Stream Ecological Valuation: Application to Intermittent Streams

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Stream Ecological Valuation: Application to Intermittent Streams

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Executive summary

There is an increasing body of evidence on the importance of intermittently flowing streams, including their biological values and influences on downstream reaches. Within the Auckland region, the Stream Ecological Valuation (SEV) has been the primary tool used for assessing and determining management actions for permanent streams. The potential application of the SEV to intermittent streams has been conceptually considered, but there has not been an empirical test of the SEV in intermittent streams. Consequently, Golder Associates (NZ) Limited was commissioned by Auckland Council to test the SEV method in intermittent streams.

Between September and November 2015, 25 intermittent stream sites were selected throughout the Auckland region in four land use types (10 in native forest, three in exotic forest, seven rural and five urban). The SEV method was applied to 50 metre reaches of streams that met the intermittent stream definition as defined for the PAUP. SEV scores were calculated using the SEV calculator, with intermittent stream reference data included for the five variable scores that require reference data from the same stream type.

Macroinvertebrates were sampled and processed according to standard New Zealand protocols. In addition to the use in the SEV functions, the macroinvertebrate data were also summarised as indices, including the Macroinvertebrate Community Index (MCI) and the number of mayfly, stonefly and caddisfly taxa (EPT richness). Electric fishing was conducted in the pools and runs of intermittent streams.

SEV scores for intermittent streams across all land uses ranged from 0.32 to 0.96 with a mean of 0.67. As with the results of SEV scores for permanent streams, the native forest sites had the highest values (mean 0.87) with progressive reduction in value from exotic (mean 0.78), to urban (mean 0.54) to rural (mean 0.43). The largest difference between permanent and intermittent SEV scores was observed in the rural sites. The intermittent rural sites produced the lowest SEV scores of the four land use types, which was considered a consequence of the poor condition of the riparian vegetation present at these sites. In addition, biodiversity functions were notably lower in exotic forest and rural intermittent streams, compared to permanent streams.

The native forest intermittent streams showed the highest MCI scores and EPT richness. MCI and EPT richness decreased from exotic forest to urban to rural land use, which is similar, but not identical, to the patterns observed in permanent streams.

Four fish species (*Galaxias fasciatus, Anguilla australis, Anguilla dieffenbacchii* and *Gobiomorphus huttoni*) and koura (*Paranephrops planifrons*) were recorded from the intermittent stream sampling sites. All five of the species listed above were found in native forest sites, with lesser native fish diversity in the other land use types. Shortfin eels (*A. australis*) and banded kokopu (*G. fasciatus*) were found in urban sites, shortfin eels and

koura in rural sites and only koura in exotic forest sites. The size range of individuals present indicates that intermittent streams provide valuable habitat for native fish at various life stages. Fish community data was used to calculate using the Auckland Fish IBI and ranged from 0 to 48. Native streams had the highest mean IBI (24.8), followed by urban (22.4), rural (9.14) and exotic forest (7.33).

We propose no changes to the SEV method, formulae or algorithms as a result of this first field investigation of the use of SEV in intermittent streams. It is recognised that some functions operate differently in intermittent streams compared with permanent streams, but using intermittent stream reference data accounts for much of this variation. Thus, in using the SEV in intermittent streams it is important that appropriate reference data from intermittent streams is used for several of the functions. One of the key outputs of this project was the collection of data from intermittent streams in native forest catchments to provide this reference data to allow the calculation of SEV scores for intermittent streams.

The SEV was able to distinguish between the broad land-use types in intermittent streams. Based on this finding, the practical experience gained of collecting SEV field data in intermittent streams, and the desktop review of Storey (2010), it is concluded that the current SEV method can be applied to intermittent streams in the Auckland region without modification. Any SEV assessments of intermittent streams should take place when flowing water is present in the stream, following a minimum of two months of winter flows and preferably between July and October to provide an accurate assessment of the biological values.

SEV scores from intermittent streams can be used with the Environmental Compensation Ratio (ECR) framework to manage environmental effects on intermittent streams. However the interchangeable use of intermittent and permanent SEV scores in ECR calculations is not supported.

It is recommended that the performance of the SEV in intermittent streams is evaluated and refined once a larger dataset of SEV assessments is available (in a similar approach to that of the original version of the SEV). In addition we recommend further investigations to support some functions, for example, based on our understanding of the temperature regimes in intermittent streams, it is recommended that further investigation is undertaken to assess whether the Water Temperature Control function should be modified to account for any effects of pool depth.

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1.0 Introduction

Systems for assessing the value or condition of ecosystems have been developed for a number of reasons, including informing the development and evaluation of policy and regulatory frameworks, supporting resource management decisions and monitoring for environmental outcomes. In relation to rivers and streams, most of the assessment tools have been developed for use in permanently flowing waters (e.g. Stark *et al.*, 2001; Joy *et al.*, 2004). This is likely a result of the relative ease of sampling in permanent flowing water (i.e. not restricted temporally by dry conditions) and the perception that rivers and streams with permanent flowing water are of greater importance than those that dry up for periods of time.

However, there is an increasing body of evidence describing the importance of intermittently flowing streams (Leigh *et al.*, 2015; Datry *et al*., 2014; Larned *et al.* 2010). Intermittent streams are those that have defined banks and represent the uppermost definable channels in most stream catchments. They possess intermittent flow and typically dry up for a period of time in years of average rainfall. Their downstream boundary is located where the channel supports permanent flow (Hansen, 2001).

The connectivity between river reaches and the importance of upstream influences on downstream reaches has been conceptually recognised since at least 1980 (Vannote *et al.*, 1980). More specifically, there has been an exponential increase in the knowledge and understanding of the role and importance of intermittent streams globally over the past 15 years, partially in response to a US Supreme Court ruling in relation to the interpretation of 'navigable waterways' (*Rapanos v United States*, 547 U.S. 715).

The literature produced during this time has described the roles, functions and values of intermittent streams (see recent reviews by Leigh *et al.*, 2015; Datry et al 2014; Larned *et al.* 2010). In many river systems intermittent streams represent the majority of the stream length and they interact more strongly with the surrounding land than do larger downstream permanent reaches (Acuna *et al.* 2014). However, in Auckland it has been estimated that there is 4480 km of intermittent streams, compared with 16650 km of permanent and 7110 km of ephemeral streams (Storey and Wadhwa, 2009). Intermittently flowing streams have important intrinsic values, supporting diverse and abundant biological communities; furthermore, it is recognised that intermittent streams influence the chemical, physical and biological integrity of downstream waters.

Whilst much of this literature concerning intermittent streams is international in origin, there are a small number of New Zealand based studies of intermittent streams that demonstrate similar findings. The absence of water in intermittent streams is often considered to be an indication of lesser values, however 37 of the 53 taxa found in nearby permanently running water survived in the dry substrates of intermittent headwater hard bottom streams in Hawke's Bay (Storey and Quinn, 2013), and the total density of aquatic invertebrates was similar in intermittent and permanent streams (Storey and Quinn, 2008). Similarly in Auckland, intermittent soft bottom streams contained biological communities that were not significantly different from those of permanently flowing waters, and additionally intermittent stream communities were important in maintaining regional-scale diversity (Parkyn *et al.* 2006; Storey *et al.* 2011a). Storey *et al.* (2011a) concluded that based on biological values, there is no reason to manage intermittent streams differently to permanent streams.

The increasing understanding of the importance of intermittent streams has been reflected in proposed changes to the regulatory framework for the management of streams in Auckland, which extends the management framework for rivers and streams to include intermittent streams, treating them in a similar manner to permanent streams. The recently released National Policy Statement for Freshwater Management (MfE, 2014), also applies equally to intermittent and permanent rivers and streams. Hence the shift to managing intermittent rivers in a similar way to permanent rivers is consistent with the current statutory context within which Auckland Council must manage the region's freshwater resources.

The inclusion of intermittent streams in the management framework creates the need for a standardised approach for assessing the ecological value of intermittent streams to enable informed management approaches and decisions to be implemented and evaluated. In Auckland, the Stream Ecological Valuation (SEV) method is the primary tool used to inform the management of permanent streams. The development, history and methodology of the SEV are described in detail elsewhere (Rowe *et al.*, 2008; Storey *et al.*, 2011b; Neale *et al.*, 2011).

The SEV, as with most river assessment tools, was designed for use in permanently flowing systems. The potential application of the SEV to intermittent streams was considered in a desktop assessment by Storey (2010), who reviewed each of the components of the SEV in relation to intermittent streams. Storey concluded that the SEV should produce '*reasonable results for small intermittent streams provided that intermittent reference sites are used where reference data are needed to calculate scores*'. However, there has been no robust field assessment of the performance of the SEV in intermittent streams. As a consequence, Golder Associates (NZ) Limited ('Golder'), in partnership with the National Institute of Water and Atmospheric Sciences (NIWA), were commissioned by Auckland Council to test the performance of the SEV in intermittent streams in Auckland and provide recommendations for its use where appropriate.

