Tools to Determine Enforcement Driven Rehabilitation Objectives on Urban River Reaches
GUIDELINE DOCUMENT

Sam Braid

WATER RESEARCH COMMISSION
TT 594/14

TOOLS TO DETERMINE ENFORCEMENT DRIVEN REHABILITATION OBJECTIVES ON URBAN RIVER REACHES

GUIDELINE DOCUMENT

Report to the

Water Research Commission

by

S. Braid

WRC Report No. TT 594/14

February 2014

Obtainable from

Water Research Commission
Private Bag X03
GEZINA, 0031

orders@wrc.org.za or download from www.wrc.org.za

This Guideline document emanates from the project entitled *Determining Procedures for Setting Enforced Rehabilitation Objectives for Urban River Reaches* (WRC Project No. K5/2036). The main project report, **WRC Report No. TT 593/14**, is also available.

ISBN 978 143 120 5486
Printed in the Republic of South Africa

INTRODUCTION

About the project

Craigie, Snijman and Fourie (2009) have observed that there “appears to be reluctance among environmental authorities to give compliance advice to the regulated community for fear of being held liable for inappropriate advice.” Subsequently enforcement reporting is only quantitative (DEA, 2012), meaning that only the number of enforcement cases is reported, and no qualitative measurement, for example, the improved state of environment as a result of the enforcement interventions is reported. Both of these issues occur because enforcement officials do not have the capability, time or budget to run detailed EcoStatus assessments on every site inspection. This research set out to develop tools to aid compliance and enforcement officials in determining the impacts of contravening activities, thereby being more informed when requesting specialist studies and determining the objectives of the rehabilitation plans and activities, as well as for the monitoring of the effects of these directed rehabilitation measures on the site.

In a similar vein, the Promotion of Administrative Justice Act, Act 3 of 2000 (PAJA) requires all administrative action to be lawful, reasonable and procedurally fair and the right to written reasons for administrative action, as provided for in section 33 of the Constitution. Administrative notices, issued in terms of compliance and enforcement, are administrative decisions and must therefore comply with the PAJA. The aim of this WRC project was to develop tools to aid officials in their decision-making.

Why the Guideline & target audience

This guideline is aimed at compliance and enforcement officials who are involved in compliance monitoring and enforcement of sites including urban rivers. This guideline can be used by enforcement officials in all three spheres of government, for example National, Provincial and Local Government.

Guideline structure

This Guideline is structured in 3 parts:

Part 1 – Introduction

This Part provides the background to the project and to the development of the tools and guideline. It provides a revision of basic ecological concepts related to riverine management. This part also indicates the current applicable South African environmental legislation.

Part 2 – Tools

This Part details the use of the tools that were developed in the scope of this research. The tools include:

Legislation Search Tool (LST): A database of environmental legislation related to rivers. The database can be searched against a specific section of legislation or using a search word. The database identifies other sections of legislation that may be relevant or overlap and the institution responsible for that section of legislation.

Site Assessment Form (SAF): An interactive form that the enforcement officials complete when conducting their site assessments. The completed form provides a comparable record of the state of the site on the days of inspection.

Dashboard Tool (DT): Based on the completed Site Assessment Form, the selected answers are linked to indicators of basic riverine function. The DT automatically calculates the potential impact of the contravening activity on riverine functions. Based on this, the official can then better inform the perpetrator as to what ecosystem functions the specialist studies and rehabilitation plan need to address.

Part 3 – Additional Guides (Annexures)

This Part provides additional guides to assist compliance and enforcement officials. These additional guides include:

- Environmental Management Inspector (EMI) Standard Operating Procedure for Site Inspections;
- Wetland and riverine indicator plant lists;
- Alien and invasive plant lists; and
- MiniSASS aquatic invertebrate identification.

ACKNOWLEDGEMENTS

All those that have been involved in the project to determine procedures for setting enforcement rehabilitation objectives for urban river reaches are gratefully acknowledged. The following people are specifically thanked for their direct input to this project: Mark Rountree, Nevil Quinn, Mandy Uys, Maritza Uys, Karl Reinecke, Nico Rossouw, Natalie Newman and Stephanie Coetzee.

Reference Committee:
Mr BR Madikizela – WRC (Chairman)
Mr KB Itholenge – Gauteng Department of Agriculture and Rural Development
Mr DH Kleyn – Department of Agriculture, Fisheries & Forestry
Dr SA Mitchell – Eon Consulting
Ms N Newman – Cape Town Metropolitan Municipality
Pieter Ackerman - Department of Water Affairs
Dr Ernst Wohlitz- City of Tshwane Metropolitan Municipality
Mr F Letsoko – City of Johannesburg Metropolitan Municipality
Mr M Rountree – Fluvius Consulting

The majority of the photos used in this guideline have been taken by the author. Where others have contributed photos to the report and guideline, the photos are referenced to the photographer.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BMP	:	Best Management Practice
IHI	:	Index of Habitat integrity
PES	:	Present Ecological Status
SUDS	:	Sustainable Urban Drainage Systems
VEGRAI	:	Vegetation Assessment Index
WSUD	:	Water Sensitive Urban Design
WWTW	:	Waste Water Treatment Works
m^3	:	Volume, cubic metre of water (1m x 1m x 1m)
m/s	:	flow rate, metres per second

GLOSSARY OF TERMS

Active channel is the part of the channel that receives water flow most often. It is usually marked by noticeable banks on either side of the channel (Freeman and Rowntree, 2005). Regular storm events such as 1:2 or 1:5 year events occur within the active channel.

Accretion / Aggradation The rising of the grade or level of a river valley by deposition or accumulation.

Adjacent properties include next-door properties located both up and downstream, and surrounding the property in question. It is not limited to a common boundary, i.e. it may be across the road, servitude or river.

Benthic The benthic zone is the ecological region at the lowest level of a body of water, including the sediment surface and some sub-surface layers.

Catchment "is the land surface that contributes water and sediment materials to a river channel" (Freeman and Rountree, 2005:8).

Channel a term used collectively meaning the course of a river or stream including, the bed and banks. It can be individually referred as in-stream and banks (EA, 1998).

Criteria a standard of judging; a principle or fact by which a correct assessment may be formed.

Disposal means the burial, deposit, discharge, abandoning, dumping, placing or release of any waste into, or onto, any land (NEM: Waste Act 59 of 2008).

EcoClassification the term used for the Ecological Classification of rivers; it refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers compared to the natural or close to natural reference condition (Kleynhans and Louw, 2008).

EcoStatus ability of a river to support appropriate natural flora and fauna and relates directly to the capacity of the system to provide a variety of goods and services (Kleynhans and Louw, 2008).

Ephemeral stream a stream that has short-lived flow, for example flows only when it rains.

Floodplain a relatively level alluvial (sand and gravel) area lying adjacent to the river channel, which has been constructed by the present river in its existing regime.

Habitat means the natural home of species of plants or animals.

Indicator means to show or signify a symptom.

In-stream occurring in the stream water body, as opposed to on the banks.

Lentic means living in ponds, swamps or other still water.

Lotic means water which is in motion.

Macro-channel is the area between the regular flow of the active channel and the maximum height of a major flood, e.g. 1:100 or 1:1000 year flood.

Non-perennial means a river that does not flow continuously.

Perennial means a river that flows continuously.

Reach of River a length of an individual river which shows broadly similar physical characteristics (EA, 1998).

Rehabilitation is the remedying of some ecosystem functions and processes in a degraded state or site.

Rehabilitation activities refer to the suite of rehabilitation, remediation or restoration activities.

Remediation Breen and Walsh (1999) explain the aim of remediation is to improve the ecological condition of the river, while not aiming for an endpoint which resembles its original condition.

Reserve According to the National Water Act, Act 36 of 1998, the "Reserve means the quantity and quality of water required -

(a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be -
  (i) Relying upon;
  (ii) Taking water from; or
  (iii) Being supplied from,
  The relevant water resource; and

(b) To protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource."

Restoration defines ecological restoration as *"the process of returning an ecosystem as closely as possible to pre-disturbance conditions and functions"* (FISRWG, 1998:1-3).

Riffles / Rapids arrangement of cobbles and stones where water flows between them. "Riffles are areas, often downstream of a pool, where the water is breaking over rocks or other debris causing surface agitation" (USDA, 1998:17).

Riparian zone / habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas (NWA 36 of 1998). The riparian zone is found along the banks of a river and includes some form of flood plain. The abundant ecosystems in the riparian zone depend on water, sediment, and nutrients carried by the river. "Riparian zones are an unusually diverse mosaic of landforms, communities, and environments within the larger landscape, and they serve as a framework for understanding the organization, diversity, and dynamics of communities associated with fluvial ecosystems" (Decamps 1996; Gregory, 1991; Naiman, 1988; Naiman, 1993; Naiman 1997) in Naiman and Décamps (1997:622).

River Corridor / Habitat / Zone includes the riparian and in-stream habitats. A river corridor comprises the watercourse and associated wetlands, floodplain and ecological buffer. A river corridor includes the land to either side of the channel and from the outer edge of one riparian area to the opposite riparian area outer edge.

Run to migrate upstream to spawn, as a fish. A 'run' is also an area of faster flowing water between successive riffles.

Runoff means flow from a site or the catchment hat contributes to the stream channel flow.

Soil erosion “is the movement of soil components, especially surface littler and topsoil, from one place to another. The two main agents of erosion are flowing water and wind. In undisturbed vegetated ecosystems, the roots of plants help anchor the soil, and usually soil is not lost faster than it forms. However, farming, logging, construction, overgrazing by livestock, off-road vehicles, deliberate burning of vegetation, and other activities that destroy plant cover leave soil vulnerable to erosion. If topsoil erodes faster than it forms on a piece of land, the soil there becomes a non-renewable resource” (Miller, 1998:552).

Storm event means a weather event including the occurrence of thunder, lightning, rain, hail, snow or sleet.

Storm water runoff means water as a result of a storm event.

Terrestrial confined to living or occurring on land as opposed to water or air.

Watercourse as defined by the National Water Act, Act 36 of 1998, means:

a) A river or spring;
b) A natural channel in which water flows regularly or intermittently;
c) A wetland, lake or dam into which, or from which, water flows; and
d) Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes where relevant, its bed and banks.

PART 1 - INTRODUCTION

1 BACK TO BASICS

1.1 Identifying riverine/riparian areas

The riverine corridor is composed of both the riparian habitat (the flood zone, includes 1:100 year floodline) and the aquatic habitat (active channel, includes 1:2 year floodline), as illustrated by Figure 1-1.

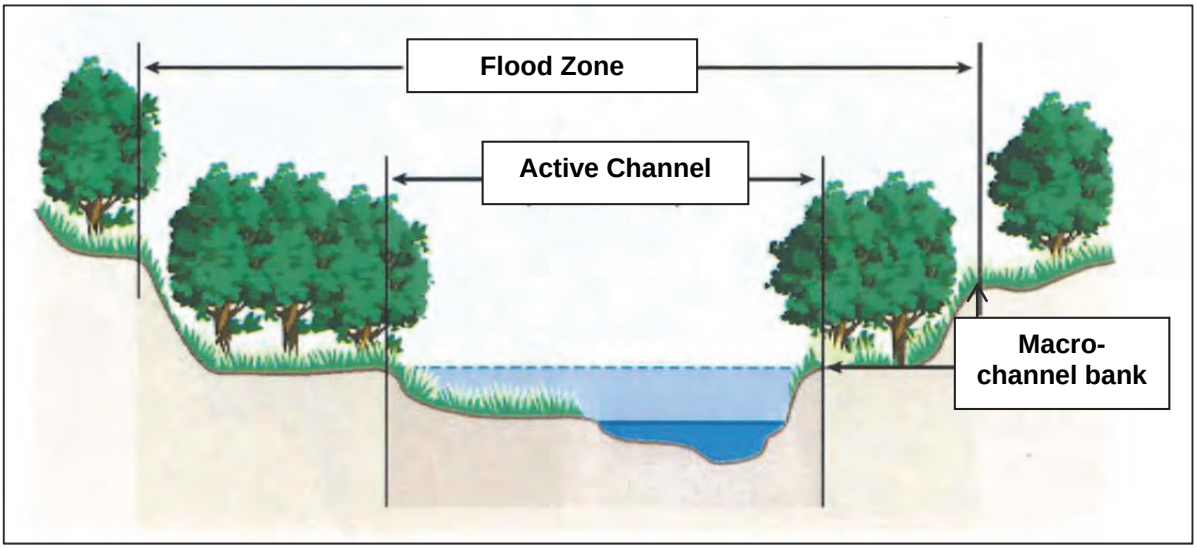


Figure 1-1 Typical cross-section of a river channel (Adapted from FISRWG, 2001:1-18)

The National Water Act (Act 36 of 1998) (NWA) defines a riparian habitat as including "the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

According to DWAF (2008:42), "riparian zones can be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas" as illustrated in Figure 1-2. As observed in Figure 1-2, the riparian area is greener and lusher, whereas the vegetation in the terrestrial area is smaller and is browner in colour. DWAF (2008) continues to explain that unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic (mottling) features to develop in their soils; riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Figure 1-2 Aerial view of vegetation line between terrestrial and riparian vegetation. (Source: M Rountree).

DWAF (2005:16) go on to explain that riparian areas may thus range from a few metres wide adjacent to small stream channels to more than a kilometre wide in floodplains. Both perennial and non-perennial streams support riparian vegetation. Because riparian areas represent the interface between aquatic and upland ecosystems, the vegetation in the riparian area may have characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require plenty of water and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high and the vegetation under the trees is usually lush in comparison to the upland terrestrial vegetation.

The **active channel** is the area of the channel where the daily regular flow of a watercourse or small flood events (e.g. 1:2 year) occurs. The **macro-channel or flood banks** are the area between this regular flow of the active channel and the maximum height of a major flood (e.g. 1:100 or 1:1000 year flood).

The NWA definition of riparian zones refers to the structure of the banks and presence of alluvium. DWAF (2008) identified that a good indicator of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised “macro-channels”; where alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers.

The DWAF identification (2008) of riparian areas relies heavily on vegetative indicators; using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs:

- In species composition relative to the adjacent terrestrial area; and
- In the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

The relative change in species composition and growth forms between the vegetation immediately adjacent to the channel versus that of the upland terrestrial areas identifies the riparian zone. DWAF concludes that these differences between riparian and terrestrial vegetation are primarily a result of:

- More water being available to species growing adjacent to watercourses than to those growing further away; and
- Increased levels of flooding disturbances experienced by the species within the riparian zone than those in the upland terrestrial zone.

1.2 Riverine Functions

The Millennium Ecosystem Assessment (MEA) report 2005 defines *ecosystem services* as benefits people obtain from ecosystems. Ecosystem functions include the biological, geochemical and physical processes and components that take place or occur within an ecosystem. These services are typically grouped according to the flows of products or services provided by the ecosystem. These groups of "flows" or functions are:

- Production functions: This refers to the ecosystem's ability to produce resources such as water supply, fish, hydropower, agriculture, cultivation and harvesting (including reeds for weaving, *muti*), and forestry. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Regulation functions: This refers to an ecosystem's ability and/or capacity to regulate environmental processes such as carbon storage, flood attenuation, nutrient cycling, sediment trapping, etc. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Carrier functions: This refers to the capacity of the ecosystem to provide space for various processes to occur, such as navigation and transport, energy generation, recreation, and cultivation. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Habitat functions: This refers to the ability and capacity of the ecosystem to provide habitat, refuge, nurseries, diversity, food for species and ecosystems. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Information/cultural functions: This refers to the ecosystem's contribution to human well-being, i.e. through sense, experience, religious / cultural practices, tourism, recreation, and aesthetics. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)

Maintaining or rehabilitating riverine function and integrity is important to us because of the "services" provided to us by these functions. These services are referred to as ecosystem-services, and include the movement of energy and nutrients through the air, water and land, and through the food chain, (Ehrlich, in Pimm 1994). When these functions are negatively impacted by land-use activities, the services they provide are also reduced. For the scope of this work, these groups of ecosystem functions have been further broken down into specific ecosystem services or infrastructure that is applicable to urban rivers, i.e. flood attenuation (regulation), sediment trapping (regulation), water quality (regulation), carbon storage (regulation), habitat provision (habitat), subsistence (production), and cultural, aesthetic and recreational (information/cultural and carrier) functions.

1.2.1 Flood attenuation (Regulation)

Flood attenuation refers to the ability of the river or reach of river to store flood water. Good attenuation adds to the lag time of a flood event by increasing the time between the middle of the rainfall event and the runoff peak. A reduction in the ability to attenuate flood water will decrease

the time between the middle of the storm event and the peak runoff, which has a resultant increase in velocity and increase in energy and erosive power, and a reduction in silt deposition and sediment trapping (FISRWG, 1998). Storage for flood water is provided by open (undeveloped) floodplains, open river channels, riparian vegetation assists to slow flood waters thereby providing some attenuation. In summary "flood attenuation protects landscapes from flood damage (Dosskey *et al.*, 1997, Postal and Carpenter 1997, Field *et al.*, 2006 in Soman 2007:3), moderates the velocity of flood waters, reduces high flows and floods, and decreases downstream flooding through flood water moderation and/or uptake" (Forman (1995) in FISRWG 1998:2-86), and may also increase baseflow.

1.2.2 Sediment trapping (Regulation)

During both regular flow and flooding, the natural river acts as a sediment trap. "Dissolved substances such as nitrogen, phosphorus and silt and other nutrients, entering a vegetated stream corridor are restricted or 'trapped' from entering the channel by friction, root absorption, clay, soil organic matters" (FISRWG, 1998:2-86).

Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where pollutants may settle with the sediment or become soluble in the water column. For example, in Johannesburg, the Klip River wetlands have trapped tonnes of heavy metal toxicants from the surrounding mine dump runoff. However, the rapidly eroding wetland is threatening to release these pollutants back into the Klip River and to the Vaal River – the source of drinking water for Johannesburg.

In summary, sediment trapping provides for the storing and recycling of organic matter and nutrients (Barling and Moore, 1994 in Soman 2007:3), and the removal of nutrients such as nitrogen, phosphorous and sediment from surface and subsurface flow (Lowrance *et al.*, 1985, Hill 1996, USDA-WRCS 1999, in Soman 2007:3).

1.2.3 Habitat provision (Habitat)

"Habitat provision" is defined according to Thirion (2008) as any combination of velocity, depth, substrate (bedrock, cobbles, vegetation, sand, gravel, mud), physicochemical characteristics (such as chemical composition, turbidity, oxygen concentration, temperature) and biological features (food source and predators) that will provide the organism with its requirements for each specific life stage at a particular time and locality.

"The biological diversity and species abundance in streams depends on the diversity of available habitats; naturally functioning, stable stream systems promote the diversity and availability of habitats" (FISRWG, 1998:2-59). However there is no fixed reference for aquatic habitat as different stream structures provide for different habitats.

The important role that riparian forests play in stream ecology is often diminished in urban watersheds since tree cover is partially or totally removed along the stream as a consequence of development (May *et al.* 1997). Even when stream buffers are reserved, encroachment often reduces their effective width and indigenous species are replaced by alien and invasive trees, shrubs and ground covers, e.g. kikuyu grass. The loss of tree cover and exposure of impervious surfaces, ponds, and poor riparian cover in urban watersheds can increase the average summer stream temperatures by 4°C (Galli, 1991). Since temperature plays a central role in the rate and timing of living (*biotic*) and non-living (*abiotic*) reactions in the stream, such increases have an adverse impact on streams.

May *et al.*, (1997) highlight other impacts to urban rivers include:

- The quantity of large woody debris is reduced due to the loss of riparian forest cover, storm washout, and channel maintenance. This also affects the water temperature;
- Many forms of urban infrastructure are linear in nature, such as roads, sewers, pipelines, and cross stream channels. The number of stream crossings increases directly in proportion to impervious cover in the catchment and riparian area, and many of the crossings become partial or total barriers to upstream fish migration.

In summary, "the function of habitat provision includes the provision of shade, shelter, breeding areas and food for fish and other aquatic organisms; wildlife habitat (Soman, 2007:3), habitat and nursery functions for fish and wildlife "(Castelle *et al.*, 1994 and Bren 1993 in Soman, 2007:3), and habitat connectivity.

1.2.4 Carbon storage (Regulation)

"As a heat-trapping gas, carbon dioxide is a key component of nature's thermostat. If the carbon cycle removes too much CO_2 from the atmosphere, the earth will cool; if the cycle generates too much, the earth will get warmer" (Miller, 1998:113). The earth has developed a natural process for regulating the CO_2 levels in the atmosphere; this is based on carbon storage. Carbon storage takes many forms, such as trapping CO_2 in sedimentary rocks such as limestone, in plants such as rainforests, and the ocean floor. Organic matter and nutrients are stored and recycled through the regulation of carbon sequestration. However, human interventions such as mining, burning of forests, vegetation clearing and fossil fuels, noxious industry etc. disturb these natural processes and release greater volumes of CO_2 into the atmosphere. "While stored, this carbon is not released into the atmosphere as CO_2, unless geomorphological processes expose them to air, e.g. excavation and erosion. Similarly, where carbon is dissolved in water, as the water warms e.g. by more exposure to sunlight, more dissolved CO_2 returns to the atmosphere." (Miller, 1998:113).

1.2.5 Water quality (Regulation)

The riverine zone and its components provide an important service of improving water quality by filtering and trapping pollutants. Pollutants can be reduced through sediment trapping, prolonged exposure to sunlight, carbon trapping and so forth. Further the river channel provides a dilution effect on effluent discharges. Natural river structures such as rapids, riffles, and falls provide aeration of the water. The water quality can be negatively affected by changes in temperature, reduced oxygen availability, altered pH, effluent discharges, dumping and waste, high silt loads, amongst others. These changes in water quality composition affect the ecosystems and biota living in the riverine zone, as well as the usability of the water such as for potable use and irrigation.

1.2.6 Subsistence (Production)

Riverine zones provide socio-economic resources such as food, fuel-wood, reeds for weaving, and medicinal plants that are used by humans for subsistence purposes. The degradation (especially by development or clearing) of riverine zones reduces the ability to produce these resources and services. The loss of access to the river and riparian vegetation negatively impacts these functions.

1.2.7 Cultural, Aesthetic and Recreational (Information / Cultural and Carrier)

Rivers "visually diversify a rural or urban landscape, enhancing landscapes aesthetically, expanding recreational opportunities (Dosskey *et al.*, 1997, Postal and Carpenter 1997, Field *et al.*, 2006 in Soman 2007:3), and provide scientific and educational opportunities" (USDA-NRCS

1999 in Soman 2007:3). Unfortunately a decrease in ecological functions usually results in an inverse increase in the aesthetic and recreational use of water courses, for example the clearing of riparian vegetation provides increased access for fishing and similarly the construction of impoundments results in the increased provision of access for sailing, canoeing, fishing, swimming, model boating, and so forth. The river and riparian vegetation are also used for cultural and religious rituals such as baptisms and wedding traditions.

In summary, not all riparian areas would be able to perform these functions to the same extent. Whilst some may be very good for flood attenuation, others may play more important bank stabilisation roles. The protection of the riverine function requires a suitable buffer to be maintained between land use activities in the terrestrial areas and the possible impacts within the aquatic river channel itself. Maintaining riparian zones – including their naturally dense vegetation - also allows for riverine functions to be maintained. It is important that a riverine area's capacity to provide the functions listed in Table 1.1 are not reduced. On occasion it is better to protect river reaches that have some good function as a priority (see Rutherfurd *et al.*, 1999) than to repair some reaches that have become detrimentally degraded. Many of these areas are best managed as natural areas, rather than being converted to other land uses.

Table 1.1 Summary of riverine functions

Flood zone (Banks)	Flood attenuation	Flood water storage, slowing down, reducing severity
	Sediment trapping	Trap and retain sediment from runoff water
	Habitat provision	Reproduction, shelter, migration corridors
	Carbon storage	Trap carbon as organic soil and peat
	Cultural / Aesthetic/ Recreational use	Fishing, picnic, walking, cycling, not birding, baptisms
	Subsistence	Firewood, reeds for weaving.
Active Channel (In-stream)	Flood attenuation	Flood water storage, slowing down, reducing severity
	Sediment trapping	Trap and retain sediment from runoff water
	Water Quality	Phosphate, Nitrate, Toxicant assimilation
	Aquatic habitat provision	Reproduction, shelter, migration corridors
	Cultural / Aesthetic/ Recreational use	Fishing, swimming, canoeing, sailing
	Subsistence	Fire wood, reads for weaving, fishing.

1.3 The law

Law provides the framework within which all activities are conducted in order to protect state resources and the rights of the citizens. The law should only pose an obstacle should a person not comply, e.g. they breach a provision of the law. Therefore, in determining processes for river rehabilitation or setting rehabilitation objectives there are various applicable laws and legislation, including, constitutional, administrative, criminal and environmental law, that need to be considered in order to prevent further, or rectify, any breaches of the laws protecting rivers. The primary statutes affecting rivers, after the Constitution, are:

- National Environmental Management Act, Act 107 of 1998 (NEMA) and its SEMAs;
- National Water Act, Act 36 of 1998 (NWA), and
- Conservation of Agricultural Resources Act, Act 38 of 1983 (CARA)
- National Heritage Resources Act, Act 25 of 1999 (NHRA)
- National Minerals and Petroleum Resources Act, Act 28 of 2002 (NMPR).

There are several pieces of South African environmental legislation that affect the use-of and impact-to urban rivers. The key activities identified in the legislation as requiring authorisation prior to commencement include:

- Vegetation / Site clearing
- Excavation and erosion (includes dredging, removal, etc.)
- Infilling, impeding and encroachment (includes depositing and storage)
- Discharge
- Bank stabilising / channel straightening
- Abstraction (includes stream flow reduction, transfers, etc.)
- Impoundments (includes storage of water, dams, etc.)
- Diversion
- Structures (including bridges, culverts, jetties, piers, storm water outlets, etc.)
- Canalising and levees
- Alien vegetation infestation

These activities all require authorisation, permits or licences prior to being carried out, in terms of the South African Environmental legislation.

The administrative notices available to officials in terms of the various legislation and spheres of government are summarised in Table 1.2.

Table 1.2 Summary of administrative enforcement mechanisms and responsible institutions

Institution	Applicable Legislation	Mechanism	Objective	Sphere of Government	Enforcement Inspectorate
Department of Water Affairs	National Water Act, Act 36 of 1998	s.19(3) Directive	Prevention and remedying effects of pollution	National, Regional, CMA	Water Control Officer
		s.20(4)(d) Directive	Control of emergency incidents		
		s.53(1) Directive	Rectification of contravention	National, Regional	
Department of Environmental Affairs	National Environmental Management Act, Act 107 of 1998 and SEMAs	s.28(4) Compliance Notice	Duty of care and remediation of significant pollution or degradation of the environment.	National, Provincial	Environmental Management Inspectorate (EMI)
		s.24G Directive	Direct removal and remediation of unauthorised structures		
		s.30(6) Directive	Control of emergency incidents		
		s.31L Compliance Notice	Contravention of the law or a condition of authorisation		
	National Environmental Management: Biodiversity Act, Act 10 of 2004	s.69(2) Directive	Contravention of applicable permit (alien species)	National, Provincial	Competent Authority
		s.73(3) Directive	Contravention of applicable permit (invasive species)		
	National Environmental Management: Waste Act, Act 59 of 208	s.37(1) Directive	Independent site assessment	National, Provincial	Minister or MEC
		s.38(2) Remediation Order	To remediate / rehabilitate		
	Environment Conservation Act, Act 73 of 1989	s.31A Directive	Where environment is damaged, endangered or detrimentally affected.	National, Provincial, Municipal	Government Official
	Mountain Catchment Areas Act, Act 63 of 1970	s.3 Directive	Regulations to conserve land within a defined "Mountain Catchment Area" and 5km buffer.	Provincial	Any duly designated officer of a Department of State
Department of Agriculture,	Conservation of Agricultural Resources Act, Act 43 of 1983	s.7 Directive	To comply with a control measure.	National Municipal	Executive officer and authorised persons

Forestry and Fisheries	GN R1048 in terms of section 6 of the Conservation of Agricultural Resources Act, Act 43 of 1983	s.4(2) Directive s.6(2) Directive s.13(2) Directive s.14(2) Directive s.16(3) Directive	Contraventions of specific control measures	Irrigation Boards	
	National Forest Act, Act 84 of 1998	s.4(8) Written Notice	Breach of a particular standard	National, Provincial	Forest Officer
Department of Mineral Resources	Mineral and Petroleum Resources Development Act, Act 28 of 2002	s.45(1) Directive	Ecological degradation, pollution or environmental damage	National	Minister
		s.46 Instruction	Remedy environmental damage (where no mine owner)		Minister
		s.93(1) Order	Contravention of the Act		Authorised person
South African Heritage Resources Agency	National Heritage Resources Act, Act 25 of 1999	s. 45(1) Compulsory Repair Order	Prevention of disrepair of a heritage resource	Regional	Heritage Inspector SAPS
		s.50(10) Stop Order	Stop or prevent degradation of a heritage resources		
Department of Safety and Security	South African Police Service Act, Act 68 of 1995	No specific written mechanism	Contravention of legislation and constitutional rights	National, Provincial	South African Police Service (SAPS)
National Disaster Management Centre	Disaster Management Act, Act 57 of 2002	s.27(2) Directive	Post-disaster recovery and rehabilitation, and preventing escalation of a disaster	National	Minister (member of cabinet appointed)
		s.41(2) Directive	Post-disaster recovery and rehabilitation, and preventing escalation of a disaster	Regional	Premier of the Province
		s.55(2) Directive	Post-disaster recovery and rehabilitation, and preventing escalation of a disaster	District Municipality	Municipal Council
Local Municipalities	South African Police Service Amendment Act, Act 83 of 1998	J534 Fines	Non-compliance	Local Municipality	Municipal Police
	Applicable Municipal By-laws	J534 Fines By-Law Notice	Non-compliance		
	Environment Conservation Act, Act 73 of 1989	s.31A Directive	Where environment is damaged, endangered or detrimentally affected.		

	National Health Act, Act 61 of 2003	s.83 Compliance Notice	Non-compliance	District Municipality	Environmental Health Inspector

PART 2 - TOOLS

2 LEGISLATION SEARCH TOOL

2.1 About the Legislation Search Tool

The South African environmental legislation affecting riverine systems is both complex and overlapping and at times contradictory. As enforcement officials are only mandated to work within the jurisdiction of their allocated legislation, a tool was developed to assist officials in identifying overlaps with other legislation and therefore overlaps in jurisdiction with other institutions.

The various sections of national legislation related to riverine systems and rehabilitation were identified. Search words (called “tags”) were attached to each of the identified sections of legislation. These sections of legislation were captured into a searchable database. Each section was assigned a set of applicable search tags and the sphere of government responsible for its implementation. Users are able to search specific sections of the legislation or to search the tag words for applicable legislation. The results of these two searches present all the sections of legislation that are applicable or that overlap with the searched section of legislation or the searched tag word. The results pane shows the Act, section reference and text of the legislation, as well as other relevant search tags to the text, and the sphere of government responsible for that section of the legislation.

2.1.1 How it works

The legislation search tool provides two types of search functions as illustrated in Figure 2-1.

The first is where the user is familiar with a particular section of legislation, and the second where the user selects a word to identify what legislation they are looking for.

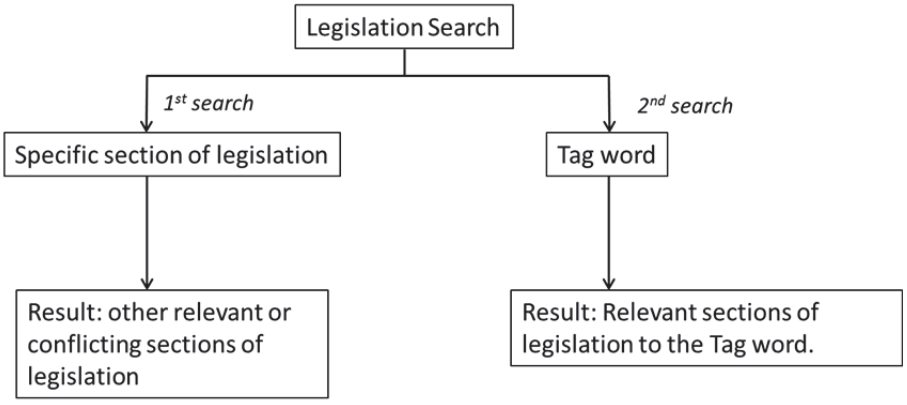


Figure 2-1 Legislation search flow diagram

2.2 How to install the Legislation Search Tool

Step 1: Insert the CD into the CD-ROM drive.

Step 2: Open the CD drive, usually the d:\ drive.

Step 3: Click on the Legislation Search folder.

Step 4: Click on the **LegSearch.exe** file. The program will install automatically. Follow the prompts of the installation.

Step 5: When installation is complete, click on the windows “start” button, select the Legislation Search program, Figure 2-2. Click on Legislation Search to run the program.

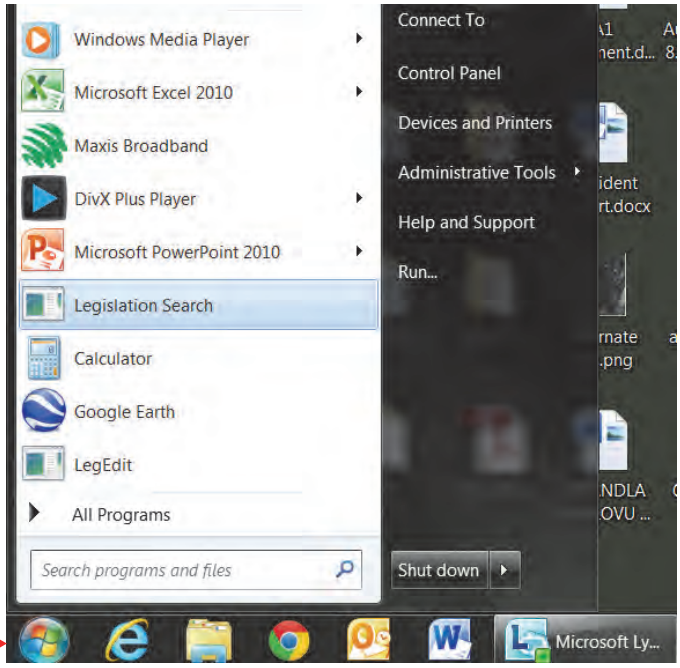
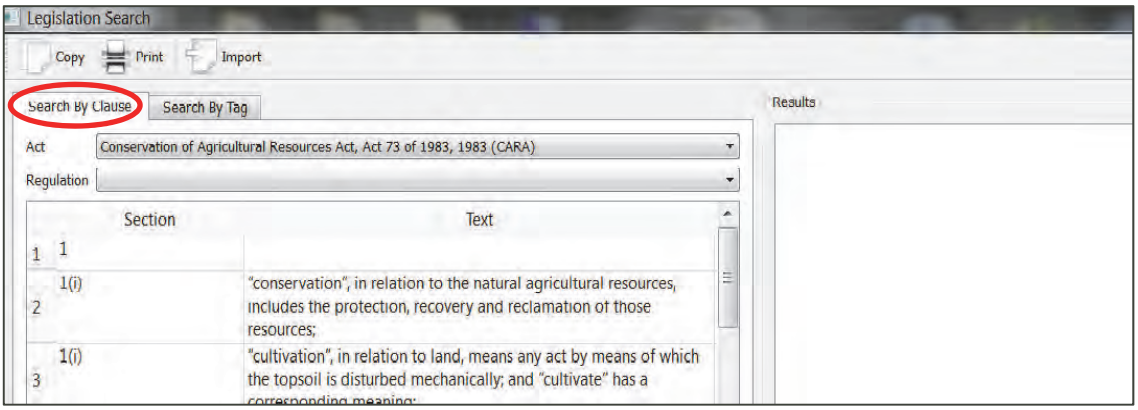


Figure 2-2 Click on “start” icon, select Legislation Search

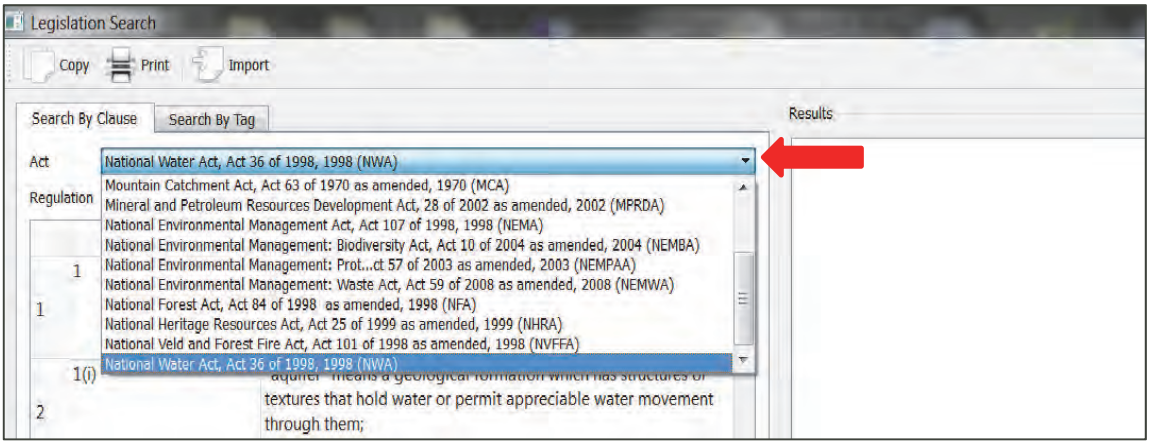
2.3 How to use the Legislation Search Tool

Step 1: Open the Legislation search tool. Select the type of search.

Search type 1: Specific legislation search

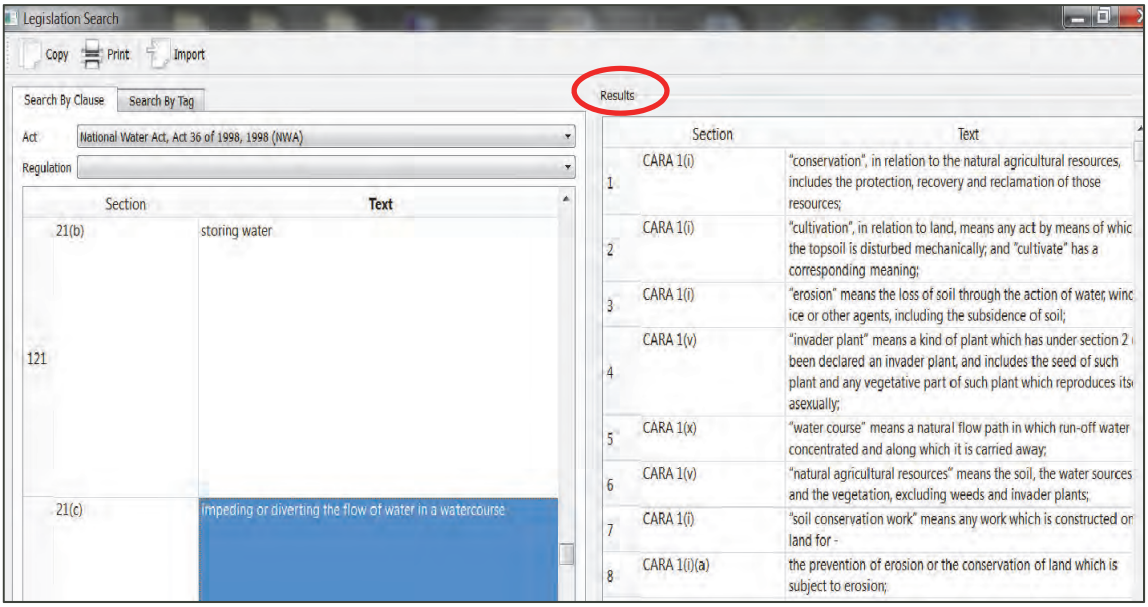


Step 2: Select legislation



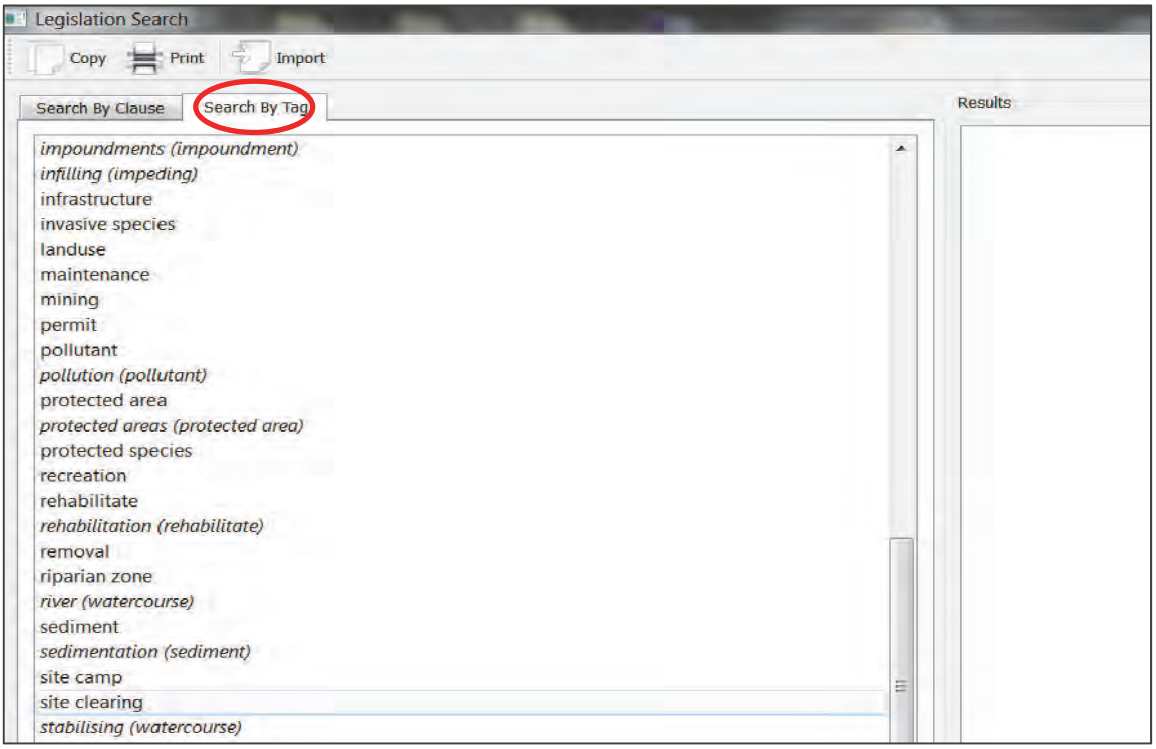
Step 3: Scroll down and select appropriate section of the legislation.

Step 4: Click on selected section. Result appears on right hand pane.

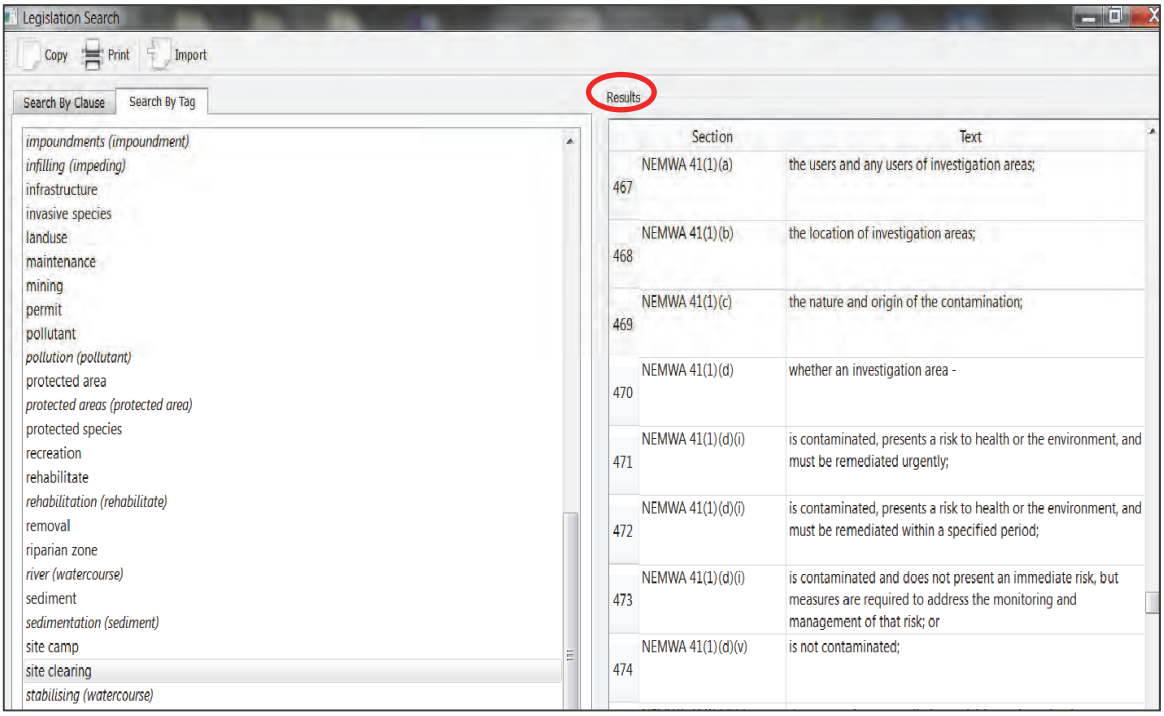


Search Type 2: Search by Tag word

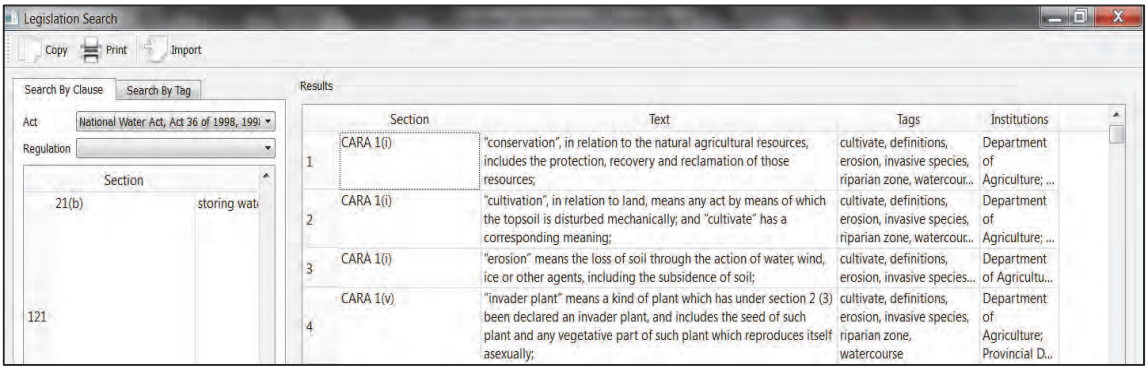
Step 1: Select “Search By Tag”.



