Watercourse Assessment Methodology: Infrastructure and Ecology (Version 2.0)

January 2016 Technical Report 2016/002

Auckland Council
Technical Report 2016/002
ISSN 2230-4525 (Print)
ISSN 2230-4533 (Online)

ISBN 978-0-9941336-6-3 (Print)
ISBN 978-0-9941336-7-0 (PDF)

This report has been peer reviewed by the Peer Review Panel.

Submitted for review on 29 October 2015
Review completed on 20 January 2016
Reviewed by two reviewers

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Recommended citation
Lowe, M., Ingley, R and Young, D (2016). Watercourse assessment methodology: infrastructure and ecology version 2.0. Prepared by Morphum Environmental for Auckland Council. Auckland Council technical report, TR2016/002

Watercourse Assessment Methodology: Infrastructure and Ecology (Version 2.0)

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Document history

Version	Date	Authors	Update details
1.0	Dec 2011	Young, D, Coup, J	Stream Survey and Watercourse Management Plan Specification -Draft for Internal Review
1.2	Nov 2012	Young, D, Coup, J	Stream Survey and Watercourse Management Plan Specification -Revisions by Auckland Council for clarification
1.3	Nov 2013	Young, D, Coup, J	Stream Survey and Watercourse Management Plan Specification –Auckland Council Revised Appendices A7 and B7
1.4	Dec 2013	Young, D, Coup, J	Stream Survey and Watercourse Management Plan Specification -Updates by Richard Challis
2.0	Nov 2014	Lowe, M., Ingley, R., Young, D	Watercourse Assessment Methodology - Complete revision of assessment method and reporting process. One report, one map series, one geodatabase incorporating photos

Executive summary

Watercourse Assessment Reports (WARs, previously called Watercourse Management Plans – WMPs) provide baseline information on the existing condition of waterways. A Watercourse Assessment Report is a core resource in managing waterways to multiple objectives within realistic environmental, economic and social constraints. Watercourse Assessment Reports aim to provide information which can be used to maintain high value streams, enhance degraded streams and remedy specific stormwater issues while recognising the future growth pressures facing the Auckland region and the essential function of urban streams in conveying stormwater.

The purpose of WAR is to collect and report on meaningful data (engineering assets, biological and geomorphological stream state) in order to inform effective management of:

- Stream ecological health (biological and physical attributes)
- Stormwater infrastructure
- Stormwater conveyance

The Watercourse Assessment Methodology (WAM) (this Document) rationalises and improves on the previous specification document (the Stream Assessment Survey and Watercourse Management Plan Specification – version 1.4).

The process for undertaking a Watercourse Assessment involves four main steps: a pre-survey desktop review; a field watercourse assessment; a post-survey desktop review; and the production of deliverables (including quality assurance).

The field component assesses and collects information on the following: the ecological character of stream reaches, stream mouths, and wetlands; the presence and condition of engineering assets including inlets, pipes, and lining; erosion issues; fish passage issues; and identification of Enhancement Opportunities (EO).

EO are used to inform project works with multiple benefits for ecological, amenity, and conveyance values. These are also used to highlight significant issues for public safety or key areas identified for community engagement.

A WAR also includes the identification of Management Zones (MZs). MZs are reaches with similar pressures and issues. The purpose of the MZs is to summarise key values, assessments, and recommended actions at a high level to guide unified management across the zone and the wider catchment. MZs are not used to identify specific options which are encompassed by the EOs section (section 3.11).

Figure 1 illustrates how both the methodology document and the deliverables relate to each other in the development of a Watercourse Assessment. Refer to the Watercourse

Assessment Report Template for further guidance on deliverable content and structure. Reporting includes a summary of relevant literature on the subject catchment, a synthesis of key data collected, a discussion of potential management issues, and a summary of Management Zones and Enhancement Opportunities. Data delivery must be in the format of the geodatabase developed and provided by Auckland Council, with all photos and other attachments attached to the GIS features. Deliverables also include PDF maps in the format outlined in Section 5.3.

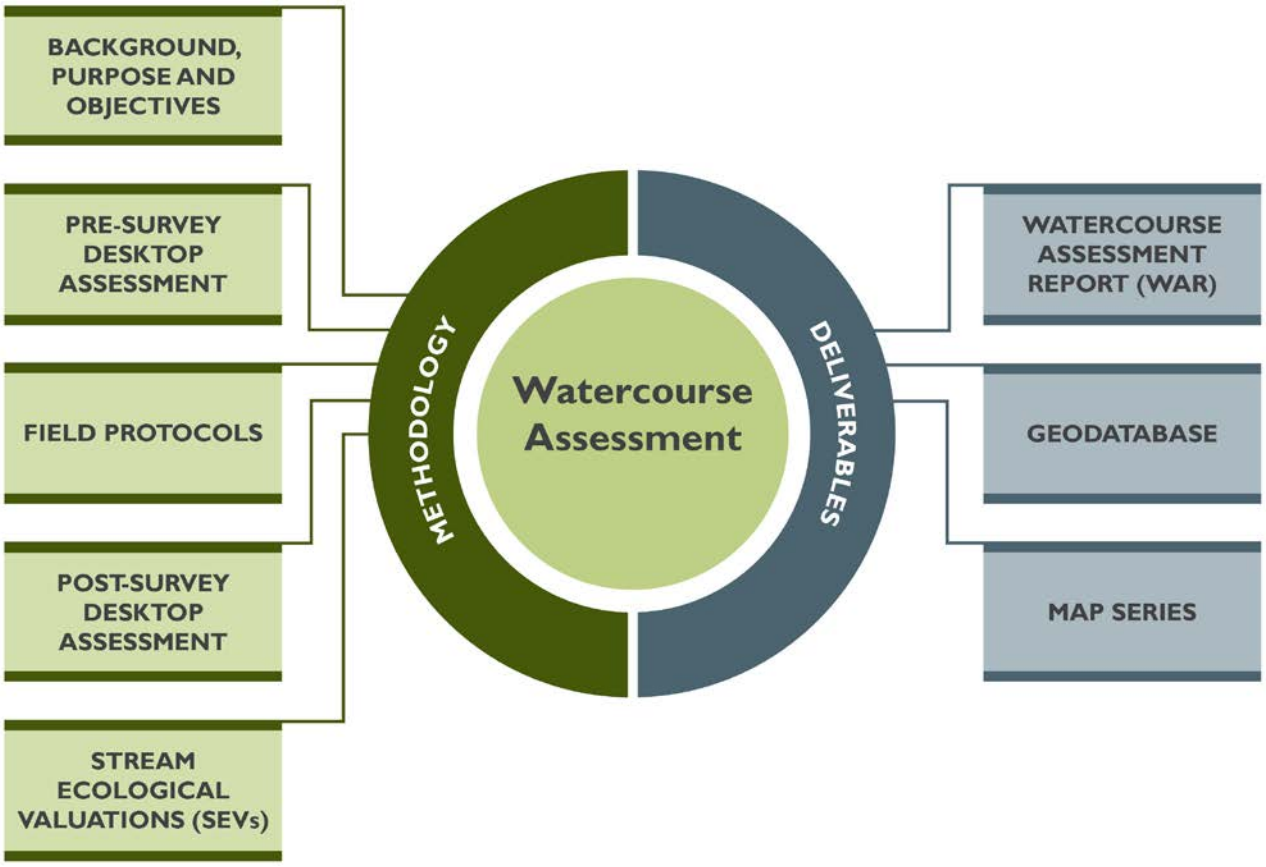

Figure 1: Sections of this document and how they relate to the preparation of a Watercourse Assessment

It is possible to undertake partial Watercourse Assessments. This might be desirable when only specific information is required or a rapid assessment of certain components is needed. Partial assessments allow for different Auckland Council units to use the Watercourse Assessment Methodology with flexibility, yet collect and store data in a consistent manner that is comparable and available to multiple end users. Partial assessments also allow for different levels of assessments to be undertaken in rural and urban areas of the same catchment. For the purposes of Watercourse Assessment; urban areas comprise all urban developed areas including key infrastructure such as parks and roads, and rural areas comprise areas within predominantly agricultural land use. These may not necessarily be defined by the Rural Urban Boundary (RUB).

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Glossary

Abbreviation	Definition
AC	Auckland Council
ACRPS	Auckland Council Regional Policy Statement
ALWP	Air, Land and Water Plan
ASWSD	Auckland Stormwater Unit Strategic Direction
EO	Enhancement Opportunity
IBI	Index of Biological Integrity
MZ	Management Zone
NPS	National Policy Statement
NSCC	North Shore City Council
NZFFDB	New Zealand Freshwater Fish Database
PAH	Polyaromatic Hydrocarbons
PAUP	Proposed Auckland Unitary Plan
RMA	Resource Management Act
SEV	Stream Ecological Valuation
TLB	True Left Bank
TRB	True Right Bank
WAM	Watercourse Assessment Methodology
WAR	Watercourse Assessment Report
WMP	Watercourse Management Plan

1.0 Introduction

1.1 Auckland watercourse context

Auckland typically has relatively small order and narrow streams. There are 16,650km of permanent stream, an additional 4480km of intermittent stream and a further 7110km of ephemeral stream in the Auckland region (Storey and Wadhwa, 2009). Approximately 18 per cent of the region's land area is urban (falls within the rural urban boundary (RUB), while approximately 14 per cent of the region's natural open stream length is located within urban areas.

Auckland watercourses are under different pressures from urban and rural factors. The growth of Auckland needs to be balanced against the protection, maintenance, and enhancement of watercourses in both urban and rural areas. Watercourses are utilised as integral natural components of the stormwater system, while managing the adverse effects of stormwater runoff and structures on streams.

In rural areas livestock access and intensive agriculture (resulting in erosion, turbidity, downstream sedimentation, stream bed disturbance, and nutrient loadings) and the loss of natural open stream length (through reclamation, piping, and realignment) are the most significant issues. In urban areas, increased impervious area causes changes in hydrology. Groundwater baseflow and stream recharge decreases. Stormwater volumes and flow rates increase, causing adverse effects on streams through increased pollutant loadings and accelerated erosion. Water temperature is also increased. Loss of riparian vegetation, artificial barriers to fish passage, and the loss of natural open stream length are also significant issues within urban areas.

1.2 Background to the methodology

In 2002 a Streamwalk Survey style of assessment was designed and created by North Shore City Council (NSCC) to support the 'assessment of effects' components of the North Shore City Stormwater and Wastewater Network Consent applications. This consisted of surveying streams and associated existing network infrastructure. The result was the availability of spatially representative data of engineering assets, and biological and geomorphological stream state.

The method used to undertake the Streamwalk surveys was first formally presented in a North Shore City Council report referred to as 'KC01 Stream and Asset Survey Methodology, 2004'. This method was then used in the survey of streams in Waitakere City, Rodney District, and Auckland City, including Waiheke Island.

The concept of a Watercourse Management Plan (WMP) was developed by Metrowater to provide guidance on stream objectives, management and enhancement options.

Metrowater previously undertook the planning and management function of stormwater infrastructure, including watercourses, on behalf of Auckland City Council (Environmental and Utility Management) and developed Watercourse Management Plans for four 'public' watercourses (Meola Creek, Motions Creek, Oakley Creek, and Remuera Stream).

Following transition from the seven legacy Territorial Authorities (District and City Councils) and the Auckland Regional Council into a single Regional Authority on the 1st November 2010, Metrowater ceased to operate as a business and the ownership and management of all stormwater assets passed to Auckland Council. In an effort to provide a consistent management approach to watercourses within the Auckland urban area, Auckland Council adopted the use of Watercourse Management Plans to be applied to all streams requiring assessment for planning purposes.

In 2012, Auckland Council commissioned Morphum Environmental to formalise the methodology; the result was the 'Stream Assessment Survey and Watercourse Management Plan Specification (version 1)'. The specification has had a number of revisions since this time and version 1.4 was the most recent version.

In 2013 all available streamwalk data was amalgamated to provide a functional database that could be used to support the management of catchments, infrastructure, and receiving environments throughout Auckland. Deviation from the methodology for data capture and delivery, inconsistent quality assurance practices, and *ad hoc* changes to the specification from version 1 to the current version 1.4 made the amalgamation of data challenging due to incomplete and disparate data with a number of errors in the data format, structure, and attribution.

At the time of writing, the Stream Assessment Survey and Watercourse Management Plan Specification (version 1) was largely focused on collecting data for private and public urban streams where Auckland Councils Stormwater Unit had a responsibility to maintain infrastructure and conveyance. This focus is reflected in the introduction section of the specification document and the data collected. More recently, rural streams are also being surveyed and included in the reporting of Watercourse Management Plans, either because of identified planned development within these areas or because the streams are connected to and inherently affect (for example through nutrient loading increasing macrophyte growth and sediment loading) the urban stream which preform a stormwater conveyance function. Furthermore, there is increased interest in undertaking rural stream assessments to meet local board and community group requests for information.

1.3 Relevant policies and plans

Several policies and plans are relevant to the purpose and implementation of Watercourse Assessments. Some of the more relevant policies and plans have been outlined in Appendix A. These are the Resource Management Act (RMA); the National Policy

Statement for Freshwater Management (Freshwater NPS); the Auckland Council Regional Plan: Air, Land and Water (ALWP); the Auckland Plan; the Proposed Auckland Unitary Plan (PAUP); the Auckland Council Regional Policy Statement (ACRPS); the Auckland Council Biodiversity Strategy; and the Auckland Council Stormwater Asset Management Plan 2015 - 2045. Please see Appendix A for a summary of the relevant aspects of these policies and plans.

1.4 Vision for the current methodology

The historical 'Stream Assessment Survey and Watercourse Management Plan Specification' document is now referred to as the 'Watercourse Assessment Methodology (Version 2.0)'. The Watercourse Assessment Methodology (WAM) (this Document) rationalises and improves on the previous specification (the Stream Assessment Survey and Watercourse Management Plan Specification – version 1.4). The methodology has also been developed with consideration of the Stormwater Asset Data Standard (July 2014). Where possible, pick lists (selection lists in Watercourse Assessment Geodatabase) match those of the data standard (e.g. material types and dissipation structures) allowing better alignment with the SWU strategic direction and management of the natural asset. The main aims of the revision are as follows.

- Improve standardisation of data collection and data delivery in order to:
    - Reduce processing time for quality assurance of data;
    - Reduce report review time;
    - Simplify the importing of data into master shape files;
- Ensure the scale and type of data collection is appropriate and fit for purpose;
- Create a single method that multiple Auckland Council units can adopt resulting in the population of a single geospatial database;
- Improved clarification of field survey requirements and field interpretation by removing ambiguity, resulting in more robust and comparable data;
- Minimise changes in attributes and pick lists in order to minimise issues in amalgamating future data with historical data;
- Streamline and standardise the process for identifying and reporting on project opportunities from data collected;
- Ensure data collected fits with the Stormwater Units asset data standard;
- Reduce the requirement of printed material by rationalising appendices, especially photo schedules and data tables; and,
- Standardise methodology and remove ambiguity to improve consistent pricing from consultants.

1.4.1 Development of the current methodology

In developing this WAM, consultation was undertaken with stakeholders and users of both the document itself and the deliverables (report, maps and data). Workshops were held with Auckland Council staff across multiple departments to gain an understanding of what data they felt is important to inform strategy and project work across multiple Auckland Council departments. Further workshops were held with consultants with a track record of delivering projects under the previous specification. Workshops with the consultants were undertaken to gain further understanding of what aspects of the previous methodology consultants found were ambiguous, onerous or superfluous, as well as, to help identify improvements to the methodology. The workshops were successful in confirming many of the ideas regarding the initial direction of the update and obtaining additional input to the methodology, while also creating 'buy in' from stakeholders.

Following development of a draft WAM, field testing was undertaken. Any ambiguity in the method and errors in the geodatabase were identified and amended prior to release of the final WAM and Geodatabase.

1.5 Purpose and objectives of watercourse assessment reports

1.5.1 Purpose

Watercourse Assessment Reports (WARs, previously called Watercourse Management Plans – WMPs) provide baseline information on the existing condition of waterways in both urban and rural settings. A WAR is a core resource in managing waterways for multiple objectives within realistic environmental, economic and social constraints. WARs aim to provide information which can be used to protect and maintain high-value streams and identify degraded streams for potential enhancement while recognising the future growth pressures facing the Auckland region and the essential function of urban streams in conveying stormwater.

The purpose of a Watercourse Assessment is to collect and report on meaningful data (engineering assets, biological and geomorphological stream state) in order to inform effective management of:

- Stream ecological health;
- Stormwater infrastructure; and,
- Stormwater conveyance.

1.5.2 Objectives

The main objectives for creating WARs are as follows:

- Summarise existing studies and review existing datasets;
- Undertake a baseline condition assessment – including identifying and summarising issues within the catchment (predominantly ecological and stormwater related issues);
- Collect and report on data that will allow for the identification of both OPEX and CAPEX projects for Auckland Council's Stormwater Unit;
- Collect and report on data that will allow for the identification of issues and potential projects (including EOs) for Local Boards and community groups;
- Identify risk to communities, property, and infrastructure;
- Support water sensitive growth and development;
- Protect and maintain the higher value streams and identify degraded streams for potential enhancement;
- Encourage collaboration between key stakeholders; and,
- Provide high level data that can be used by Auckland Council to compare catchments across the region and inform projects undertaken by Auckland Council or other organisations.

Data collected as part of a WAR provides important information for identifying projects that may be included in Asset Management Plans. All data collected as part of the geodatabase is designed to be integrated into council's information systems and used as a source of raw data for interrogation and analysis for a number for outcomes.

1.5.3 Audience

Watercourse Assessment Reports are a useful source of information and tool for multiple stakeholders, including (but not limited to):

- Auckland Council Stormwater Unit;
- Auckland Council Regulatory;
- Auckland Council Parks;
- Auckland Council Research and Evaluation Unit (RIMU);
- Auckland Transport;
- Watercare Services Limited (WSL);
- Environmental Services Unit (ESU);
- Iwi;
- Local Boards and Community Groups; and,
- Pollution Prevention.

1.6 How to use this document

The process for preparing a WAR involves four main steps:

- Pre-survey desktop assessment;
- Field Watercourse watercourse assessment;
- Post-survey desktop assessment;
- Quality assurance and the production of deliverables.

Figure 1 illustrates how both the methodology and the deliverables relate to each other in the development of a Watercourse Assessment. The sections of this document (The Watercourse Assessment Methodology Document) that are relevant to each of the four main steps are outlined in Figure 2.

