Client

Envirosure

ASSESSMENT OF THE GROOT RIVER, MEIRINGSPOORT FOLLOWING DIESEL CONTAMINATION

1ST MONITORING REPORT

Prepared by

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1 INTRODUCTION

1.1 Background

On the 15th August 2017, 41 000 litres of diesel was accidentally spilled from an overturned tanker into a roadside stormwater drain which discharges runoff directly in the Meirings River as it flows through the Meiringspoort Pass. The bulk of the diesel flowed down the drain and discharged into the sandy river bank, entering the Groot River immediately downstream of the bridge crossing the river.

In response to an initial evaluation of the potential impacts of the incident on the ecological integrity of the Meirings River, The Breede Gouritz Catchment Management Agency (BGCMA) issued a directive indicating quarterly monitoring of the affected environment for at least one year.

Freshwater Consulting cc were contracted by Envirosure Underwriting Managers (Pty) Ltd who insure the Kelrn Vervoer vehicle responsible for the spillage, to fulfil the requirements outlined in the directive.

1.2 Terms of Reference

Accordingly, the Freshwater Consulting Group was commissioned to:

1. Undertake a baseline assessment of the Meirings River to understand its condition and integrity prior to the spill and to establish a baseline for evaluating the potential impacts of surfactants, if necessary, on the biota associated with clean-up operations.
2. Undertake a site visit to guide the removal of sediments and vegetation (if necessary).
3. Establish the extent and need for rehabilitation through collaboration with the clean-up team to understand the proposed Action Plan and the timeframe for implementation of the Action Plan.
4. Following on from the baseline assessment, compile a monitoring plan for fish and macroinvertebrates.
5. Monitor key biological (fish and invertebrates), physical (habitat) and chemical indicators for a minimum period of one year at key sites within the catchment. Monitoring to be undertaken every 3 months and the need for longer term monitoring to be addressed after this period.
6. Compile quarterly reports that provide details of the recovery of the aquatic ecosystem based on data collected in the field with recommendations for ongoing monitoring or the need to adapt the monitoring approach.

The first four of these TORs have been addressed and are included in several communiques to the client, the most recent and detailed being the Baseline Assessment Report.

1.3 The Baseline Assessment

A Baseline Assessment of the Meirings River was undertaken following an initial assessment of the area undertaken in September 2017. During the survey, five key monitoring sites were identified as part of the monitoring plan and the first set of ecological data was collected. In response to the need for and potential impacts associated with the use of surfactants during the clean-up operations, a section field trip was undertaken in October 2017 for the collection of water chemistry samples only and these data, together with the baseline data, are included in the Baseline Assessment Report. In addition, the Baseline Assessment Report includes findings of the fish rescue operation undertaken in September 2017 as a baseline for monitoring recovery of indigenous fish within the system.

Baseline evaluation of water chemistry, macroinvertebates and fish within the Meirings River clearly showed that the diesel spill had a significant adverse impact on the ecological integrity of the system. Of particular concern was evidence to suggest that the impact had extended downstream of the impact zone, despite no visual evidence of diesel contamination beyond this river reach.

Among a list of recommendations made in the Baseline Assessment report were the following:

- Monitoring of biological and physical components of the Meirings River continue according to the initial programme of quarterly sampling over an annual cycle, assuming that no further surfactants or remediation agents are used in the clean-up operation.
- Should any further application of surfactants or remediation agents be applied, it is strongly recommended that changes in water chemistry be closely monitored with the immediate collection of samples to inform any potential adverse effects to the ecological integrity of the Meirings River.
- Water quality sampling at all 5 sites should include analysis of hydrocarbons as far downstream as Aalwyns Drif. If any hydrocarbons are detected at this site, the sampling protocol should be updated to include a site further downstream.
- Sediment samples at all five sites should be collected for assessment of hydrocarbons to determine whether any hydrocarbons have settled on to the substrata downstream of the impact zone.

1.4 Contents of this report

This report constitutes the first quarterly report on recovery of the aquatic ecosystem based on biophysical data collected in December 2017. It includes an evaluation of the condition of the river relative to the baseline ecological state established following the oil spill incident.

2 THE AFFECTED RIVER ECOSYSTEM

A full description of the Groot River catchment and the Meirings River within the study area is given in the Baseline Assessment Report (Ewart-Smith 2017). Essentially, the Groot /Meirings River is a river ecosystem with a relatively good ecological condition which supports two threatened native freshwater fish species, namely smallscale redfin *Pseudobarbus asper* and the slender redfin *Pseudobarbus tenuis*. *P. asper* is listed as endangered and only occurs in the Gouritz and Gamtoos catchments, while *P. tenuis* is listed as near threatened and is endemic to the Gouritz catchment (van der Walt 2017). Thus the Groot/Meirings River is an ecosystem of very high conservation importance and a listed priority for the conservation and protection of aquatic ecosystems.

3 ASSESSMENT APPROACH AND METHODOLOGY

Considering the lack of quantitative background information on the water chemistry and biota of the Groot/Meirings River, the basic approach to this study was to select sites upstream and downstream of the impact zone as controls against which to monitor recovery over time within the impacted zone. Also, sites were selected both within the impact zone and with distance downstream to establish whether the biological effects extended beyond what was visibly evident as the impacted zone.

3.1 Sampling date

Following on from the Baseline Assessment when data were collected in September 2017, the first quarterly monitoring survey was undertaken between the 17th and the 19th December 2017.

3.2 Sampling sites

The selection of five monitoring sites (Figure 3.1) for this study took into consideration available habitat for macroinvertebrates and fish at a time (September 2017) when water levels and baseflows were higher than encountered in December 2017. Flows were reduced to a slight trickle at Middelwater and Derde Tol Drif while no flow was encountered at Ontploffings Drif. Table 3.1 provides a summary of the available habitats between the baseline survey and that sampled in December 2017. A full description of site characteristics is given in the Baseline Assessment Report (Ewart-Smith 2017).

Table 3.1 **Comparison of habitat availability during September 2017 and December 2017 due to differences in flow between sampling surveys.**

Site	Available habitats	
	September 2017	**December 2017**
Site 1: Middelwater (Control)	Stones-in-current (SIC) include mostly shallow riffles and runs over gravel and small cobble, marginal vegetation (mostly sedges) both in current and out of current (pool margin) and stones-out-of-current (SOOC) within a large pool. Habitat availability moderate.	SIC limited to slow trickle over small cobble and gravel; marginal vegetation included sedges along the pool margin but poor availability; no submerged SOOC; GSM included in pool habitat. Habitat availability in flowing biotopes is poor.
Site 2: Spiltech (impact)	SIC includes runs and riffles over boulders and cobbles, SOOC includes cobbles in pool; GSM includes gravels in runs and slackwater margins; marginal vegetation (mostly sedges) in current and out of current with some gravel in the pool. Habitat availability is good.	SIC includes runs and riffles over boulders and cobbles, SOOC includes cobbles in pool; GSM includes gravels in runs and slackwater margins; marginal vegetation (mostly sedges) in current and out of current with some gravel in the pool. Although water level is low, habitat availability is relatively good.
Site 3: Derde Tol Drif (impact)	SIC included runs and riffles over cobble; SOOC includes cobbles in the downstream pool; GSM includes gravels and fine sediments in the upstream pool; Marginal vegetation includes sedges both in current and out of current. Habitat availability is good.	SIC includes a slow trickle through cobble; SOOC includes cobbles in the downstream pool; GSM includes gravels and fine sediments in the pool; Marginal vegetation includes sedges but only out of current. Habitat availability is marginal in terms of flowing biotopes.
Site 4: Ontploffings Drif (unknown)	SIC includes riffles and runs over boulders and bedrock; SOOC included cobble substrates in large pools. Some gravel and sand is present in slackwaters but the channel is dominated by large material. Marginal vegetation is sparse with isolated patches of sedge along pools (only vegetation out of current sampled). Habitat availability is moderate to good.	No flowing biotopes available. The site is reduced to a series of stagnant pools and thus SASS and water quality sampling is not applicable.
Site 5: Alwyns Drif (control)	SIC includes cobbled runs and riffles; SOOC includes cobbles in large pools. GSM is limited as the substrate is predominantly stony. Marginal vegetation includes both sedges and shrubs with aquatic macrophytes both in and out of current. Habitat availability is good.	SIC includes cobbled runs and riffles; SOOC includes cobbles in large pools. GSM is limited as the substrate is predominantly stony. Marginal vegetation includes both sedges and shrubs with aquatic macrophytes but only out of current. Habitat availability is good.

