Tools to Determine Enforcement Driven Rehabilitation Objectives on Urban River Reaches

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WATER RESEARCH COMMISSION

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TOOLS TO DETERMINE ENFORCEMENT DRIVEN REHABILITATION OBJECTIVES ON URBAN RIVER REACHES

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by

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EXECUTIVE SUMMARY

This research focuses on rehabilitation of rivers in the South African urban context, and more specifically enforced rehabilitation, e.g. by directive, compliance notice, or court order. The enforcement driven rehabilitation of rivers, especially urban rivers, is overlooked and under resourced. This research aimed to develop tools to assist the officials with enforcement-driven rehabilitation.

Background

Initiative-driven restoration projects tend to comply with environmental authorising requirements prior to initiation. However, cases of illegal or non-compliant activities requiring rehabilitation works tend to ‘slip through the cracks’. Within the compliance and enforcement procedures relating to rehabilitation of riparian areas, there is little guidance and legislative requirements to determine the impacts of transgressions on the riparian environment. 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 of the improved state of environment as a result of enforcement interventions is reported. Therefore enforcement processes tend to be focused on ‘legal box ticking’ rather than the appropriate rehabilitation of degraded ecological functions as a result of non-compliant activities.

Problem Identification

This research highlighted the concept of enforcement driven rehabilitation, as opposed to initiative driven rehabilitation; where enforced rehabilitation refers to a contravention that a person is then directed by an administrative notice to rehabilitate. Within this concept of enforcement driven rehabilitation several problem areas were identified. These included the myriad of environmental legislation that officials must operate within, but they are tied to operating within the jurisdiction of their own legislation, e.g. although the National Water Act, Act 36 of 1998 (NWA) overlaps in several areas with the Conservation of Agricultural Resources Act, Act 38 of 1983 (CARA) and the National Environmental Management Act, Act 107 of 1998 (NEMA) an official from the Department of Agriculture can only operate within the mandate of the CARA and not within the NWA or NEMA. Similarly, the guidance provided by the legislation in the formal authorising processes is very prescriptive and detailed, whereas there is no similar guidance in the sections pertaining to enforcement. Further, the administrative and accountability requirements and capacity and capability constraints of enforcement officials further hinder the officials and the enforced rehabilitation process.

In time, the enforcement and compliance regime will stabilise. However, given the dynamic nature of urban rivers, as well as the plethora of activities that could degrade riparian environments and the need to identify the impacts on the receiving ecosystems and riverine functions, this guidance is required both by the relevant enforcement officials and the transgressors. This research developed

various tools as a means of assisting the current enforcement officials in light of the problems identified.

Before setting out rehabilitation processes and activities, it is necessary to understand the different types of rehabilitation objectives, rehabilitation drivers, and the applicable scale to which they apply in order to ensure the appropriate process is followed. When carrying out rehabilitation activities, apart from the individual objectives such as improving water quality or re-establishing riparian zone vegetation, there is an overall aim that the rehabilitation activities are trying to achieve. This overall aim or desired state will be captured in the goal of the rehabilitation plan, and it sets out the intention for carrying out the rehabilitation activities.

Rogers and Biggs (1999) stipulate that clear definitions of desired conditions, given surrounding land uses, are required for effective management and assessment for rehabilitation. These objectives fall into one of three categories: that of restoration, rehabilitation, or remediation. While these terms are often used interchangeably in various countries around the world to describe the physical rehabilitation activities, it is important to identify which one is the intention of the overall rehabilitation objectives in order to avoid disappointment or set unrealistic objectives. For example, "*often, pre-European (colonial era) disturbance conditions are set as restoration goals (e.g. Chapman, 1992; Scrimgeour & Wicklum, 1996), but those conditions may not be attainable; further this target denies the place of humans in the landscape*" (Norris and Thoms, 1999:201). Simply put, each objective deviates from the pristine state, and when setting the objectives for rehabilitation a clear understanding of "how far from" the pristine state the rehabilitated river reach will result, needs to be clarified to avoid confusion or misrepresentation. These objectives are defined as:

- **Restoration**

  The Federal Inter-Agency Stream Restoration Working Group (FISRWG, 1998:1-3) defines ecological restoration as "the process of returning an ecosystem as closely as possible to pre-disturbance conditions and functions". It stresses that it is implicit in this definition that stream ecosystems are dynamic and that it is consequently not possible to recreate a system exactly. Rather, the stream restoration process is aimed at re-establishing the "general structure, function and dynamic, but self-sustaining behaviour of the ecosystem". In summary, the objective of restoration is to restore the river reach to as close to pristine as possible.
- **Rehabilitation**

  In its most simple form, rehabilitation can be considered as a series of actions which make the landscape useful again after a disturbance, and usually involves "the recovery of some ecosystem functions and processes in a degraded habitat" (Dunster and Dunster in FISRWG, 1996:1-3). The objective of rehabilitation, as a specific goal, would be to address specific or selected ecological and riverine functions, i.e. not all functions will be addressed.
- **Remediation**

  The term "remediation" is appropriate in cases where it is not possible to rehabilitate due to a river system being irretrievably degraded, or where a system has been fundamentally altered in character but has over time, adjusted and achieved a state of dynamic equilibrium or stability. The aim of remediation is to improve the ecological condition of the river, while not aiming for an endpoint which resembles its original condition. Rutherfurd *et al.* (2000:15) suggest the action of remediation would be "to establish a new ecosystem on the basis that the stream has changed so much from the original condition that it [the original condition] is no longer relevant, and therefore a new condition is intended." The objective of remediation would be to stabilise the impacts on the river and prevent further degradation thereby creating a new or different structure and functioning.

Gonzalez del Tánago, (2004) suggest that restoration or rehabilitation alternatives can be defined more straightforwardly if the main degradation causes are correctly identified and the human pressures that are limiting natural riverine function are known and assessed. Therefore, during enforcement activities, when conducting site inspections and initial investigations, the causes of degradation and resultant impacts on riverine functions must be timeously identified.

Note: In this research the term "rehabilitation" is used as a general term to describe physical activities and should not be interpreted as a preferred objective unless specifically stated otherwise.

River Functions – measuring function impact

Rehabilitation should not merely focus on "fixing" ecosystems, but also on the services derived from the river system and its ecosystems. 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:

- <u>Production functions</u>: This refers to ecosystems' ability to produce resources such as water supply, fish, hydropower, agriculture, cultivation and harvesting (including reeds for weaving), and forestry. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- <u>Regulation functions</u>: This refers to ecosystems' 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)
- <u>Carrier functions</u>: Refers to the capacity of ecosystems to provide space for various processes to occur, such as navigation and transport, energy generation, recreation, cultivation. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- <u>Habitat functions</u>: Refers to the ability and capacity of ecosystems to provide habitat, refuge, nurseries, diversity, food for species and ecosystems. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)

- Information / cultural functions: Refers to ecosystems' contribution to human well-being, i.e. through sense, experience, religious practices, tourism, recreation, and aesthetics. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)

There are many existing tools, processes and methodologies to assess ecosystem and river health, however, these focus specifically on species or ecosystem health rather than the broader aspect of river functions. The scope of this research looks at the impacts of non-compliant activities to river function. Specialists are still required to determine the specific ecosystem health and determine measurable rehabilitation objectives and targets.

Tools developed:

In response to operational constraints and in an effort to support setting of appropriate rehabilitation objectives in enforcement driven rehabilitation, this research has developed several 1st order tools. (1st order meaning they provide a base to be built and expanded on).

- Legislation Search Tool – 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. This will assist enforcement officials to identify other stakeholders, especially other government departments, that need to be informed of the enforcement process and ensure the requirements of the enforcement action is compliant with adjacent legislation.
- Site Assessment Form – After reviewing existing methodologies and processes for river visual assessments for strengths and weakness, a field assessment form was compiled. When officials conduct site inspections, they complete the form as part of their site report. The form is completed by selecting appropriate description words (from a prescribed list) that best describe the site. Based on the description words selected, scores are calculated in a "back-office" spreadsheet and illustrated in the Dashboard Tool. 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 impact of the contravening activity on the riverine environment and provides a graph illustrating the negative impact per riverine function. 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.

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, C.J. *et al.,* 2009) and should be compiled by an appropriately accredited or professionally registered specialist or ecologist.

ii. Environmental management plan/programme (EMP) – 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 should include best practice methodologies for site management, e.g. bunding of stockpiled soil; no toilets or storage of substance within the buffer of the riparian zone; delineate the riparian zone and clearly indicate that it is a sensitive environment.

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.

Workshops and testing the tools

Case studies were used in development and refinement of the Site Assessment Form indicators and the adjusting of the Dashboard calculations and weightings. The case studies presented in this report outline this development and refinement process. The first case study presents a status quo of how environmental compliance is currently conducted. This case study illustrated the need for such tools to guide enforcement officials in determining rehabilitation objectives. The case studies thereafter provide different testing scenarios of the Site Assessment Form and “tuning” of the Dashboard. The Site Assessment Form and Dashboard Tool that have been developed were successfully tested in the field. These testing case studies have been completed to adjust the tools to the current capability of environmental enforcement officials and to ensure the tools are suited to a range of site characteristics.

In general, the comments and feedback received on the tools were highly positive, and indicated that the tools will be very useful to the officials. Future development of the Dashboard Tool could further test the score-allocations of the indicators, as well as the weightings of the activities to indicators, and the activities to functions. However, for the purpose of this research, the testing of the Tool has confirmed its usability.

Conclusions / policy recommendations

With the operational problems identified hindering enforcement driven rehabilitation, this research set out to develop an initial set of tools to assist environmental enforcement officials to determine the appropriate rehabilitation objectives in their administrative notices. This was done to ensure that rehabilitation activities target impacts to the urban riverine functions and do not simply legalise a contravention. In developing these tools, existing assessment methodologies were considered, however many focused on river health rather than river function; whereas river function is more holistic and appropriate for the context.

The process of developing the tools was an interactive and evolutionary one. Workshops with the target audiences were held during the development stages, in order to ensure the tools were tailored to the officials' requirements. This will also provide buy-in and support for the utilisation of the tools in the future.

This body of work is further being expanded and more detailed technical guidelines on carrying out physical rehabilitation are currently being developed in further studies.

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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.

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LIST OF ABBREVIATIONS

BMP	:	Best Management Practice
FRAI	:	Fish Assessment Index
IHI	:	Index of Habitat Integrity
PES	:	Present Ecological Status
RHP	:	River Health Programme
SUDS	:	Sustainable Urban Drainage Systems
VEGRAI	:	Vegetation Assessment Index
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.

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, e.g. it may be across the road, servitude or river.

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.

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 the natural home of species of plants or animals.

Indicator to show or signify a symptom.

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

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.

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. (Dunster and Dunster in FISRWG, 1996)

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

Remediation Breen and Walsh (1999) explain that 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"* (FISCRWG, 1998:1-3).

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.

Runoff refers to stream channel flow.

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

Stormwater is runoff water as a result of a storm event.

Terrestrial means 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.

1 INTRODUCTION

Water is a necessity to life. Although the hydrological cycle as we understand it today was only formally accepted in the 18th Century the need for water in order to drink, irrigate and navigate, is evident in the location of great ancient cities along major river banks and in the ancient cultures. This includes, for example, the Egyptians and their sacred river gods of Osiris and Hapi, and the Aztecs with their rain god Tlaloc. Access to water played a significant role in the location of towns, as well as engineering advancements to secure water resources for towns under siege in times of conflict, e.g. with the construction of sinnōrs or water tunnels (Biswas, 1970). The advancements in "transporting" water from water resources to inland areas led to the establishment of towns away from major rivers. With survival being reliant on access to clean water, laws governing the management and impacts to water resources also date back to the ancient times, such as the Codes of King Hammurabi around 1700 BC (Biswas, 1970:20):

"Sec.53. If any one be too lazy to keep his dam in proper condition, and does not keep it so; if then the dam breaks and all the fields are flooded, then shall he in whose dam the break occurred be sold for money and money shall replace the corn which he has caused to be ruined.

Sec. 55. If any one open his ditches to water his crop, but is careless, and the water flood the field of his neighbour, then he shall repay his neighbour with corn for his loss.

Sec. 56. If a man let out the water, and the water overflow the land of his neighbour, he shall pay 10 gur of corn for every 10 gan of land flooded."

Continuing in this vein, Plato (427-347BC) made significant contributions to the advancement of water laws by assimilating pollution and water quality and equitable use into the principles of water management (Biswas, 1970:61): "

- Anyone was permitted to draw water from a common stream on his land as long as he did not cut off the flow of a private stream.
- The water could be caused to flow in any direction except through a house, temple, or sepulcher, but one needed to be careful not to do any harm in excess to the excavation of the channel.
- In case of water deficiency, one should dig down to the clay layer, and if still no water found, he had the right to obtain water for his household from his neighbour. If his neighbour's supply was limited, he was permitted to obtain from him an amount as determined by a warden.
- A man living on higher ground was not permitted to allow the runoff resulting from a heavy rain to drain recklessly on to the land of his lower neighbour, nor could the lower neighbour refuse to furnish an outlet for reasonable drainage from the higher land. In case of dispute the warden would decide what would be required of each man.

- If anyone intentionally polluted or wasted the water of a stream or reservoir of another by poisoning, digging, or by theft, he would be required to pay damages equal to the value of the loss. If he had polluted the water, he also had to purify the water."

This provided the initial grounds for enforced rehabilitation, e.g. "if he polluted the water, he also had to purify the water."

These basic concepts were adhered- and added to over the centuries, and formed the basis of most water laws and water resources management throughout the world, well into the 1800s. For example "in 1372 a writ to the mayor and corporation of the City of London forbade the casting of dirty rushes, dung and refuse into the River Thames" (Haslam, 1990:18), and "in 1553 Henry VIII again prohibited this practice" Rogers (1947-8) in Haslam (1990:18). In South Africa, the Bill of Rights in the Constitution, Act 108 of 1996, makes provisions for a *safe and protected environment* (Section 24) and *access to safe water* (Section 27). These rights are enacted by the National Environmental Management Act, Act 107 of 1998 (NEMA) and the National Water Act, Act 36 of 1998 (NWA) for environmental management and water resource management respectively, and the Water Services Act, Act 108 of 1997 (WSA) for access to drinking water. The need or reason behind these global laws and management of the water resources has adapted over the years, from that of ensuring water for basic irrigation use to more recently the scarcity of clean water for drinking and potable use and therefore more consideration of environmental protection.

An important process developed in 1979, to identify and mitigate against impacts of developments that of the Environmental Impact Assessment (EIA). According to Munn (1979) cited in Glasson, Therivel and Chadwick (1999:3) the aim of the EIA is "to identify and predict the impact on the environment and on man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts." The EIA was a tool to bring together environmental management, with development; Glasson *et al*, (1999) summarised it as the better management of development in harmony with the environment. While used effectively as a planning tool in more environmentally conscience countries to guide appropriate spatial development to environmental constraints. The process in South Africa is more of an afterthought, where impact assessments are conducted for the specific site/erf and not in a boarder scale (DEAT, 2008b), and realistic alternative land uses are not considered, as the land in question is purposefully purchased for a particular activity e.g. housing development. Similarly EIA requirements are only legislated for the formal application of environmental authorisations and not in the enforcement branch of the regulatory framework.

Similar to the EIA, the National Water Act, Act 36 of 1998 (NWA) provides for setting management objectives for water resources, including determining the Present Ecological State (PES), determining the ecological Reserve, and setting Resource Quality Objectives (RQOs).

However, similar to the EIA, these are targeted at proactive resource management, and are not suitable for the enforcement context.

Environmental enforcement in South is relatively new and evolving. The environmental legislation in South Africa is "*contemporary*" (Du Plessis, 2009:18), however the implementation, and in particular, the enforcement of such legislation, still has some "*lacunae"* (Du Plessis, 2009:40) Issues of capacity and capability plague the maturing of the enforcement regime (Loubser and Freeman, 2011) and reporting is still quantitative rather than qualitative (DEA, 2012), e.g. number of cases rather than measured improvement in the environment.

Within the compliance and enforcement procedures relating to rehabilitation of riparian areas, there is little guidance and legislative requirements to determine the impacts of transgressions on the riparian environment. Therefore, enforced rehabilitation focuses mainly on resolving the illegal activity (box ticking), and provides little or poor objectives for ecological rehabilitation. Given the dynamic nature of urban rivers, as well as the plethora of activities that could degrade riparian environments and the need to identify the impacts on the receiving ecosystems, this guidance is required both by the relevant enforcement officials and the transgressors.

Conceptual Overview of the Research

International research and trends together with Quinn's (2003) *A decision support systems for rehabilitation and management of riparian systems* local adaption, have set the groundwork for river rehabilitation in South Africa. While Quinn's team work focuses mainly on prioritising rivers for rehabilitation; this research focuses on rehabilitation of rivers in the urban context, and more specifically enforced rehabilitation, e.g. by directive, compliance notice, or court order. The enforcement driven rehabilitation of rivers, especially urban rivers, is overlooked and under resourced.

In terms of the Public Administrative Justice Act (Act 3 of 2000) (PAJA), decision makers are accountable for the decisions they take. Therefore, when instructing an accused to conduct rehabilitation, a decision has been made in terms of what are the objectives of the rehabilitation and measures to be taken. Thus the regulators are accountable for this decision making. In most instances this is not based on science and is usually determined by legal box-ticking; it follows an *ad hoc* process which differentiates between decision makers and between institutions. The ultimate aim of the research is to produce a set of tools (and a Guideline document) to be used by regulators when setting out instructions for riparian rehabilitation in urban contexts. This is meant as a guide for the regulators, especially those with little riverine knowledge or experience, in setting realistic objectives for rehabilitation.

Chapter 2 introduces the concept of measuring riverine function rather than river health alone to determine the impacts of contravening activities. In addition it looks at some of the historical activities of resource utilisation that has had a permanent lasting impact on water resources and will continue to do so, such inter-basin/catchment transfer schemes, engineered rivers and effluent discharge to rivers. The chapter also proposes the different types of rehabilitation objectives, those of restoration, rehabilitation and remediation and the drivers for the rehabilitation initiatives.

Chapter 3 reviews the legislative framework of water resources management and the enforcement tools. It identifies the problem areas in the existing enforcement process including the myriad of legislation and overlapping jurisdictions of institutions, accountability of decision making, capacity and capability constraints.

Chapter 4 discusses the development of the various tools and their process of development as a means of assisting the current enforcement officials in light of the problems identified. The tools include:

- *Legislation Search Tool* – 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* - 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* - based on the completed Site Assessment Form, the selected answers are linked to indicators of basic riverine function. The DT automatically calculates the impact of the contravening activity on the riverine environment. 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.

Chapter 5 provides Case Studies to support the research. The first Case study highlights the problems in the current enforcement procedures, while the remaining case studies were used to adjust the tools based on calibration and subjectivity.

Chapter 6 concludes the research making observations of the process of the research and identifying future work.

2 BACKGROUND

Rivers and streams provide important functions to sustain their surrounding environments, on which humans depend. Freeman and Rowntree (2005) highlighted that the health and integrity of riparian and riverine zones or corridors is dependent on what is happening in the river channel; and that this dependency relationship is reliant upon the quantity and quality of the water that flows down the channel. Over decades of utilisation, many natural riverine landscapes have become degraded as a result of human activities such as urbanisation, agricultural practices, development, settlement, water abstraction, damming and encroachment on river systems (Lovett and Price, 1999). These activities within the catchment, both natural and manmade, have influenced the most basic aspects of the hydrologic cycle, which in turn, has directly impacted on riverine functions including habitat distribution, trophic structure, physical and biological processes (such as sediment transport, nitrogen cycling, and primary production), and composition and structure of the diverse biological communities (Maidment, 2003). In order to restore or remedy previous riverine function and ecological integrity, these degraded riverine functions require some form of rehabilitation.