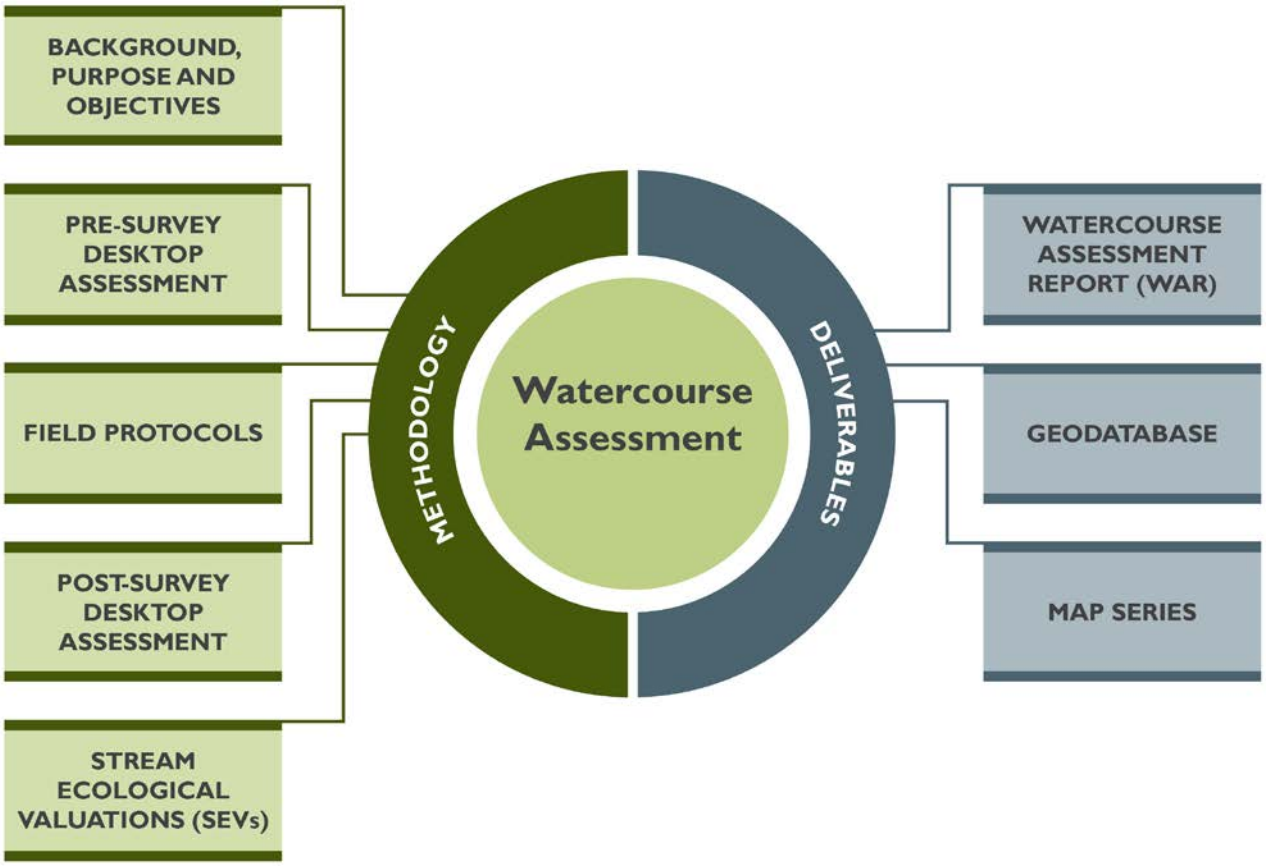


Figure 1 (repeated): Sections of this document and how they relate to the preparation of a Watercourse Assessment

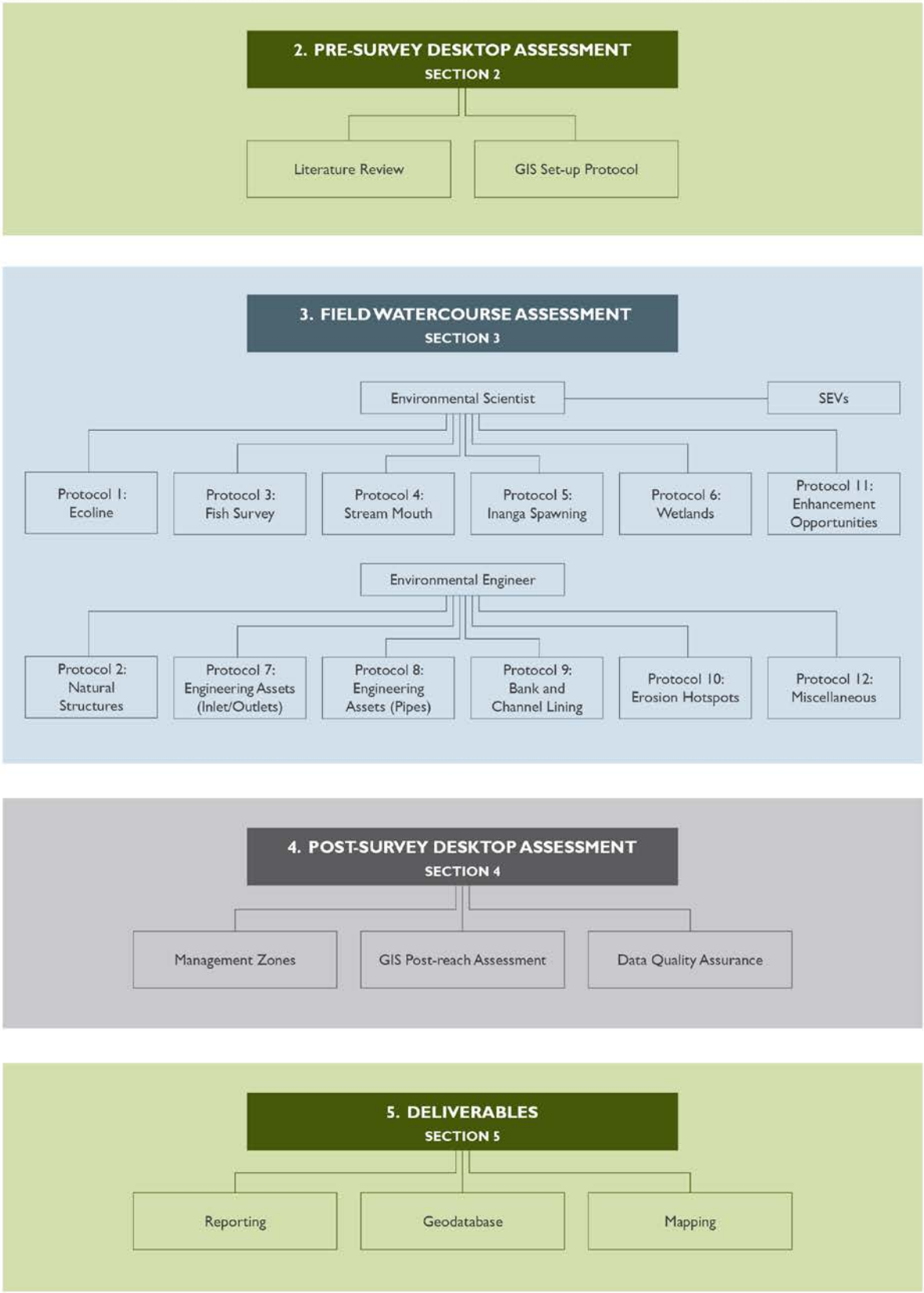


Figure 2: Overview of the elements of a Watercourse Assessment (numbers correspond to sections within this document)

1.6.1 Pre-survey desktop assessment

The pre-survey desktop assessment consists of a literature review and a GIS setup protocol.

The literature review is a high level review of studies undertaken within the watercourse survey area. This should be undertaken prior to the commencement of the field watercourse assessment. This background information is useful to guide interpretation of the site while in the field and is particularly useful when considering EOs. Section 2.1 describes the literature review process in more detail.

The GIS setup protocol outlines the process required to prepare GIS information and data capture devices prior to the field watercourse assessment. This process allows existing GIS information to be used to prepopulate attribute information where possible. This also ensures that relevant GIS information is available to field staff in the field and provides for a holistic understanding of the catchment's land use and stormwater network prior to undertaking the field survey. Section 2.2 describes the GIS setup protocol process in more detail.

1.6.2 Field watercourse assessment

The field watercourse assessment method includes a comprehensive infrastructure assessment, a broad ecological assessment and also integrates well with other methods including the Stream Ecological Valuation (SEV). The method incorporates criteria from other assessment guidelines including Auckland Council technical publications TP 131 (Fish passage guidelines for the Auckland region), TP 148 (Riparian zone management strategy guidelines), elements of the Stream Habitat Assessment Protocols (Harding *et al.* 2009), and other supporting documents which are outlined as required. Section 3.0 of this document describes the field watercourse assessment process in more detail.

Stream Ecological Valuations (SEVs) can be undertaken as part of the field watercourse assessment. The need for and number of SEVs to be undertaken is to be determined by the council and stipulated in any Request for Proposals (RFP).

1.6.3 Post-survey desktop assessment

Further desktop assessment is required following the completion of the field watercourse assessment. This includes the identification of MZs; and quality assurance of the data collected in the field. The post-survey desktop assessment also provides an opportunity to populate any attribute information which was not feasible to collect in the field (such as vegetation extents when this is several hundred metres. This may only be possible where suitable GIS information (such as aerial photography) is available. The post-survey desktop assessment is also used to populate the SEV polyline within the geodatabase with

the results of any SEVs undertaken as part of the assessment. Section 4.0 describes post-survey desktop assessment in more detail.

1.6.4 Deliverables

As outlined in Figure 1 the deliverables of a Watercourse Assessment are: the Watercourse Assessment Report, Geodatabase and Map Series.

The WAR summarises the field data captured. Broader watercourse issues within the catchment are summarised into MZs. Identified EOs are also described and placed within the context of a high level prioritisation. A template document is provided by Auckland Council to ensure consistency of WAR formatting and content. Do not include information on methodology, the background to the Watercourse Assessment process, or policies and plans within the final report. Reference can be made to the WAM (this document) where required.

Section 5.0 describes the required deliverables in more detail.

1.6.5 Partial watercourse assessments

It is possible to undertake partial Watercourse Assessments. This might be desirable when only certain components of the full WAM are of interest. For example a partial assessment could be used to undertake a re-inspection of only the engineered stormwater assets throughout an urban area previously surveyed. Any deviations from the full WAM must be clearly documented within Section 1.1 of the final WAR.

Partial assessments allow for different Auckland Council units to use the WAM with flexibility, yet collect and store data in a consistent manner that is comparable and available to multiple end users. Partial assessments also allow for different levels of assessments to be undertaken in rural and urban areas of the same catchment. The engineering protocol can also be partially used to capture location and photographic evidence without completing a full assessment of the structure where appropriate (such as in some rural environments). Refer to Table 1 for an example urban and rural assessment. Miscellaneous points may also be utilised for high level data capture of location and photographs fit for purpose.

The need for and number of Stream Ecological Valuations (SEVs) to be undertaken is to be determined by the council and stipulated in any RFP. The need for and number of SEVs should be appropriate for the catchment, as well as the scope and purpose of works. See Appendix B for more details on SEV site selection.

Table 1: Example of options to modify the scope of Watercourse Assessment

Watercourse Assessment Protocol		Full Urban Assessment	Partial Urban Assessment	Rural Assessment
Pre-survey Desktop Assessment				
Literature Review		Yes	Yes	Yes
Field Watercourse Assessment				
Ecology	Reach Assessment (Ecoline)	Yes	No	Yes
Engineering	Natural Structures	Yes	No	No
Ecology	Fish Survey	Yes	No	Yes
Ecology	Stream Mouths	Yes	No	No
Ecology	Inanga Spawning	Yes	No	Yes
Ecology	Wetlands	Yes	Yes	Yes
Engineering	Asset Inspection (Inlets / Outlets)	Yes	Yes	No
Engineering	Asset Inspection (Culverts / Pipes)	Yes	Yes	No
Engineering	Bank and Channel Lining	Yes	No	No
Engineering	Erosion Hotspots	Yes	Yes	Yes
Both	Enhancement Opportunities	Yes	No	Yes
Both	Miscellaneous Points	Yes	No	Yes
Post-survey Desktop Assessment				
Management Zones		Yes	No	No
Additional Assessment				
Stream Ecological Valuations		Yes	No	Yes
Fish assessment*		Yes	No	No
Clarity Measurements		Yes	No	Yes
Sediment Chemistry and *E. Coli*		Yes	No	No

*If the NZFFDB has no information recorded that is less than five years old within the length of the watercourse (tributary scale) selected for SEV then electrofishing or trapping must also be performed.

1.7 Limitations

1.7.1 Identified options

Auckland Council is not obligated to undertake any works identified as enhancement or management options in a WAR, nor is Auckland Council bound by preliminary prioritisation of projects undertaken as part of this methodology. Recommendations made will be considered within the context of Auckland Councils obligations, constraints, drivers, project identification, and catchment prioritisation undertaken or identified by Auckland Council.

1.7.2 Stream classification

The Watercourse Assessment provides an unofficial field estimate of stream classification only and this classification is not specifically intended for Resource Consent purposes. Although specific and detailed assessment is required prior to consent approval for any works within a subject reach, the details contained in this document can be used to guide associated investigations for a resource consent application. Failure to identify a stream reach during this Watercourse Assessment process does not suggest that a stream does not exist or that any such stream is ephemeral.

1.7.3 Temporal limitations

Watercourse Assessment undertaken as per this methodology must be considered within the seasonal context. Variables such as water depth and velocity are dependent on the level of base flow, and antecedent conditions such as stormwater inflows prior to the assessment. Time since last rainfall event is recorded to guide interpretation. Factors that are more variable over diurnal time scales, such as temperature, are not recorded as part of this assessment as time series data is required for meaningful results.

1.7.4 Assessment methodology

It is acknowledged that the Watercourse Assessment Methodology is largely a visual assessment of engineering assets as well as biological and geomorphological stream state. Parameters are also typically averaged over the extent of each reach and there will be some variability along this length.

Where possible, definitions and procedures detailed in more intensive quantitative or semi quantitative standard methods have been used to inform parameters included in the WAM.

2.0 Pre Survey Desktop Assessment

2.1 Literature review

The desk top review consists of a high level literature review of studies undertaken within the watercourse survey area and should be undertaken prior to the commencement of the field watercourse assessment. This background information is useful to guide interpretation of the site while in the field and is particularly useful when considering enhancement opportunities.

Relevant resources include (but are not limited to):

- Catchment Management Plans;
- Discharge Consent Applications and supporting reports;
- Auckland Council technical reports and state of the environment reporting;
- Historical Stream Walk documents;
- Local Board and Community group commissioned studies and reports
- Cultural Heritage reports;
- Treaty of Waitangi Settlement supporting documents (statement of values and association);
- Proposed Auckland Unitary Plan (PAUP) Appendices – Schedules of significant sites and places;
- Reserve Management Plan from Parks Department;
- Contaminated land or landfills; and,
- Stormwater modelling report.

2.2 GIS setup protocol

The GIS setup protocol outlines the process required to prepare GIS information and data capture devices prior to the field watercourse assessment. This process allows existing GIS information to be used to prepopulate attribute information where possible. The process ensures that relevant GIS information is available to field staff in the field and provides for a holistic understanding of the catchment's land use and stormwater network prior to undertaking the field survey.

The ESRI File Geodatabase (FGDB) is the basis for the Watercourse Assessment Geodatabase. The Watercourse Assessment Geodatabase contains all feature classes (GIS layers) and domains (pick lists) required for the field survey. The geodatabase is compatible with ESRI brand products. The use of the ArcGIS online (AGOL) and the Collector application with an iOS or Android device for the field survey is recommended.

A map space available to field staff should be created using the layers specified below as a minimum:

- Watercourse Assessment Geodatabase;
- Contours;
- Aerial Photographs;
- Stormwater Infrastructure;
  - Domain values can be prepopulated with Asset Id numbers and pipe diameters for Protocols Seven (Section 3.7), and Eight (Section 3.8).
- Parcel Boundaries;
- Roads;
- Residents' Comments Points;
  - Following the letter drop, any comments obtained from residents in the area regarding access, dogs, or other relevant information, are to be added as points.
- Locations of Historical and Cultural Significance (PAUP Schedules); and,
- Flood Plains and Flood Prone Areas.

If using the Collector for ArcGIS application, survey staff will require a smart iOS or Android device (Windows is estimated to be supported sometime in 2015) to collect data in the field.

If a 3G data connection is not available, the Collector application can be configured to be used offline, which requires the base maps and other data to be loaded onto the device prior to the field survey and used with an offline map. The offline maps need to be configured using the AGOL account. Once in the field, data can then be collected and stored on the mobile device and subsequently synchronised when an internet connection is available.

The FGDB had been developed and distributed with no attachment functionality. Once the database is uploaded to AGOL, make sure that attachments are enabled by going through "My Content" to the Feature Layer's properties and enabling attachments.

Default domain (pick list) values for some of the feature class attributes have been set within the database. However, the user can set different default values based on their preferences. To make use of the same functionality in Collector (through AGOL) the user needs to be aware of the correct workflow to upload and add the FGDB to AGOL. If the database is not loaded into AGOL correctly the desired functionality will not be available.

ESRI offers the user different methods to upload a FGDB to AGOL, but it is recommended to use the following method:

- Open ArcGIS desktop.
- Add all FCs from the WAM Geodatabase.
- Set up editing templates. The default values need to be present or set at this stage.
- Log in to AGOL using ArcGIS desktop.

- Use the Publish a Service function to upload the database to AGOL.
- Once this process is finished, the FGDB can be added to an editing map in AGOL. At this stage all the required default values or subtypes should be available when creating new features.

3.0 Field Watercourse Assessment

The following sections outline the field watercourse assessment process and provide guidance on how to assess the attributes required under each of the protocols. Definitions and diagrams are provided where necessary. Table 2 outlines the feature classes to be used for each of the protocols.

Table 2: GIS feature classes

Watercourse Assessment Protocol	GIS Feature Class
Reach Assessment	The centreline of the stream following the real path of the stream is to be drawn as a polyline. Each reach assessment (Eco Line) will have a new polyline.
Natural Structures	Point
Fish Survey	Point
Stream Mouths	Polyline
Inanga Spawning	Polygon (around the perimeter of suitable or potential inanga spawning habitat)
Wetlands	Polygon (around the perimeter of the wetland).
Asset Inspection (Inlets/Outlets)	Point (for all inlets or outlets interacting with the watercourse. Only inlets and outlets with pipes ≥ 225 mm internal diameter associated with them are recorded)*.
Asset Inspection (Pipes/Culverts)	Point (additional for each pipe/culvert associated with an inlet/outlet point or otherwise interacting with the watercourse. Only pipes with an internal diameter ≥ 225 mm are recorded)*.
Bank and Channel Lining	Polyline
Erosion Hotspots	Polyline
Enhancement Opportunities	Polygon
Miscellaneous Features	Point
SEVs	Polyline (Note: this is to be populated as part of the Post-survey desktop assessment).

* Inlets, outlets, pipes and culverts smaller than 225 mm (both private and public) that are causing degradation of the waterway (such as erosion issues or presenting a barrier to fish passage) or pose a safety risk should be recorded using the appropriate protocol. Inlets, outlets, pipes and culverts smaller than 225 mm that are not resulting in a specific issue may be recorded as a miscellaneous point if a point of interest is desired to be captured.

3.1 Protocol one: reach assessment (Eco Line)

The survey start point (the first reach) will be the upper boundary of the stream mouth (freshwater/saltwater interface) or, in the case where a tributary to a major watercourse is to be considered separately, the confluence of that tributary with the major watercourse.

The survey and assessment of each reach proceeds in an upstream direction with information being noted as the reach is navigated. In most instances the survey is conducted either from within the watercourse or from the upper bank if access to the watercourse channel itself is not possible.

In accordance with established practice for a reach based stream survey, the extent of a reach is determined by significant changes in linear characteristics (e.g. land use, channel morphology, overhead cover) that are maintained for a significant section upstream from that point. Professional judgement needs to be applied as to whether an isolated change in morphology, e.g. isolated, small scale, changes in riparian vegetation cover, should be assessed in relation to the contextual significance of the effect of the change on stream ecology. Conversely, a significant narrowing and steepening of the natural channel and flood plain will affect stream flows and, if not simply a localised feature, should be treated as a discrete reach.

Examples of significant change could include:

- Riparian Vegetation (more than 50 per cent increase or decrease in overhead cover or length of intact vegetation etc.);
- Bank height (<1m ↔ >2 m);
- Channel width (<1 m↔ >2 m);
- Bank and channel modifications (timber banks ↔ unmodified);
- Erosion (slight less than 10% ↔ severe 60%); or,
- Any other assessment parameter which changes significantly.
- A change in land use (e.g. sports field to industrial) also requires a change in reach, due to data collection practicalities

Typically reach lengths will be in the order of 50 – 200m but may extend up to 400m where, for example, the stream is in a uniform concrete lined channel through a sports field. Conversely reaches may be as short as 30m where there is a short length of open stream between sections of piped network.

It is not necessary to complete the full Reach Assessment protocol for ephemeral streams or overland flow paths. It is sufficient to draw the reach line and record the preliminary information and classification only as per the assessment protocols.

Throughout this document, references to True Right Bank (TRB) and True Left Bank (TLB) are the left and right banks when facing downstream. To ensure TRB and TLB data are correctly recorded, each ecoline must be drawn from downstream to upstream.

3.1.1 Preliminary information

3.1.1.1 Stream name

The Stream Name attribute includes the name of the stream being surveyed. Spelling and formatting of the name must be as per Council Stream Names GIS layer or if a name is not available from council use the 1:50,000 Topographical reference map series. Additional names may be identified from relevant literature. Streams must not be assigned names arbitrarily; streams that do not have a name should be referred to as 'Unknown' followed by an identifying letter, for example, 'Unknown A' (UNK_MAIN_1).

3.1.1.2 Tributary code

The Tributary Code attribute is used to identify the tributary and survey reach. The numbering convention is determined based on the number of tributaries entering the main reach. Examples of tributary codes are as follows (Figure 3):

- DAN_MAIN_1: The first reach on the main branch of Dansey Creek.
- DAN_MAIN_2: The second reach on the main branch of Dansey Creek.
- DAN_TRIB3_1: The first reach of the 3rd tributary heading upstream on Dansey Creek.
- DAN_TRIB3_2: The second reach of the 3rd tributary heading upstream on Dansey Creek.
- DAN_TRIB3a_1: The first reach of the 1st tributary off tributary 3 heading in an upstream direction on Dansey Creek.
- DAN_TRIB3_FORK1: The first fork of the 3rd tributary heading upstream on Dansey Creek.

These names can be populated either during the time of survey or as a desktop GIS exercise following the field watercourse assessment (when there are a large numbers of reaches and tributaries involved). The name must always include the first three letters of the stream name as shown above.

Where a tributary has an assigned name that is different from the main channel, use the tributary name to generate a three letter code.

Where a tributary branches into two roughly equal forks name each fork as per the above convention rather than designating one branch as 'Trib' and one as 'Fork'. The right fork when facing upstream should always be assigned the lower number.

