water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DETERMINATION REVIEW AND IMPLEMENTATION OF THE RESERVE IN THE OLIFANTS/LETABA SYSTEM

CAPACITY BUILDING: EWR DETERMINATION

OLIFANTS-S5 (EWR1)
B11J

10 JUNE 2016

Training Objectives

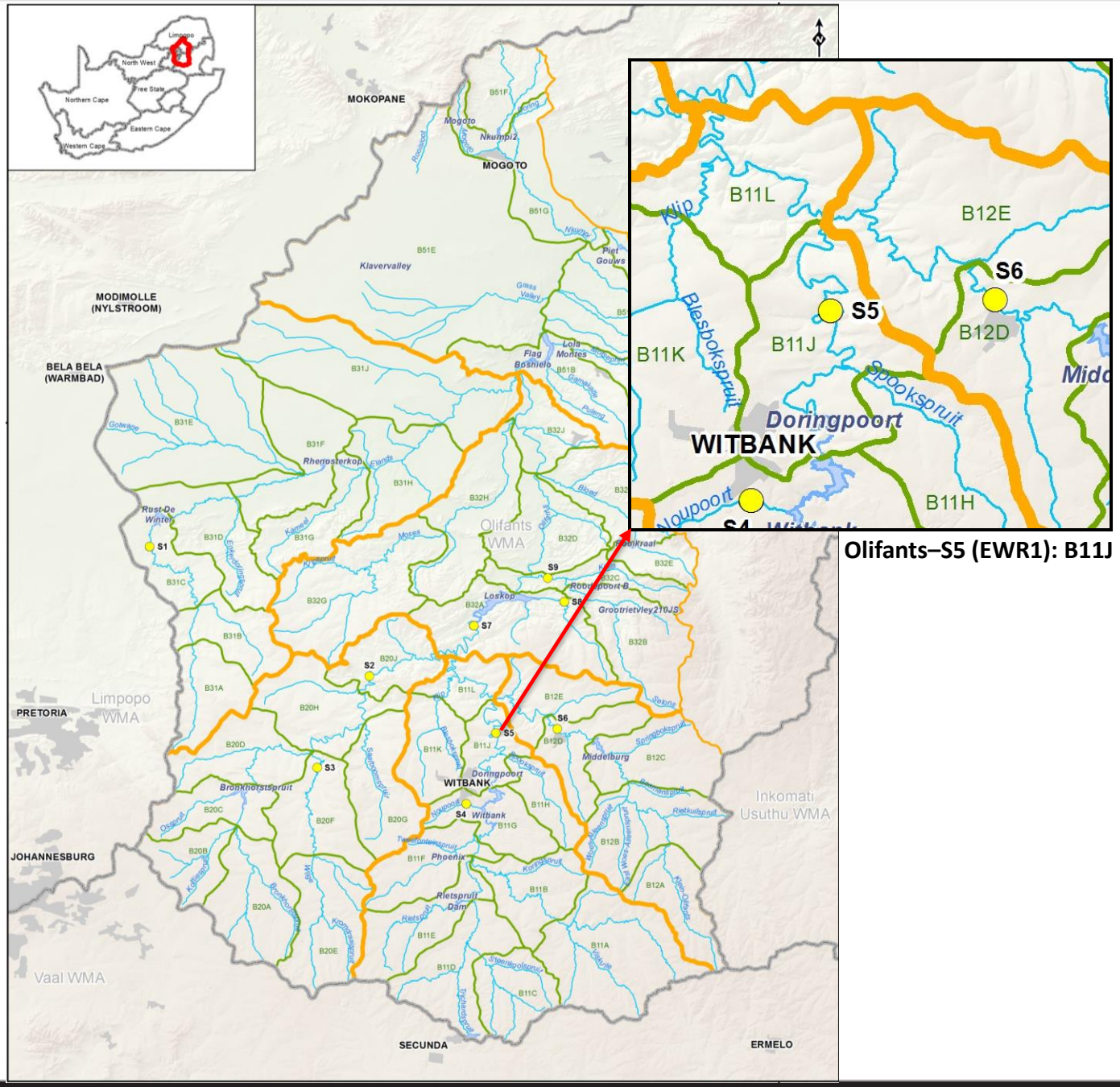
Subject	Specialist
Overview and discussion of main impacts and possible mitigation to determine REC	*Retha Stassen*
FRAI, MIRAI, IHI models and results	*Dr Wynand Vlok*
Hydrological preparation	*Retha Stassen*
Setup and running of Desktop Reserve Model (DRM) to determine EWR for REC (drought flows, maintenance flows and freshets/floods)	*Retha Stassen*
Hydraulics modelling and preparation	*Trevor Pike*
Interpretation of data with hydraulics information	*Trevor Pike*
Adjustments to DRM where necessary to define final EWR	*Retha Stassen*
Recommendations to water quality	Priya Moodley

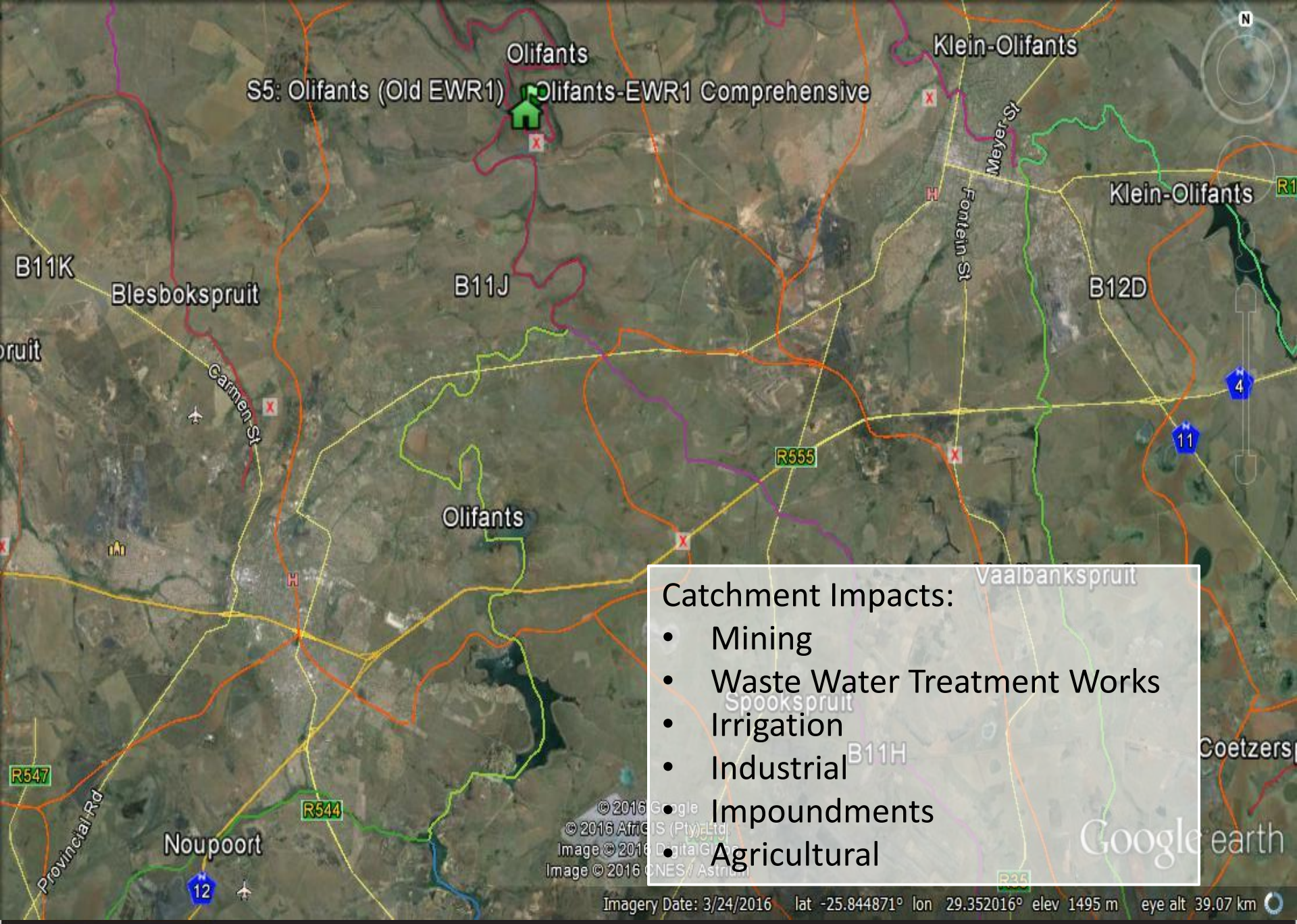
water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Overview and discussion of main impacts and possible mitigation to determine REC

Upper Olifants




Olifants
S5: Olifants (Old EWR1)
Olifants-EWR1 Comprehensive
Klein-Olifants
Meyer St
Fontein St
Klein-Olifants
B11K
Blesbokspruit
B11J
B12D
Carmen St
R555
Olifants
Vaalbankspruit
Spookspruit
B11H
Coetzers
R547
R544
Provincial Rd
Noupoort
12
4
11
Catchment Impacts:
• Mining
• Waste Water Treatment Works
• Irrigation
• Industrial
• Impoundments
• Agricultural
© 2016 Google
© 2016 AfriGIS (Pty) Ltd
Image © 2016 CNES / Astrium
Google earth
Imagery Date: 3/24/2016 lat -25.844871° lon 29.352016° elev 1495 m eye alt 39.07 km

Olifants-S5


5: Olifants (Old EWR1)
Olifants-EWR1 Comprehensive
© 2016 Google
© 2016 AfriGIS (Pty) Ltd.
Image © 2016 DigitalGlobe
Google earth
2001
Imagery Date: 2/15/2016 lat -25.760260° lon 29.313926° elev 1389 m eye alt 1.24 km

Olifants-S5 (EWR1): Site Photos

- Low flow
- Lack of habitat diversity
- Poor *in situ* water quality
- Considerable algal growth (completely smothered
- Invasive fish species

PES 2015: D

- Potential negative trajectory's need to be managed to prevent the degradation to a lower category

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

FRAI, MIRAI and IHI

(Fish, Aquatic Macroinvertebrates and Instream and Riparian Habitat Integrity)