Figure3.1 Location of the sites sampled on in September 2017 and again in December 2017.

3.3 Water quality Assessment

In situ measurements of Electrical Conductivity (EC) (mS m^{-1}), pH, Dissolved Oxygen (DO) (mg/l) and temperature (^{0}C) were carried out at the sites described above during the three site visits, using a calibrated hand-held Lovibond Sensodirect 150 multimeter.

Water samples collected for analysis of various water quality components were kept cool and sent to a laboratory for further analysis within 48 hours of collection.

Methods for analysis of inorganic components and hydrocarbons are described in the Baseline Assessment Report (Ewart-Smith 2017).

3.4 SASS5 Bioassessment

The South African Scoring System version 5 (SASS5) was used for the assessment of macroinvertebrate communities within the Meirings River. Details of the method are included in the Baseline Assessment Report (Ewart-Smith 2017). The SASS5 approach to the evaluation of macroinvertebrate communities is not appropriate to systems that are not flowing. Considering that Site 4 (Ontploffings Drif) was not flowing at the time of the site visit, no aquatic invertebrate samples were collected from this site in December 2017.

SASS5 sampling was done separately for each available biotope (defined by flow and substratum characteristics) (Table 3.1). While all habitats (i.e. 'stones-in-current' (SIC), , 'stones-out-of-current' (SOOC), 'gravel-sand-mud' (GSM) and Vegetation were present, habitat quality was someone impaired by low flow conditions during December 2017, compared to those sampled in September 2017 (Table 3.1).

SASS5 scores, Average Scores Per Taxon (ASPTs)[1] – (calculated by dividing the SASS5 score by the number of taxa) and total number of taxa were calculated for each biotope.

For this study, samples from each habitat were preserved in 98% ethanol for later identification to species level (or closest taxonomic level) if necessary.

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[1] ASPTs are particularly useful as indicators of water quality of an aquatic system, as a low score will indicate that the community is dominated by species resistant to anthropogenic perturbations such as pollution, while high scores indicate the occurrence of more sensitive and, often rare, species, that would be expected to occur in undisturbed systems.

3.5 Fish communities

Samples were collected using Fyke nets situated in suitable pool habitat located within the vicinity of each of the 5 biomonitoring sites thus representative of communities 1) above spill, 2) within the spill zone and 3) below spill zone. The fyke nets (60 cm x 60 cm bottom entrance) were set at the top of each pool with the open end of the net downstream and the wings attached to the banks. Fyke nets were left overnight and retrieved the following morning and all fish caught were identified to species level, measured and total length (TL) recorded.

Figure 3.2 Fyke nets were set at the upstream end of the selected pool habitats and left overnight.

4 RESULTS AND DISCUSSION

4.1 Water Quality

Diesel Range Organic (DRO) concentrations in the range C_{10}-C_{19} were recorded in the sediments within the Impact Zone during December 2017 with the highest concentrations at site 2 (Spiltech) decreasing with distance downstream (site 3: Derde Tol Drif) (Table 4.1). Surprising, low concentrations C15 and C17 were recorded at site 1: Middelwater, which is the upstream control site where it was expected that hydrocarbon contamination would be zero. This suggests that, besides contamination from the diesel spill event, the Meirings River may be contaminated with hydrocarbons from other sources, possibly vehicular activity within the river channel upstream or runoff from the road.

Despite the presence of hydrocarbons within the Impact Zone during December 2017, the concentrations were significantly lower than those measured by Geomeasure (Geomeasure 2017) immediately following the diesel spill (Table 4.1). While no slicks or sheens typical of refined fuels such as diesel were evident initially, following disturbance of the substratum and marginal vegetation for sampling purposes, clear diesel slicks were evident, particularly at the Spiltech site during December 2017 (Figure 4.2). This suggests that while surface water clean-up operations have been effective, the sediments along the river are still contaminated with hydrocarbons.

Figure 4.1 Surface water slicks present at site 2 (Spiltech) following disturbance of the marginal vegetation and substrate during December 2017

Table 4.1 A comparison of hydrocarbon concentrations measured in the sediments within the impact zone immediately following the spill event and again 4 months later (December 2017).

Group	C	Compound	September 2017		December 2017				
			SS3 (~ Spilltech)	SS4 (~ Derdetol)	Middlewater	Spilltech	Derdertol	Ontplof	Aalwyn
		Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			µg/ℓ						
GRO's	6	Benzene	< 200	< 20	< 20	< 20	< 20	< 20	< 20
	7	Toluene	< 2000	< 200	< 200	< 200	< 200	< 200	< 200
	8	Ethyl Benzene	1600	< 40	< 40	< 40	< 40	< 40	< 40
	8	Xylene(*m + p + o*)	10400	< 40	< 40	< 40	< 40	< 40	< 40
	8	Xylene - *m + p*	7100	< 40	< 40	< 40	< 40	< 40	< 40
	9	1,3,5-Trimethyl Benzene	4600	< 40	< 40	< 40	< 40	< 40	< 40
	9	1,2,4-Trimethy Benzene	23000	170	< 40	< 40	< 40	< 40	< 40
PAH's	10	Naphthalene	< 400	< 40	< 40	< 40	< 40	< 40	< 40
	12	Acenaphthylene	< 200	< 20	< 20	< 20	< 20	< 20	< 20
	12	Acenaphthene	< 200	< 20	< 20	< 20	< 20	< 20	< 20
	13	Fluorene	1100	< 20	< 20	< 20	< 20	< 20	< 20
	14	Phenanthrene	< 200	< 20	< 20	< 20	< 20	< 20	< 20
	14	Anthracene	< 200	< 20	< 20	< 20	< 20	< 20	< 20
	16	Pyrene	< 200	24	< 20	< 20	< 20	< 20	< 20
	16	Fluoranthene	< 200	32	< 20	< 20	< 20	< 20	< 20
DRO's	10	C10	15000	2900	< 20	< 20	< 20	< 20	< 20
	11	C11	35000	22000	< 20	27	< 20	< 20	< 20
	12	C12	39000	28000	< 20	130	< 20	< 20	< 20
	13	C13	47000	11000	< 20	230	< 20	< 20	< 20
	14	C14	38000	29000	< 20	210	< 20	< 20	< 20
	15	C15	34000	11000	27	140	140	< 20	< 20
	16	C16	17000	4100	< 20	120	24	< 20	< 20
	17	C17	7100	1600	72	120	170	< 20	< 20
	18	C18	2600	750	< 20	44	< 20	< 20	< 20
	19	C19	920	380	< 20	31	< 20	< 20	< 20
	20	C20	< 200	85	< 20	< 20	< 20	< 20	< 20
Total VPH's (identified)			277320	111041	< 200	1052	334	< 200	< 200
Estimated VPH's (Unidentified)			3200000	1200000	< 200	20000	1500	< 200	< 200
Estimated Total VPH's			3477320	1311041	< 200	21052	1834	< 200	< 200

In situ measurements of pH, Electrical Conductivity (EC) , water temperature and Dissolved Oxygen (DO) in December 2017 are given in Table 4.2.

