

Hemel en Aarde Wellfields Expansion Project

*HAV1 Replacement and T4/5 Borehole Drilling/Testing –
Section 21(c) and (i) Water Use Licence
Conditions Monitoring Report January–April 2024*



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Final Draft

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Overstrand Local Municipality

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Drilling/Testing – Section 21(c) and (i) Water
Use Licence Conditions Monitoring Report
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List of Abbreviations

~	-	approximately
°C	-	degrees Celsius
>	-	greater than
<	-	less than
%	-	percent
µg	-	microgram
a	-	annum
ASPT	-	Average Score Per Taxon
BGCMA	-	Breede-Gouritz Catchment Management Agency
BOCMA	-	Breede-Olifants Catchment Management Agency
CBA	-	Critical Biodiversity Area
DWAF	-	Department of Water Affairs and Forestry (1994-2009)
DWS	-	Department of Water and Sanitation (post-2014)
EC	-	electrical conductivity
e.g.	-	for example
FEN	-	Freshwater Ecologist Network
GSM	-	gravel, sand and mud
HAV	-	Hemel en Aarde Valley borehole
HR	-	Hamilton Russell
i.e.	-	in other words
l	-	litres
LM	-	local municipality
m	-	metre
Ma	-	millions of years
MAT	-	mean annual temperature
MAT _{mn}	-	average monthly minimum temperature
MAT _{mx}	-	average monthly maximum temperature
mbgl	-	metres below ground level
mg	-	milligram
mm	-	millimetre
m ³	-	cubic metre
mS	-	milliSiemens
Ma	-	millions of years
MAP	-	mean annual precipitation
No.	-	number
NTU	-	Nephelometric Turbidity Units
OM	-	Overstrand Local Municipality
PES	-	Present Ecological Status
Repl.	-	Replacement
SANBI	-	South African National Biodiversity Institute
SANAS	-	South African National Accreditation System
SANSA	-	South African National Space Agency
SASS5	-	South African Scoring System 5
SAWQG	-	South African Water Quality Guidelines
SAWS	-	South African Weather Service
TDS	-	total dissolved solids
TMG	-	Table Mountain Group
TS	-	Tokara Siberia
TSS	-	total suspended solids
TWQR	-	Target Water Quality Range
WCBSP	-	Western Cape Biodiversity Spatial Plan
WUL	-	water use licence

1. INTRODUCTION

1.1 Background

The greater Hermanus area within the Overstrand Local Municipality (OM) is supplied by a combination of surface water from the De Bos Dam and Peninsula Aquifer groundwater from the Gateway, Camphill and Volmoed Wellfields. The Gateway Wellfield Section 21(a) water use license (WUL; No. 18/G40H/A/1035; not applicable to this report) was awarded in June 2011 for a maximum daily combined groundwater abstraction rate of up to 60 litres per second (l/s), and a maximum groundwater abstraction volume of 1.6 million cubic metres per annum (m³/a).

The Camphill and Volmoed Wellfields (termed the Hemel en Aarde Wellfields in combination) Section 21(a) WUL (No. 18/G40H/A/2377) was awarded on 8th December 2013 (and amended on the 1st December 2021) for groundwater abstraction of up to 1.6 million m³/a, and the Section 21(c) and (i) WUL (No. 18/G40H/A/2377) on 12th December 2023. The Section 21(a) WUL for both Camphill and Volmoed Wellfields will be utilised in three stages of 0.8 million m³/a (Stage 1), 1.2 million m³/a (Stage 2) and 1.6 million m³/a (Stage 3). Upgrade to Stage 2 (1.2 million m³/a) was authorised by the Department of Water and Sanitation (DWS) and the then Breede-Gouritz Catchment Management Agency (BGCMA, now the Breede-Olifants CMA [BOCMA]) on 20 July 2016, due to the adherence to licence conditions and monitoring data indicating sustainable abstraction during Stage 1 of the WUL. These two wellfields have been in production since September 2013 and are operated in association with the Gateway Wellfield by Veolia Water Technologies South Africa on behalf of the OM, with support from Umvoto.

The Camphill and Volmoed Wellfields have reached their production potential in terms of Stage 2 of the WUL, and thus need to be optimised and/or expanded to increase to the Stage 3 WUL volume of 1.6 million m³/a and meet the growing water demand in Hermanus. The Hemel en Aarde Wellfields Expansion Project in Hermanus will involve the following:

- The drilling of three new production boreholes (T4/5, T4/6 and HAV10).
- The replacement via re-drilling of the HAV1 borehole (which has never been utilised as a production borehole due to construction issues) with a new adjacent, wider diameter production borehole (HAV1 Replacement or HAV1 Repl.).
- The deepening of an existing monitoring borehole (T4/3) and conversion to a production borehole (this has been undertaken and due to the low yields still present following deepening, T4/3 will remain a monitoring borehole).
- The drilling of a new monitoring borehole T4/7.
- The installation of connector pipes between the production boreholes and the existing bulk water pipeline.
- The installation of electrical reticulation and transformers to supply power to the wellfield.

The production boreholes will be drilled/tested and developed for abstraction via the construction of wellheads and borehole chambers, and the installation of production pumps. The connector pipelines will link the boreholes to the existing main Hemel en Aarde Wellfields bulk water pipeline, which currently feeds groundwater from the existing production boreholes to the Preekstoel Water Treatment Works in Hermanus. New electrical reticulation will be provided to supply power to production boreholes. Production boreholes are expected to be 200-300 metres (m) deep and ~0.25 m diameter at surface, tapering to narrower diameters with depth. The surface wellhead structure and pump are to be enclosed in a partially subterranean borehole chamber, with dimensions of ~4 m x 2 m in plan and ~2 m in height.

Construction activities associated with the Hemel en Aarde Wellfield Expansion Project will take place across several farm portions/properties within the Hemel en Aarde Valley in the greater Hermanus area, namely (see **Figure 2-2**):

- Hemel en Aarde 3/585 (HAV10 and HAV1 Repl.).
- Farm 1/586 (T4/3).
- Farm RE/586 (T4/5, T4/6 and T4/7).

1.2 Monitoring Requirements

Umvoto was appointed by the OM under ix engineers to conduct a freshwater monitoring programme, including water quality monitoring and a rapid South African Scoring System 5 (SASS5) bio-monitoring field assessment (Dickens and Graham, 2002), on watercourses that may be affected by discharged groundwater from the development (i.e. drilling and testing) of the HAV1 Repl. and T4/5 production boreholes. This forms part of the DWS's Section 21(c) and (i) WUL conditions (Appendix II Conditions 2.3, 3 and 4), which states the following must be undertaken as part of the Hemel en Aarde Wellfields Expansion Project:

- Condition 2.3.1 – In-stream water quality must be analysed on a two-weekly basis during construction, otherwise monthly at monitoring points both upstream and downstream of the activities, until pre-construction water quality levels have been reached.
- Condition 2.3.2 – Monitoring must be undertaken as set out in Condition 3 below.
- Condition 2.3.3 – Activities must be scheduled to take place during the dry seasons when flows are lowest where reasonably possible.
- Condition 2.3.4 – The licensee must ensure that the quality of the water to downstream water users does not decrease because of the water use activities listed under Condition 1.1.
- Condition 3.1 – The monitoring plan must be implemented, and reporting done to the Delegated Authority as stipulated under Condition 3.2.
- Condition 3.2 – Six (6) monthly monitoring reports must be submitted to the Delegated Authority for the duration of the construction phase and yearly thereafter or until otherwise agreed in writing with the Regional Head/CEO.
- Condition 4.1 – At least two water quality monitoring points, one upstream and one downstream of the affected length of the watercourse/s.
- Condition 4.2 – A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.
- Condition 4.3 – Exact positions of monitoring points must be indicated on the master layout plan (including their co-ordinates).

1.3 Purpose and Schedule of the Monitoring Report

This monitoring report's objective is to document the results of the freshwater monitoring programme implemented for the drilling and testing of the HAV1 Repl. and T4/5 boreholes between January and April 2024, and to assess adherence to the Section 21(c) and (i) WUL conditions (specifically Appendix II Conditions 2.3 and 4).

The only construction activities in the six-monthly reporting period were the drilling and testing of the HAV1 Repl. and T4/5 production boreholes. HAV1 Repl. borehole drilling occurred from the 1st-14th February 2024, and testing from the 14th-17th March 2024, and T4/5 borehole drilling occurred from the 14th-28th February 2024, and testing from the 6th-10th March 2024.

2. SITE DESCRIPTION

2.1 Locality

All activities relating to the expansion of the Hemel en Aarde Wellfields are taking place within the Hemel en Aarde Valley located northwest of the town of Hermanus in the OM (see **Figure 2-1**). A detailed locality map of the proposed Peninsula Aquifer production boreholes is provided in **Figure 2-1**, co-ordinates for the HAV1 Repl. (210 m deep) and T4/5 (179 m deep) production boreholes are listed in **Table 2-1**, and specific borehole locality maps are provided in **Figure 2-2**.

Table 2-1 Positions and details of the HAV1 Repl. and T4/5 production boreholes.

Borehole Name		Latitude	Longitude	Elevation (mamsl)	Depth (mbgl)	Target Aquifer
Production Borehole	HAV1 Repl.	-34.398480	19.209470	108	210	Peninsula
	T4/5	-34.375420	19.246180	153	179	Peninsula

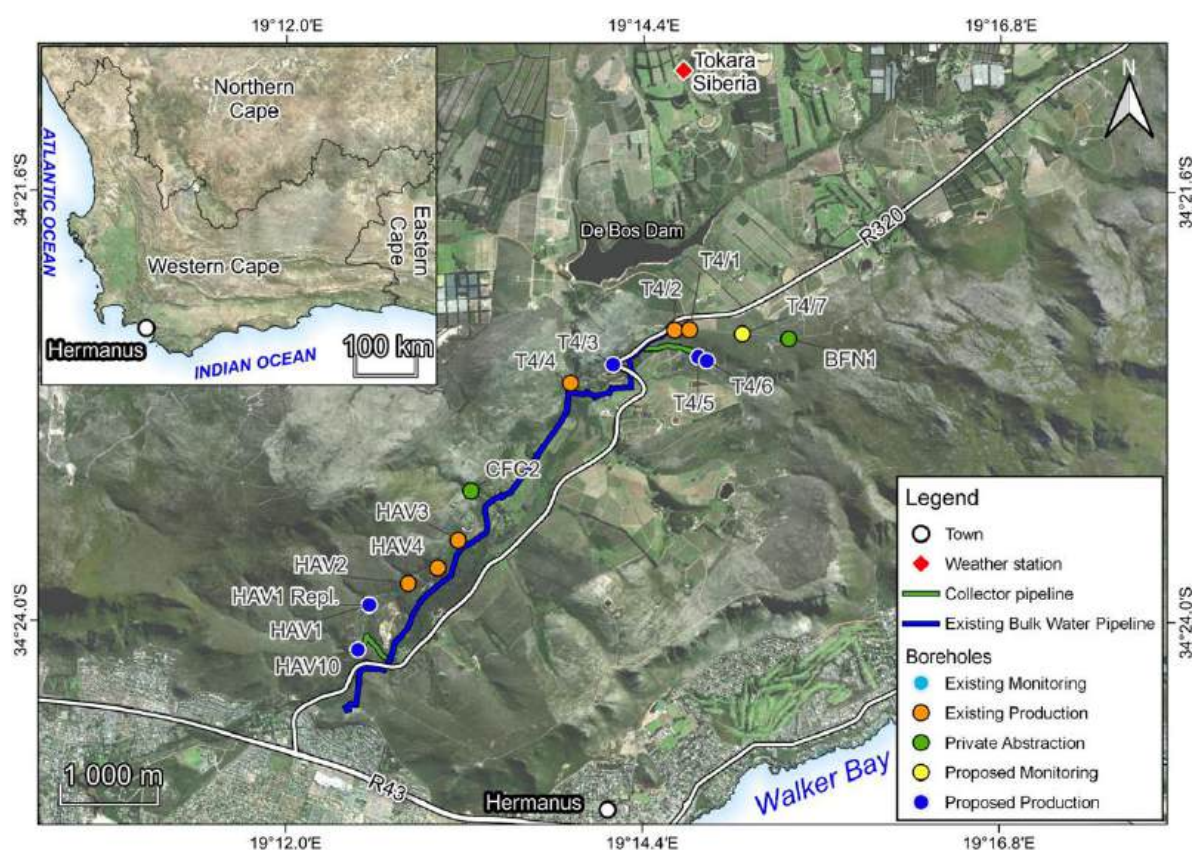


Figure 2-1 Overview of the Hemel en Aarde Valley showing borehole locations for the Hemel en Aarde Wellfield Expansion Project. Proposed new production boreholes (dark blue circles – T4/5, T4/6, HAV1 Repl. and HAV10; T4/3 deepening has been completed and remains a monitoring borehole due to low yields) are shown with collector pipelines (green line) joining to the existing arterial pipeline (blue line). Proposed new monitoring boreholes (yellow circles – T4/7), existing production boreholes (orange circles – HAV2, HAV3, HAV4, T4/1, T4/2 and T4/4), and selected existing Peninsula Aquifer monitoring boreholes (green circles – CFC2 and BFN1) are also shown. The De Bos Dam can be seen to the north of the wellfield.

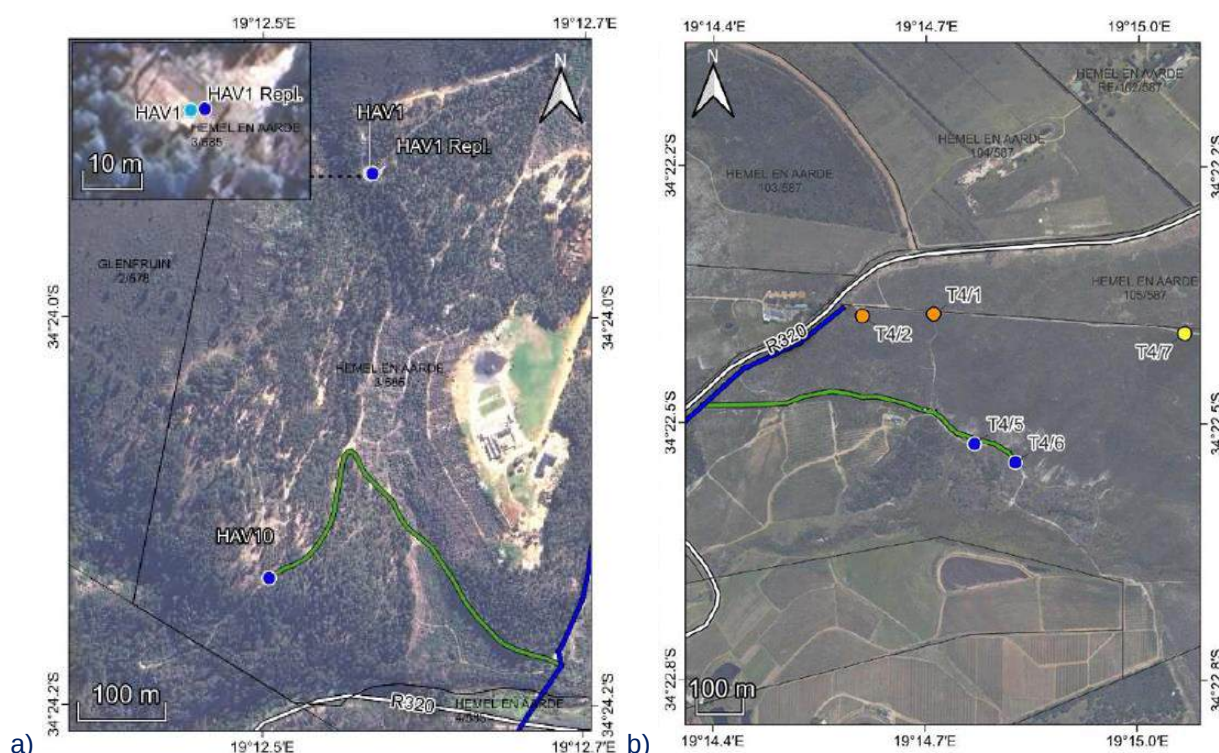


Figure 2-2 a) HAV1 Repl. production borehole (dark blue circle) located adjacent to the existing HAV1 borehole on Hemel en Aarde 3/585; b) T4/5 and T4/6 production boreholes (dark blue circles) on Farm RE/586, southeast of the existing T4/1 and T4/2 production boreholes (orange circles). Pipeline colours as per Figure 2-1.

2.2 Climate

The climate of the Hermanus area is warm, temperate, and dry; and is classified as “Csb” according to the Köppen and Geiger classification system (Beck et al., 2018). Regionally, Hermanus falls within the Western Cape Mediterranean climate regime, characterised by cold, wet winters and warm, dry summers.

Hermanus occurs in Rainfall Catchment Zone G4B and surface water quaternary catchment G40H, with the mean annual precipitation (MAP) (based on a 1920-2009 dataset from WR2012) is 752 mm. Rainfall is influenced considerably by topography and relief – the various mountain ranges to the northwest (Onrus Mountains), north (Babilonstoring Mountains) and northeast (Fernkloof Mountains) of Hermanus represents the high precipitation recharge area of the locally utilised Table Mountain Group (TMG) aquifers.

SA Atlas of Climatology and Agrohydrology temperature data (Schulze, 2009) for the Hermanus region, based on a 50-year recording period (1950-2000), records the mean annual temperature (MAT) for Hermanus as 16oC, while average monthly maximum (MATmx) and minimum temperatures (MATmn) range between 21oC and 12oC, respectively.

Rainfall was measured at five weather stations over the period May 2023 to April 2024 (see **Figure 2-3**): three within Hermanus town (South African National Space Agency [SANS], South African Weather Services [SAWS], and the OM) and two at a higher altitude within the Hemel en Aarde Valley (Hamilton Russell [HR] and Tokara Siberia [TS]) (see OM [2024] for details on longer-term climate monitoring). The monthly rainfall bar graph (see Figure 2-3) shows that 28% of the rainfall occurred during winter (June to August), with stations recording between 46 mm and 157 mm per month. The spring (March to May) and autumn (September to November) period produced 59% of annual rainfall, with rainfall in September 2023 recording 261 mm at the HR station. The extremely high September 2023 rainfall was linked to a major cut-off low system that

caused extreme rainfall (almost 200 mm of rainfall at the HR station from the 23rd-25th September 2023, including ~154 mm on the 24th September alone) and severe flooding in the Hemel en Aarde Valley on the Heritage Day long weekend. A subsequent cut-off low system also caused elevated rainfall during the 7th-8th April 2024 (with the HR station reporting ~168 mm). Summer (December to February) rainfall for this reporting period contributed 13% for the year, with rainfall in December 2023 recording 109 mm at the HR station (although summer rainfall in the greater Hermanus area was generally low from November 2023 to March 2024).

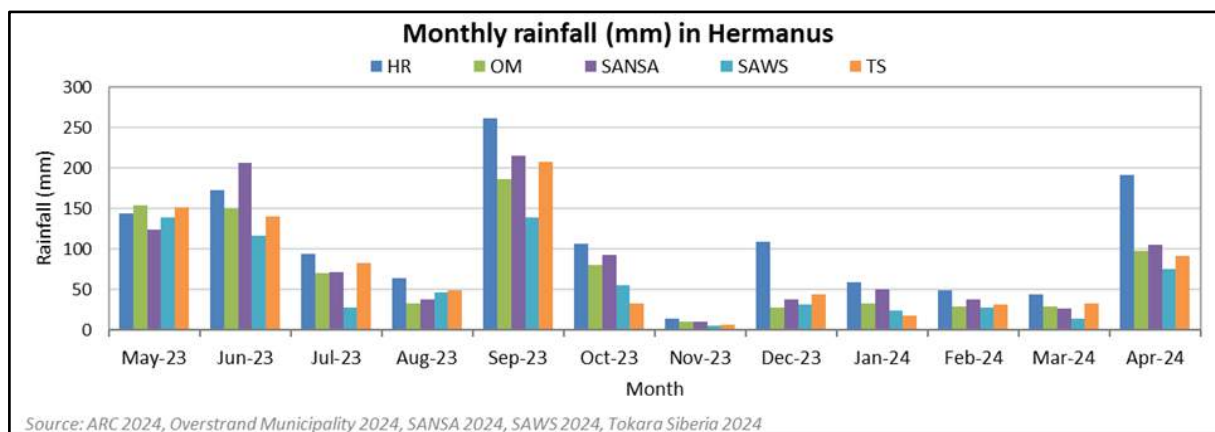


Figure 2-3 Monthly rainfall (mm) recorded at the five weather stations in the greater Hermanus area over the May 2023 to April 2024 period (including the September 2023 Heritage Day long weekend and early April 2024 cut-off low systems).

2.3 Geology

The main stratigraphic units represented in the study area belong to the Malmesbury Group, Cape Granite Suite, TMG, Bokkeveld Group and Bredasdorp Group (see **Table 2-2**), with the geology and hydrogeology of the greater Hermanus area being outlined in detail in OM (2024).

Rocks of the Malmesbury Group, intruded by the Cape Granite Suite, are the oldest rocks in the region (Namibian-Cambrian; ~800-510 million years old [Ma]), and form the basement upon which the thick layers of the Ordovician to Devonian (~480-375 Ma) TMG and Bokkeveld Group sediments were deposited (with the latter two groups forming the Cape Supergroup with the Witteberg Group). Granite outcrops can be found north of Stanford at the foot of the Klein River Mountains, and in the Hemel en Aarde Valley north of the De Bos Dam along the base of the Babilonstoring Mountains.

The TMG dominates the Hermanus region as a whole and is composed of the (from oldest to youngest) Peninsula, Pakhuis, Cedarberg, Goudini, Skurweberg and Rietvlei Formations. Due to the folded and resistant nature of the fractured quartzites of the Peninsula and Skurweberg Formations, the TMG outcrops as steep, rocky hills and mountains i.e. the east-west trending topographic backbone of the Onrus, Babilonstoring, Fernkloof and Klein River Mountains. Geological mapping of the area by Umvoto in 2007 indicated that the area to the southeast of the Hermanus Fault is underlain by the Skurweberg Formation, and not Peninsula Formation as shown in the existing 1:250 000 Worcester 3319 geological map (Umvoto, 2007). Consequently, the Hermanus Fault is a normal (extensional) fault dipping to the southeast along its entire trace, with the downthrown hanging wall block to the southeast and up-thrown footwall block to the northwest.

The Cape Supergroup and underlying basement rocks were subsequently highly deformed (faulted, fractured and folded) by the Permian-Triassic (~280-230 Ma) Cape Orogeny (i.e. tectonic mountain building event), with the thick quartzitic sandstone-rich formations (specifically the Peninsula, Skurweberg and Rietvlei Formations of the TMG) being highly brecciated along major

fault zones and forming excellent secondary fractured aquifers.

The Hermanus coastal platform is intermittently covered by Quaternary sediments of the Bredasdorp Group. The Bredasdorp Group was deposited across the exposed marine terraces from the Late Cenozoic to Present (~20-0 Ma) and forms the youngest formations within the study area. The Bredasdorp Group consists mainly of calcareous-rich aeolian (dune) sands and limestones, and fluvial shelly gravels (see **Table 2-2**) and extends north-eastwards from the coastal plain of Walker Bay towards Stanford.

Table 2-2 Stratigraphy of the Hermanus area (acronyms as per the 1:250 000 3319 Worcester geological map).

Group	Formation	Lithology	Age (Ma)
Bredasdorp	Strandveld (Qs)	Unconsolidated white dune sand	Holocene (0.01-0 Ma)
	(unnamed) (Qg)	Sandy soil and loam	Early-Late Pleistocene (~1-0.01 Ma)
	Waenhuiskrans (Qw)	Semi-consolidated to unconsolidated dune sand and calcrete, locally highly calcareous	
	Klein Brak (Qk)	Consolidated to semi-consolidated shelly coarse sand, gravel, conglomerate and coquina	Early Pleistocene (~2.5-1 Ma)
Major unconformity			
	False Bay Suite	Dolerite	Early Cretaceous (136 Ma)
Major hiatus and unconformity – Cape Orogeny (~280-230 Ma) and Gondwana breakup (~180-110 Ma)			
Bokkeveld	Gamka (Dga)	Dark grey feldspathic sandstone	Middle Devonian (~390-385 Ma)
	Gydo (Dg)	Black to dark grey shale/mudstone and siltstone	
Table Mountain	Rietvlei (Dr)	Feldspathic sandstone, siltstone and minor shale	Early Devonian (~416-390 Ma)
	Skurweberg (Ss)	Cross-bedded quartzite (quartzitic sandstone)	Silurian ~445-416 Ma
	Goudini (Sg)	Reddish brown-weathering sandstone, siltstone and shale	
	Cedarberg (O-Sc)	Dark grey to black shale (lower Soom Member); siltstone and fine sandstone (upper Disa Member)	
	Pakhuis (Opa)	Massive tillite (glacial conglomerate) and sandstone	Ordovician (~480-445 Ma)
	Peninsula (Ope)	Thickly bedded quartzite (quartzitic sandstone)	
Major unconformity			
Cape Granite Suite	Hermanus Pluton (N-Chp)	Coarse-grained to porphyritic granite	Cambrian (~520 Ma)
Malmesbury	Tygerberg (Nt)	Metasediments (shale, phyllite, greywacke, hornfels)	Namibian (~800-510 Ma)

2.4 Hydrogeology

The main targeted aquifers for groundwater use in the region include the deep fractured Peninsula Aquifer (formed by the Peninsula Formation and targeted by OM for municipal supply, and some farmers within the Hemel en Aarde Valley), the shallower fractured Nardouw Aquifer (formed by the Rietvlei and Skurweberg Formations and targeted by Hermanus residents and farmers) and the thin surficial, primary or sandy Quaternary Aquifer (targeted by residential wellpoints).

The Peninsula Aquifer is hydraulically separated into various fault-bounded compartments within the Hermanus area that represent structural sub-areas, across which it is interpreted that no hydraulic connection exists due to the sealing nature of annealed fault cores (Umvoto, 2007). In some of these compartments the Peninsula Aquifer is overlain by confining aquitard units e.g. the Pakhuis, Cedarberg and Goudini Formations of the TMG (which combined form the Winterhoek Mega-aquitard), and the shale-rich Ceres Subgroup of the Bokkeveld Group. The Nardouw Aquifer is hydraulically separated from the Peninsula Aquifer by the Winterhoek Mega-aquitard, and therefore municipal groundwater abstraction from the Peninsula Aquifer does not impact on private residential and agricultural groundwater abstraction from the Nardouw Aquifer (as indicated by long-term groundwater level monitoring in Hermanus and the Hemel en Aarde Valley). The three OM municipal TMG wellfields target the Peninsula Aquifer along the following major structures:

- Gateway Wellfield – confined Peninsula Aquifer (depths of >100 metres below ground level [mbgl]) along the damage zones of the ~NE-SW to ~E-W orientated Hermanus, Gateway and Mount Pleasant Faults.
- Camphill Wellfield – semi-confined to confined Peninsula Aquifer along the damage zone of the ~NE-SW orientated Attakwaskloof Fault.
- Volmoed Wellfield – unconfined to semi-confined Peninsula Aquifer along the damage zone of the ~NW-SE orientated Fernkloof Fault and ~NE-SW orientated Attakwaskloof Fault.

The Bredasdorp Group, which forms the relatively thin (~5-10 m thick) surface alluvial/sandy or primary Quaternary Aquifer, overlies TMG units along the Hermanus coastal platform (which is in hydraulic connection with whichever TMG aquifer underlies the coastal sediment). Many private wellpoints within the various Hermanus suburbs penetrate the Quaternary Aquifer and are predominantly used for domestic irrigation purposes.

2.5 Hydrochemistry

All three aquifers (Peninsula, Nardouw and Quaternary Aquifers) are characterised by acidic pH values between 3-6. The low pH values are a result of these aquifers being quartz (silica) rich (>95%), having a low buffering capacity against organic (humic and fulvic) acids produced by decomposing fynbos vegetation in recharge zones. The precipitation of hydrated iron, manganese and aluminium oxides can also release hydrogen ions into the aqueous system, causing further acidification of the groundwater. pH also tends to exhibit seasonality i.e., more acidic water in the end of winter/spring samples compared to summer samples, which could possibly be due to increased rainfall in winter flushing increase amounts of organic acids from the soil into the groundwater system, as well as oxygenated rainwater influx causing the precipitation of hydrated aluminium, iron and manganese oxide and the associated acidification of groundwater.

High iron and manganese concentrations are present within the Peninsula and Nardouw Aquifers, due to hydrothermal oxide mineralisation via fractured zones during the Cape Orogeny, combined with later secondary supergene enrichment by groundwater flowing along these preferential flow paths. Weathered sediment from these mineralised/supergene zones occur within the Bredasdorp Group sediments, resulting in high concentrations of iron and manganese also commonly occurring within the Quaternary Aquifer. Relatively deep aquifers such as Peninsula and Nardouw Aquifers usually have minimal dissolved oxygen, and in conjunction with the acidic

nature of the groundwater this further results in dissolved manganese and iron entering the groundwater system.

2.6 Ecological Site Classification

The Hemel en Aarde Valley is comprised mostly of fynbos, thicket/dense bush, cultivated orchards and vineyards. The ecological site classification as per the 2017 Western Cape Biodiversity Spatial Plan (WCBSP; produced by the South African National Biodiversity Institute [SANBI]) mapping of biodiversity, vegetation types, terrestrial ecosystem status, and where applicable wetland status, is given in **Table 2-3**. A description of the land use type as well as any possible heritage implications are also included.

Table 2-3 HAV1 Repl. and T4/5 borehole site ecological classification.

Criteria	HAV1 Repl.	T4/5
Critical Biodiversity Areas (CBA)	Within CBA2 and adjacent CBA1	Within CBA2 and adjacent CBA1 and ESA1
Desired Management Objectives ¹	CBA2: Maintain in a functional, natural or near-natural state, with no further loss of natural habitat. These areas should be rehabilitated. CBA1: Maintain in a natural or near-natural state, with no further loss of habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.	CBA2 – see HAV1 Repl. CBA1 – see HAV1 Repl. ESA 1: Maintain in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised.
Vegetation ²	Overberg Sandstone Fynbos	Overberg Sandstone Fynbos with Elim Ferricrete Fynbos. No plant Species of Conservation Concern recorded.
Proximity to Wetland (m)	~8.5 m	~116 m
Wetland Type ³	Seasonal mountain stream in vicinity*	Hillslope seep wetland in vicinity*
Ecosystem Status	Critically Endangered (CR)	
Rivers and Proximity (m)	Onrus River, ~457 m	Onrus River, ~1 328 m
Heritage	None	
Land Use Type	Within existing borehole (HAV1) footprint	Road reserve and access track

* The seasonal mountain streams and hillslope seep wetland were avoided, and all water discharged away from these so as not to contaminate or destroy the natural ecosystems therein.

¹ Western Cape Biodiversity Spatial Plan Handbook, 2017 pg. 55

² SANBI, 2018 via CapeFarmMapper

³ CSIR via CapeFarmMapper

3. MONITORING ACTIVITIES

3.1 Monitoring Sites

As per the Hemel en Aarde Wellfields Section 21(c) and (i) WUL conditions (see **Section 1.2**), two monitoring points per borehole were identified and utilised to monitor the impact of groundwater discharge near or into watercourses during the drilling and testing of the HAV1 Repl. and T4/5 production boreholes (see **Table 3-1**, **Figure 3-1** and **Figure 3-2**). These monitoring points were located along watercourses (in this case non-perennial tributaries of the Onrus River) that passed both borehole sites, where monitoring sites both upstream and downstream of the potential groundwater discharge locations could be located. The Onrus River in the vicinity of the HAV1 Repl. borehole underwent significant alteration during the end-September 2023 flooding, with other subsequent construction activities (unrelated to the Hemel en Aarde Expansion Project) occurring within the river (Camphill bridge rebuilding and pipeline repair) during borehole drilling, making it unsuitable for monitoring.

Upstream monitoring sites act as unimpacted reference conditions (i.e. if unimpacted reference conditions are changing due to unknown factors, then it may be reasonable that these changes can be expected to also occur at sites downstream from drilling activities, and not be related to drilling activities). Downstream monitoring sites act as impact monitoring sites, to determine if discharge of groundwater during borehole drilling and testing activities had any significant impact to watercourses. In-stream water quality monitoring was undertaken before drilling occurred to establish baseline conditions at all sites, and thereafter every two weeks (as per Section 21(c) and (i) WUL conditions [Appendix II Conditions 2.3 and 4]) until reference conditions were restored. Monitoring of the HAV1 Repl. watercourse sites occurred between 23rd January and 24th April 2024 (with HAV1 Repl. borehole drilling occurring from the 1st-14th February 2024, and testing from the 14th-17th March 2024), and between 16th February and 24th April 2024 for the T4/5 watercourse sites (with T4/5 borehole drilling occurring from the 14th-28th February 2024, and testing from the 6th-10th March 2024).

SASS5 bio-monitoring occurred on a monthly basis in the vicinity of the same upstream and downstream monitoring sites at each borehole (see **Table 3-1**, **Figure 3-1** and **Figure 3-2**), on the 19th January 2024, 22nd February 2024 and on the 28th March 2024. In this case, all January 2024 data is representative of baseline conditions prior to borehole development, and the February-March 2024 data is representative of the construction phase for both boreholes. All construction activities were scheduled during the dry summer season (January-March) when surface water flows were lowest.

