What is a wetland?

- *Land which is transitional between terrestrial and aquatic systems, where the water table is usually at, or near the surface, or the land is periodically covered with shallow water and which land in normal circumstances supports, or would support, vegetation adapted to life in saturated soil.*
  - National Water Act (Act No. 36 of 1998)

- Three key components of wetlands, based on the more appropriate “narrow” definition (Mitsch and Gosselink, 2007):
  - **Hydrology**: wetlands are distinguished by the presence of water, either at the surface or within the root zone
  - **Physiochemical environment**: wetlands have unique soil conditions that differ from adjacent uplands
  - **Biota (vegetation)**: wetlands support biota such as vegetation adapted to saturated conditions, and are characterised by an absence of flooding-intolerant biota

Key component 1: HYDROLOGY

- Either
  - prolonged inundation to a depth of less than 2m (limit for emergent macrophyte growth)
- OR
  - prolonged saturation of the root zone (upper 0.5m of the soil surface)

Key component 2: Physiochemical environment (SOILS)

- Organic soil / peat
  - wetlands accumulate organic plant material that decomposes slowly
  - not present in all wetlands (requires near-permanent saturation / shallow inundation)

- Clastic (mineral) soil
  - under anaerobic conditions, clastic soils become more acidic, and metals in soils become soluble and are leached through the profile
  - leaching leads to gleyed / low-chroma soils (pale browns, greys, blues – colour from metals has been removed)
  - where the saturation level fluctuates and oxygen is introduced, mottling occurs (red or orange flecks in the pale soil matrix)

peat

- “sedentarily accumulated material consisting of at least 30% (dry mass) of dead organic matter”
- requires near-permanent saturation or shallow inundation and limited clastic deposition

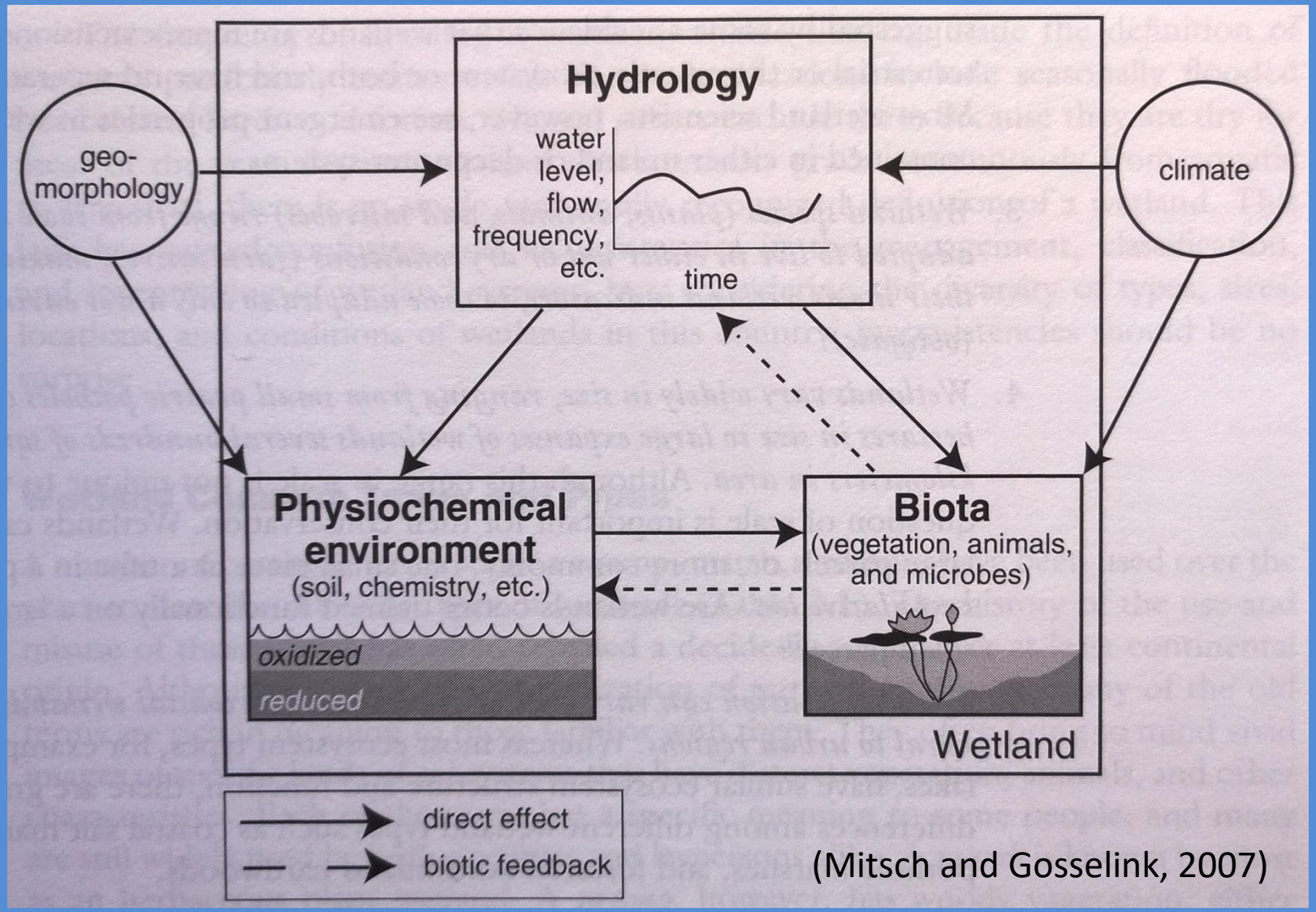
gleyed clastic soil

iron mottles in gleyed clastic soil

Key component 3: Biota (VEGETATITON)