MIRAI and FRAI

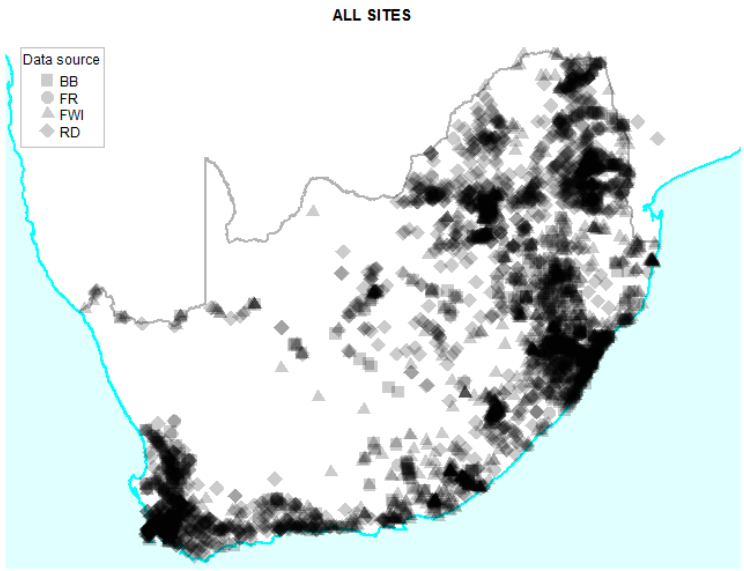
- Similar approach for the MIRAI and FRAI models
- Will use the MIRAI as example
- Will indicate differences – related to flow velocity classes

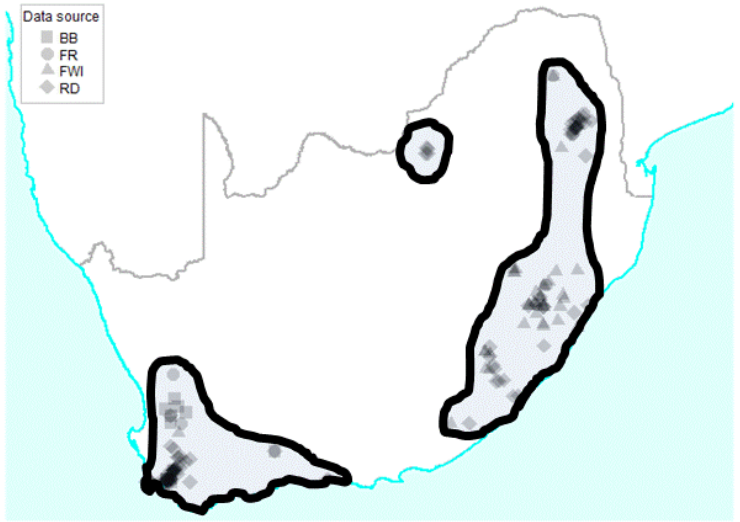
Why Determine Aquatic Macroinvertebrate Integrity

- Indicator of the PES
- Information on invertebrates and their habitats inform us about the ecological condition of a river.
- By setting the desired conditions for the invertebrate assemblage and associated habitat one can monitor and compare the present condition against the natural (reference) and desired condition.
- Can determine if the desired condition is achieved and if not, why not.
- Indices may be used in biodiversity assessment - main objective is to use the biota and their habitat as indicators and warning systems to the ecological condition of the resource.

How is the MIRAI Determined?

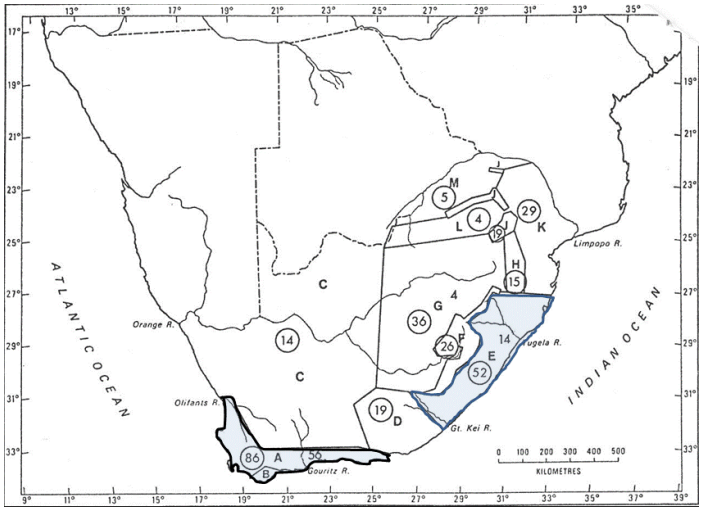
- Determine reference conditions
  - Historical information
  - Reference sites
  - Combination
- Data sources
  - Rivers database
  - Biobase
  - FWI Abany Museum

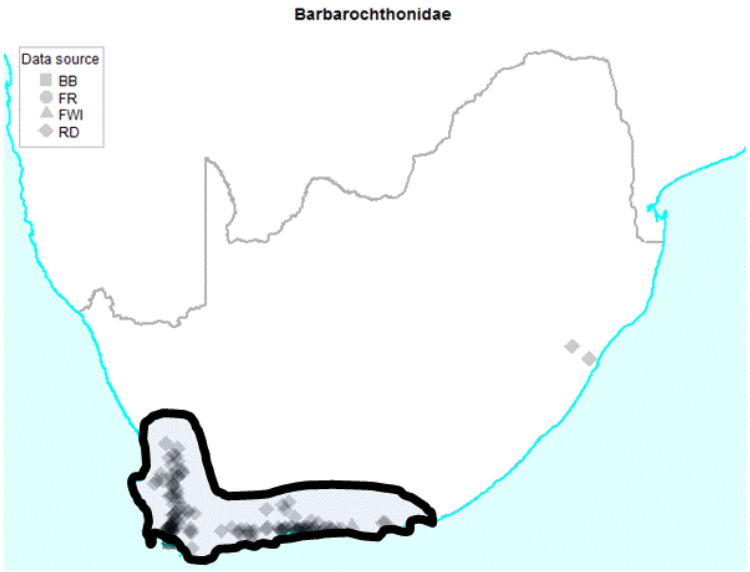


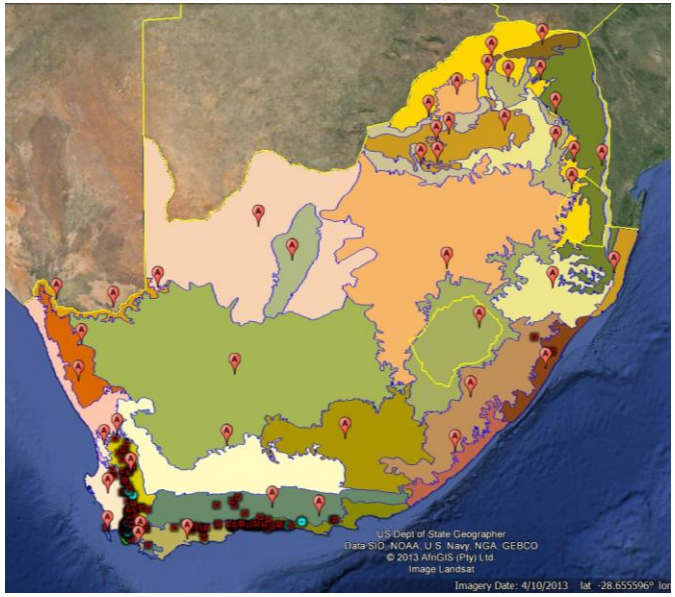


How is the MIRAI Determined?

- Link to areas
  - Hydrobiological regions
  - Ecoregions
  - Geozones

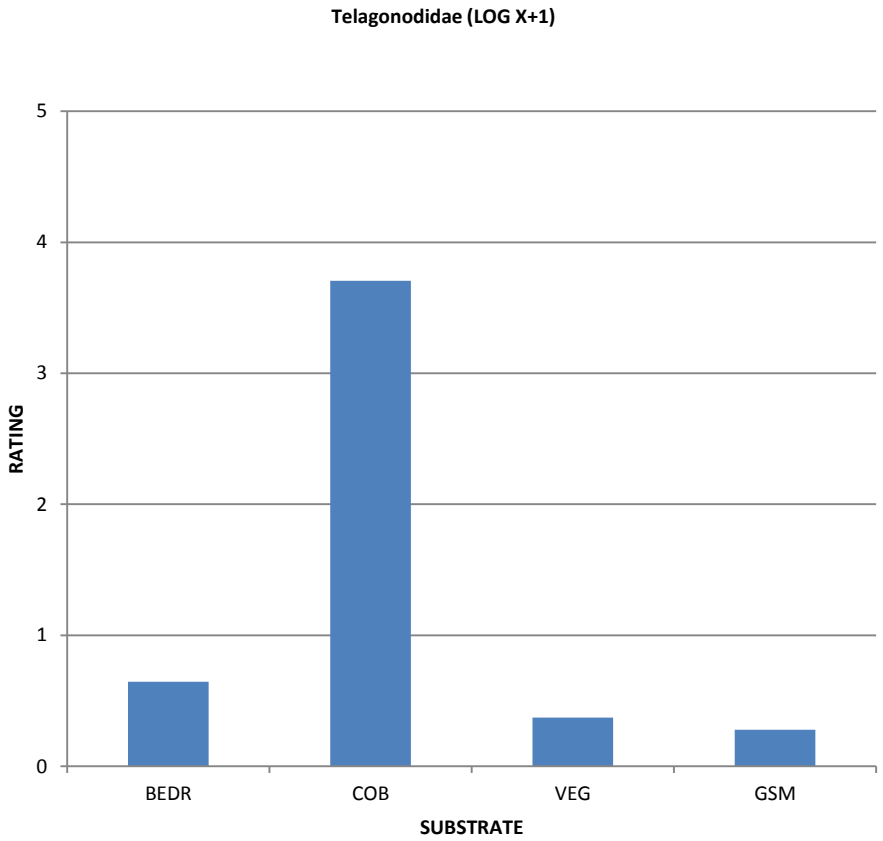






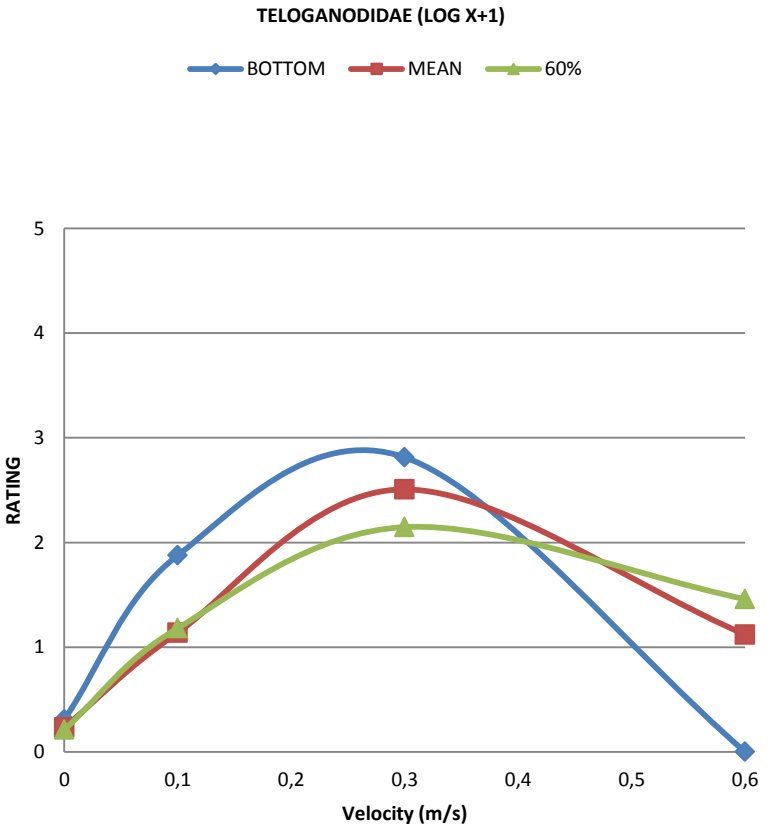
How is the MIRAI Determined?