Table 3-1 Upstream and downstream monitoring sites used for watercourse water quality and SASS5 bio-monitoring sampling for the HAV1 Repl. and T4/5 boreholes.

Borehole Name	Monitoring Site Name	Latitude	Longitude	Elevation (mamsl)
HAV1 Repl.	HAV1 Repl. Upstream	-34.398658	19.209021	105
	HAV1 Repl. Downstream	-34.402372	19.210063	59
T4/5	T4/5 Upstream	-34.377295	19.245340	123
	T4/5 Downstream	-34.377511	19.241453	103

3.2 Water Quality

As stipulated in Appendix II Conditions 2.3 and 4 of the Section 21(c) and (i) WUL, in-stream water quality monitoring must be undertaken to ensure no contamination of watercourses occurs downstream of drilling and testing activities due to discharged groundwater. Grab water samples

were collected (as per relevant sampling procedures) from the monitoring sites located upstream and downstream of where boreholes discharged groundwater (see **Figure 3-1** and **Figure 3-2**), and submitted to SANAS-accredited Integral Laboratories for analysis of macrochemical parameters listed in Appendix II Condition 2.3.1 of the Section 21(c) and (i) WUL – pH, electrical conductivity (EC), total suspended solids (TSS), turbidity, total dissolved solids (TDS), and fats, oil and grease.

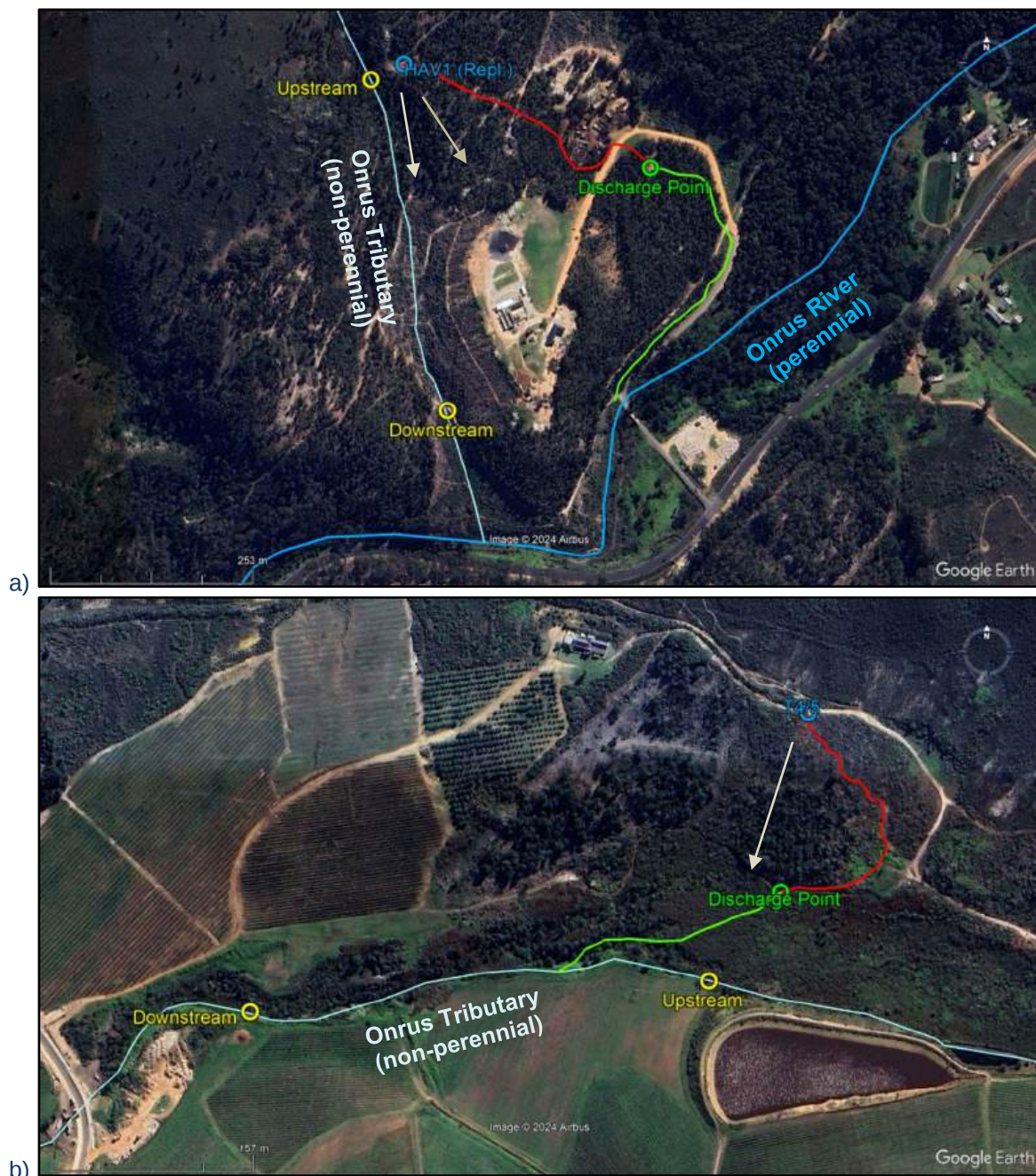


Figure 3-1 Location of upstream and downstream (yellow circles) monitoring sites along non-perennial Onrus River tributaries (light blue lines) in the vicinity of the HAV1 Repl. (a) and T4/5 (b) production boreholes (blue circles). Light brown arrows indicate general direction of groundwater discharge during borehole drilling. Discharge layflat used during test-pumping represented by the red line, with the test-pumping discharge point and discharge drainage pathway represented by the green circle and green line respectively.

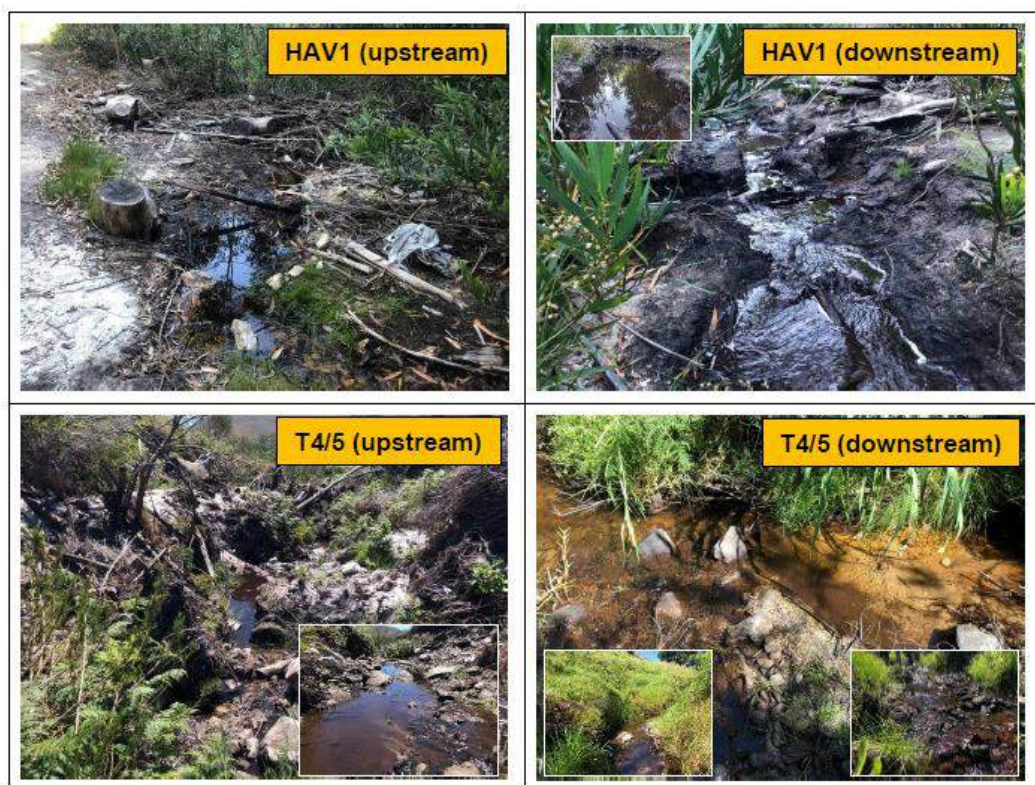


Figure 3-2 Onrus River tributary reaches sampled upstream and downstream of the proposed HAV1 Repl. and T4/5 production borehole drilling/testing discharge locations for water quality and SASS5 bio-monitoring (from FEN Consulting [2024a]).

The hydrochemical results were compared to the South African Water Quality Guidelines (SAWQG) Target Water Quality Range (TWQR) for aquatic ecosystems (Department of Water Affairs and Forestry [DWA], 1996), to evaluate possible water quality exceedances caused by borehole drilling/testing activities, and to establish whether baseline conditions were restored over time. There are no Breede-Gouritz Water Management Area Resource Quality Objectives (RQOs; DWS 2020) in terms of surface water quality for rivers within the G40H catchment for comparative purposes, with RQOs only in place for TMG groundwater of <117 mS/m (with the EC of Peninsula Aquifer groundwater within both the HAV1 Repl./T4/5 boreholes being 26 mS/m).

3.3 SASS5 Bio-monitoring

The SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macro-invertebrates identified amongst stoney, vegetation, and gravel, sand and mud (GSM) biotopes at a given river reach (measured in the vicinity of the HAV1 Repl. and T4/5 upstream and downstream sites by Freshwater Ecologist Network [FEN] Consulting and Umvoto; see **Table 3-1**, **Figure 3-1** and **Figure 3-2**). Each macro-invertebrate is assigned a SASS5 sensitivity score that ranges from 1-15, which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15 highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope to calculate the SASS5 score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT; the average sensitivity of aquatic macro-invertebrates per biotope). It is also possible to calculate these indices across all biotopes to determine the SASS5 Total Score, number of taxa and ASPT per site. SASS5 scores are then used to derive the Present Ecological Status (PES) of the river system which is classified as follows: Class A (Pristine), Class B (Largely Unmodified), Class C (Moderately Modified), Class D (Largely Modified), and Class E/F (Severely to Critically Modified).

4. MONITORING RESULTS

4.1 Water Quality

Both Onrus River tributaries/watercourses assessed in this report are categorised as non-perennial rivers (i.e. seasonal in nature, and generally only flow during winter/spring and after heavy unseasonal rainfall events), which generally characterised by unpredictable flow regimes and fluctuating water quality.

Water quality results from the HAV1 Repl. and T4/5 upstream and downstream monitoring sites are shown in **Table 4-1** and **Table 4-2** respectively, with the Integral Laboratories results sheets available in **Appendix A**. Hydrochemical constituents within both tables that exceed the SAWQG TWQR for aquatic ecosystems are highlighted in green (see **Table 4-1** and **Table 4-2**):

- pH within both monitored Onrus River tributaries is naturally acidic (~4.5-5 and ~3.5 for the HAV1 Repl. upstream and downstream sites respectively, and ~5-5.5 for both the T4/5 upstream and downstream sites), caused by organic humic/fulvic acids from decomposing fynbos vegetation entering the surface water systems, along with acidic TMG groundwater discharge (especially during summer, when rainwater input is limited). The tributary in the vicinity of the HAV1 Repl. site is likely slightly more acidic than the tributary near the T4/5 site for two reasons:
 - The catchment of the tributary in the vicinity of the HAV1 Repl. site is highly invaded by *Eucalyptus* (Blue Gum), whose decomposing leaves would further acidify surface water (with increased *Eucalyptus* downstream resulting in lower pH being observed at the downstream site versus the upstream site).
 - The catchment of the tributary in the vicinity of the T4/5 monitoring sites includes a relatively large extent of Gydo Formation (Bokkeveld Group) shales, which would produce clay-rich weathered sediment that would buffer the naturally acidic organic acids produced from any decomposing vegetation (especially during summer, when there would be limited surface water input from the mountain catchment of the watercourse further eastwards). The tributary catchment in the vicinity of the T4/5 monitoring sites also incorporates extensive vineyards, which may result in less acidic watercourse pH if the soils are limed (and these carbonates wash into the tributary).
- It can be observed that pH remained relatively stable at all monitoring sites during borehole drilling/testing activities – the changes to pH observed at the HAV1 Repl. downstream and both T4/5 upstream/downstream sites in the 11th and 24th April 2024 samples is likely due to a heavy rainfall event of >150 mm (based on the HR weather station – see **Figure 2-3**) occurring on the 7th-8th April 2024, which would have resulted in fresh mountain catchment water entering both watercourses (and negating the two impacts outlined above).
- EC/TDS was expectedly low in both watercourses, increasing from ~15 mS/m / ~120 mg/l to ~60-85 mS/m / ~300-500 mg/l from the HAV1 Repl. upstream and downstream sites respectively, and from ~20-25 mS/m / ~180-230 mg/l to ~40-45 mS/m / ~250-300 mg/l from the T4/5 upstream and downstream sites respectively. The increase in EC from the upstream to downstream sites in both watercourses is likely related to increased clay-rich weathered sediment input from the Gydo Formation shales moving further downstream within both watercourse catchments. EC remained relatively stable during drilling/testing activities at both borehole sites, with the slight variations in TDS of just above 15% of the baseline sample likely related to natural variations in surface water discharge (as these slight variations occur in both upstream and downstream monitoring sites).

Table 4-1 Macrochemical laboratory analysis results for the HAV1 Repl. upstream and downstream water quality monitoring sites for January-April 2024, in comparison to the 1996 SAWQG TWQR for aquatic ecosystems. Green highlighted results indicate constituents that do not meet the SAWQG TWQR for aquatic ecosystems, while red and orange highlighted sample dates indicate samples collected pre- and post-HAV1 Repl. borehole drilling/testing activities respectively.

Parameter	SAWQG TWQR (1996) Aquatic Ecosystems	HAV1 Repl. Upstream									HAV1 Repl. Downstream								
		23/01/2024	05/02/2024	16/02/2024	20/02/2024	04/03/2024	14/03/2024	28/03/2024	11/04/2024	24/04/2024	23/01/2024	05/02/2024	16/02/2024	20/02/2024	04/03/2024	14/03/2024	28/03/2024	11/04/2024	24/04/2024
pH	<0.5 pH unit difference to baseline	4.64	4.67	4.84	4.78	4.70	4.76	4.68	4.49	4.52	3.54	3.44	3.71	3.29	3.59	3.51	n/a*	4.17	4.05
EC (mS/m)	<15% difference to baseline	15.3	15.0	14.8	14.7	14.9	14.6	14.8	16.2	16.4	77.8	82.9	75.2	81.6	65.9	64.7	-	24.3	33.9
TDS (mg/l)	<15% difference to baseline	119	122	133	152	158	124	173	135	114	407	499	394	376	310	379	-	191	179
TSS (mg/l)	<10% difference to baseline	<2	<2	<2	<2	<2	6	<2	<2	<2	<2	<2	<2	10	<2	30	-	<2	<2
Turbidity (NTU)	-	1.84	1.29	1.73	0.89	11.9	2.28	14.9	1.80	1.62	79.1	30.4	10.1	28.4	13.5	23.3	-	2.57	5.15
Fats, oils, grease (mg/l)	-	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	-	<0.5	<0.5

*Monitoring site was dry and therefore unable to be monitored during this period.

Table 4-2 Macrochemical laboratory analysis results for the T4/5 upstream and downstream water quality monitoring sites for January-April 2024, in comparison to the 1996 SAWQG TWQR for aquatic ecosystems. Green highlighted results indicate constituents that do not meet the SAWQG TWQR for aquatic ecosystems, while red and orange highlighted sample dates indicate samples collected pre- and post-T4/5 borehole drilling/testing activities respectively.

Parameter	SAWQG TWQR (1996) Aquatic Ecosystems	T4/5 Upstream						T4/5 Downstream					
		16/02/2024	01/03/2024	14/03/2024	28/03/2024	11/04/2024	24/04/2024	16/02/2024	01/03/2024	14/03/2024	28/03/2024	11/04/2024	24/04/2024
pH	<0.5 pH unit difference to baseline	5.39	5.33	5.28	5.31	4.32	4.90	5.43	5.36	5.35	5.55	4.54	4.90
EC (mS/m)	<15% difference to baseline	23	22.6	22.8	23.8	14.1	19.1	42	41.9	40.7	42.7	16.8	30.3
TDS (mg/l)	<15% difference to baseline	184	185	196	233	125	137	263	268	256	304	140	194
TSS (mg/l)	<10% difference to baseline	<2	<2	8	<2	<2	<2	<2	<2	8	<2	<2	<2
Turbidity (NTU)	-	7.87	4.67	6.32	4.75	3.01	10.6	9.32	4.77	5.32	4.33	5.31	4.37
Fats, oils, grease (mg/l)	-	<0.5	<0.5	1.4	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

- EC/TDS of groundwater from both the HAV1 Repl. and T4/5 boreholes (~26 mS/m / ~150 mg/l) is significantly lower than the downstream monitoring site EC/TDS at both HAV1 Repl. (~60-85 mS/m / ~300-500 mg/l) and T4/5 (~40-45 mS/m / ~250-300 mg/l). The reduction in EC/TDS observed in both the HAV1 Repl. (~25-35 mS/m / ~180-190 mg/l) and T4/5 (~16-30 mS/m / ~140-200 mg/l) downstream sites in the 11th and 24th April 2024 samples is also likely related to fresher rainwater input from the 7th-8th April 2024 rainfall event.
- Slight increases in TSS at both the HAV1 Repl. and T4/5 downstream sites during borehole drilling/testing may be potentially attributed to these activities, however TSS returned to <2 mg/l following the cessation of borehole drilling/testing and the subsequent 7th-8th April rainfall event. Turbidity (measured in Nephelometric Turbidity Units [NTU]) was highly variable across both upstream and downstream monitoring sites within both watercourses, and therefore there were no indications of drilling/testing activity impacts on turbidity. Turbidity decreased significantly within the HAV1 Repl. downstream site (from ~10-80 NTU to ~2.5-5 NTU) following the 7th-8th April 2024 rainfall event, likely due to the flushing of muddy pools from the watercourse. Minor fats, oils and grease (0.6 mg/l) were observed in the HAV1 Repl. downstream site sample taken on the 4th March 2024, although no drilling/testing activities took place at the HAV1 Repl. borehole from the 14th February-14th March 2024. Minor fats, oils and grease were also observed in the HAV1 Repl. upstream site sample taken on the 14th March 2024 (0.8 mg/l) and the T4/5 upstream site samples taken on the 14th (1.4 mg/l) and 28th March 2024 (1.2 mg/l), with the minor presence of these within the watercourses likely related to potential natural oils released by decomposing fynbos and invasive vegetation.

The in-stream water quality results therefore indicate no definitive deterioration of Onrus River tributary watercourse quality during HAV1 Repl. and T4/5 borehole drilling/testing activities.

4.2 Habitat Assessment

As stipulated in Appendix II Condition 4.2 of the Section 21(c) and (i) WUL, a habitat assessment of the affected watercourses was undertaken at the HAV1 Repl. and T4/5 upstream/downstream monitoring sites and described below (see **Figure 3-2**) (taken from FEN Consulting [2024a]):

- **HAV1 Repl. Upstream:** This closed-canopied seasonal mountain stream is a clear light brown colour, which is <1 m wide and ~0.15 m deep. A slow, shallow run dominated the hydraulic biotope habitat, with occasional shallow pools overserved. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic *Eucalyptus* (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation. Discharge in March and February 2024 was very low compared to January 2024 (following low rainfall during these months), which limited the SASS5 biotope sample to muddy vegetated pools, with stoney habitat no longer available.
- **HAV1 Repl. Downstream:** This stream reach is significantly more open canopied, with a greater discharge compared to the upstream site, which is expected given increased lateral interflow contributions from the valley. This reach of the stream was a dark brown colour and was significantly more turbid compared to the upstream site, likely due to increased suspension loads from destabilised soils after the very high winter 2023 rainfall and end-September 2023 flooding. Although the overall vegetation community remained

dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~1 m), depth (~0.3 m) and discharge are able to accommodate a denser and more specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus sp.*, *Ficinia capillifolia* and *Carpha glomerata*. During March 2024, the site was not assessed due to zero flow conditions.

- **T4/5 Upstream:** This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion following end-September 2023 flooding, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero-flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and <0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run in January 2024, whereafter flow increased during February 2024 and decreased again in March 2024. Disturbance of this riverbed has allowed for the dominance by pioneering species such as *Pteridium aqualinum* (Bracken fern).
- **T4/5 Downstream:** This downstream river reach by comparison to the T4/5 upstream site accommodated a much more diverse SASS5 sampling habitat, consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site due to the end-September 2023 flooding, the marginal vegetation out of current was still intact, which provided a good SASS5 vegetation sampling habitat. Hydraulic biotopes were regarded as good. Cobbles at the site became increasingly covered with organic silt over subsequent monitoring periods and is likely due to a general decrease in baseflows over the summer season.

4.3 SASS5 Bio-Monitoring

This section provides a summary of the SASS5 bio-monitoring results undertaken at the HAV1 Repl. and T4/5 upstream/downstream sites during 19th January 2024, 22nd February 2024 and 28th March 2024 (see **Table 4-3** and **Table 4-4**). For a more in-depth discussion of these results, refer to the larger, all-encompassing SASS5 bio-monitoring reports prepared for Umvoto by FEN Consulting (2024a-c) in **Appendix B**.

The HAV1 Repl. upstream site deteriorated from a PES Class A (Pristine) ecological condition to a PES Class C (Moderately Modified) ecological condition between January 2024 and March 2024 due to a significant decrease in both the SASS5 and ASPT scores (see **Table 4-3**). No comparison could be made for the HAV1 Repl. downstream site as the site experienced no flow during the March 2024 assessment and was therefore not assessed (see **Table 4-3**).

The T4/5 upstream site improved from a PES Class E/F (Severely to Critically Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and March 2024, likely due to the significantly increasing SASS5 score and slightly increasing ASPT score (see **Table 4-4**). The T4/5 downstream site remained unchanged as a PES Class C (Moderately Modified) was observed during both the January and March 2024 assessments (see **Table 4-4**).

FEN Consulting (2024a-c) deemed SASS5 an inappropriate freshwater tool to monitor river health impacts in terms of the macro-invertebrate community at the HAV1 Repl. and T4/5 upstream and downstream sites during borehole drilling/testing activities for the following reasons:

- The T4/5 upstream site was significantly more degraded than the downstream site and with limited surface water in January, February and March 2024, therefore it did not meet the criteria of a control site (i.e. an unimpacted site relative to its downstream site). Control-impact site comparisons were therefore not possible at T4/5 (with the upstream site consistently returning lower SASS and ASPT scores compared to the downstream site).

Table 4-3 SASS5 bio-monitoring results for the HAV1 Repl. upstream and downstream sites assessed on the 19th January 2024 (pre-HAV1 Repl. drilling/testing), 22nd February 2024 (during HAV1 Repl. drilling/testing) and 28th April 2024 (post-HAV1 Repl. drilling/testing). SASS5 scores are used to derive the PES of the Onrus River tributary passing the HAV1 Repl. borehole, with Class A (Pristine) highlighted in blue, Class C (Moderately Modified) in yellow, Class D (Largely Modified) in orange, and Class E/F (Severely to Critically Modified) in red.

SASS5 Items	HAV1 Repl. Upstream			HAV1 Repl. Downstream		
	19/01/2024	22/02/2024	28/04/2024	19/01/2024	22/02/2024	28/04/2024
SASS5 Total Score	76	73	39	24	35	n/a*
Number of Taxa	9	11	6	6	6	n/a*
ASPT	8.44	6.64	6.5	4	5.83	n/a*
PES	A	C	C	E/F	D	n/a*

*Monitoring site was dry and therefore unable to be assessed during this period.

Table 4-4 SASS5 bio-monitoring results for the T4/5 upstream and downstream sites assessed on the 19th January 2024 (pre-T4/5 drilling/testing), 22nd February 2024 (during T4/5 drilling/testing) and 28th April 2024 (post-T4/5 drilling/testing). SASS5 scores are used to derive the PES of the Onrus River tributary river passing the T4/5 borehole, with Class C (Moderately Modified) highlighted in yellow, Class D (Largely Modified) in orange, and Class E/F (Severely to Critically Modified) in red.

SASS5 Items	T4/5 Upstream			T4/5 Downstream		
	19/01/2024	22/02/2024	28/04/2024	19/01/2024	22/02/2024	28/04/2024
SASS5 Total Score	47	67	86	114	98	121
Number of Taxa	10	14	17	23	19	21
ASPT	4.70	4.79	5.06	4.96	5.16	5.76
PES	E/F	E/F	D	C	D	C

- Low flow conditions were also observed during January and February at the HAV1 Repl. sites (which limited the scope of the SASS5 protocol), whereas the HAV1 Repl. downstream site had no flow conditions at the time of the March 2024 assessment (and the SASS5 protocol could not be applied at all in this case). Limited to no spatial comparison could therefore be drawn between the HAV1 Repl. upstream and downstream sites at the time of assessments.
- Very high erosive damage in the Onrus River catchment caused by 2023 winter and end-September 2023 flooding, with the Onrus River and its associated tributaries generally regarded as being outside of their normal biotic conditions (both from a habitat quality and water quality perspective). This is particularly true for increased water temperature due to large scale loss of shade generated from riparian/instream vegetation (which was significantly removed/altered by the end-September 2023 flooding). The T4/5 downstream site was the only site where the SASS5 biotopes (stones, vegetation, and GSM) were sampled separately, due to a sufficiently abundant presence of each.

Despite the above concerns, it could be observed that there were significantly decreasing SASS5 and ASPT scores (see **Table 4-3**) for the HAV1 Repl. upstream site – however, this deterioration in macro-invertebrate community integrity is most likely due to seasonality as the habitat suitability significantly decreased and was also impacted by prior flooding (being the upstream site this was also above any HAV1 Repl. drilling/testing activities). No other points of concern were raised by FEN Consulting (2024a-c) with respect to the macro-invertebrate communities and associated habitats during HAV1 Repl. and T4/5 borehole drilling/testing activities, with a downstream increase in the SASS5 and ASPT scores occurring in the vicinity of T4/5 (see **Table 4-4**).

5. CONCLUSIONS

In-stream water quality monitoring and SASS5 bio-monitoring was successfully completed within Onrus River tributaries in the vicinity of the HAV1 Repl. and T4/5 borehole sites, at monitoring sites both upstream and downstream of borehole drilling/testing activities.

The in-stream water quality results indicate there was no definitive deterioration of Onrus River tributary watercourse quality during HAV1 Repl. and T4/5 borehole drilling/testing activities, with watercourse quality also improving post-drilling/testing activities as a result of heavy rainfall of >150 mm occurring on the 7th-8th April 2024 flushing out the tributaries after a dry summer period.

Due to the very low summer flows within the monitored watercourses, and the erosive damage caused by the end-September 2023 flood event (>150 mm rainfall occurring on the 24th September 2023), SASS5 was found to be an inappropriate freshwater tool to monitor river health impacts in terms of the macro-invertebrate community at the HAV1 Repl. and T4/5 upstream and downstream sites during borehole drilling/testing activities. No points of concern were present however with respect to the macro-invertebrate communities and associated habitats during HAV1 Repl. and T4/5 borehole drilling/testing activities.

In-stream water quality monitoring and SASS5 bio-monitoring will be re-initiated once borehole chamber and pipeline construction activities begin post-winter 2024, with upstream and downstream sites potentially being revised based on the position of construction activities.

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**APPENDIX A – HAV1 Repl. and T4/5 Integral Laboratories
Hydrochemical Results Sheets**

Integral Laboratories (Pty) Ltd
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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-42680-A
Address:	Magnolia Street	Date of Certificate:	17-May-2024
	Hermanus	Date Completed:	17-May-2024
	7200	Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-141544	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		15.3	2024-01-25
pH @ 25°C	M6	pH units		4.64	2024-05-17
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		119	2024-01-24
Total Suspended Solids	M8	mg/L		<2.00	2024-01-29
Turbidity	M12	NTU		1.84	2024-01-30
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-01-31

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Address:	Magnolia Street	Date of Certificate:	17-May-2024
	Hermanus	Date Completed:	17-May-2024
	7200	Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-141545	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		77.8	2024-01-25
pH @ 25°C	M6	pH units		3.54	2024-05-17
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		407	2024-01-24
Total Suspended Solids	M8	mg/L		<2.00	2024-01-29
Turbidity	M12	NTU		79.1	2024-01-30
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-01-31

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	17-May-2024
		Date Completed:	17-May-2024
		Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	08-February-2024

Sample Identification:		HAV1 Rpl. Upstream			
Sample Number:	PW-24-142303	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		15.0	2024-02-12
pH @ 25°C	M6	pH units		4.67	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		122	2024-02-09
Total Suspended Solids	M8	mg/L		<2.00	2024-02-13
Turbidity	M12	NTU		1.29	2024-02-12
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-19

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	08-February-2024

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-142304	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		82.9	2024-02-12
pH @ 25°C	M6	pH units		3.44	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		499	2024-02-09
Total Suspended Solids	M8	mg/L		<2.00	2024-02-13
Turbidity	M12	NTU		30.4	2024-02-12
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-19

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	22-April-2024
		Date Completed:	22-April-2024
		Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	08-February-2024

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-142812	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.8	2024-02-22
pH @ 25°C	M6	pH units		4.84	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		133	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		1.73	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43117-A
Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	19-February-2024

Sample Identification:		HAV1 Rpl. Downstream			
Sample Number:	PW-24-142813	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		75.2	2024-02-22
pH @ 25°C	M6	pH units		3.71	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		394	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		10.1	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-142814	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		23.0	2024-02-22
pH @ 25°C	M6	pH units		5.39	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		184	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		7.87	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-142815	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		42.0	2024-02-22
pH @ 25°C	M6	pH units		5.43	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		263	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		9.32	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	22-April-2024
		Date Completed:	22-April-2024
		Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	19-February-2024

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43165-A
Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	21-February-2024

Sample Identification:					
HAV1 Rpl Upstream					
Sample Number:	PW-24-142965	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.7	2024-02-28
pH @ 25°C	M6	pH units		4.78	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		152	2024-02-28
Total Suspended Solids	M8	mg/L		<2.00	2024-02-28
Turbidity	M12	NTU		0.89	2024-02-28
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-01

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	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	21-February-2024

Sample Identification:					
HAV1 Rpl Downstream					
Sample Number:	PW-24-142966	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		81.6	2024-02-28
pH @ 25°C	M6	pH units		3.29	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		376	2024-02-28
Total Suspended Solids	M8	mg/L		10.0	2024-02-28
Turbidity	M12	NTU		28.4	2024-02-28
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-01

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	22-April-2024
		Date Completed:	22-April-2024
		Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	21-February-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43336-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	01-March-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-143416	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		22.6	2024-03-06
pH @ 25°C	M6	pH units		5.33	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		185	2024-03-06
Total Suspended Solids	M8	mg/L		<2.00	2024-03-07
Turbidity	M12	NTU		4.67	2024-03-05
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	01-March-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-143418	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		41.9	2024-03-06
pH @ 25°C	M6	pH units		5.36	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		268	2024-03-06
Total Suspended Solids	M8	mg/L		<2.00	2024-03-07
Turbidity	M12	NTU		4.77	2024-03-05
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	01-March-2024

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This certificate supersedes all previous documents bearing the reference (PW-2024-43336)

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Tel: 021 863 1238 Fax: 086 635 8874
Email: westerncape@integrallabs.co.za

T0417

Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43393-A
Address:	Magnolia Street	Date of Certificate:	24-April-2024
	Hermanus	Date Completed:	24-April-2024
	7200	Date of Sampling:	04-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	06-March-2024

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-143602	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.9	2024-03-11
pH @ 25°C	M6	pH units		4.70	2024-04-24
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		158	2024-03-11
Total Suspended Solids	M8	mg/L		<2.00	2024-03-11
Turbidity	M12	NTU		11.9	2024-03-08
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43393-A
Address:	Magnolia Street	Date of Certificate:	24-April-2024
	Hermanus	Date Completed:	24-April-2024
	7200	Date of Sampling:	04-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	06-March-2024

Sample Identification:					
HAV1 Repl. Downstream					
Sample Number:	PW-24-143603	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		65.9	2024-03-11
pH @ 25°C	M6	pH units		3.59	2024-04-24
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		310	2024-03-11
Total Suspended Solids	M8	mg/L		<2.00	2024-03-11
Turbidity	M12	NTU		13.5	2024-03-08
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		0.60	2024-03-11

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43393-A
Address:	Magnolia Street Hermanus 7200	Date of Certificate:	24-April-2024
		Date Completed:	24-April-2024
		Date of Sampling:	04-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	06-March-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43573-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:		HAV1 Rpl. Upstream			
Sample Number:	PW-24-144210	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.6	2024-03-22
pH @ 25°C	M6	pH units		4.76	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		124	2024-03-20
Total Suspended Solids	M8	mg/L		6.00	2024-03-23
Turbidity	M12	NTU		2.28	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		0.80	2024-03-19

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Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	14-March-2024

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-144211	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		64.7	2024-03-22
pH @ 25°C	M6	pH units		3.51	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		379	2024-03-20
Total Suspended Solids	M8	mg/L		30.0	2024-03-23
Turbidity	M12	NTU		23.3	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-19

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-144212	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		22.8	2024-03-22
pH @ 25°C	M6	pH units		5.28	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		196	2024-03-20
Total Suspended Solids	M8	mg/L		8.00	2024-03-23
Turbidity	M12	NTU		6.32	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		1.40	2024-03-19

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Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-144213	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		40.7	2024-03-22
pH @ 25°C	M6	pH units		5.35	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		256	2024-03-20
Total Suspended Solids	M8	mg/L		8.00	2024-03-23
Turbidity	M12	NTU		5.37	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-19

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	14-March-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43823-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-145005	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		23.8	2024-04-05
pH @ 25°C	M6	pH units		5.31	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		233	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		4.75	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		1.20	2024-04-04

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-145006	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		42.7	2024-04-05
pH @ 25°C	M6	pH units		5.55	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		304	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		4.33	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-04

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-145007	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.8	2024-04-05
pH @ 25°C	M6	pH units		4.68	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		173	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		14.9	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-04

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	02-April-2024

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Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-145768	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.1	2024-04-15
pH @ 25°C	M6	pH units		4.32	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		125	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		3.01	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-145769	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.8	2024-04-15
pH @ 25°C	M6	pH units		4.54	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		140	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		5.31	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-145770	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.2	2024-04-15
pH @ 25°C	M6	pH units		4.49	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		135	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		1.80	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	12-April-2024

Sample Identification:					
HAV1 Repl. Downstream					
Sample Number:	PW-24-145771	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		24.3	2024-04-15
pH @ 25°C	M6	pH units		4.17	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		191	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		2.57	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

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9. In the absence of client specified limits, the limits reflected are based on SANS 241-2015 or General Effluent Standards, as applicable.
10. The quality and integrity of samples submitted has a direct correlation to the results reported. As such, results reflected on this report relate only to the samples as received.
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T0417

Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44188
Address:	Magnolia Street	Date of Certificate:	29-April-2024
	Hermanus	Date Completed:	29-April-2024
	7200	Date of Sampling:	24-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	25-April-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-146333	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		19.1	2024-04-26
pH @ 25°C	M6	pH units		4.90	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		137	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		10.6	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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	Hermanus	Date Completed:	29-April-2024
	7200	Date of Sampling:	24-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	25-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-146335	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		30.3	2024-04-26
pH @ 25°C	M6	pH units		4.90	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		194	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		4.37	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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Service Request Number: PW-2024-44188
Date of Certificate: 29-April-2024
Date Completed: 29-April-2024
Date of Sampling: 24-April-2024
Date of Receiving at Lab: 25-April-2024

Contact: Patrick Robinson

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-146336	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.4	2024-04-26
pH @ 25°C	M6	pH units		4.52	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		114	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		1.62	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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Service Request Number: PW-2024-44188
Date of Certificate: 29-April-2024
Date Completed: 29-April-2024
Date of Sampling: 24-April-2024
Date of Receiving at Lab: 25-April-2024

Contact: Patrick Robinson

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-146338	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		33.9	2024-04-26
pH @ 25°C	M6	pH units		4.05	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		179	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		5.15	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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	7200	Date of Sampling:	24-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	25-April-2024

1. Sampling is outside the laboratory's scope of accreditation. Where applicable, free and total chlorine results are supplied by the sampling officer.
2. This report shall not be reproduced except in full, without written approval from the laboratory.
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Nolan Africa
Technical Signatory

APPENDIX B – FEN Consulting SASS5 Reports



Freshwater Ecologist Network Consulting

Applying science to the real world

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Name: Stephen van Staden
Date: Monday, 05 February 2024
Ref: FEN/Umvoto Africa 050224

Umvoto Africa (Pty) Ltd
8 Beach Road
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Attention: Mr. K. de Bruin

TECHNICAL MEMORANDUM

RE: THE SASS5 BASELINE BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.