Table 4.2 *In situ* measurements of physico-chemistry from the biomonitoring sites on 18th and 19th December 2017

Site	Description	pH	EC (mSm)	Temp (^{0}C)	Dissolved Oxygen (mg/l)
Site 1	Middelwater	7.58	76.1	23.9	4.1
Site 2	Spiltech	7.73	63.7	21.3	9
Site 3	Derdetols Drif	7.73	64.4	20.8	6.4
Site 4	Ontploffings Drif	-	-	-	-
Site 5	Aalwyn Drif	7.65	13.4	18.6	9.7

Dissolved Oxygen (DO) concentrations were significantly lower in December 2017, particularly at sites 1 and 3 compared with concentrations recorded in September and October 2017 (Figure 4.2). These concentrations are comparable with those measured within the impact zone immediately following the diesel spill in August 2017. Interestingly, the Spilltech site had a relatively high DO concentration (9 mg/l) during December 2017 (Table 4.2). DO concentrations < 8 mg/l are generally considered impacted (DWAF 2008). These low DO concentrations in the Meirings River may, in part, reflect natural seasonal conditions with barely perceptible flow and high water temperatures evident at the time of sampling in December 2017

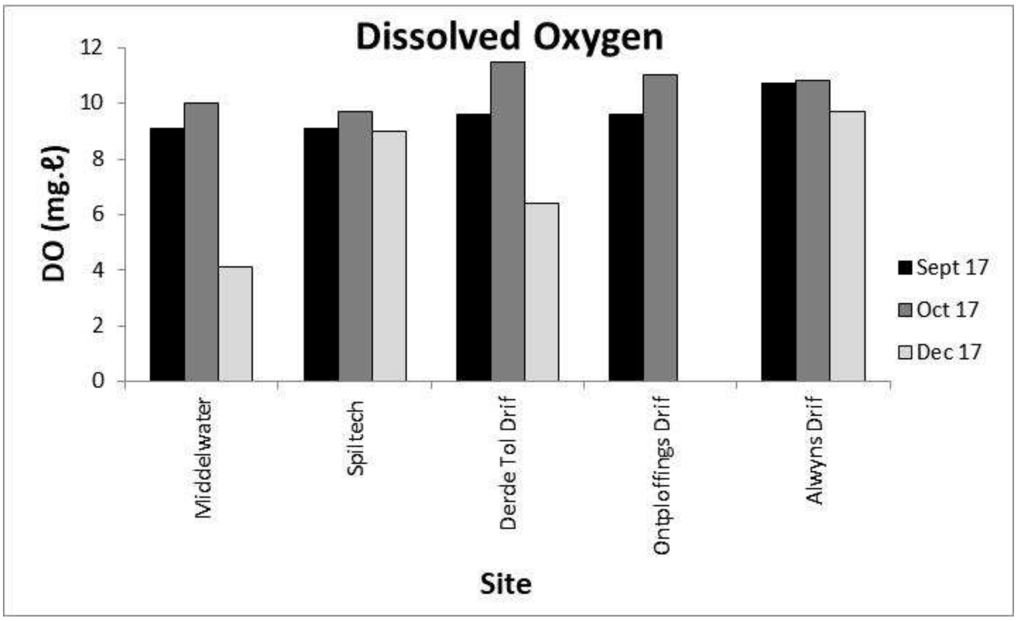

Figure 4.2 Dissolved Oxygen Concentrations (DO) measured in September, October and December 2017.

By December 2017, Chemical Oxygen Demand (COD) at all monitoring sites was below the detectible limit of 10 mg/l. Elevated COD, indicative of dissolved hydrocarbons, was still evident within the impact zone as well as downstream at Ontploffings Drif (Figure 4.3) during October 2017. Concerns around increased bioavailability of hydrocarbons following the application of BioSolve® and the indication that the effects of such contamination extended downstream of the impact zone were highlighted in the Baseline Assessment Report. The undetectable COD levels in December 2017 therefore suggest that these adverse conditions were no longer present within the system.

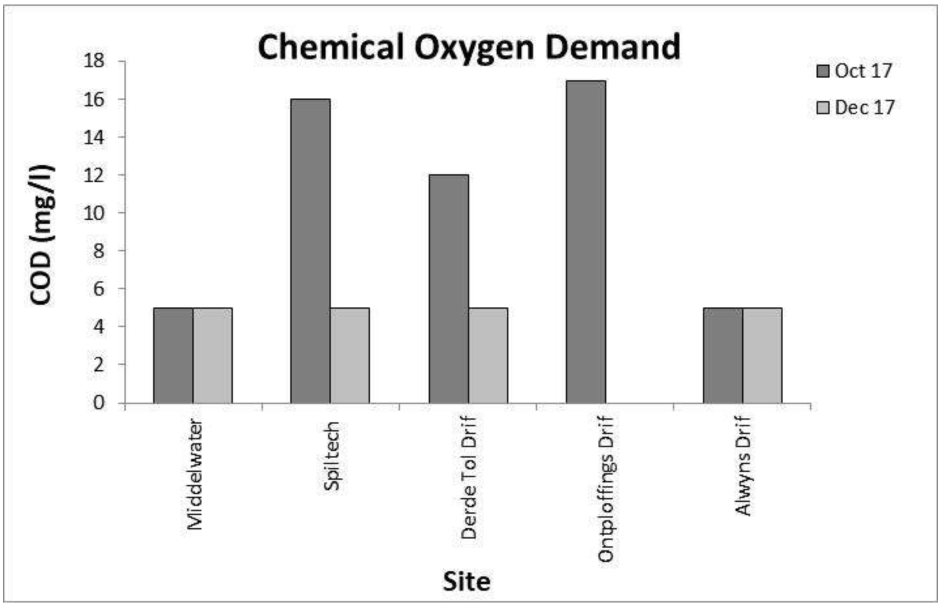

Figure 4.3 Chemical Oxygen Demand (COD) measured in October and December 2017.

Despite elevated Total Oils and Grease (TOG) concentrations in October 2017 as far downstream as Alwyns Drif, TOG concentrations were considerably lower at all sites by December 2017 (Figure 4.4). While there are no clear guidelines for thresholds of toxicity associated with oils and grease in South Africa, the United Nations Environmental Programme (UNEP 1992) stipulate maximum permissible limits of 10 ppm (or mg/l) for oils. These December 2017 data therefore suggest that soluble hydrocarbons indicated by elevated TOGs in October 2017 are currently of insignificant concern for the aquatic biota of the Meirings River.