Step 2: Scroll down the list of words and select appropriate Tag word. Results appear on the right hand pane.



Note: the size of the panes can be adjusted to view all the information in the results pane. Scroll over the centre column between the search and results panes, when the double sided arrow appears, left-click on the mouse and hold, and drag the mouse (box border) to the left or right as you require. The viewing pane of the results box will increase or decrease respectively.



2.4 Updating the Legislation Search Tool

The legislation captured in the database was the legislation on the day of compilation. The environmental legislation is regularly revised and amended. Officials should contact the National Department of Environmental Affairs for the updated database of environmental legislation if they are unsure of the latest amendments.

3 SITE ASSESSMENT FORM

3.1 About the Site Assessment Form

When conducting site inspections there is a Standard Operating Procedure (SOP) for Environmental Management Inspectors (EMIs) (DEA, 2010). This SOP, however, does not specify what indicators to assess to determine the resultant environmental impact of non-compliant activities, but rather serves as a guide as how to record samples, photos, protocols etc. Further as different institutions have differing objectives the information they are inspecting may differ between enforcement officials. In an effort to standardise site assessments that involve urban rivers this research developed a Site Assessment Form (SAF). The SAF provides the uniform collection of information regarding impacts to the river by all enforcement officials. The form will serve as part of the site inspection report and additional notes, photos, etc. can still be attached to the form. As the form is standardised this enables easy comparison of results between the initial inspection and follow-up monitoring inspections. Should there be a change in officials dealing with the case the original inspection observations are easily and clearly reported on. This is based on “layman” science, to cater for the current skills of enforcement officials.

3.2 The Site Assessment Procedure

When responding to a complaint or compliance inspection, the officials should conduct a site assessment as part of the initial site inspection, Figure 3-1. This involves completing the Site Assessment Form while inspecting the activities on site. Additional notes (including photos, site layout diagram, sample results, etc.) from the site inspection should be attached to the completed Site Assessment Form to compile the site inspection report. A site assessment should be conducted for the specific site, as well as for a site further upstream on the same river in order to provide a reference point. If the site is very large, with several hundred metres of river reach, or there are several activities impacting on the watercourse, the complete the assessment several times, i.e. 1 per 100m, or 1 per activity. Be sure to mark each assessed area on the site layout diagram. When back in the office it is important for the officials to check whether the activities in question also fall into the jurisdiction of adjacent legislation and institutions, this can be done by carrying out a search on the Legislation Search Tool. Once the Site Assessment Form is completed electronically, the Dashboard Tool will indicate the disturbances, by which activities, to the riverine functions on the specific site. Based on the findings of the Site Assessment Form and the result of the Dashboard Tool, the officials can draft the warning letter (pre-compliance, pre-directive) and request the necessary specialist studies to be carried out to inform the rehabilitation plan.

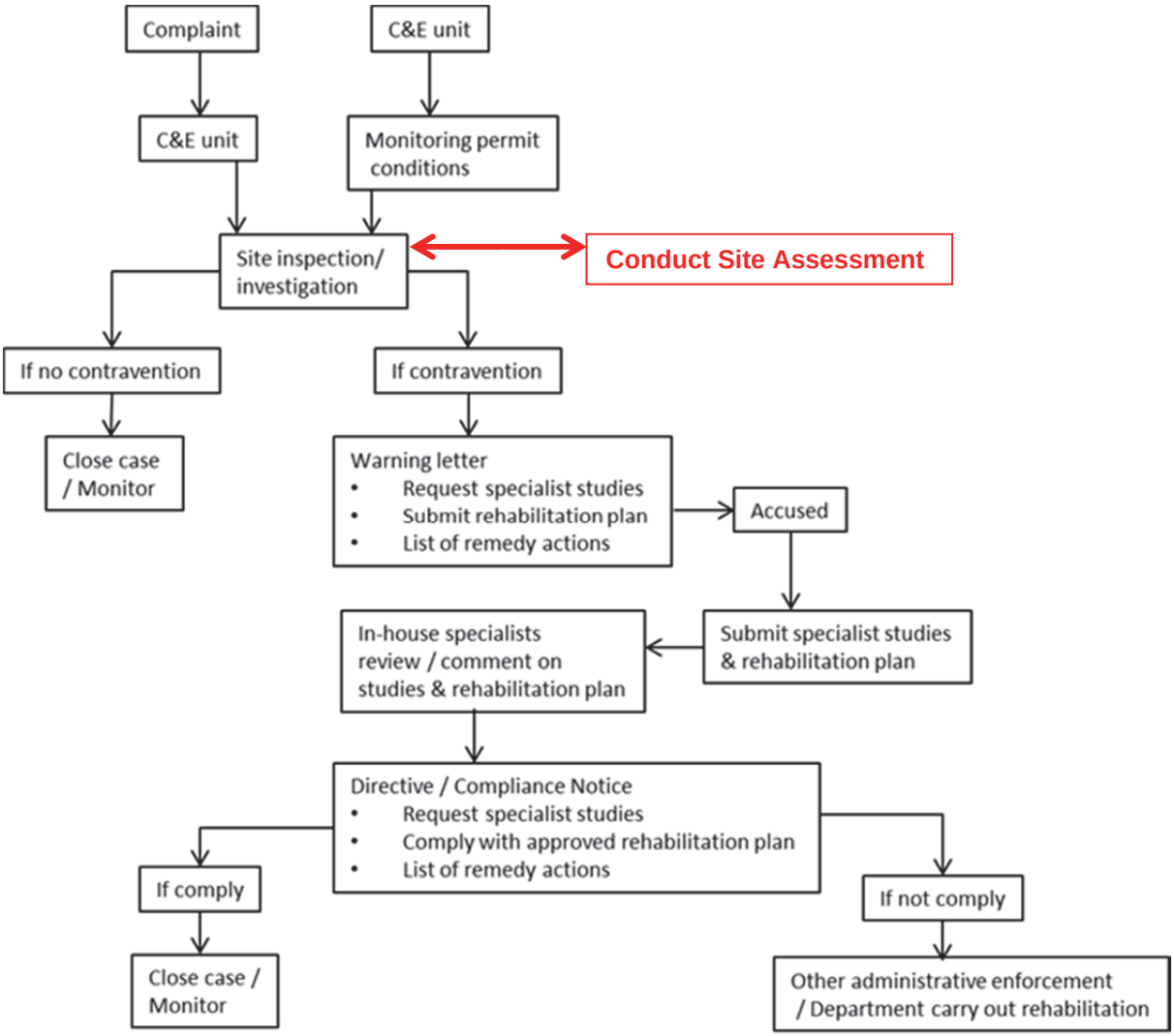


Figure 3-1 Basic case procedure

3.3 Equipment

When conducting site inspections, officials should always adhere to the Standard Operating Procedure for site inspections (refer to section Additional Guides) and to the recommended Personal Protective Equipment (PPE) advised on site, Figure 3-2. As a basic, officials should wear steel toe-capped boots, wear gloves when handling samples, if necessary wear protective goggles, gloves and breathing mask, as well as wear a hard hat and overalls or protective clothing. When working around water and liquids, officials should be vigilant for their own safety and that of their colleagues and comply with necessary health and safety protocols.

Figure 3-2 Personal protective equipment signs

Other necessary equipment includes a camera and GPS to record features on the site, a ruler and tape measure to take measurements, notebook and pen/pencil to record observations on site, and HTH dipsticks to test the water pH. A diagram of the site should be drawn (the Site Assessment Form makes provision for this diagram). The diagram should indicate useful and important information about the site e.g. the location of buildings and activities; storage/dumping of waste/ effluent/ substances; discharge outlets, storm water drains, etc. as well the different areas of assessment. Photographs of the various useful and important aspects of the site should also be taken. All photographs should be dated, and be referenced with GPS points and noted on the site diagram.

3.4 Completing the Site Assessment Form

The Site Assessment Form (the form) Figure 3-3, can be completed in hardcopy (on paper) in the field, but should then be captured electronically in the Dashboard Tool when back in the office in order for the Dashboard Tool to calculate the results. Field sheets can be printed by opening the cd and the pdf document **Field Form**.

The Field Form includes the options of measures on the form per indicator to enable the official to familiarize themselves with the characteristics of the site. Where an official is unsure of the meaning or description of the measures, they should refer to this Guideline. If they are still unsure, they should consult an in-house specialist such as an ecologist, for clarity or assistance.

Note when completing the Field Form that the left bank refers to the left bank when looking downstream.

SITE ASSESSMENT FORM

Section 1: Record of Inspection				
Site name:				
Site description:				
GPS Coordinates start of reach: *(WGS84, decimal degree format)*				
GPS Coordinates end of reach: *(WGS84, decimal degree format)*				
Date of Inspection:				
Inspection number:				
Inspector name:				
Weather on day of inspection?				
Weather 2 days prior?				
Does the site include?	Bed only	Left bank and bed	Right bank and bed	Both banks
Is the reach of river near the?	Source	Foothills	Flat lands	Sea/estuary

Section 2: Site Description

Indicators		Left Flood Bank			Right Flood Bank	
	Land use type	**Measure**	**% cover**		**Measure**	**% Cover**
Land use type and % cover	Agriculture					
	Forestry					
	Education					
	Mining					
	Recreational / Open space					
	Commercial					
	Industrial (incl. WWTW)					
	Residential					

		Left Flood Bank			Right Flood Bank	
		Type	**% cover**		**Type**	**% cover**
Type of ground cover and % cover	Dominant ground cover type					
	Other					
	Other					
	Other					
	Other					

		Left Flood Bank	Active Channel	Right Flood Bank
Geomorphic character	Height of vertical banks (60°-90°)			
	Channel substrate description			

		Left Flood Bank		In-stream		Right Flood Bank	
		Type	**Cover**	**Type**	**Cover**	**Type**	**Cover**
Riverine vegetation composition	Dominant vegetation type						
	Other						
	Other						

Section 3: Activities on the site	
Which of the following activities are taking place on site?	**Yes / No**
Vegetation / Site clearing	
Excavation / erosion (dredging, removal, etc.)	
Infilling, impeding, encroachment (includes depositing, dumping, storage)	
Discharge	
Bank stabilising / channel straightening	
Abstraction/ stream flow reduction / transfers	
Impoundments (includes storage of water, dams, etc.)	
Diverting of stream flow (includes for irrigation)	
Structures (bridges, jetties, piers, storm water outlets, etc.)	
Canalising / levees (flood prevention-banks)	
Alien and/or invasive vegetation infestation	

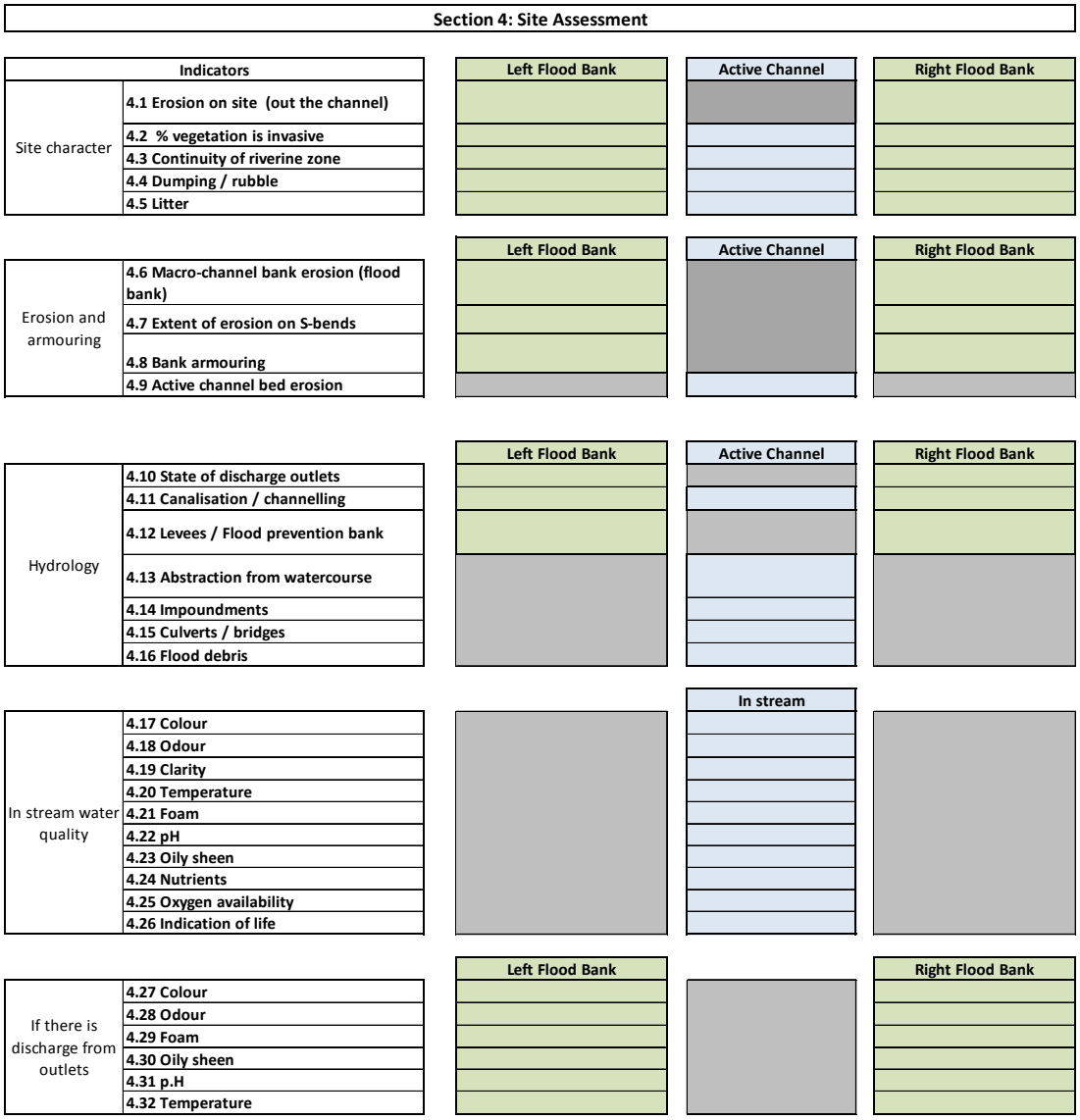


Figure 3-3 Site Assessment Form/ Field Form

3.5 The Site Assessment Form

The Site Assessment Form (the form) is comprised of 5 sections.

3.5.1 Section 1: Record of Inspection

These are the details of the assessment, Figure 3-4: where the site is located, the case/file name, which inspector/s are conducting the site assessment, the assessment number of site (e.g. initial assessment, follow up monitoring 1, follow up 2, etc.), the weather on the day of assessment and the weather on the previous two days prior to the assessment. As well as what sections of the river channel are included in the assessment, and where in the catchment is the site located i.e. source, foot hills, etc.; delete the option not applicable.

SITE ASSESSMENT FORM

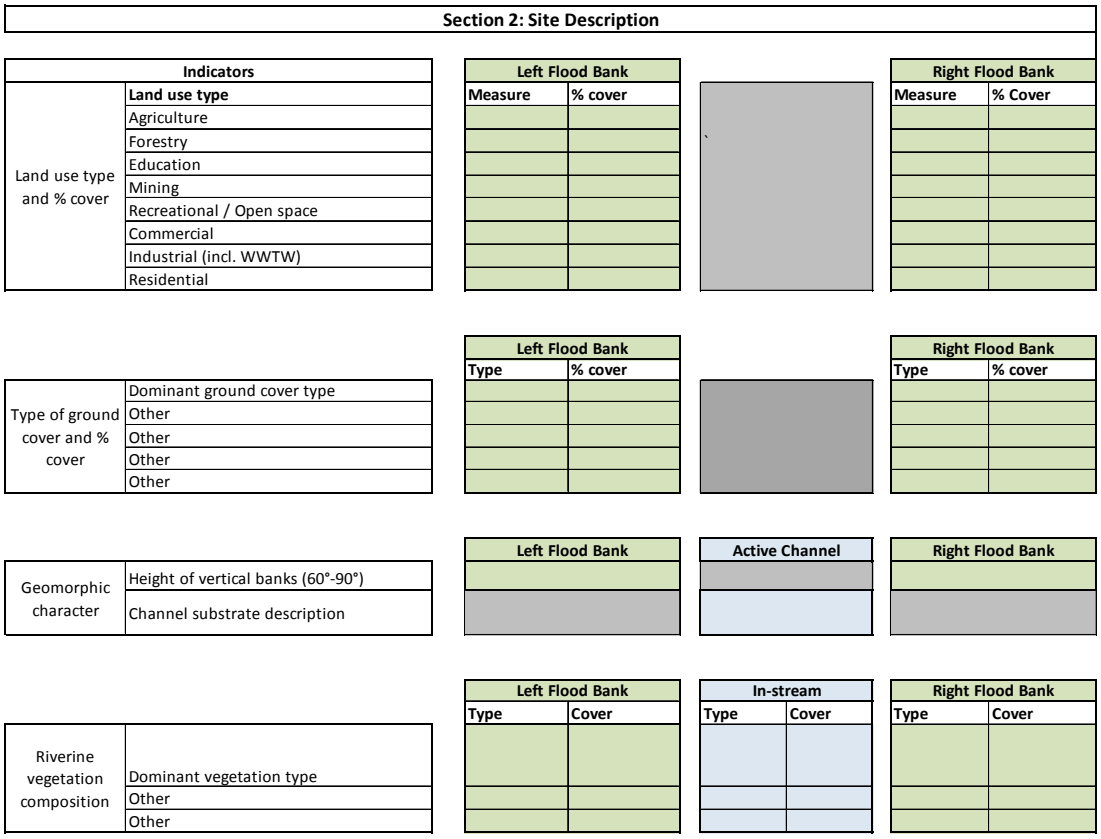
Section 1: Record of Insepction				
Site name:	**Emmerentia Dam**			
Site description:	Tributary of Braamfontein Spruit			
GPS Coordinates start of reach: *(WGS84, decimal degree format)*				
GPS Coordinates end of reach: *(WGS84, decimal degree format)*				
Date of Inspection:	19/03/2013			
Inspection number:	1 - initial inspection			
Inspector name:	Jack Black			
Weather on day of inspection?	Sunny and warm			
Weather 2 days prior?	Raining, overcast, cold			
Does the site include?	Bed only	Left bank and bed	Right bank and bed	Both banks X
Is the reach of river near the?	Source	Foothills X	Flat lands	Sea/estuary

Figure 3-4 Site Assessment Form Section 1: Record of Inspection

3.5.2 Section 2: Site Description

The Site Description provides a record of the description of the site, per flood bank (green columns) and the active channel (blue column) where relevant. If a zone does not have a coloured block for a particular indicator, then that zone does not need to be recorded for that specific indicator. For example, height of vertical banks has a green block for left and right flood banks, but no blue box for active channel, thus only the flood banks require a measure of description. Similarly the channel substrate is only found in the active channel and not on the flood banks, therefore only a description for active channel is necessary.

The site description, Figure 3-5, includes: the land use and % cover of land use on the site; the type of ground cover e.g. pervious, paved, etc., and its % cover; geomorphic characteristics such as height of the river banks and the description of the channel substrate; and the dominant types of riverine vegetation and % cover of each. The different descriptions are explained in more detail in section 4.6 of this chapter.



Section 2: Site Description									
Indicators		Left Flood Bank				Right Flood Bank			
	Land use type	Measure	% cover			Measure	% Cover		
Land use type and % cover	Agriculture								
	Forestry								
	Education								
	Mining								
	Recreational / Open space								
	Commercial								
	Industrial (incl. WWTW)								
	Residential								
		Left Flood Bank				Right Flood Bank			
		Type	% cover			Type	% cover		
Type of ground cover and % cover	Dominant ground cover type								
	Other								
	Other								
	Other								
	Other								
		Left Flood Bank		Active Channel		Right Flood Bank			
Geomorphic character	Height of vertical banks (60°-90°)								
	Channel substrate description								
		Left Flood Bank		In-stream		Right Flood Bank			
		Type	Cover	Type	Cover	Type	Cover		
Riverine vegetation composition	Dominant vegetation type								
	Other								
	Other								

Figure 3-5 Site Assessment Form Section 2: Site Description

3.5.3 Section 3: Activities on the Site

The third section, Figure 3-6, refers to the listed activities that are observed or have taken place on the site at the time of assessment. The officials are required to indicate yes or no as to which activities, or evidence of which activities are observed during the site assessment.

Section 3: Activities on the site	
Which of the following activities are taking place on site?	**Yes / No**
Vegetation / Site clearing	
Excavation / erosion (dredging, removal, etc.)	
Infilling, impeding, encroachment (includes depositing, dumping, storage)	
Discharge	
Bank stabilising / channel straightening	
Abstraction/ stream flow reduction / transfers	
Impoundments (includes storage of water, dams, etc.)	
Diverting of stream flow (includes for irrigation)	
Structures (bridges, jetties, piers, storm water outlets, etc.)	
Canalising / levees (flood prevention-banks)	
Alien and/or invasive vegetation infestation	

Figure 3-6 Site Assessment Form Section 3: Activities on the site

3.5.4 Section 4: Site Assessment

Section 4, Figure 3-7, of the form comprises the actual site assessment. The criteria are completed based on the official's observations on the site. The official selects the best description from the provided measures for each of the indicators per left flood bank, active channel, and right flood bank as required. The provided measures are included on the field form for ease of reference, and are elaborated on in Section 3.6 Assessing the Site.

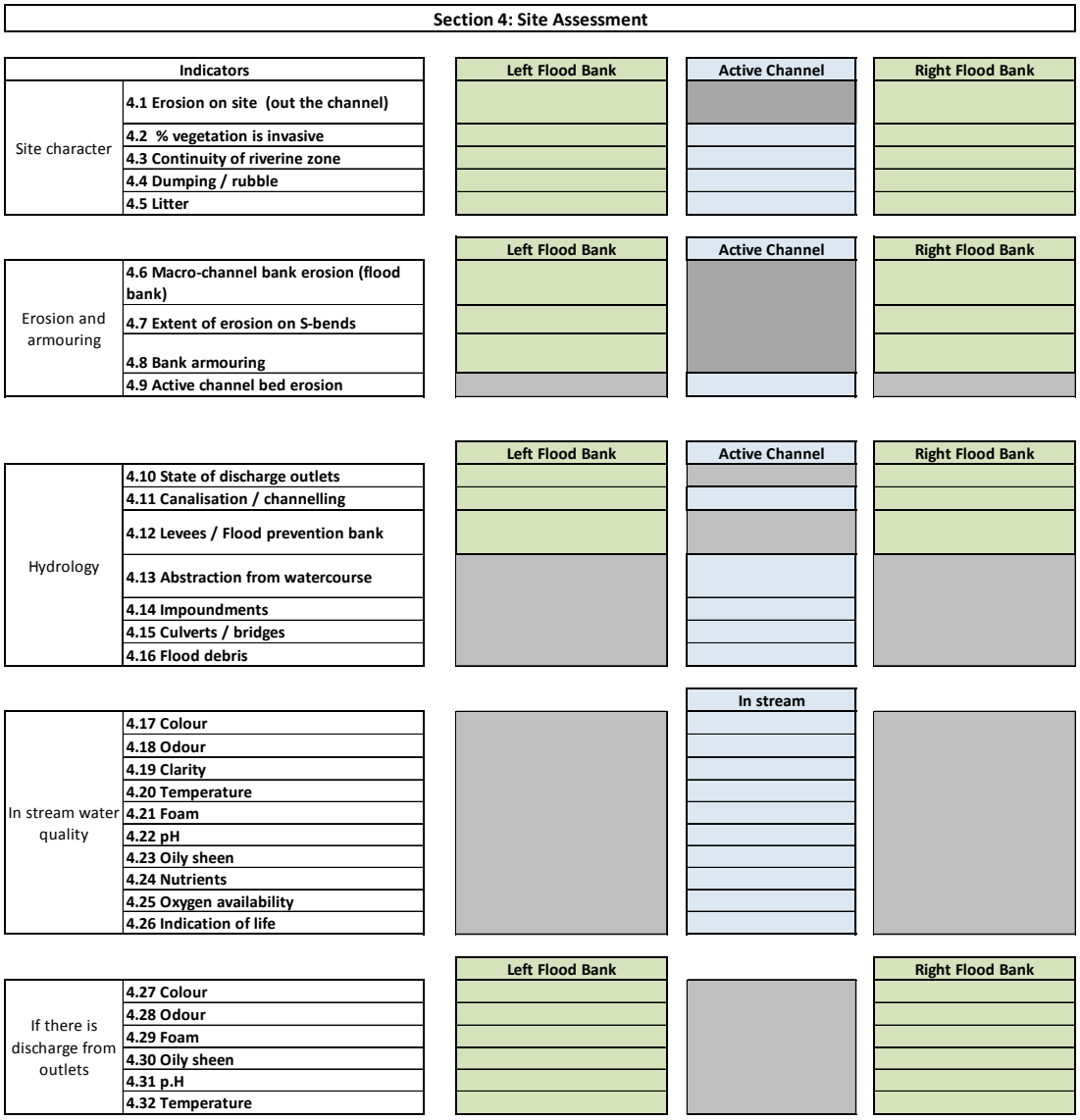


Figure 3-7 Site Assessment Form Section 4: Site Assessment

3.5.5 Section 5: Additional Information

Section 5 provides for any additional information such as the site layout diagram, and any additional notes such as number of samples collected, reports/documentation collected, or other observations of the site not captured in sections 2-4 of the field form.

3.6 Assessing the site

The criteria, indicators, measures and concepts that the Site Assessment Form are based on, are detailed further in this section.

SECTION 2: SITE DESCRIPTION

The criteria and indicators in Section 2 collect information about the description of the site. This is important for record keeping purposes, so when further monitoring of the site is carried out, changes to the site can be monitored by reviewing the changes in the scale of the measures. The site description is composed of indicators of the land use and percentage (%) cover of land use on the site; the type of ground cover e.g. pervious, paved, etc., and its % cover; geomorphic characteristics such as height of steep river banks and the description of the channel substrate; and the dominant types of riverine vegetation and % cover of each.

3.6.1 Land use type and % (percentage) cover

Indicators		Left Flood Bank			Right Flood Bank	
	Activity	Activity	% cover		Activity	% Cover
Landuse type and % cover	Agriculture					
	Forestry					
	Education					
	Mining					
	Recreational / Open space					
	Commercial					
	Industrial					
	Residential					

The City of Cape Town (2009b) has observed that watercourses in urban areas are important to a city's biodiversity network, integral to the stormwater management system and generate recreational and economic opportunities. However, urbanisation has greatly impacted natural watercourses. Land use impacts the riparian corridor in several ways, such as water quality due to runoff and effluent discharge, increased flow due to increased runoff, changes in biodiversity due to altered characteristics, etc. Many of the criteria and indicators still to be discussed in this section address these particular impacts.

The indicators of land use type look at the anthropogenic (human-induced) changes in the catchment and adjacent to the riverine corridor. As the land uses cannot be rehabilitated, these indicators are not quantifiably measured. The type of land use and the percentage of the site covered by the identified land uses are recorded as part of the site description. The estimated percentage cover relates to the proportion of the site that is occupied or covered by each of the land use types and is measured according to Table 3.1. More than one type of land use may occur on a site.

Table 3.1 Measure of land use % (percentage) cover

Measure	Description
0-20%	Little to no cover (less than ¼)
21-50%	Some activity, less than majority of site (¼ to ½ the site)
51-80%	Majority of site, with some areas excluded (½ to ¾ of the site)
81-100%	Almost, to full cover

The indicators for land use include both the type and the estimated percentage cover of the activity on the site. The land use type description is recorded according to Table 3.2, not the different descriptions per land use. The land use of the specific site is recorded for the left-hand side and the right-hand side of the riverine zone. There is no land use in the active channel and therefore this is not recorded.

Table 3.2 Measure of land use type

Measure	Description
Agriculture	
Dry	Agriculture: dry cultivation (no irrigation)
Irrigated	Agriculture: irrigated cultivation
Livestock	Agriculture: livestock farming
Mix irrigated	Agriculture: mixture livestock and irrigated cultivation
Mix dry	Agriculture: mixture livestock and dry cultivation
Education	
Fields	Educational buildings and sports fields
No fields	Educational buildings with no sports fields
Forestry	
Woodlot	Forestry: woodlot, cluster of trees
Indigenous	Forestry: Indigenous plantation
Plantation	Forestry: alien plantation (Eucalyptus, pine, etc.); Orchards
Mining	
Surface	Mining: surface mining (includes, quarries and borrow pits)
Underground	Mining: underground mining
Sand	Mining: sand mining
Recreational / Open Space	
Open	Recreational: sports fields, nature reserve, park, etc.
Closed	Recreational: other; buildings, developed, etc.
Government	Recreational: military bases
Commercial	
Commercial	Commercial: includes office parks, shops, medical centres, hotels, banks, etc.
Industrial (including WWTW)	
Heavy	Industrial: heavy / toxic, includes production of energy, chemicals, steel, plastics, oil refinery, etc., wastewater treatment works (WWTW)
Light	Industrial: light includes manufacture of consumer products, clothes, electronics, furniture, etc.
Residential	
Low	Residential: Low density = < 4 houses per hectare
Medium	Residential: Medium density = 5-25 houses per hectare
High	Residential: High density = >26 houses per hectare

The activities within the land use type may contribute to the degradation of ecosystem functions, and these can be remedied through an Environmental Management Plan (EMP), but the land use itself does not necessarily constitute an *illegal* activity.

The Federal Interagency Stream Corridor Restoration Working Group (FISRWG) (1998) includes a summary of the different types of land use and their impacts to the riverine zone. These aspects of the different land use types are replicated here.

3.6.1.1 Agriculture

Agriculture includes the regular tillage of soil and planting of uniform crops for regular production, as well as domestic livestock grazing. FISRWG (2001:3-14) conclude that agricultural activities have generally resulted in encroachment on stream corridors, resulting in significant changes to the structure and mix of functions usually found in stable systems. In recent years there has been a move away from regular tilling of agricultural land in an effort to reduce erosion and soil loss.

Agricultural land use type includes dry land cultivation (Dry), irrigated cultivation (Irrigated), livestock (Livestock) and combinations thereof (Mix irrigated or Mix Dry).

According to FISRWG (2001:3-14) disturbance activities related to agriculture include:

- Vegetation clearing – farmers often crop as much productive land as possible to enhance economic returns; therefore riparian vegetation is sacrificed to increase arable area. Vegetation removal from stream banks, floodplains and uplands often conflicts with the hydrological and geomorphic functions of stream corridors. These disturbances can result in sheet, rill and gully erosion, reduced infiltration, increased upland surface runoff and transport of contaminants, increased bank erosion, unstable stream channels and impaired habitat.
- In-stream modifications – flood-control structures and channel modifications e.g. channel straightening to square-up fields, implemented to protect agricultural systems further disrupt the geomorphic and hydrologic characteristics of stream corridors and associated uplands. Some of the potential effects caused by these changes are impaired upland or floodplain surface and subsurface flow; increased water temperature, turbidity, and pH; incised channels; lower ground water elevations; stream bank failure; and loss of habitat for aquatic and terrestrial species.
- Soil exposure and compaction – tillage and soil compaction interfere with the soil's capacity to partition and regulate the flow of water in the landscape, increase surface runoff, and decrease the water-holding capacity of soils.
- Irrigation and drainage (including abstraction) – diverting surface water for irrigation and depleting aquifers have brought about major change in stream corridors. Agricultural drainage, which allows the conversion of wetland soils to agricultural production, lowers the water table. Tile drainage systems concentrate groundwater discharge to point sources, in contrast to a diffuse source of seeps and springs in more natural discharges. These practices have eliminated or fragmented habitat and natural filtration systems needed to slow and purify runoff.
- Sediment and contaminants – disturbance of soil associated with agriculture generates runoff polluted with sediment, a major nonpoint source pollutant. Pesticides and nutrients (mainly nitrogen, phosphorous, and potassium) applied during the growing season can leach into ground water or flow in surface water to stream corridors, either dissolved or absorbed to soil particles. Further, improper storage and application of animal waste from concentrated animal production facilities are potential sources of chemical and bacterial contaminants to stream corridors.
- Soil salinity – is a naturally occurring phenomenon found in most floodplains and other low lying areas of wet soils, or shallow water tables. Agricultural activities in such landscapes can increase the rate of soil salinization by changing vegetation patterns or by applying irrigation water without adequate drainage. Since crops do not use up the salts, they accumulate in the soil.

Further to agricultural land use, domestic livestock grazing has its own impacts. Stream corridors are particularly attractive to livestock (including cattle, sheep and goats) as they are generally highly productive, providing ample forage, water is close at hand, shade is available to cool the area, and slopes are relatively gentle. Poorly managed grazing systems can result in loss of vegetative cover due to its consumption and trampling and stream bank erosion from the presence of livestock. FISRWG (2001:3-18) identified the following disturbance activities associated with domestic livestock grazing:

- Loss of vegetative cover – reduced vegetative cover can increase soil compaction and decrease the depth of and productivity of topsoil. Reduced cover decreases shade and increases water temperatures. Sediment from upland or stream bank erosion can reduce water quality through increases in turbidity and attached chemicals. Where animal

concentrations are large, fecal material can increase nutrient loads above standards and introduce bacteria and pathogens. Dissolved oxygen reductions can result from high temperature and nutrient-rich water. Extensive loss of ground cover can decrease infiltration and increase runoff, leading to higher flood peaks and additional runoff volume.

- Physical impacts of livestock – trampling, trailing and similar activities of livestock physically impact stream corridors, especially by compaction. Trailing can break down stream banks, causing bank failure and increasing sedimentation. Excessive trailing can result in gully formation and eventual channel extension and migration.

3.6.1.2 Forestry

Activities associated with forestry activities include site preparation, the removal of trees, and transportation of products. These have similar disturbance activities and resultant impacts on riparian corridors as agricultural activities. Forestry may include woodlots for basic energy supply and consumptive use, indigenous forests, and plantation forests for the productive use of wood. The plantation forests are usually alien or invasive species such as eucalyptus (blue gum) or pine trees as they are quick growing.

3.6.1.3 Mining

Mining activities refer to surface mining, including quarries and borrow pits, underground mines and sand mining. Land use activities of mining such as exploration, extraction, processing and transportation (including of coal, minerals, sand and gravel, and other materials) has historically had and still continues to have a devastating impact on stream corridors. The FISRWG (2001:3-19) identified the following disturbance activities related to mining land use:

- Vegetative clearing – mining activities (including the mine site, transportation facilities, processing plant, tailings piles, etc.) requires the removal of large areas of vegetation; the reduced shade can increase water temperatures which can harm aquatic species. Loss of cover vegetation, poor-quality water, changes in food availability, disruption of migration patterns, and similar difficulties can have serious effects on terrestrial wildlife. Species composition may change significantly with a shift to more tolerant species.
- Soil disturbance – mining activities cause extensive changes to soils including loss of topsoil and soil compaction. Covering of soils by materials such as tailings dams or mine dumps further reduces the area of productive soils. These activities decrease infiltration, increase runoff usually containing contaminants, accelerate erosion, and increase sedimentation.
- Altered hydrology – surface mining is, perhaps, the only land use with greater capacity to change the hydrologic regime of a stream than urbanisation. Increased runoff and decreased surface roughness will cause peaks earlier in the hydrograph with steeper rising and falling flow rates. Once-perennial streams may become intermittent or ephemeral as base flow decreases. Sand mining releases water that was stored in the stream banks, into the flow, thereby desiccating the adjacent wetlands.
- Contaminants – water and soils are contaminated by acid mine drainage (AMD) and the materials and chemicals used in mining activities. Many hard rock mines are located in iron sulfide deposits. Upon exposure to water and air, such deposits undergo sulfide oxidation with attendant release of iron, toxic metals (e.g. lead, copper, zinc), and excessive acidity. Toxic runoff or precipitates can kill streamside vegetation or can cause a shift to species more tolerant of mining conditions. This affects habitat required by many species for cover, food, and reproduction. Aquatic habitat suffers from several factors. AMD can coat stream bottoms with iron precipitates, thereby affecting the habitat for bottom-dwelling and feeding organisms. AMD also adds sulfuric acid to the water,

killing aquatic life. The low pH alone can be toxic, and most metals exhibit higher solubility and more bioavailability under acidic conditions. Precipitates coating stream bottom can eliminate places for egg survival. Fish that do hatch may face hostile stream conditions due to poor water quality, loss of cover, and limited food base." (FISRGW, 2001:3-21).

3.6.1.4 Recreational and open space

Recreational areas if grassed or vegetated provide a good buffer for the riparian habitat and provide flood storage area, however recreational areas are usually vegetated with alien and invasive vegetation especially Kikuyu grass. According to the FISRWG (2001:3-21), the amount of impacts caused by recreation depends on soil type, vegetation cover, topography, and intensity of use. Various forms of foot and vehicular traffic associated with recreational activities can damage riparian vegetation and soil structure. All-terrain vehicles, such as quad bikes, scramblers, 4x4, mountain bikes, etc., can cause increased erosion and habitat reduction. At locations heavily used by hikers, cyclists and horse riders, reduced infiltration due to soil compaction and subsequent surface runoff can result in increased sediment loading to the stream (Cole and Marion, 1988). In areas where the stream can support recreational motor boating, the NRC (1992) warn that propeller wash and water displacement can disrupt and re-suspend bottom sediments, increase bank erosion, and disorient or injure sensitive aquatic species; further, waste discharges or accidental spills from boats or loading facilities can also contribute pollutants to the system.

While not necessarily recreational, land zoned as Government, usually includes military bases. These are usually well buffered by vegetation and have similar impacts as recreational land use.

3.6.1.5 Industrial

Industrial land use has similar hydrological impacts as urbanisation due to the conversion of open land to impervious surfaces. However, the most significant impact from industrial land use is in the effluent that is discharged from industrial process into water courses. These are summarised in Table 3.3. Further the heating of water in the industrial processes leading to the discharge of heated effluent can seriously impact on the habitat and water quality of the watercourse; this is discussed under the Temperature indicator in the Water Quality criteria.

Table 3.3 Toxic substances present in industrial effluents (adapted from DWAF (1996) and Hellawell (1986)).

Substance	Potential environmental effect	Source
Acids	• High acidity increases the corrosive power of the river, especially on concrete • High acidity is an unsuitable habitat for common biodiversity species	Chemical industries, battery manufacture, mine waters, iron and copper pickling wastes, brewing, textiles, insecticide manufacture
Alkalis	• Alkalinity of water impacts on the ability of the water to neutralize acids	Kiering of cotton and straw, cotton mercerizing, wool scouring, laundries
Ammonia	• Fish experience a loss of equilibrium, hyper-excitability, an increased breathing rate, an increased cardiac output and oxygen intake, and in extreme cases convulsions, coma and death • Other effects include a reduction in hatching success, reduction in growth rate and morphological development, and pathological changes in tissue of gills, liver and kidneys	Gas and coke production, chemical industries

Arsenic	• Reduced growth and reproduction in both fish and invertebrate populations • Causes behavioural changes such as reduced migration in fish • Human consumption of contaminated fish can pose a health risk	Phosphate and fertilizer manufacturer, sheep dipping
Atrazine	• Results in chlorosis and death • Decreased growth and reproduction in invertebrates, while a mild skin irritant in mammals • Leads to imbalances in aquatic food-webs	Systemic herbicide
Cadmium	• Large quantities are toxic • Inhibits bone repair mechanisms, is teratogenic, mutagenic and carcinogenic	Metal plating, phosphate fertilizers
Chlorine (free)	• adverse changes in blood chemistry, damage to gills, decreased growth rate, and restlessness preceding loss of equilibrium and death • Invertebrates become immobile, and exhibit reduced reproduction and reduced survival on exposure • phytoplankton experiences reduced rates of photosynthesis and respiration	Paper mills, textile bleaching, laundries
Chromium	• Temporarily reduced growth phase for young fish	Metal plating, chrome tanning, anodizing, rubber manufacture
Copper	• Large quantities are toxic; • Causes brain damage in mammals	Plating, pickling, textile (rayon) manufacture
Cyanide	• Interferes with aerobic respiration	Iron and steel manufacture, gas production, plating, case hardening, non-ferrous metal production, metal cleaning (e.g. gold)
Endosulfan	• Effects include mortality, birth defects, tumours and genetic changes and altered behaviour	Insecticide and pesticides
Fluoride	• Skeletal fluorosis	Phosphate fertilizer production, flue gas scrubbing, glass etching
Formaldehyde	• Skin, and respiratory tract irritant • Causes severe injury to the gastrointestinal tract; • disrupts cellular functions which can result in cell death	Synthetic resin manufacture, antibiotic manufacture
Hydrocarbons	• Suffocates aquatic species and reduces dissolved oxygen • Visible sheen on the surface of the water	Petroleum-based substances, Petroleum refining, organic chemical manufacture, rubber manufacture, engineering works, textiles
Iron	• Large quantities are toxic	Coke and coal, acid mine drainage, mineral processing, sewage, landfill leachates and the corrosion of iron and steel
Lead	• Large quantities are toxic • Interferes with haemoglobin synthesis • Affects membrane permeability and can result in suffocation and death • Inhibits some of the enzymes involved in energy metabolism • Can cause spinal deformities	Paint manufacture, battery manufacture
Mercury	• Severely poisonous; • Neurological disturbances, renal dysfunction, damage to the reproductive systems	Paint, fungicide, paper and pulp, electrical

Nickel	• Toxic effects include the death of animals, birds, or fish, and death or low growth rate in plants	Metal plating, iron and steel manufacture
Nitrogen (inorganic)	• Hypertrophic conditions • Low levels of species diversity	Agricultural fertilizers, organic industrial wastes
Phenols	• Nerve poison giving rise to an increased blood supply and respiratory rates, colour changes, increased secretion of mucus, reduction in growth, general inflammation, and a loss of balance and co-ordination; • Death may occur quickly or following a period of depressed activity and occasional convulsions	Gas and coke production, synthetic resin manufacture, petroleum refining, tar distillation, chemical industries, textiles, tanning, iron and steel, glass manufacture, fossil fuel electricity generation, rubber processing
Selenium	• Reduced reproduction, changes in feeding behaviour and equilibrium, pathological changes, deformities, haematological (blood) changes and death	Paint manufacture; food processing, steel, pesticides, dye manufacturing, rubber manufacturing, and metal alloy and electrical apparatus manufacturing
Sulphides	• Toxic as hydrogen sulphide, and causes gill damage and respiratory arrest, and makes the fish susceptible to parasite attack and disease	Leather tanning and finishing, rubber processing, gas production, rayon manufacture, dyeing, pulp processing and paper mills, viscose film manufacture
Toxic Organics	• Resistant to environmental degradation • Impacts on endocrine, reproduction and immune systems	Solvents, pesticides, polyvinyl chloride, and pharmaceuticals
Zinc	• Can cause death due to formation of insoluble compounds in the mucus covering the gills • Oedema and liver necrosis;	Galvanising, plating, rubber processing, rayon manufacture, iron and steel production

3.6.1.6 Urbanisation (Commercial and residential)

Urbanization includes land uses of residential, education, commercial, industrial and government zoned land. “Impervious cover directly influences urban streams by dramatically increasing surface runoff during storm events (FISRWG, 2001:3-22).” It is advisable to investigate whether upstream detention or retention can be provided within the catchment to at least partially restore the predevelopment hydrologic regime. The FISRWG (2001:3-23) identifies the following disturbance activities associated with urbanisation:

- Altered hydrology – The peak discharge associated with the bank full flow (i.e. 1-2 year return storm) increases sharply in magnitude in urban streams. In addition, channels experience more bank full flood events each year and are exposed to critical erosive velocities for longer intervals (Hollis 1975; Macrae, 1996; Booth and Jackson 1997). Since impervious cover prevents rainfall from infiltrating into the soil, less flow is available to recharge groundwater. Consequently, during extended periods without rainfall, base flow levels are often reduced in urban streams (Simmons and Reynolds 1982).
- Altered channels – The higher flow events of urban streams are capable of performing more “effective work” (*more erosive*) in moving sediment than they had done before (Wolman 1964) The customary response of urban streams is to increase their cross-sectional area to accommodate the higher flows, by either streambed down cutting or stream bank widening or a combination of both. Stream channels react to urbanisation not only by adjusting their widths and depths, but also by changing their gradients and meanders (Riley, 1998). Urban stream channels are also extensively modified in an effort to protect adjacent property from stream bank erosion or flooding. Headwater streams are frequently enclosed within storm water drains, while others are channelized, lined or armored by heavy stone and gabions. Another modification unique to urban

streams is the installation of sanitary sewers underneath or parallel to the stream channel.

- o Sedimentation and contaminants – The exceptionally high rate of channel erosion in urban streams, coupled with sediment erosion from active construction sites, increases sediment discharge to urban streams. Urban streams tend to have a higher sediment discharge than nonurban streams, at least during the initial period of active channel enlargement. The water quality of urban streams during storm events is consistently poor. Urban stormwater runoff contains moderate to high concentrations of sediment, carbon, nutrients, trace metals, hydrocarbons, chlorides, and bacteria (Schueler 1987). Pollutants deposited in streambeds exert undesirable impacts on stream communities.
- o Impervious surfaces – more urbanisation results in increased coverage of impervious surfaces.

- Commercial activities further include disturbance activities such as contaminated runoff, pipelines/outlets, toxic pollutants, and illegal dumping.
- Education activities include schools, colleges, universities and universities of technology. Educational facilities usually include buildings and sports fields. The impacts are similar to recreational and commercial activities.
- Industrial activities include further disturbance activities such as toxic pollutants, increased runoff due to increased impervious surfaces; contaminated runoff, pipelines/outlets; illegal dumping; exposed and compacted soils e.g. truck yards.
- Residential activities increase the area of impervious surfaces causing increased runoff; runoff contains pollution such as oil, hydrocarbons, fertilizer, pesticide and litter. Residential activities also include vegetation clearing, soil compaction, overflowing sewers, and the introduction of exotic and alien vegetation. Residential areas also tend to encroach into riparian areas and can create barriers to migration along river edges.