Borehole production forms part of the Hemel en Aarde Wellfield Expansion Project which aims to provide sustainable water supply solutions to the Overstrand municipal area.

The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March

2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from early April until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

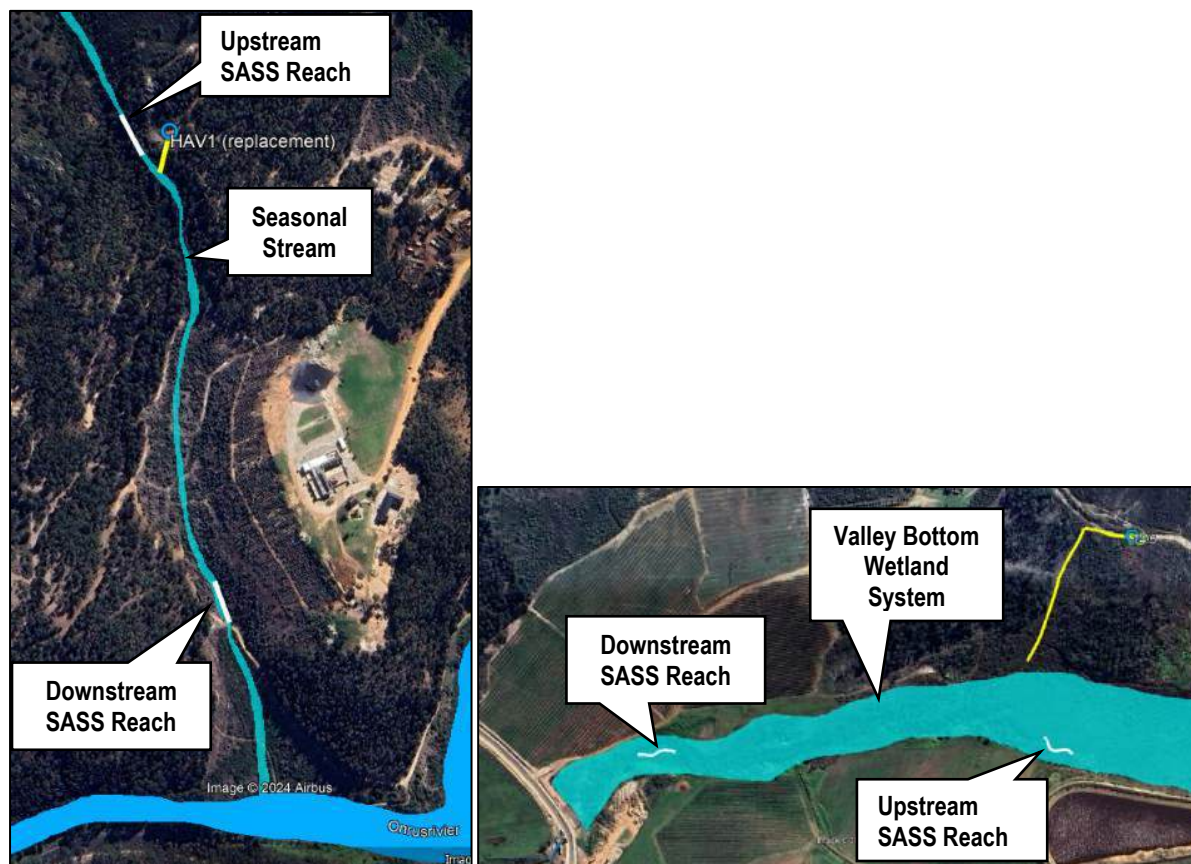


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge locations (yellow lines).

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macroinvertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macroinvertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macroinvertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

Biomonitoring took place on the 19th of January 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5) and therefore the data as presented in this technical memorandum are representative of baseline conditions prior to borehole development. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.¹

RESULTS

The site conditions for each site are described below and photographs are provided in Figure 2 below.

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools overserved. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic *Eucalyptus* (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation (pH = 5.23, temperature = 19.8 °C, Dissolved Oxygen (DO) = 10.5 mg/l, Dissolved Oxygen (%) saturation = 120.5 %, Salinity = 69.9 ppm, Electrical Conductivity (EC) = (14.9 mS/m) and Total Dissolved Carbon (TDS) = 104.3 mg/l.

HAV1 replacement (downstream): This stream reach is significantly more open canopied, with a greater discharge compared to the upstream site, which is expected given increased lateral interflow contributions from the valley. This reach of the stream was a dark brown colour and was significantly more turbid compared to the upstream site, likely due to increased suspension loads from destabilised soils after the excessively high winter 2023 rainfall. Although the overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. The water quality of this stream comprises a much higher ionic content, compared to the upstream site (perhaps due to increased groundwater input), and is considered of fair quality, with pH = 4.11, temperature = 21.7 °C, Salinity = 376 ppm, EC = 79.5 mS/m and TDS = 532 mg/l.

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, with pH = 5.65, temperature = 25.5 °C, DO = 6.51 mg/l, DO (%) = 87.3%, Salinity = 104 ppm, EC = 22.6 mS/m and TDS = 158 mg/l). The water temperature is warmer and more turbid than what it would be, compared to if the river was still vegetated.

¹ Please refer to the comprehensive project description in the Freshwater Assessment supplied by FEN as part of the technical report submission requirements for the Water Use Licence Application (WULA) pertaining to the Hemel en Aarde Wellfield Expansion Project – FEN (2022).

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. The water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality, with pH = 5.53, temperature = 20.8 °C, DO = 8.66 mg/l, DO(%) = 100.2%, Salinity = 194 ppm, EC = 34.5 mg/l and TDS = 265 mg/l.

It must be noted that the T4/5 downstream site is the only site where the SASS biotopes (stones, vegetation and GSM) were sampled separately, due to a sufficiently abundant presence of each.

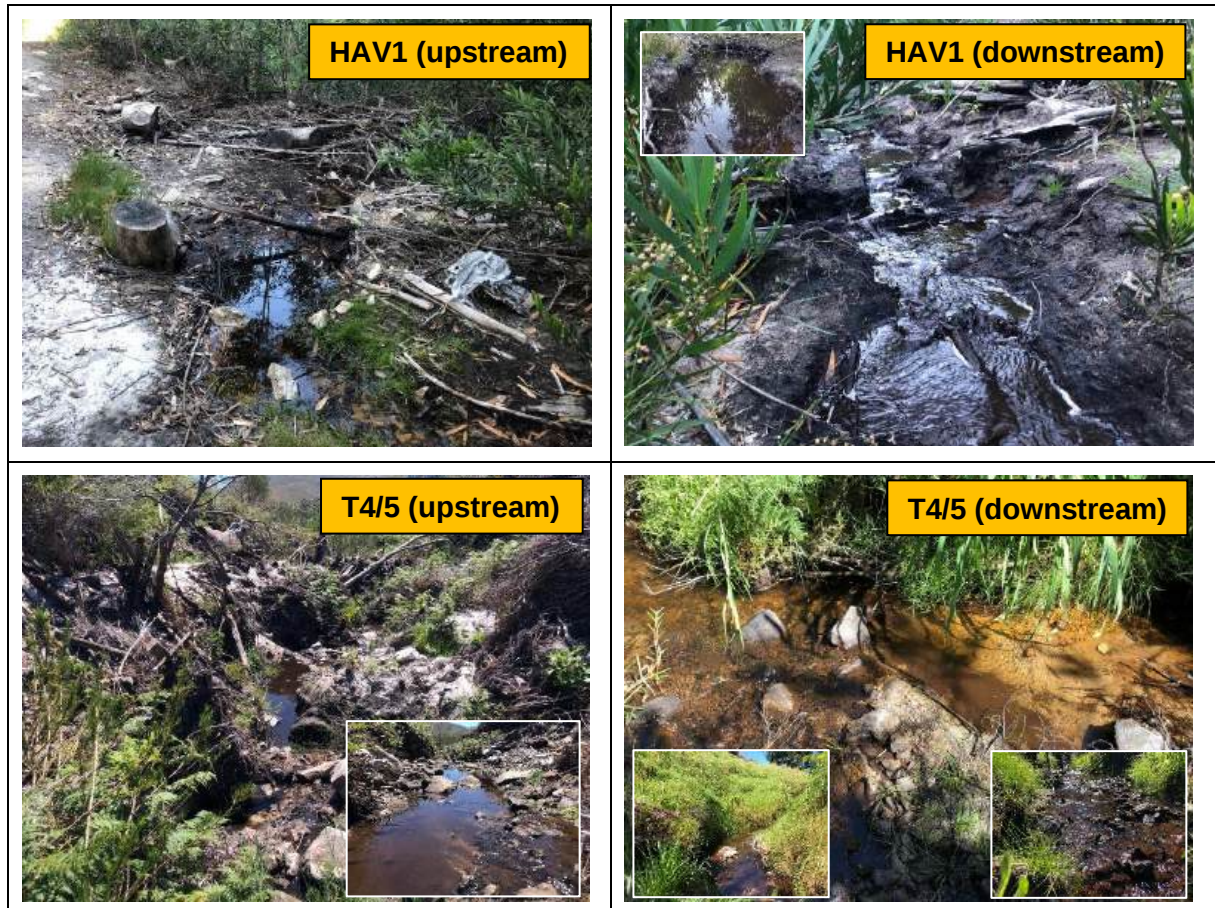


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/6 production borehole development discharge locations.

The calculated SASS 5 scores are provided in Table 1 below which are graphed on a scatterplot in Figure 3 against the Present Ecological Status (PES) Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

Table 1: SASS scores, number of taxa and ASPT scores for the sampled sites.

	HAV1 repl (upstream)	HAV1 repl (downstream)	T4/5 (upstream)	T4/5 (downstream)
SASS Total Score	76	24	47	114
Number of Taxa	9	6	10	23
ASPT	8.44	4	4.70	4.96
PES	A	E/F	E/F	C

The following inferences can be drawn from Table 1:

- The T4/5 upstream site has been heavily disturbed by large scale erosion, presumably from the recent 2023 winter rainfall and is not ideal as a control site. The limited sampleable upstream habitat compared to the downstream habitat explains the significantly lower SASS total scores between these reaches. It was not possible to sample further upstream due to zero flow conditions observed. The similarity in ASPT scores between these reaches indicates a similar community composition in terms of water quality sensitivity;
- The PES A condition at the HAV1 upstream site pertains to the very high ASPT score obtained, and not the SASS total score, considering that the aquatic macroinvertebrate community was dominated by taxa such as amphipods, stone flies, odonates; caddisflies and marsh beetles that are sensitive to water quality (Table 2);
- The comparatively lower SASS total score and ASPT scores at the HAV1 downstream site pertains to a decrease in stoney habitat in which most of the sensitive taxa at the HAV1 upstream site were found, and prevalence of sand, mud and marginal vegetation, which typically favours non sensitive hemipterans (true bugs) and coleopterans (beetles) (Table 2). The deterioration in water quality at the HAV1 downstream site in terms of increased Electrical Conductivity may also be posing a negative impact on the macroinvertebrate community.

Table 2: Taxa identified across all biotopes at the sample sites.

ORDER	FAMILY	SENSITIVITY SCORE	HAV1 repl (us)	HAV1 repl (ds)	T4/5 (us)	T4/5 (ds)
ANNELIDA	<i>Oligochaeta</i>	1				√
CRUSTACEA	<i>Amphipoda</i>	13	√			
	<i>Potamonautidae*</i>	3	√			√
PLECOPTERA	<i>Notonemouridae</i>	14	√			
EPHEMEROPTERA A	<i>Baetidae sp. (x)</i>	4			√	√
	<i>Baetidae sp. (y)</i>	6				√
	<i>Caenidae</i>	6			√	√
ODONATA	<i>Chlorolestidae</i>	8	√			
	<i>Coenagrionidae</i>	4				√
	<i>Aeshnidae</i>	8			√	√
	<i>Gomphidae</i>	6				√
	<i>Libellulidae</i>	4		√	√	√
HEMIPTERA	<i>Corixidae*</i>	3		√	√	√
	<i>Gerridae*</i>	5		√	√	√
	<i>Hydrometridae*</i>	6				√
	<i>Nepidae*</i>	3			√	√
	<i>Pleidae*</i>	4			√	√
	<i>Veliidae/Mesoveliidae*</i>	5	√			√
TRICHOPTERA	<i>Philopotamidae</i>	10	√			
	<i>Leptoceridae</i>	6	√			√
COLEOPTERA	<i>Dytiscidae*</i>	5		√	√	√
	<i>Elmidae*</i>	8				√
	<i>Gyrinidae*</i>	5				√
	<i>Helodidae</i>	12	√			
	<i>Hydraenidae*</i>	8				√
	<i>Hydrophilidae*</i>	5	√	√	√	√
DIPTERA	<i>Athericidae</i>	10				√
	<i>Chironomidae</i>	2		√		√
	<i>Culicidae*</i>	1				√

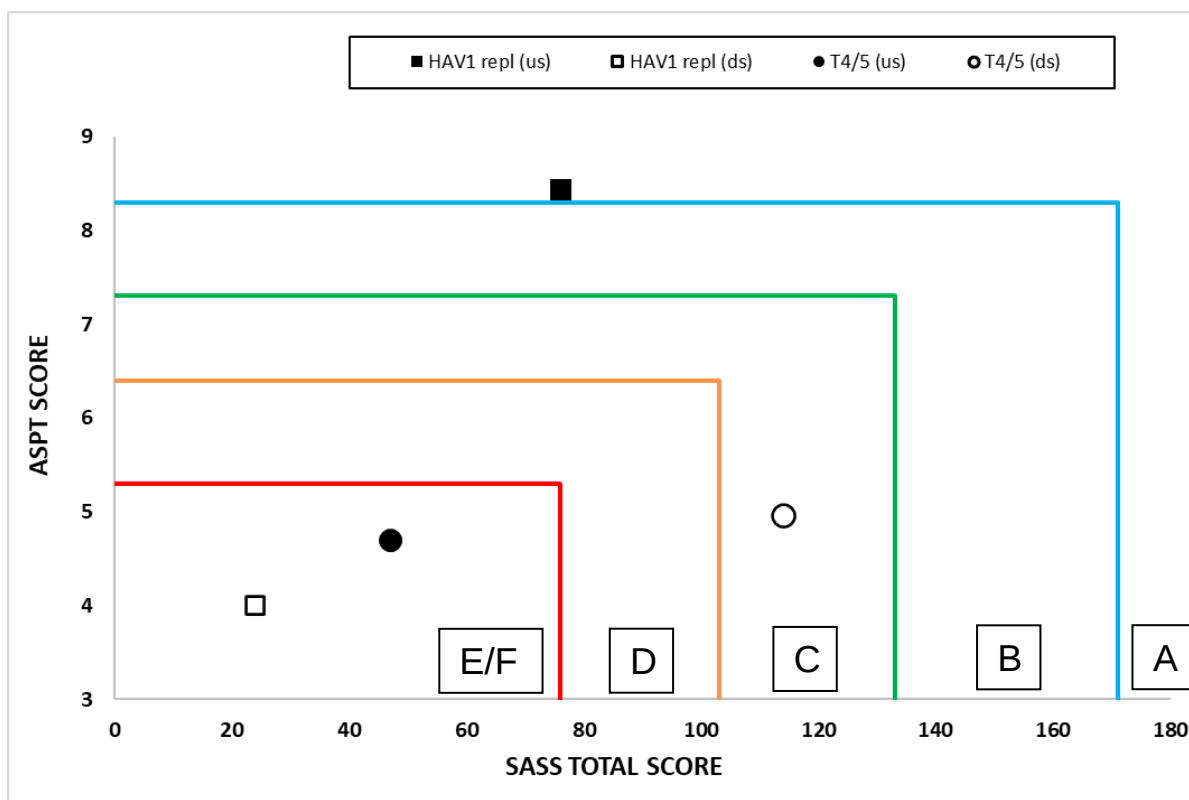


Figure 3: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Forder Mountains Ecoregion.

CONCLUSIONS

Due to the following reasons, SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macroinvertebrate community at the HAV1 repl and T4/5 sites:

Given the low flow conditions observed on the 19th January, and considering the persistent hot weather throughout February, it is unlikely that the upstream reaches of HAV1 repl and T4/5 will have flow conditions. If this proves to be the case, it would mean that there would be no comparison between baseline data and construction phase data, which is required to determine whether groundwater discharge is having a negative impact on the macroinvertebrate community;

Given that the T4/5 upstream site is significantly more degraded than its downstream site and was but a trickle on the 19th January, it does not meet the criteria of a control site, i.e. an unimpacted site that is rich in biodiversity. Therefore, control-impact site comparisons are not possible at T4/5; and

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from vegetation.

RECOMMENDATIONS

Given the challenges experienced during the site visit, and the outcomes of the SASS5 data analysis, it would offer more value to monitor for the potential smothering of the active channel and associated vegetation, considering that deposited silts would require elevated base flows to be lifted and removed further downstream. Fine silts clog the interstitial spaces that are used as refugia for eggs and small/juvenile specimens, which would have a negative impact on the survival of some species. Finally, the use of diatom or habitat indices may be more applicable to the monitoring of these sites.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the subject UCVBW in question.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd



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Applying science to the real world

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Name: Stephen van Staden
Date: Monday, 04 March 2024
Ref: FEN/Umvoto Africa 010324

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8 Beach Road
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7945
Tel : +27 (0) 21 709 6700

Attention : Dr. K. Riemann

TECHNICAL MEMORANDUM

RE: THE SASS5 BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

FEBRUARY 2024

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

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The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March 2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from late March until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

Biomonitoring has taken place on the 19th of January 2024 and as of this report, on the 22nd of February 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5). The January 2024 data is representative of baseline conditions prior to borehole development and the February 2024 data is representative of the construction phase for both boreholes. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macroinvertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macroinvertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macroinvertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

The biomonitoring assessment included the following aquatic indices:

- Invertebrate Habitat Assessment System (IHAS) - McMillan (1998) which was informed by a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates;
- South African Scoring System Version 5 (SASS 5) – which derives the Present Ecological Status (PES) of a river based on the presence of macroinvertebrate families; and
- *In situ* biota specific water quality data was collected to assist in interpreting the biological data, using a calibrated portable multimeter (Extech EC-500 and Extech DO-600).

All work was overseen by a South African River Health Program (SA RHP) SASS5 Accredited Assessor.

Please refer to Figure 1 for the locality map of the sampling sites.

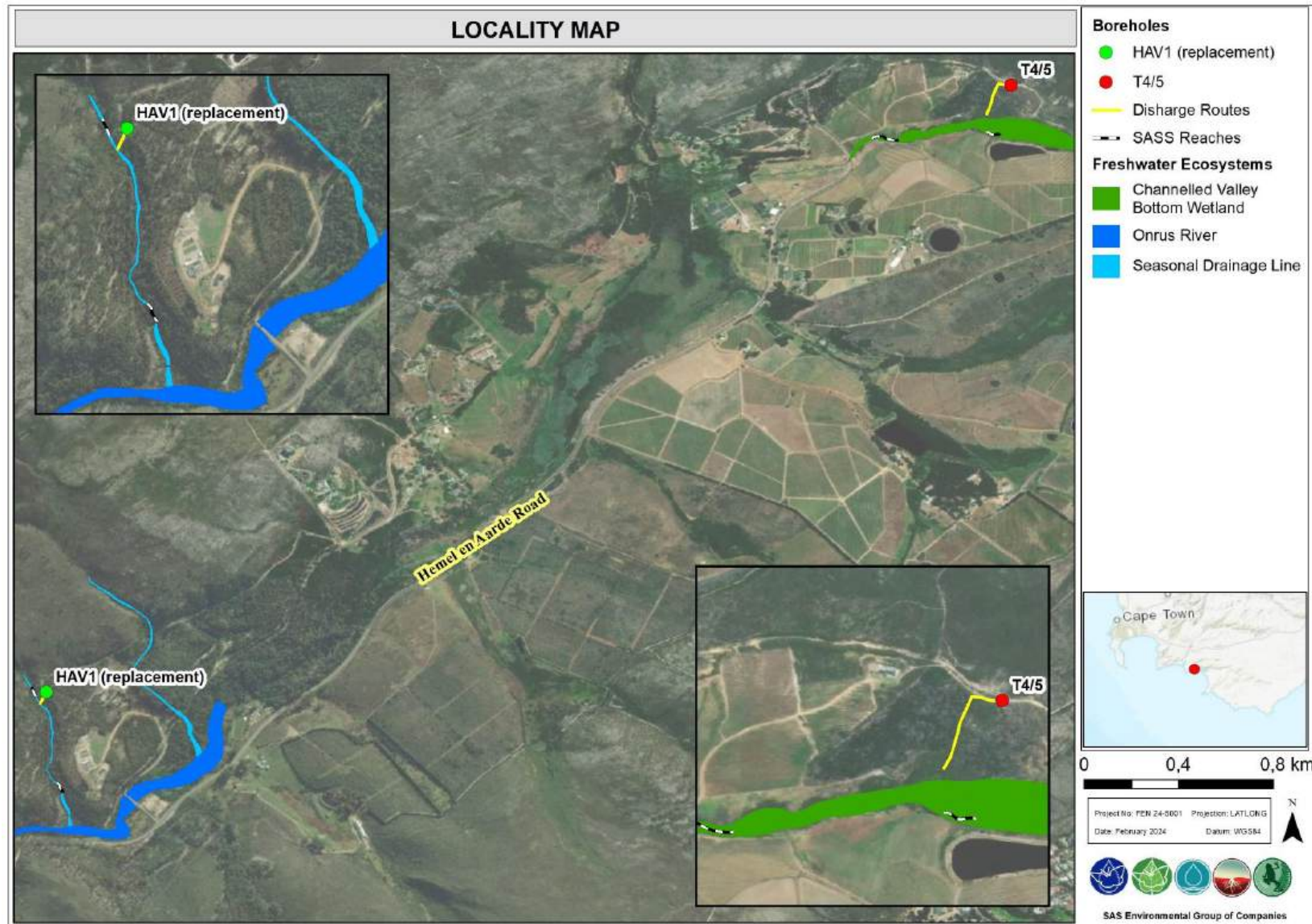


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge routes.

RESULTS

Site Descriptions

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools observed. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic and ongoing *Eucalyptus* tree (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation. Discharge in February 2024 was noticed to be less compared to January 2024 which limited the SASS biotope sample to muddy vegetated pools, with stoney habitat no longer available.

HAV1 replacement (downstream): This stream reach is significantly more open canopied, with a greater discharge compared to the upstream site, which is expected given increased lateral interflow contributions from the valley. This reach of the stream was a dark brown colour and was significantly more turbid compared to the upstream site, likely due to increased suspension loads from destabilised soils after the excessively high winter 2023 rainfall. Although the overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. The water quality of this stream comprises a much higher ionic content, compared to the upstream site (perhaps due to increased groundwater input), and is considered of fair quality.

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, although the water temperature is warmer and the clarity is more turbid than what it would be, compared to if the river was still vegetated. Discharge in February 2024 was noticed to be greater compared to January 2024, which resulted in the submergence of cobbles, thereby creating stoney habitat that was lacking during the January assessment.

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. The water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality. Discharge in February 2024 was noticed to be greater compared to January 2024, but due to the recent large erosion events and subsequent removal of the marginal vegetation component, no significant increase in habitat was observed.

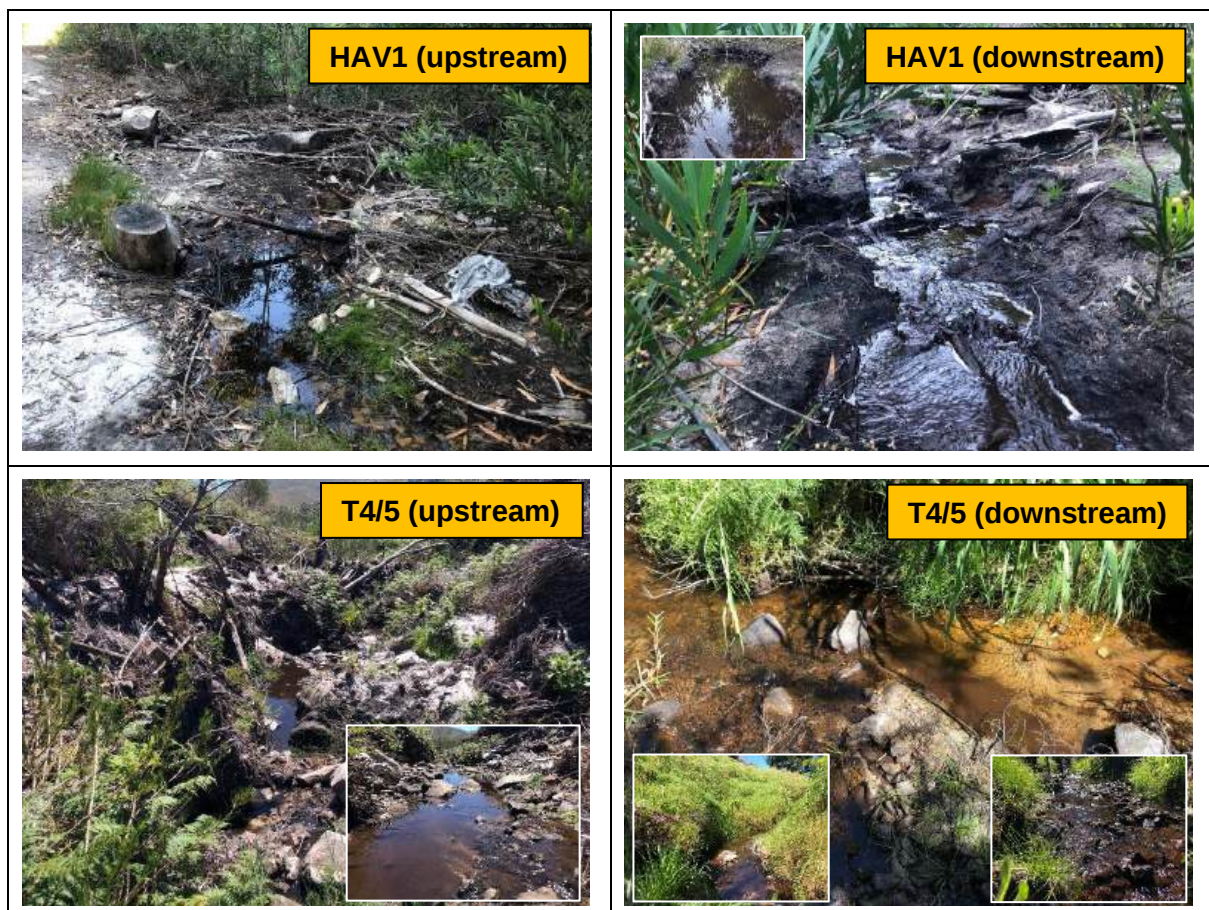


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/5 production borehole development discharge locations.

Aquatic Macroinvertebrate Community Integrity

The calculated SASS 5 indices (SASS total Score, number of taxa and Average Score Per Taxon - ASPT) for the HAV1 and T4/5 biomonitoring sites during the January and February 2024 aquatic assessments are tabulated below in Table 1 and graphed below in Figure 3. The IHAS % score was used to compare macroinvertebrate habitat integrity.

Table 1: SASS5 and IHAS results for the HAV1 and T4/5 sites in January and February 2024.

Site	HAV1				T4/5			
	Jan-24		Feb-24		Jan-24		Feb-24	
Reach	us	ds	us	ds	us	ds	us	ds
SASS Total Score	76	24	73	35	47	114	67	98
Taxa	9	6	11	6	10	23	14	19
ASPT	8.44	4	6.64	5.83	4.7	4.96	4.79	5.16
PES	A	E/F	C	D	E/F	C	E/F	D
IHAS	60	62	52	62	43	80	62	80

The percentages in variation of the SASS5 indices and IHAS % scores at the HAV1 repl and T4/5 biomonitoring sites were compared temporally and spatially in Table 2 below as follows:

- **Temporally:** % variation at an upstream or downstream site in January and then compared again in February 2024, to gauge whether a deterioration in the aquatic macroinvertebrate community and habitat integrity has taken place over time between the upstream and downstream sites; and

- **Spatially:** % variation between an upstream and downstream site in January and February 2024, to gauge for stability in the baseline differences in the aquatic macroinvertebrate community and habitat integrity between the upstream and downstream sites over time.