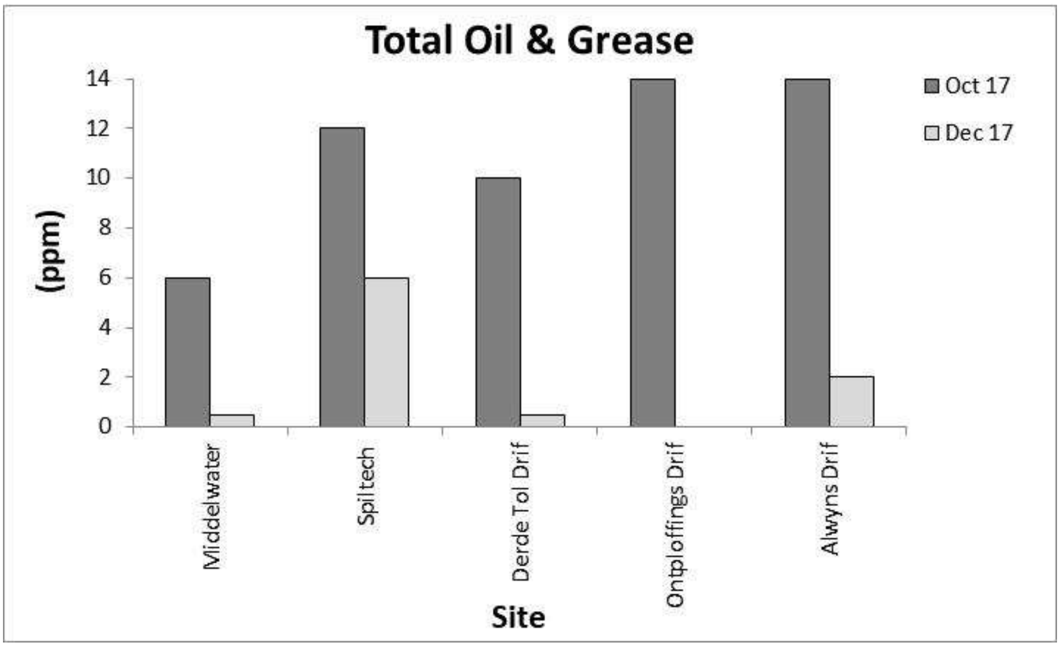

Figure 4.4 Total Oil and Grease measured in October and December 2017.

Similar to the nutrient data for October 2017, the nutrient concentrations measured in December 2017 indicate that the is no apparent effect of the diesle spill or use of surfactants on the trophic status of the Meirings River.

Table 4.2 Nutrient concentrations for water samples collected in December 2017

Site	Site Description	NO_3 - N (mg/l)	NO_2 - N (mg/l)	PO_4-P (mg/l)	$NH4^+$ + NH_3 [mg/l]	NH_3 - N [mg/l]	TIN (mg/l)
Site 1	Middelwater	<0.13	<0.001	0.015	0.03	0.0006353	0.033
Site 2	Spiltech	<0.13	<0.001	0.016	<0.001	0.0000297	0.005
Site 3	Derde Tol Drif	<0.13	<0.001	0.012	<0.001	0.0000297	0.007
Site 4	Ontploffings Drif	-	-	-	-	-	-
Site 5	Alwyns Drif	<0.13	<0.001	0.006	<0.001	0.0000248	0.003

4.2 Macroinvertebrate fauna

The macroinvertebrate community data are summarised as SASS and ASPT scores for each site (Figure 4.5) and for each biotope sampled in December 2017 (Figure 4.6). The relative abundance of each taxon reported is given in Appendix A.

At Middelwater (site 1), upstream of the impact zone, both the SASS and ASPT scores were lower than that recorded in September 2017 (Figure 4.5). Similarly, a reduction in both SASS and ASPT scores was recorded at Alwyns Drif (site 5) in December 2017 far downstream of the impact zone. However, the ecological condition of the Middelwater site dropped from a category D to a category E (Figure 4.5) in December 2017, with less change in condition evident at Alwyns Drift.

A general shift in ecosystem integrity between September and December 2017 may in part be linked to dry season conditions with lower flows and higher water temperatures which create stressful conditions for aquatic fauna over the summer period. However the presence of only a few hardy taxa over the dry season at Middelwater suggests that low flow conditions are exacerbated by significant upstream abstraction. Essentially, these results indicate that the ecological condition of the system as indicated by SASS and ASPT scores (Figure 4.5, Table 4.3) is somewhat impacted by activities that are unrelated to the oil spill event.

Relative to the September 2017 invertebrate communities within the impact zone (Sites 2 and 3), a considerable recovery was evident at both impacted sites, but particularly at the Spiltech site (site 2) immediately downstream of the spill entry point (Figure 4.5). Very few invertebrates were present during the September 2017, with those surviving taxa known to be hardy and pollution tolerant. By December 2017, a total of 57 individuals representing 12 families were recorded at this site (Appendix A2). Although most taxa within the impact zone are considered relatively hardly and pollution tolerant, indicative of a severely altered condition (ecological condition is a category E), the community in December 2017 is comparable with the upstream control site (Middelwater) (Appendix A1 and A2).

While site 3 at the lower extend of the impact zone (i.e. Derde Tol Drif) shows a drop in Ecological Condition from a Category D to a Category E (Figure 4.5), this is also likely linked to poor habitat available associated with low water levels in December 2017. Indeed, the SASS and ASPT scores for individual biotopes (Figure 4.6) show higher SASS and ASPT scores for both stones and gravel-sand-mud (GSM) in December 2017, compared with September 2017 but lower values for vegetation. While the higher scores for stones and GSM indicate recovery of the system since September 2017, the lower scores for vegetation are indicative of poor habitat quality in December relative to September 2017 because most of the marginal vegetation was above the water level at this time.