- Link to substrate
  - Bedrock & Boulders
  - Cobbles & Pebbles
  - Gravel, Sand & Mud
  - Water column
  - Vegetation
    - marginal
    - aquatic



How is the MIRAI Determined?

- Link to velocity
  - Very Fast (>0.6 m/s)
  - Fast (0.3-0.6 m/s)
  - Slow (0.1-0.3 m/s)
  - Standing (<0.1 m/s)
- Fish
  - Slow deep
  - Slow shallow
  - Fast deep
  - Fast shallow



Data used to calculate the MIRAI

- Ideally:
  - sufficient data on historical distribution patterns, abundance and FROC; excellent ecological data and knowledge on invertebrate taxa and their response to various habitat conditions
- Realistically:
  - very rarely sufficient data on historical distribution, and limited knowledge on the ecological requirements
- Practically:
  - Use available information and knowledge on the preferences and intolerances of invertebrate taxa in conjunction with environmental changes to calculate the MIRAI

Approach to and Interpretation of MIRAI Data and Results

- Spatial scale:
  - Some taxa may not be present along the total length of the reach.
  - Invertebrate taxa have particular habitat preferences and they may not be present at all habitats at a site within a defined reach.
- Temporal scale:
  - Seasonal variation
  - Inter annual variation
- Representative sampling:
  - Not all invertebrate taxa present are sampled and identified
  - Patchy distribution
- Interpret and assess habitat availability and condition in order to make conclusions on the integrity of the invertebrate assemblage.

Habitat Integrity

- The following concepts and definitions are relevant to river habitat integrity assessment:

- Biological integrity is the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitat of the region.

- Ecological integrity is the ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, and biotic components on a temporal and spatial scale that is comparable to the natural characteristics of ecosystems of the region.

- Habitat integrity then refers to the maintenance of a balanced, integrated composition of physico-chemical and habitat characteristics on a temporal and spatial scale that is comparable to the characteristics of natural habitats of the region.

Habitat Integrity

- The following concepts and definitions are relevant to river habitat integrity assessment:
- The habitat integrity status of a river provides the template for a certain level of biotic integrity to be realized.
- Habitat integrity assessment is a precursor of the assessment of biotic integrity.
- Habitat and biotic integrity together constitutes ecological integrity.

Using the Photo Guide

- When assessing a river - look at the instream and riparian zones.
  - Both need to be assessed according to various metrics.
- However, the first step is to identify the type of river
  - e.g. is it largely a bedrock dominated, boulder cobble or alluvial system?
- Having identified this, use the appropriate sections in this guide and make a rating based on the photo examples.

What to Look For?

- In-stream – hydrological modifications
  - Base flows
  - No flows
  - Moderate floods
  - Large floods
- Water clarity
- In-stream bed modifications
  - Bedrock
  - Boulder/cobble
  - Alluvial

INSTREAM

3. Bed Modification

Sedimentation

Boulder/Cobble

Umkomaas (at Umko Lodge below Staebras Farm)
Geomorph Zone: Upper foothills

Clean boulder cobble riffle with very little sediment accumulation amongst cobbles.

Kao
Geomorph Zone: Mountain stream

Clean boulder cobble riffle with very little sediment accumulation amongst cobbles.

Rating 0-1

INSTREAM

3. Bed Modification

Sedimentation

Boulder/Cobble

Komati (K1 EWR site)
Geomorph Zone: Upper foothills

Fine sediments accumulating on cobbles in backwater areas (see insert). Upstream impacts include some formal agriculture and unseasonal releases for ESKOM power generation.

Elands
Geomorph Zone: Upper foothills

Some accumulation of gravels and sediment in pools and around cobbles. Minor impact from upstream agriculture.

Rating 2-3

INSTREAM

3. Bed Modification

Sedimentation

Boulder/Cobble

Mkhondvo
Geomorph Zone: Lower foothills

Extensive upstream sugar cane farming and subsistence agriculture as well as decreased sediment transport capacity are the cause for this rating. Boulder and cobble habitat occluded by sandy sediments. Considerable loss of cobble and boulder habitat.

Kao
Geomorph Zone: Mountain stream

Extensive gravel sediments filling pools and spaces between cobbles and boulders. Loss of boulder habitat and infilling of pools.

Rating 4-5

What to look for?

- In-stream – hydrological modifications
  - Base flows
  - No flows
  - Moderate floods
  - Large floods
- Water clarity
- In-stream bed modifications
  - Bedrock
  - Boulder/cobble
  - Alluvial
- Organic/peat/wetlands
- Microphytes
- In-stream bank modifications – marginal, non-marginal zones
  - Bedrock
  - Boulder cobble
  - Alluvial
  - Organic/peat/wetlands
- Connectivity modifications
  - Longitudinal
  - lateral
- In-stream vegetation

Instream Vegetation

Rating is determined by the percentage coverage of water surface by macropytes

0-1 (0-30%)	2-3 (30-60%)	4-5 (60-90%)
		

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PRACTICAL DEMONSTRATION

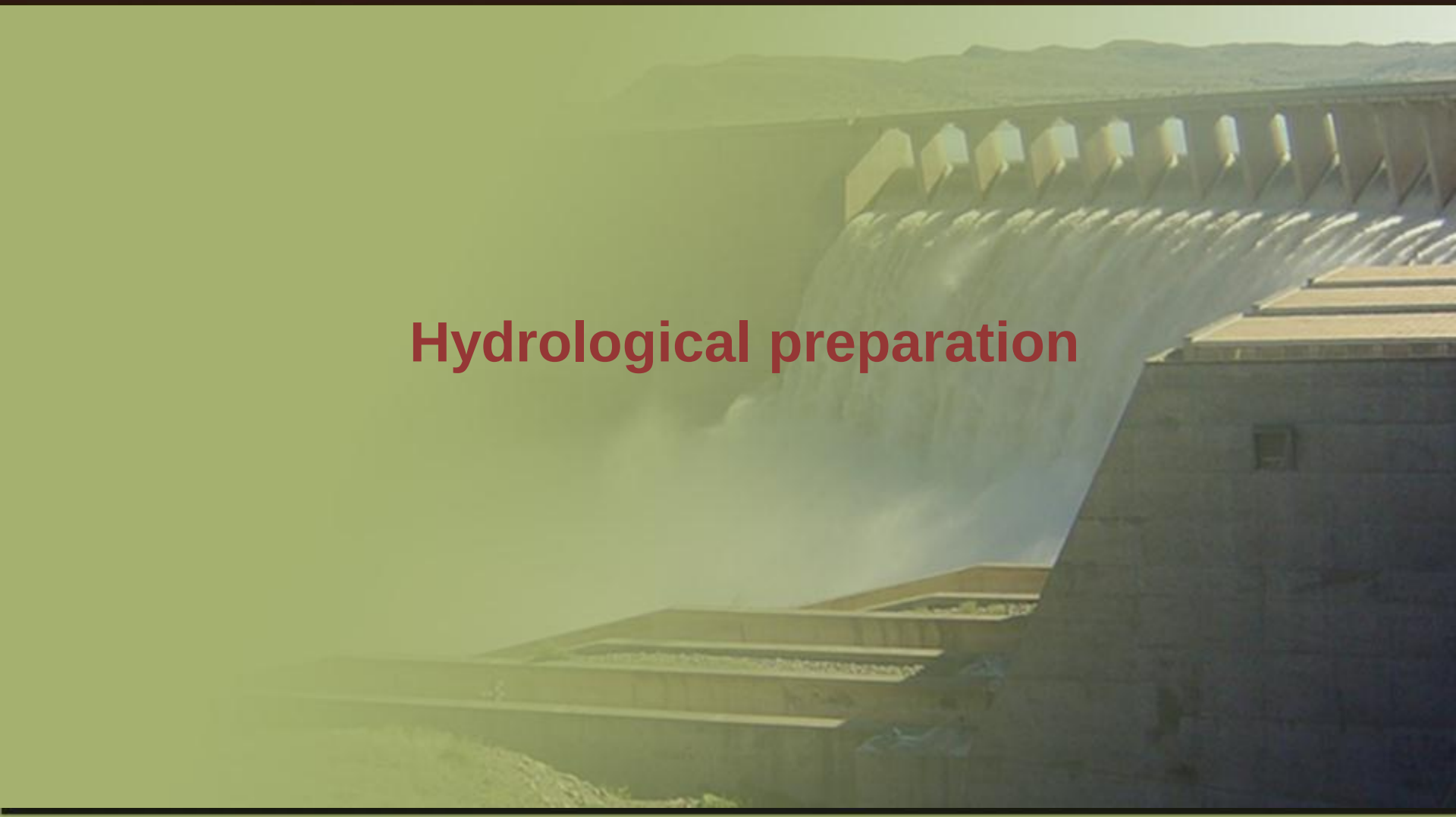
Olifants – S5
Workshop EWR Site

PES	EIS	REC	Comments / Motivation
D	Moderate	C/D	Absence of flow dependent sensitive fish species, lack of habitat diversity and poor water quality (e.g:*Labeobarbus marequensis, Labeo molybdinus, Labeo cylindricus and Petrocephalus wessels* i. *P. wesselsi* is habitat specific and thus absent from the site at the time of the survey. Alien invasive fish speciese namely M*icropterus salmoides* has an impact on the small fish species (e.g. E*nteromius (Barubus) anoplus, E. eutaenia*). The identified *Gambusia affinis* food source is eggs and thus further impacts on the indigenous fish populations by preying on their eggs. The presence of *Cyprinus carpio* further is competing for habitat betweem fish namely *Tilapia rendalli* and *Tilapia sparmanii*
			Velocity sensitive aquatic macroinvertebrates, lack of habitat diversity and poor water quality (e.g: Perlidae and Heptegeniidae). Porifera were not identified owing to the siltation on the rocks
			High nutrient loads owing to considerable algal growth
			It is recommended that RQOs set at this site in order to improve the nutrient loads to support the ecosystem