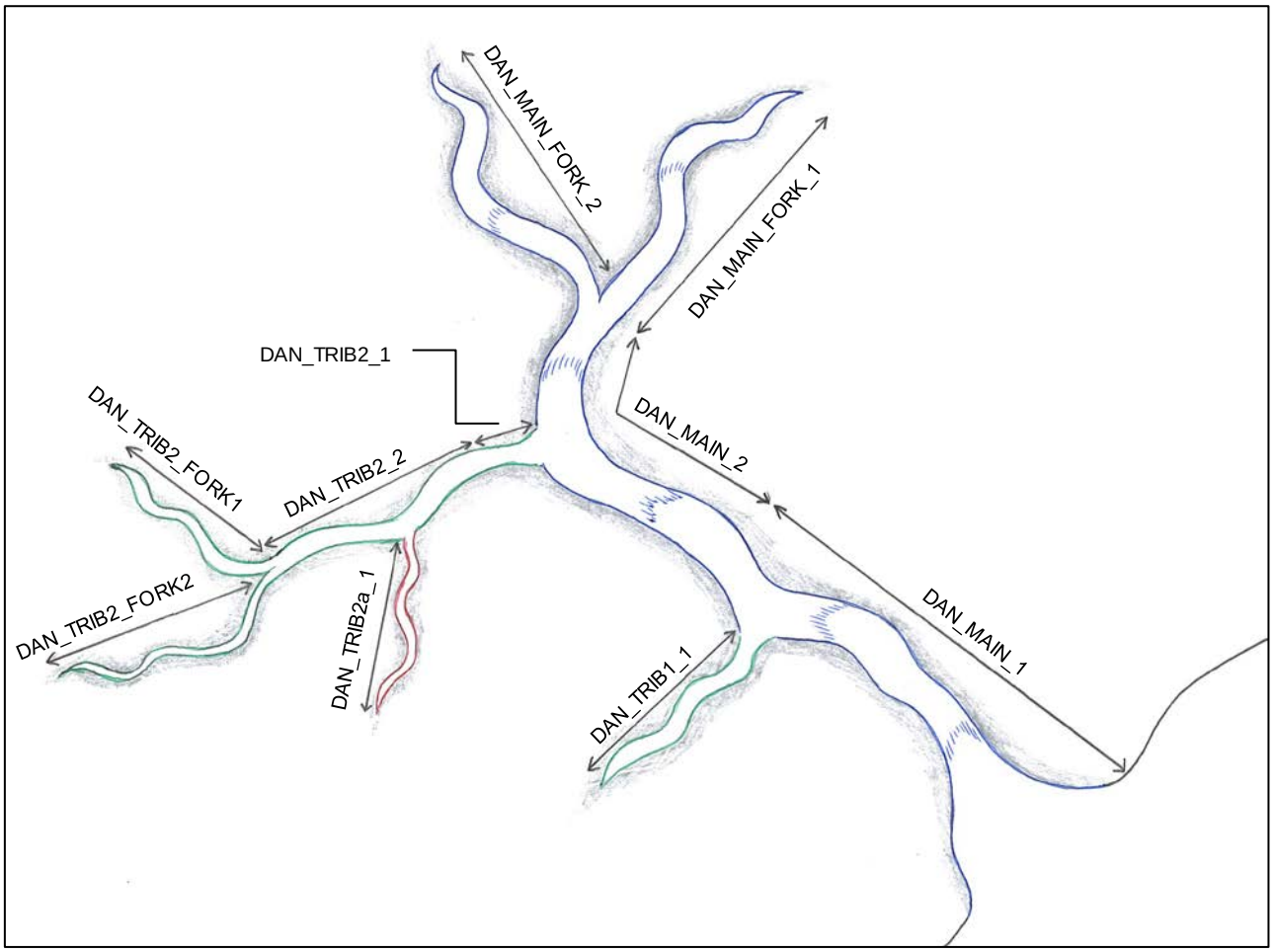


Figure 3: Watercourse Tributary Code naming convention example

3.1.1.3 Date

The Date attribute must be populated at the time of survey. It should be in DD/MM/YYYY format.

3.1.1.4 Consultant

The Consultant attribute identifies the company undertaking the field survey and must be populated with a name.

3.1.1.5 Assessor

The Assessor attribute identifies the person undertaking the field survey and must be populated with initials.

3.1.1.6 Last rainfall event date

The Last Known Rainfall Event attribute indicates the number of days since last known rainfall of >10 mm in 24 hours. This information can be found on the Auckland Council

Hydrotel website or refer to the Metservice website. It must be recorded to provide an indication of the baseflow stream condition. The date format must be DD/MM/YYYY.

3.1.1.7 Reach length

The Reach Length attribute is the total length of the reach surveyed recorded in metres. This is more accurately done as a desktop assessment post-survey and after quality assurance (once polyline locations have been confirmed). The reach length can be taken directly from the feature length.

3.1.1.8 Photographs

Clear representative photographs (or videos) are to be taken of the reach showing the context and key features. Photos must be a minimum of five megapixels. It is preferred that photographs are taken in an upstream direction and in landscape orientation. Photographs or videos must be attached to the feature in the geodatabase.

3.1.2 Physical factors

3.1.2.1 Classification

Each reach that is surveyed will be considered for its classification as a permanent, intermittent, or ephemeral waterway using the definitions of stream reaches provided in the most recent Regional Plan. The latest definition in the Auckland Unitary Plan should be used (substantial changes are proposed as a result of expert input during the PAUP mediation process). It is not necessary to complete the remainder of the Reach Assessment protocol for ephemeral streams or overland flow paths. It is sufficient to draw the reach line and record the preliminary information and classification only.

Table 3: Watercourse definitions

Class	Notified PAUP (2014) definition	Mediated version (10 June 2015)
Permanent	The continually flowing reaches of any river or stream.	No proposed changes.
Intermittent	Stream reaches that cease to flow for some periods of the year. Includes: reaches with stable natural pools having a depth at their deepest point of ≥150 mm and a total pool surface area that is ≥10 m^2 per 100m of river or stream bed length and reaches without stable natural pools.	Stream reaches that cease to flow for some periods of the year because the bed can be above the water table at some times. This category is defined by those stream reaches that do not meet the definition of permanent and meet at least three of the following criteria: • It has natural pools • It has a well-defined channel, such that the bed and banks can be distinguished • It contains surface water more than 48 hours after a rain event which results in stream flow • Rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel • Organic debris resulting from flood can be seen on the floodplain • There is evidence of substrate sorting process, including scour and deposition
Ephemeral	Stream reaches with a bed above the water table at all times with water only flowing during and shortly after rain events. If this is unclear then the following criteria may be used to guide the assessment. If at least three of the below are true at all times of the year the watercourse is likely to be ephemeral. • It lacks a well-defined channel, so that there is little or no ability to distinguish between the bed and banks. • It contains no surface water if no rain has occurred in the previous 48 hours. • It contains terrestrial vegetation. • There is no clearly visible organic debris on its floodplain from flood flows. • There is no evidence of substrate sorting through flow processes.	Stream reaches with a bed above the water table at all times with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent or intermittent.
Overland Flow Path	Low point in terrain, excluding a permanent watercourse, where surface runoff will flow, with an upstream contributing catchment exceeding 4000m².	No proposed changes.

Note: When rainfall exceeds the capacity of a stormwater system, the stormwater will begin to flow across the ground from higher land, and this is what is known as an overland flow path (easiest path for stormwater to flow to natural watercourse or channel). When a natural channel acts as an Overland Flow Path with base flows contained within a pipe, it is more appropriate to record the reach as an Overland Flow Path than an ephemeral reach. Overland Flow Paths are recorded as an ecoline when they display a level of natural channel characteristics and are frequently engaged.

3.1.2.2 Wetted channel width

The wetted stream channel width is measured in metres at regular intervals across the stream throughout the reach being surveyed. Both the mean of the measurements and the maximum width measured along the reach are to be recorded.

The wetted width is the distance across the stream (perpendicular to flow) that is submerged by water on the day of sampling.

3.1.2.3 Stream depth

The depth of the stream channel is measured in metres at regular intervals along the main channel of the stream throughout the reach being surveyed. The mean of the measurements is to be recorded. The maximum depth of the stream within the reach is also to be recorded, this will often occur in pool section where present.

3.1.2.4 Bank angle

The channel bank angle is to be measured along the length of the reach at regular intervals to calculate the average bank angle for the left and right banks separately. Bank angle is to be measured from the edge of the water to the top of the bank (immediate bank associated with the watercourse) (see below for determination of bank height). Where banks overhang the stream a negative slope may be observed. In some situations a level of discretion will need to be applied in measuring the bank angle.

3.1.2.5 Bank height

The average vertical distance between the stream bed and the top of the bank (immediate bank associated with the watercourse) must be recorded in metres. The average bank height for the left and right banks is to be recorded separately. As a guideline the top of the bank to be measured can be identified as the first significant change in angle; this can be difficult to assess where banks are not clearly defined or delineated from the floodplain. In some situations a level of discretion will need to be applied in measuring the bank height.

3.1.2.6 Substrate

The relative proportion (of area) of each substrate class within the reach is estimated and recorded to the nearest 5%. Size ranges for each class are provided below in Table 4.

Substrate size is measured along the second longest edge of the substrate. Where a reach is concrete lined, substrates on the concrete may be recorded (e.g. silt or sand deposits). Silt/Sand class may include mud or clay. It is possible that the total percentage of substrate present may exceed 100%, for example where other substrate classes is found on top of bedrock.

Table 4: Substrate Size Classes (Modified Wentworth Scale)

Substrate Class	Size Range (diameter mm)
Artificial Substrate	
Bedrock	>4000
Boulder	256 – 4000
Cobble	64 - 256
Gravel	2 - 64
Silt/mud/Sand	< 2

3.1.2.7 Active sediment deposition

The area of the channel bed covered in fine grained sediment (<2mm) deposition from fresh or active erosion in the stream is to be estimated to the nearest 5%. Natural soft bottom streams with silt/sand substrate dominant will not necessarily have high levels of active sediment deposition. The degree of substrate compactness, dominant substrate embededness, evidence of upstream slumping, and depth of accumulated sediment can be used to estimate active sediment deposition (Harding *et al.* 2009). This attribute contributes to assessing whether any erosion on the stream banks is recent and actively occurring or historical, as well as assessing the impact on the composition of stream substrate and associated adverse effects.

3.1.2.8 Floodplain connectivity

The frequency of flood flows reaching the floodplain is to be assessed and recorded according to Table 5. It is acknowledged that this is a subjective field assessment. The floodplain is defined as a low gradient area near a stream channel that is inundated by moderate floods, and is formed under present climatic conditions by sediment deposition during flooding (Harding et al. 2009). The frequency of flooding can be assessed through several means including evidence of flood debris on banks, conversations with local residents or use of flood-hazard layers in council GIS as a desktop exercise (available through council GIS viewer). Connectivity can be reduced by the presence of stop banks or urban development, or incision or widening of the channel.

Table 5: Definition of floodplain connectivity categories

Pick List	Definition
Rare	Rare (<1 yr).
Occasional	Occasional (1-2 yr).
Often	Often (3-5 yr).
Frequent	Frequent (>5 yr).
Does Not Apply	No flood plains exist within reach.

3.1.2.9 Anthropogenic bank and channel modification

Any bank or channel modification along the reach is to be assessed and recorded. Signs of channel modification can include unnaturally straight sections of stream, very high banks, or a lack of flow diversity (e.g. runs and pools). This attribute refers to constructed modification and does not include reaches that are modified by down cutting. Additional information on lining material and condition is to be added under Protocol Eight: Bank and Channel Lining.

3.1.2.10 Erosion scars

The percentage of the length of each bank with erosion scars or bank slumping is observed by identifying the area of exposed earth (or recently exposed with some herbaceous vegetation cover) on the stream bank that has resulted from bank slumping or loss. This is to be assessed and recorded for the TLB and the TRB separately as per Table 6.

Table 6: Definition of extent of erosion scarring.

Pick List	Definition
Erosion 0%	Bank lining or artificial material No sign of erosion scars.
Erosion 0 < 20%	Less than 20% of banks have erosion scars Stable banks and bed.
Erosion 20 to 40%	Between 20 and 40% of banks have erosion scars. Some bank slumping.
Erosion 40 < 60%	Between 40 and 60% of banks have erosion scars. Bank vegetation collapsing into stream. Bank slumping throughout the reach.
Erosion >60%	Over 60% of the banks have exposed erosion scars. Heavy sediment deposits which dominate the streambed. Unstable banks throughout the entire reach. Collapsing of bank vegetation.

3.1.2.11 Pfankuch upper bank stability assessment

The Pfankuch Bank Stability assessment is a standard method for assessing bank and channel stability (upper banks, lower banks and channel stability). The Watercourse Assessment Methodology adapts the Pfankuch assessment of upper bank stability. The upper banks are defined in Pfankuch (1975) as the "portion of the topographic cross section from the break in the general slope of the surrounding land to the normal high water line. Terrestrial plants and animals normally inhabit this area". The normal high water line can be defined as the mean annual flood level. In practice the area of the upper banks will need to be identified using a combination of hydrological and morphological considerations.

Each parameter is to be assessed separately for the entire reach. This does not include localised stability issues which are to be evaluated as 'erosion hotspots'.

The following criteria (Table 7) allow for the calculation of the overall stability index, which can be done as part of the Post-survey Desktop Assessment. The index is to be calculated by summing all scores. Reach scores of ≤13 = Excellent, 14-23 = Good, 24 -32 = Fair, ≥33 = Poor. These overall stability scores have been adapted from the Pfankuch methodology (Pfankuch, 1975).

Land slope

Table 7: Definition of bank gradient categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	Bank gradient <30^{o} on both banks.	2
Good	Bank gradient 30 - 35^{o} on 1 or sometimes both banks.	4
Fair	Bank gradient 35 - 50^{o} common on 1 or both banks.	6
Poor	Bank gradient >50^{o} common on 1 or both banks.	8

Mass wasting

This describes the extent of existing or potential detachment of large quantities of earth into waterways below via slumping or sliding (refer Table 8).

Table 8: Definition of mass wasting categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	No evidence of past or any potential for future mass wasting into channel.	3
Good	Infrequent and/or very small. Mostly healed over. Low future potential.	6
Fair	Moderate frequency and size, with some raw spots eroded by water during high flow.	9
Poor	Frequent or large, causing sediment nearly yearlong or imminent danger of this.	12

Debris jam

Debris jams are to be considered in terms of the likelihood of causing an impediment to flow. Table 9 provides guidance on assessing debris jams.

Table 9: Definition of debris categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	Essentially absent from immediate channel area.	2
Good	Present but mostly small twigs and limbs.	4
Fair	Present, volume and size both increasing.	6
Poor	Moderate heavy amounts, predominantly larger sizes.	8

Bank vegetation

Fine fibrous roots are good for binding sandy soils and fine gravels whilst a combination of fibrous roots and larger diameter roots are needed to stabilise clay – loam soils or steeper banks (Wilkinson 1999, Phillips *et al.* 2011). Deeper root mass is desirable for increasing geotechnical strength of banks (Simons 2015). Regenerating or mature native or exotic vegetation is to be considered for this attribute. Recently planted vegetation will not have

an established root mass area. Refer to Table 10 for definitions and Figure 4 for examples of bank vegetation categories.

Table 10: Definition of bank vegetation categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	>90% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	3
Good	70-90% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	6
Fair	50-70% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	9
Poor	<50% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	12

Excellent

Good

Fair

Poor

Figure 4: Examples of bank vegetation categories

3.1.2.12 Adjacent land use

The predominant land use (within 20 m) alongside the stream reach is to be recorded separately for TLB and TRB as one of the following:

- Bush, forest, scrub or long grasses and weeds;
- Park, sports field;
- Agricultural;
- Residential;
- Light Industry, commercial;
- Industrial; and,
- Other (such as footpaths).

These definitions are not based on any district or unitary plans, but are to be representative of the predominant land use within 20m of the stream reach being assessed. Some discretion may be needed in certain situations; for example, life style blocks may in some instances be managed more like large residential lots than agricultural land use.

3.1.2.13 Stock access

Where evidence of stock is present, the degree of access to the waterway and degree of damage to the banks is to be assessed. Extent of damage is defined below in Table 11, refer to Figure 5 for examples.

Table 11: Definition of extent of stock damage.

Pick List	Definition
None	No damage from stock is evident.
Minor	Stock trails, minor vegetation browse, low stocking density.
Moderate	Some evidence of minor bank slumping, moderate stock density, single access and exit point.
Severe	Areas of pugging, bank slumping, multiple stock entrance and exit points.
Does Not Apply	No stock in area.

None (fenced and planted)

Minor

Moderate

Severe

Figure 5: Examples of degrees of stock damage.

3.1.3 Water quality factors

3.1.3.1 Sewage fungus

The presence (or absence) of sewage fungus within the reach is to be assessed and recorded. Sewage fungus (*Sphaerotilus natans*) is a filamentous bacterium often found living in water polluted with organic wastes. It is a grey slimy substance that forms long thin threads.

3.1.3.2 Other contamination

Petroleum/hydrocarbons

Any evidence of petroleum/hydrocarbon contamination is to be recorded as Yes or No. Examples of evidence can include:

- Obvious odours;
- Surface sheens (bacterial sheens will typically break into small platelets when disturbed while a petroleum sheen will quickly reform).

Anaerobic conditions

Any evidence of anaerobic conditions is to be recorded as Yes or No. Examples of evidence can include:

- Sulphurous odours;
- Fine, black sediments;
- Outgassing (bubbles when sediments are disturbed).

Other

Any other noticeable contamination is to be recorded as Yes or No. Examples of contamination may include:

- Surface flecks, foam, or globs of slime;
- Obvious fishy, sulphurous or chemical odours;
- Coloured water (milky, cloudy brown from sedimentation, dark brown from decay, green from excessive algal growth, paint discharge etc.);
- Dead fish;
- Sewage overflows (solids and fibre).

The type of contamination and potential sources are to be recorded in the notes field.
Any specific pollution events should be recorded as a Misc Point as per Protocol Eleven and reported following the Pollution Response protocol in Appendix B.

3.1.4 Biological factors

3.1.4.1 Macrophytes

The type and abundance of all emergent and submergent macrophyte species are expressed as a percentage cover of the wetted channel area in each reach as <20%, 20-50% or >50% cover.

Emergent and submergent macrophytes refer to vegetation rooted below the base flow water level. Emergent macrophytes hold their foliage above the water level whilst submergent vegetation does not.

Any 'Total Control' or 'Containment' (ARC RPMS) macrophytes (such as water hyacinth (*Eichhoria crassipes*)) must be reported to the Auckland Council as per the Biosecurity protocol in Appendix B.

3.1.4.2 Periphyton

The abundance of all periphyton must be expressed as a percentage cover of the wetted channel area in each reach as <20%, 20-50% or >50% cover. The dominant colour and type (filamentous or diatomaceous) of the periphyton must also be recorded. Where no periphyton is present this is to be recorded as 'Does not apply'.

3.1.4.3 Riparian vegetation

Stream shading

The proportion of the water surface that is shaded by vegetation or topography (including banks, buildings, and fences) must be estimated visually. This must be expressed as a percentage of the wetted channel area for each reach as <10%, 10-30% 30-50% or 50-70%, 70-90%, >90% cover (Storey *et al.* 2011). Consider the orientation of the stream (north-south or east-west) and the path of the sun when estimating shading. Wider streams will also typically have lower overhead cover where bankside vegetation is not able to shade the entire width of the stream. Cover is to be estimated for mid-summer conditions when annual and deciduous species are in full leaf. Examples of cover categories are outlined below in Figure 6.

<10%

10-30%

30-50%

50-70%

70-90%

>90

Figure 6: Riparian vegetation overhead cover categories

Longitudinal extent

The longitudinal extent of intact riparian vegetation along the stream reach must be estimated and recorded to the nearest 5%. This is to be recorded separately for the TLB and the TRB. Intact vegetation refers to clumps of continuous vegetation patches that provide shading for the stream and does not include grasses, isolated or scattered trees or shrubs, or regularly spaced shelter belts. Vegetation that is too far away from the watercourse to provide shade also does not count towards the longitudinal extent. An example is provided in Figure 7.

Latitudinal extent

The latitudinal extent of intact riparian vegetation along the stream reach (riparian width) must be estimated and recorded in 5m intervals from 0 to >20m width. This is to be recorded separately for the TLB and the TRB. An example is provided in Figure 7. Intact vegetation refers to clumps of continuous vegetation and does not include grasses, isolated or scattered trees or shrubs, or regularly spaced shelter belts. Vegetation that does not initiate at (or near enough to) the stream edge to provide shade to the stream is not considered in this measurement (even though it is acknowledged that in some situations such vegetation will provide other benefits such as non-point source pollution filtration).