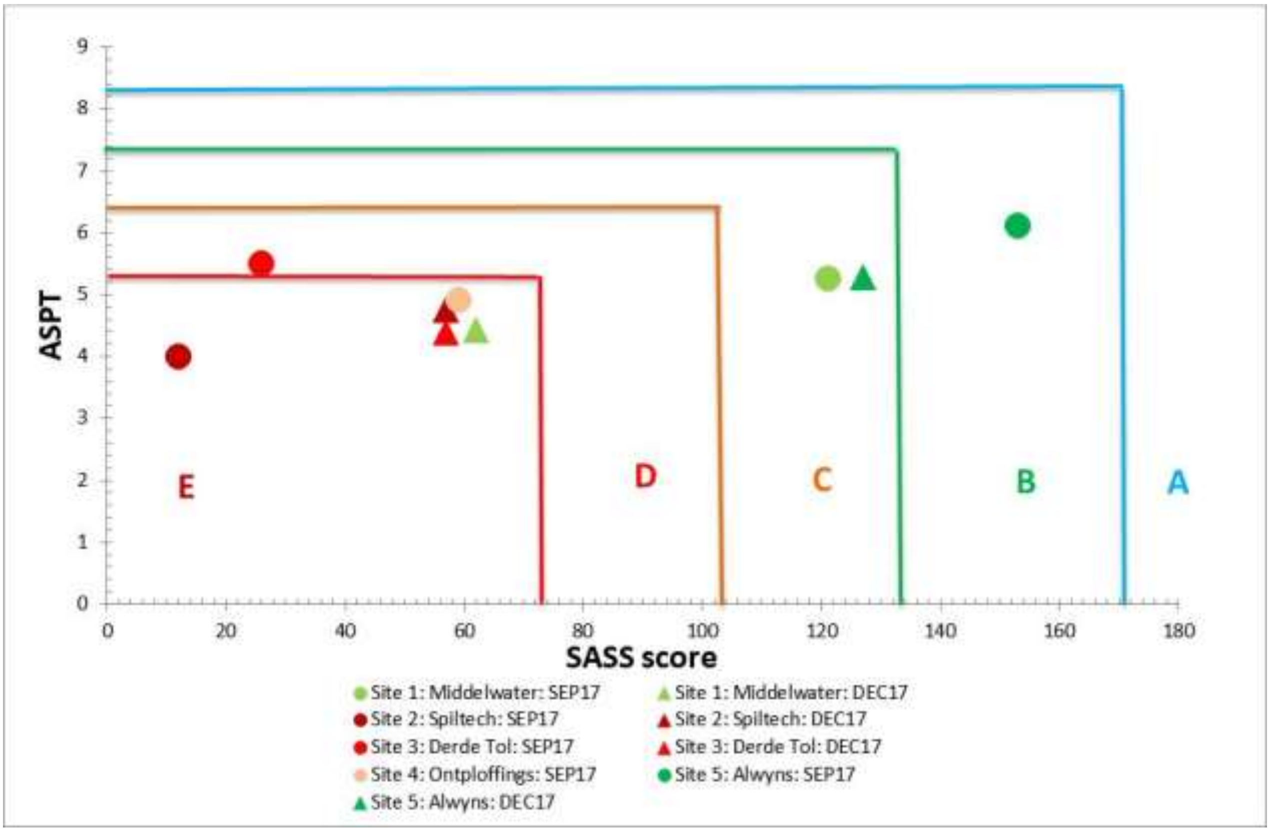

Figure 4.5 SASS scores and ASPT values at biomonitoring sites on the Meirings River for both September and December 2017. The biological bands depicting change in condition are taken from Dallas (2007).

Table 4.3 A description of the ecological categories for interpreting SASS data as an indicator of ecosystem health (after Dallas 2007).

Class	Description
A	SASS and ASPT scores are representative of reference conditions i.e. sites that are near natural with little or no impairment of habitat or water quality
B	SASS and ASPT scores are lower than expected; condition is good and the system is still largely natural i.e. there may be some impairment of water quality and/or habitat with a loss of some pollution-sensitive taxa
C	SASS and ASPT scores are much lower than expected, condition is fair and the system is moderately modified i.e. substantial impairment of water quality and/or habitat with a major loss of pollution-sensitive taxa
D	SASS and ASPT scores are considerably lower than expected, condition is poor and the system is largely modified i.e. substantial impairment of water quality and/or habitat with almost a total loss of pollution-sensitive taxa
E/F	Few of the expected taxa remain indicating severe impairment. The system is critically modified and the remaining taxa are hardy and pollution-tolerant

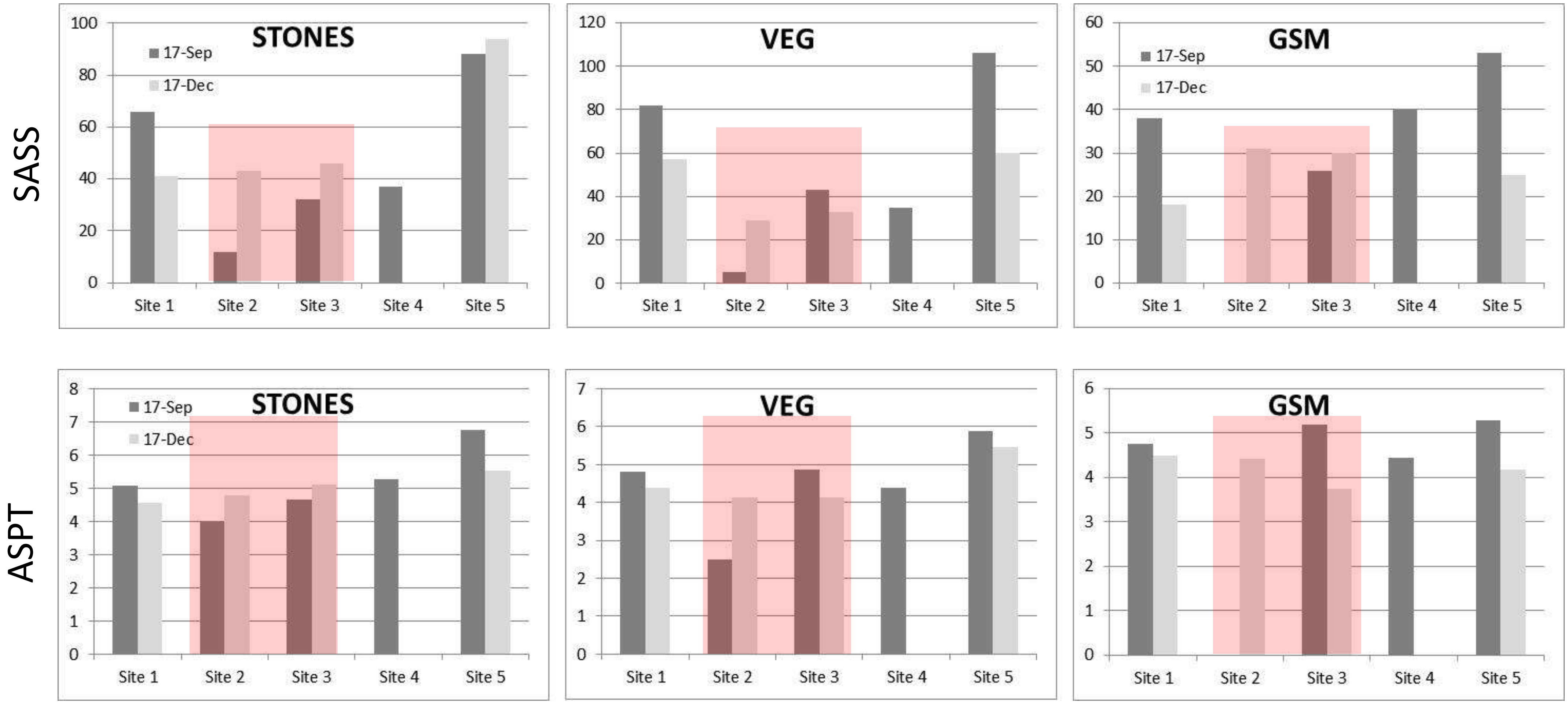

Figure 4.6 **SASS scores and ASPT values at biomonitoring sites for each of the three biotopes sampled (i.e. Stones, Vegetation and Gravel-Sand-Mud (GSM)) on the Meirings River. The red area represents sites within the impact zone and shows the difference in recovery between biotopes dependant on the availability of aquatic habitats.**

4.3 Fish communities

The abundance of fish caught during the December 2017 survey upstream of the spill zone (i.e. at Middelwater) within the impact zone (i.e. Spiltech and Derde Tol Drif) and downstream of the impact zone (i.e. Ontploffings Drif and Alwyns Drif) are given in Table 4.3.

Table 4.3 Results of the fish monitoring conducted between 17 and 19 December 2017 in the Meiringspoort River.