3.6.2 Type of ground cover and % cover

		Left Flood Bank		Active Channel		Right Flood Bank	
		Measure	% cover	Measure	% cover	Measure	% cover
Type of ground cover and % cover	Dominant gorund cover type						
	Other						
	Other						
	Other						
	Other						

Macfarlane *et al.*, (2008) highlight that the greater the extent of hardened surfaces (e.g. roofs, parking lots, etc.) or area of bare compacted soil in the catchment or on site, will lead to reduced infiltration of stormwater and groundwater recharge and therefore increase the surface runoff. This results in an increase in flood peaks. Figure 3-8 illustrates this relationship between increased impervious surfaces and increased runoff. Note how as the percentage of impervious cover increases, that the rate of evapotranspiration and infiltration (both shallow and deep) decreases, while the volume of runoff increases. According to FISRWG (2001:3-23) as little as 10% increase in impervious surfaces can lead to stream degradation.

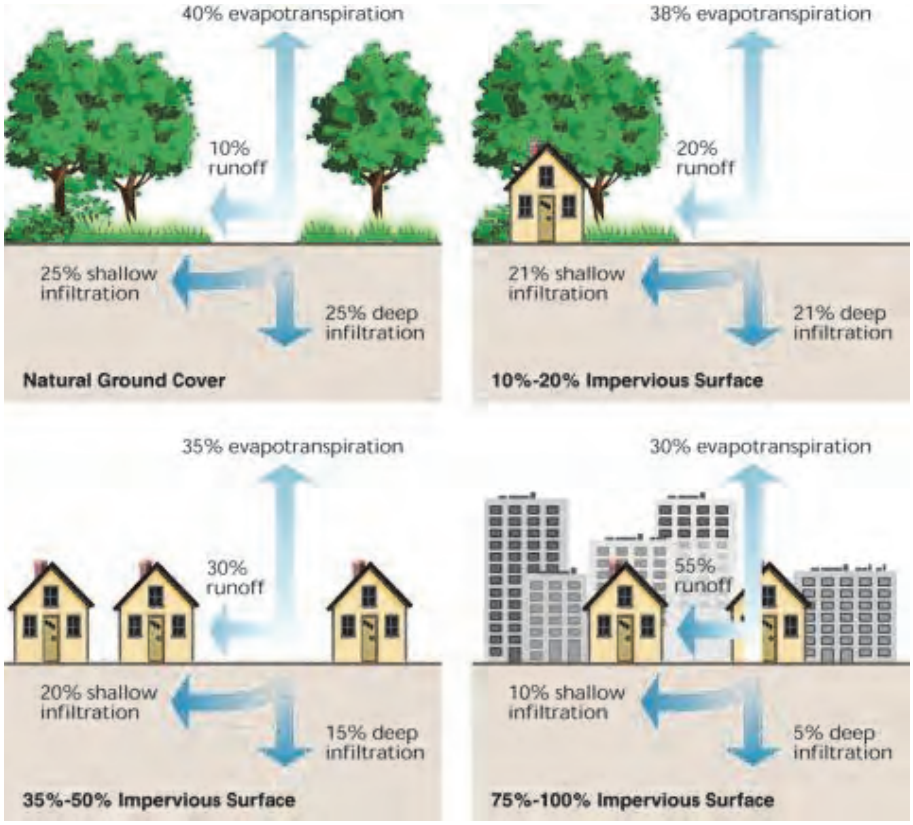


Figure 3-8 Relationship between change in ground cover and runoff. (FISRWG, 2001:3-23)

The type of dominant ground cover is measured according to the type of ground cover as well as the percentage coverage of each type of ground cover on the site. The measures of ground cover type and the percentage coverage are indicated in Table 3.4 and Table 3.5 respectively. The may be more than one type of ground cover on a site e.g. landscaped garden, road, and buildings.

Table 3.4 Type of ground cover

Good ↓ Bad	Measure	Description
	Vegetated	Natural vegetation, creeper, shrubs, etc.
	Kikuyu grass	Manicured lawns, kikuyu grass, etc.
	Pervious	Pervious surfacing, such as planted pavers, gravel, bare uncompact soil, etc.
	Compacted soil	Bare compacted soil.
	Impervious	Impervious surfacing, such as tar, concrete, brick paving, etc.

Table 3.5 Percentage (%) coverage of ground cover type

Measure	Description
None	No coverage on the site
0-30%	Small coverage on the site
30-60%	Large coverage but not majority of the site
=>60%	Majority to total coverage on the site

3.6.3 Height of steep banks (60°-90°)

Geomorphic character	Height of steep banks (60°-90°)	Left Flood Bank	Active Channel	Right Flood Bank

According to the USDA (1998) high and steep banks are more susceptible to erosion or collapse. Similarly high banks lead to channelling of the river with reduced opportunity for flood waters to reach the flood plain, or associated wetlands, which in turn can contribute to reducing the riparian zone and drying out associated wetlands. Steep bank refers to the watercourse banks that over 45° angle to the water, i.e. 60°-90°. The height of steep banks is measured from the edge of the active channel to the height of the flood bank, as indicated in Table 3.6. If there are no steep banks on the site, then select none.

Table 3.6 Height of steep banks

Measure	Description
>4m	Height of bank from active channel edge more than 4metres
2-4m	Height of bank from active channel edge between 2 and 4metres
1-2m	Height of bank from active channel edge between 1 and 2metres
<1m	Height of bank from active channel edge less than 1metres
None	No steep banks

3.6.4 Channel substrate description

		Left Flood Bank	Active Channel	Right Flood Bank
Geomorphic character	Channel substrate description			

The substrate (sediment type) provides in-channel habitat for various aquatic organisms. Fine substrate materials generally provide habitat for smaller organisms such as worms and snails, while large materials such as cobbles and boulders provide habitat for larger organisms such as crabs and fish. Each river system has different characteristics which will influence each individual river and reach-of-river substrate composition. The measure of channel substrate composition is therefore only a record of the site description. The channel substrate is described according to Table 3.7.

Table 3.7 Channel substrate description

Measure	Description
Fine	Predominantly silt, mud, clay and sand (substrate materials < 2mm)
Silt mix	Predominantly silt and gravel (substrate materials < 2mm – 16mm)
Gravel mix	Predominantly gravel, pebbles & sand (substrate materials 2-100mm);
Coarse	Predominantly cobbles and boulders (substrate materials >100mm);
No sediment	Concrete bed, bed rock, no substrate materials or sediment.

Where the substrate types are classified according to (Thirion, 2008):

Substrate type and material size	
Material	Size class (mm)
Bedrock	
Boulder	>256
Cobble	100 – 256
Pebble	16 – 100
Gravel	2 – 16
Sand	0.06 – 2
Silt/ mud / clay	<0.06

3.6.5 Riverine vegetation composition

		Left Flood Bank		In-stream		Right Flood Bank	
		Type	Cover	Type	Cover	Type	Cover
Riverine vegetation composition	Dominant vegetation type						
	Other						
	Other						

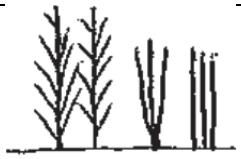
Riparian vegetation is identified in DWAF (2008) as providing "a number of critical functions within the river system, such as stabilisation of river channels, banks and floodplains, flood attenuation, water quality and temperature (e.g. shade), habitat provision, and migration corridors."

Plants offer resistance to the passage of water and plant roots provide resistance to erosion by water by binding the surface of the soil. Flows slowed due to in-stream plants such as. reeds, limit bank erosion, and may also result in accumulation of sediment (*accretion* or *aggradation*) through the deposition of suspended solids as the slowed water loses its energy to transport the materials.

The riverine vegetation is composed of both the riparian vegetation e.g. on the flood banks and the aquatic vegetation e.g. in-stream in the active channel. DWAF (2005:16) explain that riparian areas represent the interface between aquatic and upland ecosystems; the vegetation in the riparian area may have characteristics of both aquatic and upland species. Many of the plants in the riparian area require plenty of water and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high and the vegetation under the trees is usually lush and includes a wide variety of shrubs, grasses, and wildflowers. According to Graham and Louw (2009) trees are woody perennials, usually single stemmed in an undamaged state, with a distinct upper crown. Shrubs are woody perennials with two or more stems arising from near the ground, are generally smaller than trees and without a trunk. Kleynhans and Louw (2007) classify the non-woody component as comprised of grasses, sedges, forbs, and all other herbaceous plants. The non-woody component includes species such as *Phragmites*, *Palmiet*, the *Restios*, *Typha*, *Juncus*, aquatic (hydrophytic) grasses, and aquatic sedges. Both perennial and non-perennial streams support riparian vegetation. The flood zone vegetation type is measured according to Table 3.8 Flood zone: dominant vegetation type
, whereas the vegetation type in the stream is measured according to Table 3.9. Vegetation composition refers to the presence of different types of vegetation i.e. trees, shrubs, reeds, flowers, grass, on the site as well as their relative proportions (% cover) in the assemblage, as described according to

Table 3.10.

Table 3.8 Flood zone: dominant vegetation type

Description		Flood Zone (Banks)
Wild flowers		Herbs and flowers e.g. *Nasturtium*
Grasses		Grasses e.g. kikuyu
Reeds		Reeds, restios and sedges e.g. phragmites, palmiet,
Shrubs		Shrubs e.g.
Trees		Trees and saplings e.g. eucalyptus, wattle, pine, river bushwillow, weeping willow

While the presences of some aquatic vegetation is normal in streams, high levels of nutrients, especially phosphorus and nitrogen, in the water of the active channel promote the overabundance of algae and floating rooted macrophytes (USDA, 1998). These are illustrated in Figure 3-9 to Figure 3-12.

Figure 3-9 Filamentous algae, tributary to the Jukskei River, Gauteng

Figure 3-10 Sign warning of hazards of blue-green algae at Princess Vlei, Western Cape

Figure 3-11 Free floating aquatic plants, Hyacinth bloom, Black River, Western Cape

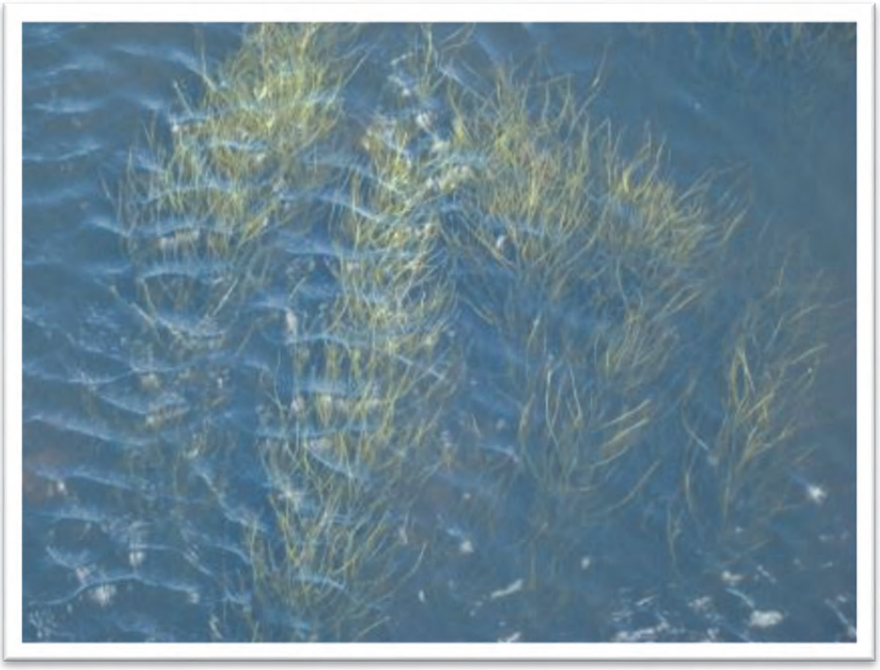


Figure 3-12 Rooted submerged vegetation, Water Grass

Table 3.9 In-stream: dominant vegetation type

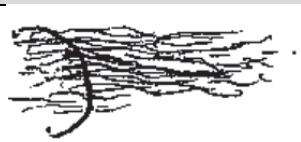
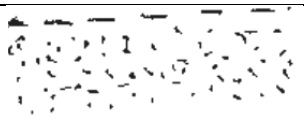
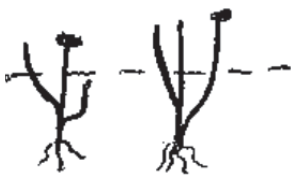
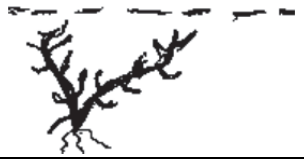
Description		Active Channel (In-stream)
Filamentous		Hair-like algae or algal mats on rocks
Free floating microscopic		Algae that gives the water a green colour (phytoplankton)
Free floating aquatic		Water weeds that float with no visible roots, e.g. water hyacinth, water lettuce, duckweed and red water fern
Rooted emerging		Water plants that protrude from the water and have visible roots, e.g. water lilies, bullrush, water reed, palmiet, phragmites and knotweeds
Rooted submerged		Water plants that are entirely submerged in the water, e.g. water grass, pondweed, parrot's feather and water weed.

Table 3.10 Riparian vegetation composition: description of percentage (%) cover

Measure	Description
80 – 100% cover	There is total or near total dominant plant type cover on the site
60 – 80% cover	More than half the site is covered with this plant type
30 – 60% cover	There are some large patches of plant type cover on the site
10 – 30% cover	There is small scattered plant type cover on the site
0 – 10% cover	There is little or no plant type cover on the site

Vegetation composition and structure in riverine areas varies from one part of the country to another, according to factors like climate, geology and water quality, therefore for the purpose of the Site Assessment, riverine vegetation composition is recorded as a description of the site.

SECTION 3: SITE ASSESSMENT

3.6.6 Erosion on the site

Indicators			Left Flood Bank		Active Channel		Right Flood Bank
Site character	4.1 Erosion on site (out the channel)						

When rain falls on exposed soil, the water runs downhill across the site. As it runs the water starts to cut/erode grooves removing bits of sand, soil and stones with it. Depending on how much and how hard it rains, and how fast the rainwater flows across the site, will affect how deep the grooves will become. This process is called erosion. The different stages of erosion include:

Sheet erosion occurs when surface water moves down a slope or across a field in a wide flow and peels off relatively uniform sheets or layers of soil. Because the topsoil disappears evenly, sheet erosion may not be noticeable until much damage has been done. (Miller, 1998:553)

Rill erosion Figure 3-13, occurs when the surface water forms fast flowing little rivulets that cut small grooves in the soil. (Miller, 1998:553)

Gully erosion Figure 3-14, occurs when rivulets of fast flowing water join together and with each succeeding rain event cut the grooves wider and deeper until they become ditches or gullies. Gully erosion usually happens on steep slopes where all or most vegetation has been removed. (Miller, 1998:553).

Dongas Figure 3-15, occur where severe gully erosion has caused deep ditches, for example greater then 1meter deep.

Figure 3-13 Rill erosion

Figure 3-14 Gully erosion

Figure 3-15 Donga erosion

If the site is made of hard rock or tar or other impervious surfaces, there will be less erosion after a storm, if any. If the site is made of clay or exposed uncompact soil, the erosion will be much more, because clay is softer than rock. Where there is vegetation covering the site, the roots of the plants help bind the soil together preventing erosion. Therefore it is important to record the ground cover type as per Section 2: Type of ground cover. Once erosion has started it will worsen very quickly, and must be stopped and rehabilitated with urgency. Severe gully erosion is much harder and more complex to rehabilitate than rill erosion. Figure 3-16 and Figure 3-17 illustrate how *rill* erosion if left unmanaged becomes severe *gully* and eventually *donga* erosion.

Figure 3-16 Rill erosion in the foreground leading to gully erosion in the background

Figure 3-17 Same site where the erosion is now severe donga erosion

Erosion moves backwards from point of disturbance. Therefore it is useful to identify and note any trigger points or activities such as excavating a bank, clearing of vegetation that may have caused the site to become exposed to erosion forces. The rehabilitation activities that target the erosion will need to consider what started or triggered the erosion.

The erosion in this indicator refers to the erosion taking place on the site i.e. outside of the riverine channel; erosion in the channel is discussed later in this chapter. The erosion on site indicator is described according to Table 3.11.

Table 3.11 Erosion on site

Good ↓ Bad	Measure	Description
	None	No erosion on site
	Sheet	Evidence of sheet erosion on site
	Rill	Evidence of rill erosion on site
	Gully	Evidence of gully erosion on site
	Donga	Deep gullies forming dongas on site

3.6.7 Percentage (%) invasive vegetation

Indicators		Left Flood Bank	Active Channel	Right Flood Bank
Site character	4.2 % vegetation is invasive			

Exotic, alien and invasive plant species are often major contributors to changes in indigenous riverine vegetation composition. Where natural vegetation is disturbed, alien and invasive plants tend to dominate the re-growth. Invasive and water-intense plant species are specifically problematic, including black wattles, port Jackson, eucalyptus, lantana, queen of the night, potato tree and kikuyu grass. For the purpose of the Site Assessment, the measure of infestation is estimated on the percentage of alien and invasive plant species in relation to indigenous species, of the vegetation on the site and is recorded for both the flood banks as well as the active channel. Percentage invasive vegetation is described using Table 3.12.

Table 3.12 Percentage (%) invasive vegetation

Good ↓ Bad	Measure	Description
	unknown	Not sure which are alien or invasive species
	no AIP	All indigenous, no alien and/or invader species.
	1 -10 %AIP	Scattered alien and/or invader species.
	11 – 40% AIP	Occasional clumps alien and/or invader species.
	41 – 60% AIP	Concentrated patches alien and/or invader species.
	60 – 100% AIP	More alien and/or invader species than indigenous.

As many officials may not be able to differentiate between indigenous and alien or invasive plant species, a list of indigenous wetland and riverine vegetation indicator species per province as well as a list of common riverine alien and invasive species is included in the Additional Guides (Annexures) of this document, where available images of these plants have been provided**.**

Further references for identification and management of alien and invasive plant species include:

- Conservation of Agricultural Resources Act, Act 43 of 1983, list of declared Alien and Invasive species
- National Environmental Management: Biodiversity Act: Act 10 of 2004, *Government Notice R508 in Government Gazette 36683 of 19 July 2013* (National list of Alien species).
- National Environmental Management: Biodiversity Act: Act 10 of 2004, *Government Notice R507 in Government Gazette 36683 of 19 July 2013* (National list of invasive species).
- *National Environmental Management: Biodiversity Act: Act 10 of 2004, Government Notice R506 in Government Gazette 36683 of 19 July 2013 (Alien and Invasive species regulations 2012) – not in operation yet.*
- Henderson, L. (2001) Alien Weeds and Invasive Plants. Agricultural Research Council, Cape Town, South Africa

- Gerber, A.; Cilliers, C.J.; van Ginkel, C. and Glen, R. (2004) Easy Identification of Aquatic Plants. Department of Water Affairs, Pretoria.

3.6.8 Continuity of riverine zone

Indicators			Left Flood Bank		Active Channel		Right Flood Bank
Site character	4.3 Continuity of riverine zone						

This indicator refers to the continuity of both the riparian corridor (vegetation or habitat provision) to adjacent erven (upstream-downstream riparian corridor) measured in the flood bank, as well as the continuity of the riparian zone between the terrestrial zone and the water's edge (terrestrial-in stream zone), i.e. the bank measured in the active channel.

The riverine zone can be disrupted by obstacles such as walls, roads, trenches, pipelines, impervious surfaces, site clearing, etc., causing fragmentation of the habitat corridor. It is important to determine the continuity of the riverine corridor in order to determine its suitability as a migration corridor, habitat provision and ecological function of the riverine zone. As an easy observation for officials, the continuity of the riparian vegetation in the riverine zone is measured according to Table 3.13. Examples of poor riparian vegetation continuation are indicated in Figure 3-18 where the continuity of the riparian habitat is disrupted either longitudinally or laterally, while examples of good riparian vegetation continuation are indicated in Figure 3-19.

Figure 3-18 Examples of poor riparian vegetation continuation (pictures a-c: K. Reinecke)

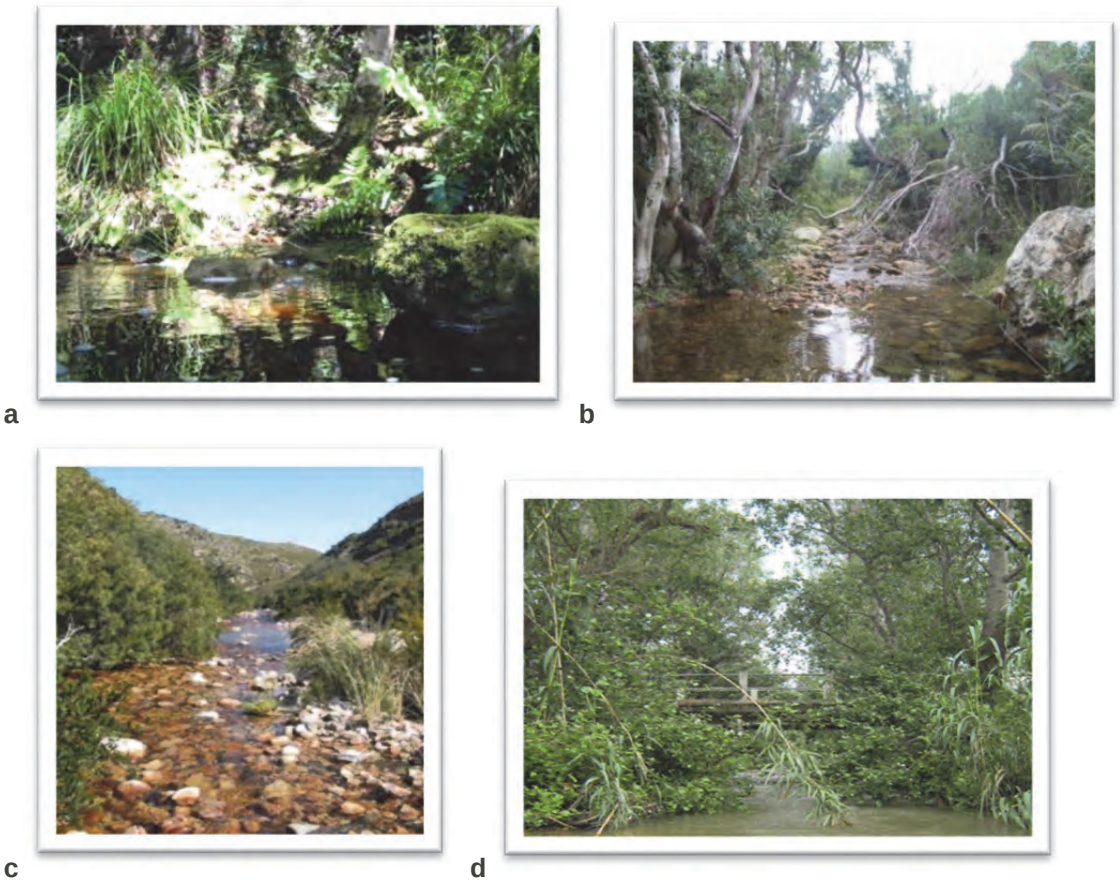


Figure 3-19 Examples of good riparian vegetation continuation (pictures a-c: K.Reinecke)

Table 3.13 Site: Continuity of the riverine zone

	Measure	Description
Good ↓ Bad	Continuous	The riparian habitat corridor is intact and links to adjacent properties with riparian vegetation. The riparian habitat zone is intact and links between the terrestrial zone and the watercourse edge.
	Fragmented	The riparian habitat corridor and vegetation is interrupted, disturbed, or broken up into smaller sections. The riparian habitat zone between the terrestrial area and water edge is interrupted.
	None	There is no riverine corridor and/or zone on the site.

3.6.9 Dumping in the river channel

Indicators		Left Flood Bank	Active Channel	Right Flood Bank
Site character	**4.4 Dumping / rubble**			

Dumping is considered the disposal of solid waste on the specific site. The solid waste may vary in composition, *inter alia* garden refuse, building rubble, product waste, household waste, etc. The measure for dumping is based on the occurrence of solid waste, building rubble and garden refuse, affecting or covering a 100-metre stretch of the watercourse, which is then extrapolated over the site. Examples of dumping are illustrated in Figure 3-20 and Figure 3-21.

Figure 3-20 Dumping covering a small portion of the riverine area

Figure 3-21 Dumping of rubble affecting the majority of the riverine area

The measures for assessing the dumping/disposal of solid waste on the banks or in the channel of a watercourse are presented in Table 3.14.

Table 3.14 Dumping / Rubble

Good ↓ Bad	Measure	Description
	None	No evidence of dumping on the site.
	0-10%	Dumping affects / covers a small portion of the riverine area.
	10-25%	Dumping affects / covers up to a quarter of the site of the riverine area.
	25-50%	Dumping affects / covers up to half of the site of the riverine area.
	=>50%	Dumping affects / covers more than half or the majority of the riverine area.

3.6.10 Litter in the river channel

Indicators		Left Flood Bank	Active Channel	Right Flood Bank
Site character	**4.5 Litter**			

For the purpose of this guide, litter differs from dumping, in that it is solid waste that has been washed down the watercourse to the site from within the catchment. The accumulation of litter in the watercourse contributes both to poor water quality as well as to reduced habitat provision. Litter can trap aquatic organisms and wildlife such as birds causing them to starve and die. An example of more than 50 pieces of litter in the watercourse is illustrated in Figure 3-22.

Figure 3-22 More than 50 pieces of litter in a watercourse

The measure for litter is based on the occurrence of solid waste that was been washed onto the site, as opposed to purposefully being dumped on the site, over a 100-metre stretch of the watercourse which is then extrapolated over the site. The litter measures for assessing litter are presented in Table 3.15.

Table 3.15 Litter

	Measure	Description: No. in 100m stretch
Good ↓ Bad	None	No evidence of litter.
	<10 pieces	10 or less pieces of litter within a 100m stretch of river.
	10 – 50 pieces	10-50 pieces litter visible.
	>50 pieces	More than 50 pieces of litter.

3.6.11 Macro-channel Bank Erosion

		Left Flood Bank	Active Channel	Right Flood Bank
Erosion and armouring	**4.6 Macro-channel bank erosion**			

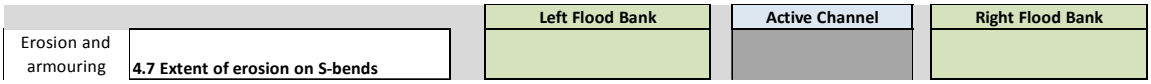
During the daily regular flow of water in a watercourse or small rain events (e.g. 1:2 year), the banks that are affected by these flow conditions form part of the active channel. The macro-channel or flood bank is the area between this regular flow of the active channel and the maximum height of a major flood (e.g. 1:100 or 1:1000 year flood). Of the macro-channel bank on the site, what percentage of it is eroded? – look for indicators of erosion such as bank

stabilisation e.g. gabions. Macro-bank erosion is only recorded for the flood bank or macro-channel, and is described according toTable 3.16.

Table 3.16 Macro-channel bank erosion

Good ↓ Bad	Measure	Description – Bank and site erosion
	N/A	No macro-channel banks visible
	None	No erosion or cutting of macro-channel bank length
	>5%	>5% of macro-channel bank length
	>20%	>20% of macro-channel bank length
	>50%	>50% of macro-channel bank length

3.6.12 Extent of erosion on S-bends



A cut bank, also known as a river cliff, is a naturally occurring phenomenon that is exaggerated by urban impacts. Cut banks are usually found along meandering streams (S-bends), where the outside bank of a watercourse is continually undergoing erosion. The cut banks are located on the outside bend of the watercourse. They resemble a small cliff, and are formed by the erosion of the bank by the fast flowing water in the watercourse. Cut banks are typified by erosion protection measure such as gabion baskets in Figure 3-23 or concrete walls. Cut banks are nearly vertical and often expose the roots of nearby plant life. Often, particularly during periods of high rainfall and higher-than average water levels, trees and poorly placed buildings can fall into the stream due to mass erosion events.

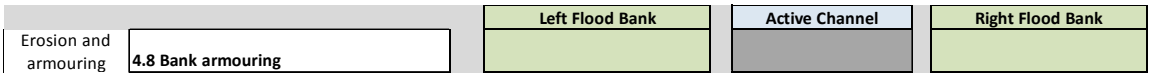
Not only are cut banks steep and unstable, they are also the area of a stream where the water is flowing the fastest and the deepest, making them rather dangerous. Cut banks are measured according to the extent of erosion on the actual S-bend, i.e. just the key-point in the bens (<10%) or the entire length of the bend (>51%), as described in Table 3.17. If there are no S-bends on the site, select none.

Figure 3-23 Example of cut bank where gabion has failed

Table 3.17 Extent of erosion on S-bends

Measure	Description
None	No cut banks
<10%	Less than 10% of bank is cut/eroded
11-50%	Between 11-50% of bank is cut/eroded
>51%	More than 51% of bank is cut/eroded

3.6.13 Bank armouring



Protecting the channel banks is essential to protecting the riparian zone. The bank is where the horizontal groundwater and active channel watercourse interaction takes place. The banks form the riparian habitat of the riverine corridor. According to the USDA (1998) extensive bank-armouring / stabilising of channels to stop lateral cutting usually leads to more problems (especially downstream). Watercourse and bank interaction are threatened by armouring e.g. by gabions, stacked tyres, shuttering, walls and berms. Armouring can be of differing levels of interference in the river system. For example, engineered armouring (see Figure 3-24) completely cuts off the interaction between watercourse and river banks and leads to channelling of the watercourse. Similarly, armoured banks such as armouring the full length of the bank with gabion baskets Figure 3-25 also reduces the bank-watercourse interaction, although during flood events there may still be some interaction. Exposed soil or bank collapse Figure 3-26, still provides for some bank-watercourse interaction but has reduced habitat provision, and carbon and sediment trapping. Toe-armouring (see Figure 3-27) still promote bank-watercourse interaction and still stabilise the watercourse bank from erosion, but reduce the riparian corridor and connectivity. Vegetated banks, (see Figure 3-28) are preferred but may not always be found in urban watercourses.

Figure 3-24 Engineered bank armouring covering 100% of the bank

Figure 3-25 Armoured bank with gabion baskets

Figure 3-26 Exposed soil on the river bank due to erosion

Figure 3-27 Bank toe armouring using gabion baskets

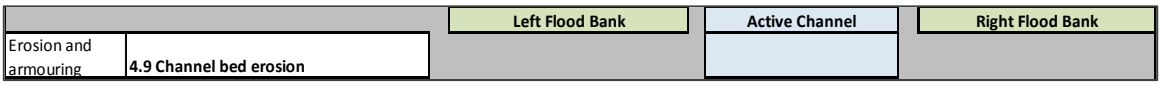
Figure 3-28 Vegetated banks

Bank armouring is only recorded for the flood zone banks, and is described according to Table 3.18. If only a section of the bank is stabilized, then it is described as occasional armouring.

Table 3.18 Active channel bank armouring

Good ↓ Bad	Measure	Description
	Toe	Gabions or similar at the base of bank only
	Occasional	Some protection along the reach
	Armoured	Gabions, shuttering, stacked tyres along the reach
	Engineered	Cement / concrete walling along the reach
	Exposed soil	Banks are exposed soil with no vegetation or armouring
	Vegetated	Banks are vegetated

3.6.14 Active channel bed erosion



According to the USDA (1998:7) “Active down cutting (bed erosion) and excessive lateral cutting are serious impairments to stream function.” Some active channel erosion is normal in a healthy stream; however excessive active channel erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in hydrology, sediment load, or isolation from the flood plain. Both conditions are indicative of an unstable stream channel. Excessive bed erosion leads to channeling of the watercourse. Active channel bed erosion or active down cutting is described according toTable 3.19.

Table 3.19 Active channel bed erosion

Good ↓ Bad	Measure	Description – Bank and site erosion
	None	No bed erosion
	Degradation	Some incision of the active channel
	Channelling	Deep incision (>1m) of the active channel

3.6.15 State of discharge outlets

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	**4.10 State of discharge outlets**			

Discharge outlets increase flow at a point source. Where these outlet structures are not adequately designed, it can cause further erosion and damage to the riparian area, for example Figure 3-29 or Figure 3-30 this collapsed storm water outlet has had a devastating impact on the surrounding flood bank. Further, discharge points introduce point source pollutants into the watercourse, for example chemical contaminants that are washed down stormwater drains Figure 3-31. Further it is best practice to install sustainable urban designed erosion protection below the outlet and on the opposite bank to prevent erosion from high velocity directed flow out the outlet structure or energy dissipation mechanisms as part of the outlet design.

Figure 3-29 Collapsed stormwater outlet

Figure 3-30 A sewer in a poor state

Figure 3-31 Chemical effluent via stormwater outlet

For the purpose of recording discharge, the water quality from the discharge outlet is assessed separately. The state of discharge structures is measured by identifying any erosion around the structure and described according to Table 3.20.

Table 3.20 State of discharge structures

Good ↓ Bad	**Measure**	**Description**
	None	No outlets on site
	Good	Outlet in good condition, no erosion
	Poor	Outlet with erosion, bank collapse, etc.

3.6.16 Canalisation / channelling

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	**4.11 Canalisation / channelling**			

The act of intentional channeling of canalising of a watercourse is a process of stabilizing / straightening a watercourse and directing its flow according to human want rather than natural choice. Channelling can also occur naturally Figure 3-32 through erosion processes, where increased or directed flow erodes the water channel thereby deepening the channel. The watercourse is then limited to that particular channel and will require a major flood to alter it.

Figure 3-32 Erosion gully causing channelling

Formal canalisation includes formal concrete canals for a reach of river, for example Figure 3-33 and Figure 3-34. Informal canalisation includes erosion gullies and piecemeal straightening or retraining of the reach of river.

Figure 3-33 Canal constructed to divert a stream around a housing complex, Gauteng

Figure 3-34 Canalised urban river, Cape Town

Remediation and rehabilitation of canalisation and channelling should include the principles of Sustainable Urban Design (SUD). Where possible the bank-watercourse interaction should be maintained, as well as vegetation function along the banks, for example Figure 3-35 is a SUD stormwater canal promoting re-vegetation while still stabilising the banks and preventing erosion, and it also still promotes groundwater infiltration and bank interaction.

Figure 3-35 Sustainable urban designed (SUD) stormwater canal

Canalisation / channelling are recorded for both the flood banks and the active channel and are described according toTable 3.21.

Table 3.21 Canalisation / Channelling

Good ↓ Bad	Measure	Description
	Natural	Natural river course, no canalisation or course straightening
	Occasional	Occasional straightening or channelling of the river course
	Deeply Eroded	Channelling of the river from erosion, down-cutting, or excavation
	Straightened	Complete artificial channel or river course straightening

3.6.17 Levees / Flood prevention banks

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	4.12 Levees / Flood prevention bank			

Where there are large floodplains, many land owners construct flood prevention banks (*levees*) in order to reclaim the land from watercourses for utilisation, such as farming. This is particularly apparent in agricultural areas and is an old traditional practice. However, levees canalise a river and separate the floodplain from the river, which in turn affects the sedimentation regime of the river and can cause flooding downstream. According to Heeg *et al*., (1989) apart from the primary effect of floodplain desiccation as a result of reduced floodplain inundation, there are also secondary effects, such as inadequate flushing of floodplain pans leading to unnaturally-high salinity levels. Where historic levees occur, the river system would have adapted to the change in regime, however the construction of new levees is now a listed activity in terms of the National Water Act, Act 36 of 1998 and the National Environmental Management Act, Act 107 of 1998. Naturally occurring levees are not common in South Africa however man-made levees are especially common in agricultural areas. Note that a levee constitutes infilling/dumping/impeding the flow within a watercourse. A levee can be a simple earthen embankment as in Figure 3-36 or more formal like stacked tyres as illustrated in Figure 3-37.

Figure 3-36 Man-made level in Wellington, Western Cape

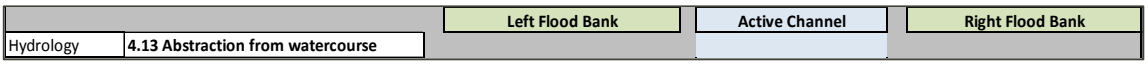
Figure 3-37 Stacked tyres as a levee to prevent flooding of the floodplain, Wellington, Western Cape

A levee causes canalising of the river. Levees only affect the banks of a watercourse and therefore are only recorded for the flood zones, and described according to Table 3.22.

Table 3.22 Levees or flood prevent banks

Good ↓ Bad	Measure	Description
	none	No levee on site.
	0-1m	Height of levee is less than 1 metre
	>1m	Height of levee is between 1 and 2metres
	>2m	Height of levee exceeds 2 metres

3.6.18 Abstraction



There are two scales to abstraction, the first being abstraction for domestic use, i.e. within the allowances of Schedule 1 of the National Water Act, Act 36 of 1998 (NWA); and secondly abstraction that requires a water use license in terms of section 21(a) of the NWA for the taking of water.

Schedule 1 of the NWA makes provision that:

(1) A person may, subject to this Act -

(a) take water for reasonable domestic use in that person's household, directly from any water resource to which that person has lawful access;

(b) take water for use on land owned or occupied by that person, for -

(i) reasonable domestic use;

(ii) small gardening not for commercial purposes; and

(iii) the watering of animals (excluding feedlots) which graze on that land within the grazing capacity of that land, from any water resource which is situated on or forms a boundary of that land, if the use is not excessive in relation to the capacity of the water resource and the needs of other users;

(c) store and use run-off water from a roof;

(d) in emergency situations, take water from any water resource for human consumption or firefighting; …

Note that the taking of water from a stream for ornamental koi ponds (an alien fish species) is not a Schedule 1 activity. Where the water is used for commercial gain activities e.g. a nursery or agricultural production, it falls out of Schedule 1 use and requires a Water Use License.

Without a flow-meter or other technical equipment, it is difficult for an official to measure the volume or rate of water being abstracted. There are different scales of pumps or diversions which can indicate whether the abstraction is for domestic or commercial purposes. A domestic purpose (Schedule 1) abstraction pump, Figure 3-38, infrastructure is usually smaller in size and capacity and located outside the watercourse channel. Whereas abstraction on a larger, commercial scale usually involves larger and more permanent infrastructure such as the pump house in Figure 3-39 or the diversion weir and channel in Figure 3-40; both of these abstractions are for agricultural purposes. However the scale of the infrastructure is not a solid rule, and the official should also take note of whether there are commercial activities taking place on the site, if so, the abstraction is likely to be for commercial purposes.

Figure 3-38 A domestic purpose abstraction pump

Figure 3-39 Commercial abstraction pump house

Figure 3-40 Diversion of water as abstraction for commercial purposes

The record of abstraction on a site is described according to Table 3.23.

Table 3.23 Abstraction

Good ↓ Bad	Measure	Description
	None	No abstraction of river water
	Domestic	Small-scale abstraction – for domestic use, i.e. NWA Schedule 1, watering vegetable garden
	Large	Large-scale abstraction – permanent infrastructure or large abstractions e.g. for irrigation of a nursery or farmland purposes

3.6.19 Impoundments

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	**4.14 Impoundments**			

Impoundment structures not only reduce flow of water, but also the transportation of sediment which is a necessary element for ecosystem processes, e.g. providing substrate for vegetation and habitat for aquatic biota and prevent fish migration. Similarly impoundments can alter the temperature of the water, for example, warmer water on the surface of an impoundment due to the long exposure to the sun and colder at the bottom of the impoundment due to lack of exposure to the sun, which also effect ecosystems processes and diversity. Impoundment of flow through in-stream dams, weirs, and water features, may impact on downstream reaches of the watercourse by reducing the necessary flows, sediment loads and thereby altering the water temperature and influence migration cues (Thirion, 2008). It may also impact on upstream reaches by altering the flood storage capacity of a reach and thereby causing more flooding or longer inundation after storm events. The USDA (1998) also point out that if the barrier is sufficiently high, the impoundment may prevent the movement or migration of fish, deny access to important breeding and foraging habitats, and isolate populations of fish with other aquatic animals.

Macfarlane *et al.*, (2008) highlight that one of the main threats to floodplains is the damming of streams upstream of or located within the floodplain, for example the illegal impoundment in

Figure 3-41, where the size of the culverts in the background versus the outlet pipes in the foreground indicate the intention to impound the flow of water. This is due to the ability of dams to trap sediment and release water that is effectively starved of sediment. This reduction in sediment load deprives floodplains downstream of the sediment required for floodplain construction and commonly leads to floodplain degradation. Impoundments don't necessarily need to be dams, they can also be small barriers that only operate as an impoundment at low flows, for example the weir in Figure 3-42, which is only effective in low flows and is negligible in high flows.

Figure 3-41 In-stream impoundment, where the inflow exceeds the outflow capacity

Figure 3-42 Low flow weir impoundment

Impoundments are recorded for the active channel only and are described according to Table 3.24.

Table 3.24 Impoundment

Good ↓ Bad	Measure	Description
	None	None
	Temporary	Small, temporary e.g. sand bags
	Low flow	Low flow only diversion (all high flows and floods overtop) e.g. low weir
	Small, permanent	Small, permanent diversion e.g. in stream farm dam
	Large, permanent	Large, permanent diversion e.g. Emmarentia dam, Bruma lake,

3.6.20 Culverts and bridges

Similar to impoundments, culverts and bridges affect the flow of water in a watercourse as well as disrupt the connectivity of the riverine zone. Ideally bridges should be single span or pier-support bridges to promote connectivity of the riverine zone under the bridge. However, single span bridges are more costly to construct than culvert bridges. Culverts concentrate the flow of water through the culverts usually resulting in erosion on the downstream side. In peak flows, where the opening of the culverts is not sufficient, the flows can back-up upstream of the culvert causing damage to the river banks, and even over-topping the culvert (Figure 3-43). Flood debris also accumulates on the culvert edges which in turn also affects the flow regime and habitat provision of the water course.

Figure 3-43 Inadequate capacity culvert bridge damaged by excessive flows

Culverts and bridges are described according to Table 3.25.

Table 3.25 Culverts and bridges

Good ↓ Bad	Measure	Description
	None	No bridge or culverts or other obstacles
	Bridge	Single span/pier bridge, with habitat continuation
	Intermediate	Culverts with habitat continuation
	Culvert/drift	Culvert /low level bridge / drift, no habitat continuation

3.6.20.1 Flood Debris

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	**4.16 Flood debris**			

Flood debris refers to the woody material and other solid waste that passes through a watercourse during a storm event. After a storm event flood debris lines the banks of the watercourse indicating the height of the water level. However, large debris such as fallen trees may block a watercourse, causing debris to accumulate. The accumulation of flood debris in a river channel can alter the hydrological characteristic of the channel. Naturally occurring fallen branches and trees in a river provide habitat for breeding and resting of aquatic biodiversity. After major storm events, this debris may be washed downstream and accumulate, Figure 3-44, against obstacles causing further impoundment and alteration of the hydrology at that point. The reduction in flow velocity due to the impoundment results in deposition of transported sediment. The river bed rises as a result of the accumulated debris and the river alters its course around the flood debris obstacle, severely impacting on the adjacent riparian zone and causing bank collapse. The accumulated flood debris should be regularly removed by the local municipality / land owner so as to prevent damage to adjacent properties because of the altered watercourse channel, or damage to infrastructure as a result of the accumulation.

Figure 3-44 Accumulated flood debris causing channel alteration

The flood debris is recorded for the active channel only and is described according to Table 3.26.

Table 3.26 Flood debris

Good ↓ Bad	Measure	Description
	None	No woody debris.
	Naturally occurring	Debris naturally occurs in the river, i.e. fallen trees, branches, sticks. Usually dispersed not accumulated.
	Scattered	Scattered woody and flood debris e.g. reeds and woody debris along the banks of the river after a flood, or a fallen branch in the river with no accumulated debris.
	Accumulated	Accumulated woody and flood debris obstacles e.g. fallen trees/branches blocking flow of water and accumulating other debris.

3.6.21 Water Quality

			Active Channel
In stream water quality	4.17 Colour		Colourless
	4.18 Odour		No odour
	4.19 Clarity		Transparent
	4.20 Temperature		Normal
	4.21 Foam		None
	4.22 pH		Neutral
	4.23 Oily sheen		None
	4.24 Nutrients		Occasional
	4.25 Oxygen availability		Oxygen available
	4.26 Indication of life		None observed

Dallas and Day (2004) explain that water quality is the combined effect of the chemical constituents and physical attributes of a sample of water. Water quality is a term “used to describe the physical, chemical, biological and aesthetic properties of water that determine its fitness for a variety of uses and for the protection of the health and integrity of aquatic ecosystems. Many of these properties are controlled or influenced by constituents that are either dissolved or suspended in water” (DWAF, 1996:3). Water quality variables potentially affecting aquatic ecosystems may be physical or chemical. Water quality components may change as a result of either flow or non-flow related activities. Flow-related impacts could result in water warming due to shallower water depths and decreased turbidity due to longer water retention times in the system allowing suspended sediments to settle out. Non-flow related impacts may possibly result from wastewater effluent discharges or irrigation return flows.

This section is applicable to the in-stream (active channel) assessment. Detailed water quality samples should still be carried out where necessary. For the purposes of the Site Assessment the indicators include: colour, odour, clarity, temperature, foam, pH, oily sheen, nutrients, algal growth and indication of life.

3.6.21.1 Colour

Water that is colourless usually lacks pollutants that affect water colour. Suspended sediment will impart the same colour to water as the surrounding soil, for example the naturally occurring tannins in fynbos soils discolour the rivers in the Cape to dark tea coloured brown, (Figure 3-46). The presence of a colour that is different from the surrounding soil colour may indicate the presence of a chemical pollutant. Brightly coloured water (Figure 3-45) usually indicates acid mine drainage or other chemical contaminants. The water quality: colour is described using Table 3.27.

