1 JBS27 (EFR O1: HOPETOWN (ORANGE RIVER))

The information is summarised from WFA (2010a;b).

1.1 SITE DESCRIPTION

EFR O1 is situated in the MRU B approximately 77 km upstream of the Vaal River confluence. The landuse in this reach is dominated by irrigation and influence by the hydro-electric operation from Vanderkloof Dam. The gross morphology is bedrock controlled, but the bed is primarily composed of mobile cobbles, gravels and sands. The site is within a relatively narrow gorge/valley. The morphology of the site is generally consistent with the reach; but the condition (especially of the banks and riparian vegetation) is in far better condition. The LB has more rocky habitats than the RB which is more alluvial. The site is atypical of the reach especially due to presence of rapids (FS and FD) over bedrock and secondary channels (therefore most probably higher habitat variability than most of reach). The reach most probably dominated by FD habitats. The site did however provide the best diversity of habitats (i.e. rapids, riffles, side channels, and pools in side channels) and therefore the highest possibility of sampling fish species present in this reach. Macroinvertebrate habitat is good at the site.

Location	EFR O1 Hopetown	**Altitude**	1060 m
Longitude	24.009270°	**Latitude**	-29.516°
EcoRegion	Nama Karoo 26	**Quaternary catchment**	D33G
Water Management Area	Upper Orange	**Geomorphological zone**	Lowland Foothills

EFR O1, Orange River. The banks and mid-channel bars are well-vegetated.

1.2 PRESENT ECOLOGICAL STATE (PES)

Geom	Present Day flows in this section are about half of the Mean Annual Runoff (MAR). A peaking hydro-power dam operates about 100km upstream of the site with twice-daily floods. Despite these daily floods, large flood sizes and frequencies are highly reduced; accounting for the increased area of bars and islands in the reach (observed over the historical record), and especially the progressive stabilisation of the sedimentary features by vegetation. Scouring events across these bars are too infrequent and small to keep sedimentary and vegetation encroachment in check. Although there are increased sediment loads from the upper catchment, much of this is trapped in the upstream dams, but tributaries and flushing of fines and suspended load through the dams compensates for some of the reduced sediment supply downstream. Additionally, large floods are reduced, so the reduced sediment is somewhat offset by a reduced frequency of large scour events. Moderate floods now occur as twice-daily flows due to peaking hydropower generation, and this has likely armoured sections of the channel, but may be responsible for the increased vegetation in the lower riparian zones due to more frequent wetting.
WQ	Salt concentrations are similar to reference condition, except for sulphate, sodium and chloride which show increases. Impacts from toxicants are expected due to farming-related pesticides and fertilizer use. Although biotic indicators suggest that a category C situation exists, instream dams have

	large impacts on water quality in terms of changing conditions from the reference state, particularly for temperature. Seasonal fluctuations have been severely impacted on, so that although that the overall present state for water quality seems acceptable, changes from the natural state have been severe. Elevated nutrients from farming impact on the water quality assessment. Aluminium levels are high, although this assessment is based on very limited data. The most likely source of aluminium in the surface water is due to alum or aluminium sulphate used in most water treatment processes as a flocculating agent for suspended solids, or aluminium loads carried in suspended solids. However, sediment loads are low due to the upstream dams. Temperature impacts due to the presence of instream dams are significant.
Fish	All the expected fish species should still be present in this river reach albeit in a moderately to highly reduced FROC. Species that are thought to have been impacted the most include L. umbratus, B. anoplus, *L. kimberleyensis* and Clarias gariepinus. The primary changes responsible for deterioration in the fish assemblage are primarily associated with altered hydrology/flow modifications related to fluctuating water releases for hydro-electric power generation. This results in loss of marginal vegetation as cover, flushing of substrates (critical impact during spawning of substrate breeders) and laying dry of marginal zone (especially significant during breeding season for vegetation spawners). The impacts of migration barriers on the natural movement of fish are furthermore expected to impact the fish assemblage negatively in this river reach. Other impacts are related to water quality deterioration (especially impacts from dams on temperature and oxygen, as well as presence of toxics). The presence of alien fish species (both predacious and habitat modifying) furthermore impact on the natural fish populations of this reach.
Inverts	2010 SASS5 score: 128 No of Taxa: 21 ASPT: 6.1 Key taxa expected but not observed were mainly taxa that prefer slow-flowing water, such as shrimps (Atyidae), Coroxidae, Notonectidae, Ceratopogonidae, and Lymnaeidae. The fauna was dominated by baetid mayflies. No other taxa were abundant. Leptophlebiid mayflies and gomphid dragonflies were less abundant than expected. A number of sensitive taxa were recorded, including Leptoceridae (Leptoceridae (Parasetodes and Oecetis sp), flat-headed mayflies (Heptageniidae) Tricoryhtidae and Leptophliidae.
Rip veg	**Marginal Zone:** Dominated by dense stands of *P. australis* with a distinct lack of woody marginal zone species such as *G. virgatum* and *S. mucronata*, although these species occur with very low abundance. The frequency of inundation disturbance is likely to prohibit recruitment of these species while reeds are able to withstand and even benefit. **Lower Zone:** The zone is frequently flooded, which is clearly shown by scour and also species composition. Marginal zone woody species are common in this zone, as well as many sedge and wetland species. Woody species have attained high densities and stature and have likely benefited from frequent wetting that is not extreme enough to be an impact as it is in the marginal zone. Upper zone and even terrestrial woody species (such as *A. karoo* and *Z. mucronata*) are also commonly recruiting in this zone, but seem to fail to reach full maturity (due to flooding disturbance). **Upper Zone:** Terrace or bar vegetation component is absent and represents the expected for the lower zone. **Macro Channel Bank**: Dominated by woody riparian and terrestrial savanna species with a mix of open areas that are either sandy or colonised by grasses.
Diatoms	Diatom results are based on samples taken during 2008 - 2010 at various sites situated in MRU B. The water entering Vanderkloof Dam was mainly impacted by agriculture as the diatoms indicated that the water was eutrophic and salinity levels were elevated. However, due to top releases, the biological water quality entering the Orange River from this dam was a B and these releases have a dilution effect on pollution impacts. Further downstream up to the confluence with the Vaal River impacts are attenuated by increased flows. The biological water quality is in a B condition with calcium based salinity and elevated nutrients being problematic at times in this reach. The results may be overestimated due to the size of the Orange River and the large flow volumes, which may have a dilution effect of pollution.