Date	Locality	GPS Coordinates	Smallscale redfin adult	Smallscale redfin juvenile	Slender redfin adult	Slender redfin juvenile	Other fish
Above spill zone							
18/12/2017	Middelwater top pool	33 21 41.42 S, 22 32 29.31 E		6			
19/12/2017	Middelwater lower pool	33 21 42.48 S, 22 32 30.73 E	10	200			
Spill zone							
19/12/2017	Spilltech top pool	33 22 22.16 S, 22 33 13.93 E	28	38			
18/12/2017	Derde tol	33 22 45.42 S, 22 33 26.80 E	81	150			
Below spill zone							
19/12/2017	Ontploffings drift	33 23 21.22 S, 22 33 27.56 E	7	28			
18/12/2017	Alwynsdrift	33 26 31.77 S, 22 33 55.32 E			1	495	2 sharptooth catfish (alien)

These results confirm the importance of the two large pools (Spilltech top pool and Derde Tol middle pool) in spill zone for the future survival of the smallscale redfin in the Gouritz catchment (Table 4.3). The combined data of the two rescue efforts and monitoring events (Figure 4.7) indicate that healthy numbers of smallscale redfins are still present in the spill zone and that recruitment has taken place this summer (Figure 4.8). During the first rescue effort by CapeNature (Jordaan 2017)between 6 and 8 September 2017, most of the smallscale redfins were caught in the lower pool at Derde Tol. This is most likely due to the fact that the redfins moved downstream in order to avoid hydrocarbon contamination and a sudden drop in oxygen associated with the spill event. This pool was not suitable for fyke netting during this monitoring due to a lack of water, most likely caused by the mechanical clearing of sand from the Derde Tol road crossing by the Provincial Roads Department. CapeNature also reported that the redfins caught during the first rescue effort were lethargic and this can also have prevented them from being trapped in the fyke nets during the two rescue efforts. The juvenile smallscale redfins caught during this monitoring were estimated to be between 10 and 5 weeks old. Some of the female redfins caught were gravid (Figure 4.7), indicating further spawning events in the upcoming weeks.

The general condition of the smallscale redfins was good and no external parasites or lesions were observed. No lethargic redfins were encountered. Further monitoring of the impact zone will indicate the degree of survival of these juvenile redfins and if contamination by hydrocarbons has had a delayed effect on the population.

The biggest threat to the survival of remaining smallscale redfin populations are alien fish species. The fact that no alien fish are present in the impact zone further highlights the importance of these pools for the future conservation of this species.

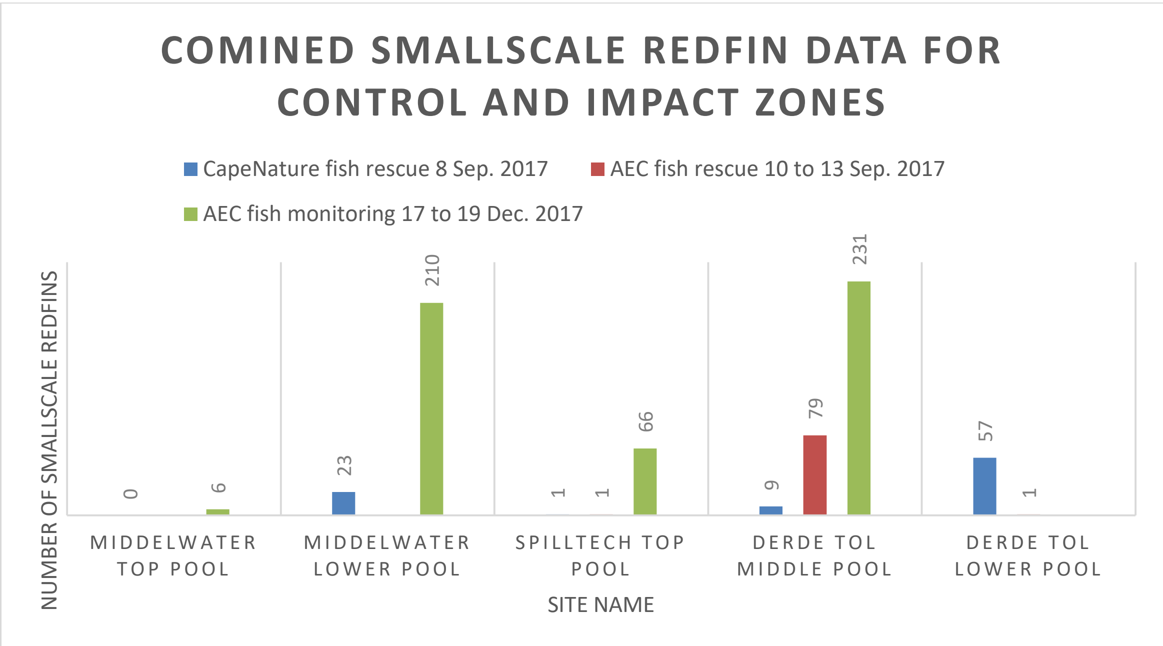

Figure 4.7 Combined data of smallscale redfins from the three rescue/monitoring efforts in 2017. Only the data for the control and spill zone sites are included.

The two control pools at Middelwater also yielded smallscale redfins during December 2017 indicative of spawning between September and December 2017.

The pool below Ontploffings Drif were also sampled In December 2017 (Figure 4.7) and yielded adult and juvenile smallscale redfins. This pool is about 500 meters below the spill zone and will be a good indicator of whether or not the impacts of the spill event have extended downstream of the spill zone that extends as far as Derde Tol Drif. All fish sampled were in a healthy state with gravid females present.

The most downstream monitoring was at Alwyns Drif and the fyke net yielded one adult slender redfin and 495 juveniles. The juveniles could not be identified to species level due to their small size but it can be assumed that they are slender redfins due to the fact that slender redfins are the dominant species in the lower Meiringspoort River system. Two invasive alien sharptooth catfish were also caught in this pool.

It seems that the slender redfin population has recovered well since the diesel spill but further monitoring is required to establish if there are delayed effects.

Figure 4.8 A gravid female smallscale redfin from the spill zone.

5 CONCLUSIONS AND RECOMMENDATIONS

The Baseline Assessment Report (Ewart-Smith 2017) presented data suggesting that the diesel spill in August 2017 had a severe negative impact on the water quality and aquatic biota of the Meirings River. This report has presented data that indicate significant recovery of the system since September 2017. Undetectable COD concentrations and low concentration of TOG suggest that surface water clean-up operations have been effective in removing diesel contamination from the water column. Nevertheless, the channel banks and bed of the Meirings River are still contaminated with slicks of diesel visible on disturbance of the substrate.

The macroinvertebrate community at all sites during December 2017 was indicative a system that is impacted. This is largely due to poor habitat availability associated with low summer base flows, the effects of which are exacerbated by abstraction upstream. Within the impact zone, recovery of the community is significant and the community supports taxa similar to that at the upstream control site.

Macroinvertebrate community data collected at Ontploffings Drif (Site 4) in September 2017 indicated that the impact of the oil spill on the Meirings River extended beyond the impact zone. No flowing water was observed at this site during the December 2017 survey. Thus, it is unclear whether the poor condition of this site in September 2017 was a result of diesel contamination or simply that flows subverge at this point in the river, resulting in poor habitat conditions. Considering that no hydrocarbons were found in the sediments during December 2017, it is likely that the poor ecological integrity of this site is driven by the periodic absence of flow, rather than the spill event.

The fish data presented indicate that a significant population of smallscale redfins has survived within the spill zone and that recruitment has occurred over the summer, despite the diesel spill event in August 2017. While the redfins appear to have recovered in the short term, the long term impacts on the population are unknown. Although it was initially planned that fish surveys would be undertaken quarterly, as planned for the aquatic invertebrate and water chemistry components, quarterly fish surveys are not considered necessary. Instead, it is recommended that the fish monitoring be extended over a three year period so that reproductive success of the populations of redfin within the impact zone can be established.