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Hydrological preparation

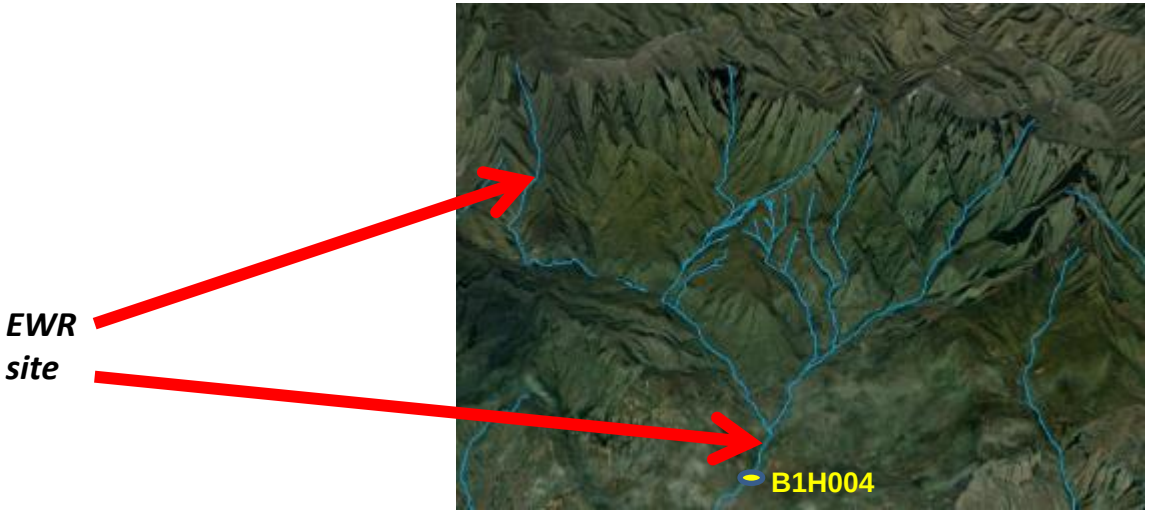


Hydrological data

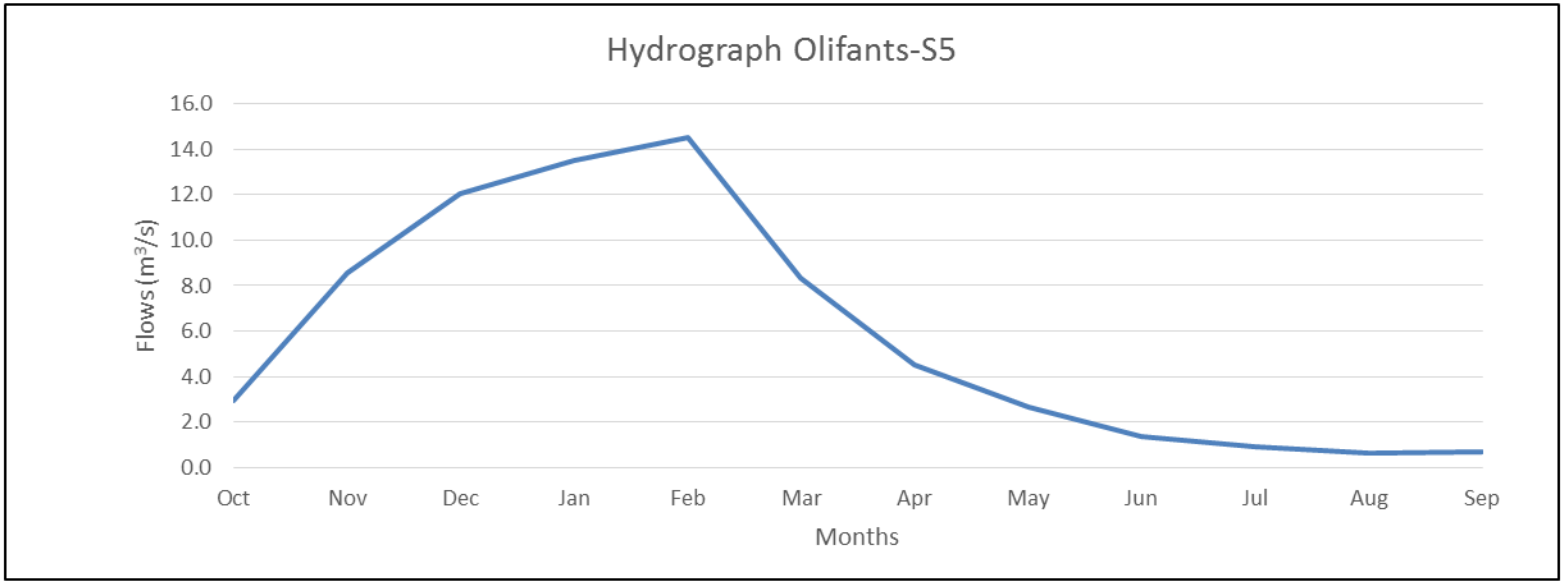
- Available hydrology (WR2005, WR2012, other studies)
- Olifants catchment: data available from WRP 2009 study per management unit/ quaternary catchment
- Letaba catchment (Recon Strategy 2014)
- Shingwedzi catchment (Recon Strategy 2014)
- Use natural flows to determine EWRs

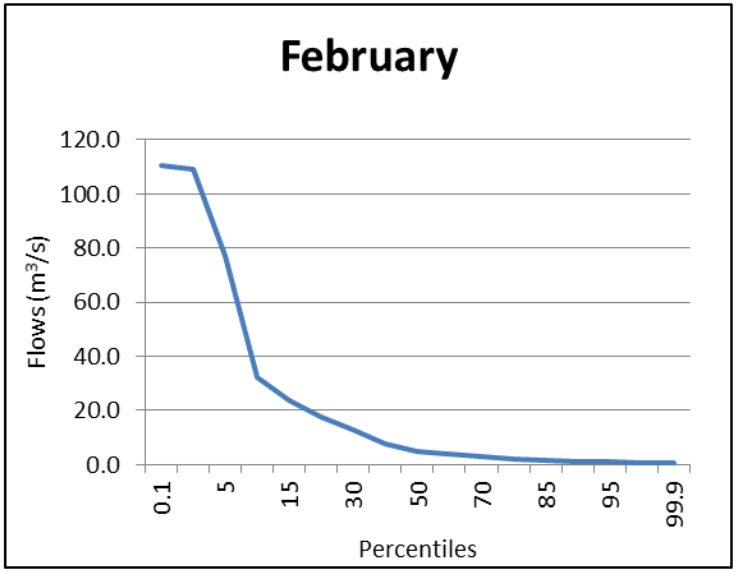
Hydrological preparation

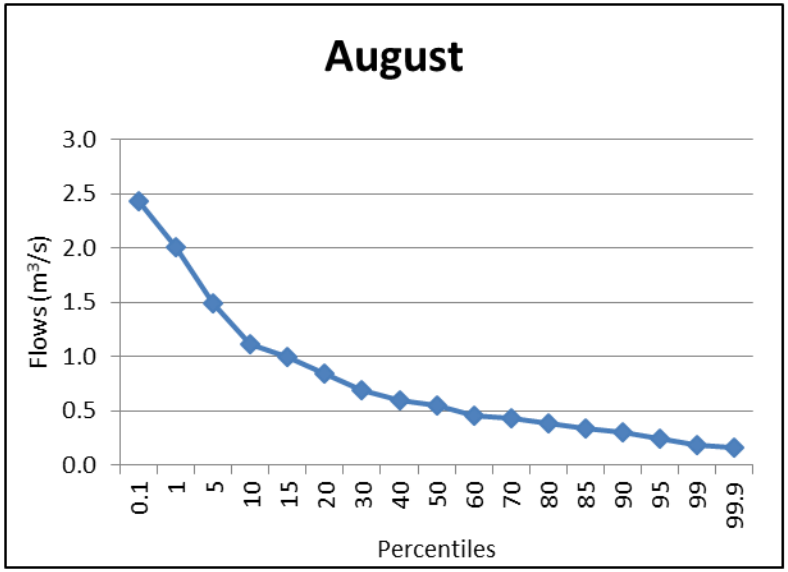
- Catchment area upstream of site
- Gauging weirs in vicinity of site without any major tributaries between site and weir
- Availability of good quality hydrological data (daily observed, monthly simulated)