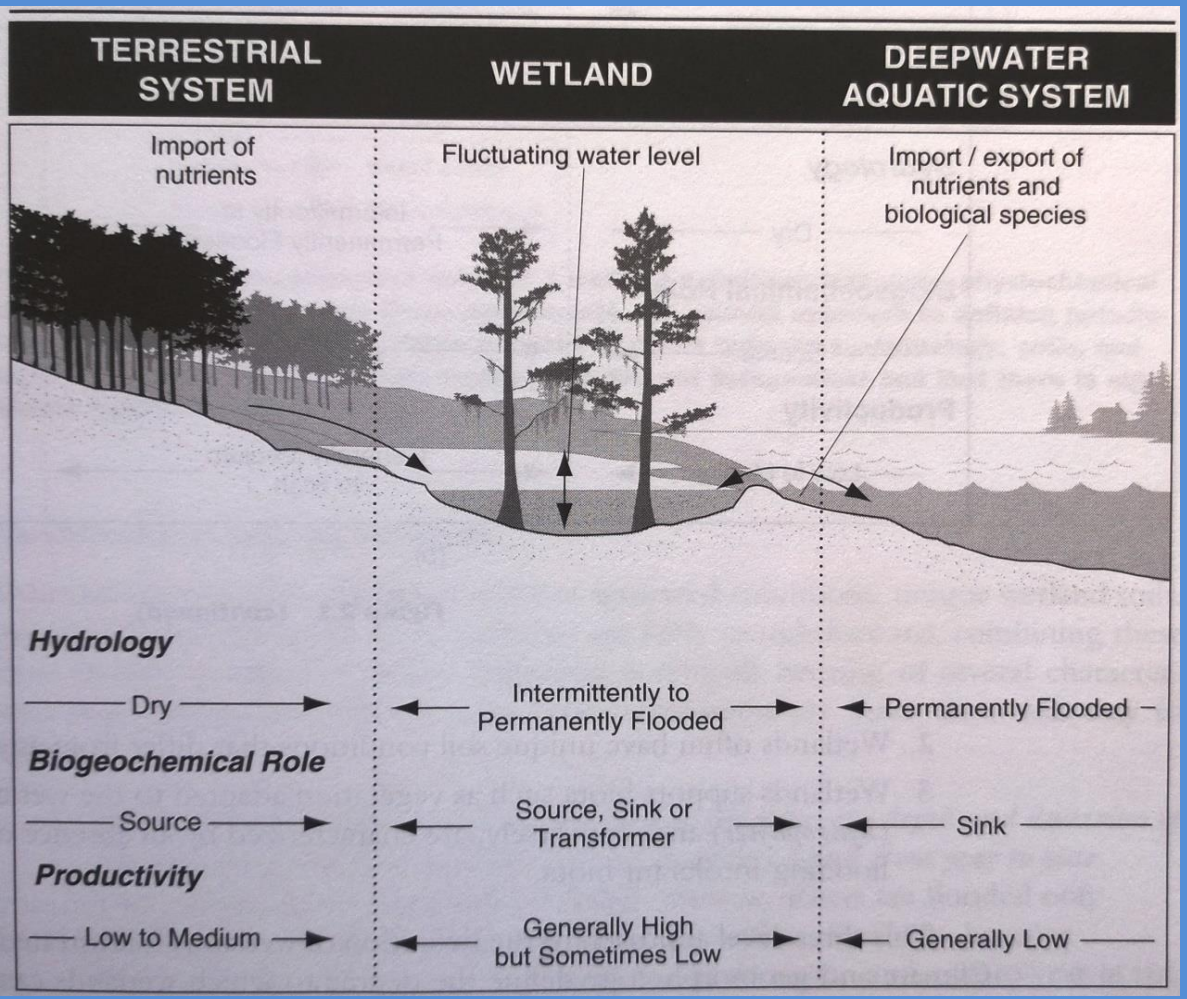
- Anaerobic conditions in the root zone are physiologically challenging for plants
- Metals in soluble form are toxic to plant growth
  - only plants with special biochemical or physiological adaptations can survive
  - plants with these adaptations tend to thrive due to moisture availability
  - these plants are called **hydrophytes**

Bringing the three components together



(Mitsch and Gosselink, 2007)

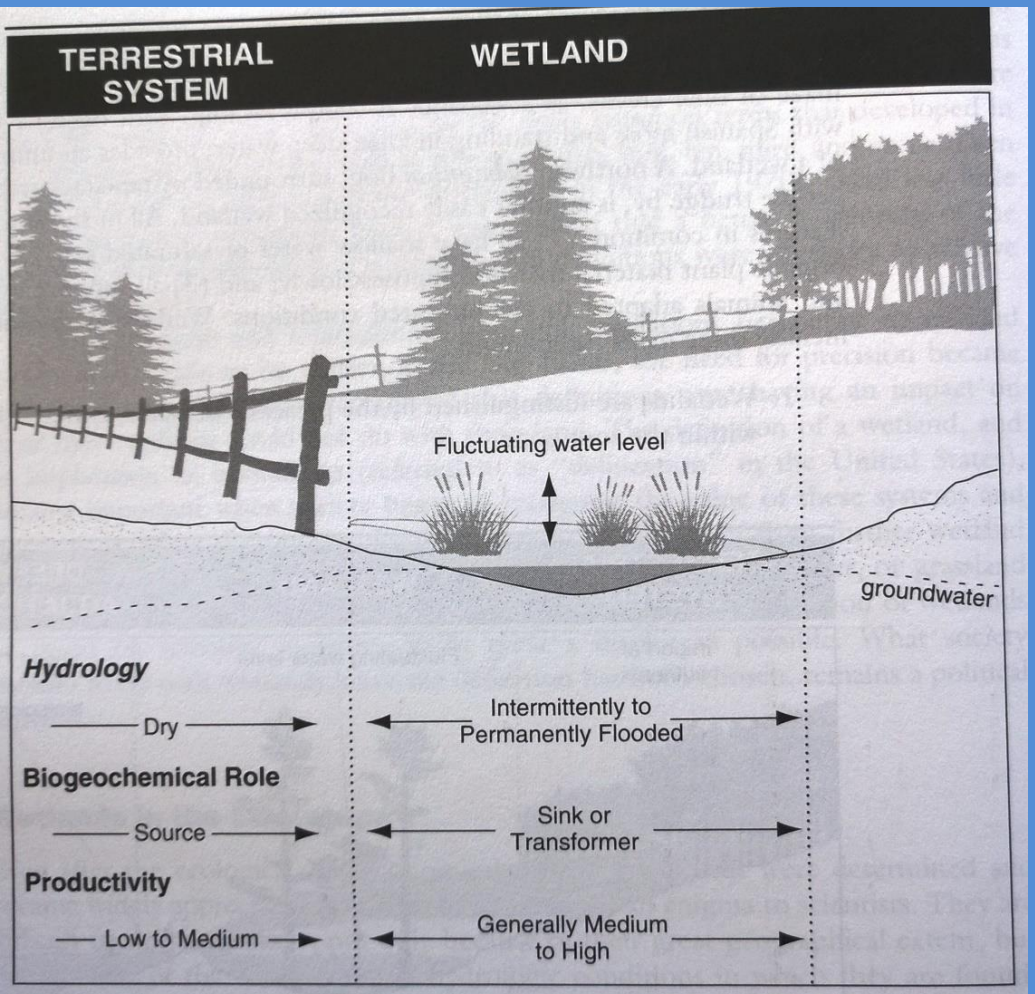
Wetlands in the landscape…



Wetlands may be located in settings that are transitional between dry terrestrial systems and deepwater aquatic systems…

(Mitsch and Gosselink, 2007)

Wetlands in the landscape...