1.1 Report scope

This report documents the findings of an investigation designed to test the SEV in intermittent streams and generate the reference site data required to calculate SEV scores in intermittent streams. It does not replace the SEV Manual Technical Report (Storey *et al.*, 2011b) or the SEV User's Guide (Neale *et al.*, 2011) and should be read in conjunction with those documents. Similarly, the issues concerning the use of SEV in intermittent streams discussed in Storey *et al.* (2010) remain pertinent and that report should be read in conjunction with this report by anybody undertaking SEV assessments in intermittent streams.

2.0 Method

The current version of the SEV method (Storey *et al.*, 2011b) was applied to 25 intermittent stream sites across the Auckland region between September and November 2015. The SEV method was applied without modification to assess its performance for each of the existing variables and functions for intermittent streams.

2.1 Site selection

The 25 sites were selected from across Auckland to capture, as far as practicable, the natural variation in stream conditions in Auckland and to capture a gradient of land use intensity (Table 2-1and Figure 2-1). Where possible, sites were selected to be in intermittent reaches upstream of the 19 sites used in the development and testing of the current SEV method (Storey *et al.*, 2011b). Additional sites were primarily selected based on the proximity to existing regional state of the environment (SOE) monitoring sites or where information was available from previous investigations (e.g. Watercourse Management Plans).

The SEV method requires stream-type specific reference data for the calculation of four variable scores (V_{surf}, $V_{physhab}$, V_{ept}, V_{invert}) for test sites. When using the SEV in Auckland, this information is sourced from the 16 permanent reference sites in Auckland Council's State of the Environment monitoring programme.

The Fish Index of Biotic Integrity (IBI) tool used in the SEV is based on fish communities of permanent streams. Little is known about the fish communities of intermittent streams, but lower diversity and abundance has been observed (Davey and Kelly, 2007). Developing a Fish IBI model for intermittent streams was beyond the scope of this study, so a simpler method was used to index the fish communities in intermittent streams against those found in reference intermittent streams. V_{fish} scales the Fish IBI score of a test site by dividing it by 60, the maximum possible score for permanent streams in Auckland. Instead of 60, we used the maximum observed IBI score for the intermittent reference sites in this study (IBI of 48).

To ensure that sufficient reference information was available to produce SEV scores for intermittent streams, 10 of the 25 sites in this investigation were selected to be reference sites (determined as those with greater than 95% native forest land cover in the upstream catchments). When analysing the fish data, it should be noted that there may be fish migrations barriers (natural and artificial) downstream of these sites. The remaining 15 sites comprised of five urban, seven rural and three exotic forest land use.

The Auckland Council overland flow path layer (available on the Council's GIS viewer), which indicates the extent and location of permanent, intermittent and ephemeral stream reaches was used to indicate the location of potential intermittent stream reaches. Potential reaches were selected for site visits where GIS indicated a length of greater than 100 m of intermittent stream.

An assessment of the suitability of potential sites was undertaken by field staff to ensure the reach met the revised PAUP criteria for intermittent streams (Table 2-2 below). A number of the sites initially selected and visited had insufficient length of intermittent channel and these sites were not used further in the project. Additional sites were selected and visited until the 25 suitable site were identified. Assessing the hydrological classification of a river as permanent or intermittent with a high level of certainty typically requires long term flow monitoring that was beyond the scope of this project. However, a follow up site visit was undertaken for all 25 selected sites in March 2016 to re-confirm the classification of the sites under late summer conditions.

Where sufficient intermittent channel was present, a 50 m reach was measured and the SEV method applied to that reach. Transects were generally placed at 5 metre intervals along the reach, but where a transect would have been located in a dry section (e.g. sub-surface flow or large debris dam prevented access), it was re-located upstream or downstream to the nearest part of the channel with accessible wetted channel. It should be noted that the site selection process resulted in all of the study sites being soft bottom (two hard bottom sites were visited, but had insufficient length of intermittent channel).

Table 2-1 SEV Sites

Land use	SEV Code	Name	Easting	Northing	Description
Native Forest	ACSEVCAS	Cascades Stream	1735348	5916750	Upstream of permanent SEV site
	ACSEVHOE	West Hoe Stream	1747979	5950785	Upstream of permanent SEV site and AC SOE monitoring site
	ACSEVNUK1	Nukumea Stream	1748847	5952124	Upstream of permanent SEV site
	ACSEVOKU	Okura River	1752906	5940577	Upstream of permanent SEV site and AC SOE monitoring site
	ACSEVOTAN	Otanerua Stream	1749735	5952368	Upstream of culvert.
	ACSEVPUH	Puhoi River	1744358	5960447	Upstream of AC SOE monitoring site
	ACSEVTAUN	Tributary of Anchor Bay	1765975	5973140	Upstream of AC SOE monitoring site
	ACSEVKAUK	Kaukapakapa River	1732202	5945365	Near AC SOE monitoring site
	ACSEVMAHU	Mahurangi River	1749231	5965634	Upstream of AC SOE monitoring site
	ACSEVFOR	McLeod Stream	1742633	5913610	Near AC SOE monitoring site
Exotic Forest	ACSEVHOT	Awarere Stream	1743823	5973862	Near AC monitoring site
	ACSEVARAS	Ararimu Stream 1	1739961	5934414	Tributary at Strip Road
	ACSEVARAL	Ararimu Stream 2	1739961	5934414	Tributary at Longridge Road
Rural	ACSEVTAUP	Tributary of Waimaru Stream	1762832	5974128	Tauwharanui Regional Park
	ACSEVDUCK1	Duck Creek	1751997	5971315	Near AC SOE monitoring site
	ACSEVOKA	Te Puru Stream	1781053	5911774	Private landowner
	ACSEVRED	Redhills Stream	1742071	5923923	Redhills Watercourse Management Plan.
	ACSEVUPWAI	Upper Waiwera River	1740155	5955755	Near permanent SEV site and AC SOE monitoring site
	ACSEVHING	Tributary of Drury Creek	1771734	5894130	Hingaia South Watercourse Assessment.
	ACSEVPUHI	Puhinui Stream	1770292	5904011	Upstream of permanent SEV site and AC SOE monitoring site
Urban	ACSEVOM	Omaru Creek	1764837	5917875	Upstream of permanent SEV site and AC SOE monitoring site
	ACSEVPAR	Paremuka Stream	1743041	5918304	Near permanent SEV site and AC SOE monitoring site
	ACSEVVIC	Remuera Stream	1760572	5918761	Remuera Stream Watercourse Management Plan
	ACSEVAYR	Newmarket Stream	1759171	5919153	Ayr Street Tributary
	ACSEVMOT	Motions Creek	1753416	5919434	Motions Creek Watercourse Management Plan

Figure 2-1 Intermittent SEV locations

Golder Associates

TITLE INTERMITTENT SEV LOCATIONS

JANUARY 2016

PROJECT 1525967

2-1

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Table 2-2 Stream Classification Definitions as agreed to in PAUP Hearing expert conferencing.

Permanent – The continually flowing reaches of any river or stream ***Intermittent – 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.*** ***This category is defined as those stream reaches that do not meet the definition of permanent or intermittent.***

2.2 Timing of assessment

2.2.1 SEV assessments

SEV assessments were undertaken between September and November 2015, following peak winter flows. As many of the SEV functions rely on water being present in the channel, Storey (2010) recommends intermittent SEVs be undertaken during the time of year when flowing-water is present. Similarly, to collect a representative sample of invertebrates, it is recommended sampling is carried out at least two months after flow has begun, with a preferred sampling window in Hawkes Bay of May to October (Storey and Quinn, 2008). After October, some insect taxa may begin to emerge as adults, reducing the diversity and abundance of aquatic invertebrate populations. A small number of sites in this study were sampled in early November because of logistical reasons, but there was no evidence of any effect on invertebrate metrics calculated from this data.

2.2.2 Confirmation of intermittent reaches

In order to confirm that stream reaches cease to flow, and therefore meet the definition of intermittent, a secondary site assessment was undertaken in March 2016. The purpose of the secondary visit was to provide a greater degree of certainty around the intermittent classification of the sampled reaches. The results of this follow up survey are presented in Appendix C.

2.3 Calculating SEV scores

SEV scores were calculated using the SEV calculator with the only modifications being the inclusion of relevant reference site data for intermittent stream sites. To calculate SEV scores for the intermittent streams in this investigation, the relevant data from the ten native forest sites in this study were incorporated into the SEV calculator to act as the reference data for this study. That is, prior to calculating SEV scores for individual sites, the relevant values from the 10 intermittent reference sites in this study were calculated and used as reference data to enable the calculation of V_{surf}, $V_{physhab}$, V_{ept}, V_{invert} and V_{fish} (Table 2-3) for each of the 25 sites. Hence, the revised SEV calculator now incorporates reference data from permanent and intermittent native forest sites.