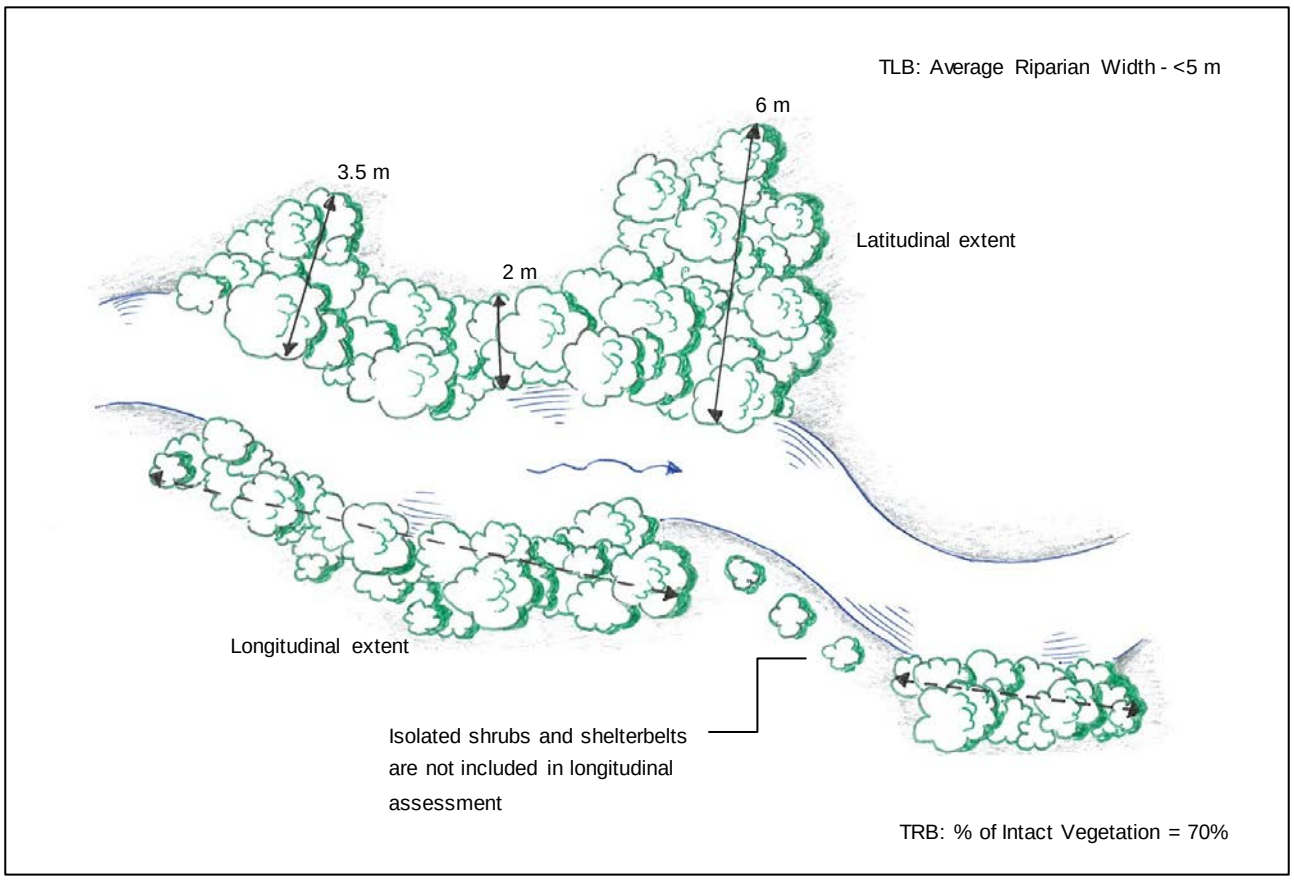


Figure 7: Example of estimation of mean latitudinal and longitudinal extent of riparian vegetation

Vegetation type

The predominant type of vegetation within 20m of the watercourse on both sides is to be recorded as Native, Mixed, Exotic, or None for each canopy layer height category. Table 12 defines the layer height categories and Table 13 defines the vegetation type categories. 'Canopy' includes emergent, canopy, and sub canopy forest layers for the purposes of this assessment. Examples of vegetation types and stages of development are outlined in Table 14.

Table 12: Definition of vegetation layer height categories (modified from Harding et al. 2009)

Pick List	Vegetation Tier Height (m)
Canopy	>5
Understorey	0.3-4.9
Groundcover	0- 0.3

Table 13: Definition of vegetation type categories

Pick List	Definition
Native	>70% native species.
Mixed	Between 30-70% of native or indigenous flora.
Exotic	>70% Exotic Species.
None	No vegetation in vegetation layer.

Vegetation development

The general stage of riparian vegetation development is to be recorded according to the categories in Table 14. Some discretion may be needed in certain situations; for example an immature monoculture stand of bamboo does not fit neatly within any of the definitions outlined below, however, it may fit best within the scrub category (refer to Figure 8 for examples). Including explanatory notes in the notes section is recommended in these situations.

Table 14: Definition of vegetation state categories (based on Storey *et al*. 2011; Johnson and Gerbeaux 2004).

Pick List	Definition
Mature	Diverse canopy cover of trees and shrubs (including tree ferns) with a trunk typically >10cm dbh* typically with a diverse understorey. May also include less diverse stands of mature exotic vegetation with less diverse understorey (e.g. pine plantation).
Regenerating	Late stage succession or regenerating understorey under exotic canopy. This can also include planted sites >5 years old. May include weedy sites with early successional native species present.
Scrub	Low diversity, dominated by manuka and/or other woody plants typically <10cm dbh*. May include weedy sites without early successional native species present.
Low growing	Flax, sedges, rushes, reeds, ferns, or herbaceous weeds.
Planted	Evidence of revegetation works completed or in progress. This will typically include planted sites <5years old.
Grassed	Pasture or parkland.

*dbd =diameter at breast height

Mature (Native Canopy, Native Under, Native Ground)

Regenerating (Mixed Canopy, Under, and Ground)

Scrub (Exotic Under, Exotic Ground)

Low Growing (Native Under, Mixed Ground)

Planted (Native Ground)

Grassed (Exotic Ground)

Figure 8: Riparian vegetation type and development stage

3.1.4.5 Habitat heterogeneity

The relative proportion (of area) for each habitat type within the reach as outlined in Table 15 is to be estimated and recorded to the nearest 5%. Where still water and backwaters are present (these are outside of the main channel) the total percentage of habitat types present may exceed 100%.

Table 15: Definition of habitat type categories

Pick List	Definition
Still	Isolated pool separated from the main channel.
Backwater	Slow or no flow zone away from the main flowing channel that is a surface flow dead end.
Pool	Slow flowing deep water with a smooth water surface.
Run	Smooth or rippled unbroken flow.
Riffle	Fast, shallow flow over boulders and cobbles which break the water surface.
Rapid	Shallow to moderate depth, swift flow and strong currents, surface broken with white water.
Cascade	A series of small waterfalls or rapid turbulent water over boulders or bedrock.

3.1.4.6 Stable bank undercut

Stable undercut banks provide important fish habitat. Stable undercut banks feature dense root masses with good riparian cover to maintain cohesion (Auckland Council, 2014). Banks that are continuously undercutting and shearing off or slumping are not to be considered in this estimate as they do not provide a stable habitat function. Banks that are continuously undercutting and shearing off or slumping can be identified through a lack of lack of vegetation and / or stabilising root structures. Fresh erosion scars and sediment deposition can also be an indication of regular shearing off or slumping of bank material. Table 16 provides definitions of undercutting categories.

Table 16: Definition of bank undercut categories

Pick List	Definition
Extensive	> 50% of total reach length.
Good	< 50% of total reach length.
Moderate	< 20% of total reach length.
Some	< 5% of total reach length.
None	No stable undercutting.
Does Not Apply	Where bank and channel is fully lined.

3.1.4.7 Fish spawning habitat

Potential fish spawning habitat must be assessed for *Gobiomorphus* and *Galaxiid* species. The presence of fish spawning habitat must be assessed as one of the following (refer Table 17).

Table 17: Definition of suitable spawning habitat (Storey et al. 2011).

Pick List	Definition
In stream	Undercut banks, large stable woody debris (>50 mm diameter), large cobbles and boulders (>150 mm), and/or thick root mats.
Bank	Dense (>50% cover), moist, shaded (>50% overhead cover), ground level vegetation or leaf litter on floodplains low enough to be frequently submerged by small floods/freshes but above the baseflow.
In Stream and Bank	Both of the above types are present.
None	No suitable habitat is present.

3.1.5 Notes

Any additional information on the reach should be recorded here as required.

3.2 Protocol two: natural structures

3.2.1 Preliminary Information

The Stream Name, Tributary Code, Consultant, Assessor, and Date should all be completed as for the Eco Line Assessment.

3.2.1.1 Photographs

Representative photographs are to be taken of the structure showing the context and detail of elements of interest. All photographs are to be attached to the feature in the geodatabase.

3.2.2 Physical variables

The width, length, and height of the natural structure is to be recorded in metres.

3.2.2.1 Type

The type of natural structure being inspected must be recorded as per Table 18.

Table 18: Definition of natural structure types

Pick List	Definition
Waterfall	Where water falls over a vertical drop in the natural stream bed more than 200 mm.
Cascade	A series of small waterfalls or rapid turbulent water over boulders or bedrock.
Ford	Natural shallow section of stream allowing easy crossing, possibly being above the water level in dryer periods. A permanent or semi-permanent feature possibly forming an upstream pool. A ford is a more stable structure than a debris jam and should not facilitate the accumulation of debris. Does not include man-made fords.

3.2.2.2 Safety

The overall extent of the hazard the structure poses to public safety must be assessed (Table 19). The location of the structure (public vs private land, surrounding land use e.g. recreation, bush), the ease of access (Table 20) and whether or not the structure is fenced, needs to be considered in this assessment.

Table 19: Definition of overall structure safety

Pick List	Definition
Appears Safe	The structure appears to be safe.
Not Safe	The structure appears to be unsafe, i.e. pollution is evident, there is an unprotected drop of >1 m, fencing is deteriorating.
Not Safe – Drop 1.5m	There is an unprotected drop from the structure of >1.5 m.
Not Certain	Unable to determine whether structure is safe or not.

Table 20: Definition of access type

Pick List	Definition
Easy	Structure is accessible via direct pathway or other clear walking route close to public areas.
Moderate	Structure is accessible via minor trails or residential access ways.
Difficult	Structure is remote and/or access is difficult due to terrain or vegetation, or access is fenced off or behind property.

3.2.3 Fish passage

Natural structures in the watercourse may impact fish passage. The extent of this must be assessed by considering several variables. Steepness, constricted flows, and low bed roughness may lead to water velocities that exceed the swimming capability of fish preventing upstream passage. Insufficient water depths in channel or over structures can

also cause problems for swimming species. Some climbing fish species may be able to navigate obstacles via a continuous wetted margin or overhanging vegetation/roots.

3.2.3.1 Drop height

The change in height of the water surface from the upstream side of the structure to the downstream side of the structure must be measured and recorded in metres.

3.2.3.2 Velocity

The velocity in and around the structure must be estimated and recorded according to Table 21. An educated estimate is to be made regarding average base flow velocity. Actual velocity at the time of assessment will vary due to seasonal and weather variation.

Table 21: Definition of velocity categories (based on analysis in Stevenson and Baker 2009).

Pick List	Definition
Low	Average flow velocity 0-0.3 m/s.
High	Average flow velocity >0.3 m/s.
Very High	Average flow velocity >1.0 m/s.
Does Not Apply	No fish habitat exists upstream.

3.2.3.3 Turbulence

Surface water turbulence in and around the structure must be visually estimated as either high or low (Table 22).

Table 22: Definition of turbulence categories

Pick List	Definition
Low	Surface water smooth to rippled and not broken.
High	Surface water is broken with white water.
Does Not Apply	No fish habitat exists upstream.

3.2.3.4 Water gradient

The associated water gradient of the structure must be measured using an inclinometer and recorded in degrees.

3.2.3.5 Water depth

The water depth flowing over the structure must be measured and recorded in metres.

3.2.3.6 Low flow impedance

During periods of low flow, the lack of flow over or through a structure may form a fish barrier. This attribute is to be estimated for conditions less than base flow (summer or drought). If the entire reach is likely to have a low flow impedance not relating to the structure assessed then do not record a low flow impedance associated with the structure (record as 'Does not Apply'). The focus is on fish passage barriers exacerbated by the structure.

3.2.3.7 Barrier impact

The permanence of the structure as a fish barrier must be recorded as per Table 23. The severity of the barrier may depend on the season, rainfall intensity, sedimentation, or other parameters. High velocities due to flood flows inhibit fish passage but are not to be considered within this attribute as these cannot be specifically targeted for mitigation.

Table 23: Definition of barrier impact categories

Pick List	Examples
Complete	Barrier is always present and completely impassable (could be a complete barrier to swimmers, or climbers, or all).
Partial	Barrier is always present and could be a barrier to swimmers, climbers, or all. However, the barrier is likely to only provide an impediment to some species within the class (swimmers, climbers etc.).
Temporary	Blocked by debris or sedimentation. Tidally submerged, or submerged under higher flows. A temporal low flow impedance.
None	There is no barrier.

3.2.3.8 Barrier type

Based on the above attributes (summarised below in Table 24) the structure must be assessed for the extent of barrier impact to different locomotory classes of fish. The barrier impact to each of the locomotory classes is recorded as yes / no.

Table 24: Definition of barrier impact categories (based on Boubee et al. 2000; Stevenson and Baker 2009).

Barrier to Locomotory Class	Definition	Example Species
Barrier to Swimmers	Average flow velocity >0.3 m/s. Water depth over/around structure is <5cm at base flow or there is a low flow impedance. Drop height of >7.5 cm. Lack of low velocity zones to rest. No suitable fish passage device.	Inanga
		Smelt
		Grey Mullet
		Common bullies
		Torrentfish
Barrier to Climbers	Overhanging and/or sharp edged structure with insufficient debris and roots or fish passage device to facilitate climbing. Lack of a continuous smooth wetted margin. Drop height >1 m. Culvert or ramp slope >40^{o}.	Lamprey
		Elvers
		Kokopu
		Koaro
		Redfin bullies
Barrier to Anguilliforms	No wetted margin present and barrier to climbers. Anguilliforms are able to travel across damp terrestrial areas for short distances if necessary.	Adult shortfin and longfin eels

3.2.4 Notes

Notes should be made about the structure or flora/fauna present.

3.3 Protocol three: fish survey

Wherever there is suitable habitat for fish such as undercut banks, deep pools, or overhanging vegetation, or fish are observed incidentally, an attempt is to be made to catch them using a hand held net (350 x 500 mm). It is acknowledged that this is a rapid chance observation and capture survey carried out during daylight, as such, it is acknowledged that there is a bias in species sighted and captured.

Attributes from this protocol in combination with fish passage assessment and Ecoline attributes can be used to complete the New Zealand Freshwater Fish Database forms. Refer to Appendix B for further details.

3.3.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.3.1.1 Photographs

A photograph should be taken of each species showing defining characteristics to assist with identification validation and attached to the feature. Photographs are to be taken on a white background with a measuring ruler in the frame. A photograph of the location and habitat should also be taken and attached to the feature.

3.3.2 Physical variables

The width and depth of the watercourse at the point of fish capture is to be recorded in metres.

3.3.3 Biological variables

3.3.3.1 Fish spawning habitat

The presence of fish spawning habitat within 10m upstream and downstream of the fish capture point must be assessed, and if present, categorised as per Table 25.

Table 25: Definition of suitable spawning habitat (Storey et al. 2011).

Pick List	Definition
In stream	Undercut banks, large stable woody debris (>50 mm diameter), large cobbles and boulders (>150 mm), and/or thick root mats.
Bank	Dense (>50% cover), moist, shaded (>50% overhead cover), ground level vegetation or leaf litter on floodplains low enough to be frequently submerged by small floods/freshes but above the baseflow.
In Stream and Bank	Both of the above types are present.
None	No suitable habitat is present.

3.3.3.2 Habitat notes

Any additional notes on habitat such as quality of habitat should be recorded here. If the fish is sighted but not caught this should be noted here.

3.3.3.3 Fish species

Up to three different species may be recorded at any given fish point distinguished as Species 1, Species 2, and Species 3 (see Table 26).

3.3.3.4 Fish attributes

For each fish species record the number of individual fish caught, the minimum length of all individuals and the maximum length of all individuals in mm.

3.3.4 Notes

Any additional information on each fish species is to be recorded in the notes field such as the extent of the area fished.

Table 26: Freshwater fish species

Pick List	Species
Yellow Eyed Mullet	*Aldrichetta forsteri*
Shortfin Eel	*Anguilla australis*
Longfin Eel	*Anguilla dieffenbachii*
Unidentified Eel	*Anguilla sp.*
Grass Carp	*Ctenopharyngodon idella*
Giant Kokopu	*Galaxias argenteus*
Koaro	*Galaxias brevipinnis*
Banded Kokopu	*Galaxias fasciatus*
Inanga	*Galaxias maculatus*
Shortjaw Kokopu	*Galaxias postvectis*
Unidentified Galaxiid	*Galaxias sp.*
Mosquitofish	*Gambusia affinis*
Lamprey	*Geotria australis*
Cran's Bully	*Gobiomorphus basalis*
Common Bully	*Gobiomorphus cotidianus*
Giant Bully	*Gobiomorphus gobioides*
Redfin Bully	*Gobiomorphus huttoni*
Unidentified Bully	*Gobiomorphus sp.*
Grey Mullet	*Mulgi cephalus*
Koura	*Paranephrops planifrons*
Common Smelt	*Retropinna retropinna*

3.4 Protocol four: stream mouths

The Auckland Regional Air Land and Water Plan defined stream mouths as the interface between rivers and streams and the marine receiving environment.

The identification of the upper boundary can be indicated by:

- The mean high water mark;
- The point of change between mangroves and saltmarsh and freshwater vegetation;
- A visible mean high water spring structure or feature such as a seawall, culvert, or waterfall that prevents tidal inundation;
- A significant change in gradient or channel form;
- The upper limit of mud crab holes which may by slightly upstream of the extent of mangroves.

The identification of the lower seaward boundary can be indicated by:

- The stream meeting a beach or shell bank;
- A dramatic increase in the downstream width of the stream.

3.4.1 Preliminary information

The Stream Name, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.4.1.1 Photographs

Representative photographs are to be taken of each boundary and attached to the feature. Other photographs of key features can also be taken.

3.4.2 Boundaries

A description of both the upper and lower boundary of the stream mouth must be provided. Examples are provided in Figure 9.

3.4.3 Energy environment

The stream mouth environment must be categorised as either high energy (beaches, open coastline with sandy or rocky sediments), or low energy (estuaries with muddy/sandy sediments). Examples are provided in Figure 9.

Lower Extent (low energy environment)

Upper Extent (upper limit of mangrove forest)

Lower Extent – (high energy environment)

Upper Extent (upper limit of crab holes)

Figure 9: Examples of upper and lower stream mouth boundaries and energy environments

3.4.4 Vegetation type

The dominant vegetation type is to be recorded (Table 27). All areas of saltmarsh or salt meadow are also to be recorded following Protocol Six: Wetlands.

Table 27: Dominant stream mouth vegetation types

Pick List	Definition
Mangroves	Dominated by *Avicinnia marina.*
Saltmarsh/meadow	Dominated by herbfield species such as sea rush, oioi, saltmarsh ribbonwood, glasswort, remuremu, sea primrose, brass buttons.
Seagrass	Beds of *Zostera novaezelandica.*
Other	

3.4.5 Notes

Any additional information on the stream mouth should be recorded here as required.

3.5 Protocol five: inanga spawning

Areas of potential (and actual) inanga spawning habitat must be identified during the field survey. Spawning habitat is to be assessed for all areas that feature suitable inanga spawning habitat or could potentially be suitable spawning habitat if enhancement works were undertaken.

Spawning areas are of low bank gradient that will be inundated by spring tide flows, commonly near bank embayments, tributary confluences, or other obstructions that break the water flow.

Identify the limit of the springtide saltwater intrusion with freshwater bank vegetation present. Most inanga spawning is within 500m of this upstream limit. The area can generally be identified as the downstream limit of common freshwater macrophytes (such as *Elodea canadensis*, *Potamogeton cheesemanii* or *P. crispus*) or the upstream limit of estuarine crab holes.

3.5.1 Preliminary information

The Stream Name, Tributary Code (closest tributary code), Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.5.1.1 Photographs

Representative photographs are to be taken of the potential spawning habitat showing the context and species composition and attached to the feature.

3.5.2 Spawning area

3.5.2.1 Length

The total length of the spawning area available along both the TLB and TRB must be recorded in metres.

3.5.2.2 Vegetation type

The general type of vegetation that forms the spawning habitat must be recorded. Examples are outlined below in Table 28.