…OR wetlands may occur as <u>isolated basins</u> with little outflow and no adjacent deepwater system

(Mitsch and Gosselink, 2007)

Inflows and Outflows…

- Inflows
  - Rainfall
  - Surface flows: streamflow or surface runoff
  - Groundwater flow
- Outflows
  - Evapotranspiration
  - Surface flows to a channel
  - Subsurface flows to groundwater
- Storage varies in relation to inflows and outflows over time

Identification & Delineation of Wetlands

- Wetlands must have **one or more of the following attributes**:
  - (1) Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation;
  - (2) The presence, at least occasionally, of water loving plants (hydrophytes);
  - (3) A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.

Identification & Delineation of Wetlands

- In many wetlands, not all parts are saturated for the same length of time.
- Generally, there are three different zones in a wetland, distinguished according to the changing frequency of saturation:
  - **Permanent Zone** - central part of the wetland, which is nearly always saturated
  - **Seasonal Zone** (surrounding the permanent zone) - saturated for a significant duration of the rainy season; surrounding the permanent zone
  - **Temporary Zone** (surrounding the seasonal zone) - saturated for only a short period of the year that is sufficient, under normal circumstances, for the formation of hydromorphic soils and the growth of wetland vegetation.
- These three zones may not be present in all wetlands.

Zonation in wetlands

- Wetlands are transitional ecosystems that occur along a soil saturation continuum between the extremes of dry land and permanently flooded areas too deep for emergent plants to grow

- Along the continuum, wetland ecosystems display zonation of veg and soil characteristics

- The primary driving force behind this zonation is variation in ***hydroperiod***; the frequency and duration of saturation (Mitsch and Gosselink, 1993) or degree of wetness (Kotze *et al*., 1994)

Wetland hydroperiod and **zonation** of veg and soil characteristics

- In South Africa, three wetness zones are recognised for palustrine wetlands:
  - a zone in which **saturation is temporary**;
  - one in which **saturation is seasonal**; and
  - one in which **saturation is permanent or semi-permanent**.

(note: all three zones not always present)

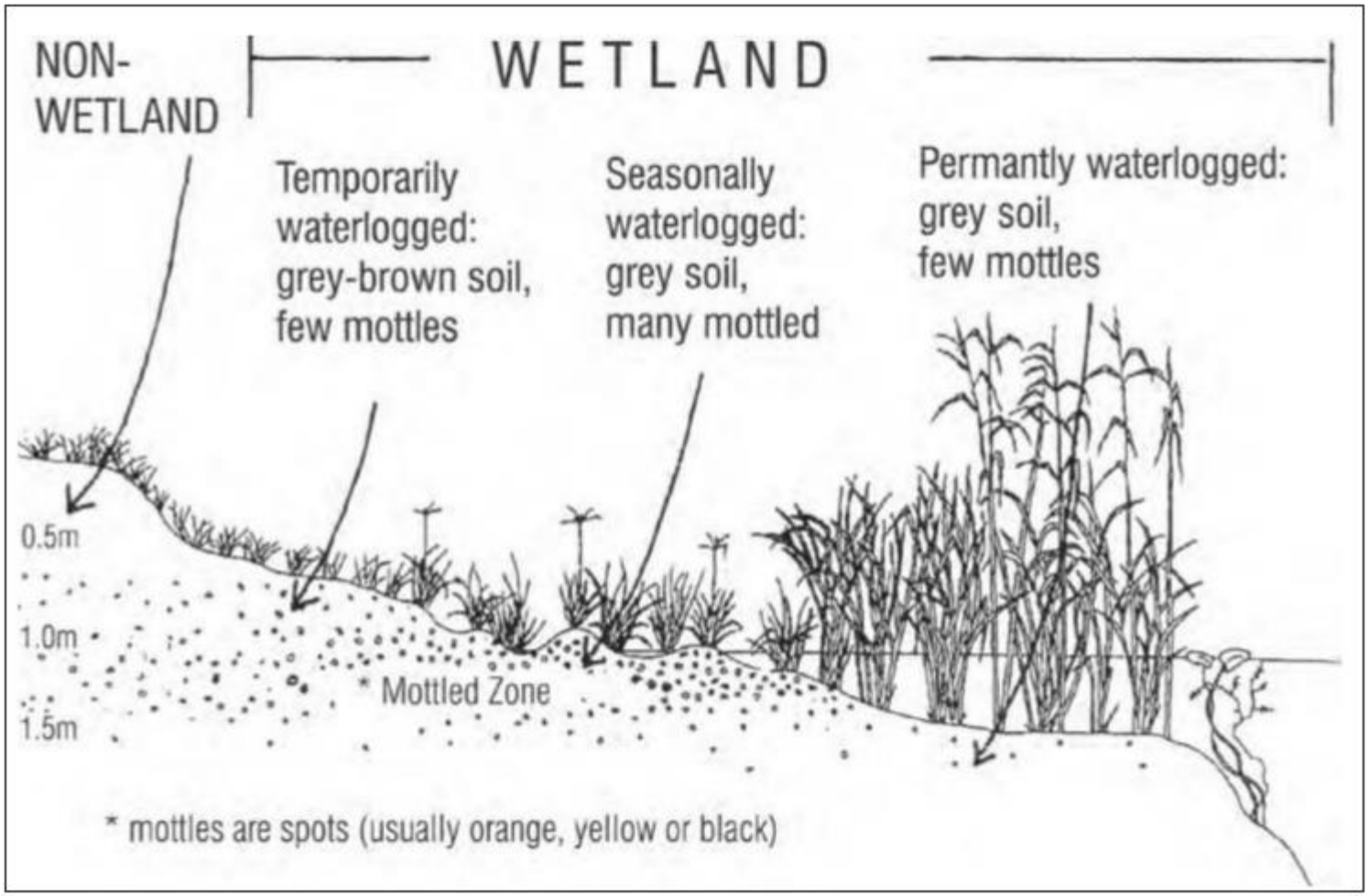


Figure1: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland.
Source: Donovan Kotze, University of KwaZulu-Natal.