To enable the relationship between SEV scores and land use in intermittent streams to be compared with that in permanent streams, the SEV scores for permanent streams were sourced from Storey *et al.* (2011b). Comparison of SEV scores between stream types (i.e. intermittent and permanent) and among land use classes (i.e. native forest, exotic forest, rural and urban) was undertaken using box plots. We did not undertake formal statistical testing for these comparisons because of the small number of sites within each stream or land use category. This should be revisited once a larger dataset of intermittent SEV data is available.

Table 2-3 Intermittent stream (soft bottom) reference values. Note: DOP = Decontamination of Pollutants. HAF = Habitat for Aquatic Fauna. FFI = Fish Fauna Intact. IFI = Invertebrate Fauna Intact.

Function	Variable	Measure	Value
DOP	V_{surf}	Reference W x P	0.68
HAF	$V_{physhab}$	Reference site score	0.86
FFI	V_{fish}	Reference site score	48
IFI	V_{ept}	EPT_{ref}	4.4
IFI	V_{invert}[1]	$Taxa_{ref}$	9.8

[1] Refer to taxa list in Appendix A.

2.3.1 Biological surveys

There are no specific protocols for sampling intermittent stream biota, therefore the standard New Zealand protocols for wadeable streams for sampling fish (Joy *et al.*, 2013) and invertebrate (Stark *et al.*, 2001) communities were used.

Electric fishing was undertaken in all streams, with pool and run habitat sampled wherever possible. Electric fishing was restricted to the 50 m reach used to undertake the SEV assessment to ensure any fish collected were from the intermittent reach (rather than potentially capturing upstream ephemeral or downstream permanent reaches). This is a deviation from the 150 m recommendation of Joy *et al*. (2013), but was considered appropriate because of the purpose of the project. Fish were identified, measured and notes made about habitat type and fish condition. New Zealand Freshwater Fish Database forms were completed for each site.

Macroinvertebrates were sampled according to protocol C2 (soft-bottom, semi-quantitative) and processed as per protocol P3 (full count, quantitative) according to Stark *et al.*, (2001). As all of the 25 sites used in this study were soft bottom, the Macroinvertebrate Community Index (MCI) was calculated using the MCI-sb methodology (Stark and Maxted, 2007).

2.4 Additional information

While not required for calculating SEV scores, additional information was collected to provide context to the reporting outcomes. This involved collecting measures of channel width (wetted channel width at each transect), bank vegetation (the presence of liverworts, bryophytes or mosses) and dry channel length (the location and length of dry reaches in the 50 m reach).

3.0 Results

The full intermittent stream SEV results for the 25 intermittent stream sites are provided in Appendix B. The following sections present the results for overall SEV scores and then each of the SEV function groups.

3.1 Overall SEV scores

SEV assessments were undertaken at the 25 sites listed in Table 2-1. SEV scores ranged from 0.32 to 0.96 (mean 0.67). The scores are summarised by the land use type in Table 3-1.

Table 3-1 Intermittent stream SEV scores.

Land use	Minimum	Mean	Maximum
Native Forest (n=10)	0.77	0.88	0.96
Exotic Forest (n=3)	0.75	0.77	0.79
Rural (n=7)	0.32	0.43	0.64
Urban (n=5)	0.45	0.53	0.63
All (n=25)	0.32	0.67	0.96

The relationship between SEV scores and land use type in intermittent streams follows a broadly similar pattern as that in permanent streams, with native forest sites producing the highest scores and decreasing scores with increasing land use impact. However, there is a noticeable difference for intermittent streams; the lowest scores are observed at rural sites, whereas the lowest scores for permanent streams are observed in urban streams (Figure 3-1).

The mean and range of SEV scores for native forest, exotic forest and urban sites are broadly similar for permanent and intermittent stream sites (Figure 3-1). As indicated above, the only substantial difference is for the rural sites, where the mean (0.43) and range (0.32 – 0.64) of SEV scores for intermittent rural sites was substantially lower than that for permanent rural sites (mean 0.61, range 0.32 – 0.83).

In general, the variation in SEV scores within a particular land use type was less for intermittent streams when compared with permanent streams.

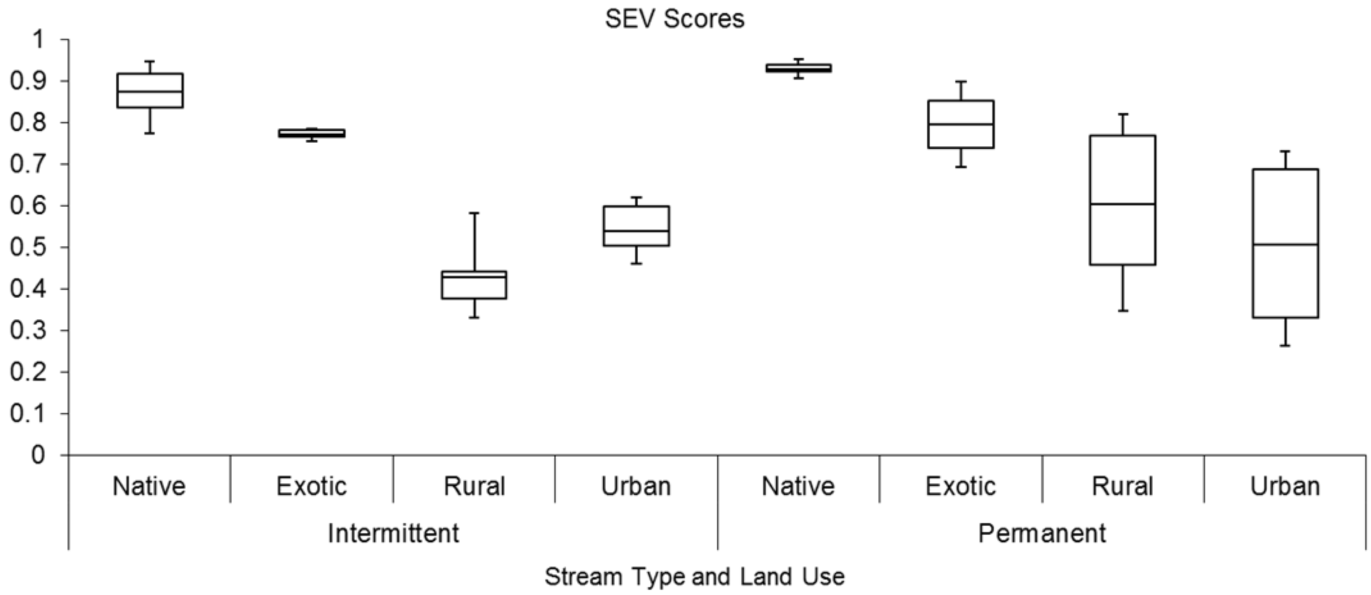

Figure 3-1 Boxplots showing the SEV scores for intermittent and permanent streams for the four land use types. The mean is shown in each box, the box shows the interquartile range and the whiskers represent the 5th and 95th percentiles.

3.1.1 Hydraulic functions

Mean hydraulic function scores for intermittent streams (Table 3-2) were similar to those for permanent streams (Figure 3-2).

The relative differences between land use types for intermittent streams are comparable to that of permanent streams where native scores highest, followed by exotic, rural and urban. As with the overall SEV scores, the range of scores for intermittent streams is smaller than for permanent streams.

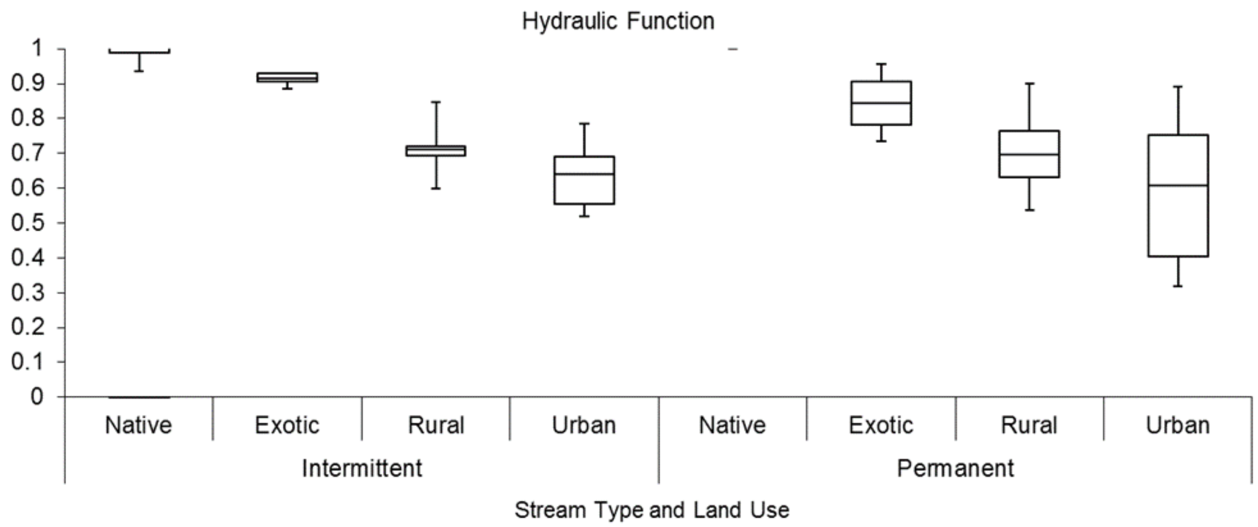

Figure 3-2 Box plots showing the Hydraulic function scores comparing stream type and land use. The mean is shown in each box, the box shows the interquartile range and the whiskers represent the 5th and 95th percentiles