Graphs

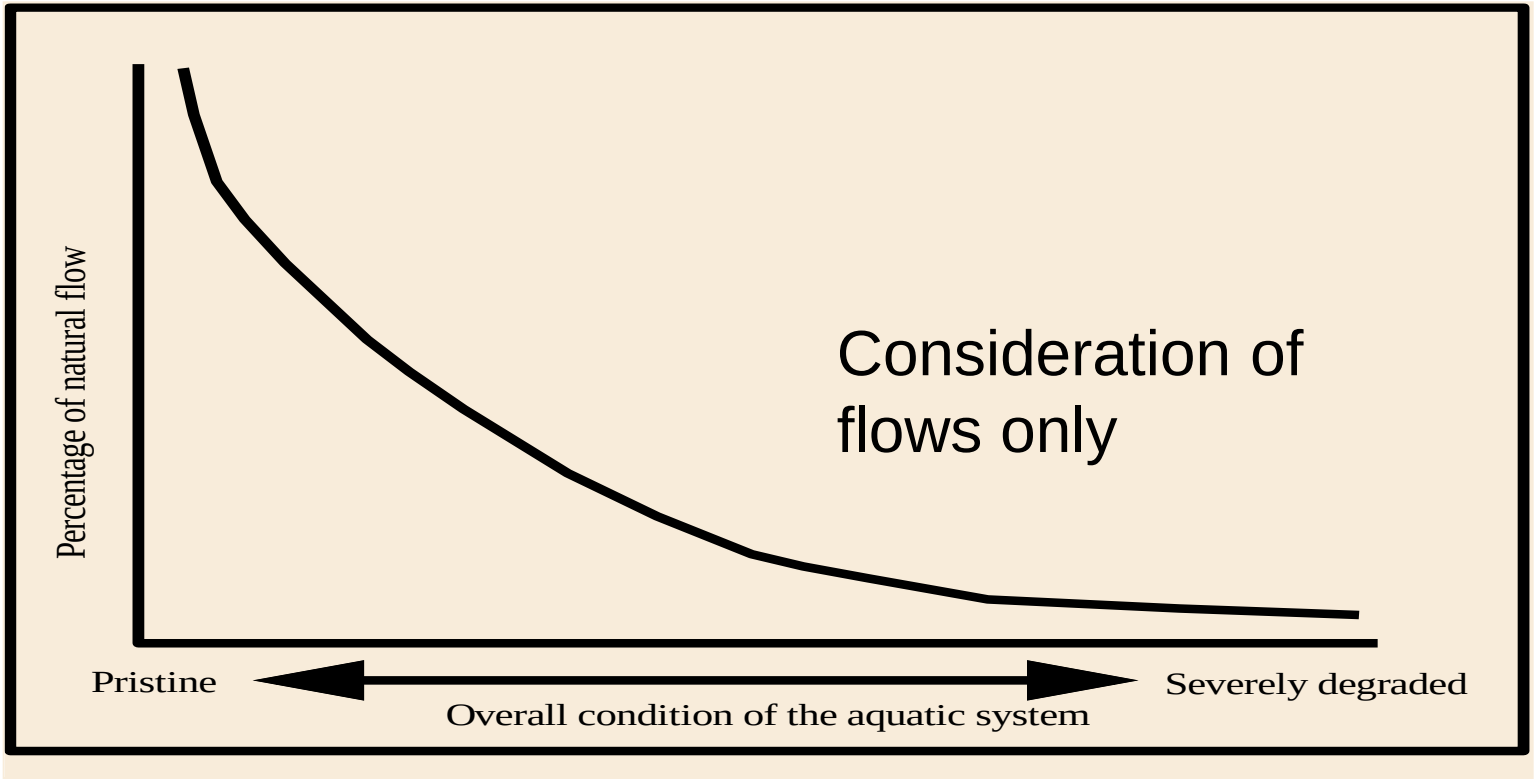

Hydrograph Olifants-S5
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Flows (m³/s)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Months


February
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Flows (m³/s)
0.1
5
15
30
50
70
85
95
99.9
Percentiles


August
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flows (m³/s)
0.1
1
5
10
15
20
30
40
50
60
70
80
85
90
95
99
99.9
Percentiles

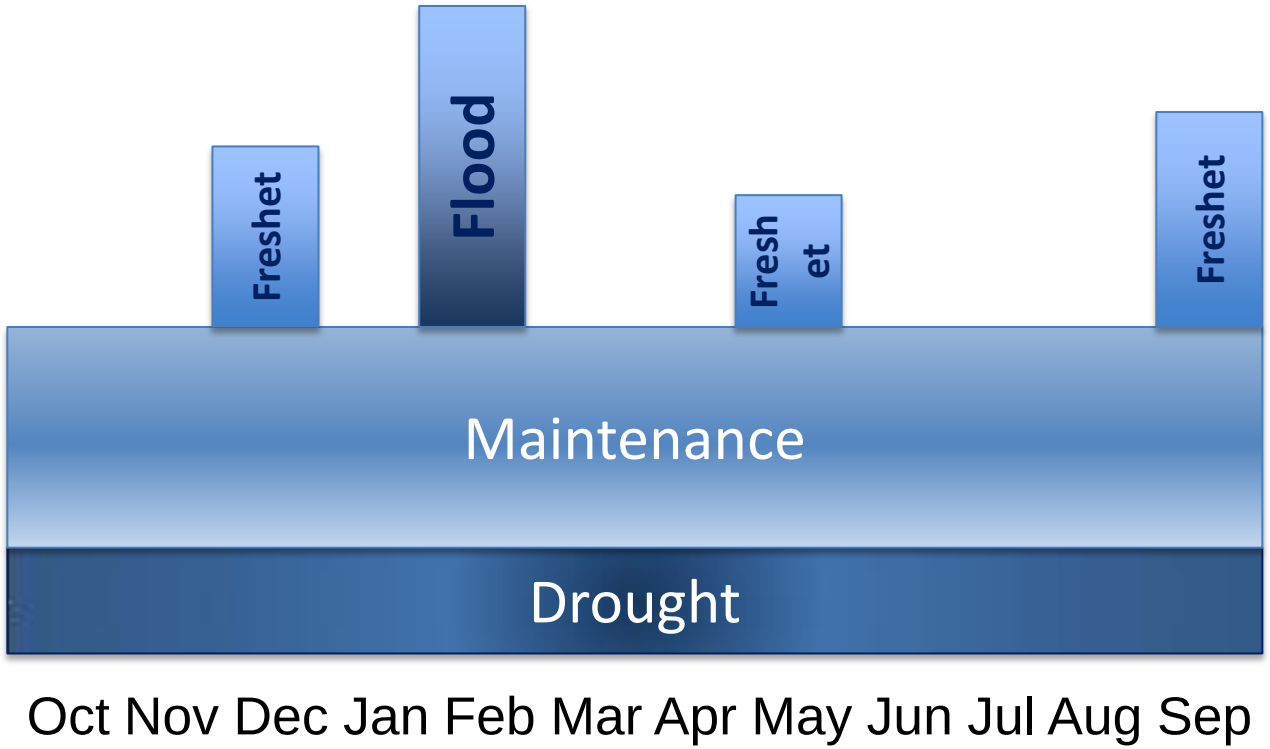
DRM setup

- Natural flows at EWR site (.prn)
- Site characteristics (single, monthly)
- Ecological Water Requirements (flows)



Flow Components to Consider

- Wet and dry season
- Wettest and driest months



water & sanitation

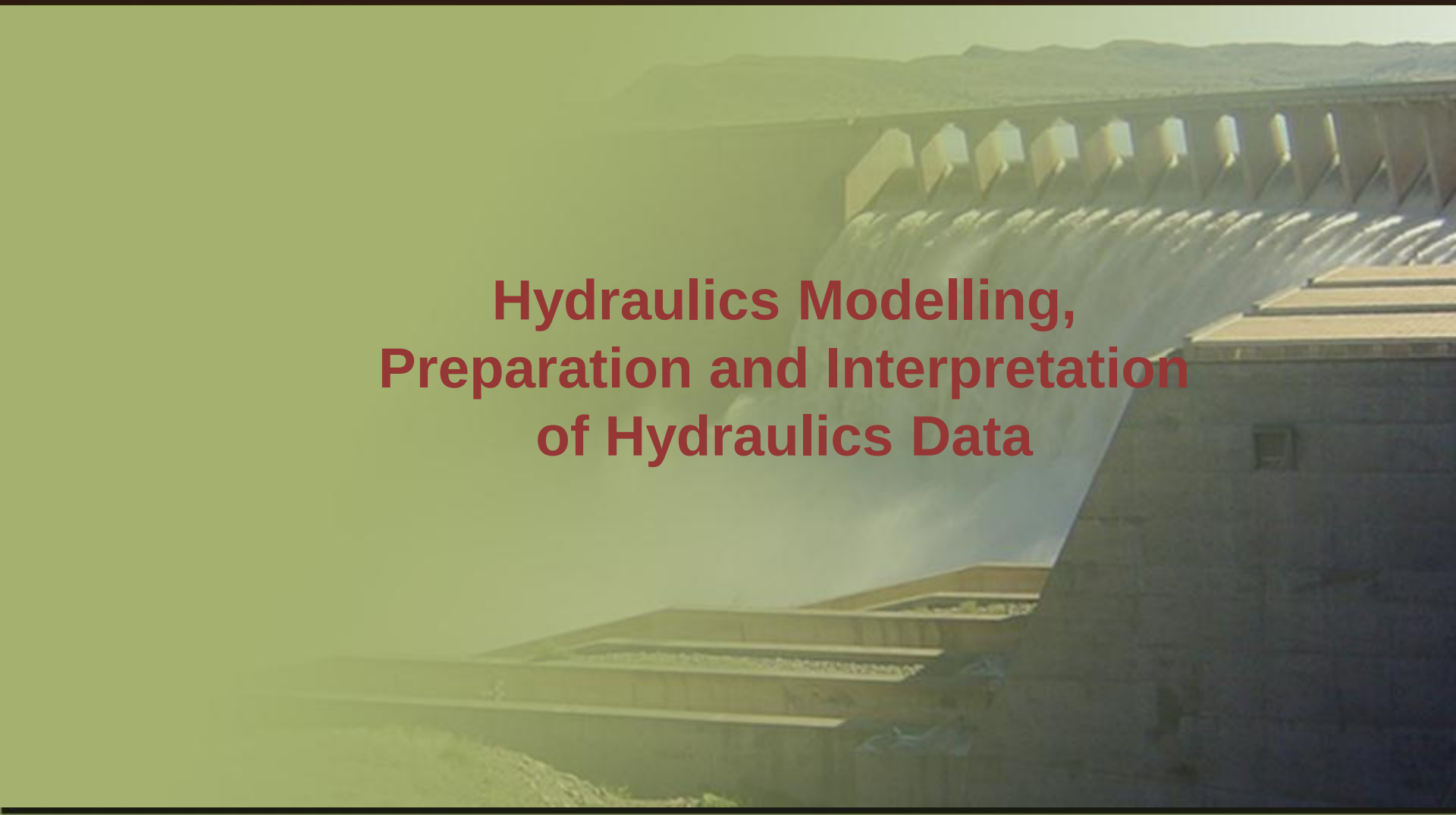
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Setup up and Running of Desktop Reserve Model (DRM) PRACTICAL DEMONSTRATION

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Hydraulics Modelling, Preparation and Interpretation of Hydraulics Data