Identification & Delineation of Wetlands

- **The primary objective of the delineation procedure is to identify and map the outer edge of the temporary zone**. This outer edge marks the boundary between the wetland and adjacent terrestrial areas….

- (It also involves, as a secondary objective, the identification and mapping of the seasonal and permanent zones, if present)

Soil Wetness Indicator

- Soil colour is strongly influenced by the frequency and duration of soil saturation.
- Generally, **the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix**.
- Coloured **mottles** are often a feature of hydromorphic soils:
  - usually absent in permanently saturated soils,
  - at their most prominent in seasonally saturated soils,
  - becoming less abundant in temporarily saturated soils,
  - disappear altogether in dry soils.
- **Generally, in mineral soils, a grey soil matrix and/or mottles must be present for the soil horizon to qualify as having signs of wetness in the temporary, seasonal and permanent zones**.
- It is important to bear in mind that soils with high organic content, such as peat, may not display these characteristics.


MUNSELL® SOIL COLOR CHART
MUNSELL® SOIL COLOR CHART

Soil Wetness Indicator

- **PERMANENT ZONE** characterised by:
  - Prominent grey matrix
  - Few to no high chroma mottles
  - Wetness all year round
  - Sulphuric odour (rotten egg smell)

Soil Wetness Indicator

- **SEASONAL ZONE** characterised by:
  - Grey matrix (>10%)
  - Many low chroma mottles present
  - Significant periods of wetness (at least 3 months per annum)


Mottles


Mottles


Mottles.


Mottles, surrounded by low chroma matrix.

Soil Wetness Indicator

- **TEMPORARY ZONE** characterised by:
  - Minimal grey matrix (<10%)
  - Few high chroma mottles
  - Short periods of saturation (less than 3 months per annum)

Soil Wetness Indicator

- The hydromorphic soils must display signs of wetness within 50cm of the soil surface.
- This depth has been chosen because experience internationally has shown that frequent saturation of the soil within 50cm of the surface is necessary to support hydrophytic vegetation.
- ID of signs of wetness within 50cm of the soil surface is usually a relatively simple procedure, except for a few specific cases (DWAF 2005):
  - alluvial deposits that are too recent to show morphological signs of wetness;
  - sandy soil profiles that occur in the coastal aquifer systems;
  - Dolomite and Quartzite

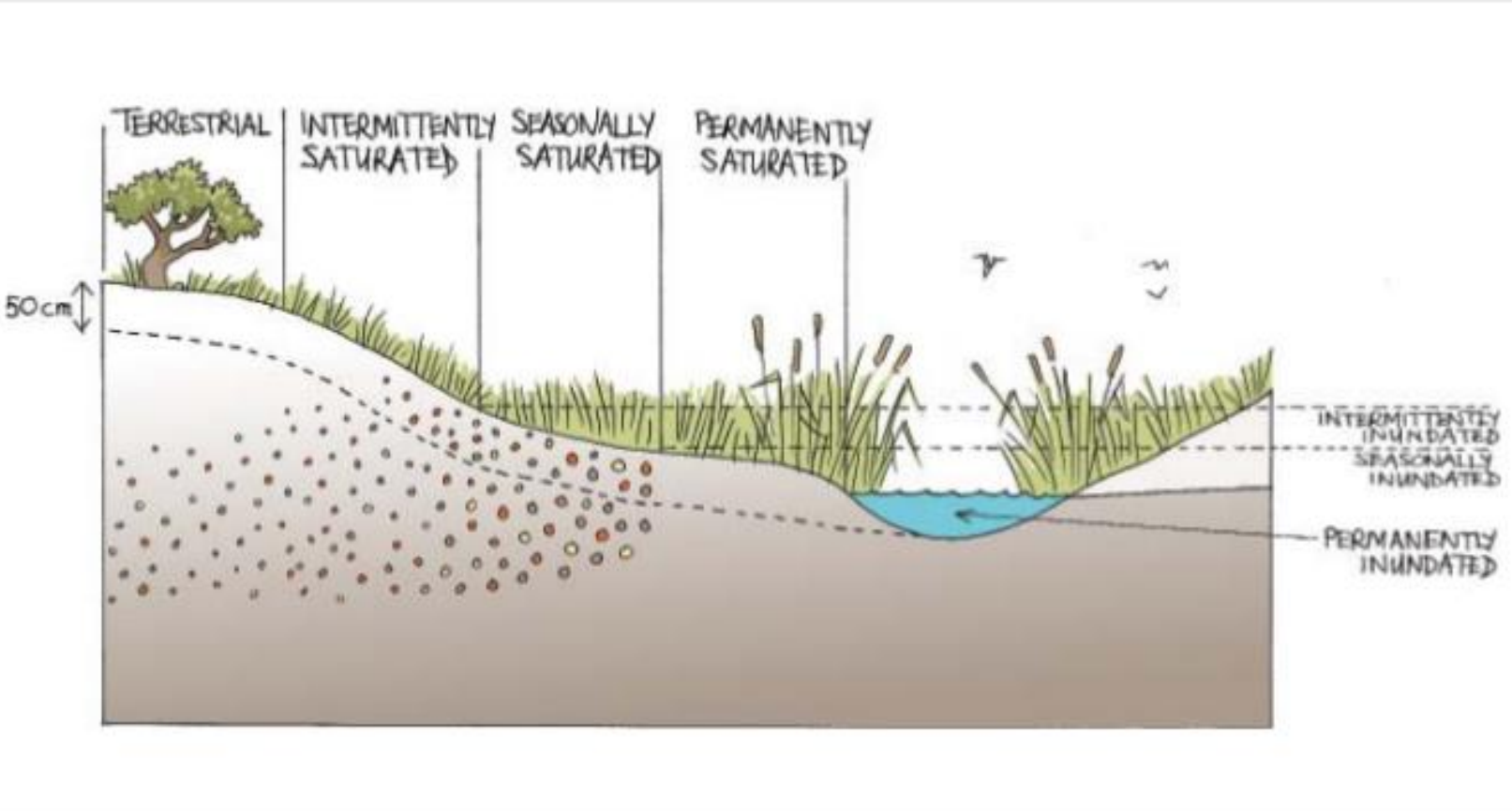


Figure 34. Diagrammatic cross-section through a hypothetical wetland, showing the different zones of saturation and inundation that could occur and illustrating how the vegetation and soils in the upper 50 cm of the ground surface typically respond to the hydroperiod [modified from Kotze 1996].