Global trends since the 1980s have focused on river restoration and rehabilitation, where 100 years previously rivers were “work horses” for navigation, communication, transport, waste discharge and water supply. Even more recently, riverine zones have become a major focus in the restoration and management of landscapes (Knopf et al., 1988; Naiman, Decamps and Pollock, 1993, cited in Fischer, 2000). The relatively recent acknowledgement of environmental impacts and climate change on rivers and their ecosystems have changed the focus of water resource management, to one of environmental sustainability and sustainable utilisation. Consequently, “guidelines for protection of rivers have shifted their focus from mainly physical and chemical measures (on the assumption that acceptable river condition would be achieved if these were met), to the inclusion of more biological measures” (Norris and Thoms, 1999:197). According to Challen, Quinn and Blanché (2003) some of the functions of riparian and riverine zones important in preserving the ecological integrity of ecosystems include sediment filtering, nutrient cycling, maintenance of biodiversity, and aquatic and terrestrial habitat provision. Therefore the rehabilitation of riverine function is as important as rehabilitating ecological integrity.

Before getting into the details of setting riverine function rehabilitation objectives, one needs to understand what encompasses the riverine zone, what are the riverine functions requiring rehabilitation, what is causing degradation to these functions and what are the drivers for the rehabilitation.

2.1.1 The Riverine Zone

The riverine zone is composed of both the riparian zone and the active channel zone and their components and habitats.

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 2-1. As observed in Figure 2-1, 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; 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 2-1 Aerial view of the vegetation line between terrestrial and riparian areas (Rountree, 2008)

In the context of South Africa, 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." This definition distinguishes rivers from wetlands based on the alluvial soils that would lack mottling features.

Some rivers may also be considered as wetlands, but according to this definition not all rivers are wetlands. The focus of this research is on rivers only.

In contrast to the riparian zone, the active channel refers to the components and habitats located within the wetted or in-stream channel. It is comprised of the water, rocks, pools, riffles, rapids, runs, plants, biota and so forth that are submerged or emergent from the water in the channel.

The riverine zone is thus composed of the riparian zone and the active channel zone as illustrated by Figure 2-2.

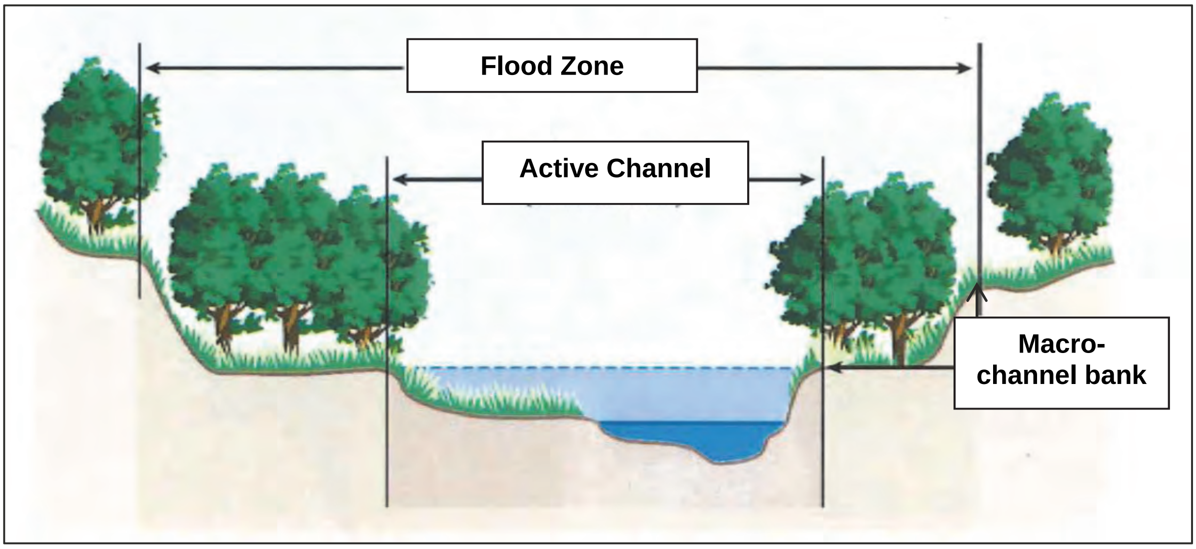


Figure 2-2 Typical cross-section of a river channel. (Adapted from FISRWG, 2001:1-18)

2.1.2 Measuring river functions versus river health

The common process to determine the degradation, and thereby identify the necessary rehabilitation activities to rehabilitate the environment and ecosystem integrity, is through the process of measuring the health of the river. River health is used to describe the ecological condition of a river. "The condition or health of the river may be influenced by a number of factors including its ecological status, water quality, hydrology, geomorphology and physical habitat" (Maddock, 1999:374). Further, "an organism is healthy when it performs all its vital functions normally and properly, when it is able to recover from normal stresses, when it requires minimal outside care. An environment is healthy when the supply of goods and services required by both human and non-human residents is sustained" (Karr, 1999:222). In support of this notion, Rapport (1989) in Norris and Thoms (1999:198) suggests three approaches that might differentiate "healthy" from "sick" ecosystems, these include:

(i) the absence of distress defined by measured characteristics or indicators e.g. biological monitoring;

(ii) the ability of an ecosystem to handle stress, or bounce back – its resilience (Holling, 1973); and

(iii) The identification of risk factors such as industrial or sewage effluents.

Karr (1999:221) explains that “biological monitoring is essential to identify the biological responses to human actions.” By using the results of the biological monitoring one can describe the condition or health of rivers and their adjacent landscapes and thereby diagnose the causes of degradation. Using this information, Karr goes on to explain that we can then develop restoration plans, estimate the ecological risks associated with land use plans in a catchment, or select among alternative development options to minimise the river degradation.

Bio-monitoring is reliant on biological indicators. However Norris and Thoms (1999) warn that most indicators are highly specific measurements of single chemical or biota and offer little integration. Further that interpretation is based largely from experimental tests on the effects that they have on biota and results from these are used to set guidelines to protect rivers. Such monitoring [physical and chemical indicators] are distinctly “bottom-up” and may explain cause of damage to river health and biotic integrity rather than ecosystem condition (Karr, 1991; Chapman, 1992).

The South African River Health Programme (RHP) primarily makes use of biological indicators, for example fish communities, riparian vegetation, and aquatic invertebrate, to assess the condition or health of river systems. The rationale for using biological monitoring is that the integrity of biota inhabiting river ecosystems provides a direct, holistic and integrated measure of the integrity or health of the river as a whole, which is reported as the Present Ecological State (PES). The aim of the RHP is to assess and report on the ecological state of aquatic ecosystems (RHP, 2008).

According to Rapport (1989) and Chapman (1992) cited in Norris and Thoms (1999:201) “ecosystems need not be pristine (few are, now, because of large-scale changes such as the ozone hole, acid rain, global air pollution), but still can be judged healthy.” They explain further that the riverine functions themselves should be assessed in determining impacts to rivers, “changes to catchment conditions and flow regimes can markedly alter the functioning of river channels and thus the habitat available for organisms. Biota aside, changes to catchments and flows modify river channels via changes in erosion rates after catchment and riparian clearing, separation from floodplains resulting from drainage and flow reduction. It may be quite possible to have degraded channels that have a quite healthy biota associated with them.” (Norris and Thoms, 1999:202).

Clapcott and Young (2008) highlight that there have been several recent studies that have demonstrated the relevance and applicability of measuring river function in river health assessment such as Fellows et al. 2006, Udy *et al*. 2006, Young *et al*. in press. They summarise that indicators of function measure the rates of ecological interactions e.g. what is happening in the river, whereas the traditional measures of ecosystem structure measure the river health e.g.

what lives there. Similarly Matthews (1982 as cited in Young Townsend and Matthaei, 2004) differentiates function indicators as measures of the rate, or relative importance, of a particular process happening in an ecosystem, while structural indicators focus on patterns of abiotic resources or biological community composition. Young *et al*. (2004:2) illustrate this differentiation by the analogy of pastures on a farm; "The health of pasture on a farm (or a lawn) could be measured by looking at the species of grass growing there, the nutrient concentrations in the soil, and perhaps even the types of worms in the soil. All of these are examples of structural measurements. However, another good indicator of pasture health is the rate at which it grows – a functional measurement. Two contrasting sites may have the same types of grass, worms and nutrient concentrations but pasture growth may be much faster at one site than the other because of a difference in some causal factor such as rainfall or temperature. This difference between sites would be missed if only structural features were measured in each pasture." Therefore functional indicators provide direct measurements of the functions that river ecosystems perform and thus provide an alternative, but complementary, view of ecosystem health (Bunn 1995; Gessner & Chauvet 2002; Brooks et al. 2002 cited in Young *et al*., (2004)). In other words a change in ecosystem function will have a resultant change in ecosystem structure (diversity or number) and would be a more holistic indicator of the ecosystem.

Ecosystems are individual ecological units that consist of biotic and abiotic factors. Every ecosystem that exists within a river system consists of a combination of all the factors that make up the river environment; these include living organisms (e.g. insects, fish, birds, animals, vegetation, diatoms), and environmental features such as temperature, pH and clarity (water quality component), flowing water and rainfall (hydrology component), materials that make up the banks and bottom of the river bed (geomorphology component) (Freeman and Rowntree, 2005). Human activities, such as land use change and water resource development, can alter physical, chemical and biological processes (functions) of river ecosystems thus modifying their biological communities (health) (Karr (1991) cited in Norris & Thoms, 1999:203). For example, Boon ((1992) cited in Maddock, 1999) points out that changes in water quantity, water quality and the physical structure of the channel have almost without fail led to changes in the composition of the biotic community occurring in the river, usually with a resultant reduction in the biological diversity of the aquatic ecosystem. Therefore, when carrying out rehabilitation activities, it is important to assess the status of existing riverine functions, as well as ecosystem health and species diversity.

According to Pimm (1994), ecosystems have some capacity for resilience, in other words the ability to resist change or to recover from it; and, that there is some *balance of nature* or *stability*, and this balance is affected by the loss of diversity. This is referred to as dynamic equilibrium. Disturbances of sufficient magnitude or duration can significantly affect an ecosystem and may even force an ecosystem to reach a threshold beyond which a different regime of processes and structures predominates (Folke, *et al*., 2004). These disturbances usually directly affect the riverine function with the resultant impact on river health. The FISRWG (1998:2-86) explain that "the maintenance of dynamic equilibrium requires that a series of self-correcting mechanisms be active in the riverine corridor. These mechanisms allow the riverine functions to control external stress or disturbances within a certain range of response thereby maintaining a self-sustaining condition. The threshold levels associated with these ranges are difficult to identify and quantify. Many stream systems can accommodate fairly significant disturbances and still return to functional condition in a reasonable timeframe, once the source of the disturbance is controlled or removed. The main benefit of an active rehabilitation approach is regaining functionality more quickly, but the biggest challenge is to plan, design, and implement rehabilitation activities correctly to re-establish the desired state of dynamic equilibrium." This new equilibrium condition however, may not be the same that existed prior to the initial occurrence of the disturbance e.g. engineering design of urban rivers. In addition, disturbances can often stress the system beyond its natural ability to recover. In these instances rehabilitation is needed to remove the cause of the disturbance or stress or to repair damages to the structure and functions of the riverine corridor.

Each river in each geographic region of the country differs due to geological structure, altitude, rainfall biotic structure; "normal, or expected, conditions constituting integrity vary geographically because each river's biota evolves in the context of local and regional constraints and opportunities" (Karr, 1119:224). He concludes that understanding this baseline must be the foundation for assessing change by humans. Norris and Thoms (1999:200) argue that "site specific reference characteristics need to be identified and this is very time consuming and specialist dependent. A possible flaw is that usually it is not the whole stream but sites within streams that are the units being compared. Most indicators, especially biota, from a site at the top of one stream will be unlikely to match those from a site at the bottom of the same stream, or another similar stream." In enforcement, only the specific site can be considered in the enforcement process, and therefore directed activities are limited generally to the specific site or activity and not the entire stream. For enforcement purposes an initial assessment of river functions or the degradation or disturbance to the functions may be more easily defined than to determine symptoms and the indicators of poor health, especially considering that in South Africa most enforcement officials are not ecological scientists.

Unlike common practice of assessing river health components, this research looks at assessing riverine functions as an initial measure of disturbance to river systems. This process does not replace biological assessment, but rather as an initial or preceding step in determining rehabilitation objectives. Re-establishing the structure or restoring a particular physical or biological process or ecosystem is not the only thing that rehabilitation seeks to achieve; according to FISRWG (1998:2-78) "rehabilitation aims to re-establish valued functions." By focusing on riverine functions provides the enforced rehabilitation effort its best chance to recreate a self-sustaining system. FISRWG (1998:2-78) argues that "this property of sustainability in rehabilitation is what separates a functionally sound stream that freely provides its many benefits and services to people, the natural environment and its resident ecosystems, from a degraded watercourse that cannot sustain its valued functions and may remain a costly, long-term maintenance burden."

2.2 Riverine Functions

The Millennium Ecosystem Assessment (MEA) report 2005 defines *ecosystem services* as the 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 ecosystems' ability to produce resources such as water supply, fish, hydropower, agriculture, cultivation and harvesting (including reeds for weaving), and forestry. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Regulation functions: this refers to ecosystems' 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: Refers to the capacity of ecosystems to provide space for various processes to occur, such as navigation and transport, energy generation, recreation, cultivation. (Das Gupta, A., 2008; Posthumus, H., *et al.,* 2010)
- Habitat functions: 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: Refers to the ecosystems contribution to human well-being, i.e. through sense, experience, religious 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. 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. Table 2.1 summarists the urban riverine functions and services provided by riverine ecosystems. These are discussed further in the following sections.

Table 2.1 Riverine functions and services (Adapted from Soman *et al.* 2007)

Function	Services	Literature
1. Flood Attenuation (Regulation)		
Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances such as, flood attenuation, ice damage control, stream bank stabilization, maintaining channel morphology. Biological control mechanisms.	Postal and Carpenter (1997); Fischer and Fischenich (2000); Platts (1981); Wegner (1999); Williams (1986); de Groot (2002).
Water Regulation	Role of riparian cover in regulating runoff and stream flow. Infiltration and maintenance of stream flow.	Williams (1986); Lowrance et al., (1984).
2. Sediment Trapping (Regulation)		
Filtration	Riparian buffers filter sediments, nutrients, pathogens, pesticides, and toxics in runoff. Infiltration of surface water that helps maintain baseflow. Water supply and ground water recharge.	Waters (1995); Chase (1995); Hartung and Kress (1977); Peterjohn and Correll (1984).
Soil retention	Role of vegetation root matrix and soil biota in soil retention. Reduce soil erosion and sediment control.	Waters (1995); Castelle et al. (1994);
Soil formation	Weathering of rock, accumulation of organic matter. Maintenance of top soil and soil fertility.	de Groot (1992).
Nutrient regulation	Storage and recycling of nutrients such as N and P and organic matter. Contribution of organic matter to stream from adjacent vegetation	Barling and Moore (1994); de Groot (1992).
3. Habitat Provision (Habitat)		
Pollination	Role of biota in pollination.	de Groot (1992).
Refugium function	Suitable living space for wild animals and plants. Woody debris in the stream provides habitat and shelter for aquatic organisms. Terrestrial riparian ecosystem provides habitats for amphibians, mammals and birds. Habitat for natural communities, rare threatened and endangered species. Provide travel corridors for migration and dispersal.	Chase (1995); Verry et al., (2000); Allan (1995); Wenger (1991), (2002); Kaufman (1992); Keller et al., (1993); Naiman and Rogers (1997); Hammond (2002).
Nursery functions	Suitable reproduction habitat for aquatic organisms and amphibians.	Semlitsch (1998); de Groot (1992).
4. Carbon Storage (Regulation)		
Gas regulation	Role of riparian ecosystem in biogeochemical cycles. Provides clean breathable air.	Wilson et al., 2005.
Climate regulation	Influence of land cover and biological mediated process on climate. Influence terrestrial and stream temperature, human health, recreation and crop productivity. Thermal refuge for aquatic species.	Collier (1995); Wegner (1999); Woodall (1985); Wilson et al., (2005); de Groot et al., (2002). Cunjak (1996); Waters (1995).
Food	Conversion of solar energy into edible plants and animals.	de Groot (1992). Wilson et al., (2005)
5. Water Quality (Regulation)		
Water Supply	Filtering, retention, and storage of fresh water. Riparian buffers filter sediments, nutrients,	Fischer and Fischenich (2000); Waters (1995); Chase (1995);

	pathogens, pesticides, and toxics in runoff. Infiltration of surface water that helps maintain baseflow. Water supply and ground water recharge.	Hartung and Kress (1977); Peterjohn and Correll (1984).
Waste treatment	Role of riparian vegetation & biota in removal or breakdown of xenic nutrients and compounds. Storage and recycling of human waste	Castelle et al. (1994); de Groot (1992).
6. Subsistence (Production)		
Food	Conversion of solar energy into edible plants and animals.	de Groot (1992); Wilson et al., (2005)
Raw materials	Conversion of solar energy into biomass for human construction and other uses. Genetic materials.	de Groot (1992). Wilson et al., (2005)
7. Aesthetic / Recreational / Cultural (Information / Cultural)		
Aesthetic information	Attractive landscape features. Clear and clean water enhances sensory and recreational qualities	de Groot (1992). Wilson et al., (2005)
Recreation	Water quality for recreation, boating, swimming	de Groot (1992); Wilson et al., (2005)
Science and Education	Variety in nature with scientific and educational value.	de Groot (1992); Wilson et al., (2005)

2.2.1 Flood Attenuation

Flood attenuation, a regulation function, 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).

2.2.2 Sediment Trapping

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). Sediment trapping is a regulatory function.

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).

2.2.3 Habitat Provision

"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.

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 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.

2.2.4 Carbon Storage

"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. Carbon storage provides for the storing and recycling of organic matter and nutrients (Barling and Moore, 1994 in Soman 2007:3). However, human interventions such as mining, burning of forests 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). Carbon trapping is therefore a regulatory function.

2.2.5 Water Quality

The riverine zone and its components provide an important regulatory function 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 drinking and irrigation.

2.2.6 Subsistence

Riverine zones provide socio-economic resources such as food, fuel-wood, reeds for weaving, and medicinal plants that are used by humans for subsistence and cultural 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.

2.2.7 Aesthetic, Recreational and Cultural

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 and swimming, model boating, and so forth. Conversely, 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 2.2 are not reduced. Many of these areas are best managed as natural areas, rather than being converted to other land uses.

Table 2.2 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
	Aesthetic/ recreational use / cultural use	Fishing, picnic, walking, cycling, not birding
	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
	Aesthetic/ recreational use / cultural use	Fishing, swimming, canoeing, sailing, baptisms
	Subsistence	Fire wood, reads for weaving

2.3 Activities causing degradation to river riverine functions

There are many activities that affect riverine functions and ecosystems, many of which are common practice today as means of water resources management. Their origin, however, lies in history. After the industrial revolution, which gave rise to rapid growth of populations around the world and the resultant urban sprawl, significant changes were made to water resource management. Three noteworthy activities include:

1. Catchment/Basin water transfer schemes;
2. Engineered rivers; and
3. Effluent discharge into rivers.

As a result of these three changes, the urban rivers of the world have been altered away from a natural state and are not likely to be reversed, therefore any rehabilitation plans need to factors these activities into their visions and objectives. These three activities and their impact on urban rivers are discussed further.