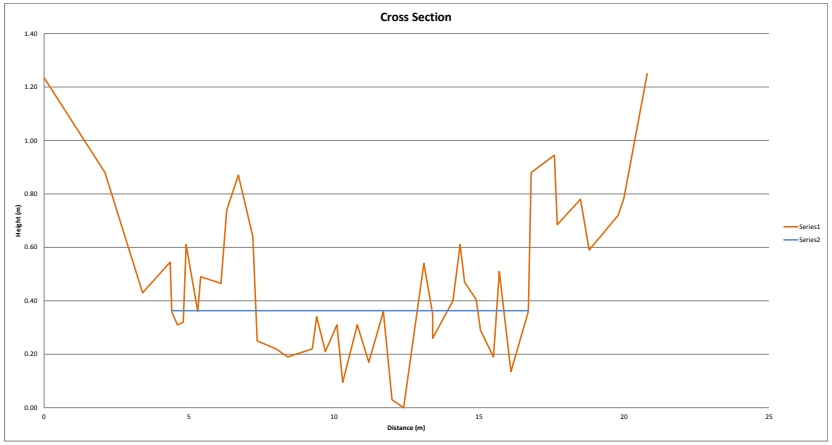
Selecting a Cross Section

- Select a CRITICAL cross section in consultation with the fish and invert specialists, which means:
  - Critical habitat (generally a riffle)
  - Constant slope
  - Even water surface
  - Straight flow path with no obstructions/diversions (to accurately model high and low flows)

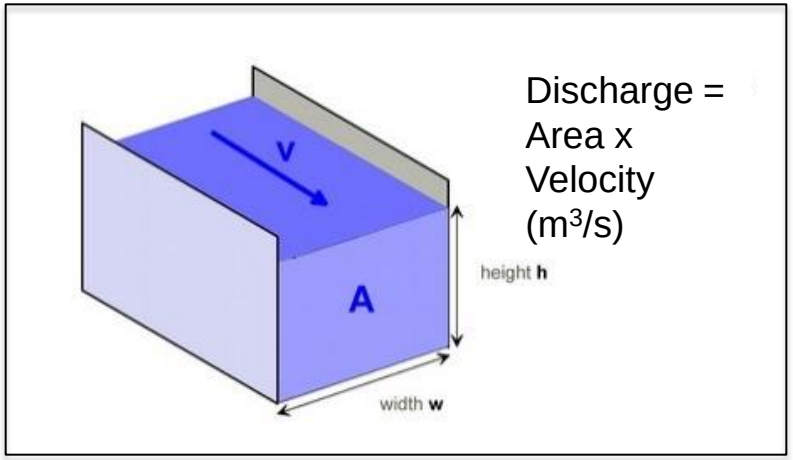
Examples

Site Survey

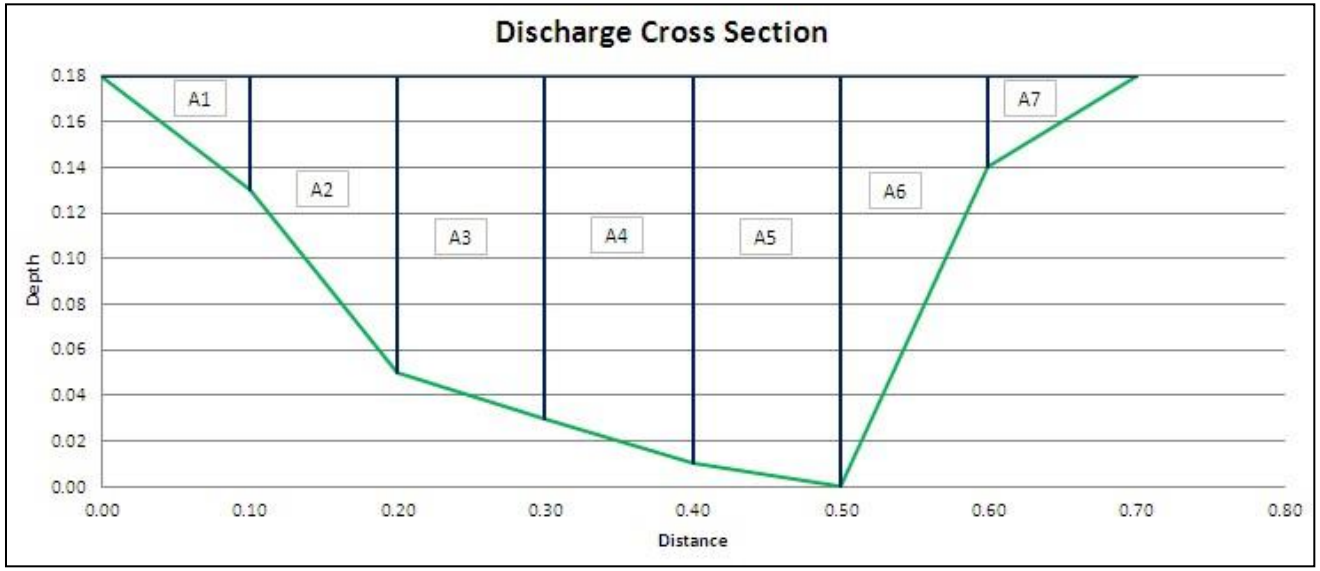
- Survey a detailed cross section including slope
- Capture photos, GPS coordinates, insert steel pegs & measure discharge



Measure Discharge



Discharge = Area x Velocity (m^3/s)

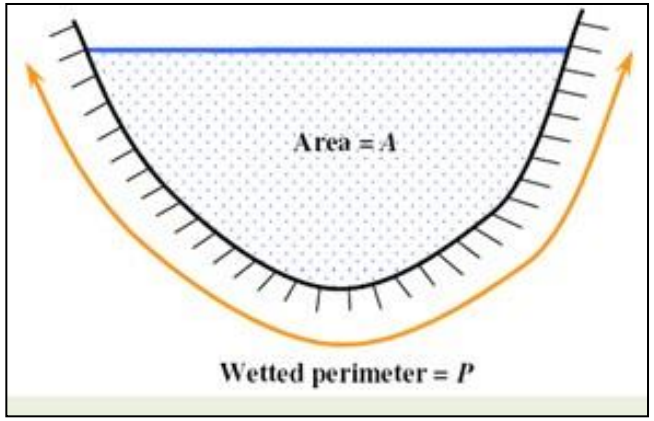


Hydraulic Modelling

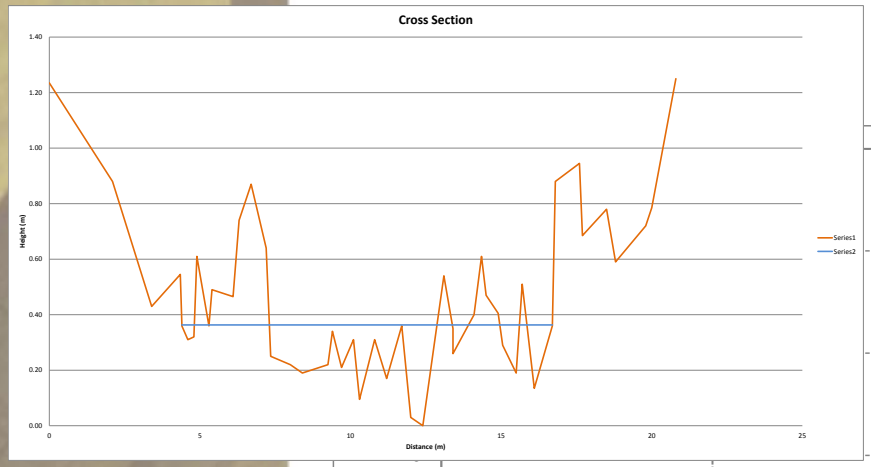
- **Based on Manning's Equation:**

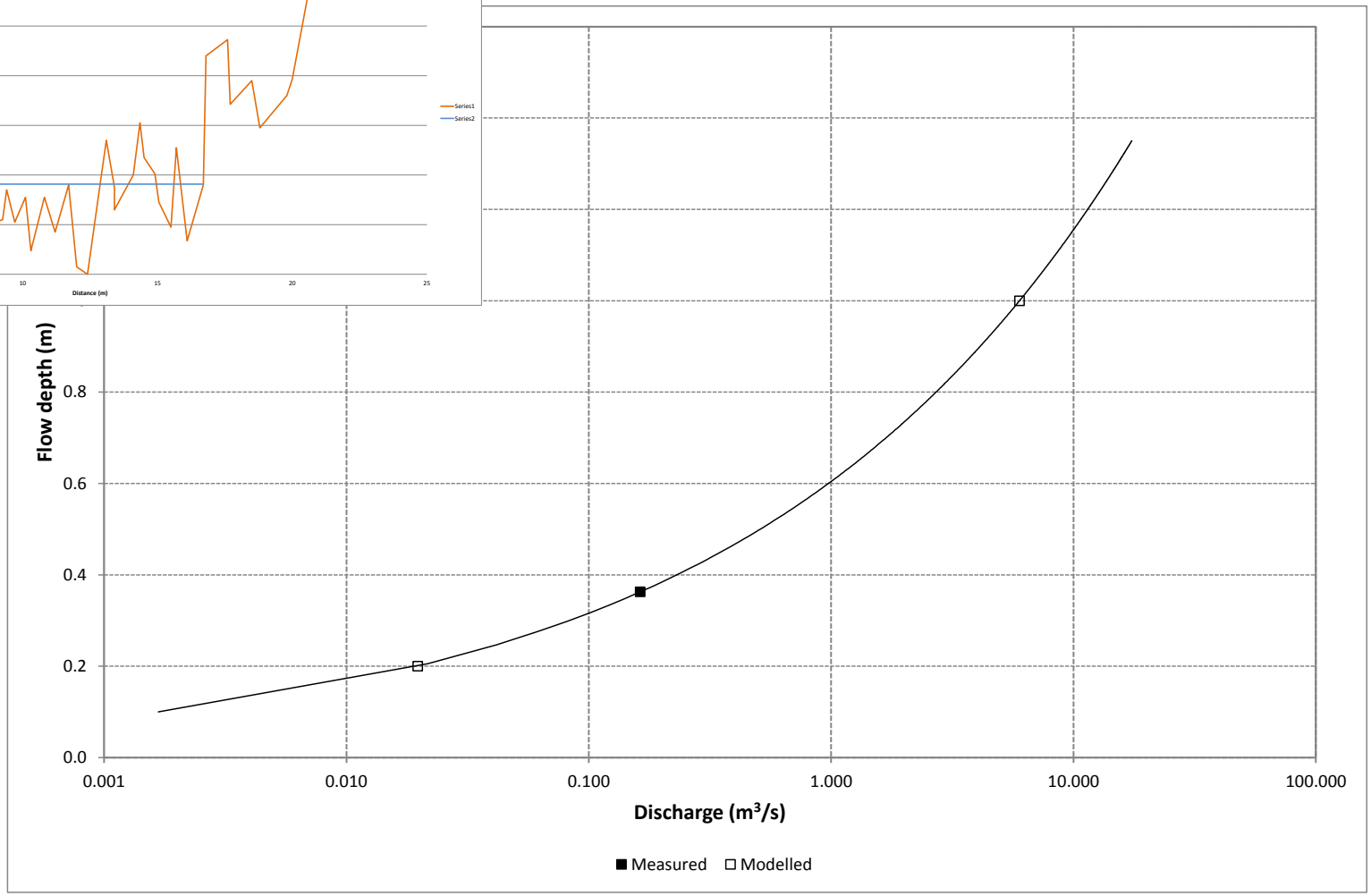
  $Q=1/n\ R^{2/3}\ S^{1/2}$

  - Q = Discharge (m^3/s)
  - n = Roughness Coefficient
  - R = Hydraulic Radius (Area/Wetted Perimeter – calculated from cross section of river)
  - S = Slope (m/m)