BOX 23: THE IMPORTANCE OF LOOKING BEYOND THE SOIL SURFACE OF WETLANDS

When classifying the substratum types for Inland Systems, particularly in the case of wetlands, it is important to take the soil profile into account (Figure 42) and not just the substratum type at the surface. This is because the soil profile has a significant influence on the formation and functioning of a wetland ecosystem, including the way in which water enters and flows through a wetland. As such, the substratum types that are encountered at different depths should be recorded (e.g. loamy soil from surface to 100 mm depth, with sandy soil layer from 100 to 300 mm overlying deep clayey soil sub-layer >1.5 m; or peat from surface to >1 m; or salt crust on surface with clayey soil from surface to 500 mm; etc.).

NOTE: If you want to see what the soil profile of a wetland looks like, you will need to use a soil auger to extract soil samples from below the ground surface or, as in the case of detailed soil surveys, dig a series of soil profile pits such as the one shown in Figure 42.

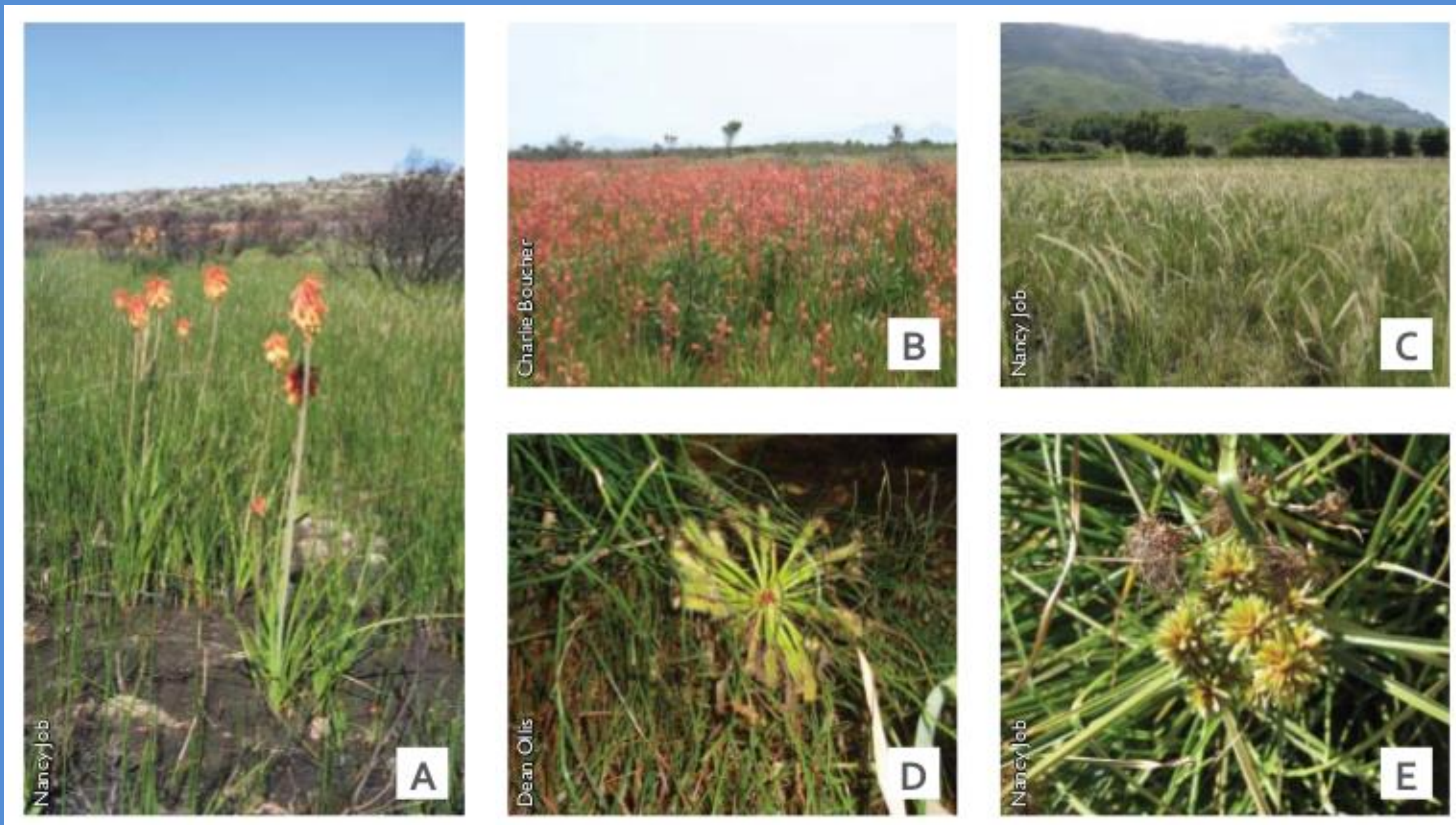
Figure 42. Photograph of a wetland soil profile (a seasonally saturated Katspruit soil) showing the different layers below the ground surface.