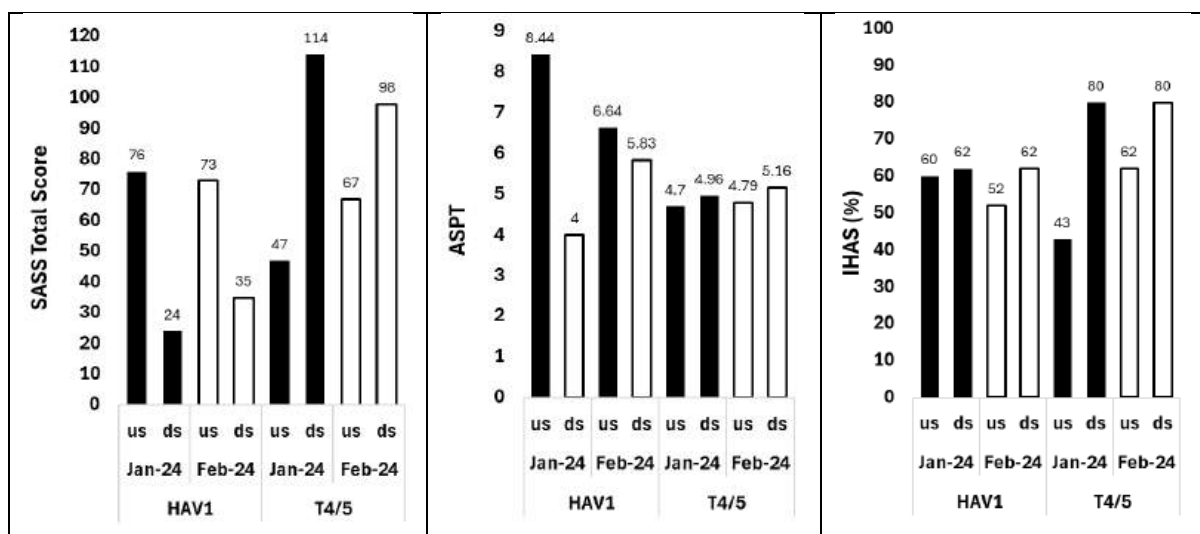


Figure 3: SASS5 and IHAS results for the HAV1 and T4/5 sites in January and February 2024.

Table 2: Temporal and spatial % variation of the SASS5 indices and IHAS scores at the HAV1 repl and T4/5 biomonitoring sites for the January and February 2024 aquatic assessments.

Site	% Variation							
	HAV1				T4/5			
	Temporal		Spatial		Temporal		Spatial	
	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)
SASS Score	-3.9%	+45.8%	-68%	-52%	+42.6%	-14%	143%	46%
Taxa	+22.2%	0.0%	-33%	-45%	+40.0%	-17%	130%	36%
ASPT	-21.3%	+45.8%	-53%	-12%	1.9%	4%	6%	8%
IHAS	-13.3%	0.0%	+3%	+19%	44.2%	0%	86%	29%

Table 3: Aquatic macroinvertebrate community comparisons at the HAV1 and T4/5 biomonitoring sites between January 2024 and February 2024.

ORDER	FAMILY	SENSITIVITY SCORE	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24
			HAV1 repl (us)		HAV1 repl (ds)		T4/5 (us)		T4/5 (ds)	
ANNELIDA	<i>Oligochaeta</i>	1							√	
CRUSTACEA	<i>Amphipoda</i>	13	√	√						
	<i>Potamonautidae</i> *	3	√	√				√	√	√
PLECOPTERA	<i>Notonemouridae</i>	14	√			√				
EPHEMEROPTERA	<i>Baetidae 1 sp.</i>	4					√	√	√	
	<i>Baetidae 2 sp.</i>	6						√	√	
	<i>Leptophlebiidae</i>	9								√
	<i>Caenidae</i>	6					√	√	√	√
ODONATA	<i>Chlorolestidae</i>	8	√	√						
	<i>Coenagrionidae</i>	4							√	√

			Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24
ORDER	FAMILY	SENSITIVITY SCORE	HAV1 repl (us)		HAV1 repl (ds)		T4/5 (us)		T4/5 (ds)	
	<i>Platycnemididae</i>	10		✓						
	<i>Aeshnidae</i>	8					✓	✓	✓	✓
	<i>Gomphidae</i>	6							✓	✓
	<i>Libellulidae</i>	4		✓	✓	✓	✓	✓	✓	✓
HEMIPTERA	<i>Corixidae*</i>	3			✓		✓	✓	✓	✓
	<i>Gerridae*</i>	5		✓	✓	✓	✓	✓	✓	✓
	<i>Hydrometridae*</i>	6							✓	
	<i>Nepidae*</i>	3					✓	✓	✓	✓
	<i>Pleidae*</i>	4					✓	✓	✓	✓
	<i>Veliidae/Mesoveliiidae*</i>	5	✓	✓				✓	✓	✓
TRICHOPTERA	<i>Philopotamidae</i>	10	✓							
	<i>Leptoceridae</i>	6	✓	✓					✓	✓
COLEOPTERA	<i>Dytiscidae*</i>	5		✓	✓	✓	✓		✓	✓
	<i>Elmidae*</i>	8						✓	✓	
	<i>Gyrinidae*</i>	5				✓			✓	✓
	<i>Helodidae</i>	12	✓	✓						
	<i>Hydraenidae*</i>	8							✓	
	<i>Hydrophilidae*</i>	5	✓		✓		✓	✓	✓	✓
DIPTERA	<i>Athericidae</i>	10							✓	✓
	<i>Chironomidae</i>	2		✓	✓	✓		✓	✓	✓
	<i>Simuliidae</i>	5						✓		✓
	<i>Culicidae*</i>	1							✓	

The following inferences can be drawn from Table 1, Table 2, Table 3 and Figure 3:

HAV1 repl:

- **Temporally at the upstream site**, the SASS Total score, which is a measure of macroinvertebrate diversity remained stable and only dropped by 3.9% between January (76) and February 2024 (73), despite 2 more taxa being identified in February 2024. The ASPT score, which describes the average sensitivity of macroinvertebrates however dropped by 21.3% between January (8.44) and February 2024 (6.64). This significant drop (>15%) is due to not finding highly sensitive taxa such as Notonemouridae and Philopotamidae due to not being able to sample stoney habitats in February 2024, as a result of lower base flows compared to January 2024. The identification of low sensitivity taxa such as Libellulidae, Gerridae, Dytiscidae and Chironomidae further brought down the ASPT score, while the finding of highly sensitive Platycnemididae has offset the decrease in the ASPT score. It must be noted that highly sensitive taxa such as Chlorolestidae and Helodidae were still identified in February 2024, indicating that the lower ASPT score is attributed to less habitat availability, as indicated by the decrease in the IHAS score by 13.3% between January and February 2024 (60% vs 52% respectively);
- **Temporally at the downstream site**, the SASS Total score increased between January (24) and February 2024 (35) by 45.8%, despite the same number of taxa being identified. The ASPT score also increased by 45.8% between January (4) and February 2024 (5.83). This significant increase (>15%) is due to finding a single highly sensitive Notonemouridae specimen in February 2024 which was not identified in January 2024, but which would have a large influence on the ASPT score, especially as macroinvertebrate community only comprises 6 taxa.

Although the downstream habitat also does not have favourable stoney habitat to sample, the water quality is still considered of sufficient quality to support Notonemourids. No change in the macroinvertebrate habitat integrity was observed at the downstream reach between January and February 2024 due to discharge being similar at these sampling times;

- **Spatially between the upstream and downstream sites**, a larger difference in the SASS Total score (68%) and ASPT score (53%) was observed in January compared to February 2024 (SASS Total score = 52% and ASPT score = 12 %). This is due to 1) more taxa of a 2) lower sensitivity being identified at the upstream site in February which has resulted in a more similar macroinvertebrate community between the upstream and downstream sites in terms of the ASPT score. A larger difference in the IHAS score was observed in February (19%) compared to January 2024 (3%) due to a notable decrease in the availability of stoney habitat at the upstream site in February, and
- The results as described above are expected given the natural environmental changes.

T4/5:

- **Temporally at the upstream site**, the SASS Total score increased by 42.6% between January (47) and February 2024 (67), due to 4 more taxa being identified in February 2024. The ASPT score, however remained stable (1.9%) between January (4.70) and February 2024 (4.79). This is due to the additional taxa identified in February 2024 (Potamonautidae, Veelidae, Chironomidae, and Simuliidae) also being of low sensitivity and therefore not having an influence on the ASPT. The identification of moderate sensitivity taxa such as Elmidae in February 2024 has likely assisted to keep the ASPT stable. The increased SASS Total score can be attributed to a significant increase (44.2%) in macroinvertebrate habitat availability between January and February 2024, whereby the slightly higher stream discharge at this time resulted in the submergence of stoney habitat and the creation of riffle hydraulic biotopes that were absent in January 2024;
- **Temporally at the downstream site**, the SASS Total score decreased between January (114) and February 2024 (98) by 14%, due to 4 fewer taxa being identified. The ASPT score however increased by 4% between January (4.96) and February 2024 (5.16). This increase is due to identifying less taxa of low sensitivity such as Oligochaeta and Culicidae that brought down the ASPT in January 2024, but also due to moderately sensitive taxa such as Leptophlebiidae that were only identified in February 2024. No change in the macroinvertebrate habitat integrity was observed at the downstream reach between January and February 2024 due to discharge being similar at these sampling times;
- **Spatially between the upstream and downstream sites**, a larger difference in the SASS Total score (143%) and IHAS score (86%) was observed in January compared to February 2024 (SASS Total score = 46% and IHAS score = 29 %). This is due to a greater disparity in the habitat integrity between the upstream and downstream site in January 2024 compared to February 2024, due to the slightly higher discharge at the upstream site in February 2024 creating habitat that was more comparable to its downstream reach at this time; and
- The results as described above are expected given the natural environmental changes.

As per Figure 4 below which has plotted the SASS Total score (x-axis) against the ASPT (y-axis) within the context of Present Ecological Status (PES) Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion, the following inferences can be drawn.

- The T4/5 upstream site remained in a PES Class E/F (Severely to Critically Modified ecological condition between January 2024 and February 2024);
- The T4/5 downstream site deteriorated slightly from a PES Class C (Moderately Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and February 2024 due to a slight, but critical decrease in the SASS Total score from 114 to 98;
- The HAV1 upstream site deteriorated from a PES Class A (Pristine) ecological condition to a PES Class C (Moderately Modified) ecological condition between January 2024 and February 2024 due to a decrease in the ASPT score, from 8.44 to 6.64; and

- The HAV1 downstream site improved slightly from a PES Class E/F (Severely to Critically Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and February 2024 due to an increase in the ASPT score, from 4 to 5.83.

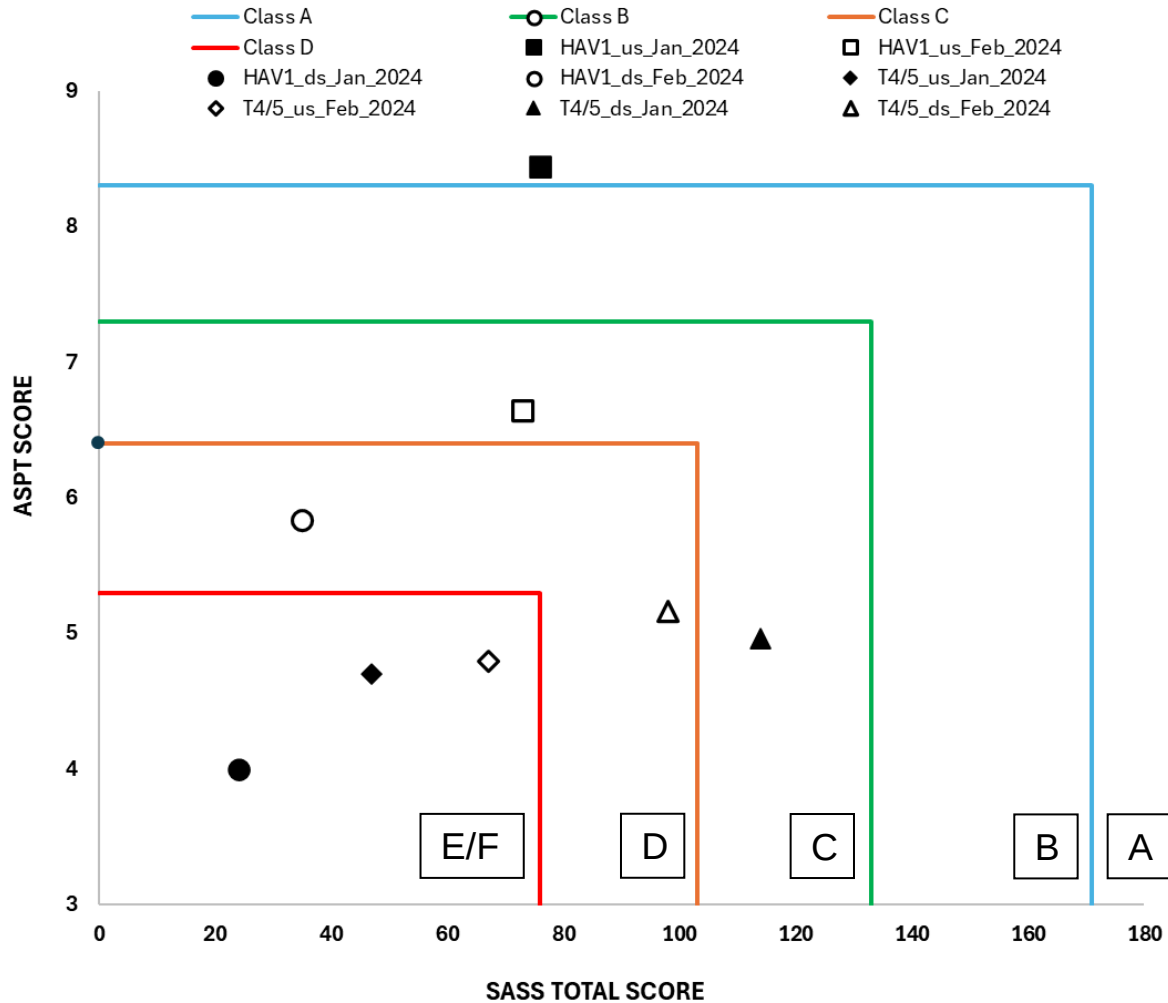


Figure 4: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

In Situ Physico-Chemistry

The following inferences can be drawn from Table 4 and Table 5 and Figure 5:

HAV1 repl:

- **Temporally at the upstream site**, the pH decreased by 9.9% between January (5.23) and February 2024 (4.71) and the EC increased by 16.2% between January (14.9 mS/m) and February 2024 (17.31 mS/m);
- **Temporally at the downstream site**, the pH decreased by 10.9% between January (4.11) and February 2024 (3.66) and the EC also decreased by 3.3% between January (79.5 mS/m) and February 2024 (76.9 mS/m);
- **Spatially between the upstream and downstream sites**, a similar difference in the pH between the upstream and downstream sites was observed in January compared to February 2024 (21% vs 22% respectively) but a larger difference in EC was observed between the upstream site compared to the downstream site (434% vs 344% respectively); and

- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the unacceptable range limit ($< 6.5 - > 8.4$) for all sites. Although the pH values do not comply to the 2011 RWQOs of South Africa, the acidic nature of the Western Cape's rivers is characteristic due to river pH being influenced largely by acidic tannin compounds, as contributed by the Fynbos vegetation they flow through, more so than the already heavily weathered and inert sandstone substrates they flow over.
- The EC values at the upstream sites fall within the ideal range limit (≤ 30 mS/m) while the EC value at the downstream sites fall within the tolerable range limit ($\geq 50 - \leq 85$ mS/m). It must be noted that the elevated EC at the downstream site probably reflects deforestation through which this stream reach flows (unlike at the upstream site), with additional dissolved salts (ions) adsorbed to sediments, or perhaps due to increased groundwater contributions, considering that discharge at the downstream site is significantly greater compared to the upstream site.

T4/5:

- **Temporally at the upstream site**, the pH decreased by 4.4% between January (5.65) and February 2024 (5.40) and the EC remained stable between January (22.6 mS/m) and February 2024 (22.7 mS/m);
- **Temporally at the downstream site**, the pH remained stable between January (5.53) and February 2024 (5.49) and the EC increased by 26% between January (34.5 mS/m) and February 2024 (43.6 mS/m);
- **Spatially between the upstream and downstream sites**, the same difference in the pH between the upstream and downstream sites was observed in January compared to February 2024 (2% vs 2% respectively) but a larger difference in EC was observed between the upstream site compared to the downstream site (53% vs 92% respectively); and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the unacceptable range limit ($< 6.5 - > 8.4$) for the upstream and downstream sites, while the EC at the upstream and downstream site fall within the acceptable range limit ($\geq 30 - \leq 50$ mS/m). Although the pH values do not comply to the 2011 RWQOs of South Africa, the acidic nature of the Western Cape's rivers is characteristic due to river pH being influenced largely by acidic tannin compounds, as contributed by the Fynbos vegetation they flow through, more so than the already heavily weathered and inert sandstone substrates they flow over; It must be noted that the elevated EC probably reflects erosion and destabilisation of the river banks from the previous winter flood events), with additional dissolved salts (ions) adsorbed to sediments, or perhaps due to increased groundwater contributions to river base flow at this time of the year.

Table 4: pH and EC results for the HAV1 and T4/5 sites in January and February 2024.

Site	HAV1				T4/5			
Month	Jan-24		Feb-24		Jan-24		Feb-24	
Reach	us	ds	us	ds	us	ds	us	ds
pH	5.23	4.11	4.71	3.66	5.65	5.53	5.40	5.49
EC (mS/m)	14.9	79.5	17.31	76.9	22.6	34.5	22.7	43.6

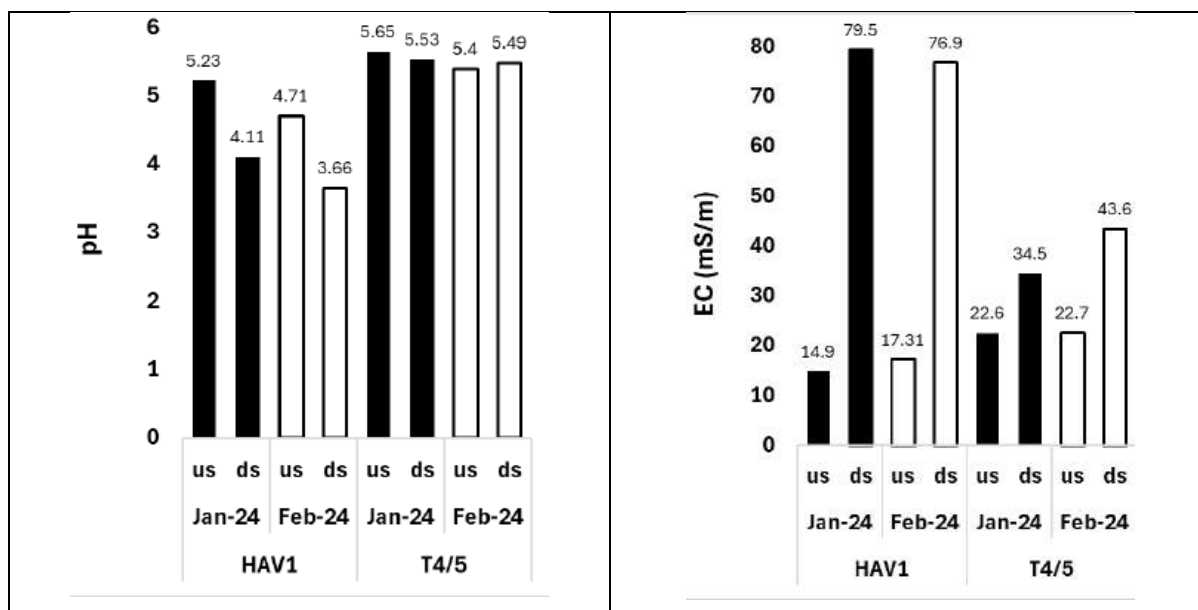


Figure 5: pH and EC results for the HAV1 and T4/5 sites in January and February 2024.

Table 5: Temporal and spatial % variation of pH and EC at the HAV1 repl and T4/5 biomonitoring sites for the January and February 2024 aquatic assessments.

% Variation								
Site	HAV1				T4/5			
	Temporal		Spatial		Temporal		Spatial	
	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)
pH	-9.9%	-10.9%	-21%	-22%	-4.4%	-1%	-2%	+2%
EC (mS/m)	+16.2%	-3.3%	+434%	+344%	+0.4%	+26%	+53%	+92%

CONCLUSIONS

SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macroinvertebrate community at the HAV1 repl and T4/5 sites due to the following reasons:

Given that the T4/5 upstream site is significantly more degraded than its downstream site and was but a trickle in January and February 2024, it does not meet the criteria of a control site, i.e. an unimpacted site relative to its downstream site. Therefore, control-impact site comparisons are not possible at T4/5. The upstream site has consistently returned lower SASS Total and ASPT scores relative to the downstream site in this regard;

It is envisaged that the flows at the HAV1 repl upstream site will dry up sometime during March/April 2024, or will be so long that the SASS5 protocol will no longer be applicable;

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from riparian and instream vegetation.

However, despite the above, no points of concern are raised with respect to the macroinvertebrate community and the associated habitat during the pre-construction and construction phases of the HAV1 and T4/5 boreholes thus far.

RECOMMENDATIONS

The potential erosion and siltation of streams must be continuously monitored in parallel with the SASS5 biomonitoring assessment, to ensure that the interstitial spaces of the streams, that are used as refugia for eggs and small/juvenile specimens remain unclogged.

In the event that the flows dry up to the degree that the SASS5 protocol can no longer be applied, the monitoring programme would need to be adjusted to accommodate the use of diatom and habitat indices that are appropriate under very low to zero flow environmental conditions.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the SASS5 biomonitoring results between January 2024 and February 2024.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd

APPENDIX A – SASS5 Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1 upstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: ° C	Amphipoda	13				B	Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				A	Pleidae*	4					Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				1	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	73
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				B	NO OF TAXA:		0	0	0	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:	####	####	####	6.64	
	Chlorolestidae	8				1	Pisuliidae	10					IHAS:	%				
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10				A	Dytiscidae*	5				1	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12				A	S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyralidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1 Downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3					Pleidae*	4					Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5					Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14				1	TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	35
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5.83
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5				A	T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyalidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3				1	Blepharoceridae	15				
SITE CODE: T4/5 upstream	ANNELIDA:						Gerridae*	5				B	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				1	Pleidae*	4				A	Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				A
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4				A	Hydropsychidae 1 sp	4					Ancyidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				A	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6				1	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Vivparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	71
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	15
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	4.73
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8				A	SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8				1	Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5				A	GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyalidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				1
E: °	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				B	Pleidae*	4				A	Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				A
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancyidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6				A	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9				1	CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Vivparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	98
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				1	NO OF TAXA:		0	0	0	19
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5.16
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4				A	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5				A	T = Tropical					
	Aeshnidae	8				A	Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6				1	Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5				A	GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyralidae	12					Psephenidae	10										

APPENDIX B – IHAS Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River	Date: 20 February 2024					
Site Name: HAV1 repl upstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):					0
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):					9
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'cor' = correct time) (* NOTE: you must still fill in the SIC section)		under		corr		over
	Other Habitat Score (max 20):					18
	HABITAT TOTAL (MAX 55):					27
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(* NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):					25
	TOTAL IHAS SCORE (%):					52

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River	Date: 20th February 2024					
Site Name: HAV1 repl downstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):			8			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
Vegetation Score (max 15):			11			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
Other Habitat Score (max 20):			20			
HABITAT TOTAL (MAX 55):			39			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
STREAM CONDITIONS TOTAL (MAX 45):			23			
TOTAL IHAS SCORE (%):			62			

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 upstream	Date: 20th February 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):				15	
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				7	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				14	
	HABITAT TOTAL (MAX 55):				36	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):				26	
	TOTAL IHAS SCORE (%):				62	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 downstream	Date: 20th February 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
			SIC Score (max 20): 18			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
			Vegetation Score (max 15): 15			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
			Other Habitat Score (max 20): 20			
			HABITAT TOTAL (MAX 55): 53			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
			STREAM CONDITIONS TOTAL (MAX 45): 27			
			TOTAL IHAS SCORE (%): 80			



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Applying science to the real world

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Name: Stephen van Staden
Date: Monday, 15 April 2024
Ref: FEN 24-5029

Umvoto Africa (Pty) Ltd
8 Beach Road
Muizenberg
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Attention : Dr. K. Riemann

TECHNICAL MEMORANDUM

RE: THE SASS5 BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

MARCH 2024

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.

Borehole production forms part of the Hemel en Aarde Wellfield Expansion Project which aims to provide sustainable water supply solutions to the Overstrand municipal area.

The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March 2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from late March until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

Biomonitoring has taken place on the 19th of January 2024, 22nd of February 2024 and as of this report, on the 28th of March 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5). The January 2024 data is representative of baseline conditions prior to borehole development and the February 2024 and March 2024 data is representative of the construction phase for both boreholes. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macro-invertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macro-invertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macro-invertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

The biomonitoring assessment included the following aquatic indices:

- Invertebrate Habitat Assessment System (IHAS) - McMillan (1998) which was informed by a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates;
- South African Scoring System Version 5 (SASS 5) – which derives the Present Ecological Status (PES) of a river based on the presence of macro-invertebrate families; and
- *In situ* biota specific water quality data was collected to assist in interpreting the biological data, using a calibrated portable multimeter (Extech EC-500 and Extech DO-600).

All work was overseen by a South African River Health Program (SA RHP) SASS5 Accredited Assessor. Please refer to Figure 1 for the locality map of the sampling sites.

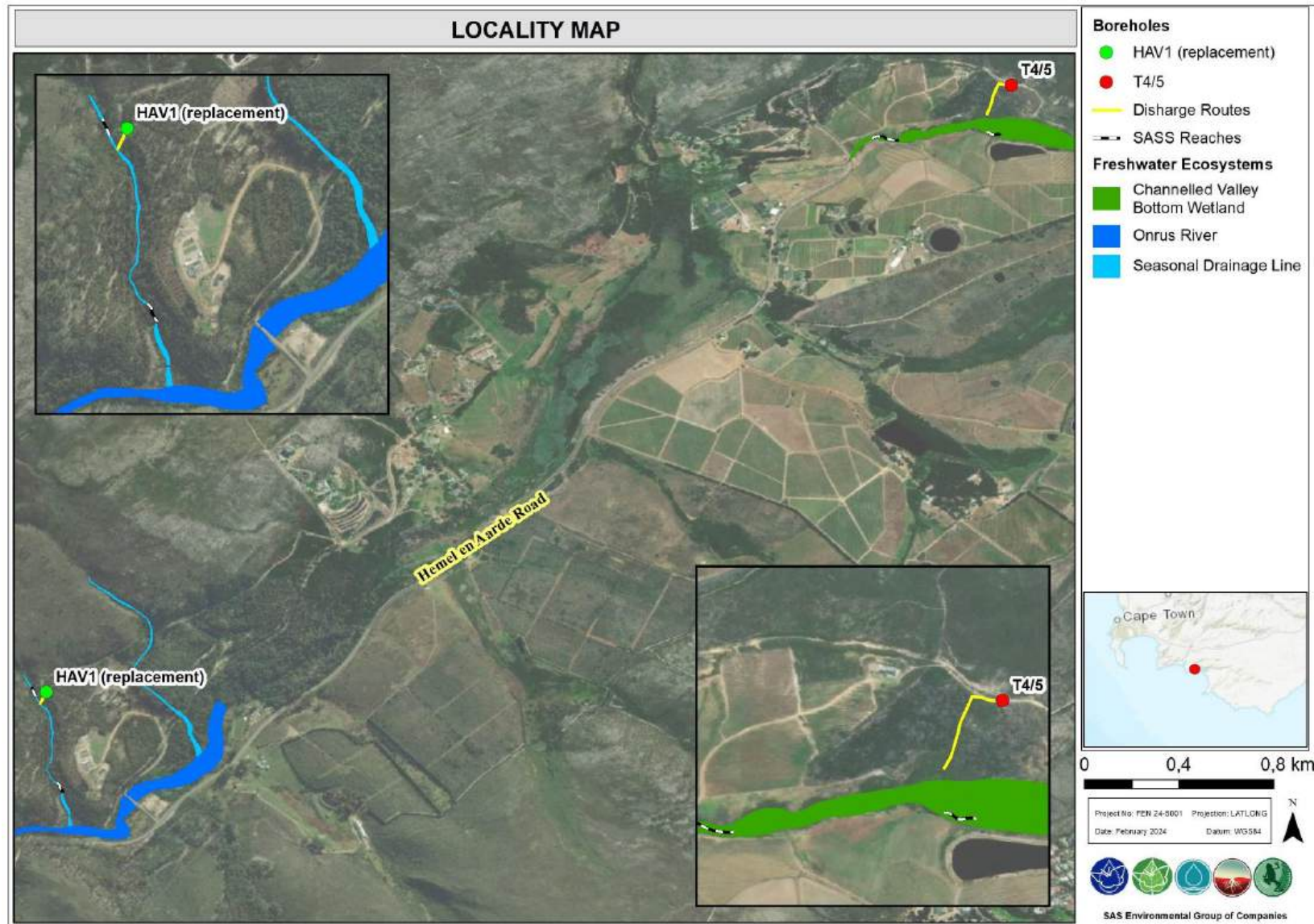


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge routes.

RESULTS

Site Descriptions

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools observed. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic and ongoing *Eucalyptus* tree (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation. During the March 2024 assessment the site was sampled, however, sampling was limited as the site was reduced to a small trickle of water of roughly 5 cm.

HAV1 replacement (downstream): The overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~ 1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. **However, at the time of the March 2024 assessment the site was not assessed due to zero flow conditions present at the site. As such no spatial comparison between sites HAV1 upstream and HAV1 downstream could be done for the March 2024 assessment.**

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, although the water temperature is warmer and the clarity is more turbid than what it would be, compared to if the river was still vegetated.

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. Visually the water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality. As with previous assessments the hydraulic biotopes were regarded as good. Cobbles at the site become increasingly covered with organic soot and is likely due to a general decrease in baseflows over the summer season.

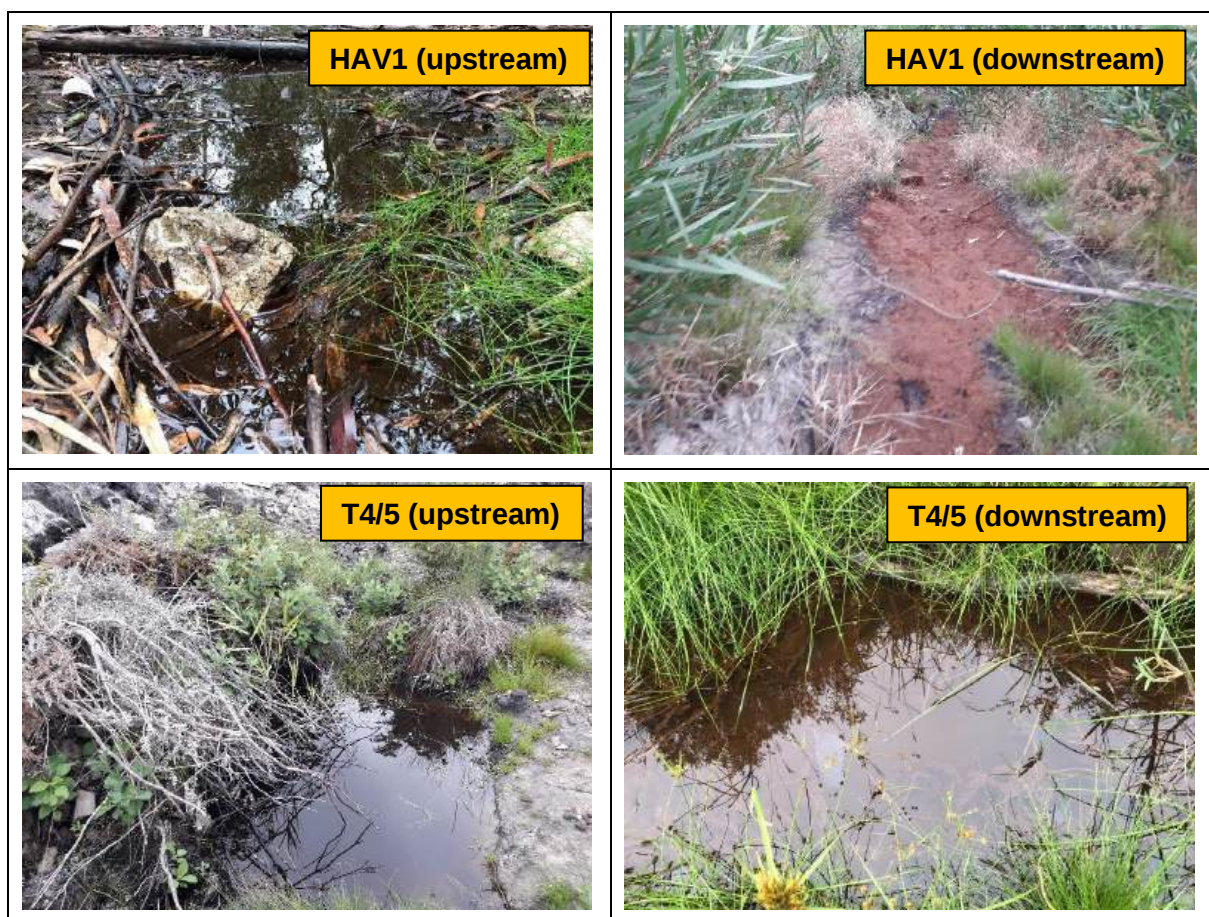


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/5 production borehole development discharge locations.

Aquatic Macro-invertebrate Community Integrity

The calculated SASS 5 indices (SASS total Score, number of taxa and Average Score Per Taxon - ASPT) for the HAV1 and T4/5 biomonitoring sites during the January, February and March 2024 aquatic assessments are tabulated below in Table 1 and graphed below in Figure 3. The IHAS % score was used to compare macro-invertebrate habitat integrity.

Table 1: SASS5 and IHAS results for the HAV1 and T4/5 sites since January 2024.