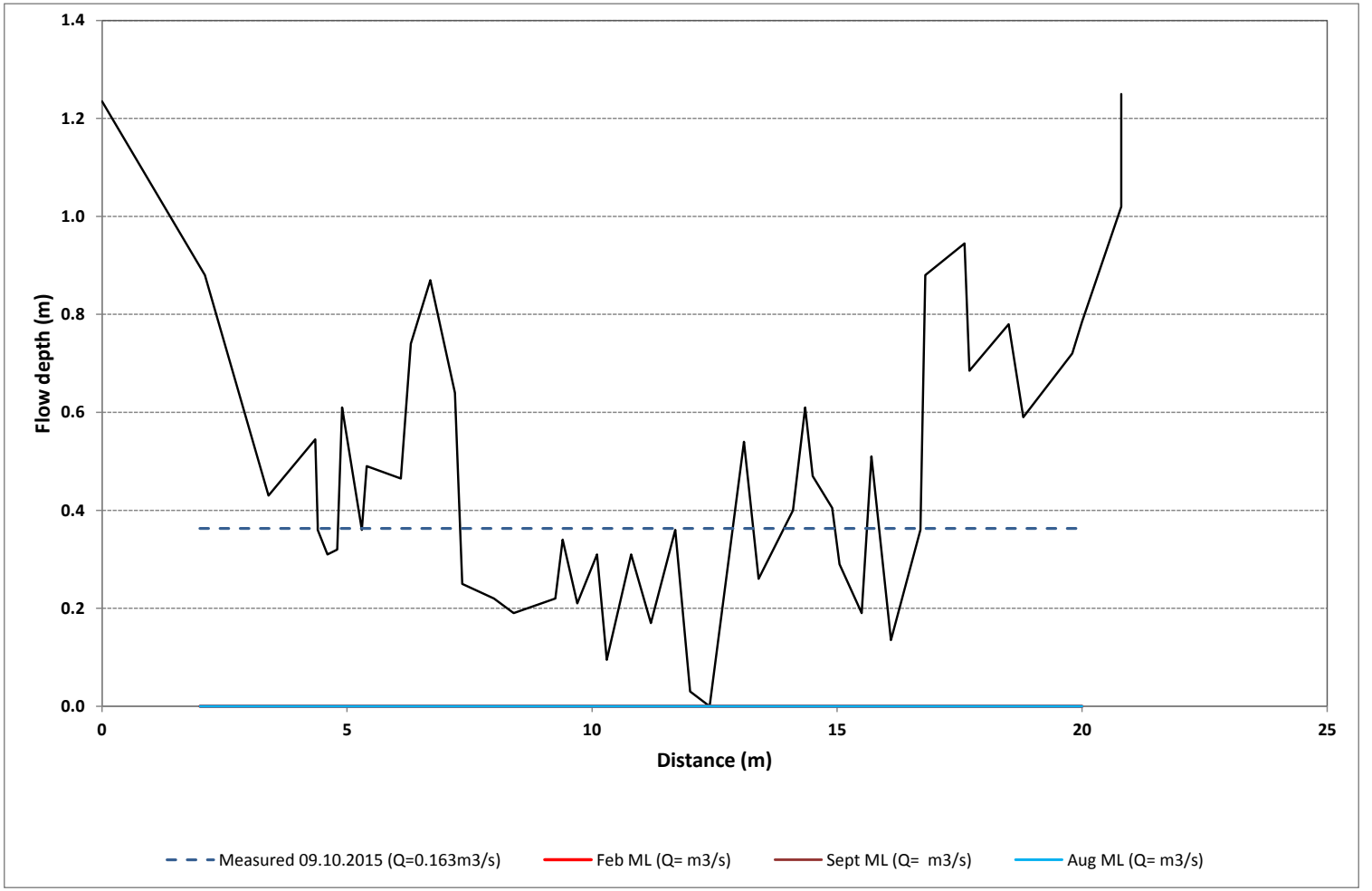


Modelling - Stage Discharge Curve





Depth and Discharge at the Cross Section



Modelling – Output Data

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)							Dist_InvertHT's(%)								
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SvS	SS	SD	FVS	FS	FI	FD	VSCS	SCS	FCS	VFCS	VSFS	SFS	FFS	VFFS	VEG
0.4	0.3	0.604	10.2	10.5	0.2	0.69	4	73	0	1	2	6	14	25	26	12	3	11	11	5	1	4
0.41	0.3	0.654	10.2	10.6	0.21	0.72	3	72	0	1	1	6	16	24	26	13	4	10	11	5	2	4
0.42	0.31	0.706	10.3	10.7	0.22	0.74	3	70	0	1	2	6	18	23	26	14	4	10	11	6	2	4
0.43	0.32	0.762	10.3	10.7	0.23	0.79	3	67	0	1	1	6	20	22	25	15	5	10	11	6	2	4
0.44	0.33	0.821	10.4	10.8	0.24	0.81	4	65	0	2	1	5	23	21	25	16	5	9	11	7	2	4
0.45	0.34	0.882	10.4	10.8	0.25	0.84	3	64	0	1	1	5	26	20	24	17	5	9	10	7	2	4
0.46	0.35	0.947	10.5	10.9	0.26	0.88	3	61	0	2	2	5	28	20	23	18	6	8	10	8	2	4
0.47	0.36	1.015	10.5	11	0.27	0.91	3	59	0	2	2	4	30	19	23	19	6	8	10	8	3	4
0.48	0.36	1.086	10.6	11	0.28	0.94	3	58	0	2	2	4	32	18	22	20	6	8	10	9	3	5
0.49	0.37	1.161	10.6	11.1	0.29	0.96	2	56	0	2	2	3	35	17	22	21	7	7	10	9	3	5
0.5	0.38	1.239	10.6	11.1	0.31	1.01	3	52	1	2	2	3	37	16	21	22	8	7	9	9	3	5
0.51	0.39	1.32	10.7	11.2	0.32	1.03	2	50	3	2	2	3	39	15	21	22	8	6	9	10	3	5
0.52	0.4	1.405	10.7	11.2	0.33	1.06	2	46	5	2	2	3	41	14	21	23	8	6	9	10	4	5
0.53	0.41	1.494	10.8	11.3	0.34	1.1	2	42	6	2	2	3	43	14	20	24	9	6	9	10	4	5
0.54	0.41	1.587	10.8	11.3	0.35	1.13	2	38	9	2	2	3	45	13	20	24	10	5	8	10	4	5
0.55	0.42	1.684	10.9	11.4	0.37	1.16	2	32	13	2	2	2	47	12	19	24	11	5	8	10	5	5
0.56	0.43	1.784	10.9	11.4	0.38	1.2	2	27	16	2	2	2	48	11	18	24	12	5	8	10	5	5
0.57	0.44	1.889	10.9	11.5	0.39	1.23	1	23	19	2	2	2	50	11	18	24	13	5	8	10	6	5
0.58	0.45	1.998	11	11.5	0.41	1.26	1	20	20	2	2	2	52	10	17	25	14	4	7	11	6	5
0.59	0.46	2.111	11	11.6	0.42	1.31	2	18	20	2	2	3	53	10	16	24	16	4	7	10	7	5
0.6	0.46	2.228	11.1	11.6	0.43	1.32	1	16	21	2	2	3	54	10	16	24	16	4	7	10	7	5
0.61	0.47	2.35	11.1	11.7	0.45	1.36	1	14	22	2	3	3	56	9	16	24	17	4	7	10	7	5

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PRACTICAL DEMONSTRATION

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Adjustments to DRM where Necessary to Define Final EWR

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Recommendations to Water Quality

Water Quality

POTENTIAL PHYSICO-CHEMICAL MODIFICATION

Water Quality → Driver of Ecological State

- **Objective**:
  - Whether the river water quality has changed from reference state due to anthropogenic changes.
  - If the water quality is currently changing, by how much, how fast and why?

Water Quality

POTENTIAL PHYSICO-CHEMICAL MODIFICATION

(1) WHETHER IT IS CHANGING: Determine PES

- Consider activities that indicate the potential that physico-chemical conditions may have changed from the reference.

- **Indicators**: Presence of land cover/land use that implies the likelihood of a change of physico-chemical conditions away from the reference.
  - Algal growth and macrophytes may also be useful response indicators.

  - *Activities* such as mining, cultivation, irrigation (i.e. agricultural return flows), sewage works, urban areas, industries, etc. are useful road indicators.