Vegetation Indicator

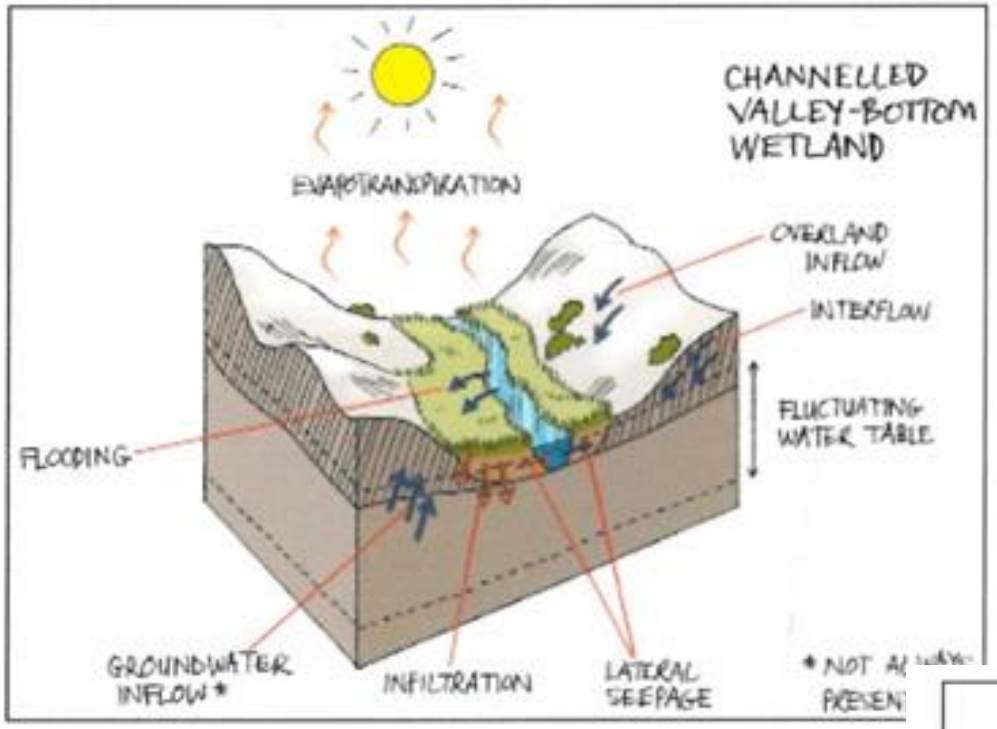
Table 2: Classification of plants according to occurance in wetlands

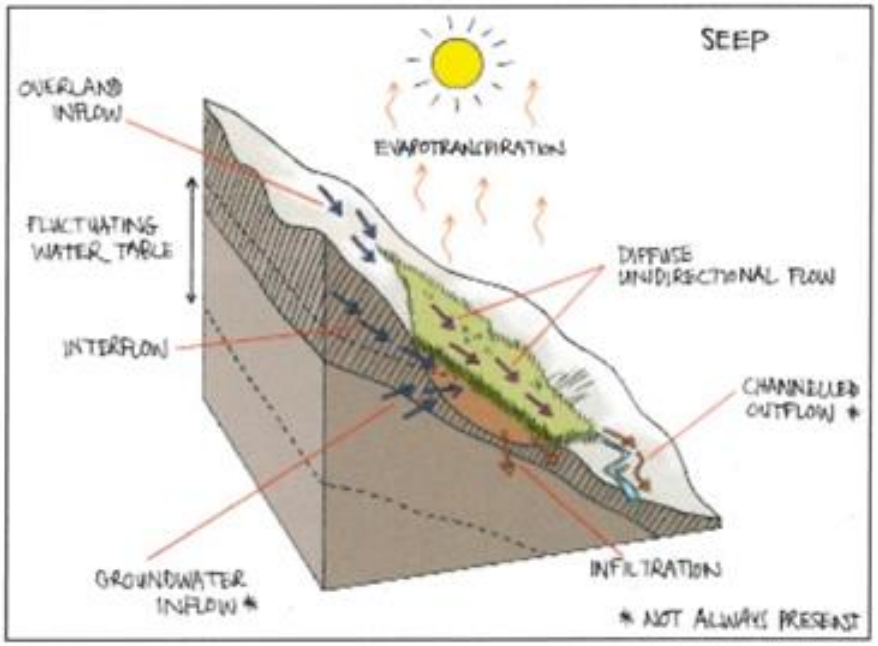
Obligate wetland (ow) species	Almost always grow in wetlands (> 99% of occurrences).
Facultative wetland (fw) species	Usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas
Facultative (f) species	Are equally likely to grow in wetlands and non-wetland areas (34-66% of occurrences).
Facultative dry-land (fd) species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% of occurrences)

Classification of plants according to occurrence in wetlands, based on U.S. Fish and *Wildlife Service Indicator Categories (Reed, 1988)*


Nancy Job
A
Charlie Boucher
B
Nancy Job
C
Dean Ollis
D
Nancy Job
E


Nancy Job
F
Nancy Job
G
Nancy Job
H
Nancy Job
I
Dean Ollis
J
Dean Ollis
K
Kate Snaddon
Nancy Job
L


CHANNELLED VALLEY-BOTTOM WETLAND
EVAPOTRANSPIRATION
OVERLAND INFLOW
INTERFLOW
FLUCTUATING WATER TABLE
FLOODING
GROUNDWATER INFLOW *
INFILTRATION
LATERAL SEEPAGE
* NOT ALWAYS PRESENT


SEEP
OVERLAND INFLOW
EVAPOTRANSPIRATION
FLUCTUATING WATER TABLE
DIFFUSE UNIDIRECTIONAL FLOW
INTERFLOW
CHANNELLED OUTFLOW *
GROUNDWATER INFLOW *
INFILTRATION
* NOT ALWAYS PRESENT

Broad approaches to measuring ecosystem health

- **Driver-based (impacts)**
  - Do the expected (reference) fundamental physical habitat requirements exist?
  - What can the availability of habitat tell us about the health of the ecosystem?
  - EcoClassification and EcoStatus Determination for *Driver Components*
- **Response-based (bio-indicators)**
  - Do the expected (reference) species exist?
  - What can individual species tell us about the health of the ecosystem?
  - EcoClassification and EcoStatus Determination for the *Response Components* (also the primary focus of SA's RHP)

DWS Ecostatus Determination

Assessment of ecological integrity

Ecostatus: "***The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services***" (Iversen *et al.,* 2000).

Present Ecological State (PES) assessments: Ecological Categories

Table 2.1 Generic ecological categories for EcoStatus components (modified from Kleynhans, 1996 & Kleynhans, 1999).

