11-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1050 to 1120

greater WELLINGTON
REGIONAL COUNCIL

FILE No.

A3 SCALE
1 : 2,000

SHEET No. 02
OF 07 SHEETS

DRAWING No.
Wn-5269/02

Drawing Reference:

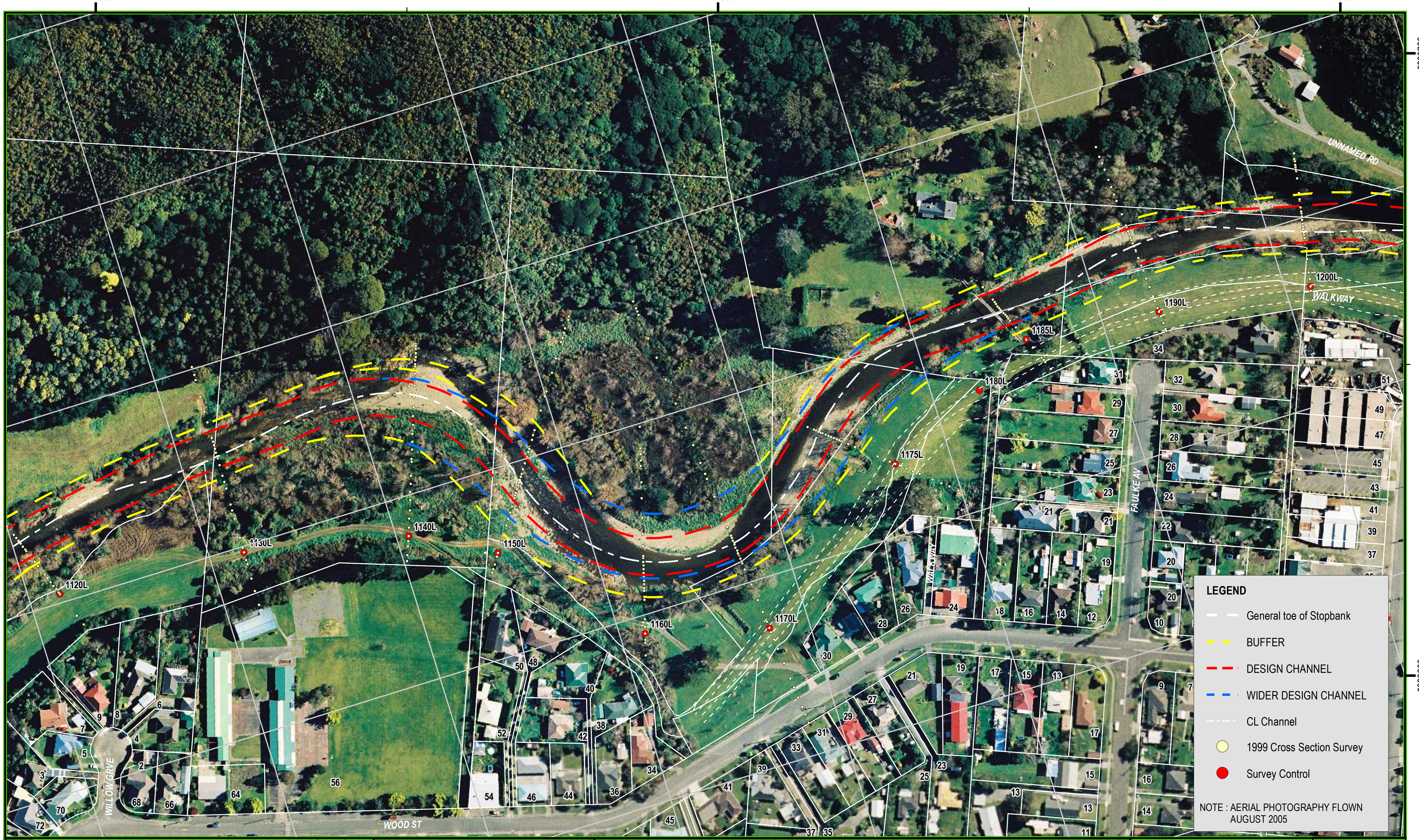
0 5 10 20 30 40 50 Metres

File Ref: Wn-5269-02.mxd

2672800 2672900 2673000

5990700

5990600



AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1120 to 1200

greater WELLINGTON REGIONAL COUNCIL

FILE No. N/4/9/14

A3 SCALE 1 : 2,000

SHEET No. 03 OF 07 SHEETS

DRAWING No. **Wn-5269/03**

Drawing Reference: 0 5 10 20 30 40 50 Metres

File Ref: Wn-5269-03.mxd

AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1185 to 1290

greater WELLINGTON
REGIONAL COUNCIL

FILE No. N/4/9/14
A3 SCALE 1 : 2,000
SHEET No. 04 OF 07 SHEETS

DRAWING No.
Wn-5269/04

N

Drawing Reference:
0 5 10 20 30 40 50 Metres
File Ref: Wn-5269-04.mxd

	AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1290 to 1390