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APPENDIX A: INVERTEBRATE TAX RECORDED IN EACH SASS BIOTOPE AT THE BIOMONITORING SITES DURING DECEMBER 2017

A1: Site 1: MIDDELWATER

Date: 19.12.2017		Sensitivity	Biotope						Sensitivity	Biotope			
Order	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**	**Order**	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**
PORIFERA		5					TRICHOPTERA	Dipseudopsidae	10				
COELENTERATA		1						Ecnomidae	8				
TURBELLARIA		3						Hydropsychidae 1 sp.	4				
ANNELIDA	Oligochaeta	1						Hydropsychidae 2 sp.	6				
	Leeches	3						Hydropsychidae >2 sp.	12				
CRUSTACEA	Amphipoda	13						Philopotamidae	10				
	Potamonautidae	3						Polycentropodidae	12				
	Atydiae	8						Psychomyiidae	8				
	Palaemonidae	10						Barbarochthonidae	13				
HYDRACARINA		8						Calamoceratidae	11				
PLECOPTERA	Notonemourdae	14						Glossosomatidae	11				
	Perlidae	12						Hydroptilidae	6	A	1		A
EPHEMEROPTERA	Baetidae 1 sp.	4						Hydrosalpingidae	15				
	Baetidae 2 sp.	6	C	C		C		Lepidostomatidae	10				
	Baetidae > 2 sp.	12						Leptoceridae	6				
	Caenidae	6	B	A		B		Petrothrinicidae	11				
	Ephemeridae	15						Pisuliidae	10				
	Heptageniidae	13						Sericostomatidae	13				
	Leptophlebiidae	9					COLEOPTERA	Dytiscid	5	A	B	A	B
	Oligneuridae	15						Elmidae	8				
	Polymitarcyidae	10						Gyrinidae	5				
	Prosopistomatidae	15						Haliplidae	5				
	Teloganodidae	12						Helodidae	12				
	Tricorythidae	9						Hydraenidae	8				
ODONATA	Calopterygidae	10						Hydrophilidae	5	A	B	A	B
	chlorocyphidae	10						Limnichidae	10				
	Chlorolestidae	8						Psephenidae	10				
	Coenagrionidae	4					DIPTERA	Athericidae	10				
	Lestidae	8						Blepharoceridae	15				
	Platycnemidae	10						Ceratopogonidae	5			A	A
	Protoneuridae	8						Chironomidae	2	A	B		B
	aeshnidae	8						Culicidae	1	1	1		A
	Corduliidae	8						Dixidae	10				
	Gomphidae	6						Empiddidae	6				
	Libellulidae	4						Ephydridae	3				
LEPIDOPTERA	Pyralidae	12						Muscidae	1				
HEMIPTERA	Belostomatidae	3						Psychodidae	1				
	Corixidae	3	A	1	A	B		Simulidae	5				
	Gerridae	5		1		1		Syrphidae	1				
	Hydrometridae	6						Tabanidae	5				
	Naucoridae	7	A	1		A		Tipulidae	5				
	Nepidae	3					GASTROPODA	Ancylidae	6				
	Notonectidiae	3						Bulininae	3				
	Pleidae	4						Hydrobiidae	3				
	Veliidae/Mesoveliidae	5		A		A		Lymnaeidae	3		A		A
MEGALOPTERA	Corydalidae	8						Physidae	3		B		B
	Sialidae	6						Planorbidae	3				
								Thiaridae	3				
								Viviparidae	5				
							PELECPODA	Corbiculidae	5				
								Sphaeriidae	3				
								Unionidae	6				
									SASS	41	57	18	**62**
									Total number of families	9	13	4	**14**
									ASPT	4.6	4.385	4.5	**4.4**
									EC	**E/F**			

A2: Site 2: SPILTECH

Date: 19.12.2017		Sensitivity	Biotope						Sensitivity	Biotope			
Order	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**	**Order**	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**
PORIFERA		5					TRICHOPTERA	Dipseudopsidae	10				
COELENTERATA		1						Ecnomidae	8				
TURBELLARIA		3						Hydropsychidae 1 sp.	4				
ANNELIDA	Oligochaeta	1	A			A		Hydropsychidae 2 sp.	6				
	Leeches	3						Hydropsychidae >2 sp.	12				
CRUSTACEA	Amphipoda	13						Philopotamidae	10				
	Potamonautidae	3						Polycentropodidae	12				
	Atydiae	8						Psychomyiidae	8				
	Palaemonidae	10						Barbarochthonidae	13				
HYDRACARINA		8						Calamoceratidae	11				
PLECOPTERA	Notonemourdae	14						Glossosomatidae	11				
	Perlidae	12						Hydroptilidae	6				
EPHEMEROPTERA	Baetidae 1 sp.	4	B		A	B		Hydrosalpingidae	15				
	Baetidae 2 sp.	6		B		B		Lepidostomatidae	10				
	Baetidae > 2 sp.	12						Leptoceridae	6			1	1
	Caenidae	6	1		1	A		Petrothrinicidae	11				
	Ephemeridae	15						Pisuliidae	10				
	Heptageniidae	13						Sericostomatidae	13				
	Leptophlebiidae	9					COLEOPTERA	Dytiscid	5	A	1	B	B
	Oligneuridae	15						Elmidae	8				
	Polymitarcyidae	10						Gyrinidae	5	1	1	1	A
	Prosopistomatidae	15						Haliplidae	5				
	Teloganodidae	12						Helodidae	12				
	Tricorythidae	9						Hydraenidae	8				
ODONATA	Calopterygidae	10						Hydrophilidae	5	1	1		A
	chlorocyphidae	10						Limnichidae	10				
	Chlorolestidae	8						Psephenidae	10				
	Coenagrionidae	4					DIPTERA	Athericidae	10				
	Lestidae	8						Blepharoceridae	15				
	Platycnemidae	10						Ceratopogonidae	5				
	Protoneuridae	8						Chironomidae	2	B	A	A	B
	aeshnidae	8						Culicidae	1				
	Corduliidae	8						Dixidae	10				
	Gomphidae	6						Empiddidae	6				
	Libellulidae	4						Ephydridae	3	A	1		A
LEPIDOPTERA	Pyralidae	12	1			1		Muscidae	1				
HEMIPTERA	Belostomatidae	3						Psychodidae	1				
	Corixidae	3			1	1		Simulidae	5				
	Gerridae	5						Syrphidae	1				
	Hydrometridae	6						Tabanidae	5				
	Naucoridae	7						Tipulidae	5				
	Nepidae	3					GASTROPODA	Ancylidae	6				
	Notonectidiae	3						Bulininae	3				
	Pleidae	4						Hydrobiidae	3				
	Veliidae/Mesoveliidae	5						Lymnaeidae	3		1		1
MEGALOPTERA	Corydalidae	8						Physidae	3				
	Sialidae	6						Planorbidae	3				
								Thiaridae	3				
								Viviparidae	5				
							PELECPODA	Corbiculidae	5				
								Sphaeriidae	3				
								Unionidae	6				
									SASS	43	29	31	**57**
									Total number of families	9	7	7	**12**
									ASPT	4.8	4.1	4.4	**4.75**
									EC	**E/F**			