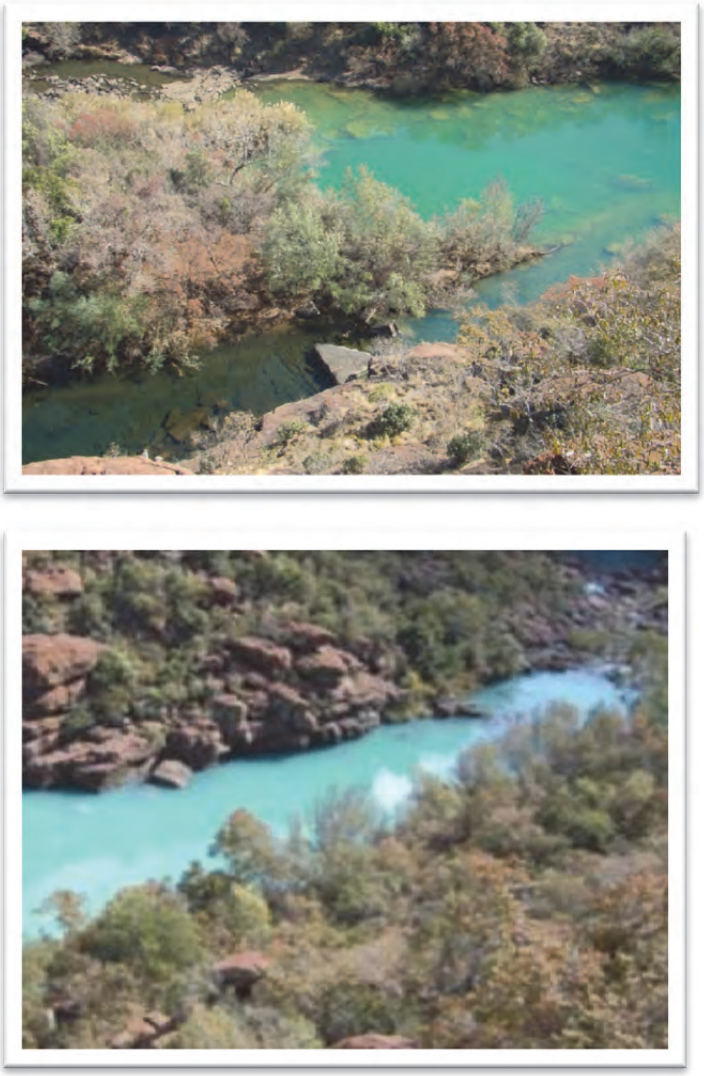


Figure 3-45 Unnatural brightly coloured acid mine drainage

Figure 3-46 Naturally occurring tea-coloured water in the Liesbeek River, Cape Town

Table 3.27 Water quality: Colour

Good ↓ Bad	Measure	Description
	Colourless	Colourless
	Tea	Tea coloured
	Unnatural	Unnatural
	Brown	Brown/muddy (soil)
	Black	Black/grey (sewage)
	Milky	Milky
	Green	Green (algal growth)

3.6.21.2 Odour

Most water is either odourless or has a slight "earthy" odour. Odours such as petrol (hydrocarbon) fumes, solvents, sulphur or rotten eggs, sewage, or a sour smell may be *indicative* of chemical pollutants. Water quality: odour is described using Table 3.28.

Table 3.28 Water quality: Odour

Good ↓ Bad	Measure	Description
	Earthy	Earthy smell
	Hydrocarbon	Petrol / diesel / oil / Aviation fuel / paraffin / sour smell
	Sewerage	Rotten egg / sewerage smell
	Pesticide	Chemical or pesticide smell (abundance of algae)
	Not observed	No odour observed

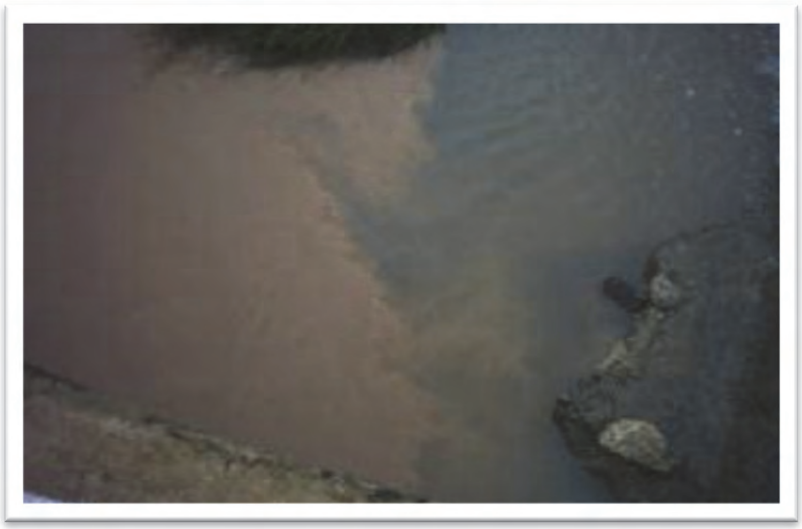
3.6.21.3 Clarity

Clarity refers to the amount of suspended material present in the water that causes the water to be dirty and limits the amount of light that can pass through the water. Over long periods of reduced sunlight, rooted and submerged plants will no longer emerge from the main body of a river. The dirtier the water is, the more likely it is to contain suspended material – which is indicative of the occurrence of large hydrological related events. 'Milky' appearance indicates chemical precipitation therefore presence of chemical contamination, see Figure 3-47.

Figure 3-47 Milky appearance of chemical contamination

a.

b.



c.

Figure 3-48 Water with high turbidity resulting in dirty or poor clarity.

Figure 3-48 provides an example of high turbidity, where the muddy water infuses with the river indicates poor clarity.

Low clarity can be a result of:

- Bad land use practices such as removal of riparian vegetation, site clearing, and accelerated erosion;
- Discharge of domestic sewage;
- Discharge of industrial effluents (such as the pulp/paper mill, china-clay, and brick and pottery industries);
- Discharge from mining operations;
- Fish-farm effluents (mostly organic suspended solids);
- Physical perturbations from road, bridge and dam construction;
- Urban runoff; and
- Algal growth.

For the purpose of the Site Assessment, clarity is assessed by observation and described using Table 3.29.

Table 3.29 Water quality: Clarity

Good  Bad	**Measure**	**Description**
	Transparent	Completely transparent. No suspended material in the water. Can see to the bottom of the river.
	Clearish	Some suspended material in water. Slightly turbid.
	Cloudy	Dirty water
	Dirty	Milky, muddy. Some turbidity.
	Poor clarity	Extremely muddy. High turbidity. Can't see anything in the water.
	Not observed	Water clarity was not observed on site.

3.6.21.4 Water temperature

DWAF (1996:103) explain that temperature affects the rates of chemical reactions and also the metabolic rates of organisms. It is one of the major factors controlling the distribution of aquatic organisms. Natural variations in water temperature occur in response to seasonal cycles and organisms use these changes as cues for activities such as migration, emergence and spawning. Artificially-induced changes in water temperature e.g. discharged effluent that has been heated, can impact on individual organisms and on entire aquatic communities. Higher temperatures reduce the solubility of dissolved oxygen in water, decreasing its concentration and thus its availability to aquatic organisms. Elevated water temperatures increase metabolic rates, including respiration and thus oxygen demand, of aquatic organisms. Oxygen demand therefore increases leading to a decrease in dissolved oxygen supply. Unnaturally low temperatures, such as those induced by bottom releases of dam water, may induce fish mortalities in a river reach or suppress normal activities such as spawning. The toxicity of most substances, and the vulnerability of organisms to these substances, is intensified as water temperature increases.

Anthropogenic sources which result in changes in water temperature include:

- Discharge of heated industrial effluents, below power stations.
- Heated return-flows of irrigation water.
- Removal of riparian vegetation cover, and thereby an increase in the amount of solar radiation reaching the water.
- Inter-basin water transfers; and

- Discharge of water from impoundments.

Remember temperature will vary due to the season. The temperature is measured according to touch, if it is warm or hot to the touch then it is described as warm (look for stream to indicate heat), if it is not significantly different to the touch then it is normal. For safety, wear gloves when handling the water. The temperature indicator is described using Figure 3-49.

Figure 3-49 Water quality: temperature

Good ↓ Bad	Measure	Description
	Normal	Natural, approximately 21°C-27°C
	Warm	Warm, warm to the touch, approximately >27°C
	Cold	Cold, chill to the touch; approximately <21°C
	Not tested	Temperature not tested on site.

3.6.21.5 Foam

The presence of foam on the water surface may *indicate* the presence of industrial foaming agents for example, Figure 3-50 or surfactants in industrial or commercial areas. This could also result from high phosphate content as a result of fertilizers in agricultural areas or waste water treatment works (WWTW) in urban areas. The foam indicator is described using Table 3.30.

Figure 3-50 Accumulation of foam in a water course

Table 3.30 Water quality: Foam

Good ↓ Bad	Measure	Description
	None	No foam
	Small	Small patches of foam / bubbles e.g. where water flows over rocks or obstacles
	Large	Large quantities of foam / bubbles e.g. including in stagnant water and along river banks.
	Not Observed	No observation made

3.6.21.6 pH

According to Marlborough, rain water is naturally acidic at about 5.6 pH whereas stream water usually ranges from a pH of 6.8 to a pH of 7.8; this range is considered to be an optimal range for most aquatic life. The natural pH of a river will vary from river to river. The natural pH range of a river is largely determined by the geology and soils of the area, for example limestone areas will result in rivers and streams having naturally higher pH levels and peat areas will have naturally low pH levels. The pH of a stream affects the organisms living there. Large fluctuations in pH outside of a rivers natural pH range can lead to stresses on aquatic life in that river.

Low pH levels (below optimal) can result in fish kills by stressing their systems causing physical damage, which in turn can make them more vulnerable to disease, similarly high pH particularly in combination with high water temperature, can increase the amount of un-ionized ammonia which is highly toxic to fish. Extreme rates of photosynthesis, whether natural or because of eutrophication, commonly result in very high pH values (>10) in standing waters during the night and lowered pH values during the day. In addition low pH also mobilises otherwise bound heavy metals, an increase in which can be toxic to aquatic life.

For the Site Assessment a basic indicative pH test can be carried out using an HTH dip stick (a quick test strip to test pool water). The dip stick provides an indication if the water is above (greater than 7.8, alkaline) or below (less than 6.8, Acidic) pH7.2 (neutral). The HTH dip sticks are available from most local swimming pool shops and supermarkets. Using an HTH dipstick, dip the stick into the water and quickly remove it. Do not flick water off. Hold the stick level for about 15 seconds. Check the colour of the markers against the colour code on the dipstick container, Figure 3-51. The second marker from the top of the stick, aligns with the second row of indicators on the container, this indicates pH.

NOTE: If you are red/green colour blind, ask someone to assist you to read the marker and colour index.

Figure 3-51 HTH dipstick indicating pH

In this Guideline manual the pH indicator is measured using an HTH dipstick, but any method for measuring pH will apply. The record of pH is described using Table 3.31.

Table 3.31 Water Quality: pH

Good ↓ Bad	Measure	Description
	Neutral	Neutral, 6.82 - 7.8
	Acidic	Low, acidic, dipstick, <6.8, orange marker
	Alkaline	High, alkaline, dipstick >7.8, pink marker
	Not Tested	pH was not tested on site.

3.6.21.7 Oily sheen

An oily sheen is present if a film of iridescent colour is observed on the water surface. Look for a rainbow effect that can appear to be floating on the surface of the water. Usually an oily sheen *indicates* the presence of oil, petrol, and diesel or aviation fuel, also known as hydrocarbons. On occasion, and usually in the autumn, a noticeable but small oily sheen can be the result of the decomposition of fallen leaves, Figure 3-52.

Figure 3-52 Naturally occurring oily sheen

TIP: To distinguish between natural and incidental sheen: using a stick swirl the iridescent patch – if it breaks up it is naturally occurring; if the sheen reforms then it is from a spill.The record of oily sheen is described using Table 3.32.

Table 3.32 Water Quality: Oily sheen

Good ↓ Bad	Measure	Description
	None	No oily sheen
	Small/Natural	Relatively small patches of sheen. Sheen can be disturbed when prodded
	Sheen	Large or regular occurrence of oily sheen
	Not observed	No observation made on site

3.6.21.8 Nutrients

There are several types of nutrients that impact on watercourses, e.g. inorganic nitrogen and phosphorus. According to USDA (1998) the presence of some aquatic vegetation is normal, and water that has slight nutrient enrichment may support communities of algae, which provide a greenish colour to the water. However, streams with heavy loads of nutrients have thick coatings of algae attached to rocks and other submerged objects. Nutrient loads in the waterbody are indicated by the growth of algal and nuisance plants.

Sources of inorganic nitrogen include:

- Commercial fertilizers contain highly soluble ammonia and ammonium salts;
- Fish-farm effluent (un-ionised ammonia);
- Sewage discharge;
- Discharge from industries that use ammonia or ammonium salts in their cleaning operations;
- Manufacture of explosives and use of explosives in mining and construction; and
- Atmospheric deposition of ammonia from distillation and combustion of coal, and the biological degradation of manure.

Sources of phosphorus in urban rivers may be a result of:

- Point-source discharges such as domestic and industrial effluents; and
- Diffuse (non-point) sources include atmospheric precipitation, urban runoff, and drainage from agricultural land, in particular from land on which fertilizers have been applied. In this case the phosphorus load is generated by surface and subsurface drainage.

Nutrient loads in the watercourse are indicated by the growth of algal and nuisance plants. The nutrients are described using Table 3.33.

Table 3.33 Nutrients

Good  Bad	**Measure**	**Description**
	None	No visible algal growth
	Occasional	Occasional clumps of algal growth observed
	Excessive	Extensive algal growth observed
	Not observed	No observation made at the site.

3.6.21.9 Oxygen availability

DWAF (1996:55) explain that decreased dissolved oxygen in aquatic ecosystems result in chronic and acute physiological and behavioural changes in aquatic biota. The sensitivity of many species, especially fish and invertebrates to changes in dissolved oxygen concentrations depends on the species, the life stages (eggs, larvae or adult), and behavioural changes (feeding and reproduction). Where possible, many species will avoid anoxic or oxygen-depleted zones. According to USDA (1998:12) “plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills.”

Factors causing reduction in dissolved oxygen concentration include:

- Re-suspension of anoxic sediments, as a result of river floods or dredging activities;
- The presence of degradable oxidizable organic matter, either of natural origin (detritus) or originating in waste discharges, can lead to reduction in the concentration of dissolved oxygen in surface waters; and
- The amount of suspended material in the water affects the saturation concentration of dissolved oxygen, either chemically, through the oxygen-scavenging attributes of the suspended particles, or physically through reduction of the volume of water available for solution.

Availability of oxygen is assessed visually by observing for life on/in the water, using Table 3.34.

Table 3.34 Oxygen availability

Good ↓ Bad	Measure	Description
	Oxygen available	Visually healthy ecosystem. Lots of living organisms. No indications of stressed organisms. Stream is well aerated at riffles and rapids.
	Some anoxia	Fish gasping at the surface. Few living organisms.
	Anoxic conditions	Dead fish present, some fish gapping at the surface.
	Not observed	No observation made on site.

3.6.21.10 Indication of life

Dead fish and birds, Figure 3-53, lack of aquatic animal life, lack of insects, are all indicators of poor oxygen content in the watercourse, and is likely to be linked with toxic contamination of the water, poor pH or algal growth.

Figure 3-53 Dead bird and fish, Klip River Gauteng

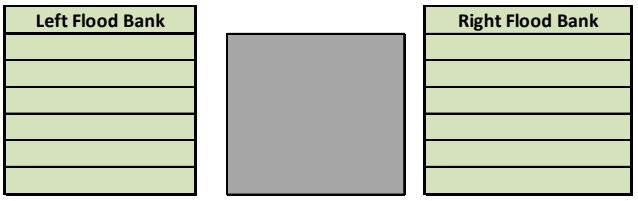
For the Site Assessment, the official observes the watercourse for any indicators of life e.g. fish, crabs, frogs, or death of organisms. The record of life is described using Table 3.35.

Table 3.35 Water quality: indication of life

Good ↓ Bad	Measure	Description
	Life	Indications of aquatic life, aquatic insects, fish, frogs, etc.
	Dead	Dead fish, birds, plants, insects visible
	None	No indication of aquatic life. Complete absence of aquatic organisms.
	Not tested	No observation made

3.6.22 Discharge quality

If there is discharge from outlets	
	4.27 Colour
	4.28 Odour
	4.29 Foam
	4.30 Oily sheen
	4.31 p.H
	4.32 Temperature



The indicators to measure discharge quality are similar to the indicators for water quality, but only limited to colour, odour, pH, temperature, foam and oily sheen. For detailed information about these indicators refer to the section on water quality. The records for the discharge indicators are measured according to Table 3.36 to

Table 3.41.

Table 3.36 Discharge quality: Colour

Good ↓ Bad	Measure	Description
	Colourless	Colourless
	Tea	Tea coloured
	Clear Unnatural	Unnatural in nature or colour
	Brown	Brown/muddy (soil)
	Black	Black/grey (sewage)
	Milky	Milky, opaque, unnatural in colour
	Green	Green (algal growth)

Table 3.37 Discharge quality: Odour

Good ↓ Bad	Measure	Description
	Earthy	Earthy smell
	Hydrocarbon	Petrol / diesel / oil / Aviation fuel / paraffin / sour smell
	Sewerage	Rotten egg / sewage smell
	Pesticide	Chemical or pesticide smell (algae)
	Not observed	No odour observed

Table 3.38 Discharge quality: Foam

Good ↓ Bad	Measure	Description
	None	No foam and/or bubbles
	Small	Small patches of bubbles and/or foam
	Large	Large quantities of bubbles and/or foam
	Not Observed	No observation made

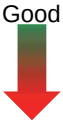
Table 3.39 Discharge quality: Oily sheen

Good  Bad	Measure	Description
	None	No oily sheen
	Small	Very small patches of sheen, patch less than area of hand / Naturally occurring oily sheen
	Sheen	Large or regular occurrence of oily sheen
	Not observed	No observation made on site.

Table 3.40 Discharge quality: pH

Good  Bad	Measure	Description
	Neutral	Neutral, 6.82 - 7.8
	Acidic	Low, acidic, dipstick, <6.8, orange marker; litmus paper red
	Alkaline	High, alkaline, dipstick >7.8, pink marker; litmus paper blue
	Not Tested	pH was not tested on site

Table 3.41 Discharge quality: Temperature

Good  Bad	Measure	Description
	Normal	Natural, approximately 21><27°C during summer months
	Warm	Warm, warm to the touch, approximately >27°C
	Cold	Cold, chill to the touch; approximately <21°C
	Not tested	Temperature not tested on site

4 DASHBOARD TOOL

4.1 How to complete the Dashboard

When the official returns to the office from site, they must capture the Site Assessment Form (SAF) in the Dashboard Tool (DT). A replica form is setup in Microsoft excel. Using the completed field form the official captures the measures that describe the site into the *Impact Form* in the Dashboard. The Dashboard, based on the selected measures, carries out a set of automated calculations. The results of these calculations are presented in the Dashboard.

Step 1: Open the Excel file *Dashboard Tool* on the cd.

Step 2: Save the workbook with the name of the site visit and the inspection number, for example Figure 4-1.

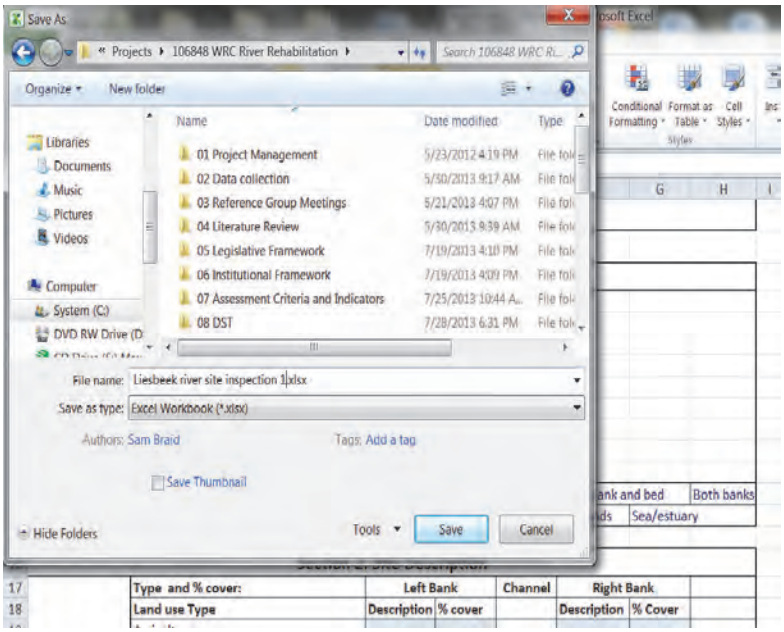


Figure 4-1 Save a Dashboard workbook per case and site inspection

Step 3: Using the field form, fill in the measures into the Impact form of the Dashboard tool, save the work. When complete, select the Dashboard tab, Figure 4-5.

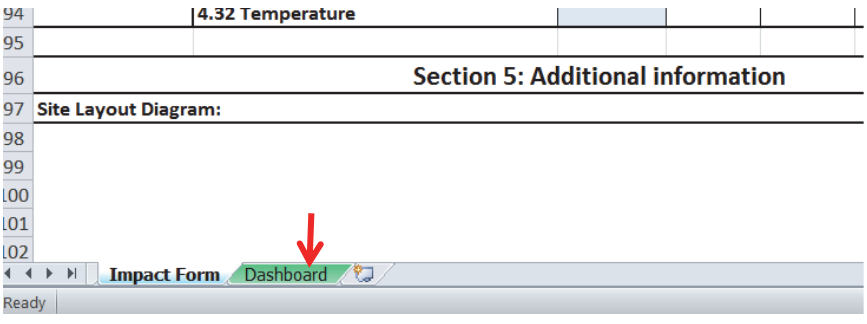


Figure 4-2 Select Dashboard tab

4.2 The Dashboard

The Dashboard screen Figure 4-3 provides two sets of graphs. The top set of graphs is a summary of the negative impacts per riverine function per zone of river reach assessed. The

bottom, colourful graph is the Dashboard. This graph indicates the impacts to the riverine functions.

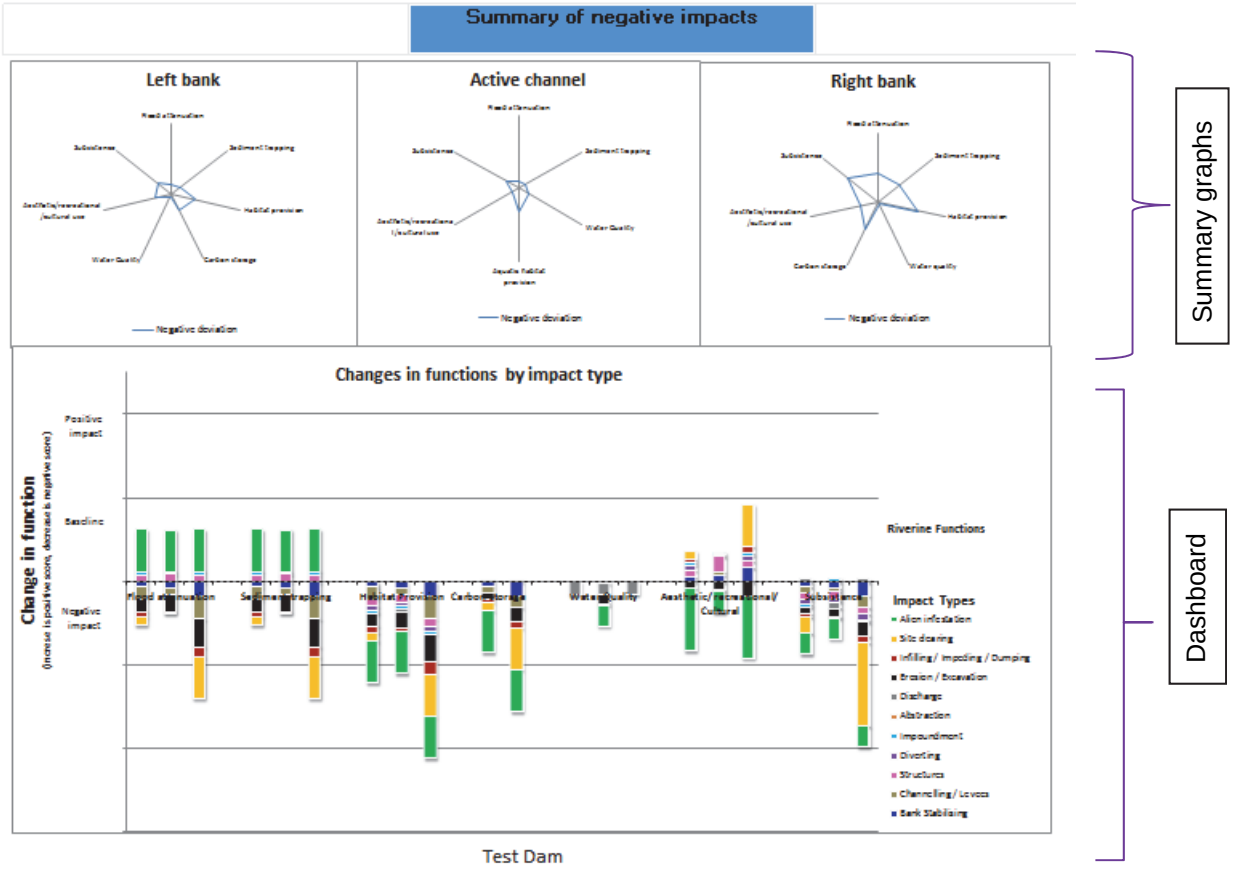


Figure 4-3 The Dashboard graphs

4.3 Reading the Dashboard

It is important to note that the Dashboard does not provide a quantitative value of impacts to riverine functions on the site. The tool provides an indication of the riverine functions being affected by the activities on the site. For a numerical reference, detailed studies will need to be conducted to provide a rating on the state of the river health for the particular reach and site.

4.3.1 Summary graphs

The summary graphs are presented for each zone of the riverine area, in other words there is a summary graph for the Left Flood Bank, the Active Channel and the Right Flood Bank. The blue line indicates the extent of impact to the riverine functions on the site. The summary graph only indicates the negative impacts. Where the blue line reaches the centre of the graph, there is little or no impact to that particular riverine function. The further outwards the blue line extends, e.g.

away from the centre of the graph, the greater the negative impact to the riverine function.

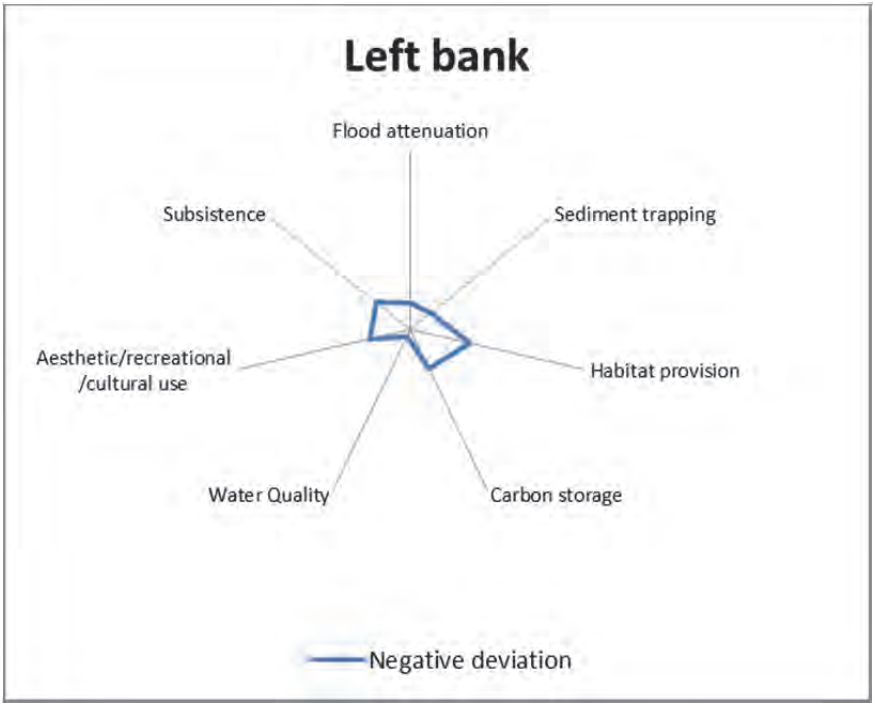


Figure 4-4 provides an indication of the different aspects of the summary graphs.

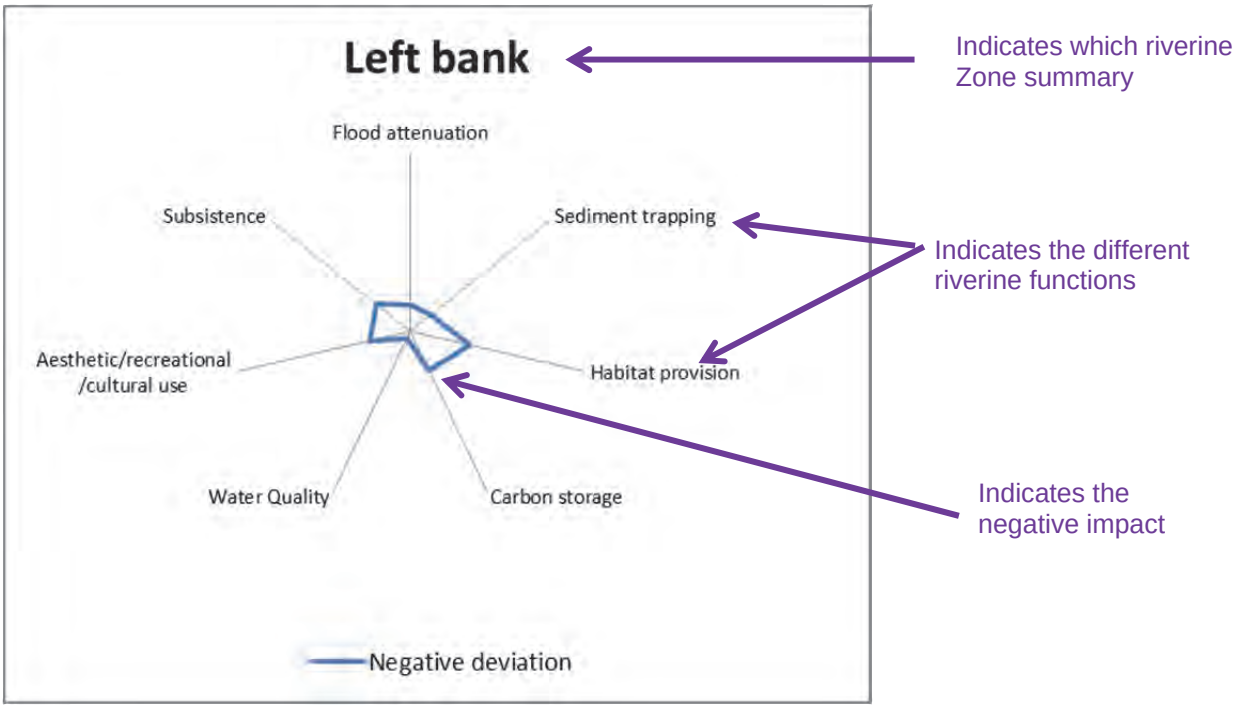


Figure 4-4 Reading the summary graphs

4.3.2 Dashboard Graph

Figure 4-5 provides an indication of the different components of the Dashboard graph.

1. The Dashboard graph is composed of seven groups of coloured stacked bar graphs. Each one of the seven groups represents one of the riverine functions. For example, the first group

illustrates flood attenuation, the second group illustrates sediment trapping, and the third group illustrates habitat provision, and so on.

2. Each of the riverine function groups of graphs is composed of three stacked bar graphs. These three stacked bar graphs indicate the zone of the river. For example, the left bar stack illustrates the left flood bank, the centre bar stack illustrates the active channel, and the right bar stack illustrates the right flood bank. Where there is no impact to a zone, there is no bar stack, for example carbon storage only affects the river banks, so there is no bar stack for the active channel. Similarly, if there is no discharge on a particular bank on the site, there is no bar stack for the river bank in the water quality function.

3. The coloured stacks indicate the different activities that are contributing to the impacts on the riverine functions. For example, in Figure 4-5, the green bars indicate Alien infestation, the black bars indicate erosion or excavation, the brown bars indicate channelling or levees, etc.

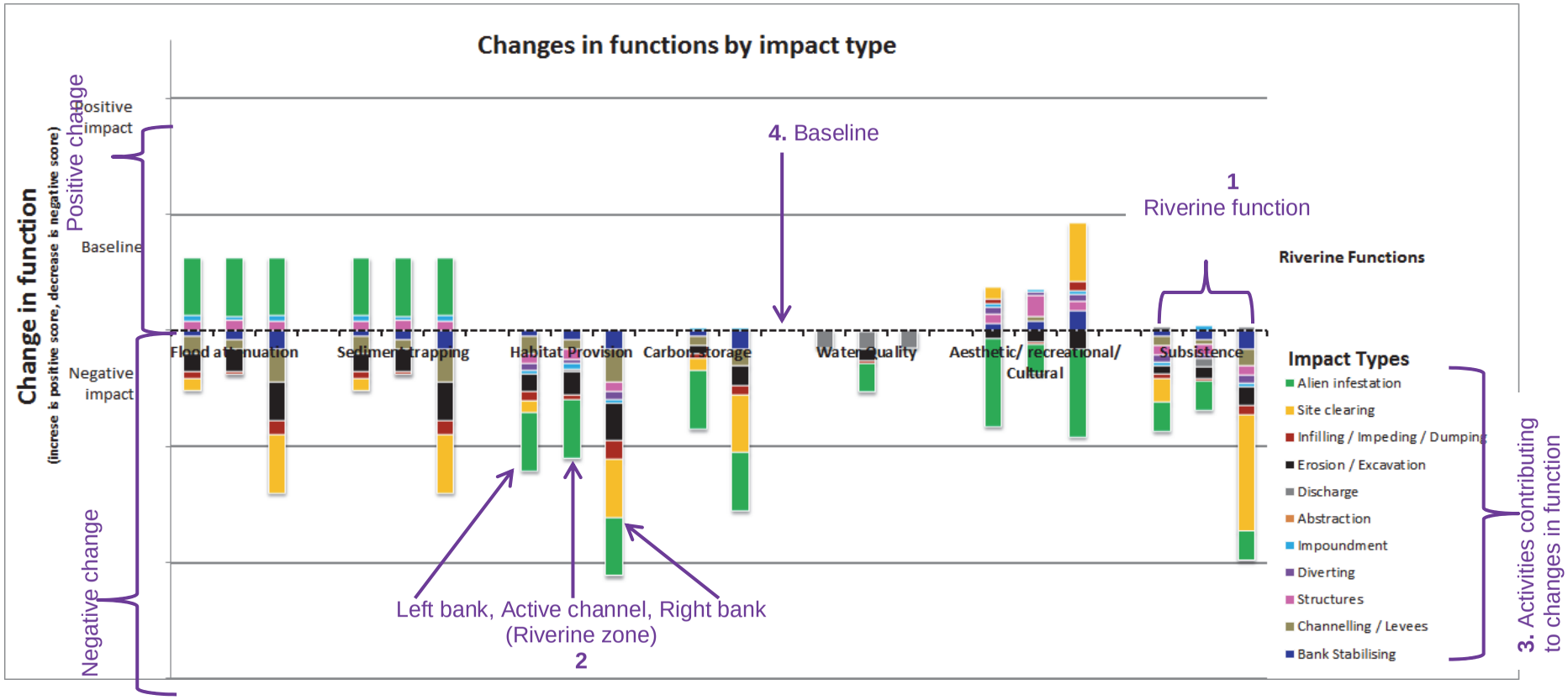


Figure 4-5 Dashboard graph

4. The dashed baseline indicates no change. The stacked graphs indicate the change in function. Some activities will have positive impacts and some will have negative impacts. The total length (both positive and negative impacts) of the stacked bar should be considered, when determining which functions have been most impacted by activities on the site. Rehabilitation activities should focus on the activities causing negative impacts on the site.

Of particular concern are the negative impacts to riverine functions. The stacked graphs that are the furthest/longest below the baseline indicate the most negative change in riverine function. In the Figure 4-5, Habitat provision, subsistence are the two most negatively impacted functions, followed by sediment trapping, flood attenuation, water quality and carbon storage. Aesthetic/Recreational/Cultural has the least negative change in function. This means that rehabilitation objectives of this site should focus on rehabilitating habitat provision as a priority.

5 INFORMING THE ADMINISTRATIVE NOTICE

Using the results from the Dashboard, the official can then direct the rehabilitation plan to specifically target the remedying of identified riverine functions.

The request for a Rehabilitation Plan should include three aspects:

i. The function(s) to be rehabilitated and any necessary specialist studies;
ii. Environmental Management Plan / Programme;
iii. Monitoring Programme.

For example, submit a rehabilitation plan within 30 days from receipt of this notice for approval by this Department. The rehabilitation plan should address the following issues:

i. Impacts to habitat function – a detailed habitat integrity assessment should be carried out in accordance with requirements of the EcoClassification Module G: Index of Habitat Integrity (Kleynhans *et al.,* 2009) and should be compiled by an appropriate accredited or professional registered specialist or ecologist.

ii. Environmental management plan - must recognize the potential impacts of activities on the site, provide mitigation for these impacts, as well as allocate responsibility for implementing the mitigation. The EMP should include best practice methodologies for site management, e.g. bunding of stockpiled soil; delineate the riparian zone and clearly indicate that it is a sensitive environment; no toilets or storage of substances within the buffer of- or the riparian zone.

iii. Monitoring plan – detailing the parameters to be measured, the timing of monitoring and responsibility of monitoring activities, to determine progress of the rehabilitation activities to the rehabilitation objectives and if necessary compliance activities.

5.1 Specialist studies

The fundamental aim of EcoClassification is to determine the cause and origin of the deviation (impact) of the Present Ecological State (PES) from the reference condition of the biophysical components. “The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river” (Kleynhans and Louw, 2008:A1-1). This is necessary in order to determine suitable and appropriate rehabilitation objectives and activities. The EcoClassification process provides detailed assessments, carried out by specialists, for each of

the component –drivers and responses, Figure 5-1. These specialist studies can be applied according to which function(s) has been identified in the Dashboard

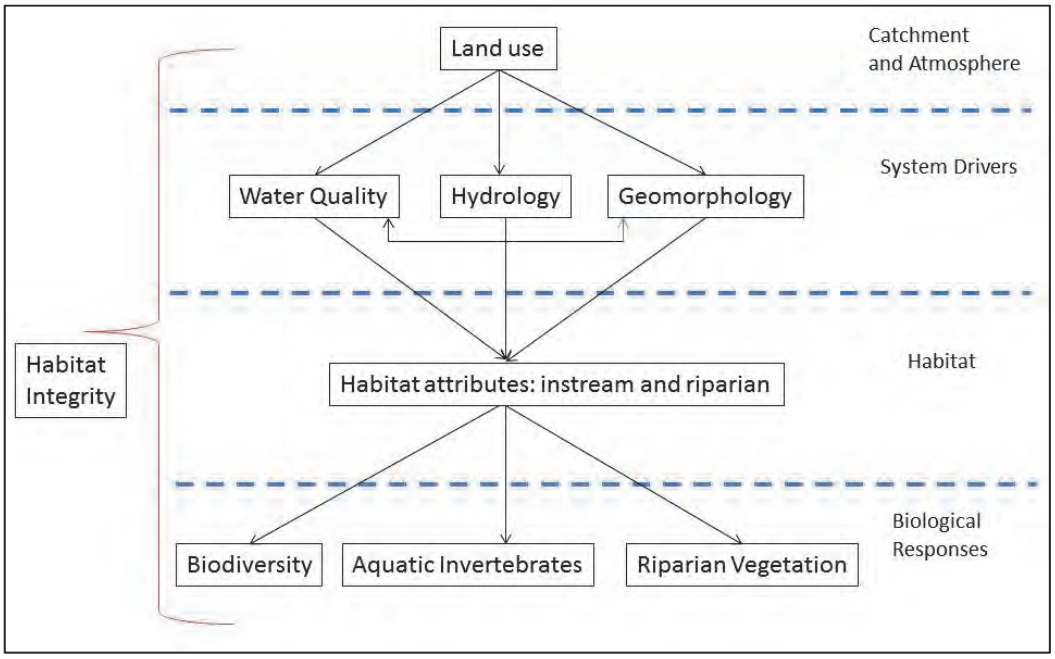


Figure 5-1 Interaction between drivers and biological response (Adapted: Kleynhans and Louw, 2008:A2-7)

5.1.1.1 Habitat Integrity (Habitat Provision Function)

Habitat provision is the most common riverine function to be impacted in urban rivers as a change in each system driver (hydrology, water quality, etc.) will always result in a change to habitat attributes. "The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans 1996 in Kleynhans *et al.*, 2009:G1:v). Aquatic physical habitat refers to the environment for the in-stream biota created by the interaction of the physical structure of the channel (the geomorphology) and the flow regime (discharge pattern over time). Table 5.1 summarises the various component and metrics (aspects) that affect habitat integrity.

Table 5.1 Summary of the Index of Habitat Integrity components and metrics

IN-STREAM HABITAT INTEGRITY ASSESSMENT		**RIPARIAN ZONE HABITAT INTEGRITY**	
Component	**Metric**	**Component**	**Metric**
Hydrological modification	Base (low) flows	Hydrological modification	Base flow
	Zero (no) flows		Zero flow
	Floods		Moderate floods and freshes
Physico-chemical modification	pH		Large floods
	Inorganic salts	Bank structure modification	Marginal
	Nutrients		Non-marginal
	Water temperature	Riparian zone connectivity	Lateral
	Water clarity		Longitudinal
	Oxygen concentration		

	Toxics	
Bed modification	Sedimentation	
	Benthic growth. (Algal growth)	
Bank modification	Marginal characteristics (vegetation and abiotic (e.g., undercut banks)	
	Non-marginal characteristics (vegetation and abiotic)	
Connectivity modification	Longitudinal	
	Lateral	

Where any of the metrics in Table 5.1 have been or are likely to be affected by the contravention, then a detailed habitat assessment is required in order to determine the state/health of the habitat integrity on the site. The assessment should be in accordance with the requirements of the EcoClassification Module G: Index of Habitat Integrity (Kleynhans, C.J. *et al.,* 2009) and should be compiled by an appropriate accredited or professional registered specialist or ecologist. The Habitat Integrity Assessment will provide information regarding a variety of the other drivers and responses resulting in the impact to habitat provision. As a guideline, a habitat assessment will also provide information about the other drivers and responses, and can be used as a minimum requirement for specialist studies, but this should be reviewed on a specific case basis.

5.1.1.2 Water Quality (Water Quality Function)

Where there are serious water quality-related impacts on the site e.g. fish and bird deaths, strong smelling/odorous water, unnatural water colour, excessive algal blooms, etc., a detailed water quality analysis must be conducted. This includes an assessment of Total Dissolved Solids (TDS), e.coli, pH, dissolve oxygen, and water clarity. Most of these attributes can be tested with apparatus by the officials themselves, however where laboratory testing is required, e.g. heavy metals, nutrients, e.coli, the samples must be taken according to the appropriate sample methodologies, laboratories must be accredited, and a chain of evidence must be attached to the samples at all times.

Side Note: Diatoms

Diatom assessment is not part of the Site Assessment, as it requires specialist laboratory work. However, diatoms are indicators of water quality and can be included in any detailed studies for water quality.

Diatom Sampling and Analysis by Koekemoer (2011)

"Diatoms are part of the primary producer trophic level and therefore form the base of the aquatic food web. They usually account for the highest number of species among the primary producers in aquatic systems (Leira, 2005; Bubak and Bozena, 2005). Diatoms are photosynthetic unicellular organisms and are found in almost all aquatic and semi-aquatic habitats."

"Diatoms have been shown to be reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification and metal pollution (Tilman *et al*., 1982; Dixit *et al*., 1992), as well as for general water quality (Prygiel *et al*., 2002). The reasons why diatoms are useful tools for bio-monitoring are summarised below according to Round (2001), and De la Rey *et al*., (2004):

- They occur in all types of aquatic ecosystems.
- They show a broad range of tolerance along a gradient of aquatic productivity, and individual species have specific water chemistry requirements.

- They have one of the shortest generation times of all biological indicators as they reproduce and respond rapidly to environmental change and provide early warnings of both pollution increases and habitat restoration success.
- They are sensitive to change in nutrient concentrations.
- Assemblages are usually diverse and therefore contain considerable ecological information. For this reason robust statistical and multivariate procedures can be used to analyze assemblage data.
- They respond rapidly to eutrophication and recovery. Diatoms are primarily photoautotrophic organisms, and are directly affected by changes in nutrient and light availability.
- Rapid immigration rates and the lack of physical dispersal barriers ensure little lag-time between perturbation and response.
- The taxonomy of diatoms is generally well documented.
- Diatoms can be found on substrates in streambeds even when dry, therefore they can be sampled at most times of the year."

"Diatoms are commonly employed in monitoring efforts as sensitive biological indicators to determine the anthropogenic impact on aquatic ecosystems, and have for a long time been used in bio-assessments (Kasperovičienė and Vaikutienė, 2007). As benthic diatom assemblages are sessile they are exposed to water quality at a site over a period antecedent to sampling. They therefore indicate recent as well as current water quality (Philibert *et al*., 2006).

Within the last decade diatom indices have gained considerable popularity throughout the world as a tool to provide an integrated reflection of water quality, which can form the basis of management decisions regarding rivers and streams (Taylor 2004).

Diatoms have tolerance limits and optima with respect to environmental conditions such as nutrients, organic pollution, pH, salinity and acidity (Van Dam *et al*, 1994; Bellingeri *et al*., 2006).

The specific water quality tolerances of diatoms have been resolved into different diatom-based water quality indices, used around the world. The most indices are based on a weighted average equation (Zelinka and Marvan, 1961). In general, each diatom species used in the calculation of the index is assigned two values; the first value reflects the tolerance or affinity of the particular diatom species to a certain water quality (good or bad) while the second value indicates how strong (or weak) the relationship is (Taylor, 2004). These values are then weighted by the abundance of the particular diatom species in the sample (Lavoie *et al*., 2006; Taylor, 2004; Besse, 2007). The main difference between indices is in the indicator sets (number of indicators and list of taxa) used in calculations (Eloranta and Soininen, 2002). "

"Biological water quality or diatom based water quality results are based primarily on the results provided by the SPI index. The SPI uses most species (1300 - 2000) from the database and categorizes species into five sensitivity groups. It has the broadest species base and highest taxonomic resolution of all the indices, i.e. identification of taxa in some cases needs to be down to subspecies and form level (Taylor, 2004). The index evaluates organic and inorganic pollution based on the sensitivity of each taxon, while taking into account the response of the whole diatom community (Almeida, 2001). The index is used to indicate general water quality.