Site	HAV1						T4/5					
	Jan-24		Feb-24		March-24		Jan-24		Feb-24		March-24	
Reach	us	ds	us	ds	us	ds*	us	ds	us	ds	us	ds
SASS Total Score	76	24	73	35	39	NA	47	114	67	98	86	121
Taxa	9	6	11	6	6	NA	10	23	14	19	17	21
ASPT	8.44	4	6.64	5.83	6.5	NA	4.7	4.96	4.79	5.16	5.06	5.76
PES	A	E/F	C	D	C	NA	E/F	C	E/F	D	D	C
IHAS	60	62	52	62	40	NA	43	80	62	80	62	80

*At the time of the March 2024 assessment the HAV1 ds site could not be assessed due to site having no flow at the time of the assessment.

The percentages in variation of the SASS5 indices and IHAS % scores at the HAV1 replacement and T4/5 biomonitoring sites were compared temporally and spatially in Table 2 below as follows:

- **Temporally:** Percentage variation between the upstream and/or downstream site in January 2024 compared to March 2024, to gauge whether an improvement or deterioration in the

aquatic macro-invertebrate community and habitat integrity has taken place over time between the upstream and downstream sites; and

- **Spatially:** Percentage variation between an upstream and downstream site in March 2024, to gauge for stability in the baseline differences in the aquatic macro-invertebrate community and habitat integrity between the upstream and downstream sites over time.

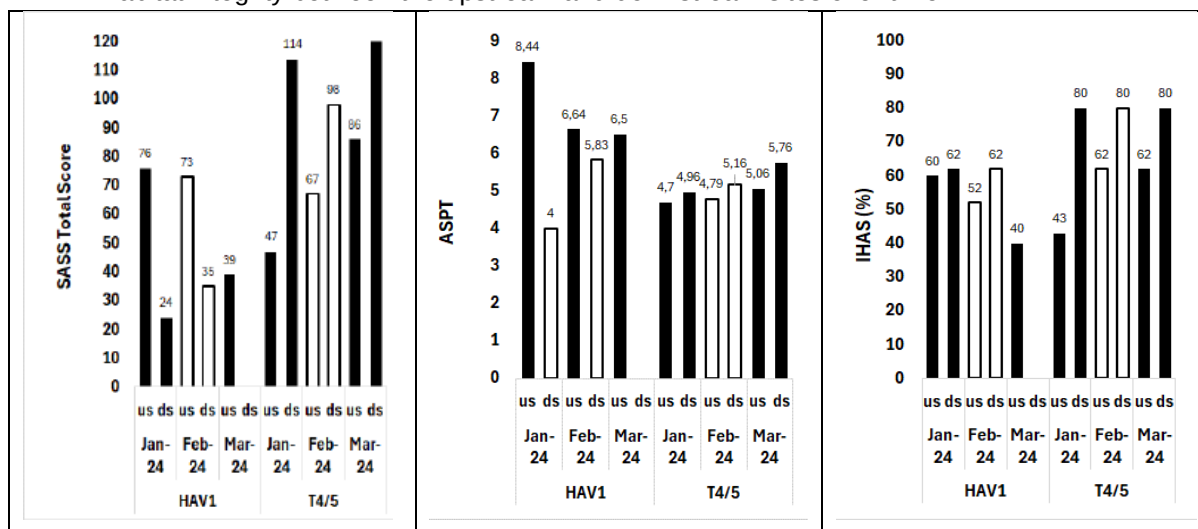


Figure 3: SASS5, ASPT and IHAS results for the HAV1 and T4/5 sites since January 2024.

Table 2: Temporal and spatial % variation of the SASS5 indices and IHAS scores at the HAV1 replacement and T4/5 biomonitoring sites for the March 2024 aquatic assessment.

% Variation						
Site	HAV1			T4/5		
	Temporal		Spatial	Temporal		Spatial
	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024		us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	
SASS Score	-48.7%	NA	NA	+83.0%	+6.0%	+41.0%
Taxa	-33.3%	NA	NA	+70.0%	-9.0%	+24.0%
ASPT	-23.0%	NA	NA	+7.7%	+16.0%	+14.0%
IHAS	-33.3%	NA	NA	+44.2%	0.0%	+29.0%

*Key to variations: Negative value = decrease; Positive value = increase; Normal text = no significant change; Bold text = significant change; Red text = significant deterioration; Blue text = significant improvement.

Table 3: Aquatic macro-invertebrate community comparisons at the HAV1 and T4/5 biomonitoring sites since January 2024.

ORDER	FAMILY	SENSITIVITY SCORE	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24
			HAV1 repl (us)			HAV1 repl (ds)			T4/5 (us)			T4/5 (ds)		
ANNELIDA	Oligochaeta	1										✓		
CRUSTACEA	Amphipoda	13	✓	✓	✓									✓
	Potamonautidae*	3	✓	✓	✓				✓	✓	✓	✓	✓	✓
PLECOPTERA	Notonemouridae	14	✓			✓								✓
EPHEMEROPTERA	Baetidae 1 sp.	4							✓	✓		✓		
	Baetidae 2 sp.	6							✓	✓	✓	✓		✓
	Leptophlebiidae	9											✓	
	Caenidae	6							✓	✓		✓	✓	
ODONATA	Chlorolestidae	8	✓	✓										
	Coenagrionidae	4										✓	✓	
	Platycnemidae	10		✓										
	Aeshnidae	8							✓	✓	✓	✓	✓	✓
	Gomphidae	6										✓	✓	
	Libellulidae	4		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
HEMIPTERA	Corixidae*	3				✓			✓	✓	✓	✓	✓	✓
	Gerridae*	5		✓		✓	✓		✓	✓	✓	✓	✓	✓
	Hydrometridae*	6										✓		
	Nepidae*	3							✓	✓	✓	✓	✓	✓
	Notonectidae	3									✓			✓
	Pleidae*	4							✓	✓	✓	✓	✓	✓
	Veliidae/Mesoveliidae*	5	✓	✓					✓	✓	✓	✓	✓	✓
TRICHOPTERA	Hydropsychidae 1sp	4												✓
CASED CADIS	Philopotamidae	10	✓											
	Leptoceridae	6	✓	✓							✓	✓	✓	✓
COLEOPTERA	Dytiscidae*	5		✓	✓	✓	✓		✓		✓	✓	✓	✓
	Elmidae*	8								✓		✓		✓
	Gyrinidae*	5					✓					✓	✓	✓
	Helodidae	12	✓	✓	✓									
	Hydraenidae*	8									✓	✓		
	Hydrophilidae*	5	✓			✓			✓	✓	✓	✓	✓	✓
DIPTERA	Athericidae	10										✓	✓	✓
	Chironomidae	2		✓	✓	✓	✓			✓	✓	✓	✓	✓
	Simuliidae	5								✓	✓		✓	✓
	Culicidae*	1									✓	✓		

The following inferences can be drawn from the above results in Table 1, Table 2, Table 3 and Figure 3:

HAV1 replacement:

- **Temporally at the upstream site**, both the SASS Total score (which is a measure of macro-invertebrate diversity) and ASPT score (which describes the average sensitivity of macro-invertebrates) significantly deteriorated by 48.7% and 23.0%, respectively, for the current assessment compared to the initial January 2024 assessment. The significant decrease in both indices is most likely due to the significantly decreasing habitat suitability (IHAS score, by 33.3%). The decrease in habitat suitability can possibly be seasonally driven with lower base flows compared to the previous assessments. The decrease in indices is also driven by the decrease in the number of taxa identified during the March 2024 assessment compared to previous assessments which is also due to the decrease in IHAS score. The absence of highly sensitive species during the March 2024 assessment is thus an indication of a decrease in presence of sensitive species with the absence of species such as Chlorolestidae, Platycnemidae, Philopotamidae and Leptoceridae. The identification of low sensitive taxa such as Potamonautidae, Libellulidae, Dytiscidae and Chironomidae further decreased the ASPT score;
- **Temporally at the downstream site**, no percentage variance could be calculated at the time of assessment due to the site not being sampled at the time of the March 2024 assessment.

This is due to no flow conditions at the time of the assessment which is likely due to seasonality and the sampling of the site being just before the start of the rainy season in the area;

- **At the time of the assessment no spatial comparison could be made between the upstream and downstream sites of the HAV1 replacement site due to the downstream site not being sampled (site had no flow);** and
- The results as described above are expected given the natural environmental changes.

T4/5:

- **Temporally at the upstream site**, the SASS Total score increased significantly by 83.0% between the January and March 2024 assessment. The ASPT score insignificantly increased by 7.7% when compared to the January 2024 assessment. The improvement in both SASS5 and ASPT scores is likely due to the significantly increasing habitat suitability (44.2%) between January 2024 and March 2024. The increase in both index scores is due to the additional taxa identified in March 2024 (Potamonautidae, 2 Beatidae sp., Veliidae, Leptoceridae, Hydraenidae and Culicidae);
- **Temporally at the downstream site**, the SASS Total score slightly increased by 6.0% with a significant increase in the ASPT score by 16.0% when compared to the January 2024 assessment. Both changes are considered an improvement, however, the reason for the improvement is unknown as the habitat suitability remained unchanged. It is thus suggested that the improvement in SASS5 and ASPT scores is possibly due to an increase in water quality (significantly decreasing [38.0%] Electrical Conductivity (EC) compared to the January 2024 assessment as will be discussed later in the report). The increase in ASPT score is due to identifying more sensitive species at the site at the time of assessment compared to January 2024;
- **Spatially between the upstream and downstream sites**, a downstream improvement in both SASS5 (41.0%) and ASPT (14.0%) scores was noted, with the former change seen as a significant improvement. The significant downstream improvement in macro-invertebrate community integrity is likely due to the significant downstream increase in habitat suitability (29.0%) compounded by the slight improvement in measured water quality (decreasing EC as discussed later) in a downstream direction at the time of assessment; and
- The results as described above are expected given the natural environmental changes.

As per Figure 4 below which has plotted the SASS Total score (x-axis) against the ASPT (y-axis) within the context of Present Ecological Status (PES). Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion, the following inferences can be drawn.

- The HAV1 upstream site deteriorated from a PES Class A (Pristine) ecological condition to a PES Class C (Moderately Modified) ecological condition between January 2024 and March 2024 due to a significant decrease in both the SASS5 and ASPT scores;
- The HAV1 downstream site could not be determined for the March 2024 assessment as the site could not be assessed (site had no flow at the time of the assessment);
- The T4/5 upstream site improved from a PES Class E/F (Severely to Critically Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and March 2024 assessment likely due to the significantly increasing SASS5 score and slightly increasing ASPT score; and
- The T4/5 downstream site remained unchanged as a PES Class C (Moderately Modified) at both sites when compared to the January 2024 assessment.

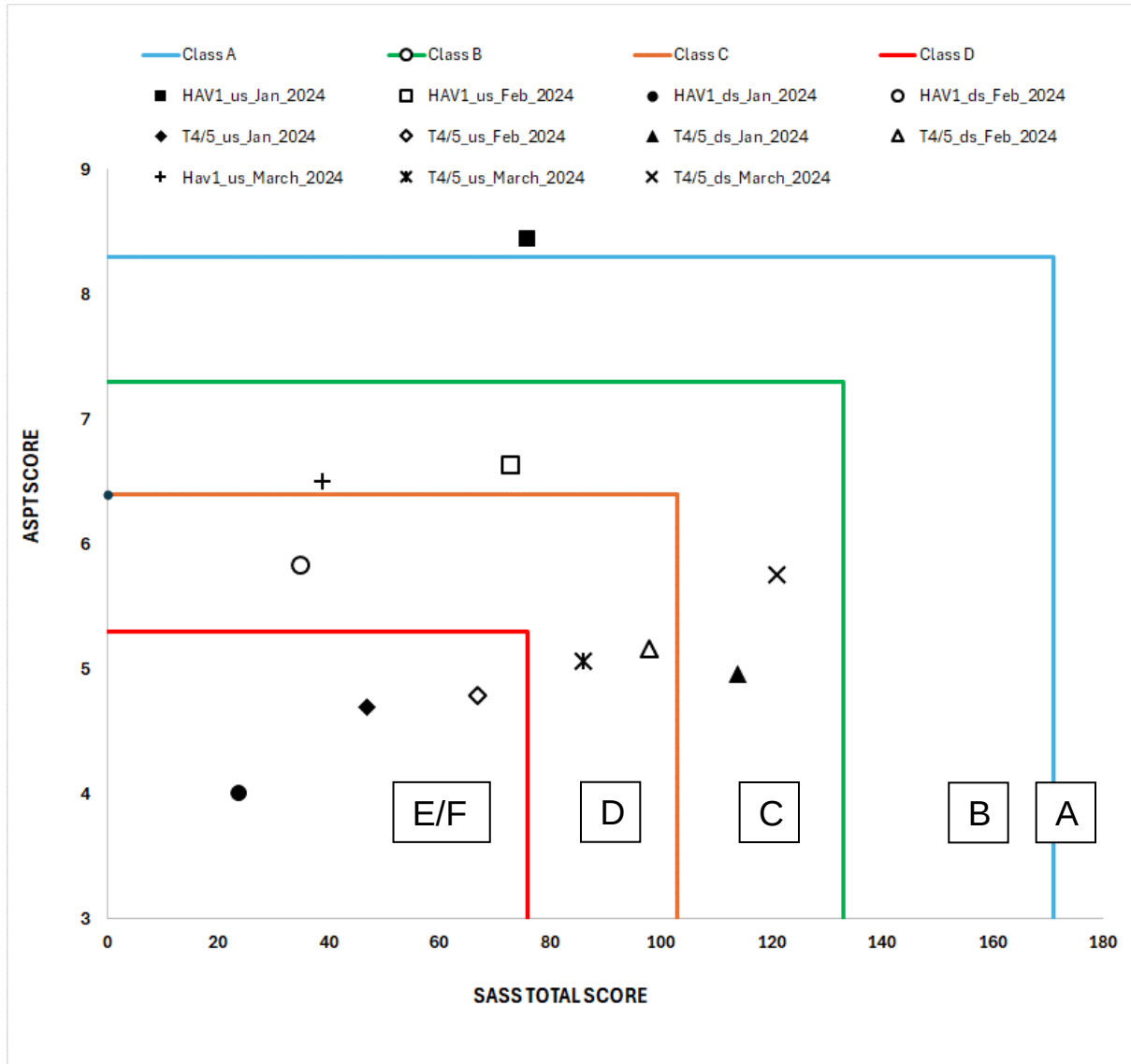


Figure 4: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

In Situ Physico-Chemistry

The measured pH and Electrical Conductivity (EC) for the HAV1 and T4/5 biomonitoring sites during the January, February and March 2024 aquatic assessments are tabulated below in Table 4 and graphed below in Figure 5. The percentages in variation of the pH and EC at the HAV1 replacement and T4/5 biomonitoring sites were compared temporally and spatially in Table 5 below as well.

Table 4: pH and EC results for the HAV1 and T4/5 sites since January 2024.

Site	HAV1						T4/5					
Month	Jan-24		Feb-24		March-24		Jan-24		Feb-24		March-24	
Reach	us	ds	us	ds	us	ds	us	ds	us	ds	us	ds
pH	5.23	4.11	4.71	3.66	7.3	NA	5.65	5.53	5.4	5.49	5.29	5.47
EC (mS/m)	14.9	79.5	17.31	76.9	14.92	NA	22.6	34.5	22.7	43.6	24.3	21.3

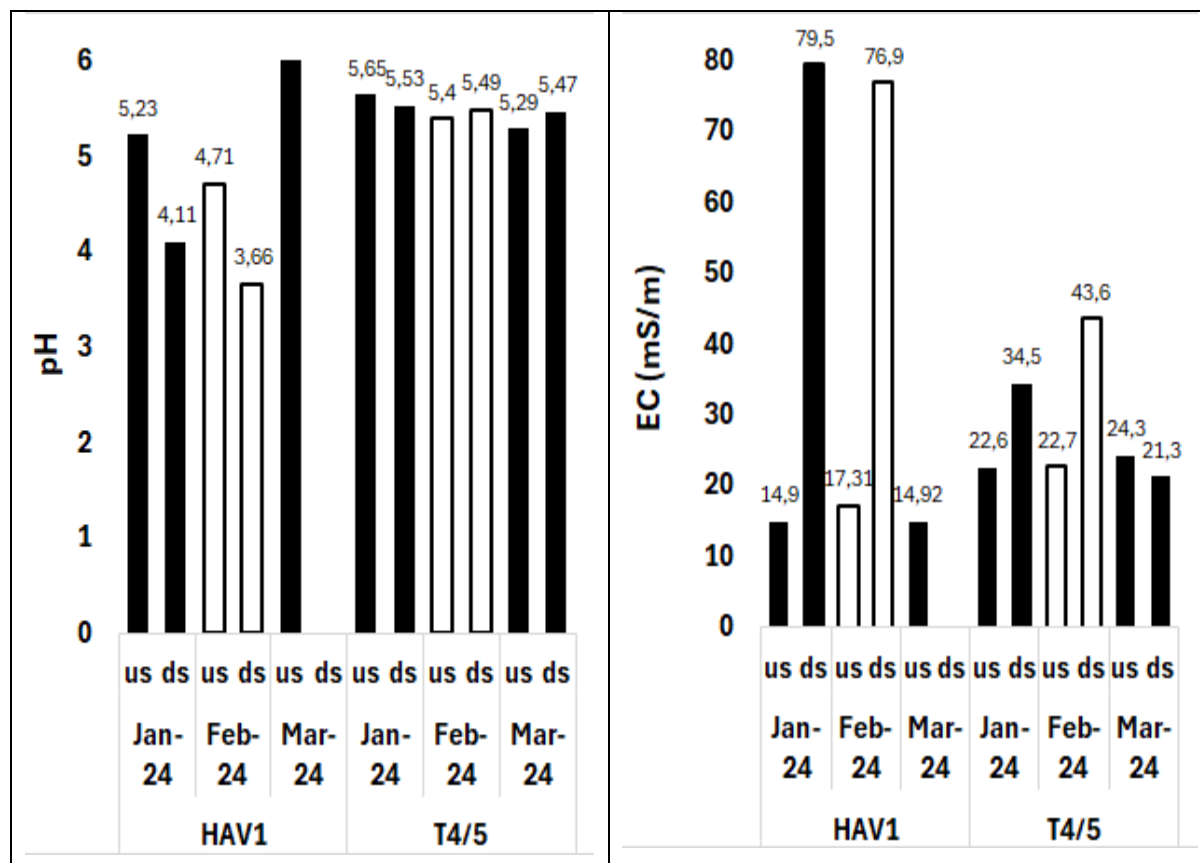


Figure 5: pH and EC results for the HAV1 and T4/5 sites since January 2024.

Table 5: Temporal and spatial % variation of pH and EC at the HAV1 repl and T4/5 biomonitoring sites since the January 2024 aquatic assessment.

% Variation						
Site	HAV1			T4/5		
	Temporal		Spatial	Temporal		Spatial
	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	us site vs ds site (Mar 2024)	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	us site vs ds site (Jan 2024)
pH	+39.6%	NA	NA	-6.4%	-1.0%	+3.0%
EC (mS/m)	+0.1%	NA	NA	+7.5%	-38.0%	-12.0%

*Key to variations: Negative value = decrease; Positive value = increase; Normal text = no significant change; **Bold text** = significant change; **Red text** = significant deterioration; **Blue text** = significant improvement.

The following inferences can be drawn from the above results in Table 4 and Table 5 and Figure 5:

HAV1 replacement:

- **Temporally at the upstream site**, the pH significantly increased by 39.6% with a slight and ignorable increase in Electrical Conductivity (EC) by 0.1% when compared to the January 2024 assessment;
- **Temporally at the downstream site**, no percentage variance could be calculated as the downstream site could not be assessed at the time of the March 2024 assessment due to no flow conditions;
- **Spatially no comparison could be drawn between the upstream and downstream sites, as the downstream site could not be assessed during the March 2024 assessment;** and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the acceptable range limit (6.5 - 8.4) for the upstream site. No impact on the aquatic community from measured pH is deemed possible at the time of assessment; and
- The EC value at the upstream site fall within the ideal range limit (≤ 30 mS/m) and as such no impact on the aquatic community is deemed possible at the time of assessment.

T4/5:

- **Temporally at the upstream site**, the pH decreased significantly by 6.4% with an insignificant increase in measured EC by 7.5% between the January 2024 and March 2024 assessments. Both changes are considered a negative change;
- **Temporally at the downstream site**, the pH remained relatively stable with a 1.0% downstream decrease, whilst the EC significantly improved in a downstream direction (38.0% decrease) between the January 2024 and March 2024 assessments;
- **Spatially between the upstream and downstream sites**, no significant change either pH (3.0% increase) or EC (12.0%) was noted between the upstream and downstream site. However, the decreasing EC between the sites is seen as a positive change; and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the acceptable range limit (6.5 - 8.4) for the upstream and downstream sites, while the EC at the upstream and downstream site fall within the ideal range limit (< 30 mS/m). As such no impacts at either the upstream or downstream sites was evident from the measured water quality (pH and EC) at the time of the assessment.

CONCLUSIONS

SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macro-invertebrate community at the HAV1 replacement and T4/5 sites due to the following reasons: Given that the T4/5 upstream site is significantly more degraded than its downstream site with limited surface water in March 2024, it does not meet the criteria of a control site, i.e. an unimpacted site relative to its downstream site. Therefore, control-impact site comparisons are not possible at T4/5.

The HAV1 replacement downstream site had no flow conditions at the time of the March 2024 assessment and as such the SASS5 protocol could not be applied. No spatial comparison could thus be drawn between the upstream and downstream sites at the time of assessment.

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from riparian and instream vegetation.

However, despite the above, concerns are raised with respect to significantly decreasing SASS5 and ASPT scores for the HAV1 upstream sites compared to the January 2024 assessment. The deterioration in macro-invertebrate community integrity is most likely due to seasonality as the habitat suitability significantly decreased. No points of concern are raised with respect to the macro-invertebrate community and the associated habitat during the pre-construction and construction phases of the T4/5 boreholes thus far with an increase in the SASS5 and ASPT scores, as well as significantly increasing SASS5 score in a downstream direction.

RECOMMENDATIONS

The potential erosion and siltation of streams must be continuously monitored in parallel with the SASS5 biomonitoring assessment, to ensure that the interstitial spaces of the streams, that are used as refugia for eggs and small/juvenile specimens remain unclogged.

In the event that the flows dry up to the degree that the SASS5 protocol can no longer be applied, the monitoring programme would need to be adjusted to accommodate the use of diatom and habitat indices that are appropriate under very low to zero flow environmental conditions such as at the time of the March 2024 assessment.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the SASS5 biomonitoring results between January 2024 and March 2024.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd

APPENDIX A – SASS5 Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1/US	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 18,0 °C	Amphipoda	13				A	Notonectidae*	3					Empididae	6				
Ph: 7,3	Potamonautidae*	3				A	Pleidae*	4					Ephyrididae	3				
DO: 5,83 mg/l 65%	Atyidae	8					Veliidae/M....veliidae*	5					Muscidae	1				
Cond: 14,92 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	39
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	6,50
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12				A	S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				A	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyrilidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: *	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: *	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 upstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				A
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: 17,6 ° C	Amphipoda	13				A	Notonectidae*	3				1	Empididae	6				
Ph: 5,29	Potamonautidae*	3					Pleidae*	4				1	Ephydriidae	3				
DO: 5,59 mg/l 57,9%	Atyidae	8					Veliidae/M...veliidae*	5				1	Muscidae	1				
Cond: 24,3 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordulidae	8					Simuliidae	5				1
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	86
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				A	NO OF TAXA:		0	0	0	17
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5,06
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5					SWC = South Western Cape					
	Aeshnidae	8				A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8				1	S = Stone & rock					
	Libellulidae	4				A	Hydrophilidae*	5				1	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: *	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				A
E: *	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				1
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: 18,2 °C	Amphipoda	13				A	Notonectidae*	3				A	Empididae	6				
Ph: 5,47	Potamonautidae*	3				A	Pleidae*	4				A	Ephydriidae	3				
DO: 6,22 mg/l 67,6%	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: 31,2 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordulidae	8					Simuliidae	5				1
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14				1	TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4				A	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	121
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				A	NO OF TAXA:		0	0	0	21
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5,76
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8				A	* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5				A	SWC = South Western Cape					
	Aeshnidae	8				A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4				A	Hydrophilidae*	5				A	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX B – IHAS Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River	Date: 28 March 2024					
Site Name: HAV1 repl upstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):			0			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
Vegetation Score (max 15):			3			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
Other Habitat Score (max 20):			18			
HABITAT TOTAL (MAX 55):			21			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
STREAM CONDITIONS TOTAL (MAX 45):			19			
TOTAL IHAS SCORE (%):			40			

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River	Date: 28th March 2024					
Site Name: T4/5 upstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):				14	
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				7	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
	Other Habitat Score (max 20):				15	
	HABITAT TOTAL (MAX 55):				36	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):				26	
	TOTAL IHAS SCORE (%):				62	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 downstream	Date: 28th March 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):			18			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
Vegetation Score (max 15):			15			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
Other Habitat Score (max 20):			20			
HABITAT TOTAL (MAX 55):			53			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
STREAM CONDITIONS TOTAL (MAX 45):			27			
TOTAL IHAS SCORE (%):			80			

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-42680-A
Address:	Magnolia Street	Date of Certificate:	17-May-2024
	Hermanus	Date Completed:	17-May-2024
	7200	Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-141544	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		15.3	2024-01-25
pH @ 25°C	M6	pH units		4.64	2024-05-17
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		119	2024-01-24
Total Suspended Solids	M8	mg/L		<2.00	2024-01-29
Turbidity	M12	NTU		1.84	2024-01-30
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-01-31

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Address:	Magnolia Street	Date of Certificate:	17-May-2024
	Hermanus	Date Completed:	17-May-2024
	7200	Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-141545	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		77.8	2024-01-25
pH @ 25°C	M6	pH units		3.54	2024-05-17
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		407	2024-01-24
Total Suspended Solids	M8	mg/L		<2.00	2024-01-29
Turbidity	M12	NTU		79.1	2024-01-30
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-01-31

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	17-May-2024
		Date Completed:	17-May-2024
		Date of Sampling:	23-January-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	23-January-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-42947-A
Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	08-February-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-142303	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		15.0	2024-02-12
pH @ 25°C	M6	pH units		4.67	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		122	2024-02-09
Total Suspended Solids	M8	mg/L		<2.00	2024-02-13
Turbidity	M12	NTU		1.29	2024-02-12
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-19

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	08-February-2024

Sample Identification:		HAV1 Rpl. Downstream			
Sample Number:	PW-24-142304	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		82.9	2024-02-12
pH @ 25°C	M6	pH units		3.44	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		499	2024-02-09
Total Suspended Solids	M8	mg/L		<2.00	2024-02-13
Turbidity	M12	NTU		30.4	2024-02-12
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-19

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	22-April-2024
		Date Completed:	22-April-2024
		Date of Sampling:	05-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	08-February-2024

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This certificate supersedes all previous documents bearing the reference (PW-2024-42947)

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43117-A
Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-142812	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.8	2024-02-22
pH @ 25°C	M6	pH units		4.84	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		133	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		1.73	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:		HAV1 Rpl. Downstream			
Sample Number:	PW-24-142813	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		75.2	2024-02-22
pH @ 25°C	M6	pH units		3.71	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		394	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		10.1	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-142814	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		23.0	2024-02-22
pH @ 25°C	M6	pH units		5.39	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		184	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		7.87	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	19-February-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-142815	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		42.0	2024-02-22
pH @ 25°C	M6	pH units		5.43	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		263	2024-02-23
Total Suspended Solids	M8	mg/L		<2.00	2024-02-23
Turbidity	M12	NTU		9.32	2024-02-21
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-02-28

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	22-April-2024
		Date Completed:	22-April-2024
		Date of Sampling:	16-February-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	19-February-2024

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43165-A
Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	21-February-2024

Sample Identification:					
HAV1 Rpl Upstream					
Sample Number:	PW-24-142965	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.7	2024-02-28
pH @ 25°C	M6	pH units		4.78	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		152	2024-02-28
Total Suspended Solids	M8	mg/L		<2.00	2024-02-28
Turbidity	M12	NTU		0.89	2024-02-28
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-01

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Address:	Magnolia Street	Date of Certificate:	22-April-2024
	Hermanus	Date Completed:	22-April-2024
	7200	Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	21-February-2024

Sample Identification:					
HAV1 Rpl Downstream					
Sample Number:	PW-24-142966	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		81.6	2024-02-28
pH @ 25°C	M6	pH units		3.29	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		376	2024-02-28
Total Suspended Solids	M8	mg/L		10.0	2024-02-28
Turbidity	M12	NTU		28.4	2024-02-28
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-01

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		Date Completed:	22-April-2024
		Date of Sampling:	20-February-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	21-February-2024

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T0417

Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43336-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	01-March-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-143416	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		22.6	2024-03-06
pH @ 25°C	M6	pH units		5.33	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		185	2024-03-06
Total Suspended Solids	M8	mg/L		<2.00	2024-03-07
Turbidity	M12	NTU		4.67	2024-03-05
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43336-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	01-March-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-143418	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		41.9	2024-03-06
pH @ 25°C	M6	pH units		5.36	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		268	2024-03-06
Total Suspended Solids	M8	mg/L		<2.00	2024-03-07
Turbidity	M12	NTU		4.77	2024-03-05
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43336-A
Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	01-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	01-March-2024

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Amended Certificate Of Analysis

Company: Overstrand Munisipaliteit (Umvoto)
Address: Magnolia Street
Hermanus
7200

Service Request Number: PW-2024-43393-A
Date of Certificate: 24-April-2024
Date Completed: 24-April-2024
Date of Sampling: 04-March-2024
Date of Receiving at Lab: 06-March-2024

Contact: Patrick Robinson

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-143602	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.9	2024-03-11
pH @ 25°C	M6	pH units		4.70	2024-04-24
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		158	2024-03-11
Total Suspended Solids	M8	mg/L		<2.00	2024-03-11
Turbidity	M12	NTU		11.9	2024-03-08
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-11

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43393-A
Address:	Magnolia Street	Date of Certificate:	24-April-2024
	Hermanus	Date Completed:	24-April-2024
	7200	Date of Sampling:	04-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	06-March-2024

Sample Identification:					
HAV1 Repl. Downstream					
Sample Number:	PW-24-143603	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		65.9	2024-03-11
pH @ 25°C	M6	pH units		3.59	2024-04-24
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		310	2024-03-11
Total Suspended Solids	M8	mg/L		<2.00	2024-03-11
Turbidity	M12	NTU		13.5	2024-03-08
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		0.60	2024-03-11

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43393-A
Address:	Magnolia Street Hermanus 7200	Date of Certificate:	24-April-2024
		Date Completed:	24-April-2024
		Date of Sampling:	04-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	06-March-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43573-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-144210	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.6	2024-03-22
pH @ 25°C	M6	pH units		4.76	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		124	2024-03-20
Total Suspended Solids	M8	mg/L		6.00	2024-03-23
Turbidity	M12	NTU		2.28	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		0.80	2024-03-19

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43573-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	14-March-2024

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-144211	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		64.7	2024-03-22
pH @ 25°C	M6	pH units		3.51	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		379	2024-03-20
Total Suspended Solids	M8	mg/L		30.0	2024-03-23
Turbidity	M12	NTU		23.3	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-19

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-144212	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		22.8	2024-03-22
pH @ 25°C	M6	pH units		5.28	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		196	2024-03-20
Total Suspended Solids	M8	mg/L		8.00	2024-03-23
Turbidity	M12	NTU		6.32	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		1.40	2024-03-19

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	14-March-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-144213	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		40.7	2024-03-22
pH @ 25°C	M6	pH units		5.35	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		256	2024-03-20
Total Suspended Solids	M8	mg/L		8.00	2024-03-23
Turbidity	M12	NTU		5.37	2024-03-19
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-03-19

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Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	14-March-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	14-March-2024

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Amended Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43823-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-145005	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		23.8	2024-04-05
pH @ 25°C	M6	pH units		5.31	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		233	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		4.75	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		1.20	2024-04-04

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43823-A
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-145006	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		42.7	2024-04-05
pH @ 25°C	M6	pH units		5.55	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		304	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		4.33	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-04

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Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	02-April-2024

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-145007	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.8	2024-04-05
pH @ 25°C	M6	pH units		4.68	2024-04-18
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		173	2024-04-08
Total Suspended Solids	M8	mg/L		<2.00	2024-04-10
Turbidity	M12	NTU		14.9	2024-04-03
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-04

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Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-43823-A
Address:	Magnolia Street Hermanus 7200	Date of Certificate:	18-April-2024
		Date Completed:	18-April-2024
		Date of Sampling:	28-March-2024
Contact:	Patrick Robinson	Date of Reveal at Lab:	02-April-2024

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Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-145768	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		14.1	2024-04-15
pH @ 25°C	M6	pH units		4.32	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		125	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		3.01	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-145769	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.8	2024-04-15
pH @ 25°C	M6	pH units		4.54	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		140	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		5.31	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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Certificate Of Analysis

Company:	Overstrand Munisipaliteit (Umvoto)	Service Request Number:	PW-2024-44010
Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

Sample Identification:					
HAV1 Repl. Upstream					
Sample Number:	PW-24-145770	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.2	2024-04-15
pH @ 25°C	M6	pH units		4.49	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		135	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		1.80	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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Address:	Magnolia Street	Date of Certificate:	18-April-2024
	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receival at Lab:	12-April-2024

Sample Identification:					
HAV1 Repl. Downstream					
Sample Number:	PW-24-145771	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		24.3	2024-04-15
pH @ 25°C	M6	pH units		4.17	2024-04-15
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		191	2024-04-17
Total Suspended Solids	M8	mg/L		<2.00	2024-04-18
Turbidity	M12	NTU		2.57	2024-04-15
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-16

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	Hermanus	Date Completed:	18-April-2024
	7200	Date of Sampling:	11-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	12-April-2024

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Hermanus
7200

Service Request Number: PW-2024-44188
Date of Certificate: 29-April-2024
Date Completed: 29-April-2024
Date of Sampling: 24-April-2024
Date of Receiving at Lab: 25-April-2024

Contact: Patrick Robinson

Sample Identification:					
T4/5 Upstream					
Sample Number:	PW-24-146333	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		19.1	2024-04-26
pH @ 25°C	M6	pH units		4.90	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		137	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		10.6	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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Address:	Magnolia Street	Date of Certificate:	29-April-2024
	Hermanus	Date Completed:	29-April-2024
	7200	Date of Sampling:	24-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	25-April-2024

Sample Identification:					
T4/5 Downstream					
Sample Number:	PW-24-146335	Sampling Time:	N/A	Sample Condition:	Chilled
				Remark:	
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		30.3	2024-04-26
pH @ 25°C	M6	pH units		4.90	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		194	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		4.37	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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Service Request Number: PW-2024-44188
Date of Certificate: 29-April-2024
Date Completed: 29-April-2024
Date of Sampling: 24-April-2024
Date of Receiving at Lab: 25-April-2024

Contact: Patrick Robinson

Sample Identification:					
HAV1 Rpl. Upstream					
Sample Number:	PW-24-146336	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		16.4	2024-04-26
pH @ 25°C	M6	pH units		4.52	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		114	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		1.62	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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Service Request Number: PW-2024-44188
Date of Certificate: 29-April-2024
Date Completed: 29-April-2024
Date of Sampling: 24-April-2024
Date of Receival at Lab: 25-April-2024

Contact: Patrick Robinson

Sample Identification:					
HAV1 Rpl. Downstream					
Sample Number:	PW-24-146338	Sampling Time:	N/A	Sample Condition:	Chilled
Remark:					
Physical / Aesthetic Parameters	Method	Unit	Limit	Result	Analysis Date
Electrical Conductivity @ 25°C	M4	mS/m		33.9	2024-04-26
pH @ 25°C	M6	pH units		4.05	2024-04-26
Total Dissolved Solids @ 105°C (Gravimetric)	M8	mg/L		179	2024-04-29
Total Suspended Solids	M8	mg/L		<2.00	2024-04-26
Turbidity	M12	NTU		5.15	2024-04-26
Organic Parameters	Method	Unit	Limit	Result	Analysis Date
Fats, Oils & Grease*	M74	mg/L		<0.50	2024-04-26

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	7200	Date of Sampling:	24-April-2024
Contact:	Patrick Robinson	Date of Receiving at Lab:	25-April-2024

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Applying science to the real world

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Name: Stephen van Staden
Date: Monday, 05 February 2024
Ref: FEN/Umvoto Africa 050224

Umvoto Africa (Pty) Ltd
8 Beach Road
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Attention: Mr. K. de Bruin

TECHNICAL MEMORANDUM

RE: THE SASS5 BASELINE BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.