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

Reference conditions in EcoStatus determination…

- The *reference condition* describes the **condition of the site, river reach or delineation prior to anthropogenic change** and is formulated for each component considered in EcoStatus determination (all drivers and responses) following the process below:
  - Locate the least-impacted sites, either in the same or in ecologically comparable river zones.
  - Use the results of historical ecological surveys conducted before major human impacts. If this is not possible, consider the use of survey information from ecologically comparable rivers. Use historical aerial photographs and land cover data to get an indication of the degree of catchment changes. The Internal Strategic Perspective (ISP) reports of the Department of Water Affairs and Forestry (now DWS) also provide relevant information.
  - Use expert knowledge

Physical drivers

- Drivers define the physical habitat template available to biota.

- 3 key physical drivers in river ecology:
  - **Hydrology**: quantity and dynamics of flow
  - **Geomorphology**: physical structure of the channel environment, nature of the bed material (substrate) for organisms to live in
  - **Physico-chemistry**: **water quality**

Biological responses

- Biological responses provide an indicator of the overall physical state of the river environment (they integrate the effects of hydrology, geomorphology, and physico-chemistry)
- 3 responses used in EcoStatus determination
  - **riparian vegetation**
  - **aquatic invertebrates**
  - **fish**

moving up through the food chain…

- Diatoms also used in River Ecostatus

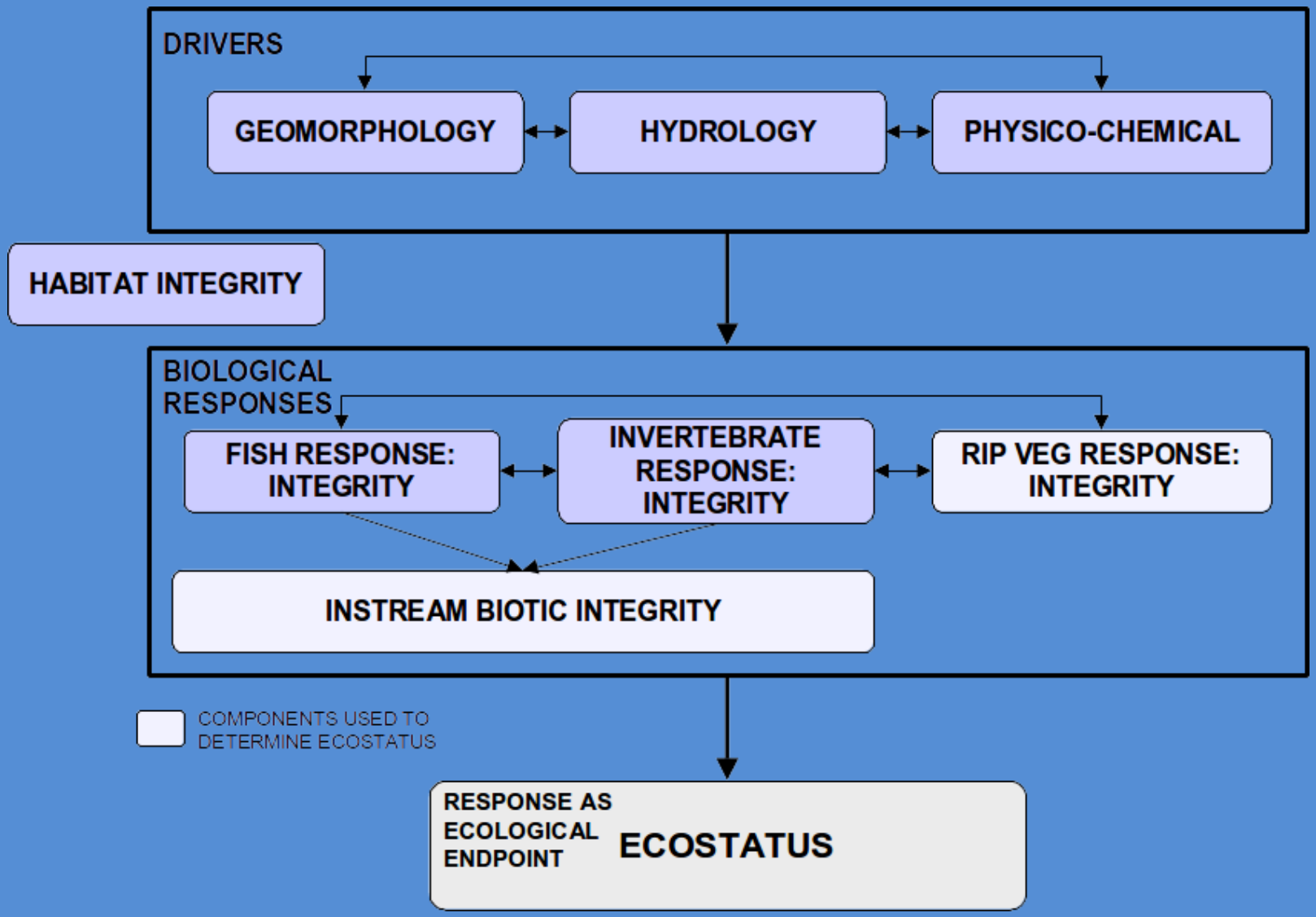
DWS River EcoStatus

Table 1. Overview of the metrics* used for determining the EcoStatus of river ecosystems in South Africa [from Kleynhans & Louw 2008)]

COMPONENTS	Desktop	Level 1	Level 2	Level 3	Level 4
DRIVER					
Geomorphology	QHI	IHI (instream and riparian)	IHI (instream and riparian)	IHI (instream and riparian) en GAI 3	GAI 4
Water quality					PAI
Hydrology					HAI
RESPONSES					
Fish	Rating	Rating	None	FRAI	FRAI
Invertebrates			MIRAI	MIRAI	MIRAI
INSTREAM	Combination of fish, invert ratings and QHI	Combination of fish, invert ratings and IHI	Combination of fish rating and MIRAI and IHI	FRAI & MIRAI & confidence	FRAI & MIRAI & confidence
Riparian vegetation	Rating	Rating	Rating	VEGRAI 3	VEGRAI 4
ECOSTATUS					
EcoStatus	Combination of Instream (2/3) and riparian vegetation (1/3)	Combination of Instream (2/3) and riparian vegetation (1/3)	Combination of Instream (2/3) and riparian vegetation (1/3)	Combination of Instream & VEGRAI. Confidence and weights included	

* QHI = Quick Habitat Integrity; IHI = Index of Habitat Integrity; GAI = Geomorphology Driver Assessment Index; PAI = Physico-chemical Driver Assessment Index; HAI = Hydrology Driver Assessment Index; MIRAI = Macroinvertebrate Response Assessment Index; FRAI = Fish Response Assessment Index; VEGRAI = Vegetation Response Assessment Index.