Table 28: Definition of vegetation types for Inanga spawning protocol

Pick List	Definition
Sedge/Rush	Native or exotic sedges, rushes, raupo, flax.
Pasture	Pasture grasses and common pasture weeds.
Park	Mown or unmown parkland or other public land.
Other	Exotic weeds, straw bales placed for spawning enhancement etc.

3.5.2.3 Potential for enhancement

The overall quality of the potential inanga spawning area is to be assessed. Where potential habitat is degraded due to mowing, stock access, litter, lack of shade, or lack of suitable vegetation the potential for enhancement field should be recorded as 'Yes'.

Vegetation that restrict and chokes streams such as reed sweet grass (*Glyceria maxima*) and mercer grass (*Paspalum distichum*) are considered to be unsuitable for inanga spawning (as streams constricted by excessive vegetation growth within the channel are not suitable habitat for inanga).

Examples of both native and exotic vegetation that provide suitable inanga spawning habitat are outlined below in Table 29.

Table 29: Examples of vegetation that provides suitable Inanga spawning habitat (Taylor 2002).

Preferred Vegetation	Species
Native	Flax (*Phormium tenax*) Toetoe (*Cortadaria fulvida*) Raupo (*Typha orientalis*) Wiwi (*Juncus gregiflorus*) Sedges (*Carex sp.*)
Exotic	Tall fescue (*Festuca arundinacea*) Creeping bent (*Agrostis stolonifera*) Yorkshire fog (*Holcus lanatus*) Clover (*Trifolium* sp.) Monkey musk (*Mimulus guttatus*) Water cress (*Rorippa* sp.) Cow parsley (*Anthriscus sylvestris*) Buttercup (*Runninculus* sp.)

3.5.3 Notes

Notes should be made on potential spawning habitat such as the quality of the habitat, any evidence of spawning, or enhancement requirements. Inanga spawning sites that can be realised or improved through enhancement should also be recorded as enhancement opportunities.

3.6 Protocol six: wetlands

Stormwater flowing through a wetland is treated by a variety of mechanisms including settling, filtration, biological degradation, microbial uptake, adsorption, volatilisation and plant uptake. Wetlands can also provide peak flow attenuation and extended detention, and landscape and wildlife habitat benefit.

Natural wetlands are defined as permanently or intermittently wet areas of shallow water, with land/water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions. Wetlands can be an integral part of the stream, they may form the start of a stream due to seepage, or in some cases, intermittent streams can be sections of wetlands. Water running within a channel will typically be a stream rather than a wetland though there may be associated riparian wetlands. This protocol also records artificial wetlands that may fall outside this definition.

3.6.1 Preliminary information

The Stream Name, Tributary Code (downstream or closest tributary code), Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.6.1.1 Photographs

Photographs are to be taken of the wetland showing the context and species composition and attached to the feature.

3.6.1.2 Wetland name

The wetland name includes the name of the wetland being surveyed. Spelling and formatting of the name must be as per council GIS or if a name is not available from council use the 1:50,000 Topographical reference map series. If neither source provide wetland names give the wetland a unique name based on the closest (or downstream) reach.

3.6.2 Wetland assessment

3.6.2.1 Wetland type

The general type of wetland must be recorded as either natural (Table 30) or artificial (Table 31) categories.

Table 30: Definition of natural wetland categories.

Pick List	Definition
Palustrine	Permanent or ephemeral swap or bogs with emergent vegetation.
Lacustrine	Perimeter of lakes and open water bodies.
Riverine	Headwaters or floodplains of larger rivers and streams.
Sand Dune	Wetlands associated with sand dunes.
Volcanic	Wetlands associated with volcanic craters.
Coastal	Wetlands associated with coastal waters.
Other	
Does Not Apply	Artificial Wetland.

Table 31: Definition of artificial wetland categories.

Pick List	Definition
Culvert Damming	Wetland created by restricted flow through a culvert.
Farm Pond	An artificial pond created for agriculture functions i.e. providing drinking water for stock.
Constructed Wetland	Includes surface flow, sub surface flow and hybrid constructed wetlands.
Detention Pond Wet	Stormwater detention ponds with a permanent standing pool of water. May be either on-line where the outflow enters the natural stream network or off-line where the outflow enters the stormwater drainage system.
Detention Pond Dry	Dry ponds which temporarily store stormwater runoff to control the peak rate of discharge; these ponds are typically dry between storm events.
Aesthetic Pond	Artificial pond created for aesthetic purposes.
Other	
Does Not Apply	Natural Wetland.

3.6.2.2 Vegetation

The composition of the vegetation within the wetland is to be recorded according to the vegetation type and categories outlined in Table 32 and Table 33.

Table 32: Definition of overall vegetation type.

Pick List	Definition
Native	>80% native species.
Mixed	Between 20-80% of native or indigenous flora.
Exotic	>80% Exotic Species.
None	No vegetation present.

Table 33: Definition of wetland vegetation categories (Auckland Council)

Pick List	Definition
Swamp Forest	Dominated by forest species such as kahikatea, swamp maire, pukatea, cabbage tree.
Raupo Swamp	Dominated by Raupo.
Sedgeland and Rushlands	Dominated by a mix of genera such as *Carex, Juncus, Cyperus, Machaerina, Eleocharis*, and *Isolepis*.
Flax/Cabbage Tree Swamp	Dominated by flax. Often occurs with raupo, rushes, and sedges.
Manuka Shrubland Bogs	Dominated by manuka along with cabbage trees, karamu, tangle fern, *Sphagnum* moss, rushes and sedges etc.
Dune lakes	Often fringed with raupo.
Saltmarsh	Dominated by sea rush, oioi and saltmarsh ribbonwood.
Sea Meadows	Dominated by glasswort, remuremu, sea primrose and brass buttons.
Other	All wetlands dominated by exotic weeds, pasture or open water.

3.6.3 Notes

Any additional information on the wetland including infestations of exotic species should be recorded here as required.

3.7 Protocol seven: asset inspection (inlet/outlet)

All stormwater inlets and outlets interacting with the watercourse that have pipes or culverts ≥225 mm in internal diameter must be assessed during the survey. Information must also be collected for smaller outlets causing degradation of the waterway (such as erosion issues or presenting a barrier to fish passage) or pose a safety risk. Inlets and outlets, with pipes or culverts less than 225 mm in diameter that are not causing degradation of the waterway or pose a safety risk may be recorded as a miscellaneous point if a point of interest is desired to be captured. No more than five minutes should be spent searching for any given structure identified via stormwater and network asset GIS layers. Such features should be noted as 'Not Located' under the GIS record with no further information recorded.

Collect information on all of the attributes listed in this protocol for assets fitting the above definition within developed (urban) land including rural assets that intersect with key infrastructure (such as roads). For other rural assets, collect only Preliminary Information attributes (including Photographs, Asset id, GIS Record and Asset Type) unless there are significant issues of concern associated with a structure, such as fish passage barriers with suitable upstream habitat or outlets with moderate to severe erosion. If significant issues are present, complete the entire protocol.

Each pipe or culvert associated with an inlet/outlet structure is to be assessed as per Protocol Eight (Section 3.8). Fish passage issues may be associated with the inlet/outlet structure or with the associated pipe, or both. These are to be assessed separately under Protocols Seven and Eight respectively.

Depending on the asset type (Inlet Point, Outlet Point, Standard Inlet (Headwall and Wingwalls) or Standard Outlet (Headwall and Wingwalls)) different attributes may not apply. 'Does not apply' is available within the domains (pick lists) for these attributes. For numerical attributes (i.e. height of structure) '999' should be used where the attribute does not apply.

Attributes that do not apply for any asset type where there is no upstream habitat present are shown in Table 34.

Table 34: Attributes that do not apply for assets where there is no upstream habitat.

Attribute	Definition
Upstream Network Barrier	Does Not Apply
Drop Height (m)	999
Velocity	Does Not Apply
Turbulence	Does Not Apply
Gradient (deg)	999
Water Depth (m)	999
Fish Barrier Surface Type	Does Not Apply
Fish Passage Device	None
Low Flow Impedance	Does Not Apply
Barrier Impact	Does Not Apply
Barrier to Swimmers	Does Not Apply
Barrier to Climbers	Does Not Apply
Barrier to Anguilliforms	Does Not Apply

Attributes that do not apply for inlet and outlet points (no structure) are shown in Table 35.

Table 35: Attributes that do not apply for inlet and outlet points (no structure)

Attribute	Does Not Apply Value
Structure Material	None
Dissipating Structure	None**
Area (m2)	999**
Height (m)	999
Height Above Adjacent Channel (m)	999
Condition Rating	Does Not Apply**
Maintenance Type	Does Not Apply**
Flood Risk	Does Not Apply
Structure Safety	Does Not Apply
Upstream Network Barrier	Does Not Apply
Drop Height (m)	999**
Velocity	Does Not Apply**
Turbulence	Does Not Apply**
Gradient (deg)	999**
Water Depth (m)	999**
Fish Barrier Surface Type	Does Not Apply**
Fish Passage Device	None**
Low Flow Impedance	Does Not Apply**
Barrier Impact	Does Not Apply**
Barrier to Swimmers	Does Not Apply**
Barrier to Climbers	Does Not Apply**
Barrier to Anguilliforms	Does Not Apply**

** May apply if there is an apron or dissipating structure present

3.7.1 Preliminary Information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.7.1.1 Photographs

Clear photographs that record the structure and surrounds of the asset must be taken and attached to the feature. Any weeds obscuring the asset must be moved to allow the

condition of the asset to be assessed. The asset must occupy 40-70 per cent of the frame. Additional photographs may be taken to show important features.

3.7.1.2 Asset ID and GIS record

The Asset ID should be obtained from the Auckland Council GIS database. If there is no record in GIS the asset will be recorded as not in GIS and assigned a unique ID number (UNKxxx). Any other details of corrections to information in GIS are to be included in the notes section.

3.7.1.3 Asset type

Asset Type is to be recorded as per Table 36. Inlet and outlet points with no wingwall or headwall, but with an apron or dissipating structure present are to be recorded as inlet or outlet points (i.e. not standard inlet or outlet points).

Table 36: Definition of asset types

Pick List	Definition
Inlet Point	Inlet with no structure, (e.g. pipe or channel start point).
Outlet Point	Outlet with no structure (e.g. pipe or channel end point).
Standard Inlet (Headwall and Wingwalls)	Standard inlet at the start of gravity pipe, pond or channel comprised of wing wall and headwall structures.
Standard Outlet (Headwall and Wingwalls)	Standard outlet at the end of gravity pipe, pond or channel comprised of wing wall and headwall structures.

3.7.2 Physical variables

3.7.2.1 Material, and dissipating structure

Structure Material, and Dissipating Structure are to be recorded for each asset, using the categories in Table 37.

Table 37: Definition of dissipating structures

Pick List	Definition	Example
Apron	A widened, flat, armoured area located at the discharge point of an outlet.	
Concrete with Staggered Blocks	A flat concreted area with inset blocks for additional dissipation.	
Gabion Baskets	Rectangular wire mesh baskets filled with rock at the project site to form flexible, permeable, monolithic structures.	
Rock	Loose rocks placed around the outlet to reduce localised erosion.	

Pick List	Definition	Example
Reno Mattress	These are thinner mattress shaped versions of gabion baskets made with double twisted hexagonal mesh steel wire.	
Bubble Up Chamber	Open topped chamber.	

3.7.2.2 Area/Height

The overall area and height of any structure present is to be recorded in metres. The height of a structure is from the bottom to the top of any headwall or wingwall not including fences. See Figure 10.

The horizontal area of an inlet or outlet structure is to be measured (i.e. the footprint of the apron or dissipating structure).

For inlets and outlets points (without Headwall and/or Wingwalls) the height and area fields must be entered as '999'.

3.7.2.3 Height of structure above channel

The height of any inlet/outlet point is to be recorded in metres from the top of the structure (not including fences) to the channel bed. See Figure 10 for locations of measurements.

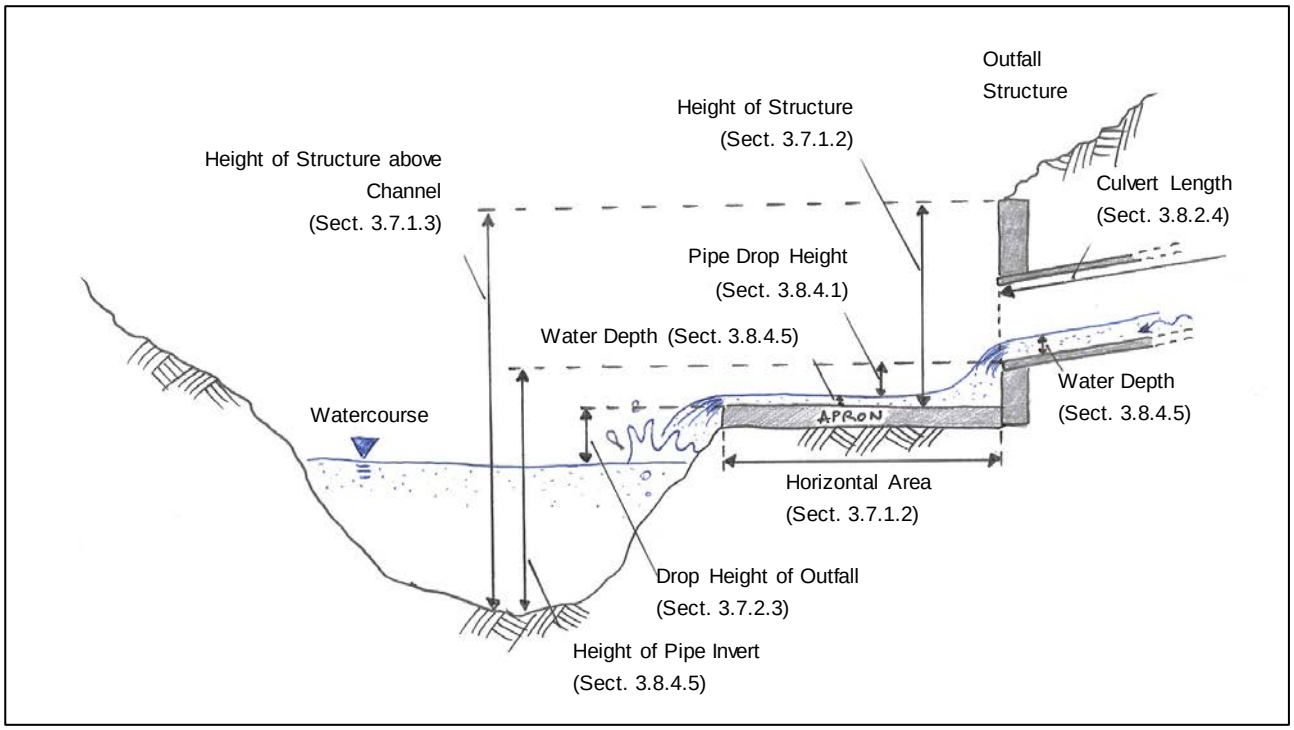


Figure 10: Example of measurements to be taken at inlet/outlet structures for Protocols 7 and 8.

3.7.2.4 Position

The position of the structure is to be recorded as either on the TLB, TRB, or in stream.

3.7.3 Asset assessment

3.7.3.1 Condition assessment

The overall condition of the asset must be assessed as according to Table 38.

Table 38: Definition of condition rating

Pick List	Definition
Very Good	Asset in new or near new condition. Sound physical condition. No action is required.
Good	Asset in acceptable physical condition. Some minor deterioration. Minimal short term failure risk.
Average	Asset has deterioration evident but is still functioning but is need or maintenance.
Poor	Asset is functioning poorly or not functioning due to damage or deterioration and should be maintained or replaced.
Very Poor	Asset has failed or is at risk of failure and/or poses a safety risk. Requires urgent attention.
Does Not Apply	Inlet /Outlet points with no Headwall, Wingwall, or Apron structure.

3.7.3.2 Type of maintenance required

The type of maintenance works required (if any) for the structure must be recorded. Enter 'Does Not Apply' for inlet and outlet points (without Headwall and/or Wingwalls, and/or Apron).

3.7.3.3 Erosion

Any erosion within five metres of the inlet/outlet location must be recorded according to Table 39.

Table 39: Definition of extent of erosion associated with outfall.

Pick List	Definition
None	No erosion.
Slight	Erosion at outfall or within two metres of the outfall. No erosion in receiving channel. Potential for ongoing erosion.
Moderate	Considerable erosion at outfall or within five metres. Erosion in receiving channel. Potential for ongoing erosion or structural damage.
Severe	Significant erosion at outfall or within five metres (such as structural collapse). Severe erosion along receiving channel. Likelihood of major ongoing erosion or structural collapse.

3.7.3.4 Flood risk

In stream inlets and outlets must be assessed to determine if there is an existing or potential risk of blockage causing flooding. This could, for example, be a result of excessive debris, erosion, or collapse. Flooding for this purpose is considered as flooding of habitable or non-habitable floors or flooding that will potentially cause damage to recreational land, such as sports fields and golf courses. Flooding that will potentially result in severe stream bank erosion is also considered here, along with flooding that will potentially cause damage to assets (both public and private). Flooding of flood plains which do not meet the above criteria are not considered here as a flood risk.

3.7.3.5 Sewage fungus

The presence of any sewage fungus in or on the structure must be recorded (see section 3.1.3.1 for more details).

3.7.3.6 Land and asset ownership

The location of the asset should be recorded as within council owned, other public (e.g. schools), or private land.

The ownership of the asset should also be recorded as council owned, public, private or unknown. This is to be informed by the Auckland Council underground services GIS layer either during the pre-survey desktop assessment or post-survey desktop assessment.

3.7.3.7 Safety

The overall extent of the hazard the structure poses to public safety must be assessed (Table 40) considering the location of the structure (public vs private land), the ease of access (Table 41) and whether or not the structure is fenced.

Table 40: Definition of overall structure safety

Pick List	Definition
Appears Safe	The structure appears to be safe.
Not Safe	The structure appears to be unsafe, i.e. pollution is evident, there is an unprotected drop of >1 m, fencing is deteriorating.
Not Safe – Drop 1.5 m	There is an unprotected drop from the structure of >1.5 m.
Not Certain	Unable to determine whether structure is safe or not.
Does Not Apply	Inlet /Outlet points with no Headwall, Wingwall, or Apron structure.

Table 41: Definition of access type

Pick List	Definition
Easy	Structure is accessible via direct pathway or other clear walking route close to public areas.
Moderate	Structure is accessible via minor trails or residential access ways.
Difficult	Structure is remote and/or access is difficult due to terrain or vegetation or access is fenced off.

3.7.5 Fish passage

Engineered structures in the watercourse may impact fish passage. Barriers may be formed at the time of installation or can develop as a result of erosion. Undercutting of artificial structures often leads to the free fall of water in the watercourse which may also isolate any wetted connection.

If there is no Upstream Habitat present and there is no possibility of future daylighting works then it is not necessary to assess the structure for fish passage.

3.7.5.1 Upstream habitat

Prioritisation of works to improve fish passage can be informed by knowledge of the suitability of upstream habitat.

3.7.5.2 Upstream network barriers

Upstream network barriers include features such as stepped manhole drops in a piped network and do not include other outlet barriers identified.

3.7.5.3 Drop height

The change in height of the water surface from the apron structure to the downstream base flow water level must be measured and recorded in metres. The drop height differs from the structure height in that it measures the height from the base flow water level to the apron, whereas, the structure height is measured from the channel bed to the top of the structure. See Figure 10.

3.7.5.4 Velocity

The velocity in and around the structure must be recorded according to Table 42. An educated estimate is to be made regarding average velocity (base flow). Actual velocity at the time of assessment will vary due to seasonal and weather variation.

Table 42: Definition of velocity categories (based on analysis in Stevenson and Baker 2009)

Pick List	Definition
Low	Average flow velocity 0-0.3 m/s.
High	Average flow velocity >0.3 m/s.
Very High	Average flow velocity >1.0 m/s.
Does Not Apply	No fish habitat exists upstream.

3.7.5.5 Turbulence

Surface water turbulence in and around the structure must be visually estimated as high or low (Table 43).

Table 43: Definition of turbulence categories

Pick List	Definition
Low	Surface water smooth to rippled and not broken.
High	Surface water is broken with white water.
Does Not Apply	No fish habitat exists upstream.

3.7.5.6 Gradient

The gradient of the fall across the inlet/outlet apron or dissipating structure must be measured using an inclinometer and recorded in degrees.

3.7.5.7 Water depth

The average water depth over the structure must be measured and recorded in metres. See Figure 10.

3.7.5.8 Device

The presence of any fish passage device must be recorded. Devices included baffles, ramps, roughened substrate, and spat ropes. Any other structures with potential to allow for fish passage should be recorded as such and described in the notes field.

3.7.5.9 Low flow impedance

During periods of low flow, the lack of flow over or through a structure may form a fish barrier. This feature is to be estimated for conditions less than base flow (summer or drought). If the entire reach is likely to have a low flow impedance not relating to the structure assessed then do not record a low flow impedance associated with the structure (record as 'Does Not Apply'). The focus is on fish passage barriers exacerbated by the structure.