Borehole production forms part of the Hemel en Aarde Wellfield Expansion Project which aims to provide sustainable water supply solutions to the Overstrand municipal area.

The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March

2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from early April until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

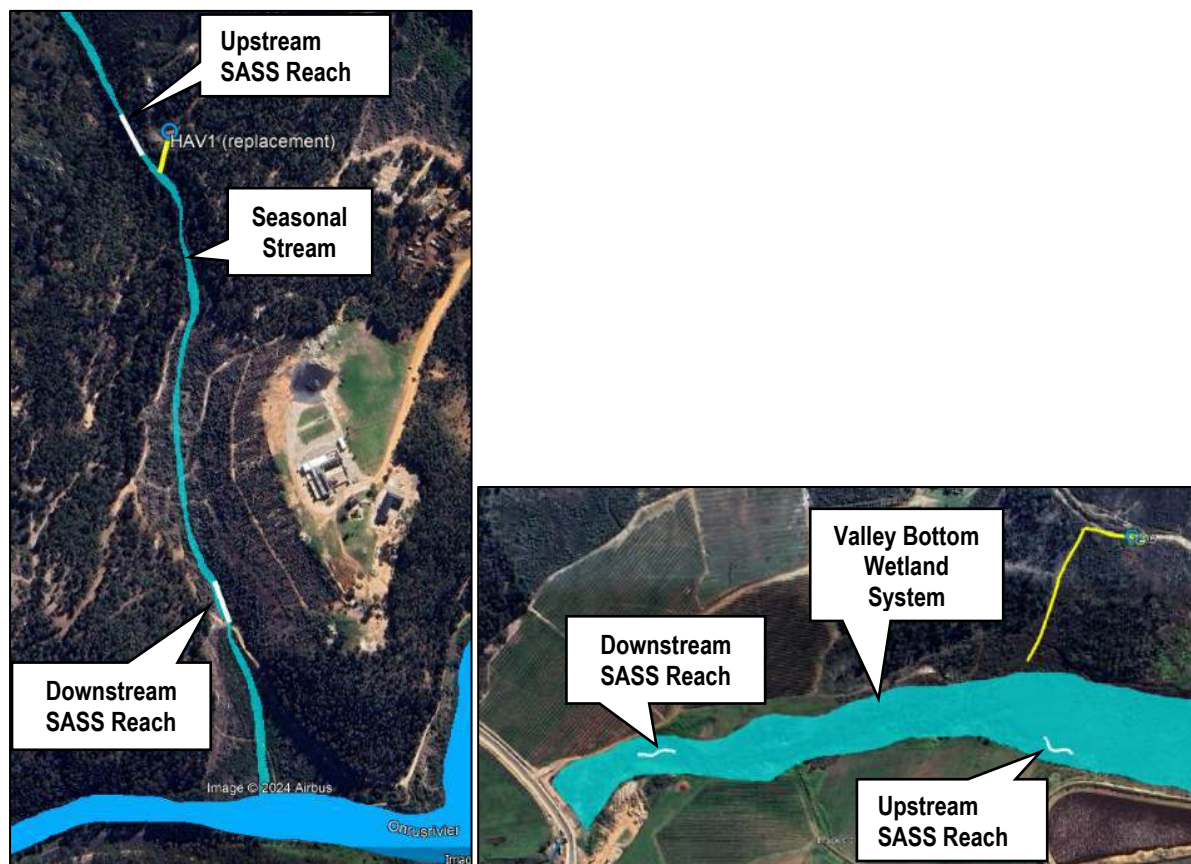


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge locations (yellow lines).

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macroinvertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macroinvertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macroinvertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

Biomonitoring took place on the 19th of January 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5) and therefore the data as presented in this technical memorandum are representative of baseline conditions prior to borehole development. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.¹

RESULTS

The site conditions for each site are described below and photographs are provided in Figure 2 below.

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools overserved. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic *Eucalyptus* (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation (pH = 5.23, temperature = 19.8 °C, Dissolved Oxygen (DO) = 10.5 mg/l, Dissolved Oxygen (%) saturation = 120.5 %, Salinity = 69.9 ppm, Electrical Conductivity (EC) = (14.9 mS/m) and Total Dissolved Carbon (TDS) = 104.3 mg/l.

HAV1 replacement (downstream): This stream reach is significantly more open canopied, with a greater discharge compared to the upstream site, which is expected given increased lateral interflow contributions from the valley. This reach of the stream was a dark brown colour and was significantly more turbid compared to the upstream site, likely due to increased suspension loads from destabilised soils after the excessively high winter 2023 rainfall. Although the overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. The water quality of this stream comprises a much higher ionic content, compared to the upstream site (perhaps due to increased groundwater input), and is considered of fair quality, with pH = 4.11, temperature = 21.7 °C, Salinity = 376 ppm, EC = 79.5 mS/m and TDS = 532 mg/l.

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, with pH = 5.65, temperature = 25.5 °C, DO = 6.51 mg/l, DO (%) = 87.3%, Salinity = 104 ppm, EC = 22.6 mS/m and TDS = 158 mg/l). The water temperature is warmer and more turbid than what it would be, compared to if the river was still vegetated.

¹ Please refer to the comprehensive project description in the Freshwater Assessment supplied by FEN as part of the technical report submission requirements for the Water Use Licence Application (WULA) pertaining to the Hemel en Aarde Wellfield Expansion Project – FEN (2022).

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. The water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality, with pH = 5.53, temperature = 20.8 °C, DO = 8.66 mg/l, DO(%) = 100.2%, Salinity = 194 ppm, EC = 34.5 mg/l and TDS = 265 mg/l.

It must be noted that the T4/5 downstream site is the only site where the SASS biotopes (stones, vegetation and GSM) were sampled separately, due to a sufficiently abundant presence of each.

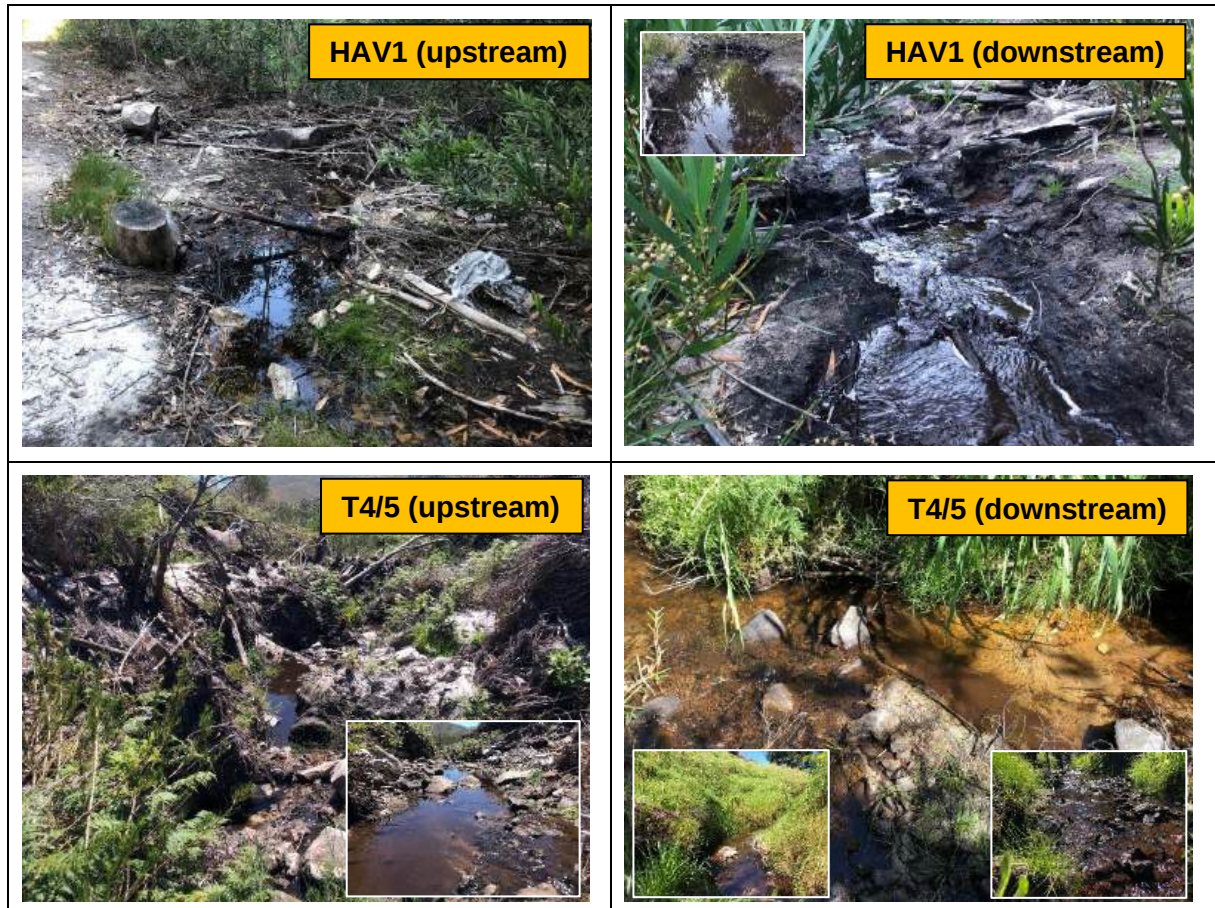


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/6 production borehole development discharge locations.

The calculated SASS 5 scores are provided in Table 1 below which are graphed on a scatterplot in Figure 3 against the Present Ecological Status (PES) Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

Table 1: SASS scores, number of taxa and ASPT scores for the sampled sites.

	HAV1 repl (upstream)	HAV1 repl (downstream)	T4/5 (upstream)	T4/5 (downstream)
SASS Total Score	76	24	47	114
Number of Taxa	9	6	10	23
ASPT	8.44	4	4.70	4.96
PES	A	E/F	E/F	C

The following inferences can be drawn from Table 1:

- The T4/5 upstream site has been heavily disturbed by large scale erosion, presumably from the recent 2023 winter rainfall and is not ideal as a control site. The limited sampleable upstream habitat compared to the downstream habitat explains the significantly lower SASS total scores between these reaches. It was not possible to sample further upstream due to zero flow conditions observed. The similarity in ASPT scores between these reaches indicates a similar community composition in terms of water quality sensitivity;
- The PES A condition at the HAV1 upstream site pertains to the very high ASPT score obtained, and not the SASS total score, considering that the aquatic macroinvertebrate community was dominated by taxa such as amphipods, stone flies, odonates; caddisflies and marsh beetles that are sensitive to water quality (Table 2);
- The comparatively lower SASS total score and ASPT scores at the HAV1 downstream site pertains to a decrease in stoney habitat in which most of the sensitive taxa at the HAV1 upstream site were found, and prevalence of sand, mud and marginal vegetation, which typically favours non sensitive hemipterans (true bugs) and coleopterans (beetles) (Table 2). The deterioration in water quality at the HAV1 downstream site in terms of increased Electrical Conductivity may also be posing a negative impact on the macroinvertebrate community.

Table 2: Taxa identified across all biotopes at the sample sites.

ORDER	FAMILY	SENSITIVITY SCORE	HAV1 repl (us)	HAV1 repl (ds)	T4/5 (us)	T4/5 (ds)
ANNELIDA	<i>Oligochaeta</i>	1				√
CRUSTACEA	<i>Amphipoda</i>	13	√			
	<i>Potamonautidae*</i>	3	√			√
PLECOPTERA	<i>Notonemouridae</i>	14	√			
EPHEMEROPTER A	<i>Baetidae sp. (x)</i>	4			√	√
	<i>Baetidae sp. (y)</i>	6				√
	<i>Caenidae</i>	6			√	√
ODONATA	<i>Chlorolestidae</i>	8	√			
	<i>Coenagrionidae</i>	4				√
	<i>Aeshnidae</i>	8			√	√
	<i>Gomphidae</i>	6				√
	<i>Libellulidae</i>	4		√	√	√
HEMIPTERA	<i>Corixidae*</i>	3		√	√	√
	<i>Gerridae*</i>	5		√	√	√
	<i>Hydrometridae*</i>	6				√
	<i>Nepidae*</i>	3			√	√
	<i>Pleidae*</i>	4			√	√
	<i>Veliidae/Mesoveliidae*</i>	5	√			√
TRICHOPTERA	<i>Philopotamidae</i>	10	√			
	<i>Leptoceridae</i>	6	√			√
COLEOPTERA	<i>Dytiscidae*</i>	5		√	√	√
	<i>Elmidae*</i>	8				√
	<i>Gyrinidae*</i>	5				√
	<i>Helodidae</i>	12	√			
	<i>Hydraenidae*</i>	8				√
	<i>Hydrophilidae*</i>	5	√	√	√	√
DIPTERA	<i>Athericidae</i>	10				√
	<i>Chironomidae</i>	2		√		√
	<i>Culicidae*</i>	1				√

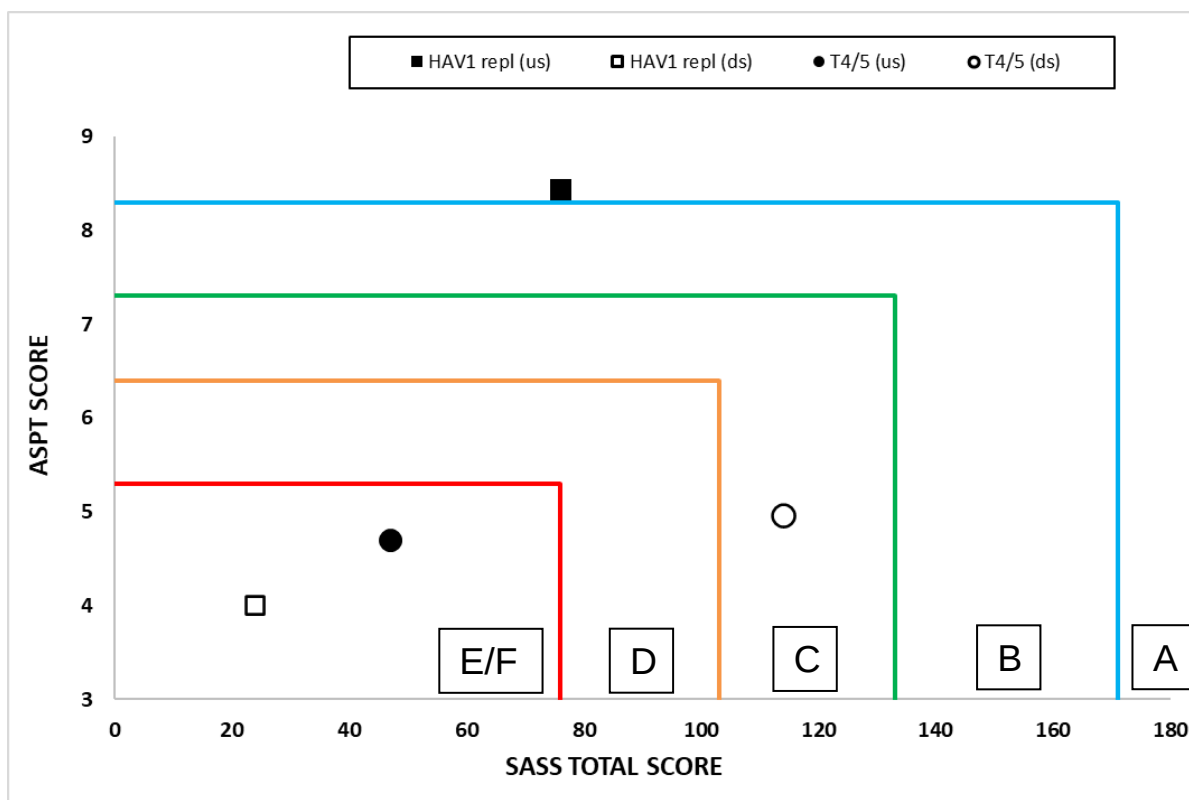


Figure 3: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Forder Mountains Ecoregion.

CONCLUSIONS

Due to the following reasons, SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macroinvertebrate community at the HAV1 repl and T4/5 sites:

Given the low flow conditions observed on the 19th January, and considering the persistent hot weather throughout February, it is unlikely that the upstream reaches of HAV1 repl and T4/5 will have flow conditions. If this proves to be the case, it would mean that there would be no comparison between baseline data and construction phase data, which is required to determine whether groundwater discharge is having a negative impact on the macroinvertebrate community;

Given that the T4/5 upstream site is significantly more degraded than its downstream site and was but a trickle on the 19th January, it does not meet the criteria of a control site, i.e. an unimpacted site that is rich in biodiversity. Therefore, control-impact site comparisons are not possible at T4/5; and

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from vegetation.

RECOMMENDATIONS

Given the challenges experienced during the site visit, and the outcomes of the SASS5 data analysis, it would offer more value to monitor for the potential smothering of the active channel and associated vegetation, considering that deposited silts would require elevated base flows to be lifted and removed further downstream. Fine silts clog the interstitial spaces that are used as refugia for eggs and small/juvenile specimens, which would have a negative impact on the survival of some species. Finally, the use of diatom or habitat indices may be more applicable to the monitoring of these sites.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the subject UCVBW in question.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd



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Attention : Dr. K. Riemann

TECHNICAL MEMORANDUM

RE: THE SASS5 BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

FEBRUARY 2024

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.

Borehole production forms part of the Hemel en Aarde Wellfield Expansion Project which aims to provide sustainable water supply solutions to the Overstrand municipal area.

The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March 2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from late March until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

Biomonitoring has taken place on the 19th of January 2024 and as of this report, on the 22nd of February 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5). The January 2024 data is representative of baseline conditions prior to borehole development and the February 2024 data is representative of the construction phase for both boreholes. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macroinvertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macroinvertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macroinvertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

The biomonitoring assessment included the following aquatic indices:

- Invertebrate Habitat Assessment System (IHAS) - McMillan (1998) which was informed by a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates;
- South African Scoring System Version 5 (SASS 5) – which derives the Present Ecological Status (PES) of a river based on the presence of macroinvertebrate families; and
- *In situ* biota specific water quality data was collected to assist in interpreting the biological data, using a calibrated portable multimeter (Extech EC-500 and Extech DO-600).

All work was overseen by a South African River Health Program (SA RHP) SASS5 Accredited Assessor.

Please refer to Figure 1 for the locality map of the sampling sites.

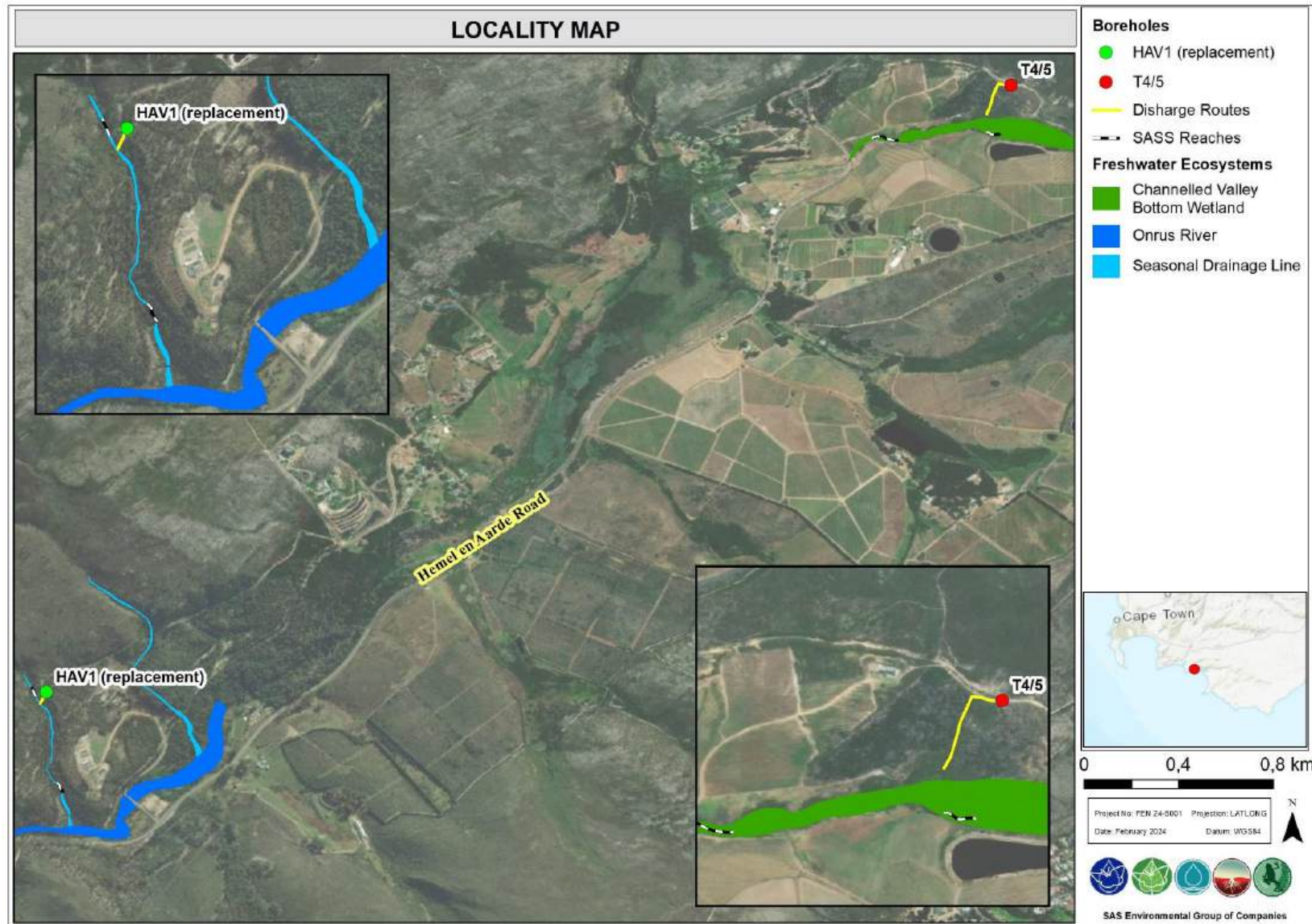


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge routes.

RESULTS

Site Descriptions

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools observed. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic and ongoing *Eucalyptus* tree (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation. Discharge in February 2024 was noticed to be less compared to January 2024 which limited the SASS biotope sample to muddy vegetated pools, with stoney habitat no longer available.

HAV1 replacement (downstream): This stream reach is significantly more open canopied, with a greater discharge compared to the upstream site, which is expected given increased lateral interflow contributions from the valley. This reach of the stream was a dark brown colour and was significantly more turbid compared to the upstream site, likely due to increased suspension loads from destabilised soils after the excessively high winter 2023 rainfall. Although the overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. The water quality of this stream comprises a much higher ionic content, compared to the upstream site (perhaps due to increased groundwater input), and is considered of fair quality.

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, although the water temperature is warmer and the clarity is more turbid than what it would be, compared to if the river was still vegetated. Discharge in February 2024 was noticed to be greater compared to January 2024, which resulted in the submergence of cobbles, thereby creating stoney habitat that was lacking during the January assessment.

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. The water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality. Discharge in February 2024 was noticed to be greater compared to January 2024, but due to the recent large erosion events and subsequent removal of the marginal vegetation component, no significant increase in habitat was observed.

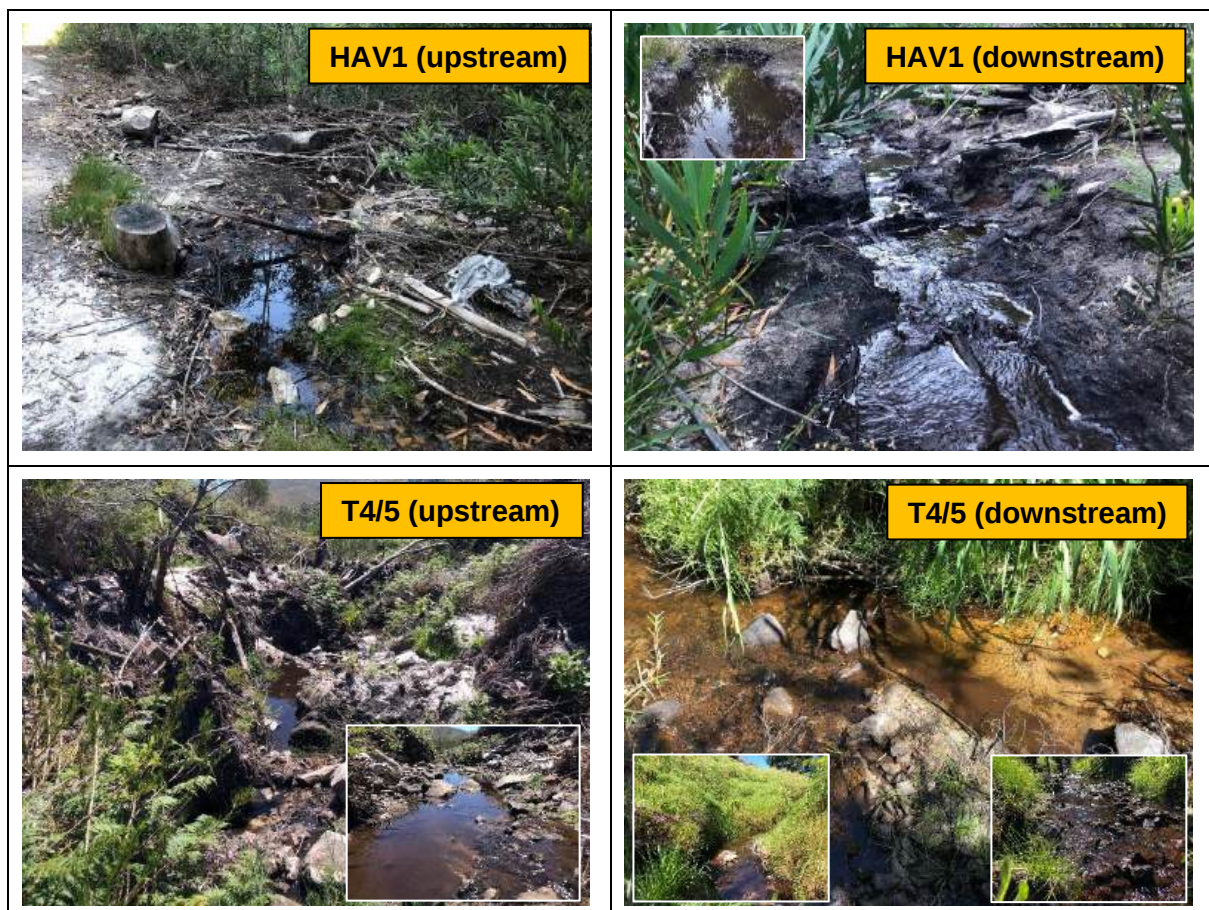


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/5 production borehole development discharge locations.

Aquatic Macroinvertebrate Community Integrity

The calculated SASS 5 indices (SASS total Score, number of taxa and Average Score Per Taxon - ASPT) for the HAV1 and T4/5 biomonitoring sites during the January and February 2024 aquatic assessments are tabulated below in Table 1 and graphed below in Figure 3. The IHAS % score was used to compare macroinvertebrate habitat integrity.

Table 1: SASS5 and IHAS results for the HAV1 and T4/5 sites in January and February 2024.

Site	HAV1				T4/5			
	Jan-24		Feb-24		Jan-24		Feb-24	
Reach	us	ds	us	ds	us	ds	us	ds
SASS Total Score	76	24	73	35	47	114	67	98
Taxa	9	6	11	6	10	23	14	19
ASPT	8.44	4	6.64	5.83	4.7	4.96	4.79	5.16
PES	A	E/F	C	D	E/F	C	E/F	D
IHAS	60	62	52	62	43	80	62	80

The percentages in variation of the SASS5 indices and IHAS % scores at the HAV1 repl and T4/5 biomonitoring sites were compared temporally and spatially in Table 2 below as follows:

- **Temporally:** % variation at an upstream or downstream site in January and then compared again in February 2024, to gauge whether a deterioration in the aquatic macroinvertebrate community and habitat integrity has taken place over time between the upstream and downstream sites; and

- **Spatially:** % variation between an upstream and downstream site in January and February 2024, to gauge for stability in the baseline differences in the aquatic macroinvertebrate community and habitat integrity between the upstream and downstream sites over time.

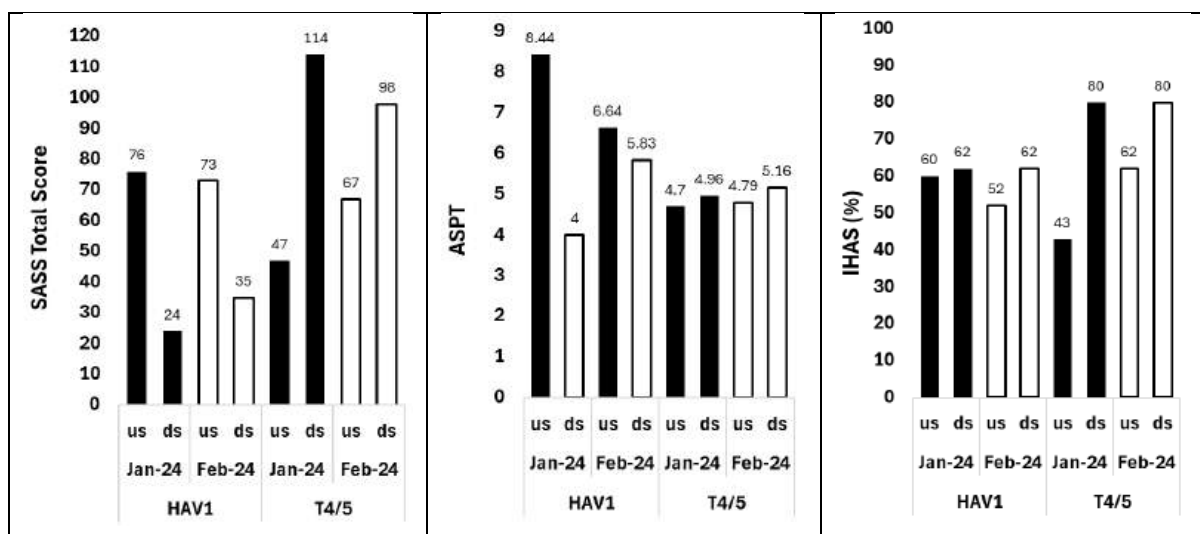


Figure 3: SASS5 and IHAS results for the HAV1 and T4/5 sites in January and February 2024.