2.3.1 Catchment/Basin Water Transfer Schemes

In order to alleviate the inefficient condition of the City of Paris's water condition, in 1768 the Paris City administrators recommended that additional water should be brought in from the river Yvette (Du Buat (1786) in Biswas 1970). This activity of water transfer schemes has since become common practice. In South Africa the location of the population and GDP contributing activities, does not correlate with the location of available water resources needed to support them. Therefore, South Africa has over 25 inter-catchment transfers to supply water to areas of high demand with insufficient water availability in order to meet the demand. The most famous if which is the Lesotho Highlands Transfer Scheme, which supports Gauteng Province located in the Upper Vaal and Crocodile (West) & Marico Water Management Areas. Figure 2-3 illustrates the location of the Water Management Areas and the main transfer schemes across South Africa. The three most significant WMAs where GDP and population demand far exceed Mean Annual Runoff (MAR), are that of the Crocodile (West) & Marico WMA, and Upper Vaal WMA (which include the City of Johannesburg and City of Tshwane Metropolitan areas), and Berg WMA (which includes City of Cape Town Metropolitan area). Figure 2-4 indicates the relation between MAR, population and Gross Domestic Product (GDP) contribution between the 19 Water Management Areas (WMAs) of South Africa.

A significant impact as a result of these transfer schemes is that the original river character has been irreplaceably lost. The additional volume of water flowing into these “recipient” catchments from the transfer schemes has resulted in changes to the physical, chemical and biological character of the catchments. For example the increased volume of flow has altered flow regimes, flood patterns and floodlines and resultant erosion and sedimentary patterns, as well as biota species have adapted to the change in flow regime. Similarly as a result of abstraction of water from the donor-river there are reduced flows and resultant ecosystem changes in the “donor”

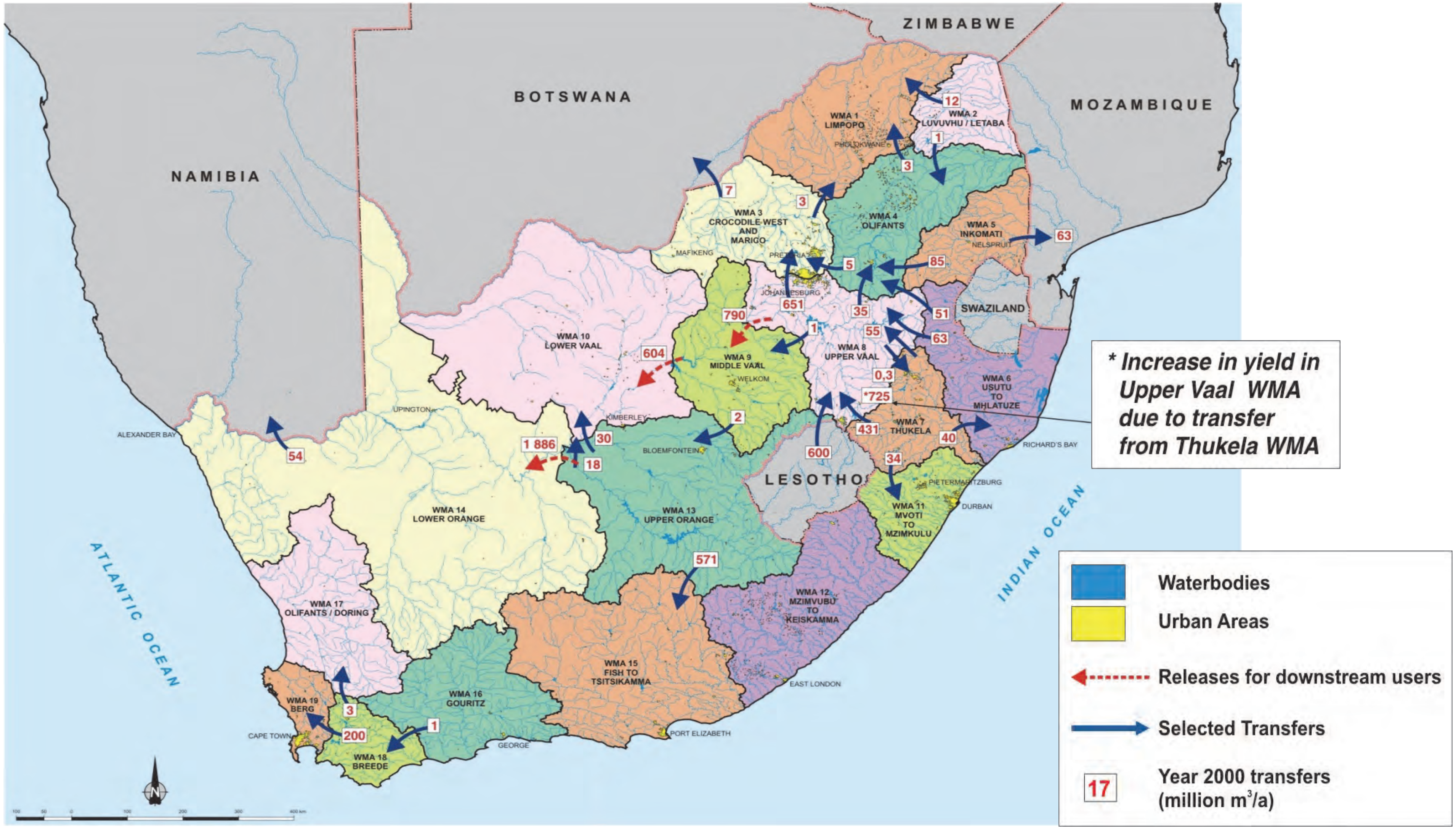


Figure 2-3 Map indicating water management areas and major water transfers schemes (NWRS, 2004)

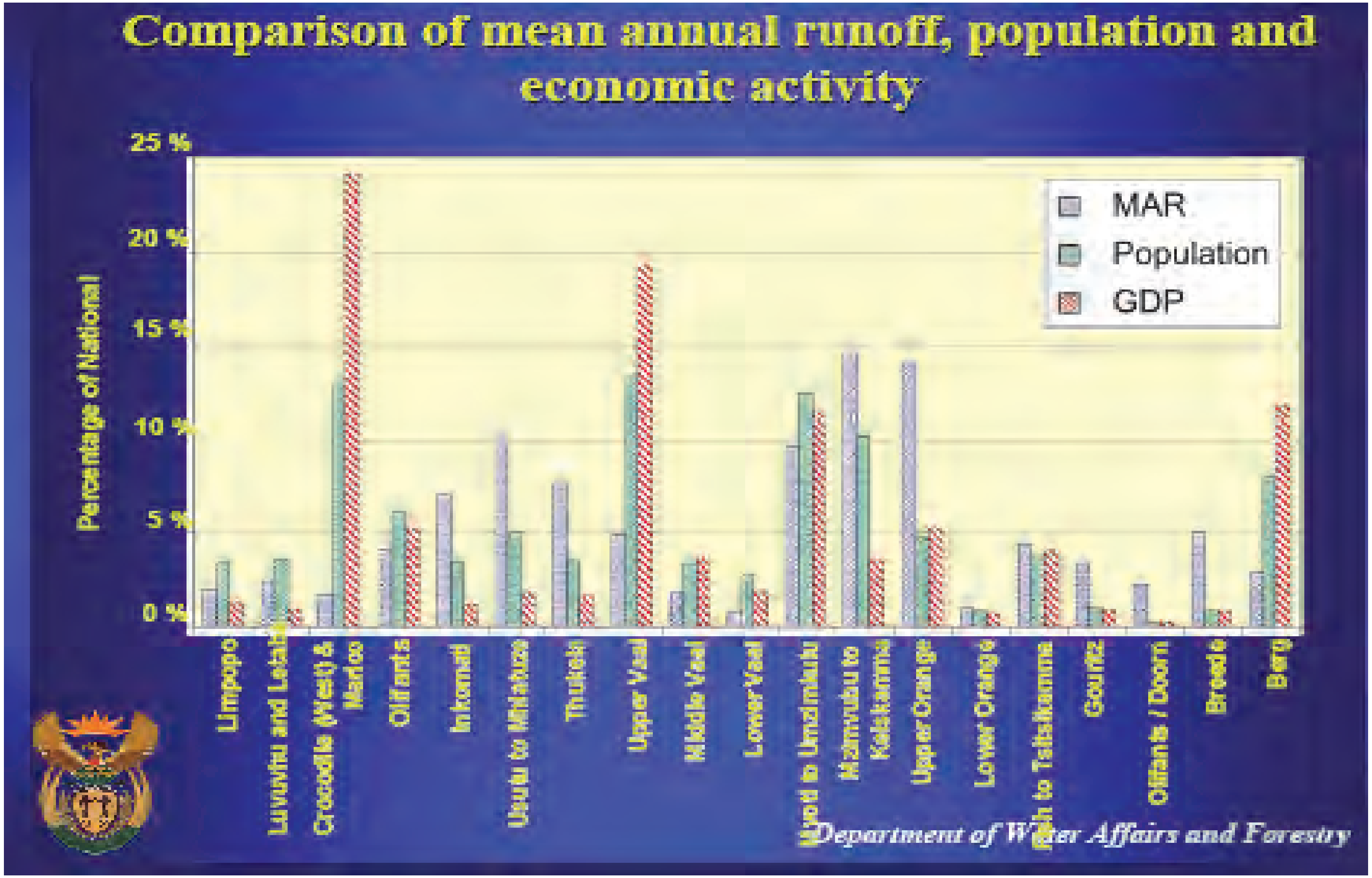


Figure 2-4 Graph indicating relation between MAR, population and GDP of WMAs (Van Riet and Slabbert,1996).

catchments. One of the knock-on impacts is that there is more water available downstream from the primary demand area, and therefore growth and development has spread to these areas too because of increased water availability, for example irrigated agriculture along the banks of the Vaal River in the Middle and Lower Vaal WMAs, and the Orange River in the Upper Orange WMA as a result of the increased water availability in Gauteng.

2.3.2 Engineered Rivers (River by design)

Runoff waters from rain events have been directed away from properties to prevent damage since the Egyptian era. However, it wasn't until after the industrial revolution and the rapid urban sprawl of cities and towns that significant drainage measures, macadamising of roads and pavements, and modification of river channels for flood control were put into place. "As urban populations spread over once-avoided flood plains and encroached to the river's edge, river stabilisation and training, including bank protection, became increasingly important in order to prevent, or at least control erosion of the bed and banks, shoaling or channel migration" (Downs and Gregory, 2004:26). They further explain that modification of river channels for flood control involves alterations of the channel by widening, dredging and straightening the channel, relocating small streams, removing vegetation and or the construction of levees or flood protection schemes, and the use of upstream storage reservoirs to control downstream flood impacts. The practice essentially converted rivers into stormwater channels. Figure 2-5 illustrates a stormwater warning alongside an urban river in Johannesburg. By the 19th Century, the principles and practice of canal and engineering of rivers, e.g. river stabilisation activities or modification to river channels, river straightening, river channelling and flood control schemes had become everyday practice (Stephenson, 1858 in Downs and Gregory, 2004). The practice of "river engineering" expanded from flood protection activities to a variety of channel modifications to suit a range of river channel uses. Friedman and Auble (2000) point out that although floods are commonly regarded as a hazard to human communities, they are usually necessary to maintain biotic diversity in bottomlands. Therefore, by changing the magnitude, frequency, or duration of floods, flood control often constitutes a hazard to riparian ecosystems and habitats.

Figure 2-5 A warning sign located on the banks of the Klein Jukskei River in Johannesburg.

Globally, these “engineering” activities led to a significant loss of riparian function, structure and ecological biodiversity in the riparian zones. Paul and Meyer (2001, cited in Groffman *et al*., 2003) noted that the most obvious hydrologic changes associated with this river engineering is where natural features are replaced by concrete channels and stream bank stabilisation efforts designed to resist increased flood flows. These changes in hydrology and geomorphology result in changes in the ability of the river to attenuate floods and trap sediment, to provide habitat and improve water quality and store carbon. Further, extensive piped stormwater drainage networks often completely bypass riverine zones, channelling large amounts of water from impervious surfaces directly into streams, both quickly and with increased frequency (Paul and Meyer, 2001; CWP, 2003 cited in Groffman *et al.¸ 2003*). A result of this altered hydrology is that incision or “downcutting” is a common feature of urban stream channels (Wolman, 1967, Henshaw and Booth, 2000, cited in Groffman *et al.,* 2003). Downcutting results from large volumes of water scouring out sediment that has accumulated in the river channel. According to Brookes (1987a, b) cited in Downs and Gregory, 2004) in many countries, river channelisation was pursued particularly vigorously after the Second World War until the 1980s, by which time it is estimated that 98% of all rivers in mainland Denmark had been modified; as had up to 96% of river channels in river catchments in lowland Britain, and in the USA 26 500km of rivers were channelized by 1977 (Leopold, (1977) in Downs and Gregory, 2004). In addition, “by 1973, at least 15% of stable world annual runoff was contributed by storage reservoirs” (Lvovitch, (1973 in Downs and Gregroy, 2004:42) through extensive flow regulation. As such, in the industrialised nations very few rivers were left in their natural state. While the practice of river engineering spread across industrialised nations, colonial powers transferred the practice to developing countries under their regulation. Consequently, when the older cities of South Africa were established, the engineering practices of river engineering of the colonial powers were applied. The principle of diverting runoff water into rivers is captured in the South African Traffic Road Act, Act 54 of 1971, which is still in effect. Table 2.3 summaries the potential effects on water courses as a result of land use disturbances.

Table 2.3 Potential effects of major land use activities (Adapted from FISRWG, 2001:3-27)											
	Disturbance Activities										
Potential Effects	Alien Infestation	Site Clearing	Infilling and Impeding	Erosion and Excavation	Discharge	Abstraction	Impoundment	Diverting	Structures	Canalising / Levees	Bank Stabilising
Homogenisation of landscape elements	■	■	■	■	■	●	●	■	●	■	■
Point source pollution	●	●	●	■	■	●	■	●	■	●	●
Nonpoint source pollution	●	■	●	■	■	●	●	■	■	■	■
Dense compacted soil	●	■	■	■	●	●	■	■	■	■	■
Increased upland surface runoff	●	■	●	■	■	●	●	●	■	●	●
Increased sheetflow w/surface erosion rill and gully flow	●	■	●	■	■	●	●	●	■	●	●
Increased levels of fine sediment and contaminants in stream corridor	●	■	■	■	■	●	■	■	■	■	■
Increased soil salinity	●	●	●	●	■	■	●	■	●	●	●
Increased peak flood elevation	●	■	■	■	■	●	■	■	●	■	■
Increased flood energy	●	■	■	■	■	●	●	■	●	■	■
Decreased infiltration of surface runoff	●	■	●	■	■	●	●	●	■	●	■
Decreased interflow and subsurface flow	●	■	●	■	■	●	●	●	●	■	■
Reduced ground water recharge and aquifer volumes	●	■	■	■	■	■	■	■	■	■	●
Increased depth to ground water	●	■	■	■	■	■	■	■	■	■	■
Decreased groundwater inflow to stream	●	■	■	■	■	■	●	■	■	■	■
Increased flow velocities	●	■	■	■	■	●	■	■	■	■	■
Reduced stream meander	●	■	■	■	■	●	■	■	●	■	■
Increased or decreased stream stability	●	■	■	■	■	■	■	■	■	■	■
Increased stream migration	●	■	■	■	■	●	●	■	●	●	●
Channel widening and downcutting	●	■	■	■	■	■	■	■	■	■	■
Increased stream gradient and reduced energy dissipation	●	■	■	■	■	■	■	■	●	■	■
Increased or decreased flow frequency	●	■	■	■	■	■	■	■	■	■	●
Reduced or prolonged flow duration	●	■	■	■	■	■	●	■	■	■	■
Decreased capacity of floodplain and upland to accumulate, store, and filter material and energy	●	■	■	■	■	●	●	■	■	■	●
Increased levels of sediment and contaminants reaching stream	●	■	●	■	■	●	●	■	■	■	■
Decreased capacity of stream to accumulate and store or filter materials and energy	●	■	●	■	■	●	●	■	●	■	■

Potential Effects	Alien Infestation	Site Clearing	Infilling and Impeding	Erosion and Excavation	Discharge	Abstraction	Impoundment	Diverting	Structures	Canalising / Levees	Bank Stabilising
Reduced stream capacity to assimilate nutrient/pesticides	●	■	■	■	■	■	■	■	●	■	■
Confined stream channel w/little opportunity for habitat development	●	●	■	■	●	●	●	■	●	■	■
Increased streambank erosion and channel scour	●	■	●	■	■	●	■	■	●	■	■
Increased bank failure	●	■	●	■	■	■	■	■	●	■	■
Loss of instream organic matter and related decomposition	●	■	■	■	●	●	■	■	●	■	■
Increased instream sediment, salinity, and turbidity	●	■	■	■	■	●	■	■	■	■	■
Increased instream nutrient enrichment, siltation, and contaminants leading to eutrophication	●	■	■	■	■	●	■	■	■	■	●
Highly fragmented stream corridor with reduced linear distribution of habitat and edge effect	●	■	■	■	●	■	■	■	■	■	■
Loss of edge and interior habitat	■	■	■	■	●	●	●	■	■	■	■
Decreased connectivity and width within the corridor and to associated ecosystems	■	■	■	■	●	●	■	■	■	■	■
Decreased movement of flora and fauna species for seasonal migration, dispersal, and population	■	■	■	■	●	■	■	■	■	■	■
Increase of opportunistic species, predators, and parasites	■	■	●	●	■	●	■	■	■	■	■
Increased exposure to solar radiation, weather, and temperature extremes	●	■	■	■	●	■	●	■	■	■	■
Magnified temperature and moisture extremes throughout the corridor	●	■	●	■	●	●	●	●	●	■	●
Loss of riparian vegetation	■	■	■	■	●	■	■	■	■	■	■
Decreased source of instream shade, detritus, food and cover	●	■	●	■	●	■	●	■	●	■	■
Loss of vegetative composition, structure, and height diversity	■	■	■	■	■	●	●	■	■	■	■
Increased water temperature	●	■	■	■	●	■	■	■	●	■	■
Impaired aquatic habitat diversity	■	■	■	■	■	■	■	■	●	■	■
Reduced invertebrate population in stream	●	■	■	■	■	■	■	■	●	■	■
Loss of associated wetland function including water storage, sediment trapping, recharge, and habitat	■	●	■	■	■	■	■	■	■	■	■
Reduced instream oxygen concentration	●	■	■	■	■	■	■	■	●	■	■
Invasion of exotic species	■	■	■	●	■	■	●	■	●	■	■
Reduced gene pool of native species for dispersal and colonisation	■	■	■	●	●	■	●	■	●	■	■

Reduced species diversity and biomass	■	■	■	■	■	■	●	■	●	■	■

■ Activity has potential for direct impact

● Activity has potential for indirect impacts

2.3.3 Effluent Discharge to Water Courses

One of the dramatic changes in water resources management took place in the 17th century with the reversal in position regarding effluent discharge to water courses. The growth in population density after the industrial revolution and medical advancements resulted in increasing pressure in the area of sewerage disposal. The most infamous example is the cholera outbreaks in 1840 which were linked to groundwater contamination as a result of poor sewerage disposal. “In 1815 in London, 1823 in Boston, and 1880 in Paris, the cesspools of houses were allowed to connect to sewers, and run into the rivers” (Haslam 1990:18) without treatment. The result of this discharge without prior treatment led to the Big Stink in London in 1858, where a resolve was quickly required for the treatment of the sewer waste prior to discharge into the river. The Royal Commission on Sewerage Disposal, set up in 1898 developed the leading protocol for domestic effluent disposal standards. The Thames River, whose purification was so praised in the 1970s, now fails this criterion (Haslam, 1990). With regards to the disposal of industrial effluent to water courses, it took longer for industrial discharge to rivers to become legal. “The 1847 (British) Gas Works Act prohibited industrial discharge, and it was not until 1937 that British industry had the right, under certain conditions, to discharge to sewers” (Hynes, 1960 in Haslam 1990:18). These decisions have contributed to the significant impact and degradation of the majority of urban rivers around the world. The impacts of discharged effluent into rivers results in reduced water quality which leads to the loss of biodiversity, fish kills, and potential harm to humans. Table 2.4 summarises some of the environmental effects and consequences of various factors of domestic and industrial effluent discharge to water courses. Appendix A further lists the pathogenic organisms known to occur in domestic sewer effluents, and the toxic substances found in industrial effluents, respectively. In South Africa, one only needs to look at the impact of sewer discharge into the Jukskei River and its impact on the Hartbeestpoort Dam, or the Black River in the Western Cape to observe the detrimental environmental impacts, similarly Figure 2-6 illustrates this impact with regard to the blue-green algal contamination of the Princess Vlei in Cape Town, which is regularly used for recreational activities.