3.7.5.10 Barrier impact

The permanence of the structure as a fish barrier must be recorded as per Table 44. The severity of the barrier may depend on the season, rainfall intensity, sedimentation, or other parameters.

Table 44: Definition of barrier impact categories

Pick List	Definition
Complete	Barrier is always present and completely impassable (could be a complete barrier to swimmers, or climbers, or all).
Partial	Barrier is always present and could be a barrier to swimmers, climbers, or all. However, the barrier is likely to only provide an impediment to some species within the class (swimmers, climbers etc.).
Temporary	Blocked by debris or sedimentation. Tidally submerged, or submerged under higher flows. A temporal low flow impedance.
None	There is no barrier.
Does Not Apply	No fish habitat exists upstream.

3.7.5.11 Barrier type

Based on the above attributes (summarised below in Table 45) the structure must be assessed for the extent of barrier impact to different locomotory classes of fish. The barrier impact to each of the locomotory classes is recorded as yes / no / does not apply.

Table 45: Definition of barrier impact categories (based on Boubee et al. 2000; Stevenson and Baker 2009).

Barrier to Locomotory Class	Definition	Example Species
Barrier to Swimmers	Average flow velocity >0.3 m/s. Water depth over/around structure is <5cm at base flow or there is a low flow impedance. Drop height of >7.5 cm. Lack of low velocity zones to rest. No suitable fish passage device.	Inanga
		Smelt
		Grey Mullet
		Common bullies
Barrier to Climbers	Overhanging and/or sharp edged structure with insufficient debris and roots or fish passage device to facilitate climbing. Lack of a continuous smooth wetted margin. Drop height >1 m. Culvert or ramp slope >40^{o}.	Lamprey
		Elvers
		Kokopu
		Koaro
		Redfin bullies
		Torrentfish
Barrier to Anguilliforms	No wetted margin present and barrier to climbers. Anguilliforms are able to travel over damp terrestrial areas for short distances if necessary.	Adult shortfin and longfin eels

3.7.6 Notes

Any additional information on the asset should be recorded here as required.

3.8 Protocol eight: asset inspection (pipes and culverts)

Each pipe or culvert with an internal diameter ≥225 mm which is associated with an inlet/outlet point interacting with the watercourse must be recorded. Information must also be collected for smaller pipes and culverts causing a barrier to fish passage or which pose a safety risk (erosion is recorded under Protocol Seven). Pipes and culverts less than 225 mm in diameter that are not causing a barrier to fish passage or which pose a safety risk may be recorded as a miscellaneous point if a point of interest is desired to be captured.

Collect information on all of the attributes listed in this protocol for assets fitting the above definition within developed (urban) land including rural assets that intersect with key infrastructure (such as roads). For other rural assets, only the Preliminary Information attributes (including Photographs, Asset id, GIS Record and Asset Type) are to be completed unless there are significant issues of concern associated with a structure, such as fish passage barriers with suitable upstream habitat. Similarly, only record Preliminary Information attributes (including Photographs, Asset id, GIS Record and Asset Type) for pipe leads from road side catch pits or similar, unless there are significant issues of concern associated with a structure.

Depending on the asset type (Pipe or Culvert) different attributes may not apply. 'Does not apply' is available within the domains (pick lists) for these attributes. For numerical attributes (i.e. height of structure) '999' should be used where the attribute does not apply.

Attributes that do not apply for pipes and culverts where there is no upstream habitat present are shown in Table 46.

Table 46: Attributes that do not apply for pipes and culverts with no upstream habitat present

Attribute	Does Not Apply Value
Upstream Network Barrier	Does Not Apply
Drop Height (m)	999
Velocity	Does Not Apply
Turbulence	Does Not Apply
Gradient (deg)	999
Water Depth (m)	999
Fish Barrier Surface Type	Does Not Apply
Fish Passage Device	None
Low Flow Impedance	Does Not Apply
Barrier Impact	Does Not Apply
Barrier to Swimmers	Does Not Apply
Barrier to Climbers	Does Not Apply
Barrier to Anguilliforms	Does Not Apply

Attributes that do not apply for Pipes are shown in Table 47.

Table 47: Attributes that do not apply for pipes.

Attribute	Does Not Apply Value
Piped Length (m)	999
Depth of Culvert in Stream Bed (m)	999
Bedload	Does Not Apply

3.8.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.8.1.1 Photographs

Clear photographs that record the structure and surrounds of the asset must be taken and attached to the feature. Any vegetation that obscures the asset must be removed to allow the condition of the asset to be assessed.

Additional photographs may be taken to show important features. Photographs of in stream culverts must show the crest height of the embankment over the culvert with an identifying marker at the crest level.

3.8.1.2 Asset ID and GIS record

The Asset ID should be obtained from the Auckland Council GIS database. If there is no record in GIS an asset will be recorded as not in GIS and assigned a unique ID number (UNKxxx). Any other corrections to information in GIS are to be included in the notes.

3.8.1.3 Asset type

The Asset Type is to be recorded for each structure as either a culvert or a pipe (Table 48).

Table 48: Definition of asset types

Pick List	Definition
Culvert	A 'pipe' crossing under a road, crossing, railway line or embankment which does not connect immediately to other stormwater network (open channel is present at both ends of the 'pipe').
Pipe	A 'pipe' that is connected to a wider stormwater network (the wider network is likely to contain manholes, risers and other pipe connections).

3.8.2 Physical variables

3.8.2.1 Shape

The shape of the culvert or pipe must be recorded.

3.8.2.2 Size

The internal diameter, or width and height (for non-circular pipes) must be recorded in metres. '999' is to be recorded for size attributes that do not apply.

3.8.2.3 Height of structure above channel

The height of the invert above the adjacent or downstream channel bed must be recorded in metres. See Figure 10. Record a value of '0' for culverts and pipes that are at or below the channel bed.

3.8.2.4 Culvert length

The length of culverts must be recorded in metres. A value of '999' must be recorded for lengths that are not measureable, this will include most piped lengths. Due to health and safety reasons access into the pipe is outside the scope of this assessment.

3.8.2.5 Material

The material of the pipe or culvert must be recorded as one of the options provided within the supplied geodatabase.

3.8.2.6 Position

The position of the structure is to be recorded as either on the TLB, TRB or in stream.

3.8.3 Asset assessment

3.8.3.1 Condition assessment

The overall condition must be assessed according to Table 49. The condition of pipes (c.f. culverts) refers to the condition of the asset at the inlet/outlet point (as far as can be seen). It is acknowledged that health and safety and access issues prevent a full assessment of pipe assets, and this is outside the scope of this assessment and is undertaken by the Auckland Council Asset Management Team.

Table 49: Definition of condition rating

Pick List	Definition
Very Good	Asset in new or near new condition. Sound physical condition. No action is required.
Good	Asset in acceptable physical condition. Some minor deterioration. Minimal short term failure risk.
Average	Asset has deterioration evident but is still functioning.
Poor	Asset is functioning poorly or not functioning due to damage or deterioration and should be maintained or replaced.
Very Poor	Asset has failed or is at risk of failure and/or poses a safety risk. Requires urgent attention.

3.8.3.2 Type of maintenance required

The type of maintenance works required (if any) for the structure must be recorded.

3.8.3.3 Flood risk

Pipes and culverts must be assessed to determine if there is an existing or potential risk of blockage causing flooding. This could, for example, be a result of excessive debris, erosion or collapse. Flooding for this purpose is considered as flooding of habitable or non-habitable floors or flooding that will potentially cause damage to recreational land, such as sports fields and golf courses. Flooding that will potentially result in severe stream bank erosion is also considered here, along with flooding that will potentially cause damage to assets (both public and private). Flooding of flood plains which do not meet the above criteria are not considered here as a flood risk.

3.8.3.4 Land and asset ownership

The location of the asset should be recorded as within council owned, other public (e.g. schools), private land, or mixed.

The ownership of the asset should be recorded as public, private or unknown.

3.8.3.5 Sewage fungus

The presence of any sewage fungus in or on the structure must be recorded, see Section 3.1.3.1 for further details.

3.8.4 Fish passage

Engineered structures in the watercourse may impact fish passage. Barriers may be formed at the time of installation or can develop as a result of erosion. Undercutting of artificial structures often leads to the free fall of water in the watercourse which may also lack a wetted connection. The extent of fish passage must be assessed for each culvert or pipe by consideration of the following variables.

If there is no Upstream Habitat present and no possibility of future daylighting works then it is not necessary to assess the structure for fish passage.

3.8.4.1 Drop height

The height from the culvert or pipe invert to the base flow water level must be measured and recorded in metres. If this value is less than 0 (if the culvert or pipe is installed below the bed of the stream) record this value as 0. The drop height differs from the structure height in that it measures the height from the base flow water level to the invert; whereas, the structure height is measured from the channel bed to the invert. See Figure 10.

3.8.4.2 Velocity

The velocity in and around the structure must be recorded according to Table 50. An educated estimate is to be made regarding average velocity (base flow). Actual velocity at the time of assessment will vary due to seasonal and weather variation.

Table 50: Definition of velocity categories

Pick List	Definition
Low	Average flow velocity 0-0.3 m/s.
High	Average flow velocity >0.3 m/s.
Very High	Average flow velocity >1.5 m/s.
Does Not Apply	No fish habitat exists upstream.

3.8.4.3 Turbulence

Surface water turbulence in and around the structure must be visually estimated as high or low (Table 51).

Table 51: Definition of turbulence categories

Pick List	Definition
Low	Surface water smooth to rippled and not broken.
High	Surface water is broken with white water.
Does Not Apply	No fish habitat exists upstream.

3.8.4.4 Gradient

The gradient of the culvert or pipe must be measured using an inclinometer and recorded in degrees.

3.8.4.5 Water depth

The average water depth within the culvert or pipe must be measured and recorded in metres. See Figure 10.

3.8.4.6 Device

The presence of any fish passage device must be recorded. Devices include baffles, ramps, roughened substrate, formed fish resting structures and spat ropes.

3.8.4.7 Low flow impedance

During periods of low flow, the lack of flow over or through a structure may form a fish barrier. This feature is to be estimated for conditions less than base flow (summer or drought). If the entire reach is likely to have a low flow impedance not relating to the structure assessed then do not record a low flow impedance associated with the structure (record as 'Does Not Apply). The focus is on fish passage barriers exacerbated by the structure.

3.8.4.8 Depth of culvert in stream bed

The depth of the culvert embededness in the stream bed is to be recorded in metres. Enter a value of '999' if this field is not applicable.

3.8.4.9 Culvert bed load

The extent of bed load present in the culvert is to be estimated in 5 per cent increments. Bed load refers to the accumulation of substrates (≥gravel) and organic debris that increases roughness or provides resting areas that assist fish passage. Enter a value of '999' if this field is not applicable.

3.8.4.10 Barrier impact

The permanence of the structure as a fish barrier must be recorded as per Table 52. The severity of the barrier may depend on the season, rainfall intensity, sedimentation, or other parameters.

Table 52: Definition of barrier impact categories

Pick List	Definition
Complete	Barrier is always present and completely impassable (could be a complete barrier to swimmers, or climbers, or all).
Partial	Barrier is always present and could be a barrier to swimmers, climbers, or all. However, the barrier is likely to only provide an impediment to some species within the class (swimmers, climber, etc.).
Temporary	Blocked by debris or sedimentation. Tidally submerged, or submerged under higher flows. A temporal low flow impedance.
None	There is no barrier.
Does Not Apply	No habitat exists upstream.

3.8.4.11 Barrier type

Based on the above attributes (summarised below in Table 53) the structure must be assessed for the extent of barrier impact to different locomotory classes of fish. The barrier impact to each of the locomotory classes is recorded as yes / no / does not apply.

Table 53: Definition of barrier impact categories (based on Boubee et al. 2000; Stevenson and Baker 2009).

Barrier Locomotory Class	Definition	Example Species
Barrier to Swimmers	Average flow velocity >0.3 m/s. Water depth over/around structure is <5cm at base flow or there is a low flow impedance. Drop height of >7.5 cm. Lack of low velocity zones to rest. No suitable fish passage device.	Inanga
		Smelt
		Grey Mullet
		Common bullies
Barrier to Climbers	Overhanging and/or sharp edged structure with insufficient debris and roots or fish passage device to facilitate climbing. Lack of a continuous smooth wetted margin. Drop height >1 m. Culvert or ramp slope >40^{o}.	Lamprey
		Elvers
		Kokopu
		Koaro
		Redfin bullies
		Torrentfish
Barrier to Anguilliforms	No wetted margin present and barrier to climbers. Anguilliforms are able to travel across damp terrestrial areas for short distances if necessary.	Adult shortfin and longfin eels

3.8.5 Notes

Any additional information on the asset should be recorded here as required.

3.9 Protocol nine: bank and channel lining

Each length of stream with bank and/or channel lining must be assessed. Where the length of bank lining extends further on one bank, complete this protocol for the extent of both banks and start a new polyline for the continuing section. To ensure TRB and TLB data is correctly recorded, it is important that each bank lining line is drawn from downstream to upstream.

3.9.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.9.1.1 Asset ID and GIS record

The Asset ID should be obtained from the Auckland Council GIS database. If there is no record in GIS an asset will be recorded as not in GIS and assigned a unique ID number. The ID number will be provided by the consultant in the format of 'UNKxxx' and be unique to the catchment.

3.9.1.2 Photographs

Representative photographs are to be taken of the structure showing the context and detail of the elements of interest.

3.9.2 Physical variables

3.9.2.1 Channel shape

The channel shape at the location of the channel and/or bank lining must be recorded as half round, rectangular, trapezoidal, V-shaped, or other. Other is to be recorded for natural channels where the lining does not dictate the channel shape.

3.9.2.2 Material

The lining material of the channel and banks must be recorded for both the TRB and TLB.

3.9.2.3 Height and length

The average height of the lining must be recorded in metres for the TRB and TLB.

The length of the section of channel/bank lining must be measured in metres. Where the length of the bank lining extends further on one bank than the other, record the length of the additional extension separately in a new polyline. The total length may be combined in post-processing.

3.9.2.4 Depth

The average water depth of the watercourse at the bank lining location must be measured in metres.

3.9.3 Lining assessment

3.9.3.1 Condition assessment

The overall condition of the bank and/or channel lining must be assessed as according to Table 54.

Table 54: Definition of condition rating

Pick List	Definition
Very Good	Lining in new or near new condition. Sound physical condition. No action is required.
Good	Lining in acceptable physical condition. Some minor deterioration. Minimal short term failure risk.
Average	Lining has deterioration evident but is still working.
Poor	Lining is functioning poorly or not functioning due to damage or deterioration and should be maintained or replaced.
Very Poor	Lining has failed or is at risk of failure and/or poses a safety risk. Requires urgent attention.

3.9.3.2 Impact on stormwater flows

The potential for the bank or channel lining to impede stormwater flows must be assessed as per Table 55.

Table 55: Definition of stormwater impact rating

Pick List	Definition
Critical	Impedance of flows leading to actual or potential flooding of habitable floors and/or flooding leading to the actual or potential damage to assets (both public and private) and/or severe stream bank erosion.
Significant	Impedance of flows leading to actual or potential flooding of non-habitable floors and/or recreational land such as sports fields and golf courses.
Not Significant	May impede flows but will not result in any notable issues or actual or potential flooding is likely to be confined to flood plains and not meet the criteria of 'significant' or 'critical'.
Does Not Apply	

3.9.3.3 Land ownership

The location of the asset should be recorded as within council owned, other public (e.g. schools), private land or mixed.

3.9.3.4 Safety

The overall extent of the hazard the structure poses to public safety must be assessed as per Table 56 and
Table 57.

Table 56: Definition of overall structure safety

Pick List	Definition
Appears Safe	The structure appears to be safe.
Not Safe	The structure appears to be unsafe.
Not Safe – Drop 1.5m	There is an unprotected drop from the structure of >1.5 m.
Not Certain	Unable to determine whether structure is safe or not.

Table 57: Definition of access type

Pick List	Definition
Easy	Structure is accessible via direct pathway or other clear walking route close to public areas.
Moderate	Structure is accessible via minor trails or residential access ways.
Difficult	Structure is remote and/or access is difficult due to terrain or vegetation. Or access is fenced off.

3.9.4 Notes

Any additional information on the bank lining should be recorded here as required.

3.10 Protocol ten: erosion hotspots

To ensure TRB and TLB data is correctly recorded, it is important that each erosion hotspot line is drawn from upstream to downstream.

An erosion hotspot is defined as:

- Severe erosion located within the channel and/or lower or upper banks resulting in slumping and/or exposed soil surfaces.
- The hotspot must also:
    - exceed two metres in length and/or have a total surface area of disturbed soil >5 m^2; and,
    - Be actively eroding; and,
    - Be detrimental to stream health and/or causing significant and/or immediate safety or infrastructure concerns.

3.10.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.10.1.1 Photographs

Representative photographs are to be taken of the hotspot showing the context of the location and added to the feature. Additional photographs may be taken to illustrate any details of significance to the criticality of the erosion.

The direction of the photograph should be recorded as upstream or downstream or, where this is not applicable, as points of the compass.

3.10.2 Physical variables

3.10.2.1 Channel shape

The channel shape at the erosion hotspot must be recorded as half round, rectangular, trapezoidal, or V-shaped. Other is to be recorded for natural channels where the lining does not dictate the channel shape.

3.10.2.2 Bank height

The average bank height along the erosion must be recorded in metres for the TRB and TLB.

It can be difficult to assess this where banks are not level or not clearly defined or delineated from the floodplain.

3.10.2.3 Length and area

The length of the hotspot must be measured and recorded in metres. The total area of the hotspot must be measured and recorded in m^2. Where both banks are affected by an erosion hotspot the total length/area over both banks is to be recorded.

3.10.2.4 Location

The location of the hotspot must be recorded as TRB, TLB, or both.

3.10.2.5 Pfankuch bank stability assessment

The Pfankuch Bank Stability assessment is a standard method for assessing bank and channel stability which has been adapted for New Zealand conditions to assess the upper banks only. The upper banks are defined as the area from the mean base flow water level to bankfull height.

Each parameter is to be assessed separately for the area immediately upstream and downstream of the erosion hotspot (10m in each direction).

The following criteria (Table 58) allow for the calculation of the overall stability index. The index is to be calculated by summing all scores. Reach scores of ≤13 = Excellent, 14-23 = Good, 24 -32 = Fair, ≥33 = Poor. These overall stability scores have been adapted from the Pfankuch methodology (Pfankuch, 1975).

Land slope

Table 58: Definition of bank gradient categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	Bank gradient <30^{o} on both banks.	2
Good	Bank gradient 30 - 35^{o} on 1 or sometimes both banks.	4
Fair	Bank gradient 35 - 50^{o} common on 1 or both banks.	6
Poor	Bank gradient >50^{o} common on 1 or both banks.	8

Mass wasting

This describes the extent of existing or potential detachment of large quantities of earth into waterways below via slumping or sliding. Definitions are in Table 59.

Table 59: Definition of mass wasting categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	No evidence of past or any potential for future mass wasting into channel.	3
Good	Infrequent and/or very small. Mostly healed over. Low future mass wasting potential.	6
Fair	Moderate frequency and size of mass wasting, with some raw spots eroded by water during high flow.	9
Poor	Frequent or large mass wasting, causing sediment nearly yearlong or imminent danger of this.	12

Debris jam

Debris jams are to be considered in terms of the likelihood of causing an impediment to flow (Table 60).

Table 60: Definition of debris categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	Essentially absent from immediate channel area.	2
Good	Present but mostly small twigs and limbs.	4
Fair	Present, volume and size both increasing.	6
Poor	Moderate heavy amounts, predominantly larger sizes.	8

Bank vegetation

Fine fibrous roots are good for binding sandy soils and fine gravels whilst a combination of fibrous roots and larger diameter roots are needed to stabilise clay – loam soils or steeper banks (Wilkinson 1999, Phillips *et al.* 2011). Deeper root mass is desirable for increasing geotechnical strength of banks (Simons 2015). Regenerating or mature native or exotic vegetation is to be considered for this attribute. Recently planted vegetation will not have an established root mass area. Extent of vegetation is categorised as per Table 61.

Table 61: Definition of bank vegetation categories. Scores provided are for the calculation of the overall stability index.

Pick List	Definition	Score
Excellent	>90% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass..	3
Good	70-90% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	6
Fair	50-70% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	9
Poor	<50% of the upper bank zone area is covered with vegetation that suggests a deep, dense, soil binding root mass.	12

3.10.3 Risk assessment

3.10.3.1 Building risk

The distance to the nearest building must be recorded and the risk posed by the erosion hotspot to the building must be indicated (Table 62). It is acknowledged that the risk assessment is indicative. Any risk identified would need more extensive specialist assessment outside the scope of this methodology.