Table 2: Temporal and spatial % variation of the SASS5 indices and IHAS scores at the HAV1 repl and T4/5 biomonitoring sites for the January and February 2024 aquatic assessments.

Site	% Variation							
	HAV1				T4/5			
	Temporal		Spatial		Temporal		Spatial	
	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)
SASS Score	-3.9%	+45.8%	-68%	-52%	+42.6%	-14%	143%	46%
Taxa	+22.2%	0.0%	-33%	-45%	+40.0%	-17%	130%	36%
ASPT	-21.3%	+45.8%	-53%	-12%	1.9%	4%	6%	8%
IHAS	-13.3%	0.0%	+3%	+19%	44.2%	0%	86%	29%

Table 3: Aquatic macroinvertebrate community comparisons at the HAV1 and T4/5 biomonitoring sites between January 2024 and February 2024.

ORDER	FAMILY	SENSITIVITY SCORE	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24
			HAV1 repl (us)		HAV1 repl (ds)		T4/5 (us)		T4/5 (ds)	
ANNELIDA	<i>Oligochaeta</i>	1							√	
CRUSTACEA	<i>Amphipoda</i>	13	√	√						
	<i>Potamonautidae</i> *	3	√	√				√	√	√
PLECOPTERA	<i>Notonemouridae</i>	14	√			√				
EPHEMEROPTERA	<i>Baetidae 1 sp.</i>	4					√	√	√	
	<i>Baetidae 2 sp.</i>	6						√	√	
	<i>Leptophlebiidae</i>	9								√
	<i>Caenidae</i>	6					√	√	√	√
ODONATA	<i>Chlorolestidae</i>	8	√	√						
	<i>Coenagrionidae</i>	4							√	√

			Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24	Jan-24	Feb-24
ORDER	FAMILY	SENSITIVITY SCORE	HAV1 repl (us)		HAV1 repl (ds)		T4/5 (us)		T4/5 (ds)	
	<i>Platycnemididae</i>	10		✓						
	<i>Aeshnidae</i>	8					✓	✓	✓	✓
	<i>Gomphidae</i>	6							✓	✓
	<i>Libellulidae</i>	4		✓	✓	✓	✓	✓	✓	✓
HEMIPTERA	<i>Corixidae*</i>	3			✓		✓	✓	✓	✓
	<i>Gerridae*</i>	5		✓	✓	✓	✓	✓	✓	✓
	<i>Hydrometridae*</i>	6							✓	
	<i>Nepidae*</i>	3					✓	✓	✓	✓
	<i>Pleidae*</i>	4					✓	✓	✓	✓
	<i>Veliidae/Mesoveliiidae*</i>	5	✓	✓				✓	✓	✓
TRICHOPTERA	<i>Philopotamidae</i>	10	✓							
	<i>Leptoceridae</i>	6	✓	✓					✓	✓
COLEOPTERA	<i>Dytiscidae*</i>	5		✓	✓	✓	✓		✓	✓
	<i>Elmidae*</i>	8						✓	✓	
	<i>Gyrinidae*</i>	5				✓			✓	✓
	<i>Helodidae</i>	12	✓	✓						
	<i>Hydraenidae*</i>	8							✓	
	<i>Hydrophilidae*</i>	5	✓		✓		✓	✓	✓	✓
DIPTERA	<i>Athericidae</i>	10							✓	✓
	<i>Chironomidae</i>	2		✓	✓	✓		✓	✓	✓
	<i>Simuliidae</i>	5						✓		✓
	<i>Culicidae*</i>	1							✓	

The following inferences can be drawn from Table 1, Table 2, Table 3 and Figure 3:

HAV1 repl:

- **Temporally at the upstream site**, the SASS Total score, which is a measure of macroinvertebrate diversity remained stable and only dropped by 3.9% between January (76) and February 2024 (73), despite 2 more taxa being identified in February 2024. The ASPT score, which describes the average sensitivity of macroinvertebrates however dropped by 21.3% between January (8.44) and February 2024 (6.64). This significant drop (>15%) is due to not finding highly sensitive taxa such as Notonemouridae and Philopotamidae due to not being able to sample stoney habitats in February 2024, as a result of lower base flows compared to January 2024. The identification of low sensitivity taxa such as Libellulidae, Gerridae, Dytiscidae and Chironomidae further brought down the ASPT score, while the finding of highly sensitive Platycnemididae has offset the decrease in the ASPT score. It must be noted that highly sensitive taxa such as Chlorolestidae and Helodidae were still identified in February 2024, indicating that the lower ASPT score is attributed to less habitat availability, as indicated by the decrease in the IHAS score by 13.3% between January and February 2024 (60% vs 52% respectively);
- **Temporally at the downstream site**, the SASS Total score increased between January (24) and February 2024 (35) by 45.8%, despite the same number of taxa being identified. The ASPT score also increased by 45.8% between January (4) and February 2024 (5.83). This significant increase (>15%) is due to finding a single highly sensitive Notonemouridae specimen in February 2024 which was not identified in January 2024, but which would have a large influence on the ASPT score, especially as macroinvertebrate community only comprises 6 taxa.

Although the downstream habitat also does not have favourable stoney habitat to sample, the water quality is still considered of sufficient quality to support Notonemourids. No change in the macroinvertebrate habitat integrity was observed at the downstream reach between January and February 2024 due to discharge being similar at these sampling times;

- **Spatially between the upstream and downstream sites**, a larger difference in the SASS Total score (68%) and ASPT score (53%) was observed in January compared to February 2024 (SASS Total score = 52% and ASPT score = 12 %). This is due to 1) more taxa of a 2) lower sensitivity being identified at the upstream site in February which has resulted in a more similar macroinvertebrate community between the upstream and downstream sites in terms of the ASPT score. A larger difference in the IHAS score was observed in February (19%) compared to January 2024 (3%) due to a notable decrease in the availability of stoney habitat at the upstream site in February, and
- The results as described above are expected given the natural environmental changes.

T4/5:

- **Temporally at the upstream site**, the SASS Total score increased by 42.6% between January (47) and February 2024 (67), due to 4 more taxa being identified in February 2024. The ASPT score, however remained stable (1.9%) between January (4.70) and February 2024 (4.79). This is due to the additional taxa identified in February 2024 (Potamonautidae, Veelidae, Chironomidae, and Simuliidae) also being of low sensitivity and therefore not having an influence on the ASPT. The identification of moderate sensitivity taxa such as Elmidae in February 2024 has likely assisted to keep the ASPT stable. The increased SASS Total score can be attributed to a significant increase (44.2%) in macroinvertebrate habitat availability between January and February 2024, whereby the slightly higher stream discharge at this time resulted in the submergence of stoney habitat and the creation of riffle hydraulic biotopes that were absent in January 2024;
- **Temporally at the downstream site**, the SASS Total score decreased between January (114) and February 2024 (98) by 14%, due to 4 fewer taxa being identified. The ASPT score however increased by 4% between January (4.96) and February 2024 (5.16). This increase is due to identifying less taxa of low sensitivity such as Oligochaeta and Culicidae that brought down the ASPT in January 2024, but also due to moderately sensitive taxa such as Leptophlebiidae that were only identified in February 2024. No change in the macroinvertebrate habitat integrity was observed at the downstream reach between January and February 2024 due to discharge being similar at these sampling times;
- **Spatially between the upstream and downstream sites**, a larger difference in the SASS Total score (143%) and IHAS score (86%) was observed in January compared to February 2024 (SASS Total score = 46% and IHAS score = 29 %). This is due to a greater disparity in the habitat integrity between the upstream and downstream site in January 2024 compared to February 2024, due to the slightly higher discharge at the upstream site in February 2024 creating habitat that was more comparable to its downstream reach at this time; and
- The results as described above are expected given the natural environmental changes.

As per Figure 4 below which has plotted the SASS Total score (x-axis) against the ASPT (y-axis) within the context of Present Ecological Status (PES) Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion, the following inferences can be drawn.

- The T4/5 upstream site remained in a PES Class E/F (Severely to Critically Modified ecological condition between January 2024 and February 2024);
- The T4/5 downstream site deteriorated slightly from a PES Class C (Moderately Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and February 2024 due to a slight, but critical decrease in the SASS Total score from 114 to 98;
- The HAV1 upstream site deteriorated from a PES Class A (Pristine) ecological condition to a PES Class C (Moderately Modified) ecological condition between January 2024 and February 2024 due to a decrease in the ASPT score, from 8.44 to 6.64; and

- The HAV1 downstream site improved slightly from a PES Class E/F (Severely to Critically Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and February 2024 due to an increase in the ASPT score, from 4 to 5.83.

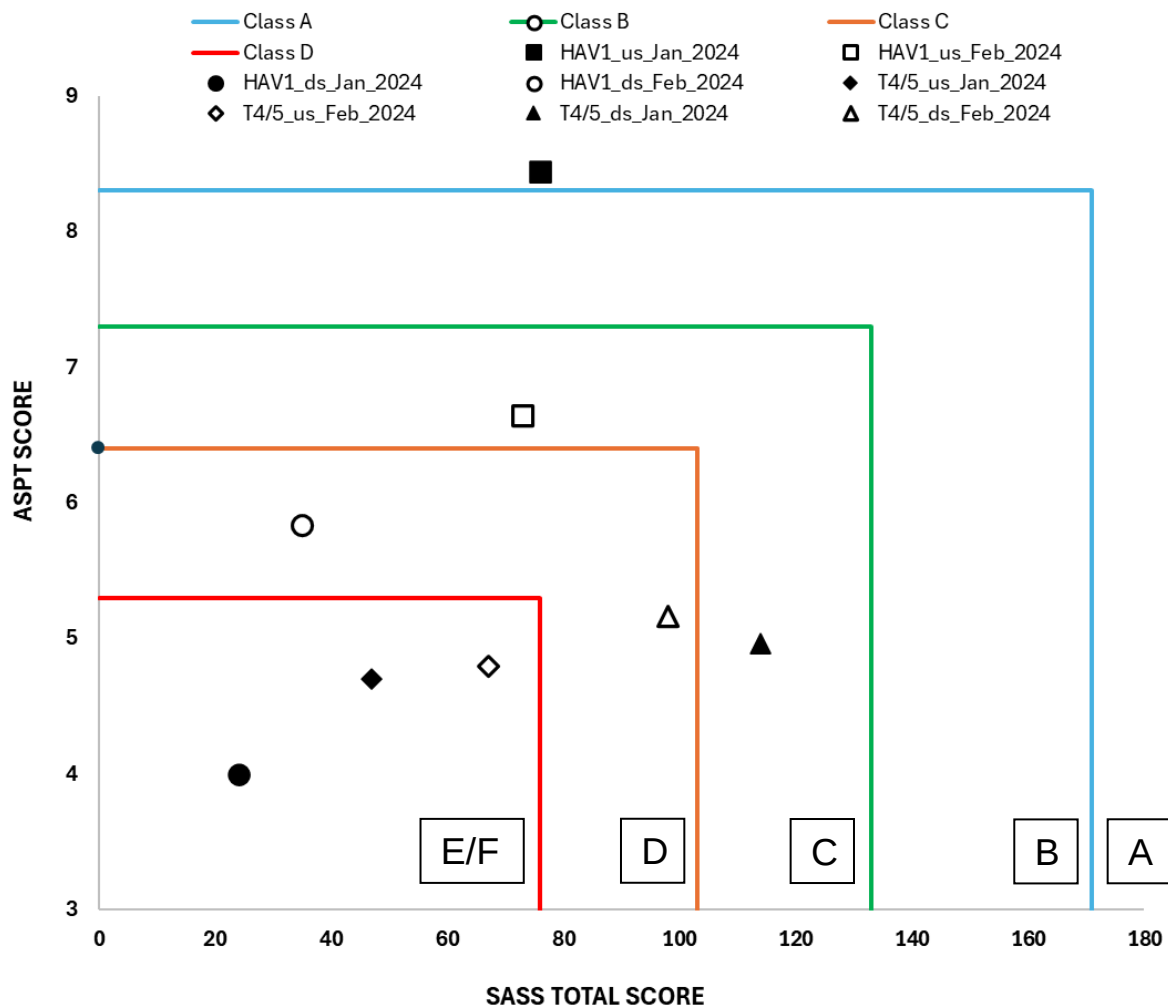


Figure 4: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

In Situ Physico-Chemistry

The following inferences can be drawn from Table 4 and Table 5 and Figure 5:

HAV1 repl:

- **Temporally at the upstream site**, the pH decreased by 9.9% between January (5.23) and February 2024 (4.71) and the EC increased by 16.2% between January (14.9 mS/m) and February 2024 (17.31 mS/m);
- **Temporally at the downstream site**, the pH decreased by 10.9% between January (4.11) and February 2024 (3.66) and the EC also decreased by 3.3% between January (79.5 mS/m) and February 2024 (76.9 mS/m);
- **Spatially between the upstream and downstream sites**, a similar difference in the pH between the upstream and downstream sites was observed in January compared to February 2024 (21% vs 22% respectively) but a larger difference in EC was observed between the upstream site compared to the downstream site (434% vs 344% respectively); and

- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the unacceptable range limit ($< 6.5 - > 8.4$) for all sites. Although the pH values do not comply to the 2011 RWQOs of South Africa, the acidic nature of the Western Cape's rivers is characteristic due to river pH being influenced largely by acidic tannin compounds, as contributed by the Fynbos vegetation they flow through, more so than the already heavily weathered and inert sandstone substrates they flow over.
- The EC values at the upstream sites fall within the ideal range limit (≤ 30 mS/m) while the EC value at the downstream sites fall within the tolerable range limit ($\geq 50 - \leq 85$ mS/m). It must be noted that the elevated EC at the downstream site probably reflects deforestation through which this stream reach flows (unlike at the upstream site), with additional dissolved salts (ions) adsorbed to sediments, or perhaps due to increased groundwater contributions, considering that discharge at the downstream site is significantly greater compared to the upstream site.

T4/5:

- **Temporally at the upstream site**, the pH decreased by 4.4% between January (5.65) and February 2024 (5.40) and the EC remained stable between January (22.6 mS/m) and February 2024 (22.7 mS/m);
- **Temporally at the downstream site**, the pH remained stable between January (5.53) and February 2024 (5.49) and the EC increased by 26% between January (34.5 mS/m) and February 2024 (43.6 mS/m);
- **Spatially between the upstream and downstream sites**, the same difference in the pH between the upstream and downstream sites was observed in January compared to February 2024 (2% vs 2% respectively) but a larger difference in EC was observed between the upstream site compared to the downstream site (53% vs 92% respectively); and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the unacceptable range limit ($< 6.5 - > 8.4$) for the upstream and downstream sites, while the EC at the upstream and downstream site fall within the acceptable range limit ($\geq 30 - \leq 50$ mS/m). Although the pH values do not comply to the 2011 RWQOs of South Africa, the acidic nature of the Western Cape's rivers is characteristic due to river pH being influenced largely by acidic tannin compounds, as contributed by the Fynbos vegetation they flow through, more so than the already heavily weathered and inert sandstone substrates they flow over; It must be noted that the elevated EC probably reflects erosion and destabilisation of the river banks from the previous winter flood events), with additional dissolved salts (ions) adsorbed to sediments, or perhaps due to increased groundwater contributions to river base flow at this time of the year.

Table 4: pH and EC results for the HAV1 and T4/5 sites in January and February 2024.

Site	HAV1				T4/5			
Month	Jan-24		Feb-24		Jan-24		Feb-24	
Reach	us	ds	us	ds	us	ds	us	ds
pH	5.23	4.11	4.71	3.66	5.65	5.53	5.40	5.49
EC (mS/m)	14.9	79.5	17.31	76.9	22.6	34.5	22.7	43.6

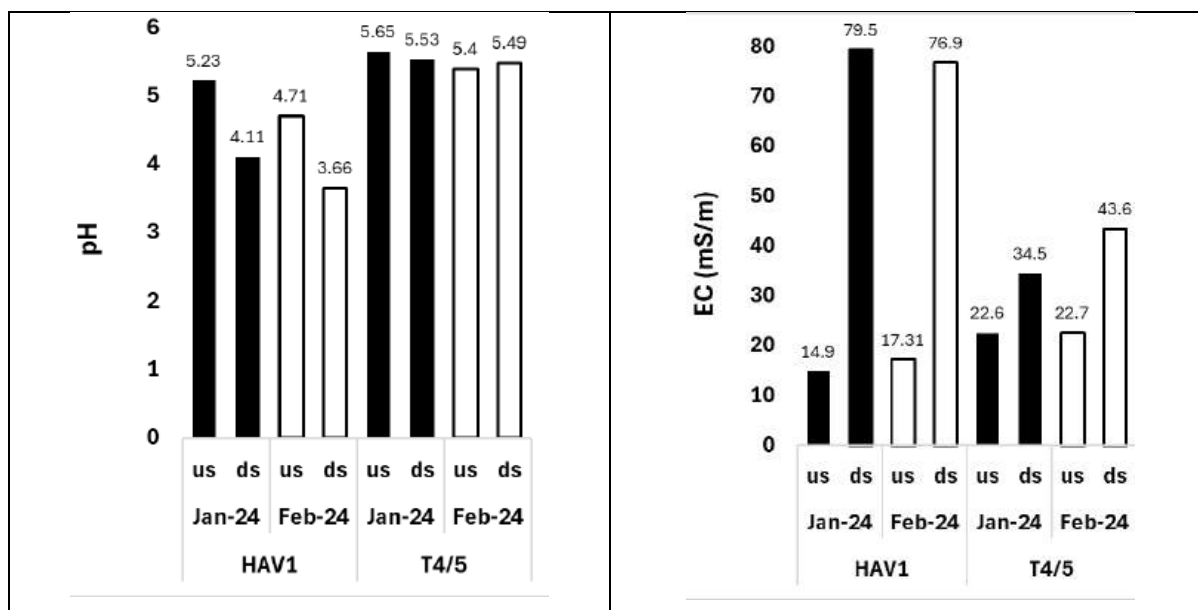


Figure 5: pH and EC results for the HAV1 and T4/5 sites in January and February 2024.

Table 5: Temporal and spatial % variation of pH and EC at the HAV1 repl and T4/5 biomonitoring sites for the January and February 2024 aquatic assessments.

% Variation								
Site	HAV1				T4/5			
	Temporal		Spatial		Temporal		Spatial	
	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)	us site between Jan 2024 and Feb 2024	ds site between Jan 2024 and Feb 2024	us site vs ds site (Jan 2024)	us site vs ds site (Feb 2024)
pH	-9.9%	-10.9%	-21%	-22%	-4.4%	-1%	-2%	+2%
EC (mS/m)	+16.2%	-3.3%	+434%	+344%	+0.4%	+26%	+53%	+92%

CONCLUSIONS

SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macroinvertebrate community at the HAV1 repl and T4/5 sites due to the following reasons:

Given that the T4/5 upstream site is significantly more degraded than its downstream site and was but a trickle in January and February 2024, it does not meet the criteria of a control site, i.e. an unimpacted site relative to its downstream site. Therefore, control-impact site comparisons are not possible at T4/5. The upstream site has consistently returned lower SASS Total and ASPT scores relative to the downstream site in this regard;

It is envisaged that the flows at the HAV1 repl upstream site will dry up sometime during March/April 2024, or will be so long that the SASS5 protocol will no longer be applicable;

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from riparian and instream vegetation.

However, despite the above, no points of concern are raised with respect to the macroinvertebrate community and the associated habitat during the pre-construction and construction phases of the HAV1 and T4/5 boreholes thus far.

RECOMMENDATIONS

The potential erosion and siltation of streams must be continuously monitored in parallel with the SASS5 biomonitoring assessment, to ensure that the interstitial spaces of the streams, that are used as refugia for eggs and small/juvenile specimens remain unclogged.

In the event that the flows dry up to the degree that the SASS5 protocol can no longer be applied, the monitoring programme would need to be adjusted to accommodate the use of diatom and habitat indices that are appropriate under very low to zero flow environmental conditions.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the SASS5 biomonitoring results between January 2024 and February 2024.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd

APPENDIX A – SASS5 Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1 upstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: °C	Amphipoda	13				B	Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				A	Pleidae*	4					Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				1	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancyliidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	73
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				B	NO OF TAXA:		0	0	0	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:	####	####	####	6.64	
	Chlorolestidae	8				1	Pisuliidae	10					IHAS:	%				
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10				A	Dytiscidae*	5				1	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12				A	S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyralidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1 Downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3					Pleidae*	4					Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5					Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14				1	TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	35
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5.83
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5				A	T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyralidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3				1	Blepharoceridae	15				
SITE CODE: T4/5 upstream	ANNELIDA:						Gerridae*	5				B	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				1	Pleidae*	4				A	Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				A
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4				A	Hydropsychidae 1 sp	4					Ancyidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				A	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6				1	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Vivparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	71
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	15
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	4.73
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8				A	SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8				1	Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5				A	GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyalidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 20/02/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				1
E: °	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: ° C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3				B	Pleidae*	4				A	Ephydriidae	3				
DO: mg/l	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				A
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancyidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6				A	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/MUSUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocn.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9				1	CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	98
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				1	NO OF TAXA:		0	0	0	19
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5.16
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4				A	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5				A	T = Tropical					
	Aeshnidae	8				A	Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12					S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6				1	Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				B	Hydrophilidae*	5				A	GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyralidae	12					Psephenidae	10										

APPENDIX B – IHAS Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River	Date: 20 February 2024					
Site Name: HAV1 repl upstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):					0
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):					9
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time) (* NOTE: you must still fill in the SIC section)		under		corr		over
	Other Habitat Score (max 20):					18
	HABITAT TOTAL (MAX 55):					27
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(* NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):					25
	TOTAL IHAS SCORE (%):					52

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River	Date: 20th February 2024					
Site Name: HAV1 repl downstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):			8			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
Vegetation Score (max 15):			11			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
Other Habitat Score (max 20):			20			
HABITAT TOTAL (MAX 55):			39			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
STREAM CONDITIONS TOTAL (MAX 45):			23			
TOTAL IHAS SCORE (%):			62			

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River	Date: 20th February 2024					
Site Name: T4/5 upstream						
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):				15	
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				7	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)	Other Habitat Score (max 20):				14	
	HABITAT TOTAL (MAX 55):				36	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)	STREAM CONDITIONS TOTAL (MAX 45):				26	
	TOTAL IHAS SCORE (%):				62	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 downstream	Date: 20th February 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
			SIC Score (max 20): 18			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
			Vegetation Score (max 15): 15			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
			Other Habitat Score (max 20): 20			
			HABITAT TOTAL (MAX 55): 53			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
			STREAM CONDITIONS TOTAL (MAX 45): 27			
			TOTAL IHAS SCORE (%): 80			



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Date: Monday, 15 April 2024
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Attention : Dr. K. Riemann

TECHNICAL MEMORANDUM

RE: THE SASS5 BIOMONITORING RESULTS OF THE RIVER REACHES PROPOSED TO RECEIVE DISCHARGED GROUNDWATER AS PART OF THE DEVELOPMENT OF THE HAV1 “REPLACEMENT” AND T4/5 PRODUCTION BOREHOLES, HEMEL EN AARDE WELLFIELD, OVERSTRAND MUNICIPALITY, HERMANUS.

MARCH 2024

INTRODUCTION

Freshwater Ecologist Network (FEN) (Pty) Ltd was appointed by Umvoto Africa (Pty) Ltd to undertake the rapid South African Scoring System 5 (SASS5) biomonitoring field assessment (Dickens and Graham 2002) on river reaches that are proposed to receive discharged groundwater during the development (drilling) of the HAV1 “replacement” and T4/5 production boreholes. This forms part of the Department of Water and Sanitation’s (DWS) – (the custodians of the freshwater resource in South Africa) Water Use License (WUL) requirements (licence 27/2/1/G840/103/1), which states the following:

A bio-monitoring programme (SASS) must be implemented along the affected length of the watercourse/s and must include a habitat assessment.

Borehole production forms part of the Hemel en Aarde Wellfield Expansion Project which aims to provide sustainable water supply solutions to the Overstrand municipal area.

The HAV1 “replacement” production borehole falls within the Camphill Wellfield and is scheduled for borehole development (drilling) as of 29th January 2024, with development continuing until late March 2024. The T4/5 production borehole falls within the Volmoed Wellfield and will be developed from late March until late June 2024. Please refer to the site photos below.

The location of these sites is provided below in Figure 1.

Biomonitoring has taken place on the 19th of January 2024, 22nd of February 2024 and as of this report, on the 28th of March 2024 on river reaches that are upstream and downstream of the proposed borehole discharge locations (HAV1 and T4/5). The January 2024 data is representative of baseline conditions prior to borehole development and the February 2024 and March 2024 data is representative of the construction phase for both boreholes. Borehole development involves the discharge of natural groundwater into temporary sumps (stilling basins) which remove sediment out of suspension, after which the groundwater will be discharged via temporary PVC pipelines/existing channels into an area of low sensitivity in a controlled/erosion preventative manner, eventually finding its way into the receiving watercourse.

METHODS

SASS5 is geared at assessing river water quality and river health based on the assemblage of aquatic macro-invertebrates identified amongst stoney, vegetation and gravel, sand and mud (GSM) biotopes at a given river reach. Each macro-invertebrate is assigned a SASS5 sensitivity score that ranges from 1-15 which is indicative of the degree of tolerance to poor water quality, with a score of 1 indicating highly tolerant, and a score of 15, highly intolerant. The sensitivity scores of the identified taxa (families and orders) are summed per biotope which calculates the SASS score, which when divided by the number of different taxa observed in that biotope determines the Average Score Per Taxon (ASPT) - the average sensitivity of aquatic macro-invertebrates per biotope. It is also possible to calculate these indices across all biotopes to determine the SASS Total Score, number of taxa and ASPT per site.

The competencies of the SASS rapid field based biomonitoring technique include the following:

- Assessing the ecological state of aquatic ecosystems;
- Assessing the spatial and temporal trends in ecological state;
- Assessing emerging problems;
- Setting objectives for rivers;
- Assessing the impact of developments;
- Predicting changes in the ecosystems due to developments
- Contributing to the determination of the Ecological Reserve as part of the National Water Act (Act 36 of 1998), as amended.

The biomonitoring assessment included the following aquatic indices:

- Invertebrate Habitat Assessment System (IHAS) - McMillan (1998) which was informed by a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates;
- South African Scoring System Version 5 (SASS 5) – which derives the Present Ecological Status (PES) of a river based on the presence of macro-invertebrate families; and
- *In situ* biota specific water quality data was collected to assist in interpreting the biological data, using a calibrated portable multimeter (Extech EC-500 and Extech DO-600).

All work was overseen by a South African River Health Program (SA RHP) SASS5 Accredited Assessor. Please refer to Figure 1 for the locality map of the sampling sites.

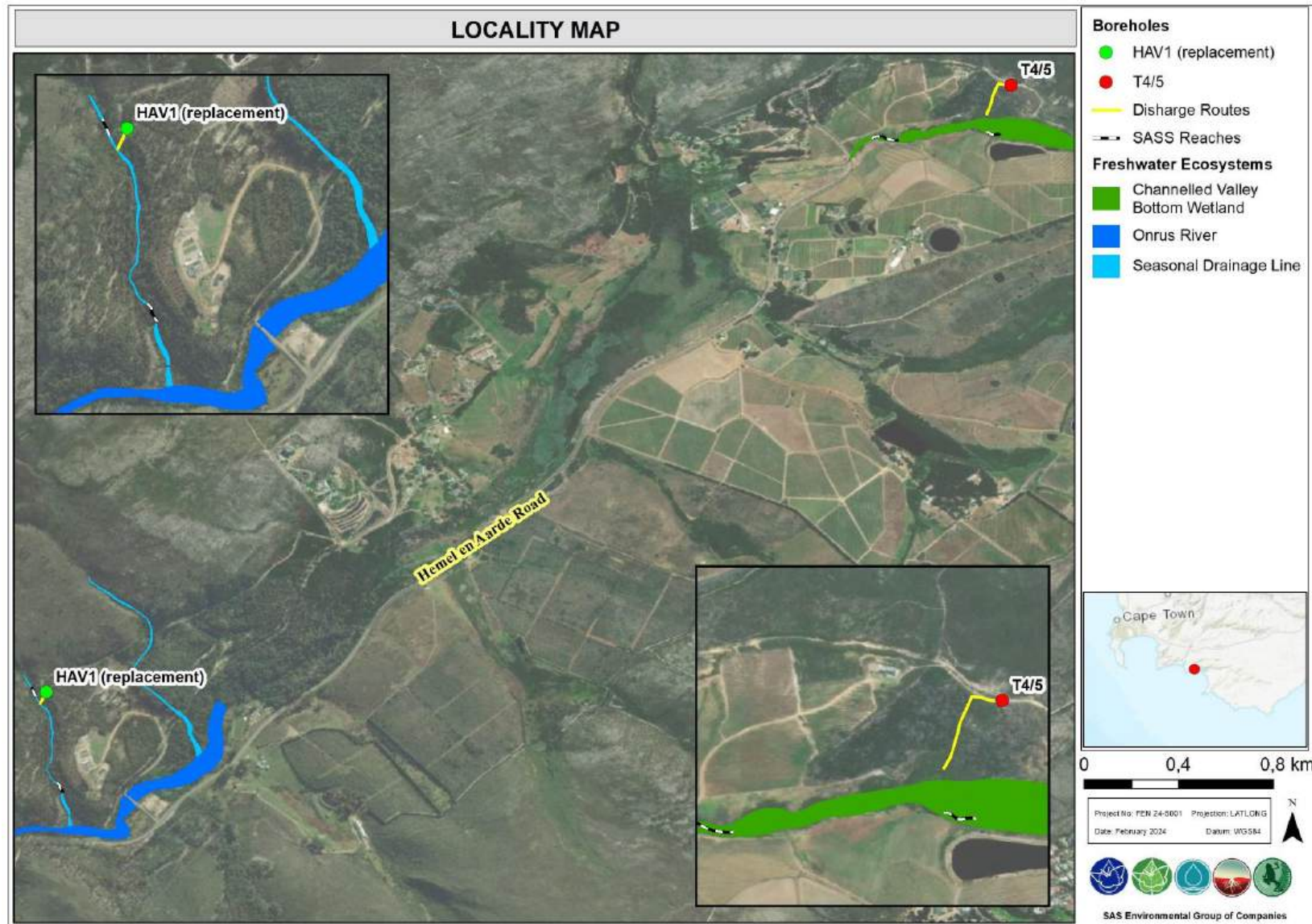


Figure 1: Location of the HAV1 replacement and T4/5 SASS5 sampling reaches in relation to the proposed borehole development discharge routes.

RESULTS

Site Descriptions

HAV1 replacement (upstream): This closed-canopied seasonal mountain stream is a clear light brown colour which is < 1 m wide and ~ 0.15 m deep. A slow shallow run dominated the hydraulic biotope habitat, with occasional shallow pools observed. This stream has had its hydrological budget, marginal and vegetation composition significantly impacted by historic and ongoing *Eucalyptus* tree (Blue Gum) afforestation practices, and subsequent invasion by several *Acacia* (wattle) species. The dominant indigenous marginal vegetation was *Ficinia capillifolia*. Parts of the stream reach were buried underneath alien vegetation debris, and it is envisaged that continued alien invasive vegetation clearing (as observed) will increase the rainfall catchment yield available to this stream, which would increase the hydroperiod and ability of this stream to support a larger vegetation community in future. The water quality of this stream is considered pristine, despite organic input almost entirely from alien invasive vegetation. During the March 2024 assessment the site was sampled, however, sampling was limited as the site was reduced to a small trickle of water of roughly 5 cm.

HAV1 replacement (downstream): The overall vegetation community remained dominated by alien and invasive vegetation, and despite the erosion, the increased stream width (~ 1m), depth (~ 0.3 m) and discharge is able to accommodate a more denser and specious aquatic vegetation community, as evidenced by species such as *Polypogon monspeliensis* (invasive), *Juncus* sp., *Ficinia capillifolia* and *Carpha glomerata*. **However, at the time of the March 2024 assessment the site was not assessed due to zero flow conditions present at the site. As such no spatial comparison between sites HAV1 upstream and HAV1 downstream could be done for the March 2024 assessment.**

T4/5 (upstream): This river reach within a larger channelled valley bottom wetland had recently undergone large scale erosion, and as a result much of the riverine habitat had been lost. The river further upstream was observed to be in a zero flow condition, and therefore it is suspected that the discharge at this site is likely being supplemented by impoundment seepage or other lateral interflow processes. The stream active channel was ~1 m wide and < 0.1 m deep, was clear and dominated by sand and mud biotopes. The hydrology of the stream was a barely perceptible run. Disturbance of this river bed has allowed for the dominance by pioneering species such as *Pteridium aquilinum* (Bracken fern) and the water quality is considered good, although the water temperature is warmer and the clarity is more turbid than what it would be, compared to if the river was still vegetated.