Water Quality

EWR 1 – Water quality modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability

EWR 1

Flow:

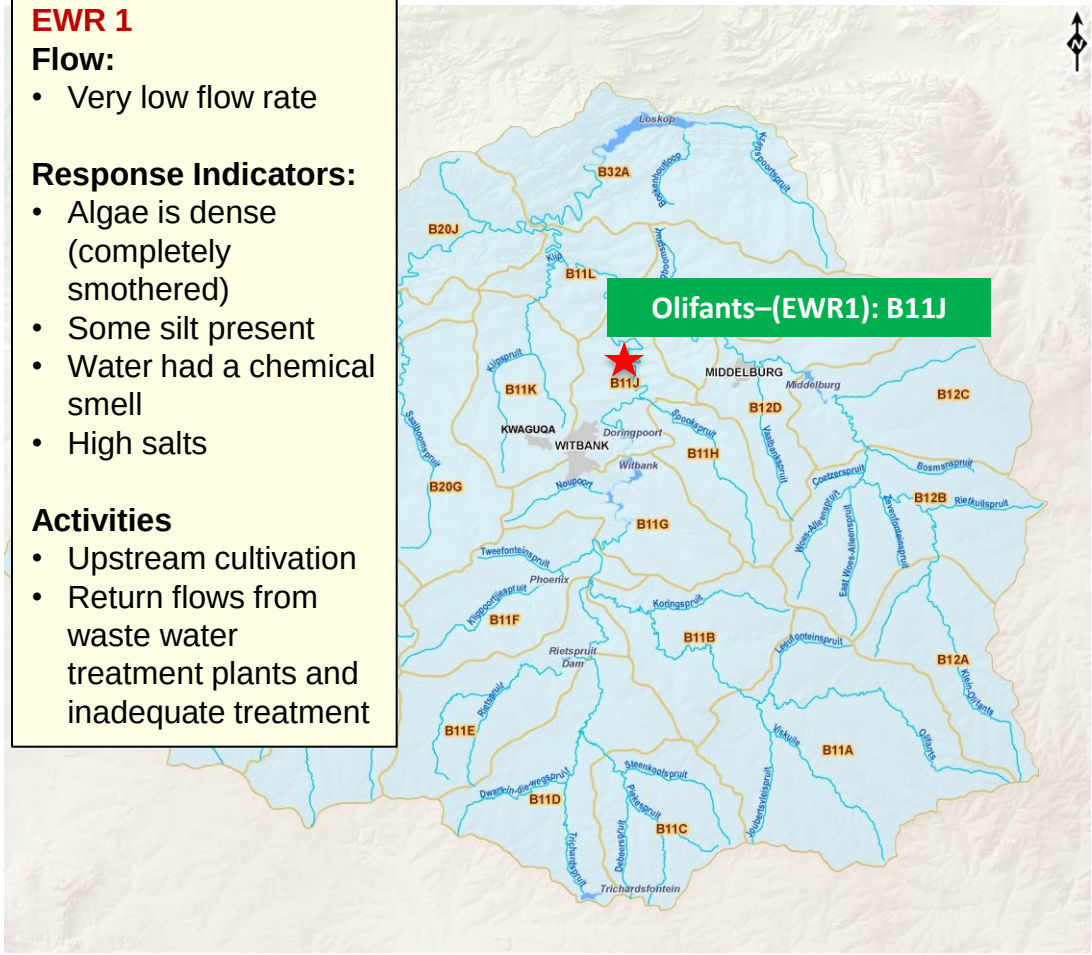
- Very low flow rate

Response Indicators:

- Algae is dense (completely smothered)
- Some silt present
- Water had a chemical smell
- High salts

Activities

- Upstream cultivation
- Return flows from waste water treatment plants and inadequate treatment



Water Quality

Require physio-chemical data

Water Quality represented as:

- Results table
- PAI Model to produce the EC for water quality (PAI consideres degree to which water quality has changed from reference per component)

- The physico-chemical status is described in terms of its hazard – what are the effects/consequences to the biotic components

Water Quality

Water Quality represented as:

- Results table
- PAI Model

RIVER	Marite River	Water Quality Monitoring Points	
WQSU	2, Marite River	RC	X3H011Q01, '79-'81, n=84
EWR SITE	5	PES	X3H011Q01, '04-'07, n=129
Confidence assessment	Confidence in the assessment is **moderate-high**, as little DO, temp., turbidity or metal data.		
Water Quality Constituents		Value (or summary statistic)	Category (Rating) / Comment
Inorganic salts (mg/L)	$MgSO_4$	-	TEACHA could not be used and EC used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	SRP	0.013	B (1)
	TIN	0.28	B (1)
Physical variables	pH (5^{th}-95^{th} percentile)	7-7.9	A (0) as natural category was re-benchmarked
	Temperature	-	Some temperature data from Weeks et al. ('95). Site downstream of Inyaka Dam. (assumed constant release from multi-level outlets. Dam completed 1999)
	Dissolved oxygen	-	
	Turbidity (NTU)	Mean: 12 NTU Maximum value: 30 NTU (Weeks et al., 1995)	Due to constant release, turbidity levels now low most of the time.
	Electrical conductivity (mS/m)	8.9	A (0)
Response variable	Chl-a: periphyton	57.85	D (3) (n=1)
	Chl-a: phytoplankton	1.57	A (0) (n=1)
	Biotic community composition: macroinvertebrate (ASPT) score	6.4	
	Diatoms	SPI=19.4	A (0) (n=1)
OVERALL SITE CLASSIFICATION (from PAI)		B (84.44)	

METRIC	RATING	THRESHOLD EXCEEDED?	CONFIDENCE	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	2.0	N	4.0	60.0		50.0
Salts	4.0	NONE SPECIFIED	4.0	50.0		60.0
Nutrients	4.0	NONE SPECIFIED	2.0	70.0		70.0
Water Temperature	2.0	YES:THRESHOLD > 3.9	2.0	60.0		50.0
Water clarity	3.0	NONE SPECIFIED	2.0	50.0		70.0
Oxygen	4.0	YES:THRESHOLD > 3.9	4.0	65.0		65.0
Toxics	2.0	N	2.0	100.0		100.0
CALCULATED PC MODIFICATION RATING	4.00	MEAN CONF →	2.86			
FINAL PC MODIFICATION RATING	1.32					

P-C RATING BASED ON DEFAULT WEIGHTS	
P-C CATEGORY %	P-C CATEGORY
73.60	C
P-C RATING BASED ON ADJUSTED WEIGHTS	
P-C CATEGORY %	P-C CATEGORY
40.22	D/E

Water Quality

(2) IF THE WATER QUALITY IS CURRENTLY CHANGING, BY HOW MUCH, HOW FAST AND WHY?:

- Water Quality trends (stable, increasing, decreasing) (whether the causes remain unchanged – change in PES over time)
- Causes and sources of the water quality changes (flow or non flow related) - influences the mitigation measures (flow modification or source directed measures are necessary)
- Sensitivity to flow related water quality changes (Ecological importance)
- Special considerations

Water Quality Recommendations

- Qualitative statements – expert judgement (expected water quality behaviour)
- Complex application of river water quality models (changes under different flows) (flow concentration modelling)

How the water quality conditions may change under selected flow scenarios?

Water Quality: EWR1 (Oliants-S5): Olifants River

- Improve water quality – improvement in habitat quality (REC = D)
- Negative trajectory (trend), upstream impacts, non-flow and flow related (need flow modification and source controls)

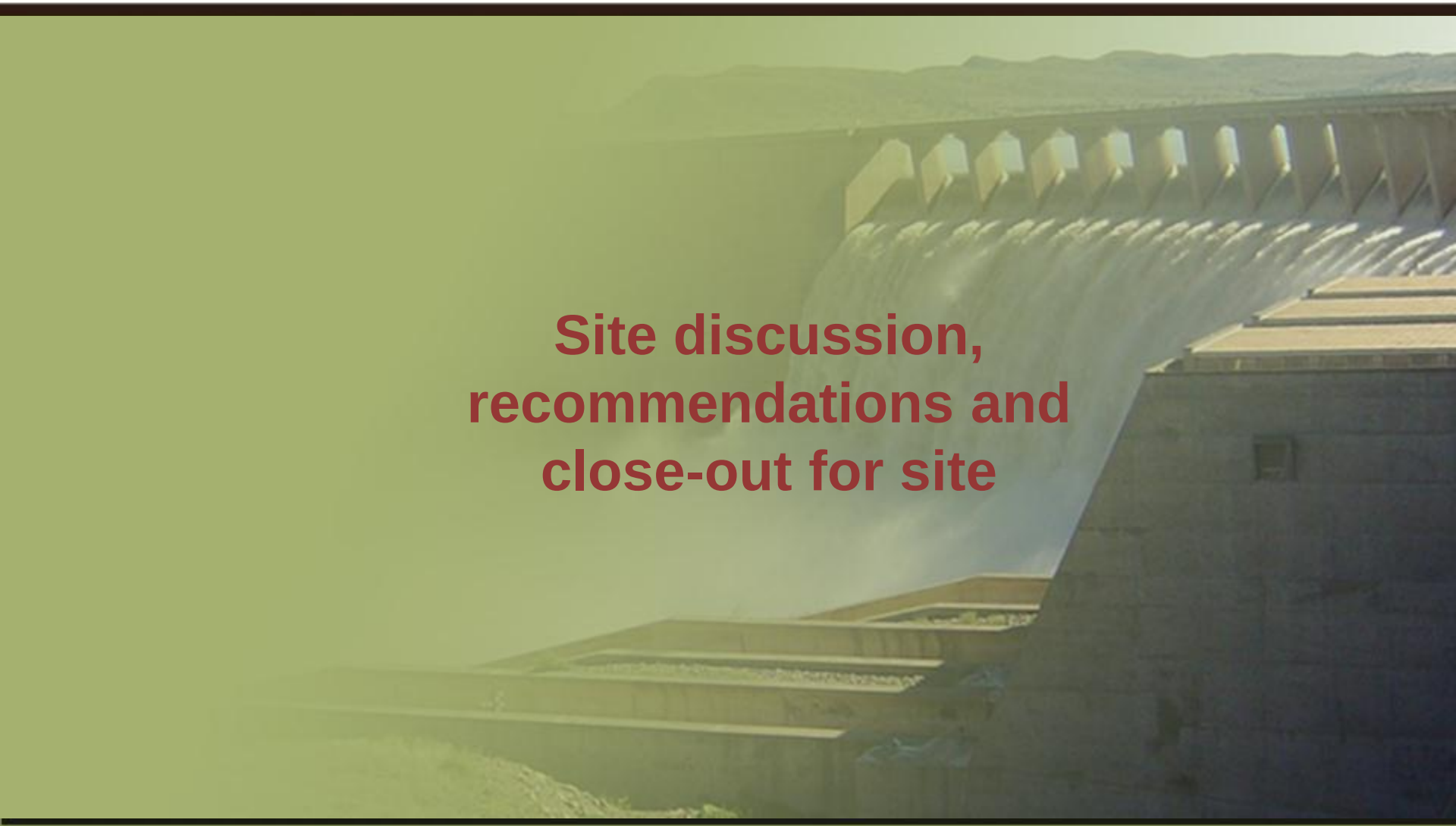
- Water quality ecological specifications (clear and measurable specifications of ecological attributes) – preliminary Reserve

- Resource Quality Objectives : Water Quality – EWR 1
  - Phosphate = ≤ 0.125 mg/l as P
  - Nitrate & Nitrite = ≤ 4.00 mg/l as P
  - Total Ammonia = ≤ 0.10 mg/l N
  - Sulphates = ≤ 500 mg/l
  - Electrical Conductivity = ≤ 111 mS/m

- Include additional ecological specifications at the node outlet to the catchment

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA



Site discussion, recommendations and close-out for site