Table 3-2 Intermittent stream Hydraulic function scores

Land use	Minimum	Mean	Maximum
Native Forest (n=10)	0.90	0.99	1.00
Exotic Forest (n=3)	0.88	0.91	0.93
Rural (n=7)	0.56	0.71	0.90
Urban (n=5)	0.51	0.64	0.81
All (n=25)	0.51	0.83	1.00

3.1.2 Biogeochemical functions

Biogeochemical function scores for intermittent streams (Table 3-3) were similar to those for permanent streams (Figure 3-3) for all land use classes, with the exception of rural.

The range of scores obtained for biogeochemical functions in rural intermittent streams was lower than for permanent streams. This difference appears to be driven by low scores for Water Temperature Control (WTC) and Organic Matter Input (OMI) functions, both of which are heavily determined by riparian vegetation.

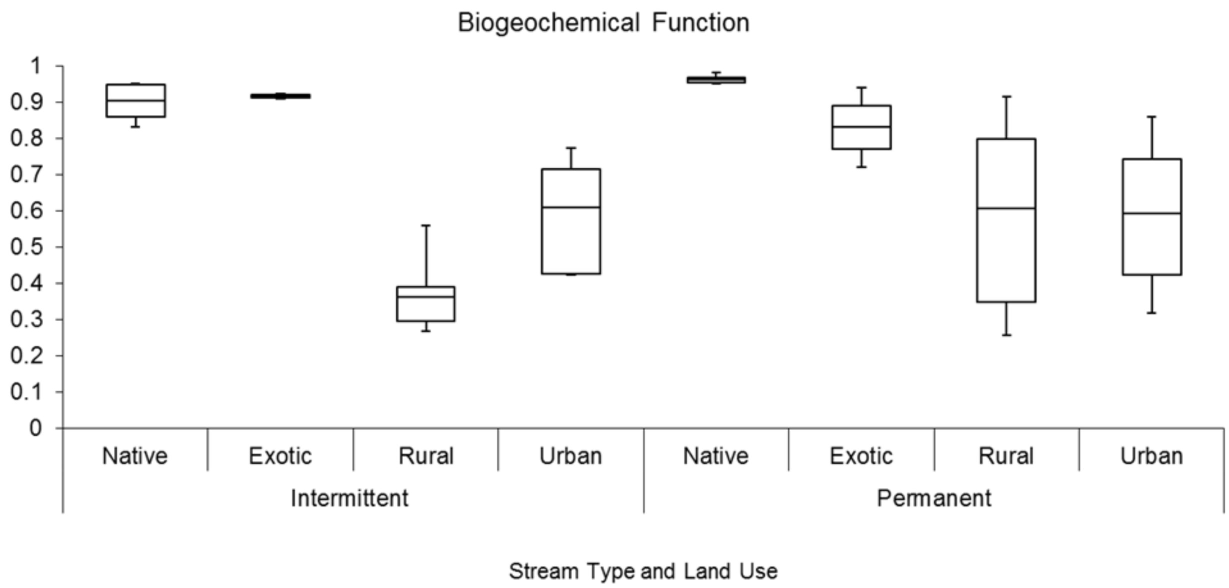

Figure 3-3 Box plots showing the Biogeochemical function scores comparing stream type and land use. The median is shown in each box, the box shows the interquartile range and the whiskers represent the 5th and 95th percentiles

Table 3-3 Intermittent stream Biogeochemical function scores

Land use	Minimum	Mean	Maximum
Native Forest (n=10)	0.83	0.91	0.95
Exotic Forest (n=3)	0.91	0.92	0.92
Rural (n=7)	0.26	0.36	0.61
Urban (n=5)	0.42	0.61	0.79
All (n=25)	0.26	0.70	0.95

3.1.3 Habitat provision functions

Habitat provision scores for intermittent streams (Table 3-4) were similar to those for permanent streams (Figure 3-4) in each land use class, with the exception of rural sites.

The range of scores obtained for habitat provision functions in rural intermittent streams was lower than permanent streams. This difference is a result of low scores for both of the habitat provision functions (Fish Spawning Habitat (FSH) and Habitat for Aquatic Fauna (HAF)). Both of these functions are partly determined by the extent of riparian vegetation.

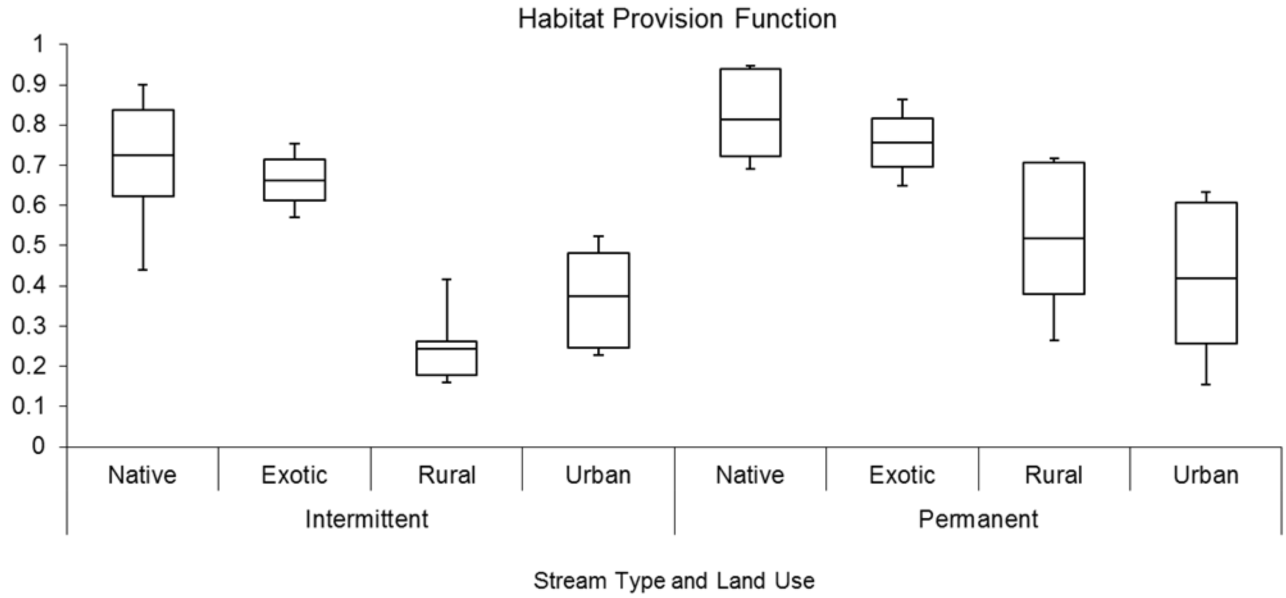

Figure 3-4 Box plots showing the Habitat Provision function scores comparing stream type and land use. The median is shown in each box, the box shows the interquartile range and the whiskers represent the 5th and 95th percentiles

Table 3-4 Intermittent stream Habitat Provision function scores

Land use	Minimum	Mean	Maximum
Native Forest (n=10)	0.42	0.73	0.92
Exotic Forest (n=3)	0.56	0.66	0.76
Rural (n=7)	0.15	0.24	0.48
Urban (n=5)	0.22	0.37	0.54
All (n=25)	0.15	0.51	0.94

3.1.4 Biodiversity functions

The biodiversity functions show a slightly different relationship with land use than the function groups described previously. Biodiversity function scores for intermittent streams (Table 3-5) were similar to those for permanent streams (Figure 3-5) in native forest and urban catchments. However, biodiversity function scores in exotic forest and rural land use were lower for intermittent streams than for permanent streams. For the exotic forest sites, this is a result of the Fish Fauna Intact (FFI) function scoring zero at two of the three sites (no fish captured at these sites). For the rural sites, low Invertebrate Fauna Intact (IFI) scores for three sites together with low Riparian Vegetation Intact (RVI) scores for most of the rural sites impacted the biodiversity function scores.