Table 2.4 Environmental implications of the discharge of sewerage and industrial effluents (Adapted from Hellawell (1986) and Haslam (1990))

Factor	Principal environmental effect	Potential ecological consequences	Probable severity	Remedial or ameliorative action	Comments
Degradable Organic Matter					
1. High biochemical oxygen demand (BOD) caused by bacterial breakdown of organic matter	Reduction in dissolved oxygen concentration	Elimination of sensitive species, increase in some tolerant species; change in community structure	Dependent upon degree of de-oxygenation, often very severe.	Pre-treatment of effluent; ensure adequate dilution	BOD can be reduced by adequate treatment
2. Partial biodegradation of proteins and other nitrogenous material	Elevated ammonia concentrations; increased nitrite and nitrate levels	Elimination of intolerant species, reduction in sensitive species	Variable, locally severe	Improved treatment to ensure complete nitrification; nutrient stripping possible but expensive	Adequate treatment is best solution
3. Release of suspended solid matter	Increased turbidity and reduction of light penetration	Reduced photosynthesis of submerged plants; abrasion of gills or interference with normal feeding behaviour (see inert solids below)	Moderate, usually local	Provide improved settlement, ensure adequate dilution	
4. Deposition of organic sludge in slower water.	Release of methane and hydrogen as sulphide matter decomposes anoxically. Modification of substratum by blanket of sludge.	Elimination of normal benthic community. Loss of interstitial species; increase in species able to exploit increased food source.	Variable, may be severe	Discharge where velocity adequate to prevent deposition	tends to be locals
Other Poisons					
1. Presence of poisonous substances	Change in water quality	Water directly and acutely toxic to some organisms, causing change in community compositions; consequential effects on prey-predator relations; sub-lethal effects on some species (changes in behaviour, etc.)	Highly variable, depending upon substance and its concentration	Increase dilution	difficult to generalise

Factor	Principal environmental effect	Potential ecological consequences	Probable severity	Remedial or ameliorative action	Comments
Inert Solids					
1. Particles in suspension	Increased turbidity. Possibly increased abrasion	Reduced photosynthesis of submerged plants. Impaired feeding ability through reduced vision or interference with collecting mechanisms of filter feeders (e.g. reduction in nutritive value of collected material). Possible abrasion.	Variable, often moderate	Improve settlement	Inert solids change the character of the substrate and are unstable. They provide no additional nutrition.
2. Deposition of material	Blanketing of substratum, filling of interstices and/or substrate instability	Change in benthic community, reduction in diversity (increased number of a few species).	Variable, often severe	Discharge where velocity adequate to prevent dispersion	

Figure 2-6 Warning sign at Princess Vlei, Western Cape

Poor quality water results in less water resource availability for utilisation, both for domestic consumption and commercial utilisation. An important and significant impact of discharged effluent to rivers lies in the downstream impact of the discharge, and accumulated toxicity of the water resource. For example, in the Western Cape, the towns of Paarl and Wellington are located in the upper reaches of the Berg River Catchment. The discharge from the towns' waste water treatment works (WWTW) is non-compliant with discharge licence conditions. Apart from the unpleasant odour in the immediate surrounds, the poor water quality has had a significant impact on downstream irrigation, especially of fruit produce, to the extent that the EUROCAP, the board responsible for health and quality control of imported food products into Europe, has threatened to bar imports from the region until the quality of the irrigation water is improved. Should this threat be carried out, it would result not only a big economic loss for the farmers themselves, but for the GDP of the province and the country. However, through enforcement efforts and pressure from the downstream irrigators, upgrading of WWTW works and an additional works is currently being constructed in order to resolve the non-compliance and improve the quality of the discharges to the river.

2.4 River Rehabilitation

Before setting out rehabilitation processes and activities, it is necessary to understand the different types of rehabilitation objectives, rehabilitation drivers, and the applicable scale to which they apply in order to ensure the appropriate process is followed. When carrying out rehabilitation activities, apart from the individual objectives such as improving water quality or re-establishing riparian zone vegetation, there is an overall aim that the rehabilitation activities are trying to achieve. This overall aim or desired state will be captured in the goal of the rehabilitation plan, and it sets out the intention for carrying out the rehabilitation activities. Rogers and Biggs (1999) stipulate that clear definitions of desired conditions, given surrounding land uses, are required for effective management and assessment for rehabilitation. These objectives fall into one of three categories, that of restoration, rehabilitation, or remediation. While these terms are often used interchangeably in various countries around the world to describe the physical rehabilitation activities, it is important to identify which one is the intention of the overall rehabilitation objectives in order to avoid disappointment or set unrealistic objectives. For example, "often, pre-European (colonial era) disturbance conditions are set as restoration goals (e.g. Chapman, 1992; Scrimgeour & Wicklum, 1996), but those conditions may not be attainable; further this target denies the place of humans in the landscape" (Norris and Thoms, 1999:201). Simply put, each objective deviates from the pristine state, and when setting the objectives for rehabilitation a clear understanding of "how far from" the pristine state the rehabilitated river reach will result, needs to be clarified to avoid confusion or misrepresentation. These objectives are defined as:

- **Restoration**

The Federal Inter-Agency Stream Restoration Working Group (FISRWG, 1998:1-3) defines ecological restoration as "the process of returning an ecosystem as closely as possible to pre-disturbance conditions and functions". It stresses that it is implicit in this definition that stream ecosystems are dynamic and that it is consequently not possible to recreate a system exactly. Rather, the stream restoration process is aimed at re-establishing the "general structure, function and dynamic, but self-sustaining behaviour of the ecosystem". In addition, Rutherford, Jerie and Marsh (2000:13) propose the objectives of ideal restoration would typically involve the sequential achievement of the following objectives:

(a) restore the natural range of water quality;
(b) restore the natural sediment and flow regime (seasonal, annual and decadal fluctuations);
(c) restore the natural channel geometry and stability;
(d) restore the natural riparian plant community; and
(e) restore indigenous aquatic plants and animals if they do not colonise on their own.

In summary, the objective of restoration is to restore the river reach to as close to pristine as possible.

- **Rehabilitation**

In its most simple form, rehabilitation can be considered as a series of actions which make the landscape useful again after a disturbance, and usually involves "the recovery of some ecosystem functions and processes in a degraded habitat" (Dunster and Dunster in FISRWG, 1996:1-3). The objective of rehabilitation, as a specific goal, would be to address specific or selected ecological and riverine functions.

- **Remediation**

The term "remediation" is appropriate in cases where it is not possible to rehabilitate due to a river system being irretrievably degraded, or where a system has been fundamentally altered in character but has over time, adjusted and achieved a state of dynamic equilibrium or stability. The aim of remediation is to improve the ecological condition of the river, while not aiming for an endpoint which resembles its original condition. Rutherfurd *et al.* (2000:15) suggest the action of remediation would be "to establish a new ecosystem on the basis that the stream has changed so much from the original condition that it [the original condition] is no longer relevant, and therefore a new condition is intended." The objective of remediation would be to stabilise the impacts on the river and prevent further degradation thereby creating a new or different structure and functioning.

When setting rehabilitation objectives within the urban context, it must be remembered that firstly, the river is already in an altered state, in other words it is not pristine, based on the context that the river has urban land use activities within its catchment; and secondly, that rivers are dynamic and continually adapt to disturbance such as altered land use within the catchment, changes in percentage of pervious and impervious ground cover in the catchment, as well as environmental fluxes, such as flooding and drought. Ebersole in Norris and Thoms (1999), argue that restoration is fundamentally about allowing stream systems to re-express their capacities. In order to achieve this, they go on to explain, that historical patterns of habitat development and developmental constraints should be identified; constraints should be relieved; sensitive, critical, or refuge habitats should be classified; the development diversity that remains should be protected; and the biotic responses to habitat development should be monitored. Their approach attempts to match the potential of the environment to produce habitat with that which could be realised given constraints of human use. However, Roux (2002) points out that trade-offs are inevitably required between protecting rivers (achieving biodiversity conservation) and achieving economic development. He observes that it is usually difficult to determine what the original condition of the river was, and therefore activities of rehabilitation over restoration would be the norm; further, restoration would possibly require the re-instatement of all the elements of the river including flow regime, sediment, biota, which is not necessarily possible in an urban context. Further, all rivers cannot be maintained in natural or even in good states. Quinn (2003:4) cautions that "at all times the focus of rehabilitation should be the re-establishment of an appropriate ecosystem structure and functions, which must be self-sustaining." Therefore, as suggested by Gonzalez del Tánago, (2004), restoration or rehabilitation alternatives can be defined more straightforwardly if the main degradation causes are correctly identified and the human pressures that are limiting natural riverine function are known and assessed. Therefore, during enforcement activities, when conducting site inspections and initial investigations, the causes of degradation and resultant impacts on riverine functions must be timeously identified.

Note: In this research the term "rehabilitation" is used as a general term to describe physical activities and should not be interpreted as a preferred objective unless specifically stated otherwise.

2.4.1 Drivers of Rehabilitation

Brierley and Fryirs (2005) point out that river recovery is not simply the reverse of river degradation, but rather suggest that river recovery would be the post-human disturbance trajectory of change towards an improved condition. When conducting riverine rehabilitation it is important to set clear objectives, determine who the driver for the rehabilitation activities are, and what their underlying objective for the rehabilitation is. There are two main categories for drivers of riverine rehabilitation, that of Initiative Driven, and Enforced Rehabilitation.

Initiative Driven rehabilitation links to the concept of "Duty of Care", for example where a land owner or community group has identified or decided to proactively rehabilitate their own property or a particular reach of river. This includes Municipal responsibility – where a municipality has identified a particular area in their jurisdiction that has suffered damage, usually from flooding, for example the

2009 Soweto floods in Johannesburg, or 2009 Drakenstein Municipal floods in the Western Cape, and has initiated a project under the municipal or NGO budget to pro-actively rehabilitate the reach of river. The rehabilitation is driven by the private landowner, the community group or the municipality and usually covers quite a long (several erven or kilometres) reach of river.

On the other hand, **Enforced rehabilitation** is driven by a regulatory body of an Organ of State, e.g. where the compliance and enforcement unit of a particular institution has issued an Administrative Notice (e.g. a Compliance Notice, Directive or Control Measure) to a landowner or person in control of the land, instructing them to rehabilitate a reach of river in order to remedy an illegal or non-compliant activity and its resultant impact or disturbance. The rehabilitation activities are usually aimed at site specific activities. The key differences between Initiative Driven and Enforced Rehabilitation are captured in Table 2.5.

Table 2.5 A comparison of Initiative driven versus Enforcement driver rehabilitation

Characteristics	**Initiative Driven**	**Enforced Rehabilitation**
Activation Process	Proactive	Reactive
Size	Sub-catchment, several km's of river	Site specific and resultant impacts; short reach
Stakeholders Involved	Government Departments, NGOs, CBOs, funding agencies, municipality, land owner	Land owner (person in control of the land), Government Departments
Funding	Donors, government funding	Land owner responsibility
Rehabilitative Objectives	Clearly set out, comprehensive, detailed	*Ad hoc*, site specific, not comprehensive
Timeframe	Long process	Short-timeframes, in order to prevent further impacts/damage
Potential Authorising Processes	Full EIA, NWA s21 Water Use Licence	Rectification, NEMA S24G, General Authorisation
Rehabilitation Drivers	Public concern / Conservation driven	Illegal or non-compliant legislative requirements and Government Department driven

For the purposes of this research, the driver of rehabilitation is Enforced Rehabilitation. Before proceeding further it is important to understand enforced rehabilitation, its triggers in the environmental legislation, requirements and current hurdles in the South African context environmental enforcement regime.

3 ENFORCED REHABILITATION

When conducting activities that may impact on the environment, Anderson and Leal (1991) propose two rules. First is the property rule and is supported by Initiative Driven rehabilitation, where the necessary authorisations are obtained prior to commencement of the activity. This affords a person the right to conduct the particular activity within a prescribed set of conditions in order to minimise or mitigate potential and cumulative impacts to the receiving environment. The second rule is that of liability which drives Enforced Rehabilitation. In this case, the person follows a process of non-compliance, in other words, that the necessary authorisations are not obtained prior to commencement, or that they are obtained but the conditions are not adhered to. According to O'Beirne (2011:7) "(t)he bureaucratisation of the EIA regulations is extremely worrying in that the emphasis in conducting EIAs is now perceived as being about "ticking boxes" rather than focusing on the quality objective assessment. It stands to reason that if EIA is seen and perceived to be nothing more than an administrative burden, rather than a process which will serve to reduce risks to the development and to the environment in which the development will be established, then EIA will continue to be discredited." Unfortunately, the current South African Environmental legislative requirements are very cumbersome, costly and time consuming (DEAT, 2008), and in some cases over five different authorisations may be required to conduct one activity. In frustration, this drives many people to rather follow the liability rule, and rather wait to be caught and pay the fine, which is usually cheaper and less onerous than following the formal property rule process and obtaining the necessary environmental authorisations.

In South African legislation, there are several statutes that address varying elements of the environment, and in particular riverine zones. These statutes and their applicable objectives are summarised in Table 3.1.

Table 3.1 Various statutes and the objectives or principles that relate to riverine zones (Adapted from Uys, 2006)

Act	Riparian/Ecosystem specific objectives of the legislation
The Constitution of the Republic of South Africa, Act 108 of 1996 (the Constitution)	**24.** Environment. Everyone has the right: *(a)* to an environment that *is* not harmful to their health or well-being; and *(b)* to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that: (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.
National Water Act, Act 36 of 1998 (NWA)	**2.** The purpose of this Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors:

	(d) promoting the efficient, sustainable and beneficial use of water in the public interest; *(g)* protecting aquatic and associated ecosystems and their biological diversity; *(h)* reducing and preventing pollution and degradation of water resources; *(k)* managing floods and droughts, and for achieving this purpose, to establish suitable institutions and to ensure that they have appropriate community, racial and gender representation.
National Environmental Management Act, Act 107 of 1998 (NEMA)	**2.** (1) The principles set out in this section apply throughout the Republic to the actions of all organs of state that may significantly affect the environment and: (b) serve as the general framework within which environmental management and implementation plans must be formulated; (c) serve as guidelines by reference to which any organ of state must exercise any function when taking any decision in terms of this Act or any statutory provision concerning the protection of the environment; and (e) guide the interpretation, administration and implementation of this Act, and any other law concerned with the protection or management of the environment. (3) Development must be socially, environmentally and economically sustainable. (4)(a) Sustainable development requires the consideration of all relevant factors including the following: (i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied; (ii) that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied; (iii) that the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided, or where it cannot be altogether avoided, is minimised and remedied; (iv) that waste is avoided, or where it cannot be altogether avoided, minimised and reused or recycled where possible and otherwise disposed of in a responsible manner; (v) that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource; (vi) that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised; (vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and (viii) that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied. (c) Environmental justice must be pursued so that adverse environmental impacts shall not be distributed in such a manner as to unfairly discriminate against any person, particularly vulnerable and disadvantaged persons. (i) The social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment. (l) There must be intergovernmental coordination and harmonisation of policies, legislation and actions relating to the environment. (o) The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage. (p) The costs of remedying pollution, environmental degradation and consequent

	adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment. (r) Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure
Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA)	**3.** The objects of this Act are to provide for the conservation of the natural agricultural resources of the Republic by the maintenance of the production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants.
National Heritage Resources Act, Act 25 of 1999 (NHRA)	To carefully manage heritage resources to ensure their survival in the interests of all South Africans, and to promote policy administrative practice and legislation, the integration of heritage resources conservation in urban and rural planning and social and economic development (Section 5).
National Minerals and Petroleum Resources Act, Act 28 of 2002 (NMPR)	**2.**The objects of this Act are to: (h) give effect to section 24 of the Constitution by ensuring that the nation's mineral and petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development.
National Environmental Management: Biodiversity Act, Act 10 of 2004 (NEM:BA)	**2.** The objectives of this Act are- (a) within the framework of the National Environmental Management Act, to provide for: (i) the management and conservation of biological diversity within the Republic and of the components of such biological diversity; (ii) the use of indigenous biological resources in a sustainable manner. (b) to give effect to ratified international agreements relating to biodiversity which are binding on the Republic.
National Environmental Management: Protected Areas Act, Act 57 of 2003 (NEM:PAA)	**2.** The objectives of this Act are: (c) to effect a national system of protected areas in South Africa as part of a strategy to manage and conserve its biodiversity; (e) to promote sustainable utilisation of protected areas for the benefit of people, in a manner that would preserve the ecological character of such areas; *[Para. (e) amended by s. 2 of Act 31/2004]*
Mountain Catchments Act, Act 63 of 1970	To provide for the conservation, use, management and control of land situated in mountain catchment areas, and to provide for matters incidental thereto.
Water Services Act, Act 108 of 1997 (WSA)	**2.** The main objects of this Act are to provide for: (a) the right of access to basic water supply and the right to basic sanitation necessary to secure sufficient water and an environment not harmful to human health or well-being; (c) the preparation and adoption of water services development plans by water services authorities; (d) a regulatory framework for water services institutions and water services intermediaries.

In order to understand enforcement one needs to understand the law that regulates watercourses (riverine zones) in South Africa and the enforcement processes that drive enforced rehabilitation activities.

3.1 Law

Laws have been around since ancient times for example the Code of Hammurabi in 1795 BC. Laws provide the boundaries within which daily activities take place. With regards to the scope of this research, it is the breaching or non-compliance of laws that is of particular relevance. However, to adequately address this breach in law, it is important to understand what law is; what principles South Africa's modern (post-1994) environmental law is based on; what the applicable relevant laws for rehabilitation of urban rivers are; and what is the administrative context that rehabilitation needs to comply with. The following sections are aimed at addressing these points, in order to create a legislative framework for setting objectives for enforced rehabilitation. The significant output from this chapter is the Legislation Search Tool which is discussed in detail in Chapter 4.

In Black's law dictionary Garner (1999) defines law as, being a framework that orders human activities and relations using a systematic application of the force of politically organised society, or through social pressure, backed by force in such a society.

Goldfarb (1988:1-10) explains that the "law creates:

a) Legally enforceable expectations (rights);
b) Duties to respect those rights; and
c) Means of redressing violations of rights (remedies)."

Therefore, the law provides the framework within which activities can be carried out in a society, e.g. at the level of an individual or an organisation, the law provides the framework within which he/she/they may operate, and provides mechanisms or remedies for "re-alignment" where the boundaries of the framework are infringed. At the level of the state, the law is an instrument for the state to create order in society, including the management of resources and services. In a democracy like South Africa, the state should be bound to its own law as well. Currently, the South African legislation is not uniform on statutes being binding on the State, especially the environmental legislation. At the international level, the law can be used to resolve conflicts and to co-ordinate policies to facilitate global development. This is particularly important for the peaceful and sustainable management of transboundary resources such as rivers, in order to minimise impacts to- and ensure sustainable and reasonable utilisation of- up- and downstream users. The difference between laws at the level of the individual in relation to other individuals in society compared to law at the national/international level is referred to as private and public law. Private law regulates the relationship between private persons. Whereas, "public law regulates the relationship between the state as bearer of political or state authority and the State's subjects as subservient to that authority, as well as regulating the mutual relationships between state or government bodies" (Du Plessis and Du Plessis, 1992:67). Law that governs the utilisation and protection of environmental resources falls within the ambit of public law. However, when there is non-compliance with the requirements of this law, individuals may also make a case in civil law, which falls under private law.