1.3 MAIN IMPACTS AT THE SITE

	PES	Causes	Sources	F/NF
WQ	D	Elevated nutrients and potential toxicant loads due to fertilizer and pesticide use.	Land-use is agricultural, resulting in some toxicant and nutrient loading expected, although data only reflects a small increase in salts and nutrients.	NF
		Temperature fluctuations result in a change in water quality category from a C to D category.	The location of the upstream dam and twice daily peaks in flow impact on temperature and levels.	F

	PES	Causes	Sources	F/NF
Geom	C/D	Reduced frequency and size of large floods.	Large dams upstream trap big floods and reduce the magnitude and frequency downstream.	F
		Reduced sediment load.	Upstream dams trap sediment and reduce supply to downstream reaches. These impacts have been ameliorated somewhat by reduced flows, and flushing of suspended loads through the dams.	NF
		Peaking power generation – daily stage fluctuations	Daily stage fluctuations are reworking sediments in the marginal and lower riparian zones, and probably armouring the bed.	F
Rip veg	B/C	Increased reed cover in the marginal zone.	Reduced and regulated flows.	F
		Increased woody cover and density especially on lower zone and mid-channel bars.	Bi-daily fluctuations and reduced moderate floods.	
		Altered species composition.	Small percentage of exotic annuals.	NF
Fish	C/D	Decreased overhanging vegetation as cover for fish resulted in decreased FROC of species with preference for these habitats. Loss of habitat (cover) also resulted in increased exposure to predators.	Continuous fluctuation in water levels due to hydro power releases. Increased bank erosion, flow modification and inundation. Farming: removal or change in riverine vegetation.	F
		Decrease in FROC and abundance of fish species with preference for fast habitats.	Loss in abundance and diversity of especially fast habitats as result of decreased base flows.	
		Reduced spawning success resulting in decreased FROC of many species.	Flushing away of eggs or laying dry of marginal zone breeding areas (rocky/cobbles and vegetated). Flow modification: Absence or lag effect on spring flushes, reduced habitat suitability and stimuli, modified flow pattern disrupt normal breeding cycle of fish species.	
		Decreased water quality affect species with requirement for good water quality.	Presence of toxins, altered temperature and oxygen due to dams and other human activities. Farming: water abstraction, reduced flows, pollutants. Farming - mineralization and eutrophication (fertilizers) due to irrigation run-off. Potential presence of pesticides and herbicide. Dams trapping silt altering water clarity, altered temperature and O_2 regimes.	NF
		Decreased species diversity and abundance as result of presence of predacious alien species (*M. salmiodes*) feeding on indigenous fish.	Presence of alien predatory species. Dams create further suitable habitat for undesirable species.	
		Bio-turbation from *C. carpio*. Increased turbidity and disturbed bottom substrates reduce bottom substrate quality and water quality for indigenous fish (especially impact on *L. umbratus* breeding habitats)	Presence of alien *C. carpio*. Dams create habitat for undesirable species.	
		Decreased abundance, and therefore FROC related to over utilization of fish resource for human consumption.	Poaching and over-fishing of fish using nets (gill and seine nets, often home-made).	
		Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Large dams and some weirs.	
Macroinvertebrates	C	Flow fluctuations (bi-daily).	Generation of peak demand hydro-powe.r	F
		Elevated low flows.	Discharges to meet demands for winter power generation and irrigation demands.	
		Increased photic depth.	Upstream impoundments trapping silt.	NF
		Altered water temperature (warmer winters, colder summers).	Thermal inertia of upstream impoundment.	
		Increased Phytoplankton.	Upstream impoundments.	
		Toxic algal blooms, such as *Microcystis.*	Annual overturn.	

1.4 RESULTS: PRESENT ECOLOGICAL STATE

Driver Components	PES	Trend
GEOMORPHOLOGY	C/D	Negative
WATER QUALITY	D	Stable
DIATOMS	B	
Response Components	**PES**	**Trend**
FISH	C/D	Stable
MACRO INVERTEBRATES	C	Stable
INSTREAM	C	
RIPARIAN VEGETATION	B/C	Stable
ECOSTATUS	C	

The major issues that have caused the change from reference conditions are the releases for hydropower, barrier effects of the dams, water quality problems and the destruction of and removal of vegetation on floodplains for agriculture. The dominant factor seems to be the hydro-electric releases. Geomorphology indicated a long term negative trend and this was due to sediment which is still moving through the system.

1.5 SUITABILITY AS FUTURE BIOMONITORING SITE

Habitat at the site is good for biotic monitoring. This site is situated well below Vanderkloof Dam and may be a suitable site for biomonitoring the impacts of irrigation and the influence of the hydro-electric operation in this reach. However it must be noted that this site is in a better condition than the rest of the reach.