The European numerical diatom index, the Specific Pollution sensitivity Index (SPI) was used to interpret results. De la Rey *et al.* (2004) concluded that the SPI reflects certain elements of water quality with a high degree of accuracy due to the broad species base of the SPI. The interpretation of the SPI scores has recently been adjusted (Taylor and Koekemoer, in press) and the new adjusted class limits are provided in Table 5.2.

Table 5.2 Adjusted to South African context, class limit boundaries for the SPI index.

Interpretation of index scores		
Ecological Category (EC)	**Class**	**Index Score (SPI Score)**
A	High quality	18 - 20
A/B		17 - 18
B	Good quality	15 - 17
B/C		14 - 15
C	Moderate quality	12 - 14
C/D		10 - 12
D	Poor quality	8 - 10
D/E		6 - 8
E	Bad quality	5 - 6
E/F		4 - 5
F		<4

The aim of the diatom based water quality results is to provide biological water quality information for conditions on the day of biological component sampling regarding the aquatic health and functioning of the aquatic system, and providing additional input to the physico-chemical component of the study as a response variable.
The report includes:

- A biological water assessment which will include an assessment of the physico-chemical variables: Dissolved Oxygen (DO), Temperature, Salinity, pH and nutrients;
- Current pollution levels as indicated by the SPI index;
- General description of the water quality related habitat specifications linked to ecologically sensitive species requirements; and
- Possible trends in biological water quality.

Approximate cost: R1000/per sample analysis (in 2012) which includes laboratory preparation of sample, diatom counting and analysis and reporting.

5.1.1.3 Hydrology / geomorphology (Flood attenuation and Sediment trapping functions)

Where contravening activities have resulted in, or themselves are, activities causing impacts to the flow regime (including the functions of flood attenuation and/or sediment trapping) of the water course e.g. impoundments, major abstractions, bridges/culverts, weirs, significant impediments or diversion of flow, excessive erosion, etc. a detailed hydrological assessment should by conducted for the site (including upstream and downstream impacts). Changes in the hydrological regime of the watercourse will impact on the erosion/sediment/deposition regime as well as the flooding patterns of the watercourse. Hydrological studies should be carried out by qualified or professional registered hydrologists. Where erosion and sedimentation/deposition are the critical issues, then an accredited or professional registered sedimentologist or geomorphologist should conduct the analysis.

Where specialist studies are identified they should be conducted by the relevant accredited or professionally registered specialists. The detailed studies need to compare the site reach to a reference condition, clearly outline the key issues, and make clear recommendations for rehabilitation, including setting objectives and identifying measures (indicators) of progress. All results should be recorded as a baseline against which to monitor progress (improvement). The Specialists need to answer the following questions in their reports:

- Describe the impact of the contravention: Has the contravention resulted in an impact to the river corridor (riparian area and in-stream)? Explain how/ what the impact (and cumulative impact if relevant) has been? What are the footprint / extent of the impact? What is the duration of the impact e.g. temporary, permanent, etc.? How has the contravention/impact affected safety (public safety), water quality, hydrology, geomorphology, biodiversity on the site and the adjacent properties?
- Should directed remedial activities seek to **Restore**, **Rehabilitate** or **Remediate** the river corridor? Where restore refers to returning the river to a pristine state; rehabilitate refers

to repairing specific functions but not returning the entire site to a pristine state; and remediate refers to maintaining the status quo and preventing further degradation. What should the objectives of the "rehabilitation" be? What measures/indicators should be used to monitor progress of the rehabilitation?

Based on the results and recommendations of the Specialists studies, a rehabilitation plan should be compiled setting clear objectives for rehabilitation, including appropriate timeframes and measures (indicators) of improvement. A compliance notice or directive can then be issued instructing the implementation of the rehabilitation plan as per the Specialist studies.

Where a person cannot afford to conduct the specialist studies, the enforcing Institution should conduct the specialist studies and remedial works, in terms of sections 28(7), 31N(2)(b) of the National Environmental Management Act (Act 107 of 1998)(NEMA), or sections 19(4), 20(6)(b), 53(2)(a) of the National Water Act (Act 36 of 1998)(NWA), and then claim the costs back where appropriate.

Information and data collected in the specialist assessments should be captured into the River Health Programme database for future monitoring and reference.

5.2 Environmental Management Plan/Programme (EMP)

The Environmental Management Plan/Programme, like formal Environmental Authorisations, must identify the potential impacts of activities on the site, provide mitigation for these impacts, as well as allocate responsibility for implementing the mitigation. The EMP is an extension of the Environmental Authorisation and in the case of compliance and enforcement will be an extension of the administrative notice (e.g. Compliance Notice or Directive). The aim of the EMP is to promote environmental awareness and best environmental practice in all activities on site not limited to the 'listed' activities.

Firstly the riparian zone should be delineated according to the DWAF (2008) guideline, and mapped spatially using the GPS co-ordinates of the riparian-terrestrial boundary. The map should also include the 32metre buffer around the riparian zone. The boundary of the riparian area and the buffer area should be clearly demarcated on site e.g. by coloured markers, fencing, signage, etc. The EMP should indicate which activities should not be carried out within the riparian area and within the buffer area e.g. storage and disposal of waste and temporary toilet facilities.

Additional EMP activities should include:

- Removal or management of alien and invasive vegetation according to the class of plant species.
- Rubble and site waste to be collected in clearly marked skips or litter bins around the site. Implement site management fines for littering/dumping. Install litter traps on storm water runoff infrastructure. Erect no dumping/no littering signs. Waste such as plastic, glass and tins, etc. should be recycled wherever possible. Remove dumping/solid waste to an approved landfills site (pink slips to prove formal dumping, or detailed motivation of recycling).
- Improved stormwater retention and/or filtration prior to discharge (SUD).
- Regular clearing of stormwater drains, riparian areas and in-stream channels of debris, sediment and solid waste washed from site.
- Erect sediment screens around stockpiles.

- Storage of hydrocarbons and other substances must be in accordance with their materials datasheets or South African National Standards (SANS).
- Maintenance of equipment must be in a bunded or secured area. Spills must immediately be cleaned up and contaminated soil and waste must be disposed of by appropriate means.

5.3 Monitoring

According to FISRWG (2001:9-29) designing the rehabilitation plan is not the end of the project. The remedial effort is not considered complete once the rehabilitation plan has been implemented, but that there should be ongoing monitoring, evaluation, and adaptive management. The purpose of monitoring rehabilitation activities is to gather data that will help determine the success of the rehabilitation effort. FISRWG (2001) suggests that monitoring of rehabilitation activities should be guided by predetermined criteria and checklists and allow for the recording of results in regular monitoring reports. The technical analysis in a monitoring report should reflect remedial objectives and should identify and discuss options to address deficiencies.

The National Research Council (NRC) (1990), based on a thorough review of freshwater monitoring plans some of which have been in place for over 30 years, recommended the following factors to ensure a sound monitoring plan:

- Clear, meaningful monitoring plan goals and objectives that provide the basis for scientific investigation;
- Flexible plans that allow modifications where changes in conditions or new information suggests the need;
- Useful and accessible monitoring information available to all interested parties.

The Monitoring aspect of the Rehabilitation Plan should set out the monitoring requirements, such as parameters to be measured, timing of monitoring and responsibilities (person e.g. specialist or ECO) of monitoring activities. The monitoring plan does not need to be complex or consist of expensive measures and assessments. It must be practical and provide some indication of the progress of attaining the rehabilitation objectives.

6 REFERENCES

ALLAN, J.D. (1995). *Stream Ecology Structure and function of running waters*. Chapman & Hall, London, United Kingdom.

ALMEIDA, S.F.P. (2001). Use of diatoms for freshwater quality evaluation in Portugal. *Limnetica* 20(2): 205-213.

ARNOLD, C., BOISON, P. and PATTON, P. (1982). Sawmill Brook: an example of rapid geomorphic change related to urbanization. *Journal of Geology* 90:pp155-166.

ASKEY-DORAN, M. (1999). Riparian Land Management Technical Guidelines. On ground management tools and techniques. In: LOVETT, S. and PRICE, P. (eds). *Riparian land management technical guidelines.* Land and Water Resources Research and Development Corporation (LWRRDC). Canberra, Australia.

BAIN, M.B. and STEVENSON, N.J. (1999). *Aquatic habitat assessment: common methods.* American Fisheries Society, Bethesda, Maryland, United States of America.

BAUER, B.B. and RALPH, C.R. (2001). Strengthening the use of aquatic habitat indicators in clean Water Act Programs. *Fisheries* 26:pp14-24.

BELLINGERI B.J., COCQUYT, C. and O'REILLY, C. (2006). Benthic diatoms as indicators of eutrophication in tropical streams. *Hydrobiologia* 573:75–87.

BESSE-LOTOTSKAYA, A., VERDONSCHOT, P.F.M. and SINKELDAM, .J.A. (2006). Uncertainty in diatom assessment: Sampling, identification and counting variation. *Hydrobiologia* 566: 247 – 260.

BOCKSTALLER, C. and GIRARDIN, P. (2003). How to validate environmental indicators. *Agricultural Systems,* 76 (2): 639-653.

BOND, W.J. Keystone species. *In*: SCHULZE, E.D. and MOONEY, H.A. (eds.) (1994). *Biodiversity and Ecosystem Function.* Springer-Verlag, New York, United States of America. pp:237-253.

BOON, P.J. (1992). *Essential elements in the case for river conservation. River Conservation and Management.* (eds.) BOON, P.J., CALOW, P. and PETTS, G.E., pp.11-33. Wiley, Chichester, United Kingdom.

BOOTH, D., MONTGOMERY, D. and BETHEL, J. (1996). Large woody debris in the urban streams of the Pacific Northwest. Cited in *Effects of watershed development and management on aquatic systems,* (ed.) ROSNER, L., pp.178-197. Proceedings of Engineering Foundation Conference, Snowbird, Utah, United States of America, August 4-9, 1996.

BOOTH, D. and. JACKSON, C. (1997). Urbanization of aquatic systems: degradation thresholds, stormwater detection and the limits of mitigation. *Journal of the American Water Resources Association (JAWRA)* 33(5):pp1077-1089.

BOURNE, C.B. (1992). *Freshwater as a Scarce Resource*. Paper delivered at a Panel discussion at the Canadian Council on International Law Conference, October 1989; X. Hanqin, Commentary-Relativity in International Water Law, Colorado Journal of International

Environmental Law & Policy, Vol. 3(1992), a p.48, n.7. (In UNEP, The greening of water law, 2010.).

BREN, L.J. (1993). Riparian Zone, Stream, Floodplain Issues: A review. *Journal of Hydrology* 150:277-299. Cited in SOMAN, S., BEYELER, S., KRAFT, S.E., THOMAS, D. and WINSTANELY, D. (2007). *Ecosystems Services from Riparian Areas: A Brief summary of the Literature.* Prepared for the Scientific Advisory Committee of the Illinois River Coordinator Council, Office of the Lt. Governor.

BRIERLEY, G. J. and FRYIRS, K. A. (2005). *Geomorphology and River Management: Applications of the River Styles Framework.* Blackwell Publishing, Oxford, United Kingdom.

BUBAKI, I. and BOŻENA, B. (2005). Fossil diatoms and Chrysophyceae cysts as indicators of paleoecological changes in Lake Ostrowite (Tuchola Pinewoods). *Oceanological and Hydrobiological Studies* 34(3): 269-286.

CENTRE FOR WATERSHED PROTECTION (CWP). (2003). *Impacts of Impervious Cover on Aquatic Systems.* Centre for Watershed Protection.

CHALLEN, D., QUINN, N. and BLANCHÉ, C. (2003). Assessing riparian habitat: an approach for planning rehabilitation. In QUINN, N. (2003). *A decision support system for rehabilitation and management of riparian systems*. WRC Report 1064/1/03. Water Research Commission. South Africa, Pretoria.

CHAPMAN, P.M. (1992). Ecosystem health synthesis: can we get there from here? *Journal of Aquatic Ecosystem Health*, 1, 69-79.

CHRISTENSEN, N.L. (1997). Managing for heterogeneity and complexity in dynamic landscapes. In: PICKETT, S.T.A., OTSFELD, R.S., SHACHAK, M. and LIKENS, G.E. (eds.), *Enhancing the Ecological Basis of Conservation: Heterogeneity, Ecosystem Function and Biodiversity.* Chapman and Hall, New York, United States of America. pp67-186.

CITY OF CAPE TOWN (CoCT). (2009a). Roads and Stormwater Department, Catchment, Stormwater and river Management Branch. *Floodplain and River Corridor Management Policy*. *Version 2.1*.Report no. C 58/05/09

CITY OF CAPE TOWN (CoCT). (2009b). Roads and Stormwater Department, Catchment, Stormwater and river Management Branch. *Management of Urban Stormwater Impacts Policy Version 1.1*. Report No. C 58/05/09

CLAPCOTT, J. and YOUNG, R. (2008) *Spatial Variation of Function Indicators in Waikato River*. Waikato Regional Council, New Zealand.

CLARK, J. (1978). Freshwater wetlands: habitats for aquatic invertebrates, amphibians, reptiles, and fish. Cited in Wetland functions and values: the state of our understanding*, (*eds.) GREEN, P.E., CLARK, J.R. and CLARK, J.E., pp330-343. Minneapolis, Minnesota: American Water Resources Association. Cited in WYDOSKI, R.S. and WICK, E.J. Flooding and Aquatic Ecosystems. In: WOHL, E.E. (ed.) (2000), *Inland flood hazards: human, riparian and aquatic communities.* Cambridge University Press. New York, NY, United States of America. p. 238-268.

CLARK, J.J. and WILCOCK, P.R. (2000). Effects of land-use change on channel morphology in northeastern Puerto Rico. *Geological Society of America Bulletin*, December 2000, v.112; no.12.

COLE, D.N. and MARION, J.R. (1988). Recreation impacts in some riparian forests of the eastern United States. *Environmental Management* 12:pp99-107.

COUCH, C. (1997). Fish dynamics in urban streams near Atlanta, Georgia. Technical Note 94. *Watershed Protection Techniques* 2(4):pp511-514.

CRAIGIE, F., SNIJMAN, P. and FOURIE, M. (2009). Dissecting environmental compliance and enforcement. In PATERSON, A. and KOTZÉ, L.J. (eds.) (2009) *Environmental Compliance and Enforcement in South Africa: Legal Perspectives*. Juta and Company, LTD. Pretoria, South Africa.

CROONQUIST, M.J. and BROOKES, R.P. (1991).Use of avian and mammalian guilds as indicators of cumulative impacts in riparian wetland areas. *Environmental Management* 19(5) p:701-714.

CUMMINS, K.W. (1993). Riparian stream linkages. In BUNN, S.E., PUSEY, B.J. and PRICE, P. (eds.). *Ecology and management of riparian zones in Australia.* Land and Water Resources Research and Development Corporation, Canberra, Australia. pp: 5-20.

CYCLE PARK (2011). *Objection to Intention to issue a compliance notice issued in terms of section 31L of the National Environmental Management Act 107 of 1998 in respect of the alleged unlawful commencement of activities along the river: Toyota –MTN Cycle Park, 1A Libertas Road, Bryanston, ("the site").* Dated 3 November 2011. Unpublished.

DALLAS, H.F. and DAY, J.A. (2004). *The Effect of Water Quality Variables on Aquatic Ecosystems: A Review.* WRC Report. WRC Report No.: TT 224/04. WRC, Pretoria, South Africa.

DEASON. J.P., DICKEY, G.E., KINNELL, J.C., and SHABMAN, L.A. (2010). Integrated planning framework for urban river rehabilitation. *Journal of water resources planning and management* Vol. 136, No.6, November 1, 2010. United states of America.

DEPARTMENT OF AGRICULTURE, FORESTRY and FISHERIES (DAFF). (1983). Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF AGRICULTURE, FORESTRY and FISHERIES (DAFF). (1998). National Forest Act, Act 84 of 1998 (NFA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF COOPERATIVE GOVERNANCE AND TRADITIONAL AFFAIRS (CoGTA). (2002). Disaster Management Act, Act 57 of 2002 (DMA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF COOPERATIVE GOVERNANCE AND TRADITIONAL AFFAIRS (CoGTA). (2005). Inter-Governmental Relations Framework Act, Act 13 of 2005 (the IGRFA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF CULTURAL AFFAIRS AND SPORT (DCAS). (1999). National Heritage Resources Act, Act 25 of 1999 (NHRA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT) (1970). Mountain Catchments Act, Act 63 of 1970 (MCA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT). (1989). Environment Conservation Act, Act 73 of 1989 (ECA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS. (1998). National Environmental Management Act, Act 107 of 1998 (NEMA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS. (DEA). (2003). National Environmental Management: Protected Areas Act, Act 57 of 2003 (NEM:PAA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS. (2004). National Environmental Management: Biodiversity Act, Act 10 of 2004 (NEM:BAA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISIM (DEAT). (2008a). National Environmental Management: *Waste Act, Act 59 of 2008* (WA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT). (2008b). *Review of effectiveness and efficiency of the Environmental Impacts Assessment (EIA) system in South Africa.* Pretoria, South Africa

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). (2010). *EMI Operating Manual* (2010). Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). (2011). *Environmental Impact Assessment and Management Strategy. Subtheme 8: Skills of EAPS and Government Officials*. Compiled by LOUBSER, J. and FREEMAN, M. Pretoria, South Africa.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). (2012). *2011-12 National Environmental Compliance and Enforcement Report.* Pretoria, South Africa

DEPARTMENT OF HEALTH (DOH). (2003). National Health Act, Act 61 of 2003 (NHA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF JUSTICE AND CONSTITUTIONAL DEVELOPMENT (DOJ&CD). (1977). Criminal Procedures Act, Act 51 of 1977 (CPA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF JUSTICE AND CONSTITUTIONAL DEVELOPMENT (DOJ&CD). (1996). Constitution of the Republic of South Africa, Act 108 of 1996 (the Constitution). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF MINERAL AND ENERGY AFFAIRS. (1996). Mine Health and Safety Act, Act 29 of 1996 (MHSA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF MINERAL AND ENERGY AFFAIRS. (2002). Mineral and Petroleum Resources Development Act, Act 28 of 2002 (MPRDA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF SAFETY AND SECURITY (1995). South African Police Service Act, Act 68 of 1995 (SAPSA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF SAFETY AND SECURITY (1998). South African Police Service Amendment Act, Act 83 of 1998 (SAPSAA). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF WATER AFFAIRS, FORESTRY AND ENVIRONMENTAL CONSERVATION. (1980). *White paper on a National Policy regarding environmental conservation*.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (1996). *South African National Water Quality Guidelines. Volume 7: Aquatic Ecosystems.* First Edition. Department of Water Affairs and Forestry.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (1998). National Water Act, Act 36 of 1998 ('the NWA'). Government Gazette, Pretoria, South Africa.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (2003). *Guide to the National Water Act*. Department of Water Affairs and Forestry, Pretoria, South Africa.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (2004). *National Water Strategy.* First Edition, September 2004. Department of Water Affairs and Forestry, Pretoria, South Africa.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (2005). *A practical field procedure for identification and delineation of wetlands and riparian areas.* Department of Water Affairs and Forestry, Pretoria, South Africa.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). (2008). *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*, draft document prepared in 2008 by ROUNTREE, M., BATCHELOR, A. L., MACKENZIE, J. and HOARE, D. for Department of Water Affairs and Forestry, Pretoria, South Africa. (unpublished).

DIXIT, S.S., SMOL, J.P., KINGSTON, J.C. and CHARLES, D.F. (1992). Diatoms: Powerful indicators of environmental change. *Environmental Science & Technology*. 26 23-33.

DOWNS, P.W. and GREGORY, K.J. (2004). *River channel Management. Towards sustainable catchment hydrosystems.* Arnold, Great Britain.

DUNSTER, J. and DUNSTER, K. (1996). *Dictionary of natural resource management*. University of British Columbia, Canada.

DU PLESSIS, L.M. and DU PLESSIS, A.G. (1992). *An introduction to law*. Juta & Co, Ltd., Cape Town, South Africa.

DU PLESSIS, A. (2009). Understanding the legal context. Cited in PATERSON, A, and KOTZÉ, L.J. (eds.) (2009) *Environmental Compliance and Enforcement in South Africa: Legal Perspectives*. Juta and Company, LTD. Pretoria, South Africa.

EATON, A.D.; CLESCERI, L.S.; and GREENBERG, A.E. (eds.) (1995). *Standard methods for the examination of water and wastewater.* American Public Health Association, Washington, United States of America.

EBERSOLE, J.L., LISS, W.J. and FRISSELL, C.A. (1997). Restoration of stream habitats in the Western United States: restoration as re-expression of habitat capacity. *Environmental Management*, 21, 1-14.

ELORANTA, P. and SOININEN, J. (2002). Ecological status of Finnish rivers evaluated using benthic diatom communities. J*ournal of Applied Phycology*. 14: 1-7.

ENVIRONMENT AGENCY. (1998). *River Habitat Quality. The physical character of rivers and streams in the UK and Isle of Man*. Compiled by RAVEN, P.J., HOLMES, N.T.H., DAWSON, F.H., FOX, P.J.A., EVERARD, M., FOZZARD, I.R., and ROUEN, K.J. Environment Agency, United Kingdom.

FELLOWS, C.S., CLAPCOTT, J.E., UDY, J.W., BUNN, S.E., HARCH, B.D., SMITH, M.J. and DAVIES, P.M. (2006). Benthic metabolism as an indicator of stream ecosystem health. *Hydrobiologia* 572: pp71- 87.

FISCHER, R.A., MARTIN, C.O., and FISCHENICH, J.C. (2000). *Improving riparian buffer strips and corridors for water quality and wildlife.* International conference on Riparian Ecology and Management in Multi-Land Use watersheds, August 2000. American Water Resources Association.

FISRWG (1998) *Stream Corridor Restoration: Principles, Processes and Practices*. Federal Interagency Stream Corridor Restoration Working Group. National Technical Information Service. United States of America.

FOLKE, C., CARPENTER, S., WALKER, B., SCHEFFER, M., ELMQVIST, T., GUNDERSON, L. and HOLLING, C.S. (2004). Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. *Annual Review of Ecology, Evolution, and Systematics* 35: 557–581. doi:10.1146/annurev.ecolsys.35.021103.105711.

FREEMAN, N.M. and ROWNTREE, K. (2005). *An introduction to the science and practice of Fluvial Geomorphology.* Water Research Commission (WRC) Report No. TT 238/05. WRC, Pretoria, South Africa.

FRIEDMAN, J.M. and AUBLE, G.T. (2000). Floods, flood control, and bottomland vegetation. In WOHL, E.E. (ed.)(2000), *Inland flood hazards: human, riparian and aquatic communities.* New York, NY: Cambridge University Press. p. 219-237.

GALLAGHER, A.S. and STEVENSON, N.J. (1999). Streamflow. In BAIN, M.B. and STEVENSON, N.J. (eds.) *Aquatic habitat assessment: common methods.* American Fisheries Society, Bethesda, Maryland, United States of America.

GALLI, J. (1991). *Thermal impacts associated with urbanisation and stormwater best management practices.* Metropolitan Washington Council of Governments, Maryland Department of Environment, Washington, DC, United States of America.

GAUTENG PROVINCIAL GOVERNMENT. (2004). *Volume II: Underlying approaches to the development of the compliance and enforcement programme.* Compliance and Enforcement Programme for the Gauteng Provincial Department of Agriculture, Conservation and Environment. September 2004.

GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT (GDARD)(2011). Pre-compliance Notice dated 28 September 2011. Unpublished. Reference No. C0086-2011

GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT (GDARD)(2012). Compliance Notice dated 19 March 2012. Unpublished. Reference No. C0086-2011

GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT (GDARD)(2012). Reply to Objective to Compliance Notice dated 8 May 2012. Unpublished. Reference No. C0086-2011

GERBER, A.; CILLIERS, C.J.; VAN GINKEL, C. and GLEN, R. (2004) Easy Identification of Aquatic Plants. Department of Water Affairs, Pretoria.

GLASSON, J., THERIVEL, R. AND CHADWICK, A. (1999). *Introduction to Environmental Impact Assessment.* 2nd Edition. Spon Press, London, Great Britain.

GLAZEWSKI, J. (2000). *Environmental Law in South Africa.* Butterworths, Durban, South Africa.

GOEBEL, P.C., HIX, D.M. and WHITMAN, H.L. (2011). *Composition and structure of riparian areas along a land-use gradient in an agricultural watershed of North Eastern Ohio*. Proceedings of the 17TH Central Hardwood Forest Conference.

GONZÁLEZ DEL TÁNAGO, M., and GARCÍA DE JALÓN, D. (2006). Attributes for assessing the environmental quality of riparian zones. *Limnetica*, 25(1-2): p.389-402 The ecology of the Iberian inland waters: Homage to Ramon Margalef.

GRAHAM, M. and LOUW, M.D. (2008). *Module G: EcoClassification and EcoStatus Determination in River EcoClassification: Manual for Index of Habitat Integrity* (Section 2, Model Photo Guide). Water Research Commission. WRC Report No TT 378-08. WRC, Pretoria, South Africa.

GREGORY, K., DAVIS, R. and DOWNS, P. (1992). Identification or river channel change due to urbanization. *Applied Geography* 12:pp299-318.

GROFFMAN, P.M., BAIN, D.J., BAND, L.E., BELT, K.T., BRUSH, G.S., GROVE, J.M., POUYAT, R.V., YESILONIS, I.C. and ZIPPERER, W.C. (2003). Down by the riverside: urban riparian ecology. *Ecological Environment* 1(6):315-321. The Ecological Society of America.

GLOBAL WATER PARTNERSHIP (GWP). (2000). *Integrated Water Resources Management.* TAC Background Papers: Number 4. Stockholm, Sweden

HARTMANN, H.T. and KESTER, D.E. (1983). Plant propagation: principles and practice. Prentice-Hall, Englewood Cliffs, New Jersey, United States of America.

HAWKINS, C.P., HOGUE, J.N., DECKER, L.M. and FEMINELLA, J.W. (1997). Channel morpholgy, water temperature, and assemblage structure of stream insects. *Journal of the North American Benthological Society* 16(4): 728-749.

HEEG, J., ACKHURST, E.G.J. and BREEN, C.M. (1989). Water quality and the need for water releases. In: WALMSLEY, R.D. and ROBERTS, C.P.R. (eds.) *Changing patterns of resource use in the Pongola River Floodplain.* FRD Occasional Report Series No.36. Ecosystem Programmes, Foundation for Research and Development, CSIR, Pretoria, South Africa.

HEEG, J. and BREEN, C.M. (1994). Resolution of conflicting values on the Pongola River and floodplain *(South Africa).* In: PATTEN, B.C. (ed.) *Wetlands and shallow continental water bodies*, Volume 2. P303-359. SPB Academic Publishing, The Hague, Netherlands.

HELLAWELL, J.M. (1986). *Biological Indicators of Freshwater Pollution and Environmental Management*. London: Elsevier Applied Science Publishers.

HENDERSON, L. (2001) Alien Weeds and Invasive Plants. Agricultural Research Council, Cape Town, South Africa.

HILDEN, M. and RAPPORT, D.J. (1993). Four centuries of cumulative impacts on a Finnish river and its estuary; an ecosystem health approach. *Journal of Aquatic Ecosystem Health* 2: 261-275

HOLLING, C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4, 1-23.

INTERNATIONAL UNION FOR CONSERVATION OF NATURE. (1980). *World Conservation Strategy. Living Resource Conservation for Sustainable Development*. IUCN, UNEP, WWF.

IVERSEN, T.M., MADSEN, B.L. and BØGESTRAND, J. (2000). River conservation in the European Community, including Scandinavia. Cited in *Global Perspectives on River Conservation: Science Policy and Practice*, Edited by BOON, P.J., DAVIES, B.R. and PETTS, G.E. John Wiley & Sons Ltd, United States of America.

JACOBY, D. and ROGERS, K. *Strategic Adaptive Management.* Unpublished.

KARR, J.R. (1981). Assessment of biotic integrity using fish communities. *Fisheries*, 6, 21-27.

KARR, J.R. (1991). Biological integrity: a long-neglected aspect of water resource management. *Ecological Applications*, 1, 66-84.

KARR, J.R. (1999). Defining and measuring river health. *Freshwater Biology* (1999) 41,221-234. Blackwell Science Ltd.

KLEYNHANS, C.J. (1996). A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). *Journal of Aquatic Ecosystem Health* 5:41-54.

KLEYNHANS, C.J., LOUW, M.D., THIRION, C., ROSSOUW, N.J. and ROWNTREE, K. (2005). *River EcoClassification: Manual for EcoStatus determination* (Version 1). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. KV 168/05. WRC, Pretoria, South Africa.

KLEYNHANS, C.J. (2007). *Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination* (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 330/08. WRC, Pretoria, South Africa.

KLEYNHANS, C.J. and LOUW, M.D. (2007). *Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination* (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry Report. WRC Report No. TT 329-08. WRC, Pretoria, South Africa.

KLEYNHANS, C.J., MACKENZIE, J. and LOUW, M.D. (2008). *Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus*

Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 333/08. WRC, Pretoria, South Africa.

KLEYNHANS, C.J., LOUW, M.D. and GRAHAM, M. (2009). *River EcoClassification: Manual for Ecostatus Determination* (Version 2). Module G: Index for Habitat Integrity. Joint Water Research Commission and Department of Water Affairs and Forestry Report. WRC Report No. TT 377/09. WRC, Pretoria, South Africa.

KOEKEMOER AQUATIC SERVICES. (2011). *Diatom sampling and analysis information document.* Internal Report. Unpublished.

LAVOIE, I., CAMPEAU, S., GRENIER, M. and DILLON, P.J. (2006). A diatom-based index for the biological assessment of eastern Canadian rivers: an application of correspondence analysis (CA). *Canadian Journal of Fisheries and Aquatic Sciences*. 63(8): 1793–1811.

LEIRA, M. and SABATER, S. (2005). Diatom assemblages distribution in Catalan rivers, NE Spain, in relation to chemical and physiographical factors. *Water Research* 39: 73-82.

LOVETT, S. and PRICE, P. (eds.) *Riparian land management technical guidelines: On ground management tools and techniques*. Published by Land and Water Resources Research and Development Corporation (LWRRDC). Canberra, Australia.

LUDWIG, D.F. and IANNUZZI, T.J. (2006). Habitat equivalency in urban estuaries: An analytical hierarchy process for planning ecological restoration. *Urban Ecosystems* 9:265-290*.*

MACFARLANE, D.M., KOTZE, D.C., ELLERY, W.N., WALTERS, D., KOOPMAN, V., GOODMAN, P., and GOGE, C. (2008). *WET-Health. A technique for rapidly assessing wetland health.* Water Research Commission (WRC), Department of Water Affairs (DWA), South Africa National Biodiversity Institute (SANBI).

MACRAE, C. (1996). *Experience from morphological research in Canadian streams: Is control of the two-year frequency runoff event the best basis for stream channel protection?* In Effects of Foundation Conference Proceedings, Snowbird, Utah, August 4-9, 1996, pp144-160.

MADDOCK, I. (1999). The importance of physical habitat assessment for evaluating river health. *Freshwater Biology* (1999) 41, 373-391. Blackwell Science Ltd.

MAIDMENT, D.R. (2003). *Arc Hydro: GIS in Water Resources*. ESRI Press.

MALANSON, G.P. (1993). *Riparian landscapes*. Cambridge University Press. United Kingdom, Cambridge.

MARLBOROUGH http://www.marlborough.govt.nz/Environment/Rivers-and-Wetlands/River-Water-Quality/Quality.aspx Last date visited: 27 August 2013.

MAY, C., HORNER, R., KARR, J., MAR, B. and WELCH, E. (1997). Effects of urbanisation on small streams in the Puget Sound ecoregion. *Watershed Protection Technique* 2(4):pp483-494.

MENDOZA, G.A. and PARABHU, R. (2000). Development of methodology for selecting criteria and indicators of sustainable forest management: A case study on participatory assessment. *Environmental Management,* 26 (6): 6590673.

MILLER, T.G. (1998). *Living on the Environment*. Wadsworth Publishing Company, United States of America.

MILHOUS, R.T. and BARTHOLOW, J.M. (2004). *Physical habitat as a limit to aquatic ecosystems. IAHR Congress Proceedings.* Fifth International Symposium on Ecohydraulics. Aquatic Habitats: Analysis and Restoration. September 12-17, 2004, Madrid, Spain.

NAIMAN, R.J., DÉCAMPS, H. and POLLOCK, M. (1993). The role of riparian corridors in maintain regional biodiversity. *Ecological Applications,* 3(2) pp.209-212. Ecological Society of America, United States of America.

NAIMAN, R.J. and DÉCAMPS, H. (1997). The Ecology of Interfaces: Riparian Zones. *Annual Reviews Ecology Systems* 28:621-658.

NATIONAL RESEARCH COUNCIL (NRC). (1992). *Restoration of aquatic ecosystems: Science, technology, and public policy*. National Academy Press, United States of America: Washington DC.

NERIDA, M.D., NORRIS, R.D. and THOMAS, M.C. (2000). Prediction and assessment of local stream habitat features using large-scale catchment characteristics. *Freshwater Biology* 45:pp 343-369.

NORRIS, R.H. and THOMS, M.C. (1999). What is river health? *Freshwater Biology* (1999) 41, 197-209. Blackwell Science Ltd.

O'BEIRNE, S. (2011). *Status Quo of NEMA Compliance and Enforcement* Activities. Report by SE Solutions. Published in Monitoring and Enforcement April 2011. http://www.custodianproject.co.za/index.php?option=com_k2&view=itemlist&task=category&id=7:monitoring-and-enforcement&Itemid=59 Date viewed: 11 January 2012

O'KEEFFE, J. and DICKENS, C. (2000). Aquatic Invertebrates. In KING J.M., THARME, R.E. and DE VILLIERS, M.S. (eds.) *Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology*. Water Research Commission Report No. 576/1/98. pp: 231-244. Pretoria, South Africa

OLIVER, C.D. and HINCKLEY, T.M. (1987). Species, stand structures and silvicultural manipulation patterns for streamside zone. In SALO, E.O. and CUNDY, T.W. (eds) *Streamside management: forestry and fishery interactions*, pp259-276. Institute of Forest Resources, University of Washington, Seattle. References B-21 United States of America.

PADFIELD, C.F. (1981). *Law made simple*. Sixth Edition, Heinemann, London, England.

PHILIBERT, A., GELL. P., NEWALL, P., CHESSMAN, B. and BATE, N. (2006). Development of diatom-based tools for assessing stream water quality in south-eastern Australia: assessment of environmental transfer functions. *Hydrobiologia* 572: 103–114 Australia.

PIMM, S.L. (1994). Biodiversity and the balance of nature. Cited in: (eds.) SCHULZE, E.D. and MOONEY, H.A. (1994), *Biodiversity and Ecosystem Function*. Springer-Verlag, Berlin, Germany

PRESIDENT'S COUNCIL. (1984a). *Report of the Planning Committee of the President's Council on Nature Conservation in South Africa*. P.C. 2/1984. Government Printer, Cape Town, South Africa.

PRESIDENT'S COUNCIL. (1984b). *Report of the Planning Committee of the President's Council on Priorities Between Conservation and Development*. P.C. 5/1984. Government Printer, Cape Town, South Africa.

PRYGIEL J., CARPENTIER, P., ALMEIDA, S., COSTE, M., DRUART, J.C., ECTOR, L., GUILLARD, D., HONORÉ, M.A., ISERENTANT, R., LEDEGANCK, P., LALANNE-CASSOU, C., LESNIAK C., MERCIER, I., MONCAUT, P., NAZART, M., NOUCHET, N., PERES, F., PEETERS, V., RIMET, F., RUMEAU, A., SABATER, S., STRAUB, F., TORRISI, M., TUDESQUE, L., VAN DE VIJVER, B., VIDAL, H., VIZINET, J. and ZYDEK, N. (2002). Determination of the biological diatom index (IBD NF T 90-354): results of an inter-comparison exercise. *Journal of Applied Phycology* 14: 27-39.

QUINN, N.W. (2003). *A Decision-support system for rehabilitation and management of riparian systems*. WRC K5/1064. WRC, Pretoria, South Africa.

RAPPORT, D.J. (1989). What constitutes ecosystem health? *Perspectives in Biology and Medicine*, 33,120-132.

RIVER HEALTH PROGRAMME (RHP). (2008). *River Health Assessment.* http://www.csir.co.za/rhp/rh_assessment.html (site accessed: 30th April 2012)

RILEY, A.L. (1998). *Restoring streams in cities: a guide for planners, policy-makers, and citizens.* Ireland Press. References B-23.

ROGERS, K.H. and BESTBIER, R. (1997). *Development of a protocol for the definition of the desired state of riverine systems in South Africa*. Department of Environmental Affairs and Tourism, Pretoria, South Africa.

ROGERS, K. and BIGGS, H. (1999). Integrating indicators, endpoints and value systems in strategic management of the rivers of the Kruger National Park. *Freshwater Biology*, 41, 000-000. Blackwell Science Ltd.

ROUND, F. E. (2001). How large is a river? The view from a diatom*. Diatom Res.* 16 (1) 105-108.

ROUX, D. (2002). *Policy and methods for the systematic conservation of rivers in South Africa.* A collaborative initiative between DWAF and CSIR Environmentek. Briefing Document No.2. CSIR. 14 November 2002. Pretoria, South Africa.

ROWNTREE, K.M. and WADESON. R.A. (1998). A geomorphological framework for the assessment of instream flow requirements. *Aquatic Ecosystem Health and Management*, 1, pp:125-141.

ROWNTREE, K. M., WADESON, R.A. and O'KEEFE, J.O. (2000). The development of a geomorphological classification systems for the longitudinal zonation of South African rivers. *South African Geographical Journal*, 82 (3): 163-172. Pretoria, South Africa

ROWNTREE, M. (2011). *Assessment of the wetlands at the Toyota-MTN Cycle Park on Main Road, in Bryanston, Johannesburg.* Dated December 2011. Unpublished. Reference No.: 037/2011.

RUTHERFORD, I.D., JERIE, K. and MARSH, N. (2000). *A rehabilitation manual for Australian Streams*. Volumes 1 & 2. A joint publication by the Cooperative Research Centre for Catchment Hydrology, and Land and Water Resources Research and Development Corporation (now Land and Water Australia). Accessible at: www.rivers.gov.au

SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE (SANBI) (2013). *Biodiversity Geographic Information System (BGIS).* Pretoria, South Africa

SCHOLZ, J.T. (1984). Voluntary compliance and regulatory enforcement. *Law &Policy* October 1984. Pp.385-404.

SCHUELER, T. (1987). *Controlling urban runoff: a practical manual for planning and designing urban best management practices*. Metropolitan Washington Council of Governments, Washington DC, United States of America.

SCHUELER, T. (1995). The importance of imperviousness. *Watershed Protection Techniques* 1(3):pp100-111.

SCRIMGEOUR, G.J. and WICKLUM, D. (1996). Aquatic ecosystem health and integrity: problems and potential solutions. *Journal of the North American Benthological Society*, 15, 2154-2261.

SEAGER, J. (2001). Perspectives and limitations of indicators in water management. *Regional Environmental Change*, 2: 85-92.

SHABMAN, L. and STEPHENSON, K. (2000). Environmental Valuation and Its Economic Critics. *Journal of Water Resources Planning and Management*, 126(6), pp:382-388.

SHAVER, E., MAXTED, J., CURTIS, G. and CARTER, D. (1995). Watershed protection using an integrated approach. In URBONAS, B. and ROSENER, L., (eds) *Proceedings from Stormwater NPDES-related Monitoring Needs*, pp.168-178. Engineering Foundation Conference, Crested Butte, Colorado, United States of America, August 7-12, 1994.

SHAVER, E., HORNER, R., SKUPIEN, J., MAY, C. and RIDLEY, G. (2007). *Fundamentals of Urban Runoff Management. Technical and Institutional Issues.* 2nd Edition. North American Lake Management Society (NALMS). United States of America.

SHIELDS, F.D., JR., KNIGHT, S.S. and COOPER, C.M. (1994). Effects of channel incision on base flow stream habitats and fishes. *Environmental Management* 18:pp43-57.

SKOROZJEWSKI, R. and DE MOOR, F. (1999). Procedures and use of data for macro-invertebrates. In: BROWN, C. and KING, J. (eds.) *Volume II: IFR methodology. LHDA 648-F-03. Consulting services of the establishment and monitoring of the instream flow requirements for river courses downstream of LHWP Dams.* Unpublished Metsi Consultants Report to Lesotho Highlands Development Authority. Metsi Consultants, Lesotho.

SOKUPA, T. (2009). *Let us have better co-ordination of inter-governmental relations*. In Transformer Jun-Jul 2009.

SOMAN, S., BEYELER, S., KRAFT, S.E., THOMAS, D. and WINSTANELY, D. (2007). *Ecosystems Services from Riparian Areas: A Brief summary of the Literature.* Prepared for the Scientific Advisory Committee of the Illinois River Coordinator Council, Office of the Lt. Governor. United States of America.

STEVENSON, N.J. and MILLS, K.E. (1999). Streambank and shoreline condition. In BAIN, M.B. and STEVENSON, N.J. (eds.) *Aquatic habitat assessment: common methods.* American Fisheries Society, Bethesda, Maryland, United States of America.

STALNAKER, C.B. (1979). *The use of habitat structure preferenda for establishing flow regimes necessary for maintenance of fish habitat*. In WARD, J.V. and STANFORD, J.A. (eds.) *The Ecology of Regulated Streams* Plenum Press, New York, United States of America.

STALNAKER, C.B. and WICK, E.J. Planning for flow requirements to sustain stream biota. In WOHL, E.E. (ed.) (2000), *Inland flood hazards: human, riparian and aquatic communities.* New York, NY: Cambridge University Press. p. 411-448.

TAYLOR, J.C. (2004). *The Application of Diatom-Based Pollution Indices in The Vaal Catchment*. Unpublished M.Sc. thesis, North-West University, Potchefstroom Campus, Potchefstroom, South Africa.

THARME, R.E. and KING, J.M. (1998). *Development of the Building Block Methodology for instream flow assessments, and supporting research on the effects of different magnitude flows on riverine ecosystems.* Water Research Commission Report No. 576/1/98. 452 pp.

THIRION, C. (2008). *Module E: Macro-invertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination* (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. Pretoria, South Africa.

THORNE, C.R. (1993). Cited in FISRWG (1998). *Stream Corridor Restoration: Principles, processes, and practices*, *volume 1.* By the Federal Interagency Stream Restoration Working Group (FISRWG).

TILMAN, D., KILHAM, S.S. and KILHAM, P. (1982). Phytoplankton community ecology: The role of limiting nutrients. *Annual Review of Ecology and Systematics*. 13: 349-372.

UNITED NATIONS (UN). (1997). *United Nations Convention on the Law of Non-navigational Uses of International Watercourses. supra,* n.93, at Art.5.

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). (2004). *Guidelines for National Integrated Environmental Assessment Report Preparation in Africa.* African Environment Outlook.

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). (2010). *The Greening of Water Law.* United Nations Environment Programme.

UNITED STATES DEPARTMENT OF AGRICULTURE (USDA). (1998). Stream Visual Assessment Protocol. *National Water and Climate Center Technical Note 99-1.* Natural Resources Conservation Service.

UDY, J.W., FELLOWS, C.S., BARTKOW, M.E., BUNN, S.E., CLAPCOTT, J.E. and HARCH, B.D. (2006). Measures of nutrient processes as indicators of stream ecosystem health. *Hydrobiologia* 572: pp89-102.

UYS, A.C. (2003). *Development of river rehabilitation in Australia: Lessons for South Africa.* WRC KV 144/03. WRC, Pretoria, South Africa.

UYS, M. (2006). *A legal review of the South African natural resources management mechanisms, towards integrated resources management.* Water Research Commission, Report No. KV 176/06. WRC, Pretoria, South Africa.

VAN DAM, H., MERTENS, A. and SINKELDAM, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. *Journal of Aquatic Ecology* 28:117-133.

VAN DER LINDE, M. and FERIS, L. (eds.) (2010). *Compendium of South African Environmental Legislation*. *2nd Edition*. Pretoria University Law Press, Pretoria, South Africa.

VAN RIET, W.F. and SLABBERT, S.A. (1996). *The ability of Catchment Basins to supply the Water Demands of Rural and Urban Areas.* WRC Report No. 680/1/96, WRC, Pretoria, South Africa.

VOLOKH, A. and MARZULLA, R. (1996). *Environmental Enforcement: In search of both effectiveness and fairness.* Policy Study No. 210, Reason Foundation.

WALMSLEY, D., HAVENGA, T., BRAUNE, E., SCHMIDT, C., PRASAD, K. and VAN KOPPEN, B. (2004). *Working Paper 90: An Evaluation of Proposed World Water Programme Indicators for use in South Africa.* International Water Management Institute. Colombo, Sri Lanka.

WEBER, N.S., BOOKER, D.J., DUNBAR, M.J., IBBOTSON, A.T. and WHEATER, H.S. (2004). *Modelling stream invertebrate drift using particle tracking.* IAHR Congress Proceedings. Fifth International Symposium on Ecohydraulics. Aquatic Habitats: Analysis and Restoration. September 12-17, 2004, Madrid, Spain.

WHIPPLE, W., GRIGG, N.S., GRIZZARD, T., RANDALL, C.W., SHUBINSKI, R.P. and TUCKER, L.S. (1983). *Stormwater Management in Urbanizing Areas*. Prentice-Hall, Inc. Englewood Cliffs, New Jersey, United States of America.

WOODWARD, F.I.(1994) How many species are required for a functional ecosystem? In SCHULZE, E.D. and MOONEY, H.A. (eds) (1994), *Biodiversity and Ecosystem Function*. Springer-Verlag, New York, United States of America.

WYDOSKI, R.S., WICK, E.J. Flooding and Aquatic Ecosystems. In: WOHL, E.E. (ed.) (2000), *Inland flood hazards: human, riparian and aquatic communities.* New York, NY: Cambridge University Press. p. 238-268.