"The law of a state, as distinct from the laws of physics or chemistry, is a rule of human conduct, imposed and enforced among the members of a given state" (Padfield, 1981:1). Laws attempt to create a certain amount of order within a state by developing specific rules of conduct, by upholding culture and society-specific norms, and by promoting a degree of certainty with regards to the nature of the rules in society. The law provides citizens the possibility of objecting to policies and decisions and challenging these in court. Within a state there are several types of law:

- Constitutional law – lays out the framework within which other laws and policies, including the Bill of Rights of citizens, operate.
- Administrative law – which governs the relationship between the government and its people.
- Criminal law – lists offences against the state and citizens and appropriate penalties and remedies.
- Civil law – relates to the legal relationship between citizens.
- There is also sector specific or resource specific law such as agrarian law, mining law, environmental law, etc., which also contains sections of administrative and criminal law.
- International law – applies to the relationships between states.

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.

3.2 South African Environmental Law

Post-1994 South African legislation has been guided by the Constitution of the Republic of South Africa, Act 108 of 1996 (the Constitution). The Bill of Rights contained in the Constitution sets out the rights of the citizens of the state. In particular, section 24 of the Constitution provides the mandate for the modern environmental legislation.

Section 24. Everyone has the right:

(a) to an environment that is not harmful to their health or well-being; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-

(i) prevent pollution and ecological degradation;

(ii) promote conservation; and

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Section 27 also relates to water in that “everyone has the right to access safe water.” While section 27 relates more to water services and sanitation, section 24 relates to the environment in general, of which water as a resources is a component. As section 27 of the Constitution identifies water as a right to life, water resources, as contemplated in section 24, are held in trust for the country and managed by the Government, through the Department of Water Affairs and the National Water Act, Act 36 of 1998 (NWA) in part to provide water for services contemplated in section 27. Further, the National Environmental Management Act, Act 107 of 1998 (NEMA) aims to achieve section 24 of the Constitution in terms of sustainable and reasonable utilisation of environmental resources. Similarly, while not a modern statute, the provisions of the Conservation of Agricultural Resources Act, Act 43 of 1983(CARA) also aim to achieve section 24. While there are many statutes relating to environmental management, the three Acts discussed below, NWA, NEMA and CARA are the principal statutes to consider when considering rehabilitation of rivers.

3.2.1 National Water Act, Act 36 of 1998 (NWA)

Prior to the gazetting of the National Water Act, Act 36 of 1998 (NWA), a discussion document on Water Law Principles (1996) was published which proposed 27 core principles to be enacted in the NWA. As proposed in the Water Law Principles, the purpose of the National Water Act (NWA) is to ensure that water resources are managed to promote the sustainable use of water in the public interest, and to protect aquatic ecosystems and their biological diversity, and to allocate water in a way that will promote environmental values which includes the human right to a healthy environment and sustainable environmental development. Equally, rehabilitation objectives should also aspire to these principles.

The NWA provides a framework to protect water resources against over exploitation and to ensure that there is water to sustain the environment, for social and economic development, and water for the future, (DWAF 2003). When referring to water resources, the Act defines water resources as including a watercourse, surface water, estuary, or aquifer, in other words the physical water. Whereas a water course is defined as meaning:

(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;

in other words, the environmental features where the physical water is located.

The principles of the Act strive for sustainability, equity and efficiency. In order to ensure management of water resources is sustainable and equitable for the benefit of all, the NWA aims to protect, use, develop, conserve, manage and control water resources as a whole. Rivers, dams, wetlands, the surrounding land, groundwater, as well as human activities that influence them, need to be managed as one integrated cycle or process.

Resource protection is carried out at a national scale, and with due consideration for the transboundary nature of water resources and the associated international agreements. In relation to the latter, the UN (1997) explains that the principle of equitable and reasonable utilisation requires riparian States to act in both an equitable and a reasonable manner when utilising, developing, or protecting an international watercourse. Yamada (2004) further explains, where "equitable utilisation[1]" refers to the fair allocation of benefits that may be derived from the utilisation of transboundary water among the riparian nations or domestically among adjacent users, and "reasonable utilisation" refers to the proper management of the shared water resource and may be equated with notions of sustainable utilisation. Further, according to Bourne (1992), what constitutes "equitable" and "reasonable" is determined by assessing various factors and circumstances relevant to the watercourse and to the different riparian parties, paying particular attention to the benefits derived by one person's actions and the injury or disadvantage that the action might impose on other persons or property. According to UNEP (2010) the principle of equitable and reasonable utilisation was not originally intended as an environmental mechanism or to produce environmentally-related outcomes; but it was rather to ensure that adequate freshwater flows and to protect freshwater resources for the benefit of humanity. In the NWA, the principle of environmental management in water resource management is inherent in the definitions of "watercourse" and "water resource", e.g. that water resources management and protection inherently includes watercourse management which includes the environmental features where physical water resources are located. Further the

[1] Note that equitable (fair and impartial) does not necessarily mean equal parts e.g. same quantity.

principles of reasonable utilisation can be likened to the principles of sustainability, equity and efficiency which are the cornerstones of the Act.

The Act makes provision for two prongs of resource management, namely that of resource directed measures e.g. protecting the physical resources; and that of resource use regulation, e.g. regulating the use of the resources. In the context of compliance and enforcement, the tools of enforcement fall under the regulation of use, however the objective of management or rehabilitation fall in the ambit of resource directed measures, thereby ensuring these two prongs of management are not implemented in isolation.

Resource directed measures include:

1. Determining the Present Ecological State (PES) - using physico-chemical characteristics and indicators (EcoClassification methodology) determines the current health of the water resource, where A category is pristine and F category is completely degraded;
2. Desired State (management objective) – taking the PES, water use, future water demand and other criteria into consideration, determines the desired state and management class of the water resource;
3. Determining and implementing the Reserve (includes both the Basic Human Need and Ecological Requirements Reserves); and
4. Resource Quality Objectives (narrative and quantitative) - these comprise of elements of the above measures, and that they are monitored and achieved.

Although these resource directed measures are usually set at a reach or segment scale within a catchment, they are still relevant and applicable when setting enforced rehabilitation objectives, because ultimately the objective of rehabilitation is to return the river to the management class it was prior to the non-compliant activity.

On the other hand, the measures for the regulation of resource use (also called Source Directed Controls) include:

1. Water entitlements – these include:
   a. The section 21 water uses requiring a formal water use licence;
   b. General Authorisations – provides thresholds below which the section 21 activities do not require a formal licence but the use must still be registered;
   c. Existing lawful Use – addresses legal uses of water in place prior to the change in 1994 and the new Act, whereby lawful uses do not need to reapply for water licences provided they were lawfully granted in terms of the previous Water Act, 1956; and

d. Schedule 1 use – which provides for the use of water resources for domestic use such as watering gardens and vegetable gardens, fire-fighting, etc. Note however, that should the produce of such a vegetable garden be sold, this becomes a commercial venture and thereby requires a formal licence.

2. Water allocations – provides an allocated amount of water within a catchment to each user, to ensure there is sufficient water to meet all the priority requirements such as the Reserve, international agreements, as well as the individual users requirements.
3. Compulsory licensing – a process to review existing lawful water uses against the current availability and demand, and thereby update the existing licences to current conditions.
4. Water Conservation and Demand Management – ensures efficiency in the systems of use in order to reduce wasteful demand of water.
5. Pricing, incentives – uses the price of water as a deterrent of over utilisation and wasteful use, especially during drought periods when stepped tariffs are implemented, e.g. per increasing volume of water the price gets more expensive.
6. Monitoring, compliance and enforcement – is carried out against these measures of regulation. Where non-compliance occurs the Act includes administrative and criminal processes, to ensure that the water resources are sustainably utilised.

Of relevance to this research are the water use licence measures, in particular the section 21 water uses. Section 21 of the Act out lines the specific activities affecting water resources or watercourses that require a formal licence and section 41 outlines the process of application for the licence. The NWA application process is relatively flexible in that it is guided by the department rather than the legislation, which provides for more flexibility on a case by case basis. The Act rather provides guidance to the decision makers with regards to criteria to be considered when reviewing an application. Of interest, despite one of the principles of the Act being to *protect aquatic and associated ecosystems and their biodiversity*, the criteria for reviewing applications, as per section 27 of the Act, does not specifically identify the environment and its ecosystems or potential impacts the water use activity may have on them. In addition, criterion *(g)* refers to the class and resource objective of the water resource; when considering this criterion, it is anticipated that the current and future class as a result of the impacting activity is to be considered. Similarly, criterion *(j)* mentions the Reserve in terms of water quality, and it is anticipated that this includes the current and potential quality as a result of the activity on the Reserve (both Basic Human Need and Ecological Reserve). It is interesting to note in NWA section 41(2)(b), that the responsible authority may carry out its own investigation into the likely effect of the proposed activity on the water resource.

In terms of regulating the use of a water resource the NWA identifies specific activities as requiring authorisation prior to utilisation. Table 3.2 outlines the activities requiring water use licences or permits. Enforcement is usually carried out where non-compliance with the conditions of a licence or permit occurs, or the illegal conducting of activities requiring a licence or permit. As part of the enforcement process, rehabilitation of the non-compliant activity and its impacts are required. As part of the authorising process, the impacts of listed activity/ies are considered within the overall catchment scale, as well as within the principles of sustainability, equity and efficiency. Therefore, when setting objectives for enforced rehabilitation, consideration of the illegal activity/ies and its impacts on the receiving environment should also be considered.

Table 3.2 Listed activities of the National Water Act, Act 36 of 1998, requiring a licence

Section	Activity
21. For the purposes of this Act, water use includes:	*(a)* taking water from a water resource
	(b) storing water
	(c) impeding or diverting the flow of water in a watercourse
	(d) engaging in a stream flow reduction activity contemplated in section 36;
	(e) engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1)
	(f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit
	(g) disposing of waste in a manner which may detrimentally impact on a water resource
	(h) disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process
	(i) altering the bed, banks, course or characteristics of a watercourse
	(j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people
	(k) using water for recreational purposes
36. (1) The following are stream flow reduction activities:	(a) the use of land for afforestation which has been or is being established for commercial purposes
	(b) an activity which has been declared as such under subsection (2)
37. (1) The following are controlled activities:	(a) irrigation of any land with waste or water containing waste generated through any industrial activity or by a waterworks;
	(b) an activity aimed at the modification of atmospheric precipitation
	(c) a power generation activity which alters the flow regime of a water resource
	(d) intentional recharging of an aquifer with any waste or water containing waste
	(e) an activity which has been declared as such under section 38.
38 (1)	The Minister may, by notice in the Gazette, in general or specifically, declare an activity to be a controlled activity

The NWA does not include any formal processes for the retrospective authorising of activities. However, in terms of administrative enforcement tools it does make provision for the prevention and remedying effects of pollution (Section 19 Directive), and control of emergency incidents (Section 20 Directive). The provisions of these sections are as follows.

Section 19 *(1) An owner of land, a person in control of land or a person who occupies or uses the land on which:*

(a) any activity or process is or was performed or undertaken; or

(b) any other situation exists, which causes, has caused or is likely to cause pollution of a water resource,

must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring.

(2) The measures referred to in subsection (1) may include measures to -

(a) cease, modify or control any act or process causing the pollution;

(b) comply with any prescribed waste standard or management practice;

(c) contain or prevent the movement of pollutants;

(d) eliminate any source of the pollution;

(e) remedy the effects of the pollution; and

(f) remedy the effects of any disturbance to the bed and banks of a watercourse.

(3) A catchment management agency may direct any person who fails to take the measures required under subsection (1) to:

(a) commence taking specific measures before a given date;

(b) diligently continue with those measures; and

(c) complete them before a given date.

Alternatively, **Section 20***(1) In this section, "incident" includes any incident or accident in which a substance:*

(a) pollutes or has the potential to pollute a water resource; or

(b) has, or is likely to have, a detrimental effect on a water resource.

(2) In this section, "responsible person" includes any person who -

(a) is responsible for the incident;

(b) owns the substance involved in the incident; or

(c) was in control of the substance involved in the incident at the time of the incident.

(4) A responsible person must:

(a) take all reasonable measures to contain and minimise the effects of the incident;

(b) undertake clean-up procedures;

(c) remedy the effects of the incident; and

(d) take such measures as the catchment management agency may either verbally or in writing direct within the time specified by such institution.

Both of these sections, while not prescriptive in terms of identifying the impacts of incidents or pollution, do include clauses for *remedying the effect of the pollution.* Subject to interpretation, this implies not only the pollution activity, but the impacts to the ecological integrity of the water resource as a result of the pollution as well, and thereby include necessary specialist studies, bearing in mind that cumulative and delayed impacts are still "effects" of the incident or pollution. Similarly these sections do not include requirements for monitoring or measuring the progress or success of the remedial activities.

Where non-compliance has occurred, in other words where activities requiring authorisation have commenced without such authorisation, or where there is non-compliance to licence or permit conditions, a section 53(1) directive may be issued to rectify such contraventions.

Section 53

(1) A responsible authority may, by notice in writing to a person who contravenes:

(a) any provision of this Chapter;

(b) a requirement set or directive given by the responsible authority under this Chapter; or

(c) a condition which applies to any authority to use water,

direct that person, or the owner of the property in relation to which the contravention occurs, to take any action specified in the notice to rectify the contravention, within the time (being not less than two working days) specified in the notice or any other longer time allowed by the responsible authority.

(2) If the action is not taken within the time specified in the notice, or any longer time allowed, the responsible authority may:

(a) carry out any works and take any other action necessary to rectify the contravention and recover its reasonable costs from the person on whom the notice was served; or

(b) apply to a competent court for appropriate relief.

While water is a scare resource within South Africa, and is unequally distributed throughout the country, the NWA addresses these issues by considering the water cycle as a whole and managing water at a catchment scale. The NWA manages water as a resource, however, water is also a component of the environment. Management of the environment and its components is enacted through the National Environmental Management Act, Act 107 of 1998.

3.2.2 National Environmental Management Act (Act 107 of 1998)(NEMA)

The first formal South African environmental management legislation was the Environment Conservation Act, Act 100 of 1982, and amended as Act 73 of 1989(ECA). There are still some provisions of this Act in effect such as the section 31A Directive. However, the current and primary environmental legislation is the National Environmental Management Act, Act 107 of 1998 (NEMA). One of the significant differences between the ECA and the NEMA lies in the definition of “environment” and what it encompasses.

The ECA defined “environment” as meaning “the aggregate of surrounding objects, conditions and influences that influence the life and habits of man or any other organism or collection of organisms.” In contrast the definition of “environment” in NEMA, includes “the surroundings within which humans exist and that are made up of –

- *(i)* The land, water and atmosphere of the earth;
- *(ii)* Micro-organisms, plant and animal life;
- *(iii)* Any part or combination of (i) and (ii) and the interrelationship among and between them; and
- *(iv)* The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and wellbeing.”

Uys (2006) argues that the ECA definition is more accommodating as it includes non-natural resources, such as health and human resources within its definition; while the NEMA definition is restricted specifically to natural elements only. However, the principles contained in section 2 of NEMA are more encompassing of the cultural, heritage, social, human and economic aspects considered in the ECA.

Unlike the NWA that provided different management mechanisms for resource protection and resource utilisation, the NEMA only provides measures of environmental resource utilisation, and leaves the resource directed management aspect to the Specific Environmental Management Acts under its ambit, for example, the Biodiversity Act (Act 10 of 2004) includes the management of specific species; the Protected Areas Act (Act 57 of 2003) addresses the management of specifically protected Areas, the Water Act (Act 36 of 1998) as already discussed addresses water resource management, the Waste Act (Act 59 of 2008) manages waste and the Air Quality Act (Act 39 of 2004) addresses measures for the specific management of air quality.

Section 2 of the NEMA identifies the principles to be applied in environmental management throughout the country. Similar to the NWA, the principles address the criteria of sustainability, equity, economic and social gains while protecting the environment.

Chapter 5 of the NEMA outlines the concept of Integrated Environmental Management and focuses on the principle that if activities have the potential to impact negatively on the environment, then such activities need to be assessed and authorised as a function of that assessment. The formal Environmental Authorisation process, which is guided by NEMA sections 23 and 24, is very prescriptive for applicants in terms of the requirements for specialist studies and identifying and mitigating impacts. For example:

- Section 23(2)(b) identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities, with a view to minimising negative impacts, maximising benefits, and promoting compliance with the principles of environmental management set out in section 2 of NEMA;
- Section 24 (1) in order to give effect to the general objectives of integrated environmental management laid down in this Chapter, the potential consequences for or impacts on the environment of listed activities or specified activities must be considered, investigated, assessed and reported on to the competent authority…;
- Section 24(1A)(f) every applicant must comply with the requirements prescribed in terms of this Act in relation to the undertaking of any specialist report where applicable;
- Section 24(4)(a) Procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment must ensure, with respect to every application for an environmental authorisation:
  - (i) Coordination and cooperation between organs of state in the consideration of assessments where an activity falls under the jurisdiction of more than one organ of state;
  - (ii) That the findings and recommendations flowing from an investigation, the general objectives of integrated environmental management laid down in this Act and the principles of environmental management set out in section are taken into account in any decision made by an organ of state in relation to any proposed policy, programme, process, plan or project;
  - (iii) That a description of the environment likely to be significantly affected by the proposed activity is contained in such application;
  - (iv) Investigation of the potential consequences for or impacts on the environment of the activity and assessment of the significance of those potential consequences or impacts; and

(v) Public information and participation procedures which provide all interested and affected parties, including all organs of state in all spheres of government that may have jurisdiction over any aspect of the activity, with a reasonable opportunity to participate in those information and participation procedures;

- Section 24(4)(b)(v) procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment must include, with respect to every application for an environmental authorisation and where applicable investigation and formulation of arrangements for the monitoring and management of consequences for or impacts on the environment, and the assessment of the effectiveness of such arrangements after their implementation.

A report by the Department of Environmental Affairs (DEA, 2008) found that the processes and regulations contemplated in terms of the NEMA are too prescriptive, cumbersome and costly, which results in many illegal activities taking place. For example, clearing sediment and flood debris from a bridge; a Basic Assessment in terms of the NEMA Regulations will cost upwards of R150 000 excluding any specialists studies, while the cost of actually carrying out the work may only be R50-R100 000, and should the activity trigger other legislation such as Water Use licence and Waste Permit, similar permitting processes and costs will need also need to be followed.

In terms of the list of activities requiring authorisation prior to conducting the activities, the Minister may gazette regulations outlining the "listed activities". However, there have been several sets of "listed activities" gazetted. One of the challenges for enforcement of the NEMA is keeping up to date with changes between what is or is not "listed". In relation to enforcement, it is important to determine the exact date that the potentially illegal activity was carried out, in order to determine which set of "listed activities" was applicable at the time, if any, and therefore which enforcement mechanisms are available. It is important to note that a Compliance Notice in terms of section 31L of NEMA cannot be issued for non-compliance with the provisions of repealed legislation, unless the replacement legislation very specifically states that the activities in the replacement legislation are to be considered an extension of the repealed legislation. For example if an activity was repealed e.g. GNR 385 in 2010, then a compliance notice may not be issued in relation to an activity as defined in GNR 544 in 2013, as the GNR544 does not specifically state that it's activities are an extension of GNR385.[2]

[2] Section 12(1) Interpretation Act, Act 33 of 1957 "[w]here a law repeals and re-enacts with or without modifications, any provision of a former law, references in any law to the provisions so repealed shall, unless the contrary intention appears, be construed as references to the provision so re-enacted." The GN 544, 545 and 546 do not include any "contrary intentions".