Table 62: Definition of building risk

Pick List	Definition
Low	Only residual level of risk to building.
Moderate	Potential risk to building.
High	Severe and imminent risk to building.
None	No discernible risk to buildings.

3.10.3.2 Safety

The overall extent of the hazard the hotspot poses to public safety must be assessed (Table 63) with regard to the location of the hotspot and the ease of access (Table 64).

Table 63: Definition of safety risk

Pick List	Examples
Low	Low or no safety risk in terms of access and physical hazard.
Moderate	Reasonable to expect safety risk posed in terms of access and physical hazard.
High	High safety risk posed in terms of access and physical hazard.

Table 64: Definition of access type

Pick List	Definition
Easy	Hotspot is accessible via direct pathway or other clear walking route close to public areas.
Moderate	Hotspot is accessible via minor trails or residential access ways.
Difficult	Hotspot is remote and/or access is difficult due to terrain or vegetation or access is fenced off.

3.10.4 Notes

Any additional information on the erosion hotspot should be recorded here as required.

3.11 Protocol eleven: enhancement opportunities

EO are used to identify projects with the greatest potential benefit, with a preference for works that achieve multiple benefits including:

- Improving aquatic and terrestrial environments;
- Enhancing amenity and access for the community;
- Engaging and educating public about watercourse health; and,
- Maintaining or improving flood water conveyance.

EO should also be recorded for:

- Potential projects that will address significant issues (such as erosion hot spots with significant safety concerns); and,
- Public land suitable for community engagement and enhancement.

Sufficient details and notes should be recorded to enable a detailed description of the site including access, the current ecological state, and the objectives for the site.

EO can be opportunities for both community and council driven projects.

The collection of information under this protocol has been designed to provide important background information. They are a guide to focus more detailed study or to direct management actions which should be augmented with additional investigations and information before onsite activities begin.

3.11.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.11.1.1 Enhancement site ID

The EO is to be assigned a unique ID code.

3.11.1.2 Photographs

Representative photographs are to be taken of the enhancement opportunity showing the context of the location and attached to the feature. Additional photographs may be taken to illustrate any details of significance.

3.11.2 Enhancement type

EOs should be selected based on the fulfilment of multiple objectives. Up to four types of enhancement may be selected for each site, examples are in Table 65. If more than four types are applicable, choose the most applicable types.

Table 65: Examples of enhancement types and relevant supporting information that should be recorded.

Pick List	Definition	Notes
Amenity	Improvement of access or aesthetic values	Identify suggested location of access and view shafts to be retained.
Aquatic Weed Control	Direct removal of aquatic weeds for biosecurity or conveyance purposes.	Identify dominant species, area of infestation and any conveyance issues.
Community Engagement	Improvement of access, rubbish removal and prevention, educational activities, planting, weed control and maintenance.	Significance of area to community groups, evidence of previous involvement, nearby schools or groups of interest.
Daylighting	Daylighting piped sections of watercourses to connect open watercourses particularly where such works will significantly improve amenity or conveyance values.	Include length of potential daylighting and any potential constraints such as bank gradient, pipe depth, access etc.
Erosion Protection	Significant bank or channel erosion causing downstream issues or safety concerns.	Include length and severity of erosion.
Fencing/Stock Exclusion	Significant impacts of stock access affecting downstream watercourse or wetland areas.	Stock density, type of stock, upstream and downstream access, landowner commitment (trees for survival criteria).
Fish Barrier	Engineering structures requiring retrofitting or replacing for fish passage particularly if suitable habitat exists upstream.	Passage structure or design required.
Naturalising	Habitat improvements such as addition of coarse substrates or large organic debris. Channel and bank modification to remove lining and/or increase meander.	Include length of potential naturalising and any potential constraints such as access.

Pick List	Definition	Notes
Conveyance	Removal of debris jams, maintenance of structures that have failed or are at immediate risk of failure, modification of banks or channel.	Record size and type of debris jam and any access restrictions. Nature of structure failure. Length and type of channel modification etc.
Inanga Spawning	Areas of potentially suitable Inanga spawning habitat that are degraded due to stock access or mowing activities. Lack of suitable spawning vegetation.	Record the potential type of improvement to habitat and any restrictions on access.
Safety Improvement	Significant safety concerns in areas of high public use such as erosion of public walkways or hazardous litter (e.g. medical waste).	Type of safety concern and level of risk including urgency of response needed.
Erosion at outfalls and inlets	Significant and severe erosion with safety concerns and/or risk of asset failure including pipes.	Risk and implications of existing situation and potential for deterioration.
Weed Control	High quality riparian areas, maintenance of planting works, maintenance of public areas. Control required to protect or maintain functionality of infrastructure or engineering assets.	Identify weed species and estimate of area.
Weed Control and Riparian Planting	Completion of ecological corridors, capacity to increase width of riparian margin to 10-15m to allow for indigenous succession (lower ongoing maintenance).	Overview of current vegetation present and any weed issues. Identify planting unit type and stage taking into account the location of the site, aspect, slope, and hydrology. Types: Stream Edge/Flood, Wetland/Spring, Slope. Stage: Initial (coloniser, nursery), Enrichment (inter-planting under established shade and shelter) (TP148).

3.11.4 Stakeholders

Up to four types of relevant stakeholders may be selected for a particular site, if more than four stakeholders are applicable, choose the most applicable ones. These can include:

- Auckland Council – Stormwater;
- Auckland Council – Parks;
- Auckland Council – Environmental Services;
- Auckland Transport;
- Residents;
- Community Groups (Wai Care, churches etc.);
- Local Boards;
- Watercare;
- DoC;
- Iwi;
- Local Schools;
- NZTA.

3.11.5 Prioritisation of enhancement opportunities

All identified potential projects are to be scored in terms of the potential benefits to amenity, ecology, and conveyance.

The EO prioritisation framework is intended to provide a simple high level indication of benefit to amenity, ecology, and conveyance at a catchment level. This is an educated estimate but inherently subjective with a number of limitations.

3.11.5.1 Amenity values

Amenity values are defined by the RMA as those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes. Potential projects with high amenity values may include stream naturalising, planting works in public areas, improving access ways or community engagement.

3.11.5.2 Ecological values

Ecological values can include a range of concepts including protection of high value areas, high capacity for improvement of degraded areas, or increasing connectivity and biodiversity values. Biodiversity includes diversity of habitats as well as species. Potential projects with high ecological values may include weed control in a high quality area, stream daylighting, riparian planting to complete an ecological corridor, or improving fish passage to high quality upstream habitat.

3.11.5.3 Conveyance values

Conveyance values are of core importance to the stormwater unit. Effective conveyance through piped infrastructure associated with development needs to be accommodated as a part of stormwater. Potential projects with high conveyance values could include redesign or replacement of collapsed, poor quality or undersized assets, channel cross-section modifications, the strategic location of detention ponds or wetlands, or the removal of weeds or woody material such as large crack willows causing blockages and debris jams.

3.11.5.4 Prioritisation score

The scores for all three attributes are summed to provide an overall ranking of highest to lowest score (Table 66).

Table 66: Definition of potential benefit scores.

Pick List	Definition	Score
High	The potential project will significantly improve this value.	4
Moderate	The potential project will moderately improve this value.	3
Low	The potential project will have some benefit for this value.	2
None	The potential project with not confer any or minimal benefit to this value.	1

3.11.6 Notes

A description of the site and any additional information on the EO is to be recorded here to aid the detailed description of potential works.

3.12 Protocol twelve: miscellaneous features

Miscellaneous points are used to record less frequent occurrences.

3.12.1 Preliminary information

The Stream Name, Tributary Code, Consultant, Assessor and Date should all be completed as for the Eco Line Assessment.

3.12.1.1 Photographs

Representative photographs are to be taken of the miscellaneous item showing the context of the location and attached to the feature. Additional photographs may be taken to illustrate any details of significance.

3.12.2 Type

Miscellaneous points may include a variety of features such as access points, less common engineering structures (such as Flap Valves or SCADA), discharges, pollution/dumping, stormwater treatment devices, significant ecological features, pipe bridges, foot bridges or debris jams.

3.12.2.1 Impact on stormwater flows

For all points, the impact of the miscellaneous feature on stormwater flow and conveyance is to be recorded (Table 67).

Table 67: Definition of stormwater impact rating

Pick List	Definition
Critical	Impedance of flows leading to actual or potential flooding of habitable floors and/or flooding leading to the actual or potential damage to assets (both public and private) and/or severe stream bank erosion.
Significant	Impedance of flows leading to actual or potential flooding of non-habitable floors and/or recreational land such as sports fields and golf courses.
Not Significant	May impede flows but will not result in any notable issues or actual or potential flooding is likely to be confined to flood plains and not meet the criteria of 'significant' or 'critical'.
Not Applicable	

3.12.3 Notes

A description of the feature must be provided, noting any actions to be followed up as required.

4.0 Post Survey Desktop Assessment

4.1 Management zones

MZs are reaches with similar pressures and issues. The purpose of the MZs is to summarise key values, assessments, and recommended actions at a high level to guide unified management across the zone and the wider catchment. The purpose of this section is not to identify specific options which are encompassed by the EO section.

MZs are to be defined by considering the overall similarity across the reaches of the watercourse in terms of:

- Common pressures and issues;
- Morphology;
- Channel and bank modifications;
- Extent of erosion;
- The character of riparian vegetation; and,
- Any major structures such as roads dividing stream sections.

Management objectives should be designed to provide the following outcomes:

- Improved stormwater conveyance and capacity;
- Erosion reduction and mitigation;
- Improved aesthetics and amenity values; and,
- Implementation of enhancement opportunities.

4.2 Post reach assessment

4.2.1 Post-survey GIS assessment

Additional GIS survey can be performed following the field survey in order to complete attributes which were not feasible or practical to record within the field. Examples include:

- Adjacent Land Use – where the land use within 20m of the watercourse cannot be seen due to vegetation or fences obscuring the view this attribute may be completed using the most recent aerial photography.
- Riparian Width – where the lateral extent of the riparian vegetation cannot be visually estimated (i.e. the vegetation extends beyond the line of vision) this attribute may be completed using the most recent GIS vegetation layers.
- Tributary Codes – it may be more practical to populate the Tributary codes as a desktop GIS exercise following the field watercourse assessment (due to the sometimes large numbers of reaches and tributaries involved).

- Reach Length - Reach Length is more accurately completed as a desktop assessment post-survey and after quality assurance has been completed (once polyline locations have been confirmed).

4.2.2 Stream Ecological Valuations (SEVs)

Auckland Council will determine the need for and numbers of Stream Ecological Valuations required, and specify this in the RFP. Refer to Storey *et al.* 2011 and Neale *et al.* 2011 for the full SEV methodology. If SEVs are undertaken as part of the Watercourse Assessment then the geodatabase needs to be populated with the SEV results and other associated information.

The SEV results are to be populated within the SEV polyline feature of the geodatabase. The length of the SEV reach is to be represented by the polyline (typically 100 m).

The geodatabase contains the header rows to be populated. Enter preliminary Information (stream name, date, consultant and assessor) as per the Field Protocols. Also include a description of the first (downstream) transect location.

A unique code is to be given to the SEV using the format 'Catchment_01'; for example OTARA_01.

Auckland Council will also determine the need for any additional sampling including water clarity measurements, water sampling for *E. coli* and sediment heavy metal sampling to be undertaken at SEV locations. Refer to Appendix B Ancillary Protocols for sampling methods for additional variables. Appendix B

The following information, once calculated from the SEV calculator, must also be populated within the SEV polyline attribute table:

- MCI Method Used (soft-bottom or hard-bottom)
- Function Scores;
    - Natural Flow Regime
    - Floodplain Effectiveness
    - Connectivity for Species Migrations
    - Natural Connectivity to Groundwater
    - Water Temperature Control
    - Dissolved Oxygen Maintained
    - Organic Matter Input
    - Instream Particle Retention
    - Decontamination of pollutants
    - Fish Spawning Habitat
    - Habitat for Aquatic Fauna
    - Fish Fauna Intact
    - Invertebrate Fauna Intact
    - Riparian Vegetation Intact
- Mean Function scores and SEV score;
    - Hydraulic Mean Score
    - Biogeochemical Mean Score

    - Habitat Provision Mean Score
    - Biodiversity Mean Score
    - SEV Score
- MCI and IBI values;
    - MCI score
    - Number of Taxa
    - EPT
    - IBI Score
- Additional Variables (if collected);
    - Clarity test tube results
    - Zn (mg/kg dry wt)
    - Cu (mg/kg dry wt)
    - Pb (mg/kg dry wt)
    - *E. Coli* (cfu / 100mL)
- Notes

4.2.3 Fish database (NZFFDB)

Data from the New Zealand Freshwater Fish database (NZFFDB) is used in the map series produced as deliverables, as well as for calculating IBI scores if Stream Ecological Valuations are undertaken. This information should be downloaded from the NZFFDB. Appendix B provides guidance on how to update the NZFFDB using data collected as part of the field assessment. This is not a compulsory requirement.

4.2.4 Statistics

A number of simple statistics are required to be generated to complete summary tables within the Report Template including minimum, maximum, and mean numbers across the extent of watercourse surveyed. Refer to the Report Template for information requirements.

4.3 Data quality assurance

The Watercourse Assessment Geodatabase has been built to use pre-populated pick lists wherever possible. This is to ensure consistent user input with no errors and to exclude any values which are not relevant or correct.

Any fields that have a freeform entry are formatted to allow only relevant data to be entered into the attribute table, such as a length field which can only have a numeric, decimal value, or some fields which only allow integer values.

Once the data has been collected in the field, the operator can use analysis tools from ArcGIS online or download the data and use ArcGIS desktop for the Quality Assurance / Quality Control process. The key points for the Quality Assurance process are a visual check to see that all data is within the project area, comparing data associated to streams with available stream data to check for spatial integrity, ensuring photos are accurate and representative, and editing any freeform text attributes such as ‘Notes’ fields. The second level of Quality Assurance is to review the attribute tables and check for inconsistent data.

5.0 Deliverables

5.1 Reporting

Reporting requirements are outlined in the Watercourse Assessment Report Template.

Reporting includes a summary of relevant literature on the subject catchment, a synthesis of key data collected highlighting management concerns, and a summary of MZs and EOs.

5.2 Geodatabase

The Watercourse Assessment Geodatabase contains all feature classes (GIS layers) and domains (pick lists) required for the field survey. The geodatabase is compatible with ESRI brand products. The use of the ArcGIS online (and the Collector application with an iOS or Android device for the field survey) is recommended.

If using Collector, the Watercourse Assessment Geodatabase will be populated online in the ArcGIS Online workspace. The data being stored is accessible as work progresses and can be updated and reviewed through Collector, with a web browser or using ArcGIS desktop.

Once the data collection has been finished, the Geodatabase can remain online and be shared. For further work in the desktop environment, the database can be downloaded using ArcGIS online. The Geodatabase will be downloaded as a File Geodatabase, which will contain all photos and other attachments that have been created during the survey. It is advisable to download and keep the finished data in a secure location and clearly marked as the master and final database for a project.

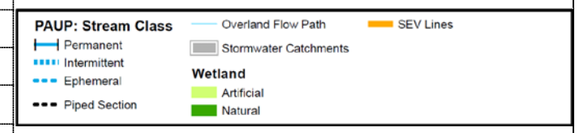
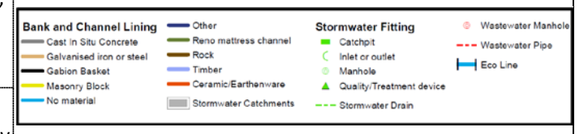
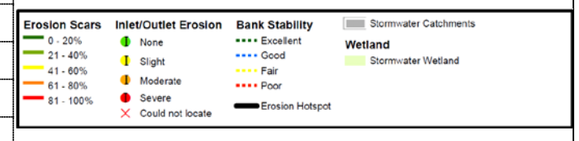
5.3 Mapping

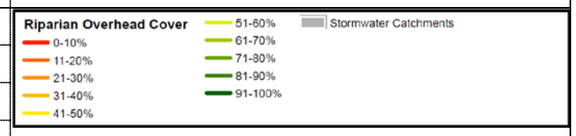
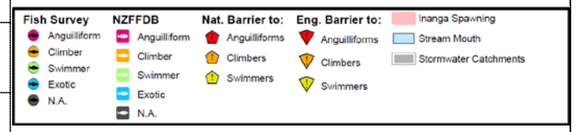
5.3.1 PDF mapping

A collection of PDF maps must be delivered at a 1:5000 scale for each of the map series outlined below. Where multiple maps are required to display the catchment at this scale, overview maps of the catchment for each map series must also be included at a scale appropriate to display the entire catchment (or survey area).

The 1:5000 scale maps are to be produced as a map book and delivered in digital format, so they can be viewed on a PC or printed at a later time if required.

Depending on the size of the catchment, one or two maps should be provided for each map series and are to be printed and attached to the report.

Series #	Map Name	Data to be Displayed	Data Source	Notes	Legend Format
1	**Overview Map**	Eco Line	Watercourse Assessment	Classified: Permanent, Intermittent, Ephemeral (requires limitation on use included in notes)	
		Wetlands	Watercourse Assessment	Classified by Natural, Artificial	
		Overland Flow Path	Auckland Council		
		Catchment Boundary	Auckland Council		
		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	
		Stream Names and Trib Codes	Watercourse Assessment		
		SEV Survey Locations	Watercourse Assessment	SEV lines	
2	**Catchment Land use**	Eco Line	Watercourse Assessment		
		Catchment Boundary	Auckland Council		
		Parks and Reserves	Auckland Council		
		Property Boundaries	Auckland Council		
		Street Names	Auckland Council		
		Land use/Zoning	Auckland Council - PAUP	Classified: Residential, Business, Public Open Space, Rural, New Growth	
3	**Bank and Channel Modification Type and Extent**	Eco Line	Watercourse Assessment		
		Bank Lining	Watercourse Assessment	Classified by Left Bank Modification Type: Cast In Situ Concrete, Gabion Basket, Reno Mattress, Rock, Galvanised iron or steel, Timber, Ceramic/Earthenware, Masonry Block, Natural State, Other, None	
		Bank Lining	Watercourse Assessment	Classified by Right Bank Modification Type: Cast In Situ Concrete, Gabion Basket, Reno Mattress, Rock, Galvanised iron or steel, Timber, Ceramic/Earthenware, Masonry Block, Natural State, Other, None	
		Bank Lining	Watercourse Assessment	Classified by Base Lining Type: Cast In Situ Concrete, Gabion Basket, Reno Mattress, Rock, Galvanised iron or steel, Timber, Ceramic/Earthenware, Masonry Block, Mass Stabilised Earth, Natural State, Other, None	
		Catchment Boundary	Auckland Council		
		Catchpit	Auckland Council		
		Inlet/Outlet	Auckland Council		
		Manhole	Auckland Council	Classified: Stormwater, Wastewater	
		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	
4	**Engineering Asset Locations, Stream Bank and Outfall Erosion**	Eco Line	Watercourse Assessment	Classified by Right Bank Erosion: 0-20%, 20-40%, 40-60% …	
		Eco Line	Watercourse Assessment	Classified by Left Bank Erosion: 0-20%, 20-40%, 40-60%, …	
		Eco Line	Watercourse Assessment	Overall Bank Stability: Excellent, Good, Fair, Poor	
		Engineering Point	Watercourse Assessment	Classified by Inlet/Outlet Erosion: None, Slight, Moderate, Severe	
		Erosion Hotspot	Watercourse Assessment	Erosion Hotspots	
		Treatment Device	Auckland Council		
		Wetland	Watercourse Assessment	Artificial – Detention Pond Wet, Dry and Constructed Wetlands only	
		Catchment Boundary	Auckland Council		
		Engineering Asset IDs	Watercourse Assessment	Only include IDs for structures recorded as moderate of severe erosion	
		Trib Codes	Watercourse Assessment	Only include trib codes for reaches with >41% bank erosion (either bank) or 'poor' overall stability score or 'erosion hotspots'	

		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	
5	**Riparian Overhead Cover**	Eco Line	Watercourse Assessment	Classified by Riparian Overhead Cover: 10% increments	
		Catchment Boundary	Auckland Council		
		Trib Codes	Watercourse Assessment	Only for Tributaries with overhead cover <60%	
		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	
6	**Inanga Spawning, Fish Locations and Potential Barriers to Fish Passage**	Natural Barriers	Watercourse Assessment	Classified by barrier type - Swimmers, Climbers, Anguilliforms Do not display natural structures which are not a barrier to fish passage.	
		Engineering Barriers	Watercourse Assessment	Inlets, Outlets, Pipes, and Culverts. Classified by barrier type - Swimmers, Climbers, Anguilliforms. Do not display engineering structures which are not a barrier to fish passage.	
		Engineering Asset IDs	Watercourse Assessment		
		Fish	Watercourse Assessment and NZFFDB	Classified by Fish Species Locomotory Type Swimmers, Climbers, Anguilliforms, Exotic. Only include NZFFDB records that are less than 5 years old.	
		Eco Line	Watercourse Assessment	Classified by Right Bank Vegetation Development Mature, Regenerating, Scrub, Low growing, Planted, Grasses	
		Eco Line	Watercourse Assessment	Classified by Left Bank Vegetation Development: Mature, Regenerating, Scrub, Low growing, Planted, Grasses	
		Inanga Spawning Habitat	Watercourse Assessment		
		Stream Mouth	Watercourse Assessment		
		Catchment Boundary	Auckland Council		
		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	
7	**Management Zones and Enhancement Opportunities**	Eco Line	Watercourse Assessment		
		Enhancement Opportunities	Watercourse Assessment	Enhancement Site ID	
		Management Zones		Management Zone ID	
		Catchment Boundary	Auckland Council		
		Public Open Space	Auckland Council - PAUP		
		Historic Heritage	Auckland Council - PAUP	Historic Heritage Place, Sites and Places of Significance/ Value to Mana Whenua	
		Natural Heritage	Auckland Council - PAUP	Notable Trees, Outstanding natural features, outstanding natural landscape, coastal natural character areas	
		Natural Resource	Auckland Council - PAUP	Significant Ecological Areas	
		Property Boundaries	Auckland Council		
		Street Names	Auckland Council		
		Significant Archaeological Sites			
		Misc Points	Watercourse Assessment	Relevant Misc points e.g. unmarked tributaries, pollution, etc.	
		Aerial Photography	Auckland Council	A transparency of 30-40% can assist in the visibility of other map features	

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Appendix A Relevant policies and plans

Plans and policies change over time. The below is a snapshot of those relevant at the time of publishing.