YAMADA, C. (2004). *Third Report on Shared Natural Resources: Transboundary Groundwater*. UN Doc. A/CN.4/551, at p.19-21.

YOUNG, R.G., MATTHAEI, C.D. and TOWNSEND, C.R. In press. Organic matter breakdown and ecosystem metabolism: functional indicators for assessing river ecosystem health. *Journal of the North American Benthological Society*.

ZELINKA, M. and MARVAN, P. (1961). Zur Prikisierung der biologischen Klassifikation der Reinheit fliessender Gewasser. *Archiv für Hydrobiologie*. 57: 389-407.

LEGISLATION *as amended* source: http://www.sabinetlaw.co.za/environmental-affairs-and-water

PART 3 - ADDITIONAL GUIDES

ANNEXURE A: EMI SITE INSPECTION SOP (DEA, 2010)

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). (2010). *EMI Operating Manual*. Department of Environmental Affairs, Pretoria, South Africa. (p87- p188)

With Permission

5. COMPLIANCE MONITORING / OPERATIONAL STANDARD OPERATING PROCEDURES

Date: 17 April 2010 **Rev:** 1

5.1 ENTERING A FACILITY ON A ROUTINE INSPECTION

1 OBJECTIVE

To facilitate the entry of EMIs, including their equipment and/or vehicles, to an inspection site for a routine inspection. This SOP applies to all routine inspections.

2 PROCEDURE

2.1.1 Decide on the number of people you need for the inspection:

2.1.2 Contact the facility in advance to arrange for the inspection (unless this may compromise the inspection) and obtain the following important information and arrangements:

- Obtain the normal operating hours of the facility
- Get the names and contact details for key management representatives for the facility
- Find out what safety and personal protective equipment (PPE) requirements are at the site
- Be informed about entry procedures and requirements, fro example safety inductions and vehicle safety/security restrictions.
- Arrange a date and time that is mutually convenient to the EMI and the facility
- Arrange to be met at the entrance if it is necessary
- Arrange to have someone escort you around the site
- You may inform the facility representative if the type of equipment you will bring onsite to prevent security delays.

2.1.3 Note that an EMI has the lawful mandate to enter the premises at any reasonable hour, and therefore these requirements and constraints may not be used as a reason to deny entry!

2.2 Arrival At The Site

2.2.1 As you approach the site:

- Observe the surrounding environment and the site:
  - Observe the topographical slope of the site
  - Are there any water courses close to the site or site boundary
  - Is there visible effluent or water discharge from the site
  - Are there visible emissions particulate or gaseous emissions from the site

- Is there visible windblown litter from the site
- Is there any visible waste disposal that may be associated with the site
- Is noise from the site audible
- Is the site close to residential areas that may be affected by atmospheric emissions, dust, noise or odours from the site.

- Observe activities that are noticeable from the outside of the site
- Take note of any issues of potential significance that you have observed while approaching the site. Use these notes to inform or update your inspection plan.
- If you have noted something of immediate concern in so far as it concerns either non-compliance with your mandated legislation or a potentially significant adverse effect on the environment which may be ceased or hidden before you have completed the facility's entrance procedures and the opening meeting, then you may have to postpone the opening meeting and site induction in order to gather evidence related to your observations.

2.3 Entering The Site

2.3.1 Ensure that you have the following documents when entering an inspection site:
- Your EMI Card
- Your letter of designation

2.3.2 Ensure that you have the correct PPE, and as a minimum on industrial sites ensure that you have
- Shoes with reinforced toe caps (commonly referred to as safety shoes)
- Ear plugs
- Clear safety goggles
- Basic dust mask
- A helmet
- A reflective vest
- Do not wear loose fitting clothing that may be caught in machinery

2.3.3 Ensure that you have the contact details of the facility's management representative that you have made arrangements with.

2.3.4 Contact the representative immediately; this may save you a lot of time when clearing through security.

2.3.5 If required, present your EMI card and/or letter of designation to security or the receiving person and explain the reason for your visit.

2.3.6 You may be required to declare all your equipment to security. This is a standard procedure at many facilities. Ensure that you keep the declaration record to prevent delays when exiting the site with your equipment.

2.3.7 Note that you may need to attend a health and safety and induction. It is important to understand the potential health and safety risks as well as emergency procedures at the inspection site.

2.4 Opening Meeting

2.4.1 The opening meeting is required to outline the scope of the inspection and related activities. You must commence with an opening meeting as soon as it is practically possible once you are on the site.

2.4.2 The meeting should be formal, chaired by the inspection team leader and records of attendance must be kept.

2.4.3 During the opening meeting you must:

- Formally introduce the inspection team and have the site/facility's representatives introduce themselves.
- Formulate an attendance register and take minutes for a written record or summary of the items discussed and agreed during the meeting.
- Explain the legal mandate for conducting the inspection
- Confirm matters relating to confidentiality in terms of commercially sensitive/ proprietary information
- Explain the aim of the inspection and the roles of each team member
- Identify the person(s) from management of the site responsible for arrangements and for the EMI's safety on the site, and confirm relevant work safety, emergency and security procedures for the inspection team;
- Clarify communication channels – who does the EMI need to speak to and how does the EMI contact them? Make a note of contact details such as cell phone number and email address.
- Inform the management that you will use the following means of documenting the inspection and findings:
  - By taking photographs.
  - By requesting photocopies of important documents and records.
  - By interviewing people on the site and recording these discussions in writing or electronic recording such as by dictaphone or camera.
- If it is necessary, confirm the language that he/she intends using to communicate with during the inspection.
- Ask the management to describe the activities that are undertaken at the site and to provide a site plan/description. If a site plan is not provided then sketch one with their help.
- Request documents and records that you have identified as necessary for your inspection

2.5 Denial Of Entry

2.5.1 An EMI has the lawful mandate to enter the premises at any reasonable hour to conduct an inspection. In the event that you are denied entry first ensure that you have taken all reasonable steps to obtain access to the site for your inspection by checking through the 'denial of entry checklist and test' below.

2.5.2 If entry has been denied then refer to your supervisor for further instructions.

Denial of Entry - When Have You Been Denied Entry?

When a facility's representative informs you that you are denied entry it is an obvious denial. However, sometimes that denial is implied and not explicitly stated, and the EMI should ensure that he/she acted reasonably before drawing a conclusion:

Denial of Entry Checklist

1. Did you identify yourself (by showing your EMI ID card) to a person-in-charge?
2. Did you explain the legal basis for your inspection?
3. Did you explain the scope of your inspection?
4. Did you visit the facility at a reasonable hour? (i.e. regular business hours, operating hours, or hours when the issues of compliance are best observed?)
5. Did you enter through the main gate or office?
6. Did you locate the person-in-charge as soon as you arrived?
7. If applicable, did you present the necessary written notices?

Once you have satisfied these first seven requirements in a patient, professional, and friendly attitude, document accordingly in your inspection logbook/notes. Should all the above-mentioned requirements have been met and the inspection effort is still frustrated, consider the Denial of Entry Test and record the basis upon which denial is assumed.

Denial of Entry Test

1. ***Refusal upon entry*** - Were you denied consent upon entry? ((In this context, consent can be defined as the intentional relinquishing of the right of privacy that has not resulted from fear, ignorance, or trickery).
2. ***Unreasonable delays*** - Were unreasonable delays required by the person-in-charge? What the EMI considers unreason-able must be communicated to the person-in-charge prior to starting the clock. (e.g. "I have been waiting 30 minutes. My time is limited and at most I can wait another half hour. If I can not begin by then, I will have to consider that I have been denied entry to conduct the inspection.")
3. ***Obstruction*** - Were conditions, which were clearly understood in the opening meeting or prior arrangements, altered by the facility or person-in-charge, to the extent that it compromised your ability to conduct, document or complete your inspection?
4. ***Safety threats*** - Was your safety deliberately threatened in any way? That includes verbal threats or suggestions that harm might come to you that is not accidental (refusing to secure a guard dog is an example of entry denial by not removing a threat to your personal safety.) Failure to shut down a routine plant operation is not denial, even if the operation makes conducting the inspection difficult.

If you are aggressively rejected, try one last time cautiously. Never allow facility behaviour to prevent you from being fair and always hold the higher moral ground. You may always maintain your poise by leaving and seeking legal authority to regain control.

HOT TIPS

LANGUAGE OPENS DOORS!

We have the privilege of living in a country with 11 official languages, but few of us will be able to speak more than two or three of these. When going to a site, the security personnel are likely to speak the "local" language as a home language, so try and include an EMI on the team who can speak this local tongue. Otherwise, knowing just the basic greetings will show you are taking effort and improve your access experience.

HAVE SAFETY FIRST AS YOUR MOTTO:

- ensure that you have a proper site induction and listen carefully if there is a safety video
- remember - wearing PPE will not automatically make you safe
- always evaluate your environment for hazards, reading signs and proceeding cautiously.

USE YOUR COMMON SENSE!

Every site has its hazards, from tripping over rocks in the veld, to corrosive acids at an industrial site. There is no substitute for good, plain common sense when approaching a new situation. Read the warning signs around you, look at the area and if you feel uncomfortable or at risk, then rather come back again later with someone who is familiar with such situations.

Date: 17 April 2010 Rev: 1

5.2 GATHERING OF EVIDENCE DURING AN INSPECTION

1 OBJECTIVE

The purpose of this document is to provide a procedure to facilitate the gathering, handling and securing of evidence during a routine inspection, with a view to obtaining and maintaining evidence which is relevant and defensible.

2 DEFINITIONS

Chain of custody: "Chain of custody" refers to the documentation or paper trail showing the sequential transfer of custody of documents, samples, photographs et cetera.

Evidence: Evidence consists of all information obtained in an inspection as a means of ascertaining the compliance status of a facility.

Transient Evidence: Evidence that might be expected to degrade or disappear within a short time frame for example pools of liquid from a spill, volatile liquids, or articles that are on fire.

3 LEGAL BACKGROUND

In terms of section 31K(5) of NEMA an EMI may, while carrying out a routine inspection, seize anything in or on any, including but not limited to, business or residential premises, land, vehicle, vessel, aircraft, pack-animal, container, bag, box or item that may be used as evidence in the prosecution of any person for an offence in terms of NEMA or any of the SEMAs. Note that this power is therefore triggered when there is a reasonable suspicion that a criminal offence has been committed, and that in such a case the EMI may seize "anything" that can be used as evidence in such a prosecution. In this regard therefore refer to the relevant parts of SOP 6.2 dealing with search and seizure and to SOP 5.3 on the issuing of the notification card.

In addition, in terms of section 31K(7), an EMI may during such an inspection, exercise all the powers mentioned in section 31H. Note that in this instance the powers are not linked to a suspected criminal offence, but are general powers of the EMI during any inspection. Section 31H provides that:

Where there is a reasonable suspicion that an act or omission constituted -

- an offence in terms of NEMA or the SEMAs (including regulations promulgated under it);
- a breach of such law; or
- a breach of a term or condition of a permit, authorisation or other instrument issued in terms of such law;

an EMI may:

- question a person in connection with such an act or omission;
- issue a written notice to a person who refuses to answer such questions, requiring that person to answer questions put to him or her (this is further described in section 31H(2) and (3));

- inspect, or question a person about, any document, book or record or any written or electronic information which may be relevant for that purpose;
- copy, or make extracts from, any such document, book or record or any written or electronic information, or remove such document, book, record or written or electronic information in order to make copies or extracts;
- require a person to produce or deliver to a place specified by the inspector, any such document, book or record or any written or electronic information for inspection;
- inspect, question a person about, and if necessary remove any specimen, article, substance or other item which, on a reasonable suspicion, may have been used in such an act or omission.

In addition an EMI may inspect, or question a person about, any document, book or record or any written or electronic information to which NEMA or a SEMA relates (in this particular case not limited to the designation of the EMI), and may then:

- copy, or make extracts from, any such document, book or record or any written or electronic information, or remove such document, book, record or written or electronic information in order to make copies or extracts;
- require a person to produce or deliver to a place specified by the inspector, any such document, book or record or any written or electronic information;

An EMI may also:

- take photographs or make audio-visual recordings of anything or any person that is relevant for the purposes of an investigation or for a routine inspection;
- dig or bore into the soil;
- take samples;
- remove any waste or other matter deposited or discharged in contravention of the relevant law or a term or condition of a permit, authorisation or other instrument issued in terms of such law; or
- carry out any other prescribed duty not inconsistent NEMA or any other duty that may be prescribed in terms of a SEMA.

All of the above powers must of course be executed within the mandate and according to the designation of the EMI.

4 *PROCEDURE*

4.1 Planning and Preparation

It is assumed that while planning your inspection you will:

4.1.1 Identify the relevant compliance criteria for the facility being inspected and that you have:

- Determined the nature and scope of the facilities activities.
- Obtained all relevant environmental authorisations issued to the facility and made an inventory of the conditions thereto.
- Determined what records the facility is required to maintain onsite and/or submit to authorities.

- Obtained copies of all relevant documents and reports that have been submitted the regulating authorities.

4.1.2 Produce an inspection plan which includes:

- A list of documents/records that should be available onsite that will be relevant to the inspection.
- A list of relevant criteria for the inspection which includes but is not necessarily limited to:
  - Conditions of EAs and/or licences that the site must adhere to.
  - Legislated requirements relevant to the facilities activities
- A site-specific health and safety plan.
- A list of the members of the inspection team
- Identification of the nature of samples which may reasonably be expected to form part of the evidence collected (e.g. hazardous waste, ground water samples, etc)
- A sampling plan with a list of sampling equipment required based on the above, your sampling plan must include as a minimum:
  - Equipment required for extraction of samples
  - Sample containers suited to the expected samples
  - A list of sampling documentation: Sample labels, chain of custody forms, sample log book (unless logged in the inspection book)
  - Appropriate sample seals
  - Sample preservation equipment
  - PPE required for sampling and handling of samples
- Samplings equipment must be cleaned/sterilised and calibrated (where necessary) before going to the scene
- A list of equipment required for documenting evidence (such as cameras, dictaphones/voice recorders, etc)
- Chain of custody forms
- Prepare for interviewing facility representatives – draft a list of matters to be covered during such an interview

4.2 Arrival at the facility

4.2.1 Upon arriving at the facility it may become evident that a transgression has occurred or is in progress, and which may require your immediate attention. This is particularly relevant in cases where evidence is transient or where the transgression may be quickly stopped and/hidden. In such a situation the EMI must postpone the opening meeting and proceed directly to the area of concern and commence with the inspection and evidence gathering.

4.2.2 Should you be denied entry to the facility be sure to document this as per SOP 5.1: Entering a Facility on a Routine Inspection.

4.3 Opening Meeting

4.3.1 An attendance register for the opening meeting must be filled and signed by all attendees

4.3.2 A summary of the opening meeting discussions and agreements must be recorded.

4.3.3 A list of all documents requested and all documents received must be logged

4.3.4 Any information relevant to the inspection obtained during the interview through discussions or interviews must be recorded. This information must be supported with documents and records wherever possible.

4.4 Interviewing Facility Representatives

4.4.1 Use an office or venue that is free from disturbances;

4.4.2 Put your cell-phone off or on silent mode;

4.4.3 Ensure that at least one of your colleagues is present;

4.4.4 Introduce yourself and likewise allow the interviewee to introduce himself/herself;

4.4.5 Ensure that you document:

- the name of the interviewee
- the person's area of responsibility and any further relevant information required to identity of the interviewee.
- Time, date and place of interview;

4.4.6 Explain the purpose of the interview;

4.4.7 Explain your powers in terms of section 31H, read with section 31K(7), to the interviewee in simple terms;

4.4.8 Provide the interviewee the opportunity to read the relevant provisions of the legislation if he/she wishes to do so;

4.4.9 Try to create an atmosphere in which will make the interviewee comfortable and encouraged to share information;

4.4.10 Proceed logically and in line with your preparation;

4.4.11 Be methodical and precise;

4.4.12 Be courteous yet firm and in control of the process;

4.4.13 Record all information substantially and accurately;

4.4.14 Ensure that all aspects have been covered before ending the interview.

4.4.15 For general guidelines on effective interviewing techniques, refer to SOP 6.3: Interviewing of Witnesses and Suspects.

4.5 Questioning on possible non-compliance

4.5.1 Exercise extreme caution before using your powers in terms of section 31H(1)(b), read with section 31H(2) and (3), which empowers the EMI to issue a notice obliging a person to answer questions about an offence or other non-compliance, even though such answers might incriminate the person. Such answers may not be used against that person in subsequent criminal proceedings, and in that way protects the person's right against self-incrimination. In practice however the answers might lead you to other documentary or real evidence. In such a case there is a real danger that a court might find that evidence uncovered because of self-incriminating answers, will also be inadmissible in court.

4.5.2 Try and avoid using this procedure where there is any possibility that the person might be criminally prosecuted, and before utilising these powers in such a situation, ensure that there is no alternative method (such as a proper search) to obtain the same result. The procedure is however ideal if you are questioning low level employees, who while possibly incriminating themselves through the answers, might provide you with evidence against high-level employees. Prosecutors will often then use section 204 of the CPA and use the low-level employee as a witness against the high level employee, rather than charging the low-level employee.

4.6 Copying and Reviewing of Documents and Electronic Information

4.6.1 Documents, books, records, and any written or electronic information may be inspected and copied, or may be removed to be copied, as is set out above in the legal background. This may be done where such items:

- may be relevant in connection with any act or omission in respect of which there is a reasonable suspicion that it might constitute an offence; or
- any such item to which NEMA or the SEMAs (including regulations promulgated under it), relates

4.6.2 Provide a receipt for any such item that is removed.

4.6.3 Return the article within a reasonable period, or where necessary to be retained for court purposes, on conclusion of the case unless of course such item was forfeited to the state by the court.

4.6.4 Make printouts of relevant documents from computers.

4.6.5 If there is however a strong possibility that the electronic evidence may be required for court purposes later, all computers, hard drives or similar devices must be handled as other seized evidence, sealed and marked and handed to an expert to retrieve documents and other information.

4.7 Photographing Evidence

The purpose of a photograph is to produce an accurate visual depiction of articles, events and patterns at the inspection, and more specifically at the site of non-compliance. This can later be used as evidence in court. The prescriptions here are therefore identical to how a crime scene will be managed, as there is the possibility that such a matter might land up in court.

4.7.1 Preparation

- Ensure that the batteries are adequately charged.
- If disposable batteries are used, ensure that you have sufficient spare batteries
- Ensure that the memory card in your camera has had all previous photos downloaded and removed before going to the site.
- Ensure that the memory card you are using is of sufficient capacity to allow you to take as many photos as you require.
- Ensure that your camera is set to record a date stamp on each photo.

- Ensure that your camera's date and time settings are accurate.
- Ensure that our camera's flash is working and adequate for taking pictures in low light conditions
- Take markers (e.g. traffic cones or differently coloured small flags) with you

4.7.2 Photographic technique

- Document what you are photographing in your pocketbook.
- Ensure that a progression of overall, medium and close-up views of the scene and evidence is established.
  - Take an initial overview shot(s) show a wide area that includes the subject and a fixed landmark to establish location and help the viewer understand where the subject is located. The overview shot(s) should cover the entire scene to bring out the relationships between objects and their location on the site.
  - Mark all the evidence/locations where evidence was found with clear distinguishable markers (e.g traffic cones or marked flags) so that the position of all exhibits can be seen in relation to the rest of the scene, and take another overview shot(s).
  - Take a subject shot (or mid range shot) that shows the important object(s) and its immediate surroundings or the special area of an event that the photographer wants to bring to the attention of the viewer.
  - The close-up shot shows unique details of the object or event that makes it unique and identifiable, such as close-up photographs of evidence uncovered.
- Take photographs from eye-level, when feasible, to represent a scene as it would be observed by normal view.
- Use a recognisable and relevant scale device to indicate size when applicable, (e.g. a coin or a ruler) this will give the viewer a reference to understand the size of the photographed object.
- When a scale device is used, first take a photograph without the inclusion of this device, to show that nothing of importance is covered by the device.
- Be observant of and photograph areas adjacent to the crime scene - points of entry, exits, windows, attics, etc. This might become relevant at a later stage.
- Where aerial photography is undertaken be aware that the angle of the camera and curvature of the earth may require the photograph to be geo-referenced before it can be used to measure items.

4.7.3 Securing photographic evidence

- All the photographs must be downloaded from the camera as soon as is practically possible.
- Do not alter photographs in any way.
- Save the originals in a non-editable format.

- All the photographs must be written to at least two non-editable mediums, such as a non rewritable recordable CD.
- One copy must be sealed in an evidence bag and the second copy can be used for investigative purposes.
- The CD in the evidence bag must be labelled in accordance with the requirements for chain of custody, handed into the SAP 13 and kept accordingly.
- Where it might be helpful to alter photo's to improve quality or enlarge a part of the photograph (e.g. zoom, contrast, brightness), this must be done using a copy, and the original photographs must always be available for comparison and corroboration.
- The EMI responsible for photographing and/or videotaping the scene must provide an affidavit on oath reflecting the fact that he/she photographed and/or videotaped the scene, and downloaded and safeguarded the evidence as set out above.

4.7.4 Compile a photo album

- Show the scene as it was first observed by the EMI
- Follow that with the photograph of the overview of the scene
- Thereafter, the photographs can follow the sequence of the discovery of the objects
- The final photographs should again be those taken from a distance, to show the numbered stakes or beacons in relation to each other;
- Fix only one photograph per page in order that they can be easily referred to and shown individually in court;
- Head the photographs with numbers only: Photograph No. 1 and consecutive numbers thereafter
- No other annotations referring to objects in the photograph may be made on the page - this allows the photograph to be used in court without any "hints" being present to suggest what appears in the photograph
- The cover of the photograph album should be headed: Photograph Album No. 1 and reflect the date, time and place where the photograph album was compiled, and the name and signature of the person who compiled the album;
- The key to the photograph album should be headed: Key to Photograph Album No. 1.
- This is followed by a list of the photographs in numerical order, with a brief description of what appears in each photograph. The date, time and place of the crime scene visit are then reflected at the end of the key, followed by the name and signature of the person who compiled the key.

HINT

Photography is a skill. Get in touch with your local SAPS Criminal Record Centre that has trained and skilled photographers, and they can assist you in this regard.

4.8 Sampling as Evidence

4.8.1 Samples should be taken when:

- Analysis is required to determine the composition of a substance
- Analysis is required to confirm the composition of a substance when there is a suspicion that the integrity of existing data is questionable
- Data is needed to document an event, discharge or release;

4.8.2 Taking a representative sample

- Representative sampling ensures that a sample or group of samples accurately reflects the concentration of the contaminant(s), or characteristics of substances of concern, at a given time and location.
- Obtaining representative samples for transient evidence requires that you apply basic logic:
  - A visual assessment of the area and items to be sampled will often indicate where the substance of concern is at its purest.
  - Avoid, if it is possible, samples that have been mixed or contaminated
  - If it is practical, take at least three samples.
  - Ensure that the samples have been documented adequately
- Non-transient samples allow for more time and effort to be spent in determining suitable sample positions, sample technique and number of samples required:
  - Visually assess the area of interest to determine the extent of contaminated area
  - Where there is contamination over a wide area a sampling plan must be set out determining how many samples must be taken and in which positions
  - Avoid, if it is possible, samples that have been mixed or contaminated
  - Ensure that the samples have been documented adequately
- All samples must be sealed and labelled immediately

4.8.3 Sampling Equipment

- Ensure that your sampling equipment is clean (and if possible sterilised for biological samples)
- To prevent contamination across samples the following precautions must be taken:
  - Sampling equipment must be cleaned after each sample is taken
  - Disposable equipment and equipment which cannot be thoroughly cleaned (for example gloves) must be attached to their respective samples to show that they have been re-used and thus potentially caused cross contamination

4.8.4 Documenting Samples

- Every sample must be labelled for unique identification
- The following information must be documented:
  - Inspection code
  - Sample Number or code (as designated in the sampling plan).
  - Sample location
  - Date & Time of sampling
  - Sample type (i.e. composite, grab sample etc)
  - Field sampler's name & signature
  - Field sample custodian's name and signature
  - Sample preservation Requirements
  - Types of analyses to be performed
- It may be impractical to document all of this information on the sample label, however the sample label as a minimum have a sample code, date and time sampling, and a the inspection code.
- The area being sampled must be sketched out
- The location each sample must be captured both in writing (i.e. narrative) and on a sketch of the site
- The sampling procedure must be photographed (refer to photographic technique above)
- Every sample must be captured on a chain of custody form

4.9 Handling and Chain of Custody

4.9.1 Evidence handling

- Refer to SOP 6:2 Search and Seizure for the procedure on the handling of seized items.
- All samples that require preservation must be subjected to the required conditions of preservation as soon as is practically possible
- Chain of custody must be established for all samples and evidence
- All evidence and samples must remain in the custody of a designated person(s) throughout the period on the crime scene and during transfer to the evidence locker.

4.9.2 Establishing chain of custody

- The person, or designated person in a group, must record the information for each article of evidence on its respective chain of custody form, including the date and time.
- Every transfer of custody must be recorded and signed by both the relenting and receiving parties. The time and date must be accurately captured.
- Any article of evidence which is not in the immediate possession of the custodian must be in a secured place to which access is controlled and recorded.
- Instructions for sample preservation must be handed over when custody is transferred.

Date: 17 April 2010 Rev: 1

5.3 ISSUING OF NOTIFICATION CARD

1 OBJECTIVE

The purpose of this SOP is to establish a procedure to be followed by an EMI conducting a compliance monitoring activity and encountering circumstances that trigger a reasonable suspicion of a criminal offence in terms of NEMA or a SEMA. The SOP aims to ensure that evidence gathered in such a situation is legally obtained and admissible in subsequent criminal proceedings.

2 BACKGROUND

The function of an Environmental Management Inspector (EMI) is to monitor compliance with; and enforce legislation within his or her mandate. Generally speaking, environment officials responsible for compliance monitoring focus on routine inspections and ascertaining compliance or non-compliance with legislation or permits, whereas officials responsible for enforcement only enter the picture when there is a reasonable suspicion of non-compliance amounting to a criminal offence.

Grades of Environmental Management Inspectors

Annexure A of the EMI Regulations provides for five grades of EMIs, each with their own set of powers in terms of NEMA and the Criminal Procedure Act, 1977 (CPA). The purpose of the ranking system was to tailor-make EMI powers to suit various job descriptions, responsibility and seniority.

Grade 4 EMIs are typically officials that are primarily involved in conducting compliance monitoring activities; and have therefore been given access to powers (e.g. section 31K – Routine Inspection) to enable them to carry out their duties effectively. However, NEMA further provides that Grade 4 EMIs may also exercise general powers set out in section 31H of NEMA on business, residential premises or land. Many of the powers included in section 31H of NEMA are "investigation" type powers that are triggered by a reasonable suspicion. NEMA therefore accords grade 4 EMIs certain evidence-gathering powers for the purposes of an investigation.

Inspectors v Investigators

The EMI Regulations provide for the designation of Grades 1, 2 and 3 EMIs who have powers that are suited to conducting criminal investigations. These grades of EMIs should possess skills necessary to gather evidence required for the purposes of an investigation e.g. search, seizure, arrest etc.

Due to the different skills, powers, procedures and objectives that are triggered by investigations and inspections, it is ideal to have two distinct components that deal with each type of activity separately. However, not all EMI institutions have the necessary staff, structure or resources to provide for this level of specialization and EMIs may find themselves fulfilling both functions.

3 PROCEDURE

3.1 In the event that a Grade 4 EMI who is conducting a compliance monitoring activity (e.g. a routine inspection) encounters circumstances in which he/she develops a reasonable suspicion of a criminal offence in terms of NEMA or SEMA, and is of the opinion that evidence exists that may be used in a criminal investigation, the following procedure will apply:

3.1.1 If the Grade 4 EMI works for an EMI Institution where there are designated Grade 1, 2 or 3 EMIs that are readily available to attend the relevant site, then the Grade 4 EMI shall:

- cease the inspection of the particular building, facility, land, area or article to which the reasonable suspicion relates;
- inform an appropriate representative of the facility that they cannot proceed with the inspection of the particular building, facility, land, area or article as they have developed a reasonable suspicion of an offence in terms of NEMA/SEMA; and will be calling a colleague who will proceed with an investigation;
- request as soon as reasonably possible a Grade 1, 2 or 3 EMI to attend the scene and proceed with the investigation process;
- take all reasonable measures to preserve the site until the arrival of the Grade 1, 2 or 3 EMI.

3.1.2 If the Grade 4 EMI works for an EMI Institution where there are designated Grade 1, 2 or 3 EMIs, but they are not available to attend the relevant site, the Grade 4 EMI may request the reasonable assistance of a Grade 1, 2 or 3 EMI from another EMI Institution that has the necessary jurisdiction, to assist in the investigation of the scene;

3.1.3 If the Grade 4 EMI:

- undertakes the procedure set out in 3.1.1 or 3.1.2 above and cannot obtain assistance after a reasonable effort to do so, or
- where there are no Grade 1, 2 or 3 EMIs designated in his/her institution, or
- where the Grade 4 EMI reasonably suspects that the delay caused by requesting assistance may cause evidence to be destroyed or lost, or
- where the evidence gathered will be used for administrative enforcement purposes only;

the Grade 4 EMI may proceed to gather evidence for the purposes of investigation by exercising the relevant "investigation" type powers referred to in section 31H.

3.1.4 In this event, the Grade 4 EMI shall, upon formulation of a reasonable suspicion of a criminal offence in terms of NEMA/SEMA, hand to a suitably authorised representative of the facility a Notification Card as per Annexure 1 of the SOP.

ANNEXURE 1

EMI Notification Card

Notice of Reasonable Suspicion of Suspected Non-Compliance Amounting to a Criminal Offence in Terms of NEMA/SEMA

1. I am an Environmental Management Inspector currently undertaking an inspection of your facility. The purpose of this inspection is to assess compliance and non-compliance with environmental legislation within my mandate.

2. You are hereby notified that in the performance of my duties, I have developed a reasonable suspicion that there exists non-compliance with the legislation which I am mandated to enforce. Such non-compliance amounts to a criminal offence in terms of NEMA and/or a SEMA.

3. All my actions from this point onward will be for the purposes of an investigation. I am therefore mandated to apply my aforesaid powers in the furtherance of an investigation, and you are furthermore notified that any items seized, any photographs or any samples taken, and any other evidence gathered form this point on may subsequently be used in a possible criminal investigation.

Date: 17 April 2010 Rev: 1

5.7 PROCEDURE FOR INSPECTION OF WASTEWATER TREATMENT WORKS

1 OBJECTIVE

To determine the extent of compliance at a wastewater treatment works ("WWTW"), with a NEMA EA, an ECA ROD, or a NWA water use licence, as well as compliance in general with the duty of care as contemplated in NEMA and prevention of pollution as contemplated in the NWA. This SOP applies to all engineered and constructed works for the treatment of wastewater or effluent, including municipal or private sewage treatment, but excludes domestic or small-scale private treatment.

2 DEFINITIONS

Sludge: Sludge is the residual, semi-solid material left from industrial, or wastewater treatment processes.

offensive odour: means any smell which is considered to be malodorous or a nuisance to a reasonable person; [NEMAQA Section 1]

3 PROCEDURE

3.1 Planning And Preparation

3.1.1 Obtain a copy of the WUL from the regulating authority and the EA from the designated competent authority for that area.

3.1.2 A desktop assessment must be undertaken of the EA and WUL to:

- Determine the nature and scope of the activities that have been authorised, and in particular how and where the site discharges waste and fluids
- Determine the conditions of authorisation and formulate an inspection checklist from these
- Review the authorised EMP and ensure that all the commitments and monitoring requirements in the EMP are included in your checklist
- Determine what documents and records are required to evaluate the EA (e.g. Regulations, EMP, licenses, etc) and which of these should available on the site and which should have been submitted to an authority
- Determine what monitoring records the site must have
- Develop an understanding of the activities and size of the operation to determine how many inspectors will be required, given the time available

3.1.3 Arrange a pre-inspection meeting/telephone call with the site management to:

- Inform them of the anticipated scope of the inspection
- Inform them of the inspection criteria if this will assist in planning and preparation
- Inform them of the date and expected duration of the inspection (ideally try to arrange a date and time that is mutually convenient to the EMI and the facility)

- Inform them of the number of inspectors that you expect to attend the inspection
- Confirm health and safety requirements (for example what PPE may be required) and whether an induction is required and how long it will take
- Obtain the concept design drawings that explain the process step-by-step
- Get an understanding of normal operating hours and security requirements
- Inform them of an approximate inspection schedule giving times and areas to be visited if this will assist in planning and preparation for the inspection
- Request documents and records in advance (in particular water and effluent discharge records, and waste disposal records) which will inform your inspection plan and preparation. In particular:
  - Incoming volumes of wastewater
  - Volumes of treated water discharged
  - Volumes of untreated water/wastewater discharged
  - Quality of treated water discharged
  - Quality of untreated water discharged
  - Water quality upstream and downstream of the plant/discharge point where treated and/or untreated water is discharged into a watercourse.
  - Mass/volume of sludge generated and disposed (and records of disposal indicating where the sludge is disposed)
  - Mass/volume of any other process waste material generated and disposed (and records of disposal indicating where the waste material is disposed)
  - Confirmation that the disposal sites used are appropriately permitted sites
- Ensure co-ordination of activities with operations and staff availability.

3.1.4 Update your inspection plan and timing based on the above.

3.1.5 Update your health and safety plan based on the above.

3.2 Arrival At The Site

3.2.1 Refer to SOP 5.1: Entering a Facility on a Routine Inspection.

3.2.2 In particular take note of the slope of terrain around the facility, and of watercourses and wetlands in the vicinity of the site.

3.2.3 It is advisable to do a preliminary visual inspection of watercourses or wetlands downstream of the works in order to establish any obvious evidence of pollution that may be associated with the WWTW.

3.3 Opening Meeting

3.3.1 Convene an introductory/opening meeting during which the EMI must:

- Formally introduce the inspection team and have the facility's representatives introduce themselves.

- Formulate an attendance register and take minutes for a written record or summary of the items discussed and agreed during the meeting.
- Explain the legal mandate for conducting the inspection
- Explain the aim of the inspection and the roles of each team member
- Identify the person(s) from management of the site responsible for arrangements and for the EMI's safety on the site
- Clarify communication channels – who does the EMI need to speak to and how does the EMI contact them? Make a note of contact details such as cell phone number and email address.
- Inform the management that you will use the following means of documenting the inspection and findings:
  - By taking photographs.
  - By requesting photocopies of important documents and records.
  - By interviewing people on the site and recording these discussions in writing or electronic recording such as by dictaphone or camera.
- If it is necessary, confirm the language that he/she intends using to communicate with during the inspection.
- Ask the management to describe the activities that are undertaken at the site and to provide a site plan/description. If a site plan is not provided then sketch one with their help.
- Ask the management for a process description and flow diagram indicating the various processes at the plant and related discharges, if you have not already ascertained these.

3.3.2 The EMI must request the following documents and records:

- The WUL for the site and the EA (you must compare the documents and ensure that you have an current copy for your inspection)
- Internal and external environmental audit reports (these may be legal compliance audits, audits against the conditions of authorisation etc)
- Operational plans, including any EMPs
- Procedures for planned and unplanned shut-downs (these may be for maintenance, unplanned plant downtime due to equipment failure)
- Emergency incidents plan and incident reports (e.g. Spills, unplanned discharges especially of non-conforming effluent or treated water or raw water)
- Monitoring committee minutes (if there is a mentoring committee)
- Register of complaints
- Monitoring data and records, if these were not obtained prior to the site visit, namely:
  - Incoming volumes of wastewater
  - Volumes of treated water discharged
  - Volumes of untreated water/wastewater discharged
  - Quality of treated water discharged
  - Quality of untreated water discharged
  - Water quality upstream and downstream of the plant/discharge

point where treated and/or untreated water is discharged into a water course.

- Mass/volume of sludge generated and disposed (and records of disposal indicating where the sludge is disposed)
- Mass/volume of any other process waste material generated and disposed (and records of disposal indicating where the waste material is disposed)
- Confirmation that the disposal sites used are appropriately permitted sites

3.3.3 Browse through the documents provided and update your inspection list to ensure that you have covered all the conditions that must be inspected

3.3.4 Refer to SOP 5.9 Inspection of Compliance with the Conditions of Environmental Authorisations.

3.4 Document Review

3.4.1 It is advisable to split the inspection team into a document review team and an operations review team. If this is not possible then begin by reviewing the site's documents and records against the conditions that must be complied with.

3.4.2 If limited time is available then prioritise which documents and records must be reviewed.

3.4.3 Systematically check the documents and records against the conditions of the site licences and EA.

3.4.4 Check the records of volume of wastewater treated versus that which is authorised and versus the design capacity of plant.

3.4.5 Check the records of treated water discharge quality and volume versus those authorised.

3.4.6 Check records of solid waste and/or sludge generated versus disposal records. Ensure that the masses generated balance with those disposed of.

3.4.7 Check that the records confirm that the wastes are disposed to appropriately licensed disposal sites. Note that the waste may in some cases be disposed to fertiliser processes.

3.4.8 Check the findings and recommendations of any environmental or engineering audits that have been undertaken on the site. Engineering audits/inspections are generally undertaken to confirm that the plant is in good working order and being operated correctly.

3.4.9 Review the complaints register and the monitoring committee minutes, and responses or commitments made in response to these.

3.4.10 Request copies of all important compliance documents and records which you do not have access to other than at the site.

3.5 Site Inspection

3.5.1 Wastewater operations:

- It is generally advisable to follow the flow of the process. Work

through the inspection list systematically attending to each condition of the environmental approvals

- Inspect each point of discharge, note any evidence of residue, eutrophication or impact on vegetation and fauna which may indicate potentially unacceptable discharge.
- Interview operators and other personnel to ascertain if there are discharges of untreated wastewater or water of unacceptable quality
- Inspect the waste storage areas and ensure that:
  - The storage area is impermeable and does not allow leakage to surface or groundwater
  - The storage area is protected for the ingress of rain water which may consequently become contaminated
  - Waste is not stored or disposed of outside the designed area
- Inspect the condition of containment facilities; ensure there are no cracks and leaks.
- Inspect the condition of the canals and channels, look for blockages signs of overflow.
- Inspect the tanks and/or ponds on the site for signs of leakage or overflow.
- Confirm that there are adequate measures for containing leaks and spills from machinery and during plant maintenance.

3.5.2 General operations:

- Check the access road to see what condition the surface is in, if it will be safe in wet weather, an unsafe access road will increase the likelihood of incidents resulting spills from vehicles delivering wastewater/sewage to be treated, or removing sludges and solid waste.

3.5.3 Stormwater:

- Confirm that there is separation of clean and dirty water on the site – i.e. there is no storm water flowing into the works which can be avoided, and there is no leakage of dirty water to storm water run-off areas and channels
- Confirm that potentially contaminated storm water is captured and tested before release, verify this by interviewing the responsible employees and checking the records

NOTE

Take note of the following legislation:

- Section 19 (Pollution Prevention), Section 21 (Water Use), Section 22 (Permissible water use) of the NWA
- Section 28 NEMA (General Duty of Care)
- Section 35 NEMAQA, (Control of Offensive Odours)

3.6 Conclusion of Inspection and Reporting of the Findings

3.6.1 Once the inspection has been completed, and depending on the findings, the EMI may wish to conduct a closing meeting. At this meeting:

- Request the attendance of the responsible management personnel
- Thank everybody for their co-operation and assistance
- If appropriate, provide feedback on your concerns/findings, however it is generally recommended that feedback be given in the form of an inspection report after findings have been confirmed.
- Inform the management if any further records or documents are required and by when.
- Confirm any further steps, if any.

3.6.2 Refer to SOP 5.11: Procedure for Drafting of Inspection Reports.

HOT TIPS

ASK AND ASK AGAIN!

Staff of industrial facilities often use jargon and acronyms to explain their processes, assuming you will understand them. Do not be afraid to ask a question more than once and to specifically request them to explain the technical terms to you.

WORK UPWIND!

At WWTW and other waste management facilities, odours can be quite unpleasant and can distract you from the job at hand. Often a simple solution is to walk on the upwind side of the plant or pond, which will allow you to breathe more easily, but also reduce the chances of splashes, dust or `steaming` vapours getting to you or your equipment.

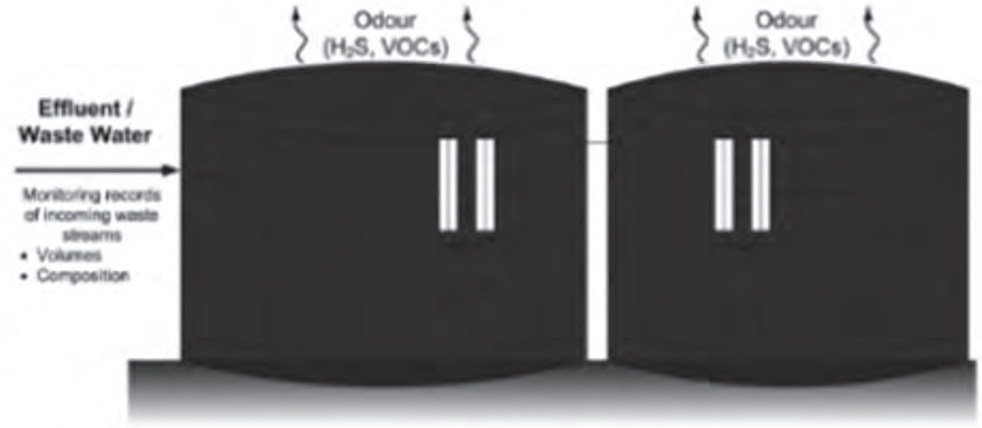
PROCEDURE DIAGRAM

WASTE WATER TREATMENT PROCESSES

(due to the large number of processes available for different effluent streams and the numerous combinations possible the EMI must obtain and understand the specific treatment process being inspected on a case by case basis)

Note that the facility may require:
- Waste Management Licence
- Water Use Licence
- Environmental Authorization

EMISSIONS TO AIR
- Are there complaints of odour nuisance?



Solid wastes e.g. screenings

Solids/ Sludges / Brine
- Disposal?
- Mass/volume of sludge generated and disposed (and records of disposal indicating where the sludge is disposed)
- Mass/volume of any other process waste material generated and disposed (and records of disposal indicating where the waste material is disposed)
- Confirmation that the disposal sites used are appropriately permitted sites

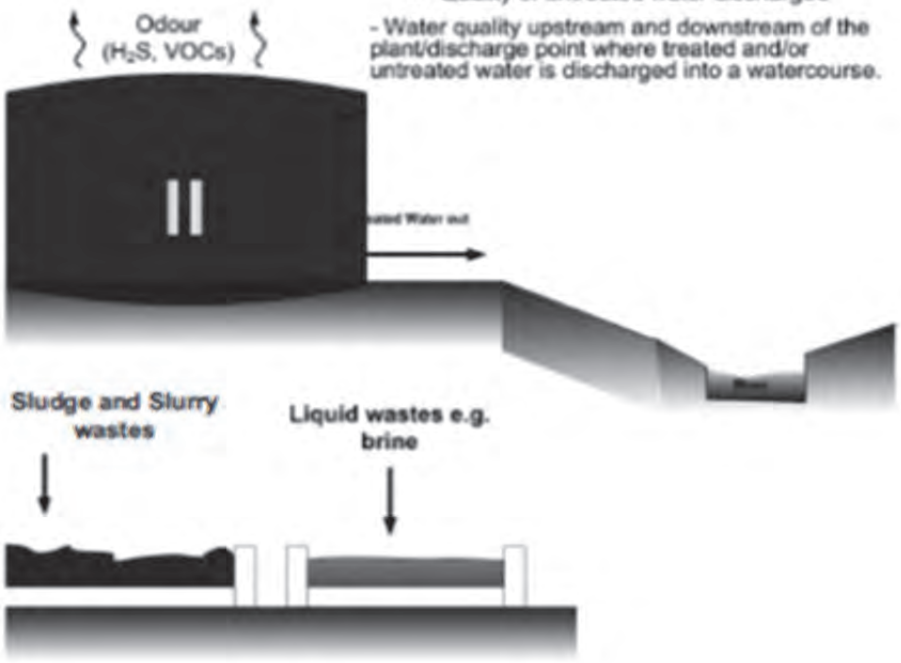
- Check Storage conditions and management of wastes.
- is the waste Treated/ recycled? Is a waste licence required? What are the conditions in the waste licence for facilities constructed after promulgation of the Waste Act.

CONTINUED OVERLEAF

PROCEDURE DIAGRAM CONTINUED

Treated Water Management
-Monitored?
-Discharged? to where? (NWA section 21)
- Volumes of treated water discharged
- Volumes of untreated water/ wastewater discharged
- Quality of treated water discharged
- Quality of untreated water discharged

- Water quality upstream and downstream of the plant/discharge point where treated and/or untreated water is discharged into a watercourse.



Also Check:
- Maintenance Records
- Groundwater Monitoring Records
- Audit reports

Date: 17 April 2010 Rev: 1

5.9 PROCEDURE FOR INSPECTION OF COMPLIANCE WITH CONDITIONS OF ENVIRONMENTAL AUTHORISATIONS

1 OBJECTIVE

This procedure is to determine compliance with a NEMA EA or ECA ROD. This SOP applies to all routine inspections undertaken in terms of NEMA Section 31K. Activities on the site will be assessed against all the conditions of the relevant EA. Compliance will be determined by way of interviews, document review and physical inspection of the site.

2 DEFINITIONS

HASP: Site specific Health and Safety Plan

Site: the area to be visited to determine compliance with the relevant EA

Site management: the person(s) in charge and responsible for the persons working on the site

3 PROCEDURE

3.1 Planning

3.1.1 A desktop assessment must be undertaken of the EA to:

- Determine what documents are required to evaluate the EA (e.g. regulations, EMP, licenses, etc)
- Determine which requirements of the EA are administrative and can be audited in office by checking documents such as permits
- Decide which areas of the site require inspection
- Understand the activities and size of the operation to determine how many EMIs will be required, given the time available.

3.1.2 Have a pre-inspection meeting/telephone call with the site management to confirm:

- The scope of the inspection
- The date and duration of the inspection
- The names of the EMIs and other parties responsible on site
- An inspection schedule giving times and places to be visited
- Co-ordination of activities with operations and staff availability
- PPE requirements and safety induction procedures.