Example of this regular updating of the listed activities:

Original list

- (ECA) GN R1182 of 5 September 1997 (listed activities)(REPEALED);
- (ECA) GN R1183 of 5 September 1997 (application process)(REPEALED);
- (ECA) GN R670 of 10 May 1998 (amended listed activities)(REPEALED).

Replaced by

- (NEMA) GN R385 of 21 April 2006 (application process)(REPEALED);
- (NEMA) GN R386 of 21 April 2006 (requires Basic Assessment)(REPEALED);
- (NEMA) GN R387 of 21 April 2006 (requires an Environmental Impact Assessment)(REPEALED).

Replaced by

- (NEMA) GN R544 of 2 August 2010 (requires Basic Assessment)(*as amended)*;
- (NEMA) GN R545 of 2 August 2010 (requires an Environmental Impact Assessment)(*as amended)*;
- (NEMA) GN R546 of 2 August (Geographic specific listed activities)(*as amended)*.

Amendments currently being drafted.

NEMA section 24G makes provision for granting of an environmental authorisation in order to rectify an illegal activity. As the s24G process is a formal Environmental Authorising process, it too is fairly prescriptive in terms of the detail to be included as part of the application:

- Section 24G(1) *on application by a person who has committed an offence in terms of section 24F(2)(a) the Minister or MEC concerned, as the case may be, may direct the applicant to compile a report containing*

  (i) An assessment of the nature, extent, duration and significance of the consequences for or impacts on the environment of the activity, including the cumulative effects;

  (ii) A description of mitigation measures undertaken or to be undertaken in respect of the consequences for or impacts on the environment of the activity;

  (iii) A description of the public participation process followed during the course of compiling the report, including all comments received from interested and affected parties and an indication of how issues raised have been addressed;

  (iv) An environmental management programme; and

  (b) provide such other information or undertake such further studies as the Minister or MEC, as the case may be, may deem necessary.

- Section 24G(2) *The Minister or MEC concerned must consider any reports or information submitted in terms of subsection (1) and thereafter may:*

(a) *Direct the person to cease the activity, either wholly or in part, and to rehabilitate the environment within such time and subject to such conditions as the Minister or MEC may deem necessary; or*

(b) *Issue an environmental authorisation to such person subject to such conditions as the Minister or MEC may deem necessary.*

However, it is not compulsory to apply for s24G authorisation nor can it be directed in enforcement action, as a person cannot be instructed to make an application, it is a person's choice to apply. Further, the s24G process only addresses illegal activities, e.g. activities that are listed and should have attained environmental authorisation prior to commencement. The s24G process is not applicable to non-compliance of activities to existing authorisations. Further, the regulations do not prescribe timeframes for the s24G Environmental Authorisation process, while many of these activities require immediate remediation to the environment.

Where an activity has commenced prior to authorisation, or where there is non-compliance with conditions of authorisation, the applicable sphere of government may issue an administrative notice. For Local Municipalities this Directive is in terms of section 31A of the ECA; and for Provincial and National spheres of the Department of Environmental Affairs it may be a compliance notice in terms of sections 28(4) or 31L.

Section 28(4) of NEMA places a general duty of care on all persons, including juristic persons (such as companies and closed corporations). It provides that any person *"who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment". The measures required in terms of the above section include but are not limited to the following:*

- *investigate, assess and evaluate the impact on the environment;*
- *inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment;*
- *cease, modify or control any act, activity or process causing the pollution or degradation;*
- *contain or prevent the movement of pollutants or the causant of degradation;*
- *eliminate any source of the pollution or degradation; or*
- *remedy the effects of the pollution or degradation.*

Section 28 (4) provides further that the Director-General of the Department of Environmental Affairs or a provincial head of the relevant environmental affairs department, may, after consultation with any other organ of state concerned and after having given adequate opportunity to affected persons to inform him or her of their relevant interests, direct any person who fails to take the measures required under subsection (1) to-

(a) investigate, evaluate and assess the impact of specific activities and report thereon;

(b) commence taking specific reasonable measures before a given date;

(c) diligently continue with those measures; and

(d) complete them before a specified reasonable date".

If urgent action is necessary for the protection of the environment, the Director-General or a provincial head of department may issue such a directive, and consult and give such opportunity to inform as soon thereafter as is reasonable.

Section 31L of NEMA provides that where there are reasonable grounds for believing that a person has not complied with any term or condition of a permit or authorisation or with a provision of the law for which an Environmental Management Inspector (EMI) has been designated (e.g. to NEMA and the SEMAs), such an EMI may issue a compliance notice setting out the details of the action constituting non-compliance, and prescribe steps that the person must take and the period within which those steps must be taken or anything which the person may not do, and the period during which the person may not do it. There is a prescribed form for the drafting of a compliance notice[3], and it must include reference to the fact that such notice may be objected to and how such objection procedure works. Only a Grade 1 EMI may issue a Compliance Notice, but this grade is usually reserved for senior officials such as Chief Directors. In reality, the compliance notices are drafted by less senior staff and case officers who may be grade 2, 3, 4 or 5 EMIs and then the Notice is checked and signed by the Grade 1 EMI, but the case is being assessed and managed by the lower EMIs.

A person who receives a compliance notice must comply with that notice within the time period stated. Failure to comply with a compliance notice is a criminal offence carrying a maximum penalty of R5 million and/or 10 years (see section 31N).

[3] Regulations Relating To Qualification Criteria, Training And Identification Of, And Forms To Be Used By, Environmental Management Inspectors, Published under Government Notice R494 in Government Gazette 28869 of 2 June 2006.

3.2.3 Conservation of Agricultural Resources Act (Act 43 of 1983) (CARA)

The objectives of the Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA), are to provide for the conservation of the natural agricultural resources of the Republic by the maintenance of the production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants.

Similar to the activities requiring licencing in the NWA, and the "listed activities" of the NEMA, section 6 of the CARA makes provision for control measures. A control measure may contain a prohibition or an obligation rather than a formal licence or authorisation contemplated in the NWA or NEMA. However, any land user who refuses or fails to comply with any control measure which is binding on him, shall be guilty of an offence. Applicable control measures, as per GN R1048 of 25 May 1984, relating to potential impacts on or from riparian areas include *inter alia* -

Control measure 4: Protection of cultivated land against erosion through the action of water;
Control measure 6: The prevention of waterlogging and salinisation of irrigated land;
Control measure 7: The utilisation and protection of vleis, marshes, water sponges, water courses;
Control measure 8: The regulating of the flow pattern of run-off water;
Control measure 9: The utilisation and protection of veld;
Control measure 13: Restoration or reclamation of eroded land;
Control Measure 14: Restoration and reclamation disturbed or denuded land;
Control measure 15: Declaration of weeds and invader plants;
Control measure 16: Indicators of bush encroachment.

One of the biggest impacts as a result of illegal activities within riparian areas is the resultant soil erosion and sedimentation, either due to bank destabilising, loss of vegetation, altered flow and sediment patterns, or increased erosive power of the watercourse. The CARA is predominantly focused on the conservation of soil resources, and agricultural impacts to water resources, and is not up to date with modern-environmental norms and principles. However it is still an important and applicable statute when addressing objectives for enforced river rehabilitation; in many instances non-compliance with relevant control measures is also non-compliance in terms of the NEMA and NWA.

The CARA does not include any administrative enforcement mechanisms. However, a person can be convicted of a crime if found to be in contravention of section 6 of CARA, e.g. non-compliance to control measures.

3.2.4 Compliance and Enforcement Discussion

When considering the compliance and enforcement legislation, there are several important points to consider:

1. In contradiction to the prescriptive and detailed nature of the processes of obtaining formal Environmental Authorisations (including licences and permits), cases of non-compliance or illegal activity are only guided by the requirements included in the NEMA section 31L pre- and Compliance Notice and NWA section 53(1) pre- and directive which state respectively:
    - o NEMA section 31L (2)(b), a compliance notice is only required to *set out any steps the person must take and period within which those steps must be taken*;
    - o NWA Section 53(1) Directive only *directs a person to take any action specified in the notice to rectify the contravention.*

   The section of law does not set out in detail, like the formal environmental authorising process, what those requirements, steps or actions must entail, how the impacts should assessed or criteria that the cases should be assessed on, for example section 27 of NWA or sections 23 and 24 of NEMA. It is important to note that a section 31L pre-Compliance Notice would be issued prior to an s24G Environmental Authorisation being granted, or the specialist studies requested in the s24G process. In many cases where a NEMA section 31L Compliance Notice or NWA section 53(1) Directive has been issued, the illegal activity or non-compliance requires immediate attention. It is also noted, but will not be addressed in this research, that the compliance and enforcement process does not require public participation, however, should the s24G Authorisation process be followed, and then public participation will be required, similar to the formal authorising process.

2. In the context of law enforcement, each statute makes provision for regulatory and enforcement functions and inspectorates. Each regulatory body, identified in the relevant Acts, is tasked with ensuring compliance of that specific Act. However, in carrying out the compliance and enforcement functions of one body may require the support of an adjacent enforcement body, due to overlaps in jurisdiction between the statutes, especially when dealing with rivers. Further, as mandates of institutions are allocated vertically and horizontally across the three spheres of government (National, provincial and local government), it is important to identify who is responsible for enforcement, at which level of government, and what their objectives and enforcement mechanisms to support enforced rehabilitation activities on rivers in an urban context are. Table 3.3

summarises the various institutions and enforcement mechanisms that may be applicable in relation to enforced rehabilitation activities on urban river reaches.

Table 3.3 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, Forestry and Fisheries	Conservation of Agricultural Resources Act, Act 43 of 1983	s.7 Directive	To comply with a control measure.	National Municipal Irrigation Boards	Executive officer and authorised persons
	GN R1048 in terms of section 6 of the Conservation of Agricultural Resources Act, Act	s.4(2) Directive s.6(2) Directive s.13(2) Directive	Contraventions of specific control measures		

	43 of 1983	s.14(2) Directive s.16(3) Directive			
	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

3. In enforcement action, an administrative warning notice (whether a NEMA S31L pre-compliance notice or ECA s31A pre-directive or NWA s53 (1) pre-directive) is issued with instructions to carry out ***any steps*** the transgressor must take. Thereafter, the person may apply for s24G Environmental Authorisation, where they may be given more detailed guidance/requirements, in terms of specialist studies or impact identification and mitigation. Should the s24G process not be followed, a Directive or Compliance Notice will be issued with instructions to implement the *steps* identified in the pre-compliance notice or pre-directive. Should new actions or instructions be required, e.g. due to new information, the existing administrative notice must be withdrawn and a new pre-directive or pre-compliance notice will need to be issued containing the new information; the new requirements cannot simply be added in when issuing the Compliance Notice or Directive. This is a timely exercise and negates the arguments of urgency usually associated with compliance and enforcement actions.

In summary these points result in two problems:

1. The resultant impacts of illegal or non-compliant activities are not identified or mitigated in as much detail as a formal authorisation application;
2. People, in various sectors, will willingly follow the liability route, as fewer studies are necessary, less cost involved and less impacts and mitigation are identified and required.

By addressing problem one will go a long way to minimising problem two. However, in order to address problem one, the enforcement process needs to be further explained.

3.3 Problem Identification

As part of the regulatory framework, routine monitoring is carried out to check compliance with authorisations, licences and/or permits, or to inspect with regards to complaints received about potential illegal activities. “Enforcement occurs after one or more violations have been detected” (Gauteng Provincial Government, 2004).

3.3.1 The Enforcement Process

The basic enforcement process as outlined in the Environmental Management Inspectors Training Manual, as it pertains to various statutes is illustrated in Figure 3-1. The process commences with a site inspection either to monitor compliance of permit conditions, or as a result of a complaint received from the public. Should a violation be identified, the routine site inspection is upgraded to an investigation. If there is a contravention then the official issues a written warning notifying the transgressor of the Department's[4] intention to issue an Administrative Notice (Directive or Compliance Notice). This warning notice also includes a set of instructions to remedy the contravention. These instructions may include the request for specialist studies and a requirement to submit a rehabilitation plan. However, these instructions currently do not include any guidance as to the objectives of the rehabilitation plan or remedial activities, or indicators to measure progress or achievement. Upon acceptance of these studies and rehabilitation plan the official will then issue the directive or compliance notice to carry out the rehabilitation plan. Criminal and civil prosecution may be carried out concurrently to the administrative notices, or as a result of non-compliance with the notices.

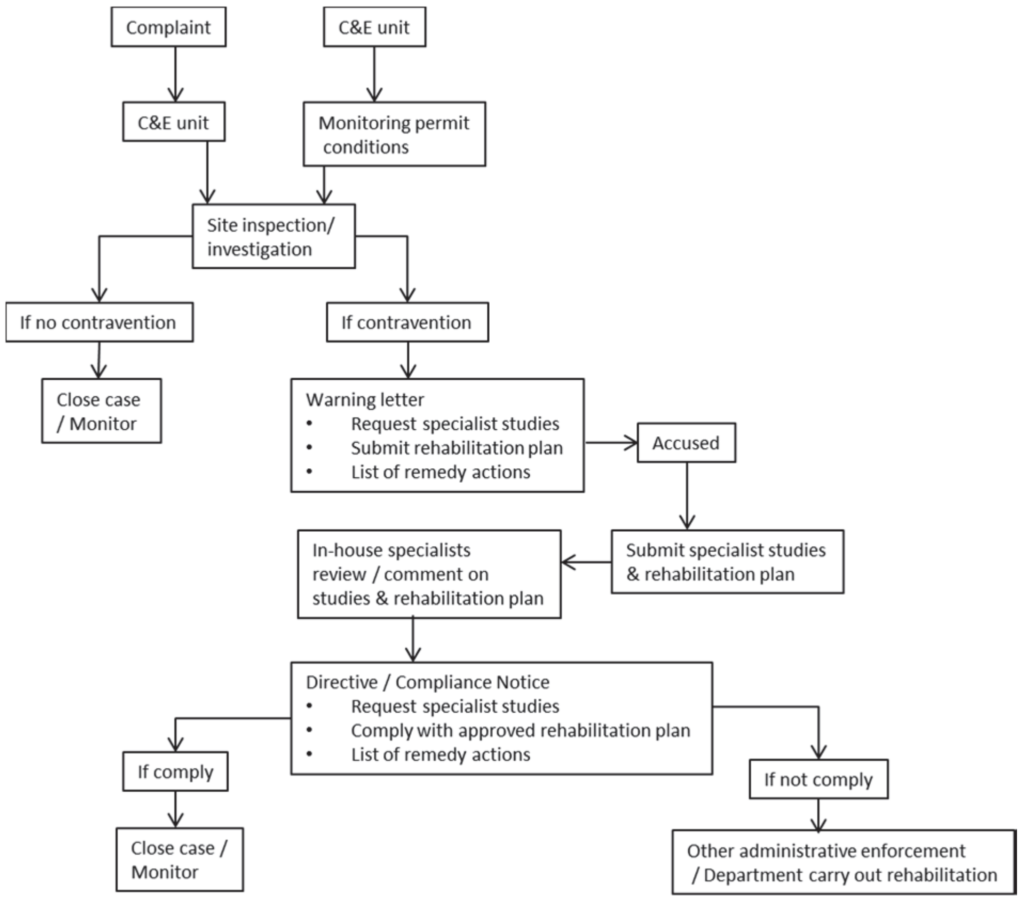


Figure 3-1 The basic enforcement process for issuing Administrative Notices (directives or compliance notices).

In compliance with law, the instructions of the directive or compliance notice must be the same as the instructions in the warning notice. Should new information come to light, or any necessary deviations, then the existing warning notice must be withdrawn in writing and a new warning notice with those additional requirements or deviations must be issued. Further, once a contravention has been addressed, the same contravention may not be addressed again, in

[4] Depending on the transgression will determine which Department is responding e.g. Department of Water Affairs, Department of Environment Affairs, Department of Agriculture, etc.

other words a new offence with new evidence is required. This implies that there is only one opportunity to ensure that the appropriate rehabilitation is carried out.

In many cases, the instructions for rehabilitation are commonly issued prior to the detailed studies, resulting in substantive science only being introduced into the enforcement process by the specialist studies, after the warning notice is issued. Where in-house specialists are utilised, they are usually brought into the process too late, or only asked to review rehabilitation plans once the warning notice has already been issued. These in-house specialists are not usually included in drafting the rehabilitation objectives or requirements in the warning notices, as they are located in a separate directorate with different mandates e.g. nature conservation as opposed to compliance and enforcement activities.

In the basic day-to-day enforcement process the official provides limited, if any, guidance as to:

- the impact or the disturbance of ecological functions as a result of the contravening activity;
- objectives that the rehabilitation plan needs to achieve in order to remedy the impacts of the pollution or ecological degradation; or
- indicators to monitor progress or achievement of the rehabilitation.

This is highlighted in Case Study 1: Status Quo in Chapter 5, which highlights the focus on legal box-ticking rather than environmental rehabilitation. Where integrated and targeted enforcement programmes are initiated, such as to monitor a particular industry sector e.g. the paper and pulp industry, a more concerted effort for cooperation between institution's enforcement units and use of appropriate specialists is undertaken.

Volokh and Marzulla (1996:2) identified that "(t)he current environmental enforcement systems often fail to improve the environment – because of unclear regulations, and because environmental enforcers inappropriately concentrate on technical compliance with regulations and not on improving environmental quality," in other words, that enforcement is currently focused on legislative "box-ticking". In addition, Nonet and Selznick (1978) cited in Scholz (1984:386) explain that "(e)nforcement is not viewed as the mechanical task of finding and penalising violators of unequivocal rules, but rather as the necessary elaboration, correction, and detailed specification of regulations required to achieve the intended public purpose." In contrast, Craigie *et* al (2009:50) highlight that "(t)here appears to be a reluctance among environmental authorities to give compliance advice to the regulated community for fear of being held liable for inappropriate advice." The implication is that current compliance and enforcement action is merely to punish an offender, and bring the activity into compliance with the legislation, but what is often lost in this legal box-ticking is that compliance and enforcement is also meant to rehabilitate the resultant impacts of the contravention, e.g. the qualitative aspect to enforcement. This qualitative aspect supports the Departments (Departments of Water and Environmental

Affairs) mandates as per section 24 of the Constitution (Act 103 of 1996), that: "*Everyone has the right:*

(a) To an environment not harmful to their health or well-being; and

(b) To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-

  (a) ***Prevent pollution and ecological degradation*** (emphasis added);

  (b) Promote conservation; and

  (c) Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

O'Beirne (2011:5) illustrates this focus on legal box ticking, "(o)n one project there were several authority audits during the construction of the project but the findings were often misdirected. For example, the EMP contained a requirement to spray water three times a day. Because drought conditions were prevailing a decision was made to stop spraying with water and to use a chemical bind rather that could be used far less frequently. The authorities rules that the failure to spray with water constituted non-compliance despite the reasoning offered for using the binder instead."

While the mandate of regulation is to ensure compliance with the legislation (the quantitative aspect), it also requires the prevention of pollution and ecological degradation (the qualitative aspect). Thus the instructions contained in the directives and compliance notices, while complying with legal processes, also need to set out clear objectives and activities to ensure rehabilitation of contraventions to remedy the effects of pollution and/or ecological degradation. An example of this focusing on the illegal activity and providing little guidance on the rehabilitation activity is given in **Box 1.** The example is an extract from a Directive notice issued by the Department of Water Affairs.

The Notice is focused on bringing the activity into legislative compliance. However with regard to the specific remedial instructions included in point 6:

a) does not identify the impact on the receiving water resource as a result of the contravention such as impacts to water quality, erosion, bank stability, sediment loading, loss of riparian zone, etc.;
b) does not require a stormwater engineer to compile the stormwater plan;
c) does not identify any specific area/function/service of the impacted water resource that that the rehabilitation plan should address; and
d) suggests no objectives for the rehabilitation plan, or any monitoring to measure improvement; and
e) does not require an any aquatic ecologist, wetland specialist or geomorphologist or other specialist to be involved in drafting the rehabilitation plan.