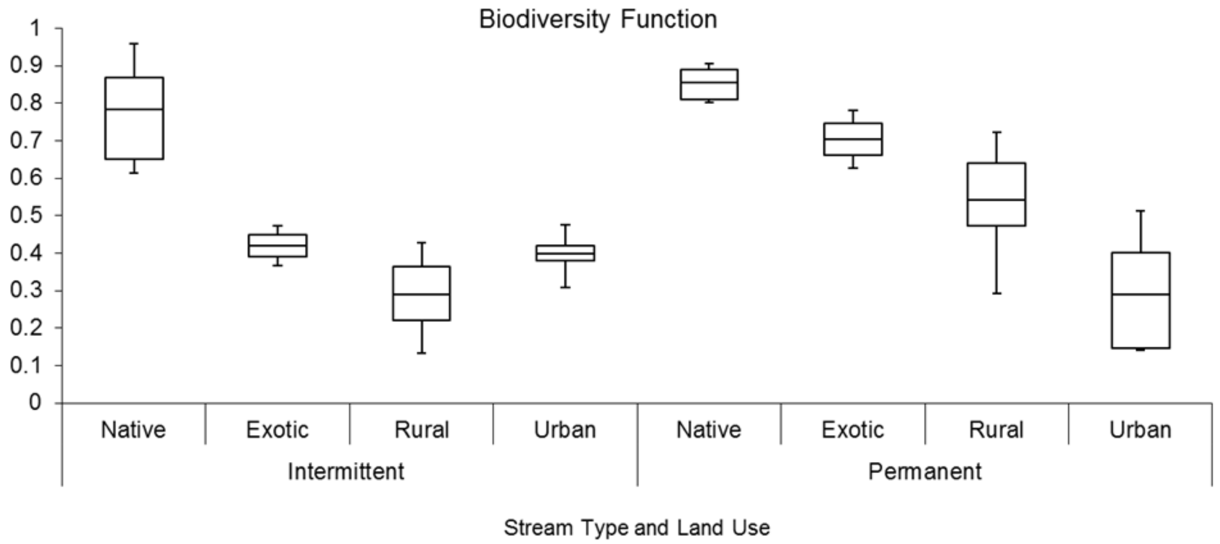

Figure 3-5 Box plots showing the Biodiversity function scores comparing stream type and land use. The median is shown in each box, the box shows the interquartile range and the whiskers represent the 5th and 95th percentiles.

Table 3-5 Intermittent stream Biodiversity function scores

Land use	Minimum	Mean	Maximum
Native Forest (n=10)	0.59	0.78	0.99
Exotic Forest (n=3)	0.36	0.42	0.48
Rural (n=7)	0.12	0.29	0.43
Urban (n=5)	0.29	0.40	0.49
All (n=25)	0.12	0.52	0.99

3.2 Biological communities

The biodiversity functions of the SEV presented in Section 3.1.4 include metrics summarising the invertebrate and fish communities. However, given the interest and importance of these communities in streams and the limited information on their presence in intermittent streams, we have provided an additional summary of the invertebrate and fish data below.

3.2.1 Invertebrates

The invertebrate taxa list from the 25 sites was used to calculate summary metrics for each of the four land use types (Table 3-6).

Native forest intermittent streams produced the highest mean MCI scores and EPT taxonomic richness, indicative of excellent habitat and water quality. The scores obtained are consistent with invertebrate indices obtained for headwater native forest sites in 2011 (Storey *et al.*, 2011b). There is a clear decline in MCI score and EPT richness with increasing land use pressure (from native to urban), consistent with the patterns observed in permanent streams (Moore and Neale, 2008).

Table 3-6 Macroinvertebrate indices for intermittent streams

Indices		Native Forest	Exotic Forest	Rural	Urban
Taxa richness	Minimum	10	6	13	7
	Mean	14.9	9.33	19.14	14.6
	Maximum	20	12	24	18
MCI-sb	Minimum	102.7	96.7	44.5	58.0
	Mean	113.6	102.0	71.5	73.5
	Maximum	126.6	106.2	95.7	83.6
EPT richness	Minimum	2.0	0.0	0.0	0.0
	Mean	4.4	1.0	1.1	0.4
	Maximum	6.0	2.0	3.0	1.0

When compared with permanently flowing streams, taxa richness and EPT richness are lower for the intermittent sites sampled in this study (Table 3-6), which is consistent with previous studies (e.g. Storey and Quinn, 2008). However, the MCI scores for the native forest and urban intermittent sites in this study were similar to those for permanent streams (Table 3-7). As the invertebrate variables in the SEV are indexed against scores for reference sites belonging to the same stream type, the lower scores for some of the invertebrate metrics at intermittent streams are accounted for. That is, the final scores for SEV variables and functions should not be lower in intermittent than permanent streams as they are indexed against the reference condition for the same stream type.

Table 3-7 Macroinvertebrate indices for permanent streams (from Storey *et al.* 2011b)

Indices		Native Forest	Exotic Forest	Rural	Urban
Taxa richness	Minimum	25	28	17	16
	Mean	31.2	31.5	27.3	20.3
	Maximum	41	35	38	26
MCI	Minimum	102.3	98.6	57.1	51.4
	Mean	113.7	116.2	83.6	64.3
	Maximum	124.2	133.7	112.1	87.4
EPT richness	Minimum	8	13	2	0
	Mean	13	16	7.5	0.8
	Maximum	22	19	19	2

Note: MCI metrics are combination of SB and HB metrics based on the substrate of the test sites.

3.2.2 Fish

Electric fishing conducted in pools and runs of the intermittent streams resulted in the capture and identification of four species of fish and koura across a range of land uses as summarised in Table 3-8. Banded kokopu were the most commonly captured fish species, with 41 individuals captured at nine sites (six native forest sites and three urban).

The size range of fish recorded is indicative of populations consisting of individuals at different life stages, indicating that intermittent streams provide habitat that is utilised by fish of a wide age range. No exotic fish species were captured at any of the sites.

Koura were recorded in all land uses except urban, and were most common in native forest habitats. Note that koura are not included in the Fish IBI score.

Table 3-8 Fish species and koura caught during intermittent SEV assessment.
Size range for koura is orbit-carapace length (OCL). For comparison, McDowall (2000) indicates the maximum length for each fish species is 260mm (banded kokopu), 122mm (redfin bully), 2000mm (longfin eel) and 1200mm (shortfin eel).

Land use	Species	Size Range (mm)
Native Forest	Koura (n = 69)	2 – 60 (OCL)
	Banded kokopu (n = 32)	40 – 240
	Redfin bully (n = 2)	50 – 70
	Shortfin eel (n = 5)	120 – 400
	Longfin eel (n = 5)	220 – 400
	Unidentified eel (n = 6)	120 – 600
Exotic Forest	Unidentified eel (n = 2)	80 - 120
	Koura (n = 13)	2 – 10 (OCL)
Rural	Koura (n = 6)	8 – 20 (OCL)
	Shortfin eel (n = 3)	260 – 600
	Unidentified eel (n = 7)	150 – 450
Urban	Banded kokopu (n = 9)	50 – 140
	Shortfin eel (n = 2)	110 – 450
	Unidentified eel (n = 3)	50 – 500
	Unidentified galaxiid (n = 1)	240

The Fish Index of Biotic Integrity (IBI) was calculated and is provided in Table 3-9. The IBI ranged from 0 to 48 across the intermittent sites, with native streams having the highest maximum and mean IBI.

At least one fish species was present in all urban intermittent streams surveyed and the mean IBI was similar to that of native forest streams (Table 3-9). This may be related to the relative proximity of the urban sites to the coast, which is a primary driver of native fish populations. Exotic forest sites had the lowest IBI for both intermittent and permanent sites.

When compared with the fish communities of permanent streams (Table 3-10), there are three species that frequently occur in Auckland streams that were not found in the intermittent streams sampled in this study. These are common bully (found at 20% of Auckland sites), inanga (=17%) and Cran's bully (10%) (Auckland Regional Council, 2010). The absence of these species from the sites sampled in this study, together with the lower IBI scores suggests the fish fauna of intermittent streams is less diverse than that of permanent streams and provides support for the approach of indexing the V_{fish} function score against the intermittent stream reference site scores for IBI. Although it should be noted that the intermittent streams in this study were located in the headwaters of catchments and therefore non-climbing species such as inanga are unlikely to be found as they do not penetrate far inland (McDowell, 2000). As a result, intermittent streams are expected to have naturally different fish communities from permanent streams, which adds to the catchment scale diversity of stream systems.