3.1.3 Create a health and safety plan.

3.1.4 Create an inspection plan that includes:

- The route to and from the site including transport arrangements
- The inspection route on the site, including key questions at each point
- The required PPE (Note 1.1: Code of Conduct)
- Other equipment, such as samplers, monitoring equipment, measuring tapes, dictaphones, cell phones and cameras.

3.2 Inspection

3.2.1 Arrive at the site in time to complete any safety induction process well in advance of the first appointment. Refer to SOP 5.1: Entering a facility on a routine inspection.

3.2.2 Convene an opening meeting during which the EMI should:

- Circulate an attendance register
- Ensure a round of introductions
- Take minutes
- Take note of the SOP 5.2: Gathering of Evidence during an Inspection
- Identify the person(s) from site management for your safety on site
- Clarify communication channels – who do you need to speak to and how do you contact them?
- Confirm the language that you intend using
- Explain the purpose of the inspection and define the roles of the various parties
- Describe requirements that you have to complete the inspection
- Ask about the history of the facility, including previous inspections
- Explain which records/documents/permits/authorisations are required for the document review part of the inspection and request these
- If samples will be taken, explain this and advise if there is anything that may be required from site management to assist with this, and ensure you will have the permission to remove the samples from the site
- Address any last minute changes to the agreed inspection schedule

3.2.3 Commence the document review, ensuring that the EA conditions are systematically checked against the documentation produced.

3.2.4 Note SOP 5.2: Gathering of Evidence During an Inspection, especially in the event that resistance to the production of any required documentation is encountered. Note SOP 4.5: Handling of Confidential Information.

3.2.5 The document review must then be completed, with any non-compliance being noted. The EMI must do an "on the spot" assessment of how serious the non-compliance is.

3.2.6 If any non-compliance is so serious as to merit involvement of more senior staff, note SOP 5.3: Issuing of a Notification Card. If the documentation is found to be inadequate, those persons assigned responsibility for managing the inspection and the site management must be informed. A decision should be made as to whether the inspection should be continued or suspended until documentation concerns are resolved.

3.2.7 The physical inspection of the facility must then be commenced, and the EMI must ensure that the EA conditions are systematically checked against physical observations and activities on the site. Remember:

- To take the required PPE. Refer to SOP 4.1: Procedure for the Use and Handling of Personal Protective Equipment
- To take the required sampling/monitoring/measuring equipment

- To reference the HASP and ensure that arrangements have been made for additional site supplied PPE

3.2.8 If during the physical inspection any non-compliance is so serious as to merit involvement of more senior staff, note SOP 5.3: Issuing of a Notification Card.

3.2.9 Be polite but firm and do not allow yourself to be rushed. Conduct the inspection at your own pace. Stick to the time schedule.

3.2.10 Insist on seeing all areas that have been identified as relevant, even if it appears that there is no activity. Remember that activities in a maintenance/shut down cycle may differ substantially from normal or emergency operations, and the inspection should take this into account.

3.2.11 If hostility is encountered on site, refer to SOP 4.4 Hostile People and Situations.

3.2.12 Detailed notes of any observations must be made, and there must be cross-referencing of the findings with the EA conditions.

3.2.13 Remember that both compliance and non-compliance must be noted.

3.2.14 Remember that when a non-compliance has been observed, there must be a description as to where and when it was observed. Photographs of each non-compliance must be taken. Look for and describe any distinguishing feature that may be obvious and the time and date of the occurrence. Example: Smoke stack for boiler with maintenance reference number 98044657vcg emitting dark black smoke at 10:09 am on 03/08/09."

3.3 Conclusion of inspection and reporting of the findings

3.3.1 Once the audit has been completed, and depending on the findings, you may wish to conduct a closing meeting. At this meeting:

- Request the attendance of management
- Thank everybody for their co-operation and assistance
- If appropriate, provide feedback on your findings, including observations that were uncertain and items that cannot be clearly stated as compliant/non-compliant
- Outline any further steps.

3.3.2 Refer to SOP 5.11: Procedure for Drafting of Inspection Reports.

Date: 17 April 2010 Rev: 1

5.10 PROCEDURE SUBSEQUENT TO REPORTING OF EMERGENCY INCIDENTS

1 OBJECTIVE

This SOP informs the relevant authority of the procedure to be complied with subsequent to an emergency incident being reported. This procedure applies to all emergency incidents reported to the relevant authority either as an alarm report or in terms of section 30 of NEMA in an alert report.

2 DEFINITIONS

S.30 Alert report: the report that must be submitted by the responsible person in terms of section 30(3) of NEMA.

Alarm report: a report that is received of a possible emergency incident other than from the responsible person in terms of section 30(3) of NEMA.

Emergency Incident: an unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed;

Emergency Incident Report means the report submitted to the Incident Controller

National Incident Coordinator: Person appointed by the DG, DEA to coordinate emergency responses

Incident Controller: Person appointed by the lead Relevant Authority to act on behalf of the authority

On-site incident: an incident that occurs within the boundaries of a particular industry, business or other type of development.

Off-site incident: an incident that occurs within the general public domain

Relevant Authority: means -

- a municipality with jurisdiction over the area in which an incident occurs;
- a provincial head of department or any other provincial official designated for that purpose by the MEC in a province in which an incident occurs;
- the Director-General;
- any other Director-General of a national department.

Responsible Person: includes any person who -

- is responsible for the incident;
- owns any hazardous substance involved in the incident; or
- was in control of any hazardous substance involved in the incident at the time of the incident;

and where the incident occurred in the course of that person's employment, will include his/her employer

3 BACKGROUND

Purpose

The measures in section 30 of NEMA are largely reactive, seeking to reduce the extent of

the impacts on the environment that have already occurred as a result of an incident. The proper management of information emanating from an emergency incident can however be used to proactively predict, prevent and better manage future emergency incidents.

What is an emergency incident?

Specific thresholds for determining when an incident qualifies as an emergency incident in terms of Section 30 of NEMA have not been provided in the legislation. According to the definition in NEMA an incident must satisfy the following cumulative requirements:

- It must be unexpected (not expected/surprising) sudden (without warning/abrupt) occurrence (of which major emissions, fires and explosions are three examples); and
- It must lead to serious danger to the public; or
- It must lead to potentially serious pollution (see definition below) of or detriment to the environment;
- Irrespective of whether the above effects are immediate or delayed.

"Pollution" is defined as any change to the environment (whether caused by substances, radioactive or other waves, noise, odours, dust or heat) having an adverse effect on human health or wellbeing, or on ecosystems or on useful materials. Note the wide definition of "environment", also in section 1 of NEMA.

If it transpires at any stage that the incident is not a NEMA emergency incident, the Incident Controller reports this to the National Incident Coordinator, who makes a final decision on the matter. The Incident Controller, with the permission of the National Incident Coordinator, closes the emergency incident record and sends the Responsible Person a notification indicating that the incident was not an emergency incident and that no further action is required in terms of Section 30 of NEMA.

Roles and Responsibilities

Due to a lack of clarity regarding the roles and responsibilities of the relevant authorities and overlapping legislation, emergency incidents are often met with either no response, or a duplicated response.

Firstly note the provisions in section 30(2) NEMA in this regard. The DG may only take steps in terms of section 30 NEMA where neither the municipal or provincial authority has done so. The provincial authority may only take steps where the municipality has not done so, and the DG of another national department may only do so if none of the other parties have done so. Where it is however necessary to do so, any of these may take the necessary steps if none of the other parties have yet done so. This means that in most cases the municipal authority might be the appointed lead Relevant Authority, but that the Incident Controller of the municipal authority will act in close cooperation with the National Incident Coordinator.

The application of other legislation or the responsibilities of other organs of state in the case of emergencies does not detract in any way from the Responsible Person's obligations in terms of NEMA. The National Incident Coordinator and Incident Controller will work

closely with any such department or organ of state, and should, for example, not issue a directive in terms of section 30(6) NEMA without consultation with such parties. In some cases it might mean that another state department or organ of state will take the lead in the response to the emergency, and that the section 30 NEMA requirements will be an additional, but secondary, response to the emergency. An example of this would be a water pollution incident where the requirements of section 20 of the NWA must be complied with or an oil spill at sea, where SAMSA will take the lead in terms of the relevant legislation.

In the case of on-site incidents and depending on the size and nature of the company involved, the relevant company may have sufficient resources available on site for the incident to be managed without the need for external assistance from municipal emergency services. Off-site incidents are generally responded to by municipal emergency services that may, depending on the nature of the incident and the resources available within the municipality, require the use of private companies to assist in the containment and cleanup operations.

4 *PROCEDURE*

4.1 Receiving an Alarm or S.30 Alert Report

4.1.1 When an Alarm Report is received, and the reported incident was determined to be an emergency incident, or the Responsible Person has submitted a S.30 Alert Report to the Relevant Authorities, the National Incident Coordinator must ensure that all other relevant authorities and role players are notified, if not already notified in terms of SOP 4.6: Referral and Reporting Protocol.

4.1.2 The National Incident Coordinator identifies a lead Relevant Authority. The lead Relevant Authority immediately appoints an Incident Controller.

4.1.3 In the case of an Alarm Report, proceed to 4.2.

4.1.4 In the case of a S.30 Alert Report, proceed to 4.3.

4.2 Reacting to Alarm Reports

4.2.1 The Incident Controller determines whether a Responsible Person can be identified. If such a person can be identified, the Incident Controller immediately notifies such person of their obligation to submit an Alert Report.

4.2.2 If a S.30 Alert Report is then submitted, proceed to 4.3.

4.2.3 If the responsible person fails to submit a S.30 Alert Report, the Incident Controller must report this to the Incident Coordinator, who then can:

- Issue a section 31L NEMA compliance notice to the Responsible Person, and
- Launch a criminal investigation into the non compliance to section 30(3), a criminal contravention in terms of section 30(11)

Note that the directive in section 30(6) does not cover the non-compliance with section 30(3). The section 31L compliance notice must be issued according to SOP 6.9: Administrative Enforcement. The criminal measures must be determined according to the Enforcement Guidelines in SOP 2.1.

4.2.4 If however:

- there is an immediate risk of serious danger to the public or potentially serious detriment to the environment, or
- no responsible person can be identified, or
- there is uncertainty as to who the responsible person is

proceed to 4.9 below.

4.3 Initial Desktop Assessment of the S.30 Alert Report

4.3.1 The Incident Controller assesses the information in the S.30 Alert Report to ensure that the following aspects have been reported on satisfactorily and in sufficient detail:

- The nature of the incident;
- Any risks posed to public health, safety or property;
- The toxicity of substances or by-products released by the incident;
- Any steps that should be taken in order to avoid or minimise the effects of the incident to public health and the environment.

4.3.2 If any of these aspects have not been dealt with satisfactorily and in sufficient detail, the Incident Controller notifies the Responsible Person and requests additional information. If circumstances require it, this can be done verbally, but as soon as possible followed up with a written instruction confirming the verbal instruction.

4.3.3 If the initial evaluation indicates there is an immediate risk of serious danger to the public or potentially serious detriment to the environment and it is essential that the Relevant Authority must step in to contain and minimise the effects of the incident, undertake cleanup and remedy the affects, then proceed to 4.9 below. Depending on the urgency, this can be done either prior to, or following on, a site visit.

4.3.4 If the circumstances do not require the step in 4.3.3 above, proceed to 4.4

4.4 Duties of Responsible Person

4.4.1 Unless the Responsible Person has clearly indicated that they understand their responsibilities in terms of section 30(4) NEMA, the Incident Controller immediately notifies them that they are under an obligation to:

- Take all reasonable measures to contain and minimise the effects of the incident;
- Undertake cleanup procedures;
- Remedy the effects of the incident;
- Assess the immediate and long-term effects of the incident on the environment and public health

4.4.2 If circumstances require it, this can be done verbally, but must, as soon as possible, be followed up with a written instruction confirming such verbal communication. If there is any indication that the Responsible Person is not fulfilling these responsibilities, the Incident Controller must consider the issuing of a directive as is set out under 4.8 below.

4.4.3 A copy of the instruction must be forwarded to the National Incident Coordinator.

4.5 Detailed Assessment of the Alert Report

4.4.4 The Incident Controller must make a comprehensive assessment of the information in the Alert Report. This step involves any or all of the following, and may involve a site visit if necessary:

- Contacting the responsible person and all other relevant authorities and determining what steps have been taken already;
- Evaluating, the effect of steps already taken;
- Evaluating the size and nature of the incident;
- Evaluating the potential hazards of the incident
- Assessing the resources needed to contain, clean and remediate the site;
- Assessing, where applicable, the ability of the local authority to control the incident

4.4.5 A copy of the assessment must be forwarded to the National Incident Coordinator.

4.6 Notification of Emergency Incident Report

4.6.1 The Incident Controller sends the Responsible Person a notification indicating that the incident has been classified as emergency incident in terms of section 30 of NEMA and that a report is due within 14 days of the date of the incident. The request must stipulate that the report must contain all available information to enable an initial evaluation of the incident, including, but not limited to comprehensive information on:

- The nature of the incident;
- The substances involved and an estimation of the quantity released and their possible acute effect on persons and the environment and data needed to assess these effects;
- Initial measures taken to minimise impacts;
- Causes of the incident, whether direct or indirect, including, but not limited to, equipment, technology, system, or management failure; and
- Measures taken and to be taken to avoid a recurrence of such an incident.
- Require acknowledgement of receipt of the above request and follow up if no such acknowledgement is received.

4.6.2 A copy of the request is forwarded to the National Incident Coordinator.

4.7 Duties of the Incident Controller

4.7.1 The Incident Controller then:

- arranges a site meeting with the Responsible Person and relevant authorities if it has not yet been done;

- agrees roles and responsibilities with other Relevant Authorities in so far as it has not yet been done;
- ensures that the relevant authority monitors the containment, cleanup and remediation of the incident.

4.8 Issuing of Directives

4.8.1 If at any stage the Responsible Person fails to fulfill his or her obligations as specified in 4.4 or 4.6 above, the Incident Controller, on behalf of the Relevant Authority, may direct that person to undertake specific measures within a specific time. This may only be done after consultation with the National Incident Coordinator, unless it is an urgent verbal directive. Prior to the decision, the relevant authority has regard to the following:

- the principles in section 2 of NEMA;
- the severity of any impact on the environment as a result of the incident and the costs of the measures being considered;
- any measures already taken or proposed by the person on whom the measures are to be imposed;
- the desirability of the State fulfilling its role as custodian holding the environment in public trust for the people;
- any other relevant factors.
- Such a directive:
  - due to the nature of the situation does not need to be preceded by a pre-directive, unless time allows for that;
  - must indicate that the above listed considerations have been taken into account;
  - may be given verbally, but such a verbal directive must be confirmed in writing at the earliest opportunity, and within 7 days

4.8.2 Where the Responsible Person fails to comply with the directive, the responsible authority may:

- follow the steps in 4.9 below and
- proceed with a criminal investigation, the outcome of which will be based on the Enforcement Policy: 2.1

Where the Responsible Person is an organ of state, follow only the steps in 4.9 below, and do not proceed with a criminal investigation (NEMA is not binding on the State as far as criminal liability is concerned).

4.8.3 The relevant authority must report the issuing of such a directive as prescribed in 4.10 below.

4.8.4 The attempted criminalisation of the non-compliance with a section 30(6) directive by section 30(11) is problematic, and it might be advisable to simultaneously issue a section 28(4) directive and/or a section 31L compliance notice according to the prescriptions in SOP 6.9: Administrative Enforcement.

4.9 Intervention by the Relevant Authority

4.9.1 Should-

- the Responsible Person fail to comply, or inadequately comply with a directive as set out in 4.8; or
- there be uncertainty as to who the responsible person is, as set out in 4.2; or
- there be an immediate risk of serious danger to the public or potentially serious detriment to the environment, as contemplated in 4.2 or 4.3

the Incident Controller, on behalf of the Relevant Authority, takes the measures it considers necessary to –

- contain and minimise the effects of the incident;
- undertake cleanup procedures; and
- remedy the effects of the incident

and claims reimbursement for all reasonable costs incurred from any Responsible Person jointly and severally, where such person(s) can be identified.

4.9.2 Where such steps have been taken, the Incident Controller addresses a letter of demand to the Responsible Person, if identified, claiming reimbursement, clearly specifying the cost in detail, as well as setting out why such cost were reasonable in the circumstances, and a reasonable timeframe for such payment. If no payment is made before the prescribed date, the matter is referred to the legal advisor of the Relevant Authority for referral to the Office of the State Attorney for recovery/collection. A Relevant Authority must then give notice as is prescribed in 4.10 below.

4.10 Reporting by the Relevant Authority

4.10.1 Where the Relevant Authority has issued a directive or has taken the necessary measures to contain, cleanup and remedy, the Incident Controller, as soon as reasonably practicable, prepares a comprehensive report on the incident, and makes it available through the most effective means reasonably available to –

- the Director-General (via the National Incident Coordinator);
- the South African Police Services and the relevant fire prevention service;
- the relevant provincial head of department or municipality; and
- all persons who may be affected by the incident.
- the public;

4.10.2 Communication with affected persons and the public can be via e-mail, letters, registered letters, newspapers, radio or other media, depending on the particular situation.

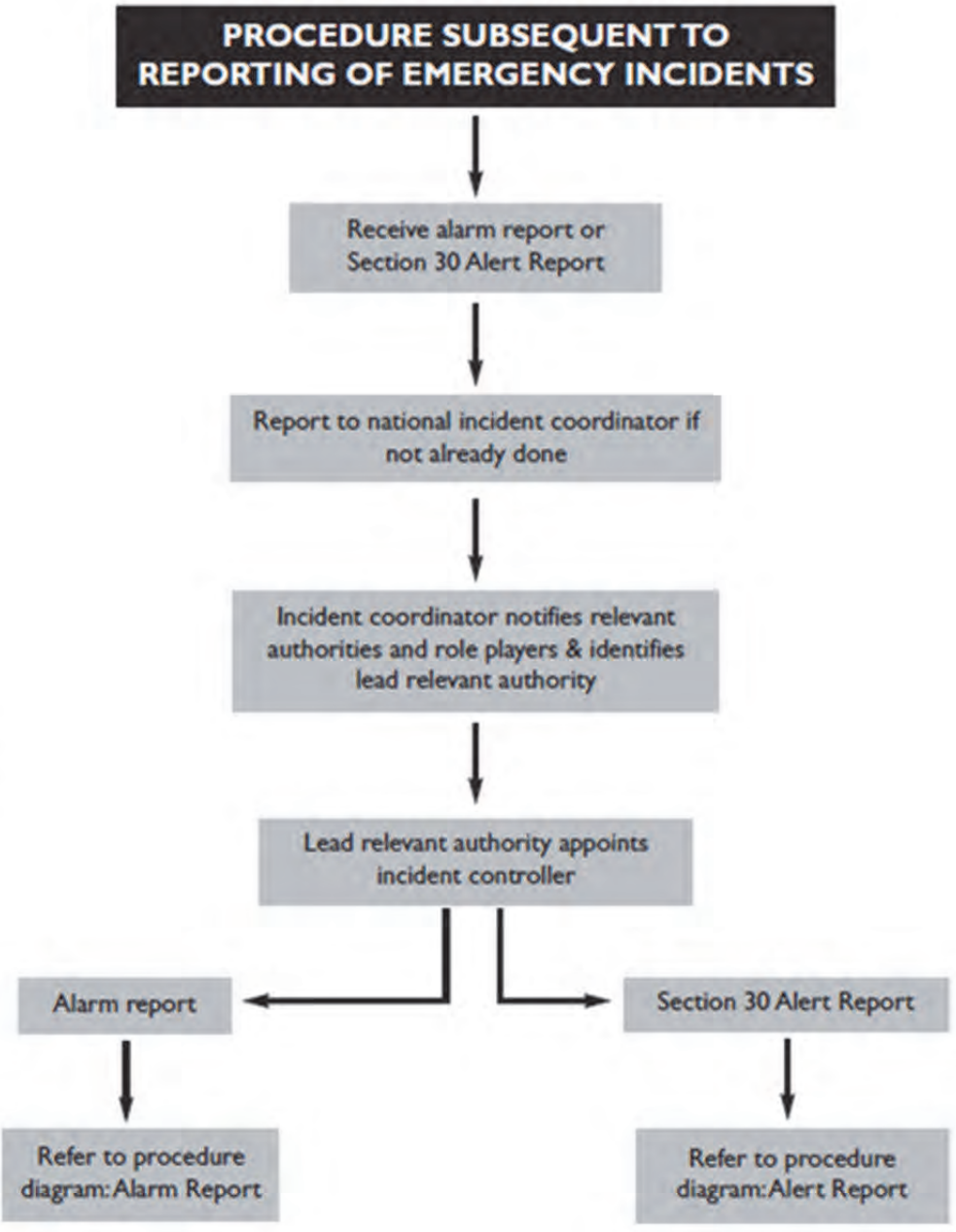
4.11 Reporting and Evaluation

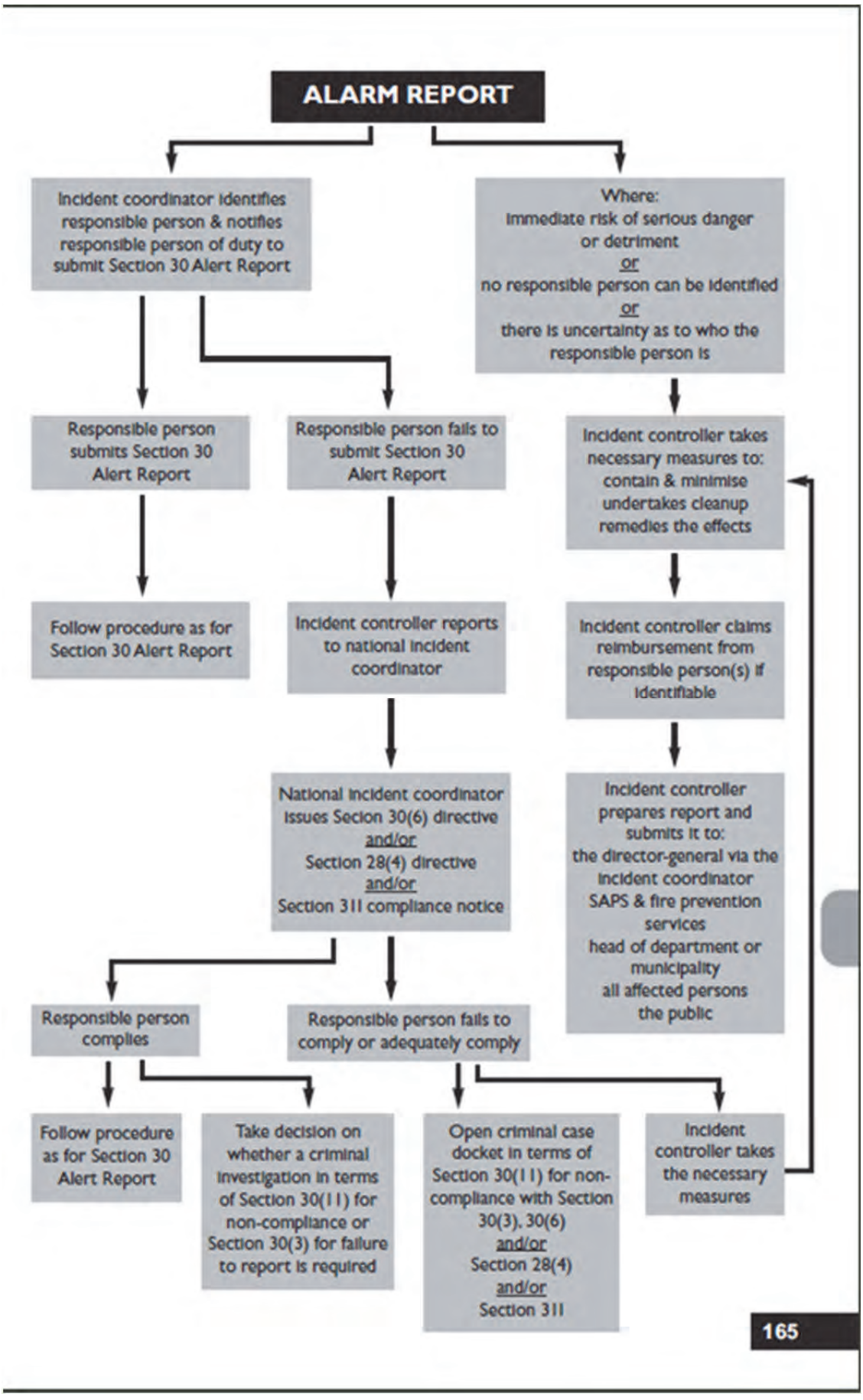
4.10.3 At the conclusion of the matter, a comprehensive report on the incident

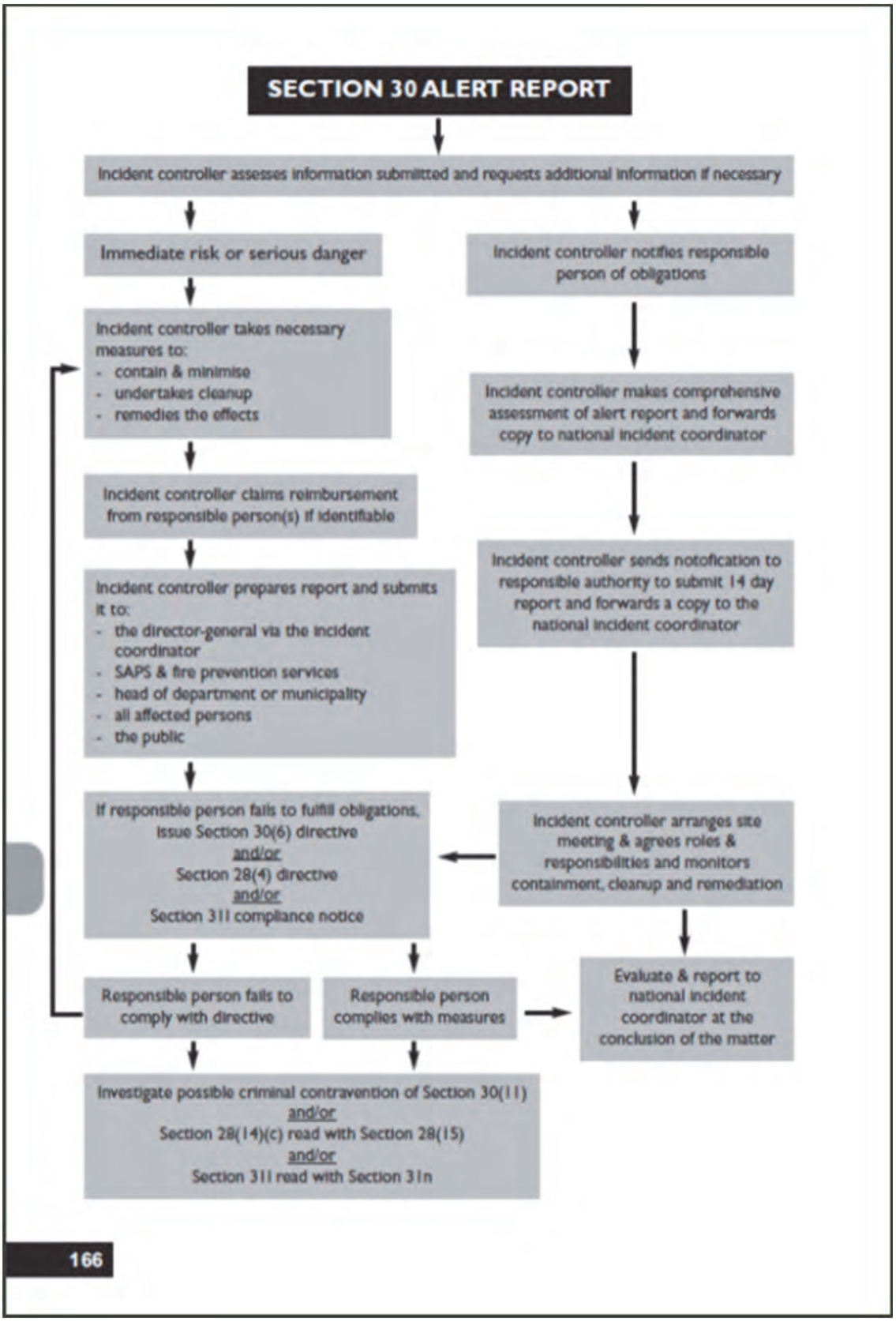
must be submitted by the Incident Controller to the National Incident Coordinator, irrespective of whether a report as contemplated in 4.10 above was submitted during the incident or not.

4.10.4 The National Incident Coordinator is responsible for compiling an annual report on the handling of emergency incidents, with specific recommendations for more effective responses based on the reports received. Where necessary, this SOP must be amended accordingly.

PROCEDURE DIAGRAM




ALARM REPORT
Incident coordinator identifies responsible person & notifies responsible person of duty to submit Section 30 Alert Report
Where:
immediate risk of serious danger or detriment
or
no responsible person can be identified
or
there is uncertainty as to who the responsible person is
Responsible person submits Section 30 Alert Report
Responsible person fails to submit Section 30 Alert Report
Incident controller takes necessary measures to:
contain & minimise
undertakes cleanup
remedies the effects
Follow procedure as for Section 30 Alert Report
Incident controller reports to national incident coordinator
Incident controller claims reimbursement from responsible person(s) if identifiable
National incident coordinator issues Section 30(6) directive
and/or
Section 28(4) directive
and/or
Section 311 compliance notice
Incident controller prepares report and submits it to:
the director-general via the incident coordinator
SAPS & fire prevention services
head of department or municipality
all affected persons
the public
Responsible person complies
Responsible person fails to comply or adequately comply
Follow procedure as for Section 30 Alert Report
Take decision on whether a criminal investigation in terms of Section 30(11) for non-compliance or Section 30(3) for failure to report is required
Open criminal case docket in terms of Section 30(11) for non-compliance with Section 30(3), 30(6)
and/or
Section 28(4)
and/or
Section 311
Incident controller takes the necessary measures
165


SECTION 30 ALERT REPORT
Incident controller assesses information submitted and requests additional information if necessary
Immediate risk or serious danger
Incident controller takes necessary measures to:
- contain & minimise
- undertakes cleanup
- remedies the effects
Incident controller claims reimbursement from responsible person(s) if identifiable
Incident controller prepares report and submits it to:
- the director-general via the incident coordinator
- SAPS & fire prevention services
- head of department or municipality
- all affected persons
- the public
If responsible person fails to fulfill obligations, issue Section 30(6) directive
and/or
Section 28(4) directive
and/or
Section 31I compliance notice
Responsible person fails to comply with directive
Responsible person complies with measures
Investigate possible criminal contravention of Section 30(11)
and/or
Section 28(14)(c) read with Section 28(15)
and/or
Section 31I read with Section 31n
Incident controller notifies responsible person of obligations
Incident controller makes comprehensive assessment of alert report and forwards copy to national incident coordinator
Incident controller sends notofication to responsible authority to submit 14 day report and forwards a copy to the national incident coordinator
Incident controller arranges site meeting & agrees roles & responsibilities and monitors containment, cleanup and remediation
Evaluate & report to national incident coordinator at the conclusion of the matter
166

ANNEXURE 1

Inspection Report

1. FACILITY INSPECTED	
Exact geographic location of the site	
Date of the inspection	

2. OBJECTIVES AND SCOPE OF INSPECTION	
Type of inspection	
Site or activity name	
Inspection scope, particularly identification of the organisational and functional units or processes inspected and the time period covered	

3. INSPECTION TEAM				
Team leader	**Name**	**Institution**	**Position**	**Contact details**
Team members	**Name**	**Institution**	**Position**	**Contact details**

4. FACILITY REPRESENTATIVES		
Name	**Position/title**	**Contact Details**

5. BACKGROUND TO INSPECTION	
History of the facility	
Brief description of the activities/operations, and process	
Compliance history, where applicable	
Ownership	
ISO 14001 Accreditation (where applicable)	
Dates, times and places where the on-site inspection activities were conducted	
Mandated legislation and permits	

6. OPENING MEETING		
Attendance register		

What was discussed	
Any specific arrangements made with the facility	
Describe if entry was granted or denied	
Problems/restrictions	

7. INSPECTION ACTIVITIES	
Team A:	
Team B:	
Documents Team	

8. RECORDS REVIEWED AND GATHERED	
Records reviewed	
Records copied and taken	
Where were the records kept, and who was in charge of them?	
What selection method was used to review records?	

9. SAMPLES AND MEASUREMENTS	
What samples were taken, where, when, and of what?	
Chain-of-custody documentation including reference to the time, method of packaging, preserving, transporting and receipt of samples at the lab	
Procedures used for the calibration of sampling and/or measurement equipment	

10. SUPPORTING DOCUMENTS AND PHOTOS	
Notes	
Documents	
Photographs	
Notices	

11. FINDINGS OF NON-COMPLIANCE, IF ANY	
Legislation/authorisation condition	Details of non-compliance
12. OPERATORS' AWARENESS OF PERMITS AND PERMIT CONDITIONS	
Team A:	
Team B:	
13. GENERAL HOUSEKEEPING	
14. DOCUMENTATION SYSTEMS	
Documentation systems to support demonstration of compliance with legislation and permits	
15. SUMMARY OF INSPECTION PROCESS	
Uncertainties or obstacles encountered	
Have the inspection objectives been met within the scope of the inspection and in accordance with the inspection plan?	
16. CLOSING MEETING	
Who was present?	
What was discussed?	
Was further information requested, from whom and by what date?	
Any areas or aspects of the inspection plan/scope not covered or areas and aspects covered not within the inspection plan/scope, and reasons for the divergence	
17. FOLLOW-UP ACTIONS	
	LIST OUTSTANDING DOCS

INSPECTION TEAM LEADER

ANNEXURE 2

EA Inspection Report

1. FACILITY INSPECTED	
Exact geographic location of the site	
Date of the inspection	
Site or activity name	

2. OBJECTIVES AND SCOPE OF INSPECTION	
Type of inspection	*Compliance inspection to determine compliance with the Environment Conservation Act, 1989 (ECA), and the National Environmental Management Act, 1998 (NEMA), as well as authorisations issued in terms of such legislation.* *The methodology followed, as evident from the report, was to assess compliance with every condition in the applicable authorisations and with the relevant legislative provisions by way of interviews, document review and on-site observations.*
Inspection scope, particularly identification of the organisational and functional units or processes inspected and the time period covered	

3. INSPECTION TEAM				
Team leader	**Name**	**Institution**	**Position**	**Contact details**
Team members	**Annexure A**			

4. FACILITY REPRESENTATIVES		
Name	**Position/title**	**Contact Details**

5. OPENING MEETING	
Date, time and venue	

Attendance register	
Any specific arrangements made with the facility	
Describe if entry was granted or denied	
Problems/restrictions	

6. RECORDS REVIEWED AND GATHERED

Records copied and taken	

7. SUPPORTING DOCUMENTS AND PHOTOS

Documents	
Photographs	

8. CHECKLISTS

AUTHORITY BASED APPROACH REVIEW CHECKLIST

Elements	Details	Yes	No	N/A	Comments / Actions to be taken / Decisions Made
Environmental Authorisation or Record of Decision (in terms of NEMA, Section 24 or ECA Section 22) **General authorisation Requirements**	Verify the following details: Authorisation exists for all "listed activities" on site; • Correct authorization, including any amendments thereto, has been issued;				
	• Site location is correct;				
	• Contact details of the proponent are correct;				

	• The authorization validity period has expired.				
Standard Conditions	• Verify the following: • Registered interested and affected parties been made aware of the conditions of the environmental authorisation within one week of the proponent receiving the environmental authorisation				
	• The conditions of the environmental authorisation are included in contracts entered into between the applicant and purchasers of property, contractors and subcontractors.				
	• Has environmental damage been detected and remedied the satisfaction of the relevant authority.				
	• The department has been notified within 30 days of a change in ownership / project developer and the conditions of the environmental authorisation have been made known and are binding to the new owner / developer				
	• The authorisation has been withdrawn or suspended				

Project Specific Conditions	• Verify that the General and Specific Requirements of the Authorisation stipulated have been implemented. This may include: • Implementation of specific mitigation measures identified in the Scoping Report, Environmental Management Plan and / or Environmental Impact Report;				
	• Implementation of Environmental Management Plans;				
	• Appointment of Environmental Control Officers;				
	• Development plans, rezoning, sub-divisions, buffer areas and approved phased development plans are being adhered to; and				
	• Impacts (cumulative, direct and indirect) associated with the development are being managed in accordance with the approved EMP.				
Environmental Management Plan	• Is there an approved EMP for the development?				
	• Are the specific measures within the EMP for the following aspects being implemented on site:				

	○ Wastewater or effluent management;				
	○ Non-hazardous solid waste management;				
	○ Hazardous solid waste management;				
	○ Buffer zones and no-go areas;				
	○ Gaseous emissions;				
	○ Soil conservation (erosion control);				
	○ Maximum development footprint;				
	○ Compilation and approval of Method Statements;				
	○ Noise management;				
	○ Management of hazardous substances;				
	○ Issuance and payment of fines for non-compliance;				
	○ Payment of fines for non-compliance				
Environmental Control Officer	If an ECO is required in terms of the authorisation, verify the following: • Does the authorisation require an independent ECO?				

	• Has an independent ECO been appointed?				
	• Have the ECO audits been submitted at the correct intervals to the relevant authority for review?				
	• Have EIA and EMP non-compliances noted in the ECO report been reported to the relevant authority?				
	• Have EIA and EMP non-compliances noted in the ECO report been addressed within the relevant time period?				
	• Has a retention fund to make provision for rehabilitation that may be required by the ECO been set aside?				
	• Has the ECO been replaced within the relevant time period?				
	• Are the actual ECO responsibilities consistent with the description of ECO responsibilities in the EMP?				
Additional Legal Requirements	• Is there suspected non-compliance with other legislation?				

SELF REGULATORY APPROACH REVIEW CHECKLIST					
ENVIRONMENTAL MANAGEMENT SYSTEM					
Elements	**Details**	**Yes**	**No**	**N/A**	**Comments / Actions to be taken / Decisions Made**
General	• Is there a copy of the authorisation available on site?				
	• Have all persons responsible for the implementation of the authorisation been provided with training on the requirements				
	• Has somebody been appointed to manage compliance with the conditions of the authorisation?				
	• Are the authorisation details correct with respect to the following:				
	• Have the conditions of the environmental authorisation been included in an Environmental Management Plan or an Environmental Management Programme?				
	• Is there a copy of the EMP available on site?				
	• Has the authorisation been incorporated into the company Environmental Management System (EMS)?				

	• Has the EMS been audited against the clauses of a standard e.g. ISO 14001?				
	• Has an EMS implementation audit been conducted?				
	• Are the commitments made within the EMP being implemented?				
	• Are compliance reports being compiled and submitted to authorities in accordance with the required content and timeframe conditions for such reports in the conditions of the authorisation				
Site audits	Has a site audit been undertaken to review all aspects of environmental management of the facility or operation?				
Legal compliance audits	• Verify the following: • Has a legal compliance audit been conducted?				
	• Has a compliance audit been conducted against the conditions of the environmental authorisation?				
	• Has a compliance audit with emission limits been conducted?				
	• Has a compliance audit been conducted for discharge permits?				
	• Has a compliance audit been conducted for any required operating licenses?				

Sector/issue specific audits	Have sector or issue-specific audits of environmental management and performance been conducted eg. waste disposal, energy use, cleaner production?				

COMMUNITY APPROACH REVIEW CHECKLIST					
Element	**Details**	**Yes**	**No**	**N/A**	**Comments / Actions to be taken / Decision Made**
Environmental Monitoring Committee	• Verify the following: • Are there authorisation conditions specific to the role of the EMC?				
	• Has an EMC been established?				
	• Has the budget and the necessary resources to implement the roles and responsibilities of an EMC been made available?				
	• Have the personnel necessary to carry out the tasks of the EMC been appointed?				
	• Has the EMC met at required intervals with formally recorded minutes?				
	• Have the tasks detailed in the environmental authorisation for the EMC been implemented?				
	• Have all complaints been recorded and addressed?				
	• Are minutes of meetings circulated to all relevant parties?				
	• Is the representation on the EMC unbiased and objective?				

	• Are reports on the monitoring activities of the EMC circulated to all authorities in accordance with the content and timeframe requirements for such reports in the conditions of authorisation?				

9. FINDINGS OF NON-COMPLIANCE, IF ANY	
Legislative provision/authorisation condition	**Details of non-compliance**
Authorisations	

Environmentally harmful activities				
Activities/situations that have or may have a major detrimental environmental impact				

Other contraventions	
NEMA Section 34A(1) *Hindering or interfering with an EMI in the execution of that inspector's official duties; furnishing false or misleading information when complying with a request of an EMI; failing to comply with a request of an EMI.*	
10. DOCUMENTATION SYSTEMS	
Documentation systems to support demonstration of compliance with legislation and permits	

11. SUMMARY OF INSPECTION PROCESS	
Uncertainties or obstacles encountered	
Have the inspection objectives been met within the scope of the inspection and in accordance with the inspection plan?	

12. CLOSING MEETING			
Date, time and venue			
	Name	Designation	Institution
What was discussed?			
Was further information requested, from whom and by what date?			

13. OUTSTANDING ISSUES/FOLLOW-UP ACTIONS

INSPECTION TEAM LEADER
DATE:

ANNEXURE 3

Inspection Report Evaluation Guide

The contents and format of an inspection report can vary according to the type of inspection, the particular circumstances of the inspection and the individual writing style of the report writer. No matter what form the report is, however, the report and its attachments should answer the following questions:

Basic Inspection Information

- Who prepared the inspection report?
- Who signed the inspection report, and on what date?
- Who performed the inspection (all participants)?
- What is the name and location of the facility or site?
- What is the mailing address and telephone number of the facility or site?
- What is the name and title of the responsible official who was contacted?
- What was the reason for the inspection (for example, routine or response to a complaint)?

Entry and Opening Conference

- What are the facts about the entry (date, time, entry location, and team leader)?
- Were all team members properly identified?
- Were there any unusual circumstances concerning gaining consent to enter (for example, reluctance, attempts to limit the scope of the inspection, or attempts to place special requirements on inspectors)? How were such circumstances handled?
- Who was present at the opening conference?
- What topics were discussed at the opening conference?

Background of the Facility or Site

- What is the type of facility or site?
- What types of activities and operations take place at the facility or site?
- Who owns the facility or site (for example, a company, a closed corporation, an individual, a partnership, an organ of state or a nonprofit organization)?
- How many years has the facility been in existence?
- How many employees work at the site?
- Have any major modifications been made at the facility? Are any modifications or expansions planned?
- At what level of capacity is the facility operating? For how many shifts does it operate, and how many hours per day and days per week? What relationship does this information have to the inspection that was performed?

- Which operations, processes, and activities at the facility were examined during the inspection?
- Which operations, processes, and activities at the facility were not examined?

Inspection Activities

Records Inspection

- Is there a general description of how records are kept at the facility?
- What was the purpose of reviewing records?
- What records of the facility were reviewed?
- Are photocopied records or data manually copied from records adequately identified and documented?
- How were the specific records selected for review (was an auditing technique used or were all records reviewed)?
- Were any suspected transgressions found? (Each should be fully documented, making sure that all the information required for the section set forth below on suspected transgressions is included.)

Physical Sampling

- What was the inspector's sampling plan for the facility or site?
- What physical samples were collected at the site?
- Are the sampling techniques used explained adequately?
- Are all samples clearly linked to an identification number, location, and purpose?
- Are sampling conditions and other physical aspects of the sample (for example, color, texture, and viscosity) described?
- Were any deviations from the sampling plan or SOPs explained and documented adequately?
- Are chain-of-custody procedures documented?
- Are the results of laboratory analysis presented clearly?
- How do the results of analysis of samples compare with limits set forth in the facility's permit?

Illustrations and Photographs

- Are photographs taken during the inspection included and properly documented?
- Is there some information about the inspection that could be made easier to understand through the inclusion of a diagram or sketch?
- If sketches, diagrams, or maps are used, is the scale or other relationship shown clearly?

Interviews

- What are the names and titles of officials of the facility and other personnel who were interviewed?
- Are their statements summarised clearly?
- What are the names and addresses of any other individuals who were interviewed or who were witnesses?

Closing Conference

- Does the report include documentation that required receipts for samples and documents were provided?
- Does the report note statements the inspector made to officials of the facility about compliance status, recommending actions to take, or other matters?

Documentation of Suspected Transgressions

The heart of the inspection report is really the documentation and substantiation of suspected transgressions, which allows the EMI to determine whether a transgression occurred, how and why it occurred, and its seriousness. This substantiating information includes all the evidence of various kinds that has been collected. In an actual inspection report, some of the questions on the preceding pages might be answered in the portion of the report that discusses the evidence collected and other particulars of each suspected transgression.

Documentation of Suspected Transgression

For each suspected transgression, the inspection report should answer the following questions:

- What requirement does the inspector suspect has been transgressed?
- What information proves that the cited requirement applies to the facility or site?
- According to the elements of the requirement, what information proves that the suspected transgression occurred?
- What sampling methods (if appropriate) were used to determine that the transgression occurred? Are any deviations from sampling methods adequately explained?
- What information shows that possible exemptions to the rule do not apply?

Cause of Transgression

Note: This information may be useful, even when it is not required, for such purposes as negotiating an appropriate remedy and planning of future inspections. Causal information must be stated carefully so that it does not provide the violator with an excuse for the transgression.

- What information documents the possible cause of the transgression (for example, direct observations of gauge readings, production logs, physical appearance of materials, or statements by facility personnel)?
- Is there any supporting information that confirms or disproves a possible claim of an upset or other exempt activity?

Other Mitigating and Aggravating Factors

The level of enforcement response is partly based on the seriousness of the transgression. The inspection report should therefore contain information that will support the appropriate determination of the seriousness and extent of the transgression.

- What is the seriousness of the transgression (for example, amount of emissions, length of time of excess emissions, nature of emissions, location of source, and perceived effect on the public)?

- What harm resulted or could result from the transgression?
- What efforts did the facility make to correct the transgression?
- How difficult will it be to comply (considering such factors as availability of technology, cost of complying, and time required to correct the transgression)?
- What is the facility's past compliance history?