T4/5 (downstream): This downstream river reach by comparison accommodated a much more diverse SASS sampling habitat consisting of runs, riffles, pools and backwaters. Discharge at this site was significantly greater compared to the upstream site, with the river being ~ 1.5 m wide and 0.2 m deep. Although erosion was still very evident at this site, the marginal vegetation out of current was still intact, which provided a good SASS vegetation sampling habitat. Visually the water quality improved significantly at this site and was a clear light brown colour and is considered to be of a very good quality. As with previous assessments the hydraulic biotopes were regarded as good. Cobbles at the site become increasingly covered with organic soot and is likely due to a general decrease in baseflows over the summer season.

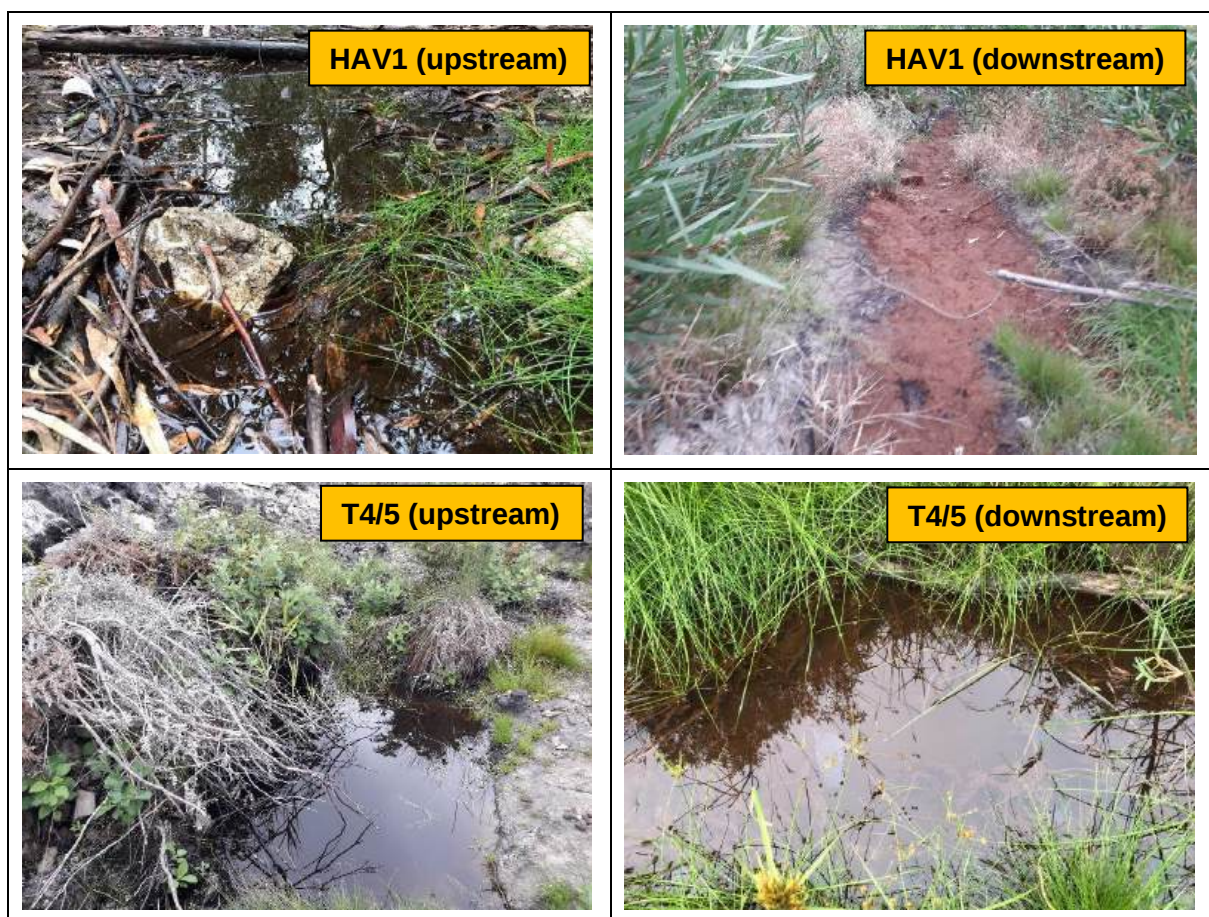


Figure 2: River reaches sampled upstream and downstream of the proposed HAV1 and T4/5 production borehole development discharge locations.

Aquatic Macro-invertebrate Community Integrity

The calculated SASS 5 indices (SASS total Score, number of taxa and Average Score Per Taxon - ASPT) for the HAV1 and T4/5 biomonitoring sites during the January, February and March 2024 aquatic assessments are tabulated below in Table 1 and graphed below in Figure 3. The IHAS % score was used to compare macro-invertebrate habitat integrity.

Table 1: SASS5 and IHAS results for the HAV1 and T4/5 sites since January 2024.

Site	HAV1						T4/5					
	Jan-24		Feb-24		March-24		Jan-24		Feb-24		March-24	
Reach	us	ds	us	ds	us	ds*	us	ds	us	ds	us	ds
SASS Total Score	76	24	73	35	39	NA	47	114	67	98	86	121
Taxa	9	6	11	6	6	NA	10	23	14	19	17	21
ASPT	8.44	4	6.64	5.83	6.5	NA	4.7	4.96	4.79	5.16	5.06	5.76
PES	A	E/F	C	D	C	NA	E/F	C	E/F	D	D	C
IHAS	60	62	52	62	40	NA	43	80	62	80	62	80

*At the time of the March 2024 assessment the HAV1 ds site could not be assessed due to site having no flow at the time of the assessment.

The percentages in variation of the SASS5 indices and IHAS % scores at the HAV1 replacement and T4/5 biomonitoring sites were compared temporally and spatially in Table 2 below as follows:

- **Temporally:** Percentage variation between the upstream and/or downstream site in January 2024 compared to March 2024, to gauge whether an improvement or deterioration in the

aquatic macro-invertebrate community and habitat integrity has taken place over time between the upstream and downstream sites; and

- **Spatially:** Percentage variation between an upstream and downstream site in March 2024, to gauge for stability in the baseline differences in the aquatic macro-invertebrate community and habitat integrity between the upstream and downstream sites over time.

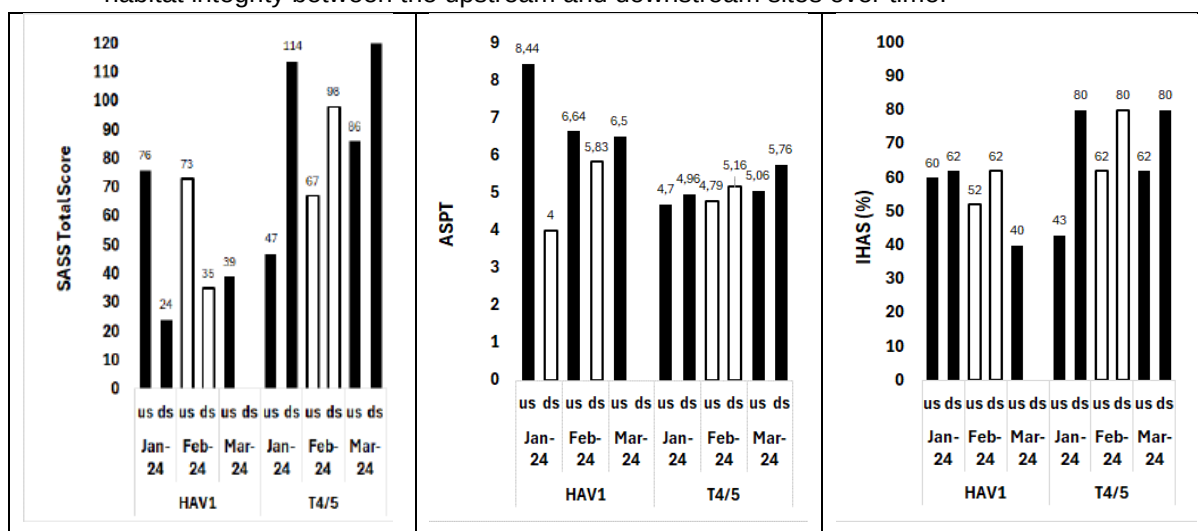


Figure 3: SASS5, ASPT and IHAS results for the HAV1 and T4/5 sites since January 2024.

Table 2: Temporal and spatial % variation of the SASS5 indices and IHAS scores at the HAV1 replacement and T4/5 biomonitoring sites for the March 2024 aquatic assessment.

% Variation						
Site	HAV1			T4/5		
	Temporal		Spatial	Temporal		Spatial
	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024		us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	us site vs ds site (Jan 2024)
SASS Score	-48.7%	NA	NA	+83.0%	+6.0%	+41.0%
Taxa	-33.3%	NA	NA	+70.0%	-9.0%	+24.0%
ASPT	-23.0%	NA	NA	+7.7%	+16.0%	+14.0%
IHAS	-33.3%	NA	NA	+44.2%	0.0%	+29.0%

*Key to variations: Negative value = decrease; Positive value = increase; Normal text = no significant change; Bold text = significant change; Red text = significant deterioration; Blue text = significant improvement.

Table 3: Aquatic macro-invertebrate community comparisons at the HAV1 and T4/5 biomonitoring sites since January 2024.

ORDER	FAMILY	SENSITIVITY SCORE	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24	Jan-24	Feb-24	Mar-24
			HAV1 repl (us)			HAV1 repl (ds)			T4/5 (us)			T4/5 (ds)		
ANNELIDA	Oligochaeta	1										✓		
CRUSTACEA	Amphipoda	13	✓	✓	✓									✓
	Potamonautidae*	3	✓	✓	✓					✓	✓	✓	✓	✓
PLECOPTERA	Notonemouridae	14	✓				✓							✓
EPHEMEROPTERA	Baetidae 1 sp.	4							✓	✓		✓		
	Baetidae 2 sp.	6								✓	✓	✓		✓
	Leptophlebiidae	9											✓	
	Caenidae	6							✓	✓		✓	✓	
ODONATA	Chlorolestidae	8	✓	✓										
	Coenagrionidae	4										✓	✓	
	Platycnemidae	10		✓										
	Aeshnidae	8							✓	✓	✓	✓	✓	✓
	Gomphidae	6										✓	✓	
	Libellulidae	4		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
HEMIPTERA	Corixidae*	3				✓			✓	✓	✓	✓	✓	✓
	Gerridae*	5		✓		✓	✓		✓	✓	✓	✓	✓	✓
	Hydrometridae*	6										✓		
	Nepidae*	3							✓	✓	✓	✓	✓	✓
	Notonectidae	3									✓			✓
	Pleidae*	4							✓	✓	✓	✓	✓	✓
	Veliidae/Mesoveliidae*	5	✓	✓						✓	✓	✓	✓	✓
TRICHOPTERA	Hydropsychidae 1sp	4												✓
CASED CADIS	Philopotamidae	10	✓											
	Leptoceridae	6	✓	✓							✓	✓	✓	✓
COLEOPTERA	Dytiscidae*	5		✓	✓	✓	✓		✓		✓	✓	✓	✓
	Elmidae*	8								✓		✓		✓
	Gyrinidae*	5					✓					✓	✓	✓
	Helodidae	12	✓	✓	✓									
	Hydraenidae*	8									✓	✓		
	Hydrophilidae*	5	✓			✓			✓	✓	✓	✓	✓	✓
DIPTERA	Athericidae	10										✓	✓	✓
	Chironomidae	2		✓	✓	✓	✓			✓	✓	✓	✓	✓
	Simuliidae	5								✓	✓		✓	✓
	Culicidae*	1									✓	✓		

The following inferences can be drawn from the above results in Table 1, Table 2, Table 3 and Figure 3:

HAV1 replacement:

- **Temporally at the upstream site**, both the SASS Total score (which is a measure of macro-invertebrate diversity) and ASPT score (which describes the average sensitivity of macro-invertebrates) significantly deteriorated by 48.7% and 23.0%, respectively, for the current assessment compared to the initial January 2024 assessment. The significant decrease in both indices is most likely due to the significantly decreasing habitat suitability (IHAS score, by 33.3%). The decrease in habitat suitability can possibly be seasonally driven with lower base flows compared to the previous assessments. The decrease in indices is also driven by the decrease in the number of taxa identified during the March 2024 assessment compared to previous assessments which is also due to the decrease in IHAS score. The absence of highly sensitive species during the March 2024 assessment is thus an indication of a decrease in presence of sensitive species with the absence of species such as Chlorolestidae, Platycnemidae, Philopotamidae and Leptoceridae. The identification of low sensitive taxa such as Potamonautidae, Libellulidae, Dytiscidae and Chironomidae further decreased the ASPT score;
- **Temporally at the downstream site**, no percentage variance could be calculated at the time of assessment due to the site not being sampled at the time of the March 2024 assessment.

This is due to no flow conditions at the time of the assessment which is likely due to seasonality and the sampling of the site being just before the start of the rainy season in the area;

- **At the time of the assessment no spatial comparison could be made between the upstream and downstream sites of the HAV1 replacement site due to the downstream site not being sampled (site had no flow);** and
- The results as described above are expected given the natural environmental changes.

T4/5:

- **Temporally at the upstream site**, the SASS Total score increased significantly by 83.0% between the January and March 2024 assessment. The ASPT score insignificantly increased by 7.7% when compared to the January 2024 assessment. The improvement in both SASS5 and ASPT scores is likely due to the significantly increasing habitat suitability (44.2%) between January 2024 and March 2024. The increase in both index scores is due to the additional taxa identified in March 2024 (Potamonautidae, 2 Beatidae sp., Veliidae, Leptoceridae, Hydraenidae and Culicidae);
- **Temporally at the downstream site**, the SASS Total score slightly increased by 6.0% with a significant increase in the ASPT score by 16.0% when compared to the January 2024 assessment. Both changes are considered an improvement, however, the reason for the improvement is unknown as the habitat suitability remained unchanged. It is thus suggested that the improvement in SASS5 and ASPT scores is possibly due to an increase in water quality (significantly decreasing [38.0%] Electrical Conductivity (EC) compared to the January 2024 assessment as will be discussed later in the report). The increase in ASPT score is due to identifying more sensitive species at the site at the time of assessment compared to January 2024;
- **Spatially between the upstream and downstream sites**, a downstream improvement in both SASS5 (41.0%) and ASPT (14.0%) scores was noted, with the former change seen as a significant improvement. The significant downstream improvement in macro-invertebrate community integrity is likely due to the significant downstream increase in habitat suitability (29.0%) compounded by the slight improvement in measured water quality (decreasing EC as discussed later) in a downstream direction at the time of assessment; and
- The results as described above are expected given the natural environmental changes.

As per Figure 4 below which has plotted the SASS Total score (x-axis) against the ASPT (y-axis) within the context of Present Ecological Status (PES). Thresholds “biological bands” for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion, the following inferences can be drawn.

- The HAV1 upstream site deteriorated from a PES Class A (Pristine) ecological condition to a PES Class C (Moderately Modified) ecological condition between January 2024 and March 2024 due to a significant decrease in both the SASS5 and ASPT scores;
- The HAV1 downstream site could not be determined for the March 2024 assessment as the site could not be assessed (site had no flow at the time of the assessment);
- The T4/5 upstream site improved from a PES Class E/F (Severely to Critically Modified) to a PES Class D (Largely Modified) ecological condition between January 2024 and March 2024 assessment likely due to the significantly increasing SASS5 score and slightly increasing ASPT score; and
- The T4/5 downstream site remained unchanged as a PES Class C (Moderately Modified) at both sites when compared to the January 2024 assessment.

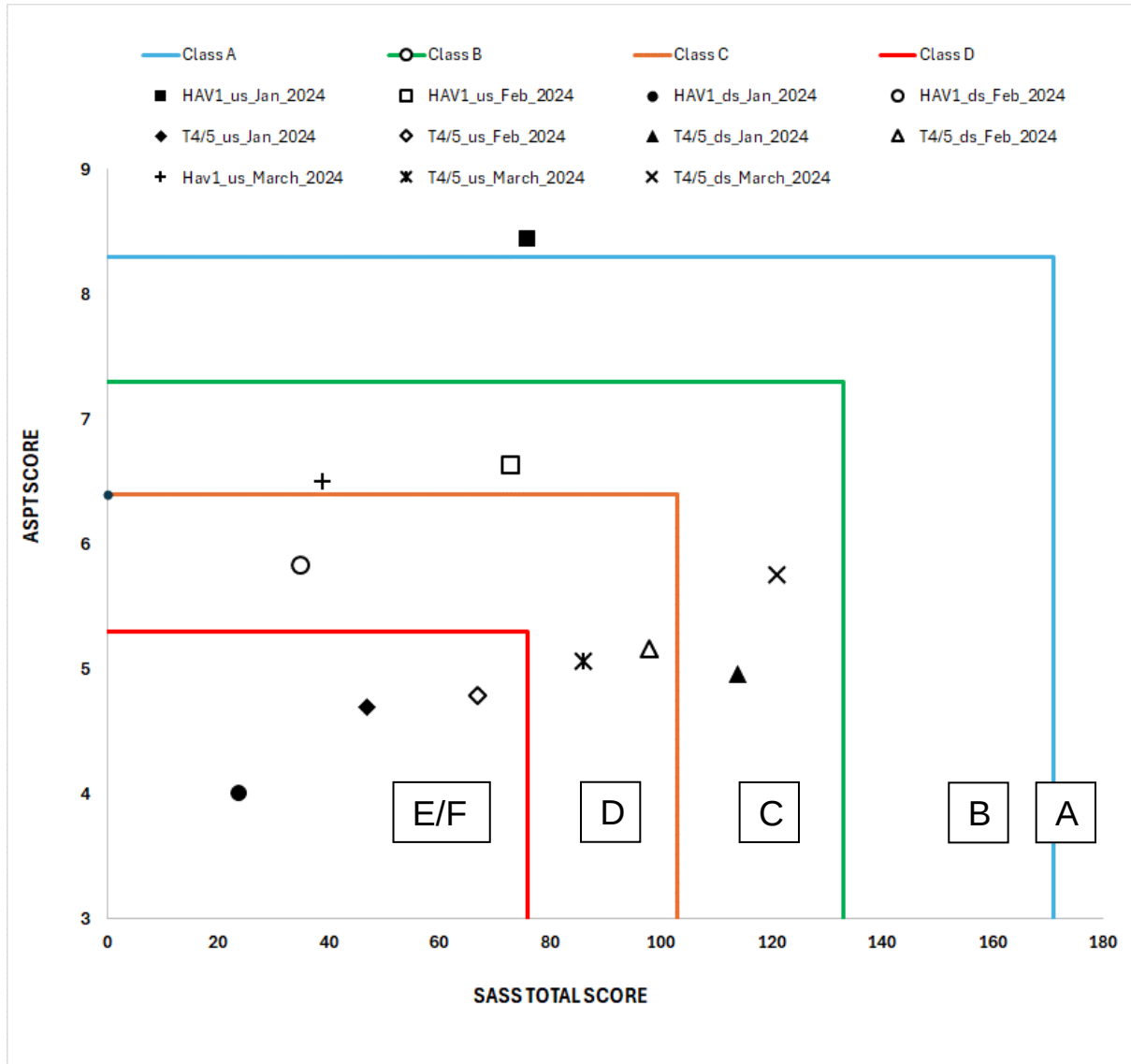


Figure 4: Scatterplots of the SASS total scores and ASPT scores within the context of their PES threshold scores as derived for an upper longitudinal profile river in the Southern Folded Mountains Ecoregion.

In Situ Physico-Chemistry

The measured pH and Electrical Conductivity (EC) for the HAV1 and T4/5 biomonitoring sites during the January, February and March 2024 aquatic assessments are tabulated below in Table 4 and graphed below in Figure 5. The percentages in variation of the pH and EC at the HAV1 replacement and T4/5 biomonitoring sites were compared temporally and spatially in Table 5 below as well.

Table 4: pH and EC results for the HAV1 and T4/5 sites since January 2024.

Site	HAV1						T4/5					
Month	Jan-24		Feb-24		March-24		Jan-24		Feb-24		March-24	
Reach	us	ds	us	ds	us	ds	us	ds	us	ds	us	ds
pH	5.23	4.11	4.71	3.66	7.3	NA	5.65	5.53	5.4	5.49	5.29	5.47
EC (mS/m)	14.9	79.5	17.31	76.9	14.92	NA	22.6	34.5	22.7	43.6	24.3	21.3

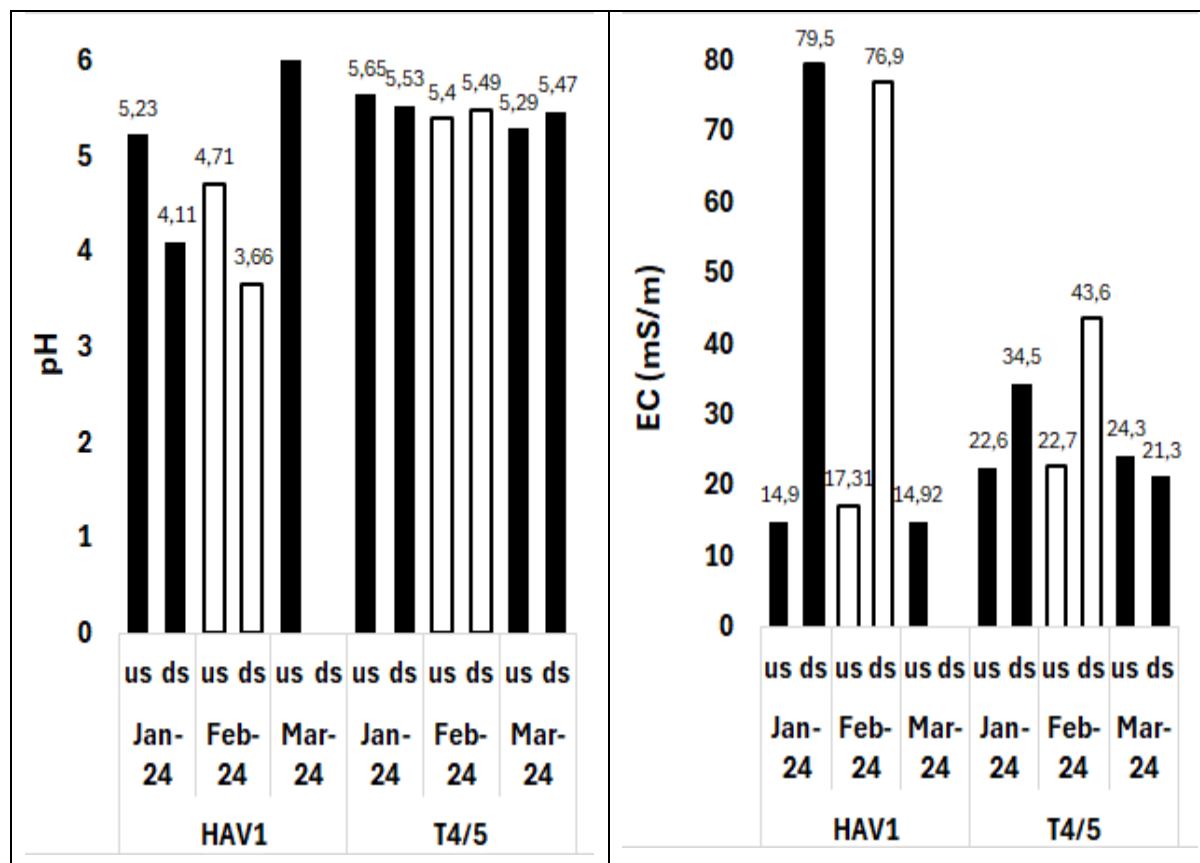


Figure 5: pH and EC results for the HAV1 and T4/5 sites since January 2024.

Table 5: Temporal and spatial % variation of pH and EC at the HAV1 repl and T4/5 biomonitoring sites since the January 2024 aquatic assessment.

% Variation						
Site	HAV1			T4/5		
	Temporal		Spatial	Temporal		Spatial
	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	us site vs ds site (Mar 2024)	us site between Jan 2024 and Mar 2024	ds site between Jan 2024 and Mar 2024	us site vs ds site (Jan 2024)
pH	+39.6%	NA	NA	-6.4%	-1.0%	+3.0%
EC (mS/m)	+0.1%	NA	NA	+7.5%	-38.0%	-12.0%

*Key to variations: Negative value = decrease; Positive value = increase; Normal text = no significant change; **Bold text** = significant change; **Red text** = significant deterioration; **Blue text** = significant improvement.

The following inferences can be drawn from the above results in Table 4 and Table 5 and Figure 5:

HAV1 replacement:

- **Temporally at the upstream site**, the pH significantly increased by 39.6% with a slight and ignorable increase in Electrical Conductivity (EC) by 0.1% when compared to the January 2024 assessment;
- **Temporally at the downstream site**, no percentage variance could be calculated as the downstream site could not be assessed at the time of the March 2024 assessment due to no flow conditions;
- **Spatially no comparison could be drawn between the upstream and downstream sites, as the downstream site could not be assessed during the March 2024 assessment;** and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the acceptable range limit (6.5 - 8.4) for the upstream site. No impact on the aquatic community from measured pH is deemed possible at the time of assessment; and
- The EC value at the upstream site fall within the ideal range limit (≤ 30 mS/m) and as such no impact on the aquatic community is deemed possible at the time of assessment.

T4/5:

- **Temporally at the upstream site**, the pH decreased significantly by 6.4% with an insignificant increase in measured EC by 7.5% between the January 2024 and March 2024 assessments. Both changes are considered a negative change;
- **Temporally at the downstream site**, the pH remained relatively stable with a 1.0% downstream decrease, whilst the EC significantly improved in a downstream direction (38.0% decrease) between the January 2024 and March 2024 assessments;
- **Spatially between the upstream and downstream sites**, no significant change either pH (3.0% increase) or EC (12.0%) was noted between the upstream and downstream site. However, the decreasing EC between the sites is seen as a positive change; and
- Although the Resource Quality Objectives for the G40H quaternary catchment have not been determined other than for the Onrus estuary, according to the Resource Water Quality Objectives of South Africa (2011), the pH falls within the acceptable range limit (6.5 - 8.4) for the upstream and downstream sites, while the EC at the upstream and downstream site fall within the ideal range limit (< 30 mS/m). As such no impacts at either the upstream or downstream sites was evident from the measured water quality (pH and EC) at the time of the assessment.

CONCLUSIONS

SASS5 is not deemed an appropriate freshwater tool to monitor for river health impacts in terms of the macro-invertebrate community at the HAV1 replacement and T4/5 sites due to the following reasons: Given that the T4/5 upstream site is significantly more degraded than its downstream site with limited surface water in March 2024, it does not meet the criteria of a control site, i.e. an unimpacted site relative to its downstream site. Therefore, control-impact site comparisons are not possible at T4/5.

The HAV1 replacement downstream site had no flow conditions at the time of the March 2024 assessment and as such the SASS5 protocol could not be applied. No spatial comparison could thus be drawn between the upstream and downstream sites at the time of assessment.

Given the very high erosive damage in the Hemel en Aarde catchment as a result of the recent 2023 winter rains, the streams and rivers in general are regarded as being outside of their normal biotic conditions, both from a habitat quality and water quality perspective. This is particularly true for increased water temperature due to large scale loss of shade generated from riparian and instream vegetation.

However, despite the above, concerns are raised with respect to significantly decreasing SASS5 and ASPT scores for the HAV1 upstream sites compared to the January 2024 assessment. The deterioration in macro-invertebrate community integrity is most likely due to seasonality as the habitat suitability significantly decreased. No points of concern are raised with respect to the macro-invertebrate community and the associated habitat during the pre-construction and construction phases of the T4/5 boreholes thus far with an increase in the SASS5 and ASPT scores, as well as significantly increasing SASS5 score in a downstream direction.

RECOMMENDATIONS

The potential erosion and siltation of streams must be continuously monitored in parallel with the SASS5 biomonitoring assessment, to ensure that the interstitial spaces of the streams, that are used as refugia for eggs and small/juvenile specimens remain unclogged.

In the event that the flows dry up to the degree that the SASS5 protocol can no longer be applied, the monitoring programme would need to be adjusted to accommodate the use of diatom and habitat indices that are appropriate under very low to zero flow environmental conditions such as at the time of the March 2024 assessment.

REFERENCES

Dickens, C.W.S and Graham, P.M. (2002): The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27: 1-10.

Freshwater Ecologist Network (2022): Freshwater Assessment for the proposed Hemel an Aarde Wellfield Expansion Project, Hermanus, Western Cape. Prepared for Umvoto Africa (Pty) Ltd.

We trust that this memorandum provides the requisite clarity with respect to the SASS5 biomonitoring results between January 2024 and March 2024.

Yours sincerely,

Digital documentation not signed for security purposes.

Stephen van Staden

(Pr. Sci. Nat.)

Director

FEN Consulting (Pty) Ltd

APPENDIX A – SASS5 Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: °	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: HAV1/US	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 18,0 °C	Amphipoda	13				A	Notonectidae*	3					Empididae	6				
Ph: 7,3	Potamonautidae*	3				A	Pleidae*	4					Ephyrididae	3				
DO: 5,83 mg/l 65%	Atyidae	8					Veliidae/M....veliidae*	5					Muscidae	1				
Cond: 14,92 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	39
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		0	0	0	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	6,50
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						COMMENTS:					
SIGNS OF POLLUTION:	Platynemidae	10					Dytiscidae*	5				A	* = airbreathers					
	Protoneuridae	8					Elmidae/Dryopidae*	8					SWC = South Western Cape					
	Zygoptera juvs.	6					Gyrinidae*	5					T = Tropical					
	Aeshnidae	8					Halipidae*	5					ST = Sub-tropical					
	Corduliidae	8					Helodidae	12				A	S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					VG = all vegetation					
	Libellulidae	4				A	Hydrophilidae*	5					GSM = gravel, sand & mud					
	LEPIDOPTERA:						Limnichidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					
	Pyrilidae	12					Psephenidae	10										

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: *	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E: *	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 upstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				A
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: 17,6 ° C	Amphipoda	13				A	Notonectidae*	3				1	Empididae	6				
Ph: 5,29	Potamonautidae*	3					Pleidae*	4				1	Ephydriidae	3				
DO: 5,59 mg/l 57,9%	Atyidae	8					Veliidae/M...veliidae*	5				1	Muscidae	1				
Cond: 24,3 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordulidae	8					Simuliidae	5				1
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	86
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				A	NO OF TAXA:		0	0	0	17
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5,06
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5					SWC = South Western Cape					
	Aeshnidae	8				A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8				1	S = Stone & rock					
	Libellulidae	4				A	Hydrophilidae*	5				1	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 28/03/2024	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S: *	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				A
E: *	TURBELLARIA	3					Corixidae*	3				A	Blepharoceridae	15				
SITE CODE: T4/5 downstream	ANNELIDA:						Gerridae*	5				A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				1
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3				A	Dixidae*	10				
TEMP: 18,2 °C	Amphipoda	13				A	Notonectidae*	3				A	Empididae	6				
Ph: 5,47	Potamonautidae*	3				A	Pleidae*	4				A	Ephydriidae	3				
DO: 6,22 mg/l 67,6%	Atyidae	8					Veliidae/M...veliidae*	5				A	Muscidae	1				
Cond: 31,2 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordulidae	8					Simuliidae	5				1
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14				1	TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4				A	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		0	0	0	121
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6				A	NO OF TAXA:		0	0	0	21
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		####	####	####	5,76
	Chlorolestidae	8					Pisuliidae	10					IHAS:		%			
	Coenagrionidae	4					Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5				A	COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8				A	* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5				A	SWC = South Western Cape					
	Aeshnidae	8				A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4				A	Hydrophilidae*	5				A	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX B – IHAS Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Seasonal Stream of the Onrus River						
Site Name: HAV1 repl upstream	Date: 28 March 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
			SIC Score (max 20):			
			0			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
			Vegetation Score (max 15):			
			3			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'cor' = correct time)		under		corr		over
			Other Habitat Score (max 20):			
			18			
			HABITAT TOTAL (MAX 55):			
			21			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
			STREAM CONDITIONS TOTAL (MAX 45):			
			19			
			TOTAL IHAS SCORE (%):			
			40			

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 upstream	Date: 28th March 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
	SIC Score (max 20):				14	
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				7	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
	Other Habitat Score (max 20):				15	
	HABITAT TOTAL (MAX 55):				36	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):				26	
	TOTAL IHAS SCORE (%):				62	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Perennial stream of the Onrus River						
Site Name: T4/5 downstream	Date: 28th March 2024					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):			18			
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
Vegetation Score (max 15):			15			
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time)		under		corr		over
Other Habitat Score (max 20):			20			
HABITAT TOTAL (MAX 55):			53			
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
STREAM CONDITIONS TOTAL (MAX 45):			27			
TOTAL IHAS SCORE (%):			80			