Table 3-9 Fish IBI for intermittent streams by each land use class

		Native Forest	Exotic Forest	Rural	Urban
IBI	Minimum	0	0	0	14
	Mean	24.8	7.33	9.14	22.40
	Maximum	48	22	18	30

Table 3-10 Fish IBI for permanent streams by each land use class (from Storey et al. 2011b)

		Native Forest	Exotic Forest	Rural	Urban
IBI	Minimum	38	28	26	10
	Mean	43.6	31	36	18.7
	Maximum	48	34	52	30

4.0 Discussion

4.1 Applicability of the SEV to intermittent streams

The applicability of the SEV to intermittent streams has previously been considered in a desktop study by Storey (2010), where no substantive issues to prevent the SEV being used in intermittent streams were identified. This field study is an extension of the desktop study, involving the collection of SEV data in the field and subsequent analysis. This study has not raised substantive issues regarding the use of the SEV in intermittent streams, either during the practical collection of the field data, nor the subsequent analysis of the collected data and the calculation of SEV variable and function scores. However, it is recommended that the timing of SEV assessments in intermittent streams should be limited to July to October (see Section 4.2.2) and that comparable intermittent reference site information should be used. Based on the results of the desktop study, the practical experience of collecting SEV field data in intermittent streams and the analysis of the data collected, it is considered that the SEV method is sufficiently robust to be applied to intermittent streams without modification.

It should be recognised that this finding is based on a relatively small dataset of test sites (25) and it is recommended that the use of the SEV in intermittent streams, and the performance of each function, is reviewed once a larger, more extensive dataset of SEV assessments in intermittent streams is available. This is consistent with the approach taken with the original version of the SEV, which was reviewed 5 years after publication.

Overall, the SEV score shows a similar relationship to land use classes in permanent and intermittent streams, however there are minor land use and function-specific differences, particularly in rural streams and for biodiversity functions.

Rural streams

The most obvious difference arising from the use of the SEV in intermittent streams is the lower overall SEV score for rural intermittent streams when compared with permanent rural streams. This is also evidenced in the range of scores for the biogeochemical, habitat provision and biodiversity functions. Review of the individual function scores for intermittent rural sites indicates that these lower scores are a result of low scores for those functions that are primarily determined by the extent of riparian vegetation (i.e. Floodplain Effectiveness (FLE), Water Temperature Control (WTC), Organic Matter Input (OMI), Fish Spawning Habitat (FSH), Riparian Vegetation Intact (RVI) and Habitat for Aquatic Fauna (HAF)).

It is considered that this is an accurate reflection of the poor riparian condition of the rural streams assessed in this study, rather than an issue with the performance of the SEV in rural intermittent streams. This is evidenced by the variable scores for riparian condition, whereby the mean Vripcond scores for rural sites in this study was 0.23, compared with 0.51 for urban sites in this study and 0.48 for rural sites in permanent streams (Storey *et al.*, 2011b). This finding does demonstrate the sensitivity of the SEV scoring system to riparian conditions.

The rural sites in this study were selected based on the entire catchment being in rural land cover (i.e. non-forested), whereas the permanent stream rural sites include sites with forest remnants in their catchment. Including rural sites with no forest remnants in the catchment is easier with intermittent streams as the contributing catchment size is smaller, however this slightly different approach may partially explain the lower SEV scores in intermittent rural sites.

The low scores for riparian conditions for rural sites are also likely due to the prevailing stream management paradigm, which has been unlikely to require the fencing or planting of riparian zones in intermittent streams. Rather the statutory and non-statutory policies and rules relating to stream and riparian management in the past generally applied to permanent waterways (e.g. Auckland Regional Plan: Air, Land and Water and the Clean Stream Accord). The importance of riparian vegetation in intermittent streams, even in reaches where no surface water remains, has been recognised as providing protection to invertebrate species through shading effects on temperature (Parkyn *et al.*, 2006; Storey, 2010; Storey and Quinn, 2013).

Biodiversity functions

We found that the invertebrate communities typically had lower richness in the intermittent streams surveyed as part of this study compared with permanent streams, consistent with the findings of Storey and Quinn (2008). However, the MCI scores for intermittent sites were broadly similar to those for permanent streams, and showed a decline with increasing land use pressure consistent with patterns observed in permanent streams (Moore and Neale, 2008). Like the invertebrate community, the fish community in this study showed lower richness in intermittent streams. This is to be expected as intermittent streams are generally at higher elevations and at further distances from the coast, both of which influence the native fish community found at a site. Nevertheless, the intermittent streams in this study contained four fish species, including individuals of a wide size range for most species, indicating that intermittent streams are used by juvenile and mature fish of some species for certain times of the year.

The differences between biological communities of intermittent and permanent streams provide support for the SEV approach to scoring, which is to index the scores for each stream type against reference data from the same stream type (i.e. intermittent test sites are indexed against intermittent reference sites). When the biodiversity functions were calculated in this way, the scores for native forest and urban sites were only slightly lower in intermittent streams than in permanent streams. In contrast, the biodiversity function scores for exotic forest and rural sites were substantially lower in intermittent streams than in permanent streams (Figure 3-5).

When comparing the biodiversity functions within the intermittent streams, the lower scores for exotic forest and rural sites are considered to be an accurate reflection of the current condition of the biodiversity at these sites, rather than an issue with the performance of the SEV in these streams. As discussed above, the poor condition of riparian vegetation at rural sites is part of the issue, in that it would have directly affected the RVI function scores. In addition, there were no fish found at two of the exotic forest sites and three of the rural sites, which resulted in low FFI scores for these five sites.

4.2 Guidance for application

It is anticipated that the SEV method will be applied to intermittent streams for a variety of reasons, including quantifying mitigation or offsetting requirements for resource consenting purposes. Based on this study, the SEV may be applied to intermittent streams in the same manner to how it is applied to permanent streams and reporting outputs provide sufficient contextual and background information to support the SEV results.

We do not consider that any revisions are required to the SEV method for use in intermittent streams; however, we provide some brief guidance specific to the application of the SEV to intermittent streams.

4.2.1 Reference data

It is a fundamental rule for the SEV that reference site data should be derived from the same stream type as the test sites (Storey, 2010). To this end, an unbalanced experimental design was used for the site network in this study by selecting 10 native forest sites to act as intermittent stream reference sites. This information has been incorporated into an updated version of the SEV calculator (as described in Section 2.3) and it is important that this version of the calculator is used for calculating SEV scores of intermittent streams.

There is a current shortcoming in that there is no information from hard bottom intermittent reference sites and we recommend that some targeted sampling of hard bottom reference sites is undertaken to resolve this. In the interim, either the soft bottom reference data can be used with a caveat explaining this limitation (as was the case when the SEV was first developed in 2006) or hard bottom reference data may be collected as required and included in the SEV calculator in the appropriate locations.

4.2.2 Undertaking SEV assessments

Many of the SEV functions and variables require water to be present within the stream channel to carry out a meaningful assessment. As such, we concur with the recommendations of Storey (2010) on the timing of SEV assessments. First, SEV assessments should be undertaken when there is water in the stream to permit the effective assessment of the Dissolved Oxygen Levels (DOM), In-stream Particle Retention (IPR), DOP, FSH and HAF functions. Second, to ensure the collection of a meaningful invertebrate sample, sampling should be undertaken at least two months after winter flows have commenced, but not before insect taxa emerge and leave the stream in spring. Therefore, we suggest the most appropriate time to undertake a SEV assessment in an Auckland intermittent stream would be between July and October. This recommendation differs from that of Joy *et al.* (2013) for the sampling of fish populations, but is necessary due to the nature of the flow regimes of intermittent streams.

4.2.3 Biotic factors

The collection of biological community data (fish and invertebrates) in this study has begun to address the use of intermittent streams by biological communities, one of the key research questions identified by Storey (2010) for intermittent streams. In the absence of specific protocols for sampling these communities in intermittent streams, we recommend the standard protocols that have been developed for permanent streams in New Zealand are utilised (e.g. Stark *et al.*, 2001; Stark and Maxted, 2007; Joy *et al.*, 2014).

4.3 Comparing permanent and intermittent SEV scores

The comparability of SEV scores between permanent and intermittent streams, in terms of assessing stream condition based on the deviation from reference condition, appears to be appropriate on the basis of this study. However, as with many of the findings of this study, we recommend that the response of intermittent streams to land use pressure is re-assessed when a larger dataset of intermittent stream assessments is available.

The performance of the SEV for intermittent streams raises no concerns for using the SEV scores from intermittent streams to manage environmental effects on these systems using the Environmental Compensation Ratio (ECR) described in Storey *et al.* (2011b). However, there are a wider range of resource management issues that need to be considered before permanent and intermittent SEV scores can be used interchangeably in ECR calculations. For example, the principle of ‘like for like’ could be compromised by managing environmental effects on permanent streams by undertaking environmental compensation activities on intermittent streams (and *vice versa*). Therefore, it is recommended that ECR calculations are carried out only for streams of the same type. For clarity, the ECR formula can be applied to assess environmental compensation requirements for intermittent streams when compared to other intermittent streams. It is not recommended that intermittent and permanent streams SEV assessments are used interchangeably in the ECR calculations as offset compensation measures should reflect and enhance the features specific to intermittent streams.