BOX 1. Extract from a Notice of Intention to issue a Directive in Terms of Section 53(1) of the National Water Act, 1998 (Act 36 of 1998) (NWA). The activity in particular is a new housing estate that channelled the stormwater directly into a pan.

2. The directive that I intend to issue relates to you using water in contravention of the provisions of Chapter 4 of the NWA, specifically Section 22. The intended directive will direct you to stop the unlawful water use(s) within two days from receipt thereof.

3. I have reasonable grounds for believing that you have commenced with or are continuing with an activity defined as a water use in Section 21(c) and 21(i) of the NWA without authorisation as required in terms of Section 22. I have reached this opinion as a result of the following:

4. The Department received a complaint regarding the above matter and officials responded by undertaking site inspections of the property on 8 June 2006, 11 July 2006 and 12 January 2007.

4.1 The findings on the site indicate that you have altered the banks of the watercourse on the property by constructing storm water discharge canals on the banks into the pan, a Section 21(i) water use, on the property without the necessary authorisation in terms of the NWA from this Department.

4.2 The findings on the site also indicate that you have impeded the flow of water in the pan and, altered the banks, bed, course or characteristics of the pan by constructing a bird hide in the pan, section 21(c) and (i) water uses on the property without the necessary authorisation in terms of the NWA from this Department.

or

5. The water uses on the site are as follows:

5.1 Impeding or diverting the flow of water in a water course and altering the bed, banks, course or characteristics of a water course – Section 21(c) and (i)

6. In accordance with Section 3 of the Promotion of Administrative Justice Act, 2000 (Act 3 of 2000), I hereby afford you an opportunity to make representations in writing to me by close of business on **1 May 2007**, should you believe there are any compelling reasons for me not to exercise my powers in terms of Section 53(1) of the NWA to issue a directive which will require you to, amongst others:

6.1 Stop impeding or diverting the flow of water in a watercourse;
6.2 Stop altering the beds, banks, course or characteristics of a water course;
6.3 Submit a storm water management plan to this office;
6.4 Submit a Rehabilitation Plan within 30 days from receipt of the directive for approval to this Department;
6.5 Submit an Gauteng Department of Agriculture, Conservation and Environment (GDACE) approved Environmental Management Plan (EMP) to this office for comments, inputs and approval before rehabilitation work starts, and
6.6 Remove all structures and rehabilitate the bed and banks of the watercourse at your own cost.

7. I would also like to bring to your attention that to use water without an authorisation constitutes an offence in terms of Section 151 of the NWA.

This current lack of qualitative support or guidance in the enforcement regime results in the particular illegal activity being addressed, but the objectives for rehabilitation do not adequately or appropriately address the resultant impacts in the environment. This can be attributed to the “insufficient skills and competences amongst environmental practitioners” (DEA, 2001:31). Similarly, as no specific guidance or standard assessment procedure is provided, adjacent cases may be addressed in contrast or even in conflict to each other, such as different objectives or focus areas, especially where adjacent cases arise at different stages in time. For example, one property is granted an authorisation with a condition of a 30 metre riparian buffer, while the adjacent property downstream requires a 100 metre riparian buffer. One of the more concerning potential results of this current enforcement regime is that the enforcing institution could be taken to court by the public for failing to:

- carry out its mandate in terms of providing “*a safe and protected environment and preventing pollution and ecological degradation”* (Constitution, 1996);
- for failing to rehabilitate the impacts to the environment; or
- questioning the validity of the current rehabilitation objective, especially where the illegal activities have resulted in downstream negative impacts such as damage to property or person(s).

Therefore, as Ludwig and Iannuzzi (2006) point out, “successful rehabilitation requires specification of desired environmental endpoints, and a generally applicable method for valuing and comparing possible rehabilitation endpoints is needed.” This is further supported by Rogers and Bestbier (1997), who contend that the proper documentation of decisions that have been taken including the reasoning behind those decisions will provide the institutional memory to keep future management on-track and is should be a fundamental principle of administrative justice. O’Beirne (2011:9) concurs that for effective enforcement it is essential to obtain high-quality, consistent and defendable information and to ensure that this information is routinely and systematically available.

3.3.2 Accountability

The Promotion of Administrative Justice Act, Act 3 of 2000 (PAJA) requires that 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 of South Africa 1996. The PAJA requires administrators (which includes an organ of state or any natural or juristic person taking administrative action e.g. an enforcement official) to be accountable for their decision making. The PAJA goes on to define a decision as:

any decision of an administrative nature made, proposed to be made, or required to be made, as the case may be, under an empowering provision, including a decision relating to – inter alia:

(a) Making, suspending, revoking [sp] or refusing to make an order, award or determination;

(b) giving suspending, revoking[sp] or refusing to give a certificate, direction, approval, consent or permission;

(c) issuing, suspending, revoking or refusing to issue a licence, authority or other instrument;

(d) imposing a condition or restriction;

(e) making a declaration, demand or requirement.

Therefore in the issuing of enforcement mechanisms requiring rehabilitation activities to be carried out, the administrators e.g. compliance officers, are accountable for their decision making in determining what the rehabilitation objectives are, what requirements are necessary and the approval of any submitted rehabilitation plans. In this context, the administrators can be called to court to prove and defend their decision-making. According to du Plessis (2009:20) "(t)hese provisions have recently been used by litigants seeking to challenge the validity of administrative enforcement measures, and environmental compliance and enforcement authorities should accordingly be prudent in using such measures to ensure that they withstand judicial scrutiny."

Decision making relating to activities, in or along watercourses, lies within the mandate of many different institutions and at various spheres of government. In terms of the PAJA, all these decision makers are accountable for their decisions. In the context of good governance, these various administrators should be making coordinated decisions, e.g. in consultation with each other. However, with regards to enforced rehabilitation activities on urban rivers, there appear to be more cases than exceptions, where contradicting decisions by the various institutions/administrators have been made. For example, a municipality issuing an ECA section 31A Directive to a land owner to clean up dumped material on a property and remove alien vegetation, when the land owner commences his clean up the Department of Environmental Affairs then issues a NEMA section 31L Compliance Notice, as the activity requires environmental authorisation as it is removing material within the floodplain.

A second key challenge relates to the myriad of legislation applicable especially to water resources management and in particular riparian and riverine areas; because there are so many overlapping statutes and mandates, it is often assumed that it is another Department's responsibility. Naiman, *et al.* (1993:211) surmise this problem that "(r)egulatory institutions usually have only one jurisdiction for a portion of the resources in the riparian corridor, and often the institutional mandates are conflicting."

For example, the removal of silt or sediment from a river, as a result of bank collapse will require authorisation in terms of:

- National Environmental Management Act, Act 107 of 1998, GNR544 Activity 18 the excavation of $5m^3$ or more of soil from a watercourse;
- National Water Act, Act 36 of 1998, section 21(i) altering the bed, banks, course or characteristics of a watercourse;
- Mineral and Petroleum Resources Development Act, Act 28 of 2002 for the excavation of $5m^3$ of sand if the sediment is then sold to re-coup costs;
- National Environmental: Waste Act, Act 59 of 2008, if the sediment is disposed of;

- National Heritage Resources Act, Act 25 of 1999 for affecting the shell midden of the watercourse or conducting linear activities over 300metres or longer;
- Conservation of Agricultural Resources Act, Act 38 of 1983 if the river is on land zoned for agriculture; and/or
- National Environmental Management: Protected Areas Act, Act 57 of 2003, if the river is in a mountain catchment area, nature reserve, or protected area, or within the 5km buffer around one of these areas.

Each of these authorisations is obtained through a different institution and application process. In conjunction municipal by-laws will also still need to be complied with. Most of these statutes are regulated and enforced by different institutions. This burdensome list of legislation contributes to the complexity of the policy environment the officials operate within. Thus Deason *et al.*, (2010:688) observe that "(t)he policy environment causes many public agencies to apply independent planning and decision making processes to address the particular problems falling under their jurisdictions, often with little coordination among program goals and execution, despite the reality that such programs often address interrelated problems of single rivers."

3.3.3 Capability and Capacity of Enforcement Officials

A major challenge for environmental compliance monitoring and enforcement is the capacity and capability constraints of the sector. O'Beirne, (2011:9) points out that this "refers to both the capacity in terms of the number of resources compared to the number of projects and activities that need to be controlled, as well as the capability to assess and interpret the compliance monitoring information." He goes on to point out that between 1997 and 2006 there were some 44 000 applications for environmental authorisations and permits, with a significant increase after 2006 following NEMA regulations; however by the end of 2009/2010 financial year only 1073 Environmental Management Inspectors were on the books.

In addition to these capacity constraints is the capability constraints of those officials. O'Beirne (2011) highlights that a single case officer may receive a multitude of applications that have to do with a variety of activities and multiple potential impacts on the environment; and it is simply unfair to expect the official to be an expert in each and every one of these activities, impacts and cases.

Currently the qualifications for individuals in compliance and enforcement posts do not require ecological sciences experience, and a background in law is preferred. While environmental management is a good starting point for reviewing EIA applications, it falls short when determining the impacts of contraventions on ecosystems and their functions. For example, consider these advertised posts in the compliance units of the Departments of Water Affairs and Environmental Affairs respectively, where the specific requirements have a legal rather than scientific emphasis:

Example: Department of Water Affairs (as advertised on 24 April 2012)

Post: Deputy Director: Compliance and Enforcement

Requirements: A Water-related Degree/National Diploma or equivalent Degree/National Diploma. Six to ten years relevant experience in compliance issues. Knowledge of water use, monitoring and enforcement. Knowledge of water use licence applications. Knowledge of the implementation of the National Water Act, 1998 (Act 36 of 1998).

Example: Department of Environmental Affairs (as advertised April 2010).

Post: Assistant Director: Reactive Administrative Enforcement

Requirements: A law degree or Environmental Management degree or equivalent relevant three-year tertiary qualification plus extensive working experience. Investigation best practice, knowledge of environmental policies, legislation, international instruments, civil procedure, criminal procedure, constitutional law and administrative law. Knowledge of the justice system and the integration of law and science. Understanding of the compliance and enforcement management system.

Compliance enforcement officials do attend training in enforcement procedures, it is primarily focused on the Criminal Procedures Act (Act 51 of 1977)(CPA) and the "legalese" of the relevant environmental legislation. This training does not include identifying the specific impacts of ecological degradation of contraventions and illegal activities, nor does it include mechanisms for rehabilitation, such as setting rehabilitation objectives or determining indicators for monitoring (EMI training manual). Ideally, in line with international practice, the compliance units should include specific specialists, such as botanists, or ecologists, so that cases that affect those ecosystems are managed by the relevant specialist within the enforcement unit. However, these fields of science are not as popular and/or working in the compliance sector is not as appealing as more lucrative sciences and private sector work, therefore currently there wouldn't physically be enough of these specialists available in South Africa to ensure each of the enforcement units had their own specialist.

3.3.4 Staff Turnover

South Africa has strict laws regarding employment equity and Black Empowerment, which in part, contribute to the appointment of less qualified or capacitated staff in order to meet "quota" requirements. The turnover of these "quota" staff is high, with staff only remaining in appointed positions for 1-2 years, "(t)he turnover is essentially as a result of a small supply of appropriate skilled and qualified people" (DEA, 2011:58). Consequently, this high turnover of staff negatively impacts on institutional memory.

3.3.5 Gaps and Problems

In summary the key problems and gaps identified include:

- *Quagmire of legislation*
  There are several overlapping sections in the various statutes, leading to over laps in jurisdictions and the separation of functions and mandates between the spheres of government. This leads to a lack of coordination between the enforcement institutions, and/or the slow uptake of cases due to confusion around mandates and therefore contraventions falling between the cracks.

- *Process and information too vague*
  The legislation provides little if any guidance as to remedial action as a result of enforcement processes, therefore remedial action or rehabilitation is not focused or targeted to achieve specific objectives or outcomes. There is no identification of the resultant impacts of contraventions, and therefore no monitoring measures or indicators to assess improvement or progress of the remedial activities. This also results in reporting being focused on quantitative information e.g. how many cases were processed in a year, rather than qualitative information e.g. measured environmental improvement as a result of enforcement activities. These contribute to the focus on legal box-ticking rather than environmental improvement.

- *Lack of capacity and capability*
  There is insufficient staff and capability within the existing staff to adequately and qualitatively address the enforcement needs. There is high turnover of staff due to limited availability of necessary specialists.

3.3.6 Case Study: Status Quo

This case study provides an example of compliance and enforcement currently being carried out. The case study points to the need for a tool that will guide the enforcement officials as to the actual impacts of the activities on site that requires specific rehabilitation or remediation.

3.3.6.1 Context of the site prior to the Cycle Park

The site is located on road-reserve land in northern Johannesburg, South Africa. The property is owned by the Provincial Department of Transport and includes a tributary to the Jukskei River and a wetland. The land is earmarked for a large interchange, Figure 3-2 (the bold line indicates the area of the cycle park), which will cover the whole site and require canalising the stream. The site was unfenced and used for illegal dumping, squatting and criminal activities. The site had infestations of alien and invasive vegetation. Due to increasing housing density in the upper catchment over the last 15 years, poor stormwater retention and directed stormwater flow into the stream, the runoff through the site has increased over the past few years. According to Rountree (2011) and based on historical Google images, "(i)t is apparent that there was erosive channelling upstream and downstream as well as at some sections of the site prior to the establishment of the Cycle Park." There are several pipeline servitudes on the property belonging to the City of Johannesburg Metropolitan Municipality that traverse the stream.

3.3.6.2 Establishing the Cycle Park and subsequent developments

In 2008 an initiative was started to establish a temporary cycling park on the land until such time as the land is developed for the proposed interchange. The Cycle Park signed a lease with the Department of Transport; erected fencing around the land to secure it; removed 500 squatters from the property with support from the local police; and removed the illegally dumped waste. Further, the Cycle Park managed to have several overflowing sewer manholes on site repaired, Figure 3-3. The Cycle Park then proceeded to develop cycling tracks and erect wooden

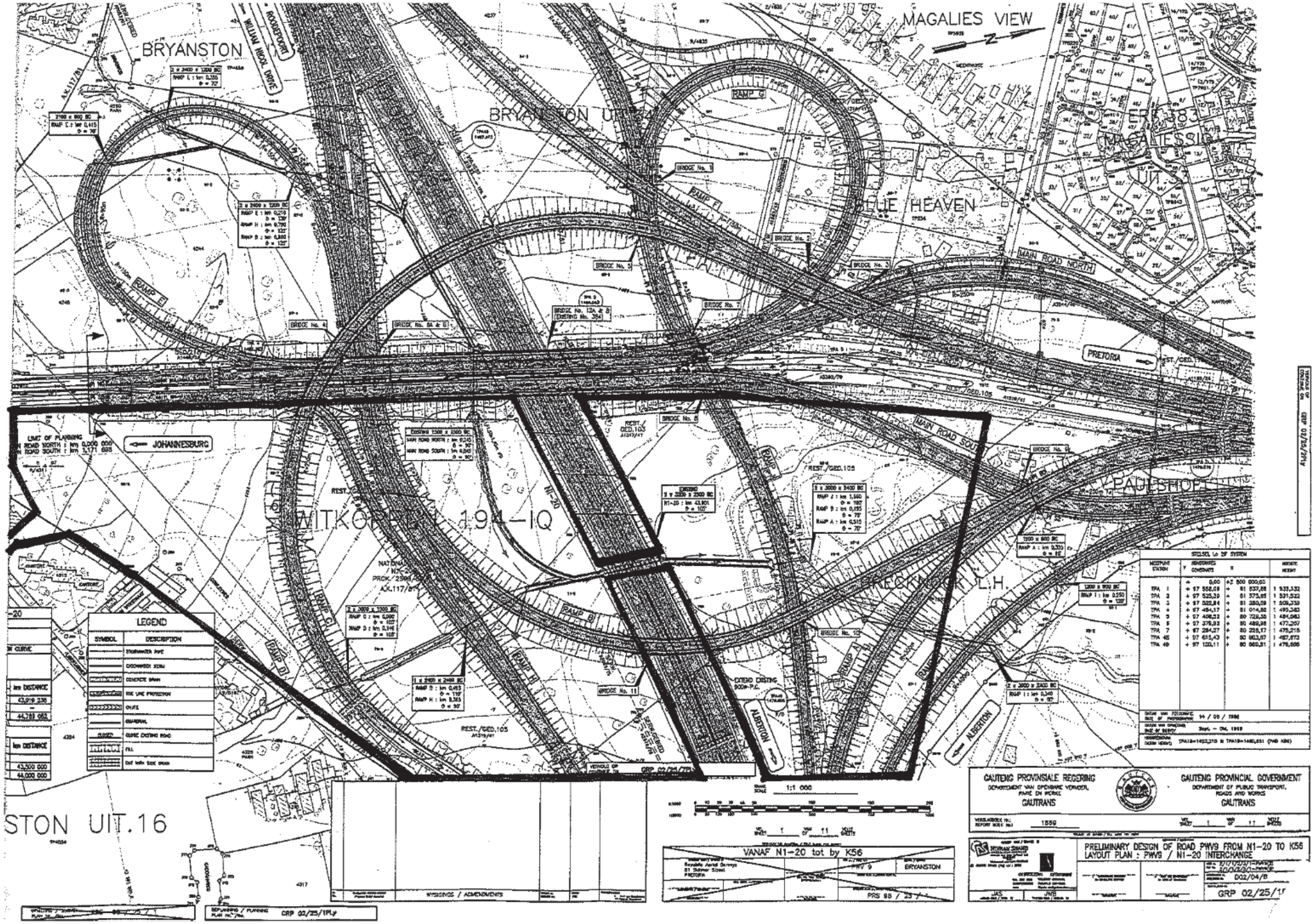


Figure 3-2 Proposed road interchange approved for the site. (Source: Ninham Shand, 1998).

structures on the land, Figure 3-4, so cyclists could traverse the stream and wetland without damaging the wetland. Because of the regular flooding of the site, the Cycle Park also widened the existing stream channel, Figure 3-5, to “improve the flow of the stream” e.g. to allow the stormwater to drain quicker and prevent flooding of the site. However ,this “widening” constituted excavation activities. The excavation lead to increased erosion on the site and the Cycle Park then installed gabions in certain locations on the site to prevent further erosion of the stream. However this widening of the stream channel effectively channelised the river. On-going removal of alien and invasive vegetation was also undertaken. Educational programmes with descriptive posters about the medicinal value of the plants in the wetland were also erected on the site.

Figure 3-3 One of nine overflowing sewerage manholes prior to the Cycle Park (Source: Author)

Figure 3-4 The wooden structures are raised over the wetland to prevent cycling through and damage to the wetland

Figure 3-5 Example of the widening of the stream by the Cycle Park

Subsequent to the establishment of the Cycle Park, requests by the Cycle Park and residents were made to the Municipality to improve the management of stormwater in the area to protect the wetland. Flooding both upstream and on the cycle park site over the past five years has caused damage to the municipal pipe infrastructure, resulting in the Municipality needing to encase the pipes across the stream in concrete, but no mitigation has been implemented to attenuate the flow. The increased flow has exacerbated the erosion in the areas where the Cycle Park widened the channels causing severe erosion in the stream and wetland, Figure 3-6. Increased urbanisation in the upper catchment of the stream, coupled with directed stormwater flow into the wetland, has resulted in severe gully erosion. Appropriate attenuation and flow dispersal would have reduced the rate of erosion. In an effort to prevent further erosion in the stream channel, the Cycle Park installed several gabions. During several major flooding events in the past five years, these gabions were washed away or severely damaged.