Resource Management Act 1991 (RMA)

The RMA is the overarching act which informs and directs the National Policy Statement for Freshwater Management (Freshwater NPS), the Auckland Council Regional Plan: Air, Land and Water (ALW Plan) and the Proposed Auckland Unitary Plan (PAUP).
The purpose of the RMA is to promote sustainable management of natural and physical resources. This is achieved by managing the use of our resources, in a manner that allows for people and communities to provide for their social, economic, environmental and cultural wellbeing, while sustaining the natural and physical resources to meet the needs of future generations. This is achieved by safeguarding the life supporting capacity of air, water, soil and ecosystems; while avoiding, remedying and mitigating adverse effects of activities on the environment.
In relation to watercourse management the RMA deals with:

- The need to sustainably manage our water resources for the future generations;
- The need to preserve the natural character of all our water bodies (coastal, wetlands, lakes, rivers and their margins);
- The need to enhance the natural and physical resources;
- The control of land use for the purpose of maintenance and enhancement of the quality of water in water bodies and coastal areas;
- The control of discharge of contaminants and water into our water bodies;
- The control of taking, damming and or diverting the water in our water bodies.

National Policy Statement for Freshwater Management (NPS)

The National Policy Statement for Freshwater Management 2014 (which includes amendments to the NPSFW 2001) took effect on 1st August 2014. The purpose of the policy statement is to set enforceable quality and quantity limits. The National Policy Statement sets out the objectives and policies for freshwater management under the Resource Management Act 1991 (RMA). The policy statement directs local government to manage water in an integrated and sustainable way, while providing for economic growth within set water quantity and quality limits. Water quality and water quantity provisions set out in the Freshwater NPS are implemented through the ALW plan while other provisions will be implemented through the PAUP. The policy statement sets national objectives around water quality, water quantity, integrated management and Tāngata whenua roles and responsibilities.

The integrated management objectives include an objective whereby all regional councils should identify freshwater management units that include all freshwater bodies within its region. Both the ALW Plan and PAUP identify freshwater management units.

The policy statement also sets national bottom lines for two compulsory values – ecosystem health and human health for recreation – and minimum acceptable states for other national values.

Section A, Objective 2 of the NPS states that the overall quality of fresh water within a region is maintained or improved while:

- protecting the quality of outstanding freshwater bodies;
- protecting the significant values of wetlands; and,
- improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated.

The Auckland Plan

The Auckland Plan was adopted by the council in March 2012 and provides strategic direction to achieve the shared vision of becoming the world's most liveable city. The plan tackles a number of issues, including protection of the environment, with specific targets that relate to streams:

- ensure no regional extinctions of indigenous species and a reduction in the number of 'threatened' or 'at risk' species from 2010 levels by 50 per cent by 2040;
- ensure no loss in the area of significant landscape, natural character and natural features; and,
- reduce the overall yield of suspended sediment to priority marine receiving environments from 2012 levels by 15 per cent by 2040.

Proposed Auckland Unitary Plan (PAUP)

Once operative the PAUP will replace the existing Regional Policy Statement and 13 district and regional plans. It is the primary document through which the council will meet its obligations under the Resource Management Act while delivering the vision of the Auckland Plan which provides strategic directions for Auckland's future for the next 30 years.

The PAUP sets out the issues, objectives, policies and rules that apply to the Auckland region and provide a framework for what activities are permitted within the region. One of the concerns of the Unitary Plan is to protect the life-supporting capacity of air, water, soil, and ecosystems in Auckland. The Unitary Plan also recognises that some of these resources have already been degraded and seeks their restoration and enhancement.

Similar to the ALW Plan the PAUP identifies management areas relevant to freshwater, these are:

- Wetland Management Areas;
- Natural Lake Management Areas;
- Natural Stream Management Areas;
- Water Supply Management Areas;
- Stormwater Management Areas;
- Urban Lake Management Areas;
- High Use Stream Management Areas;
- High Use Aquifer Management Areas;
- Quality Sensitive Aquifer Management Areas.

Urban River and Stream Management Areas have been replaced by Stormwater Management Areas. Within the PAUP the Stormwater Management Areas seeks to protect and enhance Auckland's rivers, streams and aquatic biodiversity in urban areas.

Part 2 (Regional and district objectives and policies) Section 5.14 (Lakes, rivers, streams and wetland management) of the PAUP outlines the following general objectives:

- Auckland's lakes, rivers, streams and wetlands with high natural values are protected from degradation and permanent loss;
- Auckland's lakes, rivers, streams and wetlands are restored, maintained and enhanced;
- adverse effects on lakes, rivers, streams or wetlands that cannot be avoided, remedied or mitigated are offset in exceptional circumstances, where this will better promote the purpose of the RMA;
- structures in, on, under or over the bed of a lake, river, stream and wetland occur where there is a need for the structure to be in that location as opposed to on the land or it is necessary to provide access across a river or stream;
- activities in, on, under or over the bed of a lake, river, stream and wetland are managed to minimise adverse effects on the lake, river, stream or wetland; and,
- reclamation and drainage of the bed of a lake, river, stream or wetland is avoided.

More specific objectives and policies associated with the different management areas are also outlined within the PAUP. For example Part 2 (Regional and district objectives and policies) Section 7.5 (Stormwater Management Areas- Flow) outlines the following objective specific to this management area:

High-value rivers, streams and aquatic biodiversity in identified catchments are protected from the adverse effects of stormwater runoff associated with urban development and where possible enhanced.

Auckland Council Regional Plan: Air, Land, and Water (ALWP)

The Auckland Council Regional Plan: Air, Land and Water (ALWP) was prepared by the Auckland Regional Council to assist in carrying out its functions in order to achieve the purpose of the Resource Management Act 1991 (RMA) namely to promote the sustainable management of natural and physical resources within the Auckland Region. This is achieved through outlining issues, objectives, policies and rules. The Plan is now maintained and administered by the Auckland Council. The plan was made fully operative on the 30th September 2013. The ALWP assists in enabling Auckland Council to fulfil obligations under the RMA.

Section 3 of the ALWP sets out management objectives for urban streams and rivers to maintain high values and enhance degraded values in terms of in-stream, amenity, natural character, and public access values; to recognise the essential function of urban rivers in streams for conveyance of stormwater; and to provide for appropriate use and development of rivers and streams for existing and future growth in urban areas. Where practicable, management should also:

- avoid adverse effects on urban areas with high in-stream values;
- maintain and enhance public access, natural character, and amenity values, fish passage, and riparian vegetation;
- avoid, remedy or mitigate adverse effects of erosion; and,
- minimise modification of stream beds and banks.

The ALWP identifies management areas along with management approaches for the areas. The management areas that are relevant to freshwater resources are:

- Wetland Management Areas;
- Natural Lake Management Areas;
- Natural Stream Management Areas;
- Water Supply Management Areas;
- Urban River and Stream Management Areas (which are further defined as);
    - Stream Mouths – and Tidal reaches of Urban Rivers and Streams
    - High Value Low Disturbance Urban Rivers and Streams
    - Moderately Disturbed Urban Rivers and Streams
    - Highly Disturbed Urban Rivers and Streams
    - Artificial or Concrete Channelised Urban Rivers and Streams
    - Piped Urban Rivers and Streams
- Urban Lake Management Areas;
- High Use Stream Management Areas;
- High Use Aquifer Management Areas;
- Quality Sensitive Aquifer Management Areas.

Auckland Council Regional Policy Statement (ACRPS)

The Auckland Council Regional Policy Statement (ACRPS) promotes the sustainable management of the natural and physical resources of the Auckland region. The ACRPS clarifies the roles of the agencies with responsibilities under the Resource Management Act 1991 (RMA) in the region. The ACRPS became operative on 31 August 1999 and a review was undertaken in 2008.

The ACRPS aims to achieve integrated, consistent and co-ordinated management of the regions resources as well as provide greater certainty over the ways that natural and physical resources are managed. Therefore, this statement will create an awareness of the constraints and opportunities in the Auckland Region.

The statement acknowledges that maintaining and enhancing water quality requires a comprehensive integrated approach to its management. Section 8.4.5.2 states the methods for achieving this which includes the development of the Catchment Management Plan (CMP).

Auckland Council Biodiversity Strategy

The Biodiversity Strategy (2012) applies to indigenous biodiversity on both public and private land, including people's backyards in urban areas, parks and schools, farms, industrial sites, and roadsides. It includes aquatic and terrestrial biodiversity from forests, scrubland, streams, wetlands, estuaries, coastal, intertidal, island and marine biodiversity; particular regard is given to species and ecosystems that are unique to Auckland. Objectives of the strategy are to:

- Conserve the greatest number and most diverse range of Auckland's indigenous ecosystems and sequences;
- Achieve long-term recovery of the greatest number of threatened species whose range includes the Auckland region;
- Maintain and enhance the goods and services provided by our natural environment in a way that supports indigenous biodiversity;
- Sustain and protect the mauri of natural and physical resources in ways which provide for wellbeing of Maori; and,
- To improve the knowledge and understanding of biodiversity in the region for management and community partnership.

Auckland Council Stormwater Asset Management Plan 2015 – 2045

The Asset Management Plan 2015-2045, sets out the proposed investment on improving customer and environmental levels of service, supporting growth of the city and ensuring

the stormwater system is maintained in a manner that aligns with the council's vision of creating the world's most liveable city.

It focusses on the management of Auckland stormwater assets both natural and built:

- Within the challenges of climate change and global warming,
- With a significant shift to water sensitive design of stormwater infrastructure,
- Prioritising the opportunities to develop innovative solutions in growth areas,
- Starting to reflect an integrated approach to the management of water supply, stormwater and wastewater,
- Recognising the need for collaboration with multiple stakeholders, and
- With a strong commitment to community engagement and education.

The Auckland Council Stormwater Unit plays a vital role across both the whole of Auckland Council (including Council Controlled Organisations) and externally with the many parties that have ownership and other interests in stormwater management, to ensure that good stormwater outcomes are achieved.

Auckland Councils stormwater priorities (in order of priority) are:

- Asset operation/renewals: effective operation, maintenance and renewal of the assets we already have to ensure optimum performance;
- Growth: supporting and servicing the Auckland Plan's growth strategy demonstrating innovation and best practice;
- Flooding: progressively reducing existing flood risk across the region; and
- Environmental Improvement: reducing existing negative effects on the environment, particularly streams and coastal areas.

The Asset Management Plan has been developed in conjunction with the council Long-term Plan and the Auckland Plan.

Appendix B Ancillary protocols

Stream Ecological Valuation (SEV) protocol

Site Selection

The Stream Ecological Valuation (SEV) is based on 14 hydraulic, biogeochemical, habitat provision, and biodiversity functions. The full methodology and supporting information can be found in Storey *et al.* 2011 and the accompanying illustrated user's guide (Neale *et al.* 2011).

There is no standard number of SEVs to be completed for each watercourse or per length of stream. The number of sites selected will be catchment specific taking into consideration the general guidelines outlined below. It is also vital to consider site access issues and any other health a safety issues when selecting a site.

- Representative

  The most important consideration when selecting SEV locations is that they are representative of the wider catchment or survey area. This will require consideration of major land use or catchment vegetation cover changes, major changes in stream geomorphology, or other significant differences in pressures affecting the watercourses within the region.

- High priority enhancement opportunity sites

  If SEVs are conducted after the main Watercourse Assessment survey then any high priority enhancement opportunity sites are suggested as priorities for SEV locations.

- Future development

  Future urban and/or special housing areas designated under the PAUP are recommended as priorities for SEV locations to improve understanding of watercourses within these areas to inform planning for future development.

- Electrofishing / trapping required

  If the NZFFDB has no information recorded that is less than 5 years old within the length of watercourse (tributary scale) selected for SEV then electrofishing or trapping must also be performed.

- Consider previous SEV locations

  Repeat visits are encouraged to improve understanding of changes in a stream reach over time.

Additional variables

A number of additional variables are to be assessed at SEV sites including:

Clarity Tube Test

Water is collected to undertake a visual clarity test using a 1m long water clarity tube. The visual clarity measured as represented by the distance before the black disk disappears from view must be recorded. The procedure must not be undertaken in direct sunlight.

Sediment chemistry

Sediment samples are to be collected from each SEV location for metal and polyaromatic hydrocarbons (PAH) analysis.

One composite sample of multiple grabs of sediment is to be collected using a plastic scoop for the top 10-20mm of sediment (targeting finer sediments).

Samples are to be analysed for:

- Total recoverable zinc (Zn), copper (Cu), lead (Pb);
- Total PAH.

E. coli

Water samples are to be collected from each SEV location for microbiological tests. The sample bottle should be pre-sterilised, wide-mouthed, and at least 200 mL capacity.

It is critical when monitoring bacteria that all containers and surfaces that the sample comes into contact with are sterile. Samples should be taken away from the stream bank in the main current, facing upstream. Hold the sample container at the base and plunge it, open downward below the water surface, turn the container underwater into the current and away from you. Leave an air space; do not fill the container completely. Do not sample stagnant water, and avoid disturbing stream bed sediments.

Samples must be kept cool (<8 ^{o}C) but not frozen and sent for analysis as promptly as possible (ideally within 24 hours).

Pollution Response Protocol

If you discover a pollution event follow these steps:

1. Record the location (as a Miscellaneous Point)
2. Photograph the extent of the pollution event (and attach to the Miscellaneous Point).
3. Call the Auckland Council Pollution Hotline on **09 377 3107**
4. If you see oil on the sea during the stream mouth assessment, call the Harbourmaster on **09 362 0397 (ext. 0)**
5. For sewage overflows or faults with water supply, call Watercare Services on **09 442 2222**
6. Inform the Auckland Council Project Manager and provide details of the pollution, location, photos and any reference number provided from the pollution hotline, harbourmaster or Watercare Services.

Biosecurity Protocol

If you discover a weed or pest of significance i.e. occurrence of a 'Containment' species outside of the known area of distribution, or the occurrence of any 'Total Control' species (ARC RPMS) or any of the National Interest pests identified in Table 68 follow these steps:

1. Record the location (as a Miscellaneous Point)
2. Photograph the extent of weed infestation, details of growth form and other distinguishing features (and attach to the Miscellaneous Point).
3. Take a sample of the weed – specimens should include enough of the stem and underground parts to show the habit of the plant and preferentially include flowers and or fruits. Store this in a plastic bag and keep cool. Refer to http://www.landcareresearch.co.nz/resources/identification/plants/weeds-key for the identification of weeds in NZ.
4. Call the Biosecurity New Zealand hotline on **0800 80 99 66**
5. Call the Auckland Council Biosecurity team on **09 301 0101**
6. Inform the Auckland Council Project Manager and provide details of the species, location, photos and any reference number or contact person provided from Biosecurity New Zealand

Identification of plants on the National Pest Plant Accord should be confirmed with an MPI recommended identification provider (within 2 days of plant collection).

Ewen Cameron
Herbarium: Auckland War Memorial Museum
The Auckland Domain
Parnell
Private Bag 92018

Table 68: NIPR notifiable and unwanted organisms that are likely to be found within the Auckland Region. Information and figures from MPI Biosecurity New Zealand.

Species	Definition	Photo
Kariba Weed *Salvinia molesta*	Perennial aquatic fern. Forms floating mats on still waters and swamps. Brown-green leaves up to 4cm long folded across the midrib. Upper surfaces covered in hydrophobic hairs. Fine submerged root like structures hang down into the water, often with chains of small round spore-bearing organs. Young plants have small, pale green leaves that lie flat on the surface.	
Water Hyacinth *Eichhornia crassipes*	Free floating rosette of shiny rounded leaves with thick masses of feathery roots which hang in the water. Roots are dark in colour up to 2.5m in length. A single flowering stalk with a cluster of mauve-blue flowers, each with a yellow spot is produced from the rosette. The stalk grows up to 50cm above the leaf canopy. Mature mats are held together by floating horizontal stems.	
Johnson grass *Sorghum halepense*	Robust, aggressive perennial summer grass capable of forming dense thickets that exclude other plants. Seedlings are similar to young maize plants. Mature plants vary from 500-3000mm in height. Leaf blades are flat, alternate up to 900mm long and 20-50mm wide. The midrib on the underside is whitish. Leaf sheaths are ribbed and often hairy on the inside of the junction with the blade. Flowers are large and loosely branched, purplish and hairy. Seeds are reddish brown and up to 6mm long. It has woody rhizomes.	

Species	Definition	Photo
Cape Tulip *Moraea flaccida*	Perennial herb that produced shoots annually in winter and dies back in early summer. Plants grow to 90cm tall consisting of a single strap-like leaf, curled downwards at the edges and branched flower stalk. Flowers are 6 petalled, usually salmon pink with deeper colour at the base of the petals. May or may not have a yellow centre. Flowers are usually 5cm across. Seeds are produced in narrow, green capsules.	
Rainbow lorikeet *Trichoglossus haematodus*	Rainbow lorikeets look similar to the Eastern Rosella. They can be distinguished by their blue heads. **Report to DOC on 09 445 9142 NOT Biosecurity NZ**	
Manchurian wild rice *Zizania latifolia*	Tall rhizome producing perennial grass that grows up to 3m tall. Harsh, erect, dull grey-green leaves 2-3cm wide, up to 2.5m long. Leaves have a stout midrib and taper to a point. Flower head is 40-60cm long, purplish to red-brown. Flowering from Nov to Dec. Remains green over winter unlike raupo. Raupo also has shorter leaves which twist upwards with no midrib. **Report to Auckland Council NOT Biosecurity NZ**	

NZFFDB Protocol

The data collected during the Watercourse Assessment can also be used to inform the NZ Freshwater Fish Database.

The form includes the following variables which are linked to sections of various protocols as outlined below. A separate form is required for each fish point collected.

Preliminary Information

Date, time, observer, organisation can be obtained from Protocol 3 Section 3.3.1

Altitude, inland distance, and map coordinates can be obtained from desktop assessment post survey.

Habitat Data

The following information (Table 69) can be obtained from the nearest Ecoline associated with the fish point.

Table 69: Location of data for entering NZFFDB details

Habitat Data	Protocol and Section
Average Width and Depth	Physical Factors 3.1.2.2
Maximum Depth	Physical Factors 3.1.2.3
Habitat Type (%)	Habitat Heterogeneity 3.1.4.5
Substrate Type (%)	Physical Factors 3.1.2.6 Concrete lined channels can be recorded as bedrock for this protocol.
Fish Cover	Biological variables 3.1.4.3
Riparian Vegetation	Riparian Vegetation variables 3.1.4.3
Type of River/Stream/Lake	
Water level	This may be estimated based on 3.1.2.3 and seasonal cues.
Permanent water	Physical Factors 3.1.2

Catchment vegetation, the presence of barriers to fish passage recorded at natural and engineering assets downstream of the fish point can be assessed, and any pollution Miscellaneous points recorded upstream of the fish survey point may be determined from desktop assessment post processing.

Water colour, clarity, temperature, pH and conductivity are not recorded as part of this methodology.

Large invertebrate fauna present will typically be ‘unknown’.

Small benthic invertebrate fauna will be ‘unknown’.

Fish Data

Species, life stage, abundance and length can all be taken directly from each Protocol 3 Fish Survey completed.