4.4 Recommendations for future investigation

Notwithstanding the above findings around the suitability of the use of SEV in intermittent streams in its current format, there are a small number of technical issues that it would be advantageous to investigate to support the ongoing use of SEV in intermittent streams. First, the Water Temperature Control (WTC) function is likely to operate differently in intermittent streams than permanent streams (Storey, 2010). Typically intermittent streams will be reduced to disconnected pools in summer and therefore will experience thermal stress at those times. Shade is the key factor affecting the severity of this thermal stress, however in pools, water depth is also likely to be important. Therefore, it is recommended that the temperature regimes in intermittent pools are investigated, particularly the effects of shade, depth and macrophyte coverage on pool temperatures, to inform whether a modification to the WTC function is required for intermittent streams.

Second, the Fish IBI tool (Joy, 2004) is based on the fish communities of permanent streams. We have used this model in the intermittent SEV and indexed the results against scores for intermittent reference sites, in the same way that has been done for the invertebrate metrics. This approach allows the use of the IBI and calculation of FFI scores for intermittent streams. However, little is known about the fish communities of intermittent streams and it is recommended that this issue is investigated further. The ideal situation would be a specific IBI model for intermittent streams, but it is likely to be challenging to collect sufficient data to develop a model specific to intermittent streams.

Finally, human impacts on intermittent streams may increase or decrease the length and intensity of the dry period and will affect several stream functions (including IFI, FFI, HAF, IPR and DOP). For example, dry period length could be increased by reducing connectivity to groundwater, or reduced by water sensitive stormwater management interventions. It would be valuable to investigate the effect of differing types of human impacts on dry period length and the corresponding impacts that may be observed on the SEV functions listed above.

5.0 Conclusion

The current SEV method is considered a robust tool that may be applied to intermittent streams in the Auckland region based on the collective findings of the desktop exercise of Storey (2010), the practical exercise of collecting SEV field data in this study and the subsequent analysis of the collected data. When calculating SEV scores for intermittent streams, appropriate reference data from intermittent streams must be included and Auckland specific reference data has been included in an updated version of the SEV calculator. We propose that between July and October is the most appropriate time to undertake an SEV assessment in an intermittent streams.

Permanent and intermittent streams may have broadly comparable SEV scores; however we do not support the interchangeable use of SEV scores from intermittent and permanent streams in ECR calculations as offset compensation should reflect the values specific to intermittent streams.

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Appendix A V_{invert} Taxa List

V_{invert} **Taxa List**
Arachnocolus
Acarina
Collembola
Oligochaeta
Orthocladiinae
Paradixa
Paraleptamphopus
Polypedilum
Polyplectropus
Potamopyrgus
Tanypodinae
Tanytarsini
Tepakia
Zephlebia

This taxa list is generated from soft bottom intermittent streams only (see text for further explanation).

Appendix B Intermittent stream SEV results

Land use type SEV Code Name Easting Northing	Native Forest ACSEVFOR Forest Hill 1742633.12 5913610.45	Native Forest ACSEVCAS Cascades 1735348.3 5916749.7	Native Forest ACSEVNUK1 Nukumea 1748847.45 5952123.61	Native Forest ACSEVHOE West Hoe 1747979.24 5950784.62	Native Forest ACSEVOKU Okura River 1752906.1 5940576.85	Native Forest ACSEVKAUK Kaukapakapa 1732202.02 5945364.61	Native Forest ACSEVPUH Puhoi River 1744357.66 5960446.87	Native Forest ACSEVMAHU Mahurangi 1749230.91 5965633.87	Native Forest ACSEVTAUN Tauwharanui 1765975.09 5973140.42
Natural flow regime	0.90	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00
Floodplain effectiveness	0.73	1.00	1.00	1.00	1.00	0.96	1.00	0.96	0.96
Connectivity for species migrations	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural connectivity to groundwater	0.96	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00
Hydraulic function mean	0.90	1.00	1.00	1.00	1.00	0.98	1.00	0.99	0.99
Water temperature control	0.64	0.74	0.74	0.66	0.88	0.76	0.76	0.78	0.68
Dissolved oxygen levels maintained	1.00	1.00	1.00	0.50	1.00	1.00	1.00	0.50	0.50
Organic matter input	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
In-stream particle retention	0.94	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00
Decontamination of pollutants	0.83	1.00	0.87	1.00	0.87	1.00	1.00	1.00	1.00
Biogeochemical function mean	0.87	0.95	0.92	0.83	0.95	0.95	0.95	0.86	0.84
Fish spawning habitat	0.10	0.55	0.24	0.05	0.61	0.78	0.72	0.78	0.78
Habitat for aquatic fauna	0.81	0.89	0.94	0.80	0.99	0.97	0.97	0.86	0.85
Habitat provision function mean	0.46	0.72	0.59	0.43	0.80	0.87	0.84	0.82	0.81
Fish fauna intact	0.38	0.29	0.00	0.00	0.67	0.50	1.00	0.67	0.88
Invertebrate fauna intact	0.72	0.86	0.79	0.91	0.96	0.93	0.98	0.94	0.92
Riparian vegetation intact	0.84	0.90	0.98	1.00	0.90	0.97	1.00	0.96	0.97
Biodiversity function mean	0.64	0.68	0.59	0.64	0.84	0.80	0.99	0.86	0.92
Overall SEV score	0.77	0.87	0.83	0.78	0.92	0.92	0.96	0.89	0.89

Land use type	Native Forest	Exotic Forest	Exotic Forest	Exotic Forest	Rural	Rural	Rural	Rural	Rural
SEV Code	ACSEVOTAN	ACSEVHOT	ACSEVARAL	ACSEVARAS	ACSEVDUCK1	ACSEVUPWAI	ACSEVPUHI	ACSEVOKA	ACSEVRED
Name	Otanerua	Hoteo	Ararimu Stream	Ararimu Stream	Duck Creek	Upper Waiwera	Puhinui	Okaroro	Redhills
Easting	1749735.31	1743823.12	1739960.74	1739960.74	1751997.2	1740155.42	1770291.91	1781053.3	1742070.89
Northing	5952368.32	5973862.38	5934413.58	5934413.58	5971315.04	5955754.78	5904011.12	5911774.03	5923922.55
Function									
Natural flow regime	1.00	0.98	1.00	1.00	0.93	0.79	0.71	0.77	0.84
Floodplain effectiveness	0.96	0.59	0.72	0.72	0.75	0.18	0.18	0.18	0.18
Connectivity for species migrations	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural connectivity to groundwater	1.00	0.96	1.00	1.00	0.90	0.95	0.88	0.88	0.80
Hydraulic function mean	0.99	0.88	0.93	0.93	0.90	0.73	0.69	0.71	0.70
Water temperature control	0.76	0.78	0.60	0.62	0.28	0.00	0.02	0.06	0.16
Dissolved oxygen levels maintained	1.00	1.00	1.00	1.00	1.00	0.40	0.50	1.00	0.50
Organic matter input	1.00	1.00	1.00	1.00	0.32	0.05	0.14	0.06	0.00
In-stream particle retention	1.00	1.00	1.00	1.00	0.80	0.60	0.52	0.80	0.79
Decontamination of pollutants	0.93	0.77	1.00	1.00	0.66	0.23	0.30	0.27	0.26
Biogeochemical function mean	0.94	0.91	0.92	0.92	0.61	0.26	0.30	0.44	0.34
Fish spawning habitat	0.88	0.62	0.48	0.43	0.44	0.05	0.05	0.05	0.05
Habitat for aquatic fauna	0.97	0.91	0.86	0.69	0.52	0.30	0.30	0.50	0.33
Habitat provision function mean	0.92	0.76	0.67	0.56	0.48	0.18	0.18	0.27	0.19
Fish fauna intact	0.79	0.46	0.00	0.00	0.00	0.29	0.38	0.38	0.29
Invertebrate fauna intact	0.87	0.45	0.59	0.40	0.65	0.45	0.77	0.54	0.51
Riparian vegetation intact	0.95	0.53	0.68	0.68	0.65	0.10	0.11	0.03	0.09
Biodiversity function mean	0.87	0.48	0.42	0.36	0.43	0.28	0.42	0.31	0.30
Overall SEV score	0.94	0.79	0.78	0.75	0.64	0.39	0.42	0.46	0.41