A3: Site 3: DERDE TOL DRIF

Date: 19.12.2017		Sensitivity	Biotope			
Order	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**
PORIFERA		5				
COELENTERATA		1				
TURBELLARIA		3				
ANNELIDA	Oligochaeta	1			1	1
	Leeches	3				
CRUSTACEA	Amphipoda	13				
	Potamonautidae	3				
	Atydiae	8				
	Palaemonidae	10				
HYDRACARINA		8				
PLECOPTERA	Notonemourdae	14				
	Perlidae	12				
EPHEMEROPTERA	Baetidae 1 sp.	4			A	A
	Baetidae 2 sp.	6		B		B
	Baetidae > 2 sp.	12	B			B
	Caenidae	6	B			B
	Ephemeridae	15				
	Heptageniidae	13				
	Leptophlebiidae	9				
	Oligneuridae	15				
	Polymitarcyidae	10				
	Prosopistomatidae	15				
	Teloganodidae	12				
	Tricorythidae	9				
ODONATA	Calopterygidae	10				
	chlorocyphidae	10				
	Chlorolestidae	8				
	Coenagrionidae	4				
	Lestidae	8				
	Platycnemidae	10				
	Protoneuridae	8				
	aeshnidae	8				
	Corduliidae	8				
	Gomphidae	6				
	Libellulidae	4		1		1
LEPIDOPTERA	Pyralidae	12				
HEMIPTERA	Belostomatidae	3				
	Corixidae	3	A	A	B	B
	Gerridae	5				
	Hydrometridae	6				
	Naucoridae	7	A	1	A	A
	Nepidae	3				
	Notonectidiae	3		A		A
	Pleidae	4				
	Veliidae/Mesoveliidae	5				
MEGALOPTERA	Corydalidae	8				
	Sialidae	6				

		Sensitivity	Biotope			
Order	**Family/taxa**	**rating**	**Stones**	**Veg**	**GSM**	**Overall**
TRICHOPTERA	Dipseudopsidae	10				
	Ecnomidae	8				
	Hydropsychidae 1 sp.	4				
	Hydropsychidae 2 sp.	6				
	Hydropsychidae >2 sp.	12				
	Philopotamidae	10				
	Polycentropodidae	12				
	Psychomyiidae	8				
	Barbarochthonidae	13				
	Calamoceratidae	11				
	Glossosomatidae	11				
	Hydroptilidae	6				
	Hydrosalpingidae	15				
	Lepidostomatidae	10				
	Leptoceridae	6				
	Petrothrinicidae	11				
	Pisuliidae	10				
	Sericostomatidae	13				
COLEOPTERA	Dytiscid	5	B	B	A	B
	Elmidae	8				
	Gyrinidae	5				
	Haliplidae	5				
	Helodidae	12				
	Hydraenidae	8				
	Hydrophilidae	5				
	Limnichidae	10				
	Psephenidae	10				
DIPTERA	Athericidae	10				
	Blepharoceridae	15				
	Ceratopogonidae	5	1		1	A
	Chironomidae	2	A	B	B	B
	Culicidae	1				
	Dixidae	10				
	Empiddidae	6				
	Ephydridae	3	A			A
	Muscidae	1				
	Psychodidae	1				
	Simulidae	5				
	Syrphidae	1				
	Tabanidae	5				
	Tipulidae	5				
GASTROPODA	Ancylidae	6				
	Bulininae	3				
	Hydrobiidae	3				
	Lymnaeidae	3	A	A		A
	Physidae	3			A	A
	Planorbidae	3				
	Thiaridae	3				
	Viviparidae	5				
PELECPODA	Corbiculidae	5				
	Sphaeriidae	3				
	Unionidae	6				

	Stones	Veg	GSM	Overall
SASS	46	33	30	**57**
Total number of families	9	8	8	**13**
ASPT	5.1	4.1	3.8	**4.4**
EC	**E/F**			

A4: Site 5: ALWYNS DRIF

Date: 19.12.2017		Sensitivity	Biotope						Sensitivity	Biotope			
Order	Family/taxa	rating	Stones	Veg	GSM	Overall	Order	Family/taxa	rating	Stones	Veg	GSM	Overall
PORIFERA		5					TRICHOPTERA	Dipseudopsidae	10				
COELENTERATA		1						Ecnomidae	8	A			A
TURBELLARIA		3	A			A		Hydropsychidae 1 sp.	4				
ANNELIDA	Oligochaeta	1			A	A		Hydropsychidae 2 sp.	6	B			B
	Leeches	3						Hydropsychidae >2 sp.	12				
CRUSTACEA	Amphipoda	13						Philopotamidae	10				
	Potamonautidae	3	1			1		Polycentropodidae	12				
	Atydiae	8						Psychomyiidae	8				
	Palaemonidae	10						Barbarochthonidae	13				
HYDRACARINA		8						Calamoceratidae	11				
PLECOPTERA	Notonemourdae	14						Glossosomatidae	11				
	Perlidae	12						Hydroptilidae	6	A			A
EPHEMEROPTERA	Baetidae 1 sp.	4						Hydrosalpingidae	15				
	Baetidae 2 sp.	6	B		A	B		Lepidostomatidae	10				
	Baetidae > 2 sp.	12		C		C		Leptoceridae	6				
	Caenidae	6	B		A	B		Petrothrinicidae	11				
	Ephemeridae	15						Pisuliidae	10				
	Heptageniidae	13						Sericostomatidae	13				
	Leptophlebiidae	9	1			1	COLEOPTERA	Dytiscid	5		B		B
	Oligneuridae	15						Elmidae	8				
	Polymitarcyidae	10						Gyrinidae	5				
	Prosopistomatidae	15						Haliplidae	5				
	Teloganodidae	12						Helodidae	12				
	Tricorythidae	9						Hydraenidae	8	A			A
ODONATA	Calopterygidae	10						Hydrophilidae	5	1	B		B
	chlorocyphidae	10						Limnichidae	10				
	Chlorolestidae	8						Psephenidae	10				
	Coenagrionidae	4		B		B	DIPTERA	Athericidae	10				
	Lestidae	8						Blepharoceridae	15				
	Platycnemidae	10						Ceratopogonidae	5				
	Protoneuridae	8						Chironomidae	2	A		1	A
	aeshnidae	8	A	A		A		Culicidae	1				
	Corduliidae	8						Dixidae	10				
	Gomphidae	6						Empiddidae	6				
	Libellulidae	4						Ephydridae	3				
LEPIDOPTERA	Pyralidae	12						Muscidae	1				
HEMIPTERA	Belostomatidae	3						Psychodidae	1				
	Corixidae	3		B	B	B		Simulidae	5	1			1
	Gerridae	5						Syrphidae	1				
	Hydrometridae	6						Tabanidae	5	A			A
	Naucoridae	7		A	A	A		Tipulidae	5				
	Nepidae	3					GASTROPODA	Ancylidae	6	B	A		B
	Notonectidae	3						Bulininae	3				
	Pleidae	4		A		A		Hydrobiidae	3				
	Veliidae/Mesoveliidae	5	1			1		Lymnaeidae	3		A		A
MEGALOPTERA	Corydalidae	8						Physidae	3				
	Sialidae	6						Planorbidae	3	1	B		B
								Thiaridae	3				
								Viviparidae	5				
							PELECPODA	Corbiculidae	5				
								Sphaeriidae	3				
								Unionidae	6				
									SASS	94	60	25	**127**
									Total number of families	17	11	6	**24**
									ASPT	5.5	5.5	4.2	**5.3**
									EC		**C**		