DWS River EcoStatus



Wetland Management Series

WET-Health

A technique for rapidly assessing wetland health

WRC Report TT 3
Februar

Series Editors:
Charles Breen
John Dini
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WET-Health (Version 2.0)

A REFINED SUITE OF TOOLS FOR ASSESSING THE PRESENT ECOLOGICAL STATE OF WETLAND ECOSYSTEMS

-- TECHNICAL GUIDE --

Report to the
WATER RESEARCH COMMISSION

by

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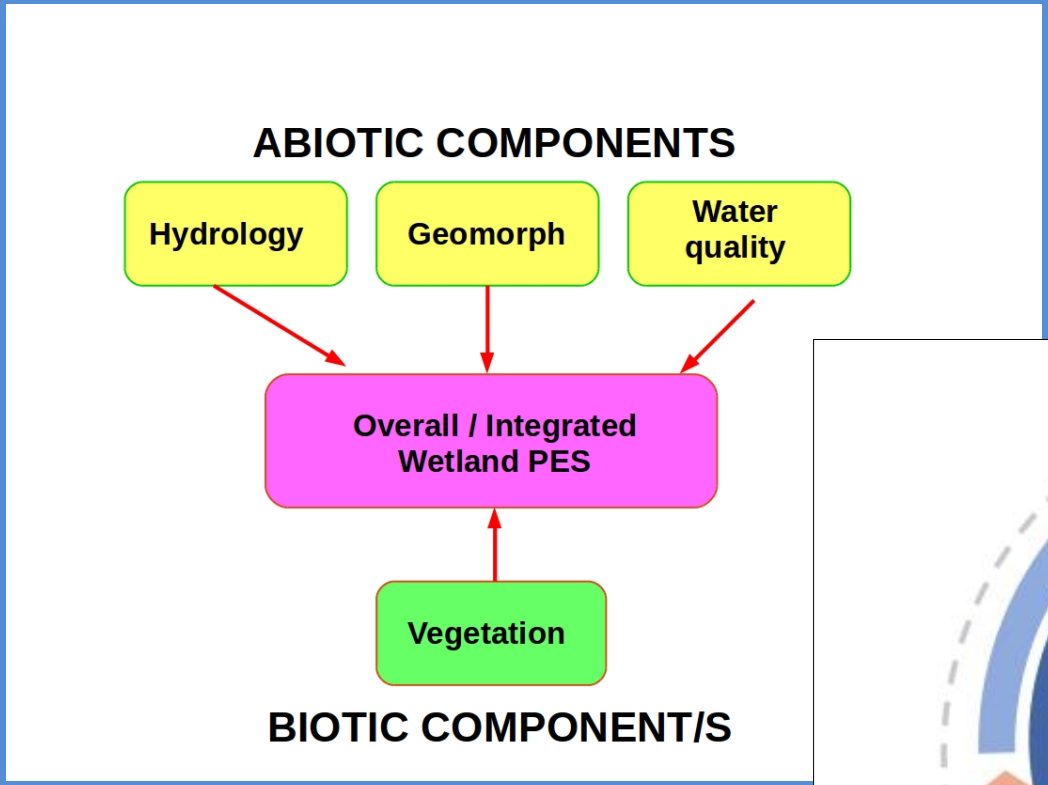
Dr Damian Walters (South African National Biodiversity Institute)
Mr Tumisho Ngobela (Freshwater Research Centre)
Dr Justine Ewart-Smith (Freshwater Research Centre)

WETLAND PES (WET-Health V2)



WET-Health Version 2

- WET-Health is designed to assess the PES of a wetland by scoring the perceived deviation from a theoretical reference condition, where the reference condition is defined as the un-impacted condition in which ecosystems show little or no influence of human actions.
- The natural reference condition of a wetland is inferred from conceptual models relating to the selected hydro-geomorphic (HGM) wetland type, the selected hydro-geological type setting and knowledge of vegetation attributes of similar wetlands in the region.
-

WETLAND PES (WET-Health)

		Valley-bottom wetland	Seep
Extent (Ha)		4 ha	0.2 ha
Hydrology	PES Score (%)	35%	65%
	Ecological Category	**E**	**C**
Geomorphology	PES Score (%)	70%	88%
	Ecological Category	**C**	**B**
Vegetation	PES Score (%)	46%	47%
	Ecological Category	**D**	**D**
Water quality	PES Score (%)	61%	75%
	Ecological Category	**C/D**	**C**
Overall PES	PES Score (%)	51%	68%
	Ecological Category	**D**	**C**

For vegetated wetlands*

IF PES Score for HYDROLOGY is in Ecological Category A / B / C / D	Wetland-PES = ([Hydro-PES]*3 + [Geo-PES]*2 + [WQ-PES]*2 + [Veg-PES]*2)/9
IF PES Score for HYDROLOGY is in Ecological Category E / F	Wetland-PES = ([Hydro-PES]*6 + [Geo-PES]*2 + [WQ-PES]*2 + [Veg-PES]*2)/12

*All wetlands are assumed to be naturally vegetated in Level 1A and 1B assessments

For non-vegetated wetlands (Level 2 assessments only)

IF PES Score for HYDROLOGY is in Ecological Category A / B / C / D	Wetland-PES = ([Hydro-PES]*3 + [Geo-PES]*2 + [WQ-PES]*2)/7
IF PES Score for HYDROLOGY is in Ecological Category E / F	Wetland-PES = ([Hydro-PES]*6 + [Geo-PES]*2 + [WQ-PES]*2)/10

WET-Health Version 2

- **Three different levels of assessment** have been developed to account for a broad range of user requirements.
- For all levels, the **assessment is based initially on a landcover assessment** that seeks to provide an initial indication of wetland condition based on a generic understanding of the impacts of different landuses on catchment and wetland processes and characteristics.
- The assessment is **refined for more detailed assessments**