ANNEXURE B: WETLAND AND RIVERINE VEGETATION INDICATOR SPECIES

DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF) (2008). Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas, draft document prepared in 2008 by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare for Department of Water Affairs and Forestry: Stream Flow Reduction Activities, Pretoria, South Africa. (unpublished).

The Table below lists what are considered to be obligate riparian plants, as well as indicating in what province/s of South Africa these species are likely to occur in such a setting (*MP: Mpumalanga; LP: Limpopo; GA: Gauteng; NW: North-West; NC: Northern Cape; EC: Eastern Cape; WC: Western Cape; FS: Free State; KN: KwaZulu-Natal*). The list includes alien weeds and invader plants.

FAMILY	TAXON	HABITAT	WC	NC	EC	FS	KZN	NW	G	LP	MP
SALICACEAE	*Populus x canescens	Variable, but especially vleis and in river valleys	X	X	X	X	X	X	X	X	X
SALICACEAE	*Salix babylonica var. babylonica	Along streams.	X	X	X	X	X	X	X	X	X
FABACEAE	Acacia xanthophloea	Low-lying, swampy areas					X			X	X
ANNONACEAE	Annona senegalensis	Sandy soils along rivers, also in mixed scrub or woodland, on rocky outcrops and in swamp forest.					X			X	X
POACEAE	Arundinaria tessellata	Margins of high altitude forest, along streams and among rocks on mountain tops			X	X	X				
VERBENACEAE	Avicennia marina	Common in mangrove swamps; also encroaching back up feeder streams, and growing on banks of fresh water rivers.			X		X				
SALVADORACEAE	Azima tetracantha	Low altitudes in bush, scrub, woodland and thornveld, frequently along watercourses and in riverine thicket.	X		X		X			X	X
FABACEAE	Baphia racemosa	Usually in riverine forest.			X		X				
LECYTHIDACEAE	Barringtonia racemosa	Always near water, along banks of rivers, in fresh water swamps and occasionally in less saline areas of mangrove swamps					X				
PROTEACEAE	Brabejum stellatifolium	Riverine species with water-dispersed fruits, occurring in sheltered valleys and along streams.	X								
ASTERACEAE	Brachylaena neriifolia	Stream banks and moist mountain forest.	X		X						
RUBIACEAE	Breonadia microcephala	Along banks of permanent streams and rivers, in riverine fringe forest.								X	X
EUPHORBIACEAE	Bridelia micrantha	Riverine forest; patches of relic forest, or in open woodland.			X		X			X	X
RHIZOPHORACEAE	Bruguiera gymnorrhiza	On seaward side of mangrove swamps.									
FABACEAE	Cassia petersiana	Most frequently found along rivers and streams in riverine fringe thicket.					X			X	X
ULMACEAE	Chaetacme aristata	Along streams in wooded grassland, in riverine fringe thicket, in wooded ravines and near the coast, often in scrub and forest			X		X	X	X	X	X

COMBRETACEAE	Combretum caffrum	Along river and stream banks and in moist areas.			X						
COMBRETACEAE	Combretum erythrophyllum	Along river banks where it can form thick stands, with trunks reclining in and overhanging the water.		X	X	X	X	X	X	X	X
COMBRETACEAE	Combretum imberbe	Medium to low altitudes, in mixed woodland, often along rivers or dry watercourses, particularly on alluvial soils.					X	X	X	X	X
FABACEAE	Cordyla africana	Low altitudes in hot areas, most often forming part of riverine forest, and also in swamp forest.					X				X
EUPHORBIACEAE	Croton megalobotrys	On alluvial flats and almost always a constituent of riverine fringe forest or thicket.						X		X	X
LAURACEAE	Cryptocarya angustifolia	River valleys of the south-western Cape.	X								
CUNONIACEAE	Cunonia capensis	On stream banks and in moist forest, being abundant in the high, wet forests and in very wet crub forests around Knysna; under harsher conditions it becomes shrubby	X		X		X				
CYATHEACEAE	Cyathea dregei	Forest margins, wooded kloofs and along streams on grassy mountainsides	X		X		X			X	X
STERCULIACEAE	Dombeya cymosa	In coastal bush or, further inland, along river and stream banks.			X		X			X	X
STERCULIACEAE	Dombeya pulchra	In wooded river valleys and along stream banks, also on mountainsides at high altitudes.								X	X
EUPHORBIACEAE	Drypetes arguta	Evergreen forest, often along streams			X		X				
ACANTHACEAE	Duvernoia adhatodoides	Evergreen forest, often along stream banks and in ravines.			X		X				
ERICACEAE	Erica caffra var. caffra	Mountain ravines, on cliffs, generally in damp situations	X		X		X				
MORACEAE	Ficus capreifolia	Swamps, and frequently forming tangled thickets along river banks and on sandy islands in the larger rivers.					X			X	X
MORACEAE	Ficus sycomorus	Frequently along river banks, forming a distinctive part of the riverine thicket; also in mixed woodland					X			X	X
SCROPHULARIACEAE	Freylinia lanceolata	Wide range of altitudes in moist areas, along stream and river banks and fringing vleis.	X		X						
GREYIACEAE	Greyia radlkoferi	In mountain forested gullies, along stream banks, fringing evergreen forest and among rocks.					X			X	X
CELASTRACEAE	Gymnosporia bachmannii	Rocky banks of rivers and streams in evergreen forest.			X		X				
ANACARDIACEAE	Harpephyllum caffrum	Riverine forest.			X		X				X
MALVACEAE	Hibiscus diversifolius subsp. rivularis	In damp places, along rivers or lining lakes, and in thickets.	X		X		X				
MALVACEAE	Hibiscus tiliaceus	Along the coast often fringing estuaries and tidal rivers.	X		X		X				

SAPINDACEAE	Hippobromus pauciflorus	Riverine thicket, scrub, along stream banks and at margins of evergreen forest.	X		X	X	X			X	X
LAMIACEAE	Iboza riparia	Rocky ourcrops and margins of evergreen forest, often near water.					X			X	X
AQUIFOLIACEAE	Ilex mitis	Most frequently along river banks and stream beds, in moist evergreen forest, sometimes straggling and leaning over the water. It is believed that the presence of this tree is an indication of underground water near the surface.	X		X	X	X	X	X	X	X
PROTEACEAE	Leucadendron conicum	In mountainous areas from 300 to 1000m asl, always in damp places, in valleys, ravines and along streams.	X		X						
PROTEACEAE	Leucadendron eucalyptifolium	Coastal mountains at altitudes 150 to 1600m asl, favouring moist conditions; frequent at edge of forests and along streams.	X		X						
PROTEACEAE	Leucadendron salicifolium	On acid soils from 0 to 1000m asl, characteristically forming almost hedge-like screens along the banks of streams.	X								
ROSACEAE	Leucosidea sericea	At high altitudes along streams and in kloofs, where it forms dense stands			X	X	X	X	X	X	X
OLEACEAE	Lincociera battiscombei	Occurring on banks of mountain streams, most frequently in riverine fringes andforested ravines.								X	
ACANTHACEAE	Macaya bella	Evergreen forest, often along stream and river banks.			X		X			X	X
CAPPARACEAE	Maerua gilgii	Arid areas of stony desert, often along river beds and dry watercourses.		X							
MYRSINACEAE	Maesa lanceolata	Margins of evergreen forest, almost always along rivers and streams, occasionally in open mountaingrassland.			X		X			X	X
MYRTACEAE	Metrosideros angustifolia	In mountainous areas, along watercourses and river banks where it can become locally common.	X	X							
RHAMNACEAE	Noltia africana	High altitudes, occassionally in open scrub and along stream banks.	X		X						
LOGANIACEAE	Nuxia oppositifolia	Along rivers and streams, in riverine thicket, among rocks and reeds.					X			X	X
OLEACEAE	Olea africana	Variety of habitats, usually near water, on stream banks, in riverine fringes, but also in open woodland, among rocks and in mountain ravines.	X	X	X	X	X	X	X	X	X
ARECACEAE	Phoenix reclinata	Along river banks in low-lying open grassland			X		X			X	X
EUPHORBIACEAE	Phyllanthus reticulatus	Low altitude riverine vegetation and thicket.					X			X	X
PIPERACEAE	Piper capensis	Moist, shady places, in forests and along streams	X		X		X			X	X
CUNONIACEAE	Platylophus trifoliatus	In forest or on stream banks	X		X						
URTICACEAE	Pouzolzia hypoleuca	Open woodland, wooded ravines, riverine thicket and sheltered among boulders on rocky koppies.					X	X	X	X	X

PRIONIACEAE	Prionium serratum	In water courses and river beds.	X		X		X				
CELASTRACEAE	Pseudosalacia streyi	Among rocks along river banks in evergreen forest, seldom far from the sea.			X		X				
APOCYNACEAE	Rauvolfia caffra	Nearly always associated with available ground water, along wooded stream banks and at the margins of evergreen forest.			X		X	X	X	X	X
RHAMNACEAE	Rhamnus prinoides	Along watercourses, in riverine forest and at margins of evergreen forest.	X		X	X	X		X	X	X
RHIZOPHORACEAE	Rhizophora mucronata	On inter-tidal mud flats, usually on the seaward side of mangrove swamp forests.			X		X				
ANACARDIACEAE	Rhus incisa	Scattered through open scrub and frequently occurring along the banks of rivers.	X	X	X						
ANACARDIACEAE	Rhus montana	Mountain areas, often along river banks.			X	X	X			X	X
ANACARDIACEAE	Rhus viminalis	Along river and stream banks.	X	X	X	X					
LYTHRACEAE	Rhyncocalyx lawsonioides	Margin of evergreen forest and along rivers.			X		X				
VERBENACEAE	Rotheca myricoides	Rocky places in thickets along streams, also in open woodland often associated with termite mounts.					X	X	X	X	X
SALICACEAE	Salix mucronata subsp. mucronata	Stream and river banks, in a wide range of habitats.	X	X	X	X	X	X			
SALICACEAE	Salix mucronata subsp. subserrata	Occurs along river and stream banks and on islands, in places likely to become inundated for at least part of the year.				X	X			X	X
CHENOPODIACEAE	Salsola aphylla	Frequently in dry, arid hot areas along dry watercourses.	X	X	X	X		X		X	
FABACEAE	Sesbania sesban subsp. sesban	In low lying areas usually near water, often on river or stream banks.			X		X			X	X
EUPHORBIACEAE	Spirostachys africana	Low altitude bush, often along rivers and streams.					X	X	X	X	X
MYRTACEAE	Syzygium cordatum subsp. cordatum	Along stream banks, in riverine thicket and forest, always near water or along watercourses, and in KZN, forming stands of almost pure swamp forest.			X		X			X	X
MYRTACEAE	Syzygium guineense subsp. guineense	Open deciduous woodland at medium to low altitudes, frequently fringing vleis, sometimes along river banks.					X			X	X
TAMARICACEAE	Tamarix usneoides	Occurring in and fringing desert areas, along brackish shore lines, river banks and frequently in dry river beds.	X	X	X						
ULMACEAE	Trema orientalis	Variety of habitats, usually moist soils, on forest margins, along watercourses, often a constituent of riverine fringe thicket, also in ravines and valleys and even along dry, sandy river beds (smaller in drier habitats).			X		X	X	X	X	X
HAMAMELIDACEAE	Trichocladus ellipticus subsp. ellipticus	Occurring in rain forest, along streams and rivers where it is frequently dominant, and in swampy places.	X		X		X			X	X

RHAMNACEAE	Ziziphus mucronata	In a wide variety of habitats, in open woodland, often in alluvial soils along rivers, and frequently on termite mounts; it is said to indicate the presence of underground water.		X	X	X	X	X	X	X	X
RHAMNACEAE	Ziziphus rivularis	Occuring among rocks and also along stream banks or in water courses.					X			X	X

ANNEXURE C: ALIEN AND INVASIVE RIVERINE VEGETATION SPECIES

CONSERVATION OF AGRICULTURAL RESOURCES ACT, Act 43 of 1983, list of declared Alien and Invasive species

National Environmental Management: Biodiversity Act: Act 10 of 2004, Government Notice R508 in Government Gazette 36683 of 19 July 2013 (National list of Alien species).

National Environmental Management: Biodiversity Act: Act 10 of 2004, Government Notice R507 in Government Gazette 36683 of 19 July 2013 (National list of invasive species).

National Environmental Management: Biodiversity Act: Act 10 of 2004, Government Notice R506 in Government Gazette 36683 of 19 July 2013 (Alien and Invasive species regulations 2012) – not in operation yet.

HENDERSON, L. (2001) Alien Weeds and Invasive Plants. Agricultural Research Council, Cape Town, South Africa

GERBER, A.; CILLIERS, C.J.; VAN GINKEL, C. AND GLEN, R. (2004) Easy Identification of Aquatic Plants. Department of Water Affairs, Pretoria.

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Acacia baileyana	Bailey's wattle	x	x	x		x	x	x	x	x	Trees & Shrubs	3		CARA	
Acacia cyclops	red eye					x	x	x			Trees & Shrubs	2	Chemical & Biological control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Acacia dealbata	silver wattle	x	x	x	x	x	x	x	x	x	Trees & Shrubs	1 &2		CARA, NEM:BA	
Acacia decurrens	green wattle	x	x	x	x		x		x	x	Trees & Shrubs	2	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Acacia elata	peppertree wattle	x		x			x	x		x	Trees & Shrubs	3		CARA, NEM:BA	
Acacia implexa	hickory/screw-pod wattle							x			Trees & Shrubs	1		CARA, NEM:BA	
Acacia longifolia	long-leaved wattle	x	x	x		x	x	x		x	Trees & Shrubs	1	Chemical & Biological control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Acacia mearnsil	black wattle	x	x	x	x		x	x	x	x	Trees & Shrubs	2	Chemical & Biological control		
Acacia melanoxylon	Australian blackwood	x	x	x			x	x		x	Trees & Shrubs	1	Chemical & Biological control	CARA	
Acacia podalyriifolia	pearl acacia	x	x	x	x		x	x	x	x	Trees & Shrubs	3		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Acacia pycnantha	golden wattle						x	x			Trees & Shrubs	1	Chemical & Biological control	CARA, NEM:BA	
Acacia salinga	Port Jackson willow					x	x	x			Trees & Shrubs	2	Chemical & Biological control		
Achyranthes aspera	burweed, chaff flower	x	x	x		x	x	x	x	x	Terrestrial herbs	1			

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Agave sisalana	sisal	x	x	x	x	x	x	x		x	Trees & Shrubs	2	Chemical control	CARA	
Ageratina adenophora & A. riparia	crofton weed & creeping creeping weed		x		x			x		x	Terrestrial herbs	1			 

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Ageratum conyzoides & A. houstonianum	invading ageratum & Mexican ageratum	x	x		x		x	x		x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA	
Ailanthus altissima	tree-of-heaven	x		x			x	x	x	x	Trees & Shrubs	3		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Albizia lebbeck & A. procera	lebbeck tree & false lebbeck									x	Trees & Shrubs	2			
Alhagi maurorum	camelthorn bush					x	x	x			Trees & Shrubs	2	Chemical control	CARA, NEM:BA	
Alpinia zerumbet	shell ginger/pink porcelain lily		x				x			x	Terrestrial herbs				
Alternanthera philoxeroides	alligator weed							x			Aquatics				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Araujia sericifera	moth catcher		x	x	x		x	x	x	x	Climbers	1		CARA, NEM:BA	
Ardisia crenata	coralberry tree, coral bush						x			x	Trees & Shrubs	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Argemone mexicana & A. ochroleuca subsp. Orchroleuca	yellow/white-flowered Mexican poppies	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA	
Arundo donax	giant reed	x	x	x	x	x	x	x	x	x	Grasses & Reeds	1		CARA, NEM:BA	
Atriplex lindleyi subsp. Inflata	sponge-fruit saltbush					x	x	x	x		Terrestrial herbs	3			

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Atriplex nummularia subsp. nummularia	old man saltbush				x	x	x	x	x		Trees & Shrubs	2			
Azolla filiculoides	red water fern	x	x	x	x	x	x	x	x	x	Aquatics	1	Biological control	CARA, NEM:BA	
Azolla pinnata	red water fern									x	Aquatics				
Bauhinia purpurea & B. variegata	butterfly orchid tree & orchid tree	x	x	x						x	Trees & Shrubs	3		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Caesalpinia decapetala	Mauritius/Myso re thorn	x	x				x			x	Climbers, Trees & Shrubs	1	Chemical control	CARA, NEM:BA	
Canna indica & C. X generalis	Indian shot & garden canna	x	x	x			x	x		x	Terrestrial herbs	1			

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Cardiospermum grandiflorum	balloon vine	x	x	x			x			x	Climbers	1		CARA, NEM:BA 1	
Cardiospermum halicacabum	heart pea, lesser balloon vine	x	x							x	Climbers				
Catharanthus roseus	Madagascar periwinkle	x	x	x	x		x			x	Terrestrial herbs				
Celtis australis, C. occidentalis & C. sinensis	nettle/ hackberry trees			x							Trees & Shrubs				
Cestrum laevigatum & C. pargui	inkberry & Chilean cestrum	x	x	x	x		x	x	x	x	Trees & Shrubs	1	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Chromolaena odorata	triffid weed	x	x				x			x	Trees & Shrubs	1	Chemical control	CARA, NEM:BA	
Cinnamomum camphora	camphor tree	x	x					x		x	Trees & Shrubs	1			
Cirsium vulgare	spear/Scotch thistle	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA 1	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Cortaderia jubata	purple grass, Jubata grass			x					x		Grasses & Reeds	1		CARA, NEM:BA	
Cortaderia selloana	Pampas grass	x		x			x	x		x	Grasses & Reeds	1			

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Cotoneaster franchetii & C. pannosus	orange & silver-leaf cotoneasters	x		x		x	x	x	x	x	Trees & Shrubs	3		CARA, NEM:BA	
Cuscuta camestris & C. suaveolens	common & lucerne dodder	x	x	x	x		x	x	x	x	Climbers	1		CARA, NEM:BA	
Cyperus eragrostis	rushes		x	x	x	x				x	Aquatics				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Datura ferox	large thorn apple	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Datura innoxia	downy thorn apple	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA	
Datura stramonium	common thorn apple	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA, NEM:BA	
Duranta erecta	forget-me-not-tree, pigeon berry	x	x	x	x					x	Trees & Shrubs			CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Egeria densa & Elodea canadensis	dense/canadian water weed									x	Aquatics	1		CARA, NEM:BA	
Eichhornia crassipes	water hyacinth	x	x	x	x	x	x	x	x	x	Aquatics	1	Chemical & Biological control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Eucalyptus camaldulensis	red river gum	x	x	x	x	x	x	x	x	x	Trees & Shrubs	2	Chemical control	CARA	
Eucalyptus cladocalyx	sugar gum					x	x	x			Trees & Shrubs	1	Chemical control	CARA	

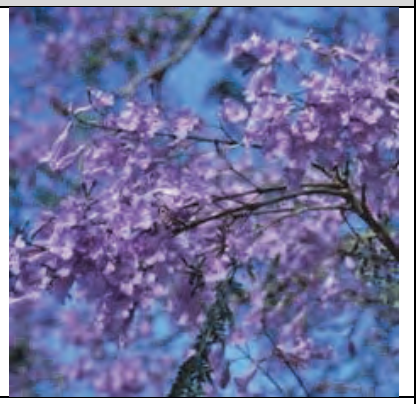
Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Eucalyptus diversicolor	karri						x	x			Trees & Shrubs	2	Chemical control	CARA	
Eucalyptus grandis	saligna gum	x	x	x			x	x		x	Trees & Shrubs	2	Chemical control	CARA	
Eucalyptus paniculata	grey ironbark	x									Trees & Shrubs	2	Chemical control	CARA	
Eucalyptus sideroxylon	black/red ironbark	x		x	x						Trees & Shrubs	2	Chemical control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Eugenia uniflora	pitanga or Surinam cherry						x			x	Trees & Shrubs	1 & 3		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Gleditsia triacanthos	honey locust	x	x	x	x	x	x	x	x	x	Trees & Shrubs	2		CARA	
Grevillea robusta	Australian silky oak	x	x	x	x		x	x		x	Trees & Shrubs	3		CARA	
Hedychium coccineum & H. garnerianum	red & kahill ginger lilies		x							x	Terrestrial herbs	1		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Hedychium coronarium & H. flavescens	white & yellow ginger lilies	x	x				x	x		x	Terrestrial herbs	1		CARA	
Hydrocleys nymphoides	water poppy			x				x			Aquatics				
Hypericum perforatum	St. John's wort							x			Trees & Shrubs	2	Biological control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Ipomoea alba	moonflower	x	x	x						x	Climbers	1 & 3		CARA, NEM:BA	
Ipomoea carnea subsp. Fistulosa	morning glory-bush, potato bush	x	x							x	Trees & Shrubs				
Ipomoea indica & I. purpurea	morning glories	x	x	x	x		x	x		x	Climbers	1 & 3	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Jacaranda mimosifolia	jacaranda	x	x	x	x		x			x	Trees & Shrubs	3	Chemical control	CARA	
Juniperus virginiana	red/pencil cedar		x	x			x		x		Trees & Shrubs				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Lantana camara	lantana	x	x	x	x		x	x		x	Trees & Shrubs	1	Chemical control	CARA, NEM:BA	
Leucaena leucocephala	leucaena	x	x				x			x	Trees & Shrubs	1 & 2		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Ligustrum japonicum & L. lucidum	Japanese & Chinese wax-leaved privets	x		x	x		x		x	x	Trees & Shrubs	3	Chemical control	CARA	
Ligustrum ovalifolium, L. sinense & L. vulgare	Californian, Chinese & common privets	x		x			x			x	Trees & Shrubs	3	Chemical control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Lonicera japonica var. Halliana	Japanese/Hall's honeysuckle	x		x						x	Climbers				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Lythrum salicaria	purple loosestrife							x			Terrestrial herbs	1		CARA	
Melia azedarach	seringa, 'syringa', Persian lilac	x	x	x	x	x	x	x	x	x	Trees & Shrubs	3	Chemical control	CARA	
Mimosa pigra	giant sensitive plant	x	x	x						x	Trees & Shrubs	3		CARA, NEM:BA	
Montanoa hibiscifolia	tree daisy	x					x			x	Trees & Shrubs	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Morus alba	white/common mulberry	x	x	x	x	x	x	x	x	x	Trees & Shrubs	3		CARA	
Myoporum tenuifolium subsp. Montanum	manatoka						x	x			Trees & Shrubs	3		CARA, NEM:BA	
Myriophyllum aquaticum	parrot's feather	x	x	x		x	x	x	x	x	Aquatics	1	Biological control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Myriophyllum specatum	spiked water-milfoil	x	x	x	x	x	x	x		x	Aquatics	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Nasturtium officinale	watercress														
Nerium oleander	oleander	x					x	x		x	Trees & Shrubs	1		CARA	
Nicotiana glauca	wild tabacco	x	x	x	x	x	x	x	x	x	Trees & Shrubs	1		CARA, NEM:BA	
Nymphaea mexicana	yellow water lilly	x		x							Aquatics				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Nymphaea sp.	water lily			x							Aquatics				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Oenothera	evening primroses	x	x	x	x	x	x	x	x	x	Terrestrial herbs		Chemical control		
Paraserianthes lophantha	stink bean						x	x			Trees & Shrubs	1	Biological control	CARA, NEM:BA	
Parkinsonia aculeata	Jerusalem thorn	x	x			x	x		x	x	Trees & Shrubs				
Parthenium hysterophorus	parthenium, feverfew, congress grass	x	x		x					x	Terrestrial herbs	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Passiflora caerulea	blue passion flower			x	x		x	x			Climbers	1		CARA, NEM:BA	
Passiflora edulis	purple granadilla, passion fruit	x	x		x		x	x		x	Climbers				
Passiflora suberosa	devil's pumpkin, indigo berry	x		x						x	Climbers	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Passiflora subpeltata	granadina	x	x	x			x			x	Climbers	1		CARA	
Pennisetum purpureum	elephant/Napier grass	x	x	x			x			x	Grasses & Reeds			NEM:BA	
Pennisetum setaceum & P. villosum	fountain grass & feahertop	x	x	x	x	x	x	x	x	x	Grasses & Reeds	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Phytolacca dioica	belhambra	x	x	x	x		x	x		x	Trees & Shrubs	3		CARA	
Pistia stratiotes	water lettuce	x	x		x		x	x		x	Aquatics	1	Chemical & Biological control	CARA	

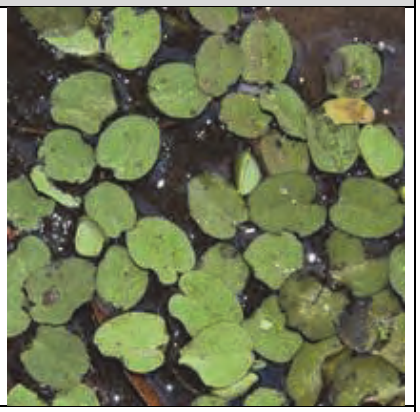
Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Pittosporum undulatum	Australian cheesewood, sweet pittosporum							x			Trees & Shrubs	1		CARA	
Plectranthus comosus	Abyssinian' coleus, woolly plectranthus		x	x			x	x		x	Trees & Shrubs	3		CARA, NEM:BA	
Populus alba	white poplar	x		x					x		Trees & Shrubs	2		CARA	
Populus deltoides	match poplar, cottonwood	x	x	x	x	x	x	x	x	x	Trees & Shrubs				
Populus nigra var. italica	Lombardy poplar	x				x	x	x	x	x	Trees & Shrubs				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Populus X canescens	grey poplar	x	x	x	x	x	x	x	x	x	Trees & Shrubs	2	Chemical control	CARA	
Potederia cordata	pickerel weed									x	Aquatics				
Prosopis glandulosa var. torreyana	honey mesquite				x	x	x	x	x		Trees & Shrubs	2	Chemical & Biological control	CARA	
Prosopis velutina	velvet mesquite				x	x	x	x	x		Trees & Shrubs	2	Biological control	CARA	
Populus nigra var. italica	Lombardy poplar	x				x	x	x	x	x	Trees & Shrubs				

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Psidium guajava	guava	x	x	x			x	x		x	Trees & Shrubs	2		CARA	
Pueraria lobata	kudzu vine	x	x								Climbers	1	Chemical control	CARA	
Quercus robur	English oak	x			x		x	x	x	x	Trees & Shrubs		Chemical control		
Rhus succedanea	wax tree	x					x			x	Trees & Shrubs	1		CARA	
Ricinus communis	castor-oil plant	x	x	x	x	x	x	x		x	Trees & Shrubs	2	Chemical control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Rivina humilis	bloodberry			x						x	Terrestrial herbs	1		CARA	
Robinia pseudoacacia	black locust	x	x	x	x	x	x	x	x	x	Trees & Shrubs	2		CARA, NEM:BA	
Rorippa nasturtium-aquaticum	watercress	x	x	x		x	x	x	x	x	Aquatics	2		CARA	
Rosa rubiginosa	eglantine, sweetbriar	x	x	x	x		x	x	x	x	Trees & Shrubs	1		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Rubus cuneifolius	American bramble	x	x							x	Trees & Shrubs	1	Chemical control	CARA, NEM:BA	
Rubus fruticosus	European blackberry	x		x			x	x			Trees & Shrubs	2	Chemical control	CARA	
Rubus spp.	brambles, blackberries	x	x	x	x		x	x	x	x	Trees & Shrubs				
Salix babylonica	weeping willow	x	x	x	x	x	x	x	x	x	Trees & Shrubs	2		CARA	
Salix fragilis	crack/brittle willow	x		x			x		x	x	Trees & Shrubs	2		CARA	
Salsola kali	Russian tumbleweed		x	x	x	x	x	x	x		Terrestrial herbs		Chemical control	NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Salvinia molesta	Kabiba weed	x	x	x			x	x		x	Aquatics	1	Chemical & Biological control	CARA	
Schinus molle	pepper tree	x	x	x	x	x	x	x	x	x	Trees & Shrubs				
Schinus terebinthifolius	Brazilian pepper tree		x							x	Trees & Shrubs	1 & 3	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Senna bicapsularis	rambling cassia		x							x	Climbers, Trees & Shrubs	3		CARA, NEM:BA	
Senna corybosa		x		x							Trees & Shrubs				
Senna didymobotrya	peanut butter cassia	x	x	x				x		x	Trees & Shrubs	3		CARA	
Senna hirsuta		x								x	Trees & Shrubs				
Senna multiglandulosa				x			x	x	x		Trees & Shrubs				

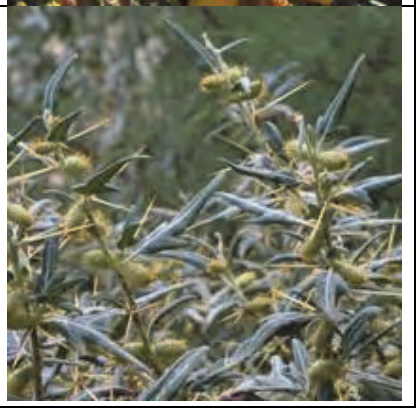
Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Senna occidentalis	stinking weed, wild coffee	x	x		x					x	Trees & Shrubs				
Senna pendula var. glabrata		x	x							x	Climbers, Trees & Shrubs	3		CARA, NEM:BA	
Senna septemtrionalis		x	x	x			x			x	Trees & Shrubs				
Sesbania punicea	red sesbania	x	x	x	x	x	x	x	x	x	Trees & Shrubs	1	Chemical & Biological control	CARA, NEM:BA	
Solanum elaeagnifolium	silver-leaf bitter apple	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Biological control	CARA, NEM:BA	
Solanum mauritianum	bugweed	x	x	x	x		x	x		x	Trees & Shrubs	1	Chemical control	CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Sorghum halepense	Johnson/ Columbus grass	x	x	x	x	x	x	x	x	x	Grasses & Reeds	2	Chemical control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Tamarix chinensis & T. ramosissima	Chinese & pink tamarisks		x		x	x	x	x	x		Trees & Shrubs	1 & 2		CARA, NEM:BA 1	
Temoca stans	yellow bells	x	x	x	x		x			x	Trees & Shrubs	1		CARA, NEM:BA	
Thelechitonia trilobata	Singapore daisy									x	Terrestrial herbs	1 & 3		CARA	

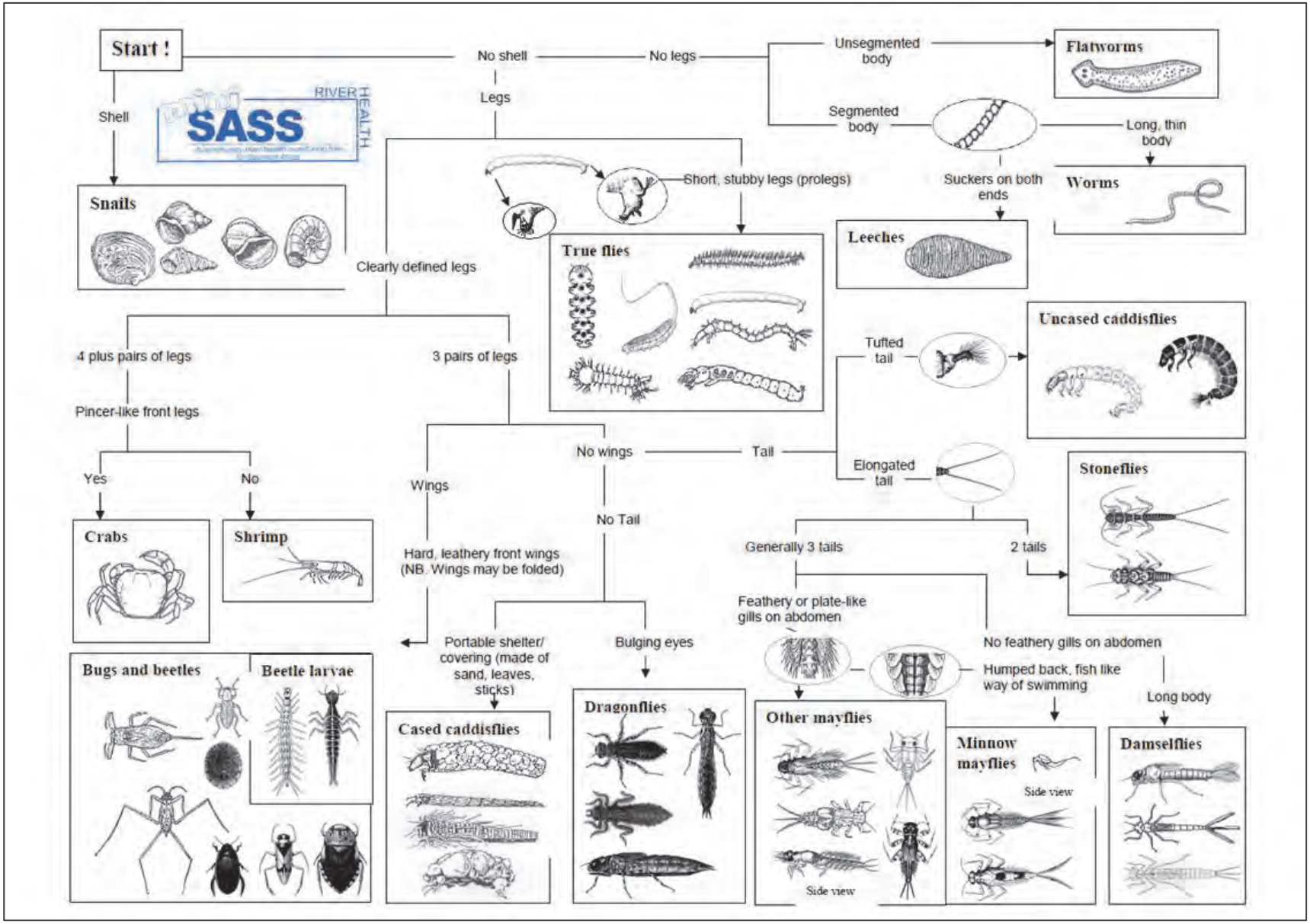
Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Thevetia peruviana	yellow oleander	x	x							x	Trees & Shrubs	1		CARA, NEM:BA	
Tipuana tipu	tipu tree	x	x	x						x	Trees & Shrubs	3		CARA	
Tithonia diversifolia	Mexican sunflower	x	x						x	x	Trees & Shrubs	1		CARA, NEM:BA	
Tithonia rotundifolia	red sunflower	x	x	x						x	Trees & Shrubs	1		CARA, NEM:BA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Toona ciliata	toon tree	x	x				x			x	Trees & Shrubs	3		CARA	
Triplaris americana	triplaris, ant tree									x	Trees & Shrubs	1		CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Ulex europaeus	European gorse		x				x			x	Trees & Shrubs	2		CARA, NEM:BA	
Xanthium spinosum	spiny cocklebur		x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA	

Latin plant Name	English plant name	Province									Scale	Category	Management /Removal Method	Act Listed	Picture
		MP	LP	GA	NW	NC	EC	WC	FS	KZN					
Xanthium strumarium	large cocklebur	x	x	x	x	x	x	x	x	x	Terrestrial herbs	1	Chemical control	CARA	

ANNEXURE D: AQUATIC INVERTEBRATE IDENTIFICATION


Start !
No shell
No legs
Unsegmented body
Flatworms
Segmented body
Long, thin body
Worms
Suckers on both ends
Leeches
Shell
Legs
Short, stubby legs (prolegs)
Snails
Clearly defined legs
True flies
4 plus pairs of legs
3 pairs of legs
Tufted tail
Uncased caddisflies
Pincer-like front legs
No wings
Tail
Elongated tail
Stoneflies
Yes
No
Wings
No Tail
Generally 3 tails
2 tails
Crabs
Shrimp
Hard, leathery front wings (NB. Wings may be folded)
Feathery or plate-like gills on abdomen
No feathery gills on abdomen
Humped back, fish like way of swimming
Long body
Portable shelter/ covering (made of sand, leaves, sticks)
Bulging eyes
Bugs and beetles
Beetle larvae
Cased caddisflies
Dragonflies
Other mayflies
Minnow mayflies
Side view
Damselflies
Side view

Flat worms

Flat worms are characterised by their flattened shape and soft bodied, worm-like form. They have an arrow-shaped head with two dorsal eyespots and are generally mottled or dark grey in colour. Flatworms move with a gliding action and are generally scavengers or carnivores.

Leeches

Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body that are used for feeding and locomotion. Leeches are variable in colour, from grey, to red-brown and black. They swim with a fast, snaking movement and are found under stones, vegetation and debris.

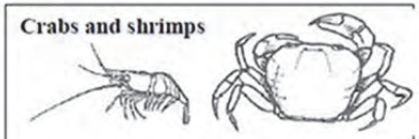
Worms

Worms are long and segmented and have a cylindrical shape much like small earth worms. Their colouring is usually pink to brown. They are usually seen writhing around in debris digesting the substrate they fed on.

Snails

Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails such as limpets clinging to rocks, whereas clams and muscles are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard for humans.

Crabs and shrimps

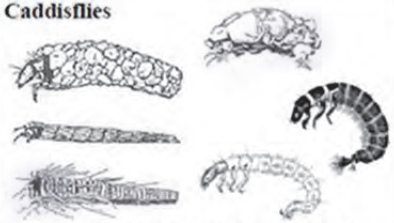


Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Stoneflies

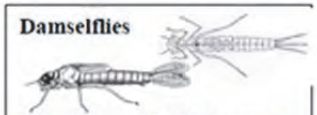
The nymphs of adult stone flies usually have two long tails and three pairs of legs each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. Some species run across the substrate very efficiently and are potent predators on other invertebrates. Other species are smaller and feed on plant material. Most live in well oxygenated, clean water.

Caddisflies



The aquatic larvae of adult caddisflies have a hard head with three pairs of legs which are attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters/cases from sand grains, bits of vegetation and/or silk that are glued together to form a characteristic case shape. Most of the case-building types cannot swim whereas the case-less type swim freely across the substrate. Some feed on algae and detritus whereas others are predators.

Damselflies

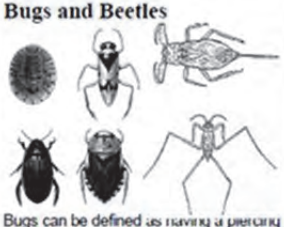


Damselflies have elongated bodies with generally three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face which hinges out to reveal a pair of pincers with which they catch their prey. They are often to be found in vegetation growing on the edge of rivers.

Dragonflies

Dragonfly nymphs are robust creatures that are stout and have a large head and protruding eyes. Some have short legs whilst others have long legs. They do not have tails, but swim using 'jet propulsion' by forcefully ejecting water from the abdomen. Dragonfly nymphs are usually the largest organisms found in a sample and are the most powerful invertebrate predators in the water.

Bugs and Beetles



Bugs can be defined as having a piercing and sucking beak for mouthparts, and two pairs of membranous wings. Beetles on the other hand have 'jaws' and outer wings that are hardened to protect the inner wings. Some bugs and beetles are well adapted to swimming, such as water boatmen, backswimmers, pond skaters and water striders. Most bugs and beetles are carnivorous, but some feed on algae.

Mayflies

Mayfly nymphs vary greatly in shape and size and live only for a day or two. In this time they will never feed and live to mate and lay eggs in the water. Mayflies fly close to rivers and lakes, usually swarming in the early evenings.

Minnow mayflies

These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

Other mayflies

Other mayflies are characterised by an elongated body, large head, well-developed mouthparts and stout legs. They live in a variety of habitats including burrowing in mud, crawling amongst decaying leaves, and scurrying over stones in fast flowing currents.

True flies

Most fly larvae have a fairly indistinct head but elaborate tail ends. They often have small, soft legs (prolegs), segmented bodies and have the appearance of maggots. Some have bristles/ spines and antennae. True flies live in a variety of habitats including sand, mud and stones in fast flowing water. They can either be carnivorous or filter feeders.

SITE INFORMATION TABLE		
Date (dd/mm/yr):		
Collectors name:		
River name:		
GPS co-ordinate:	S	E
Comments / Observations		

Co-ordinates as lat/long (e.g. 29°30'25" S / 30°45'10" E) **OR** as decimal degrees (e.g. 29.50694°S/30.75277°E)

Scoring

1. On the table below, circle the sensitivity scores of the identified insects.
2. Add up all of the sensitivity scores.
3. Divide the total of the sensitivity score by the number of groups identified.
4. The result is the average **score**, which can be interpreted below.

GROUPS	SENSITIVITY SCORE
Flat worms	3
Worms	2
Leeches	2
Crabs or shrimps	6
Stoneflies	17
Minnow mayflies	5
Other mayflies	11
Damselflies	4
Dragonflies	6
Bugs or beetles	5
Caddisflies (cased & uncased)	9
True flies	2
Snails	4
TOTAL SCORE	
NUMBER OF GROUPS	
AVERAGE SCORE	
Average Score = Total Score ÷ Number of groups	

GroundTruth
Water, Wetlands and Environmental Consultants

THE RIVER HEALTH PROGRAMME

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD
THIS CITY WORKS FOR YOU

WESSA
PEOPLE CARING FOR THE EARTH

EZEMVELO KZN WILDLIFE

UMGENI WATER · AMANZI

Water Research Commission

Interpretation of the miniSASS score: Although an ideal sample site has rocky, sandy, and vegetation habitats, not all habitats are always present at a site. If your river does not have rocky habitats use the **sandy type** category above to interpret your scores.

Ecological category (Condition)	River category	
	Sandy Type	Rocky Type
Unmodified (NATURAL condition)	> 6.9	> 7.9
Largely natural/few modifications (GOOD condition)	5.8 to 6.9	6.8 to 7.9
Moderately modified (FAIR condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (POOR condition)	4.3 to 4.9	5.1 to 6.1
Seriously/critically modified (VERY POOR condition)	< 4.3	< 5.1

miniSASS RIVER HEALTH

A community river health monitoring tool for Southern Africa

Version 2.0 January 2009

miniSASS can be used to monitor the health of a river and measure the general quality of the water in that river. It uses the composition of macroinvertebrates (tiny insects) living in rivers and is based on the sensitivity of the various animals to water quality. (note: miniSASS does NOT measure the contamination of the water by bacteria and viruses and thus does not determine if the river water is fit to drink).

Equipment list

- net
- white container / tray / ice-cream box
- pencil
- magnifying glass (optional)
- shoes/gumboots
- Hand wash / soap

How to make your own net

Take any piece of wire, for example an old clothes hanger, and bend it into the shape of a net. Then tie the netting (which can be any porous material) to the wire with a piece of string. And you have a net!

Method

The best sites are those with rocks in moving water. Not all sites have rocks (**rocky type** rivers), but may be largely sandy (**sandy type** rivers).

1. Whilst holding a small net in the current, **disturb** the stones, vegetation, sand etc. with your feet or hands.
2. You can also lift stones out of the current and **pick** insects off gently with your fingers or forceps.
3. Do this for about **5 minutes** whilst ranging across the river to **different habitats** (biotopes).
4. Rinse the net and turn the contents into a plastic tray and **identify** each group using the identification guide (see insert: you could start with the dichotomous key and then use the identification guide for more information).
5. **Mark** the identified insects off on the identification guide.
6. Fill in the site information and **Add up** the sensitivity scores to determine the average score (see scoring sheet on back page).
7. Remember to **WASH** your hands when done!

History of the miniSASS tool

South Africa has been a world leader in biomonitoring techniques using macroinvertebrates. The most successful of these is the South African Scoring System version5 (SASS5). miniSASS is based on SASS and also uses the presence of macroinvertebrates to indicate the "health of a river". Where SASS5 contains over 90 different macroinvertebrate classes, miniSASS only has 13 different classes, allowing for simpler identification and understanding. miniSASS has been found to provide similar indications of "river health" status as the more comprehensive SASS5 assessment, thereby providing a good means of generating useful biomonitoring data. The original miniSASS (version 1) was developed/based on approximately 2000 SASS4 data records, whilst this updated miniSASS (version 2) is based on over 6000 SASS5 records. This makes miniSASS ver2 more robust as a useful water quality monitoring tool & more widely applicable in Southern Africa.

Macroinvertebrates

What are they?

Macroinvertebrates are animals that have no backbone and can be seen with the naked eye.

Why they're used for biomonitoring?

- Different macroinvertebrates have different sensitivities to pollution. The higher their score, the more sensitive they are.
- They are generally easy to collect and identify.
- They are relatively sedentary which allows the source of pollution to be detected.
- They integrate the water quality conditions at a site, providing an overall measure of the "health" of a river.
- They can provide a picture of the historical water quality at a site.

What is the importance of water quality monitoring and management in South Africa?

Fresh water is essential for most life on earth. It is also used in all spheres of human life, namely agriculture, industry, biodiversity conservation, sanitation and hydration. However due to the amount of rainfall that South Africa receives, it is classified as a water stressed country. This means that if we do not monitor, manage and conserve our current water resources, we will be placing them and the population under tremendous stress in future!

As the general public, we can play a part in making a difference to managing freshwater resources in a community. miniSASS has the potential to be a powerful 'red flag' indicator for the identification of aquatic pollution sources. By using miniSASS we can actively take an interest and management in the health of freshwater bodies in our community.
Your interest and knowledge can be enhanced by adopting a local river in your community and monitoring it over time, identifying sources of pollution and taking local action to make a difference. You could also encourage more members of the community to take positive action towards monitoring and conserving water.

Additional resources

www.wrc.org.za
www.groundtruth.co.za
www.wessa.org.za
www.dwaf.gov.za

Download copies of miniSASS
www.groundtruth.co.za

Send your results to minisass@groundtruth.co.za
to contribute to a developing picture of river quality in South Africa.
miniSASS is available from Share-Net, PO Box 394, Howick, 3290. Tel (033) 3303931

River safety: take special care in polluted waters. Beware of dangerous animals (crocs/hippos!) and fast flowing waters. Wear protective gear when necessary and wash your hands regularly with soap and clean water wherever possible!!

Key words for for further readin g/resources: macroinvertebrates, benthic, water quality, conservation, biodiversity, water quality, river health, aquatic pollution.

Glossary

Biomonitoring: the monitoring of biodiversity using biological organisms
Biodiversity: diversity within species, between species and of ecosystems
Ecosystem: a complete community of living organisms and the nonliving materials of their surroundings.
Sedentary: inactive, motionless, not moving
Conservation: the maintenance of environmental quality and functioning