Land use type	Rural	Rural	Urban	Urban	Urban	Urban	Urban
SEV Code	ACSEVTAUP	ACSEVHING	ACSEVOM	ACSEVPAR	ACSEVVIC	ACSEVMOT	ACSEVAYR
Name	Tauwharanui	Hingaia	Omaru Creek	Paremuka Stream	Remuera Stream	Motions Creek	Newmarket Stream
Easting	1762831.52	1771734.1	1764837.42	1743040.95	1760571.92	1753416.01	1759170.87
Northing	5974128.14	5894130.16	5917875.19	5918303.83	5918760.78	5919433.9	5919152.93
Function							
Natural flow regime	0.69	0.43	0.73	0.46	0.19	0.19	0.42
Floodplain effectiveness	0.37	0.08	0.60	0.21	0.24	0.00	0.50
Connectivity for species migrations	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural connectivity to groundwater	0.71	0.72	0.90	0.87	0.79	0.84	0.85
Hydraulic function mean	0.69	0.56	0.81	0.63	0.55	0.51	0.69
Water temperature control	0.00	0.22	0.14	0.36	0.86	0.68	0.60
Dissolved oxygen levels maintained	0.60	0.60	0.50	0.60	1.00	0.40	0.60
Organic matter input	0.00	0.08	0.08	0.10	0.70	0.90	0.80
In-stream particle retention	0.48	0.20	0.50	0.48	0.68	0.72	0.68
Decontamination of pollutants	0.39	0.42	0.90	0.60	0.71	0.80	0.89
Biogeochemical function mean	0.29	0.30	0.42	0.43	0.79	0.70	0.71
Fish spawning habitat	0.18	0.05	0.19	0.40	0.50	0.05	0.48
Habitat for aquatic fauna	0.32	0.26	0.26	0.37	0.57	0.44	0.49
Habitat provision function mean	0.25	0.15	0.22	0.38	0.54	0.25	0.48
Fish fauna intact	0.00	0.00	0.33	0.29	0.63	0.46	0.63
Invertebrate fauna intact	0.28	0.26	0.47	0.36	0.25	0.38	0.36
Riparian vegetation intact	0.19	0.10	0.46	0.21	0.28	0.40	0.48
Biodiversity function mean	0.16	0.12	0.42	0.29	0.38	0.41	0.49
Overall SEV score	0.37	0.31	0.50	0.45	0.60	0.52	0.63

Appendix C Secondary site visits

The sites selected for this study were based on the Auckland Council overland flow path layer (available on the Council's GIS viewer), which was used to indicate the location of potential intermittent stream reaches. These potential reaches were then subject to site visits where GIS indicated a length of greater than 100 m intermittent stream. During these site visits, best professional judgment was used to assess the likelihood that stream reach was intermittent, with particular consideration of the criteria developed for the PAUP. It should be recognised that a one off assessment of stream type provides only limited information as to the hydrological classification of the reach. Whereas, assessing the hydrological classification of a river as permanent or intermittent with a high level of certainty typically requires long term monitoring that was beyond the scope of this project.

To partly address the limitation of a single visit, all of the stream reaches in this study were revisited under late summer flow conditions to re-assess the stream classification and confirm the intermittent status of the study sites. These follow up site visits were undertaken for all 25 sites in March 2016.

Of the 25 sites, 23 had ceased to flow and met the PAUP criteria (Table 2-2) for an intermittent stream. Three examples of this are shown in Table 6-1 below. Hence, the follow up visits have confirmed the intermittent status of these sites.

Table 6-1 Photographs comparing stream conditions between 2015 and 2016.

2015 Survey Photos	2016 Survey Photos
Kaukapakapa 2015	Kaukapakapa 2016
	
Paremuka 2015	Paremuka 2016

	
Redhills 2015	Redhills 2016
	

Two sites (Puhoi and Hingaia) contained flowing water at the time of these follow up visits (see Table 6-2 below). Whilst this finding creates some uncertainty around the status of these two sites, it does not confirm that these sites are not intermittent.

There are two issues that need to be considered. First, while the follow up visit was made in late summer, it may not have coincided with the low flow periods for these two streams. Second, the definitions of intermittent stream often include reference to a ‘typical’ year (i.e. flow ceases in a typical year). Whilst there is little guidance on what constitutes a typical year, hydrology monitoring undertaken by Auckland Council indicates that the austral summer of 2015/16 was wetter than normal, such that the mean annual low flow (MALF) was not reached for most of the monitored sites in the SoE programme (see Figure 7-1and Figure 7-2 for examples).

Given this contextual information, it is considered that using these two sites in the test of the SEV in intermittent streams is not a major issue, however we would caution from using the results from these two sites in isolation. Further investigation to assess the status of these two sites would be advantageous.

Table 6-2 Photographs comparing stream conditions between 2015 and 2016.

2015 Survey Photos	2016 Survey Photos
Puhoi 2015	Puhoi 2016
	
Hingaia 2015	Hingaia 2016
	

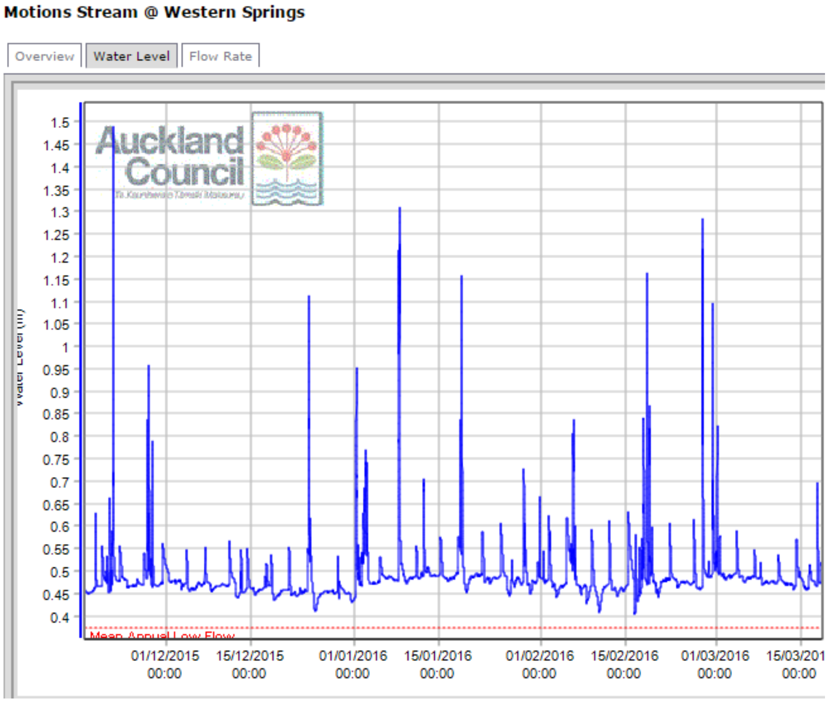

Figure 7-1: Flow record for Motions Creek during the 2015-2016 summer, indicating the stream flows did not fall to the mean annual low flow (data sourced from Hydrotel (Auckland Council website)).

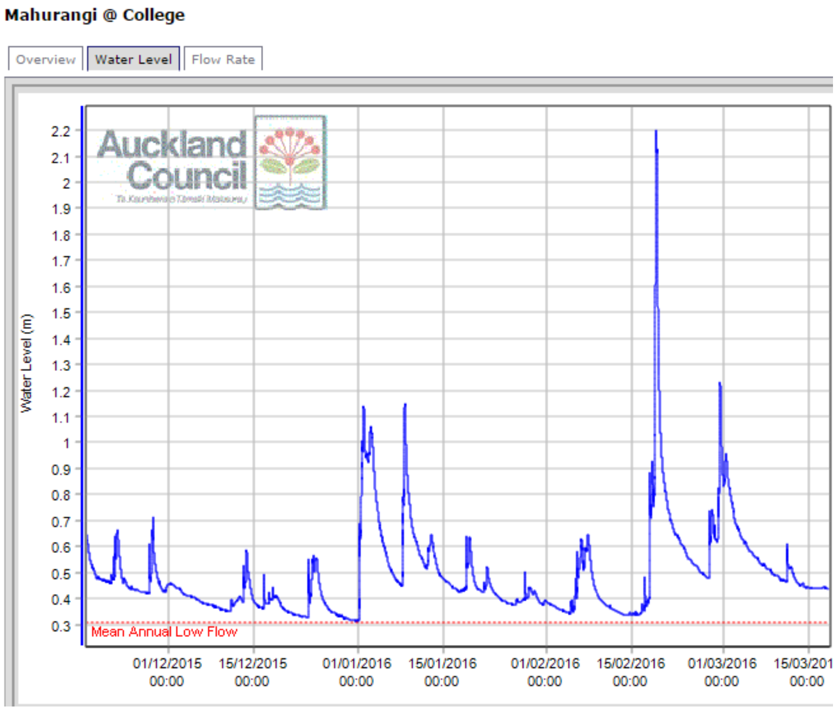

Figure 7-2: Flow record for the Mahurangi River during the 2015-2016 summer, indicating the river flows fell to the mean annual low flow on only one day.

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