greater WELLINGTON
REGIONAL COUNCIL

DRAWING No.
Wn-5269/05

FILE No. N/4/9/14
A3 SCALE 1 : 2,000
SHEET No. 05 OF 07 SHEETS

N

Drawing Reference:
0 5 10 20 30 40 50 Metres
File Ref: Wn-5269-05.mxd

AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1390 to 1510

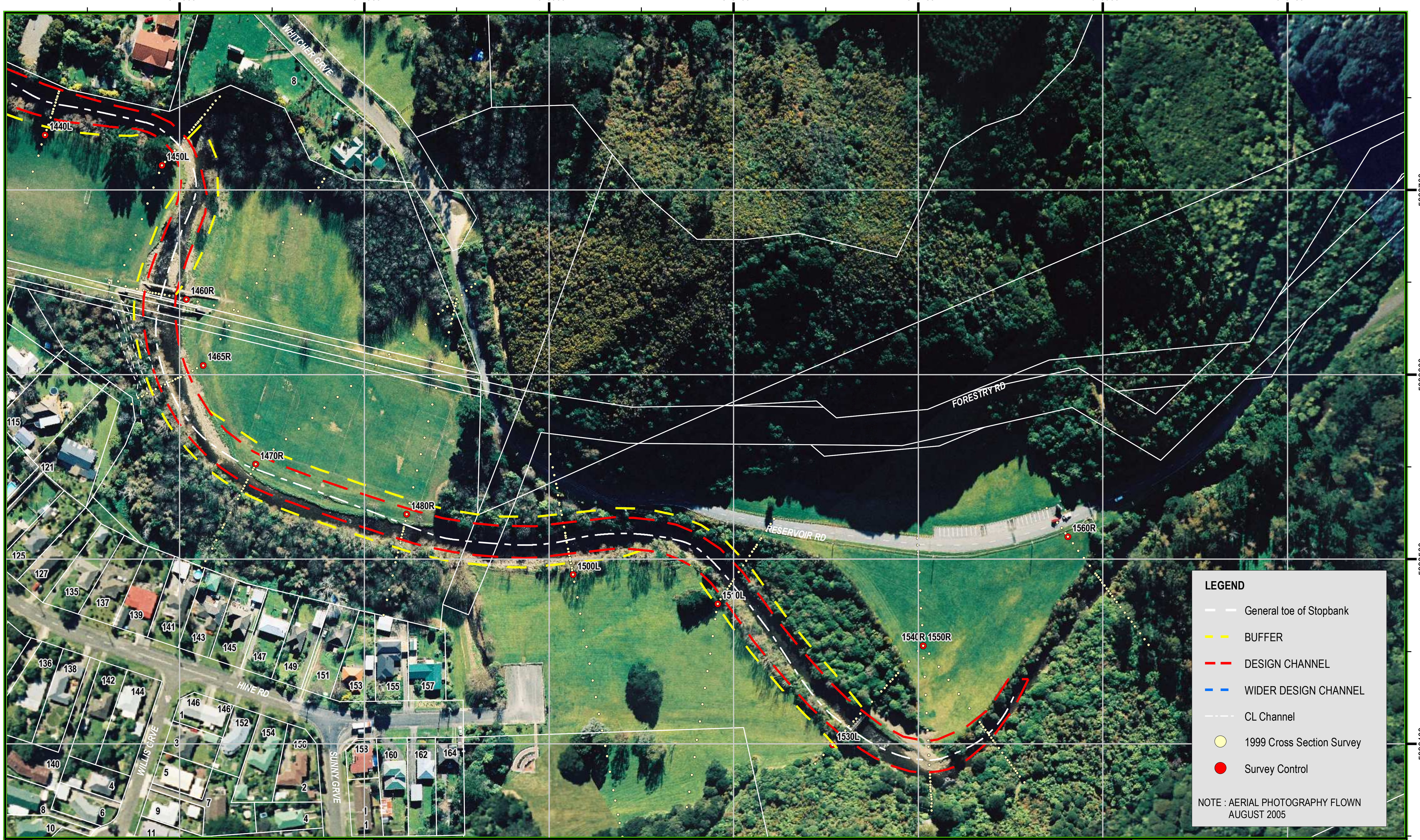
greater WELLINGTON
REGIONAL COUNCIL

FILE No. N/4/9/14
A3 SCALE 1 : 2,000
SHEET No. 06 OF 07 SHEETS

DRAWING No.
Wn-5269/06

N

Drawing Reference:
File Ref: Wn-5269-06.mxd



AMENDMENT	DWN	CHK	DATE

CATCHMENT MANAGEMENT
FLOOD PROTECTION

DESIGN	G.WILLIAMS	8-2007
DRAWN	P.COOK	9-2007
CHECKED	J.COX	10-2007
RECOM'ND		
APPROVED	S.WESTLAKE 10-2007	

WAINUIOMATA RIVER

DESIGN CHANNEL ALIGNMENT
CROSS SECTION 1440 to 1560

greater WELLINGTON REGIONAL COUNCIL

FILE No. N/4/9/14
A3 SCALE 1 : 2,000
SHEET No. 07 OF 07 SHEETS

DRAWING No.
Wn-5269/07

N

Drawing Reference:
File Ref: Wn-5269-07.mxd