Figure 3-6 Severe gully erosion.

3.3.6.3 The Complaint

In 2011, a complaint was received by the Gauteng Provincial Department of Environmental Affairs (Gauteng Department of Agriculture and Rural Development, GDARD) regarding the alleged illegal activities in a wetland and stream. The alleged illegal activities relate to the construction of bridges (wooden structures) within a wetland and the excavation of more than $5m^3$ of soil from a stream, both of which require environmental authorisation in terms of the

National Environmental Management Act, Act 107 of 1998(NEMA), prior to conducting the activities.

3.3.6.4 *The Warning Notice*

The enforcement official conducted a site inspection and then issued a Notice of Intent to issue a Compliance Notice (a warning notice), Figure 3-7, setting out “rehabilitation activities” (GDARD, 2011).

2. Steps to be taken:

a. Immediately cease with all activities along the river.

b. Appoint a suitably qualified independent Specialist (i.e. Independent environmental consultant, Independent Wetland Specialist, Aquatic Specialist) to compile and submit a Rehabilitation Plan for Departmental approval, for all areas affected by the unlawful activities.

o This Rehabilitation Plan has to include but not only be limited to the following:

- The process involved in the demolition of all physical infrastructure that has been installed and / or erected along the river, including but not limited to the temporary wooden bridges as well as structures to stabilize the bank of the river, and timeframes within which this will be concluded.
- The disposal of all materials at an accredited landfill site and the submission of proof thereof.
- The process involved in the rehabilitation of all areas affected by the unlawful activities.
- Process flow diagram and the sufficient explanation thereof indicating the methodology that will be used, as well as the timeframes associated with each step involved.

c. The Rehabilitation Plan must be submitted to the Department within 30 (thirty) days of receipt of the Compliance Notice.

d. Immediately after approval of the Rehabilitation Plan by the Department, commence with the implementation of all recommendations contained therein aimed at rehabilitation/remediation of the resultant environmental damage.

e. Within 45 (forty five) days after approval of the Rehabilitation Plan fully rehabilitate the area.

f. Submit proof of full compliance with the Rehabilitation Plan within 46 (forty six) days after approval thereof.

g. Within 10(ten) days of receipt of the Compliance Notice, submit a signed submission to the Department that no further unlawful activities associated with and regulated by South Africa Environmental Legislation, will be undertaken without the requisite prior authorisations from the applicable competent authorities.

Figure 3-7 Required rehabilitation activities in the GDARD Warning Notice (GDARD, 2011)

3.3.6.5 *Response to the warning notice by the Cycle Park*

A fluvial geomorphologist and two wetland specialists were appointed by the Cycle Park. Their studies showed that the erosion had commenced prior to the establishment of the Cycle Park and was increasing due to the increased concentrated and un-attenuated stormwater flow from the upper catchment. The erosion had been exacerbated to some degree by the widening of the stream channel by the Cycle Park, but not by the installation of the wooden structures. Due to the impending development of the interchange only mitigatory actions were identified to be implemented. These included stabilising and preventing further degradation, rather than elaborate and costly rehabilitation that would be removed in the construction process of the road interchange. In addition, maintaining the wooden structures was supported, as removing them would promote cycling through the wetland (which is not a listed activity). This, in turn would cause more damage to the wetland. The response by the Cycle Park also explained the various proactive activities they had undertaken to improve the health of the wetland, such as by removing the illegal dumped waste and fixing the sewer manholes (Cycle Park 2011). The Cycle Park pointed out that erosion would continue to occur due to the increasing stormwater inflow onto the site without attenuation, and that this was the responsibility of the Municipality. Likewise, the concrete encasing of the pipelines was both detrimental to the wetland and unlawful by the same activities.

The Cycle Park also highlighted that other institutions should be involved in the remediating process due to overlapping legislation and mandates, as well as other role-players contributing to the cumulative environmental impacts.

3.3.6.6 Response by the Department

The report compiled by the primary wetland specialist was not accepted by the Department as it did not address the removal of the wooden structures.

The Department proceeded to issue a Compliance Notice with the same rehabilitation instructions as the warning notice (GDARD, 2012). The argument presented by the Department was that the structures are illegal and must be removed and the site must be rehabilitated to its previous state, despite that the previous state of the property had been in poorer health because of the illegal dumping, squatters, overflowing sewerage manholes and alien and invasive plant infestation.

Further, the Department made no effort to incorporate the other institutions whose mandate was also being infringed. Similarly the erosion and accumulation of environmental impacts on the site as a result of activities taking place upstream of the site were also not addressed by the Department.

3.3.6.7 Response by the Cycle Park

The Cycle Park, on its own initiative, contacted the other institutions and role-players to participate in a site meeting, in order to discuss an integrated and holistic way forward on the matter. As these other role-players had not received warning notices, they did not want to participate, as this would be interpreted as an admission of guilt. The other institutions did, however, attend the site meeting on 21 June 2012, including other Cycle Park-type initiatives that would be affected by the precedent set in this case, and contributed constructively towards an integrated approach. Further, a proposal for carrying out alternative rehabilitation activities on the site in substitution of removing the wooden structures was declined by the Department. The Department was only concerned about removing the wooden structures until such time as they were authorised. However, removing the wooden structures would effectively cause the Cycle Park to close down, as the cycle routes are not accessible without the structures over the wetland, unless the cyclists physically rode through the river and wetland.

Due to the impasse with the Department, the Cycle Park has subsequently submitted an application for section 24G rectification in terms of the NEMA. The Cycle Park will attempt to mitigate the admission of guilt fine based on the motivation of the good environmental work the Cycle Park has carried out on the site. This motivation is supported in writing by various institutions including the South African Police Service and a public petition.

3.3.7 Way forward

The process of rectifying the problems identified will require a two-pronged approach. Firstly, there is a need to conduct institutional and legal reform to address the discrepancies and overlaps in mandates, and lack of co-ordinated approaches in the enforcement regime. Coupled with this is the need to increase capacity of enforcement officials in the appropriate fields (not only in riparian management but terrestrial and other ecosystems as well). However this will still take much time and is linked to the wider context of South African social maturing and increased interest in these appropriate fields of science.

Secondly, administrative tools need to be developed to ensure the accountability of enforcement officials in their decision making and to promote that the appropriate rehabilitation of ecological degradation is adequately designed and carried out. The development of these tools should be carried out as an interim measure to support the enforcement regime while it still matures and the staff capabilities develop.

The South African environmental enforcement regime is still in a “developmental” stage, and as it matures the necessary capacity, capability and institutional support will evolve. In the interim it is crucial to ensure tools, guides and mechanisms are available to support the regulators and enforcement officials thereby enabling lawful, reasonable and procedurally fair decisions resulting in the prevention, and where necessary, appropriate rehabilitation of pollution and ecological degradation.

The literature highlights that there are many environmental impacts as a result of contraventions such as aspects of riverine reaches (e.g. vegetation, flow and sediment regimes, and ecological integrity), rehabilitation objectives and activities, that need to be taken into account when rehabilitating various contraventions and the scale of severity amongst them. Thus, it would be a difficult task to draft a prescriptive section of legislation to guide rehabilitation, as rehabilitation activities cannot or should not be applied uniformly across cases. The merits, impacts and situation of each individual case need to be assessed. Therefore, a decision-support tool would be more practical to help identify priority impacts as a result of contraventions, identify rehabilitation objectives (e.g. rehabilitation, restoration or remediation), identify the necessary specialists and studies that need to inform the rehabilitation plan, and identify potential rehabilitation activities and monitoring measures. A tool provides the flexibility needed for the case-by-case approach as per enforcement activities, while still providing a clear, uniform framework in which decisions are informed from a scientific base. Within the context of enforcement, and within the situation of urban river rehabilitation, this research aims to develop an initial set of tools to provide the necessary guidance to the enforcement officials, in order to improve the appropriateness and relevancy of rehabilitation measures, and to address the impacts on ecological functions of contraventions within a science-based framework.

4 TOOLS

As identified in Chapter 3 administrative tools should be developed to support environmental enforcement officials while the sector matures and the applicable staff capabilities develop. This research has developed an initial set of tools for this purpose, these include:

- Legislation Search Tool – 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 – 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 – based on the completed Site Assessment Form, the selected answers are linked to indicators of basic riverine function. The DT automatically calculates the impact of the contravening activity on the riverine environment. 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.

This Chapter describes the process of developing these three tools. The Guideline for the use of these tools is included in Appendix 2.

4.1 Legislation Search Tool (LST)

As already discussed in Chapter 3, 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.

4.1.1 How it was developed

A review was conducted of all the applicable South African national environmental legislation. The review identified sections of the legislation that were relevant to rehabilitation activities in urban rivers, authorising processes and enforcement mechanisms. Common themes or words were also identified across the different sections. The various sections of legislation, the relevant sphere of government tasked with the section of legislation and the identified theme or search words were captured into an excel spread sheet. This spread sheet was then work-shopped with the various relevant institutions. Table 4.1 provides a summary of the identified applicable sections of national legislation.

A workshop was held in Pretoria on 29 May 2012, with representatives from the Department of Water Affairs, the Department of Agriculture, the Department of Environmental Affairs, the South African National Heritage Association, City of Cape Town Metropolitan Municipality and Advocate Maritza Uys (former head of the Water Tribunal). A copy of the workshop attendance register is included in Appendix 1. Guided by their mandates and applicable legislation, the officials discussed the identified sections of the national environmental legislation, their interpretations of the sections and attached search words (tags) to each of the identified sections of legislation. The updated spread sheet was then captured into a searchable database. Each applicable section of legislation was assigned a set of applicable search word tags and the sphere of government responsible for its implementation. An interface was programmed in *Python*, an open source programme, to enable users to search specific sections of the legislation or to search the identified search tags for applicable legislation. The results of these two searches present all the sections that are applicable or overlap with the searched section of legislation or the searched tag word.

Table 4.1 Applicable Environmental Legislation reviewed for the Legislation Search Tool Database

Act	Regulation	Sections
National Heritage Resources Act, Act 25 of 1999 as amended	The Act	Sections: 28, 34(1), 38, 45, 50, 51
	GN 1512 *GG* 24116 of 6/12/2002 Types of Heritage Objects	Sections: 1, 11
Lakes Areas Development Act, Act 39 of 1975 - repealed in wholly by NEM:PAA	The Act	Sections: 1, 11(1), 15
Mountain Catchment Act, Act 63 of 1970 as amended	The Act	Sections: 2, 3, 4(1), 10(b), 11, 14
Dumping at Sea Control Act, Act 73 of 1980 as amended	The Act	Sections: 2, 5, 6
National Forest Act, Act 84 of 1998 as amended	The Act	Sections: s.3(3)(c), 4(8), 7(1), 10(1), 11(3), 12(1), 58, 66
	GN 773 in GG 30183 of 24 August 2007	Schedule A, sections: 1(a), 1(b), 1(c)
National Veld and Forest Fire Act, Act 101 of 1998 as amended	The Act	Section: 16
National Environmental Management: Biodiversity Act, Act 10 of 2004 as amended	The Act	Sections: 52, 53, 56(1), 57(1), 65(1), 69, 70(1), 71(1), 73, 75, 76
	GN 1147 of GG 30293	Appendix 1, sections: 4, 6, 8; Appendix 3
	GNR 151 in GG 29657 of 23	Publication of lists of critically

	February 2007	endangered, endangered, vulnerable and protected species.
	GN1477 of GG 32689	Draft National List of Threatened Ecosystems. 6 November 2009
National Environmental Management: Protected Areas Act, Act 57 of 2003 as amended	The Act	Section: 86
	GNR 1061 of GG 28181 28 October 2005	Sections: 4, 25(1), 39, 40, 41, 42, 45, 46, 47, 61, 64
	GNR 99 in GG 35021 of 8 February 2012	Sections: 33, 36, 39, 40, 43, 44, 51, 52, 54
Hazardous Substances Act, Act 15 of 1973 as amended	The Act	Sections: 3A(1), 9, 18, 19
	GNR 453 in GG 5467 of 25 March 1977 as amended	Section: 10
	GNR 247 of GG 14596 in 26 February 1993 Regulations relating to Group IV Hazardous Substances	Sections: 5(1), 13, 17, 26
Disaster Management Act 57 of 2002 as amended	The Act	Sections: 20, 27, 34, 41, 47, 55
Mineral and Petroleum Resources Development Act, 28 of 2002 as amended	The Act	Sections: 5, 20(1), 27, 37, 38, 39, 41(2), 43(5), 45, 46, 50(1), 53, 98, 99
National Environmental Management: Waste Act, Act 59 of 2008 as amended	The Act	Sections: 2, 7(2)(d), 16, 19(1), 20, 21, 25, 26(1), 27, 37(1), 39, 40(1), 41(1), 65, 66, 67, 68, 81(2)
Conservation of Agricultural Resources Act, Act 43 of 1983	The Act	Section: 6, 7
	GN R1048 in GG 9238 of 25 May 1984 as amended	Sections: 3, 4, 6, 7, 8, 9(1)(d), 9(2), 13, 14, 15A, 15B, 15C, 15E,16
	GN R1047 *GG* 9238 May 1984	Sections: 6, 11, 12
National Water Act, Act 36 of 1998	The Act	Sections: 19(3), 20(4), 21, 22, 32, 36, 37, 38,39, 53
	GN 399 in GG 26187 of 26 March 2004 (sub-sections 21(a) and (b) extended in GN 970 of GG 35909 of 30November 2012)	1.7, 1.8, 1.9, 1.10, 1.11, 1.12
	GN 399 in GG 26187 of 26 March 2004 (extended in GN 94 of GG 36153 of 11 February 2013)	3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, 4.17
	GA 1198 in GG 32805 of 18 December 2009 **Applies to Organs of State only**	2, 7, 8, 9 ,10
	GN 1199 in GG 32805 of 18 December 2009	2, 7, 8, 9, 10, 11
National Environmental Management Act, Act 107 of 1998 *as amended*	The Act	Sections: 24, 28, 30, 31L,
	GN R 544 *GG* 33306 18 June 2010 *as amended* (repealed GN R386 of April 2006)	Activities: 9, 11, 12, 18, [19], [20], 37, 39, 40, 41, 52, 55
	GN R 545 *GG* 33306 18 June 2010 *as amended* (repealed GN R 387 of April 2006)	Activities: 10, 17, 19, [20, 21, 22]
Environment Conservation Act, Act 73 of 1989 *as amended*	The Act	Sections: 31A

Note: For the purposes of this research the database only included national legislation applicable to rivers. This does not include estuaries as these are viewed as a different ecosystem and the scope of this research is urban rivers. Further the database includes only national legislation, as provincial and municipal legislation is site specific and the officials are more familiar with their provincial legislation.

4.1.2 How it works

The legislation search tool provides two types of search functions as illustrated in Figure 4-1. 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.

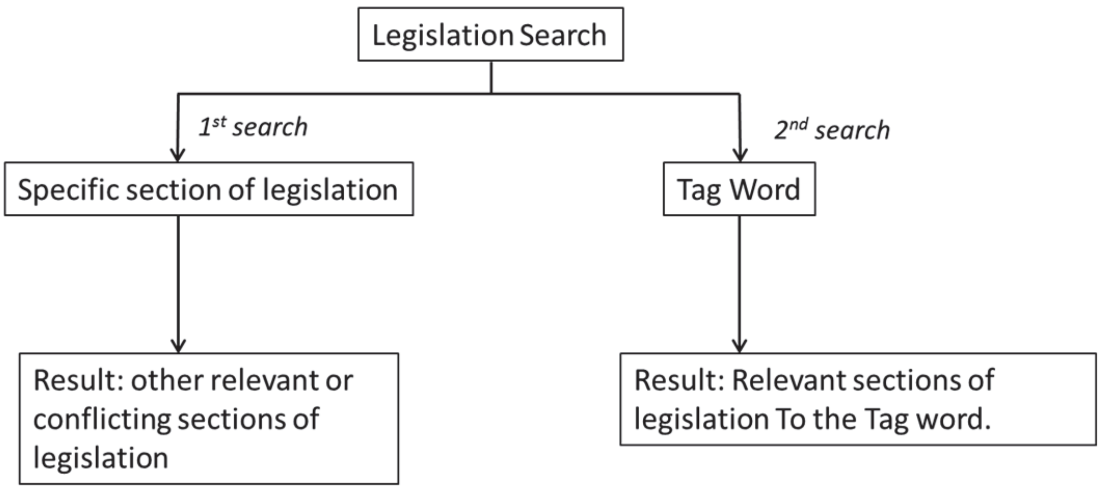


Figure 4-1 Legislation search flow diagram

In the first search type – by section of legislation, Figure 4-2, the user selects the particular section of legislation they are familiar with, in the left hand pane Figure 4-3. This is selected from the drop-down menus of the legislation and regulations. Then they scroll through the sections to the appropriate section. The user "clicks" on the appropriate section, and on the right hand pane the other applicable legislation will appear, Figure 4-4.

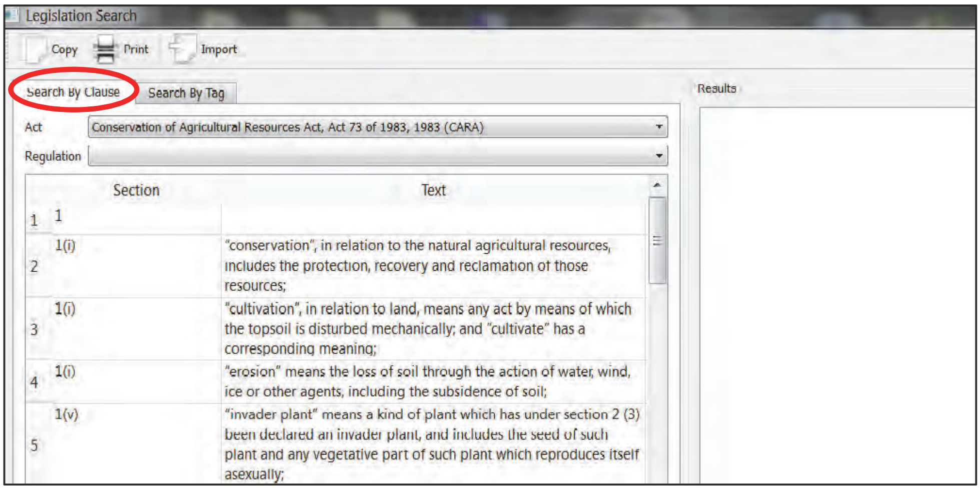


Figure 4-2 Search by Clause of legislation

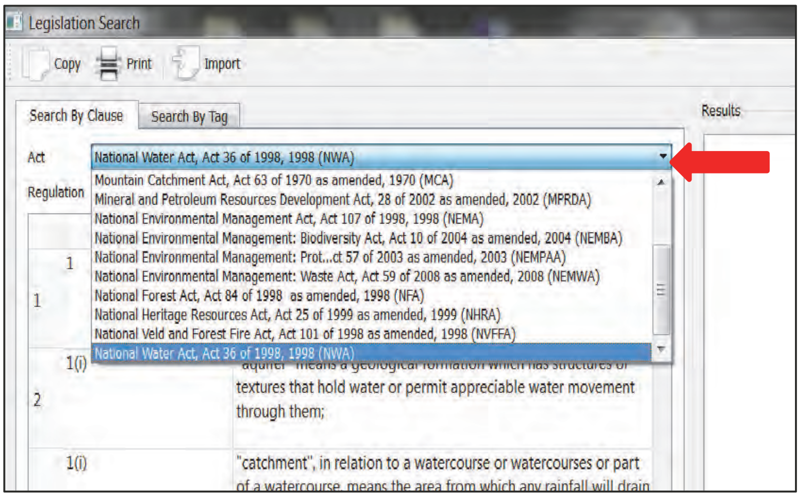


Figure 4-3 Select statute or regulation

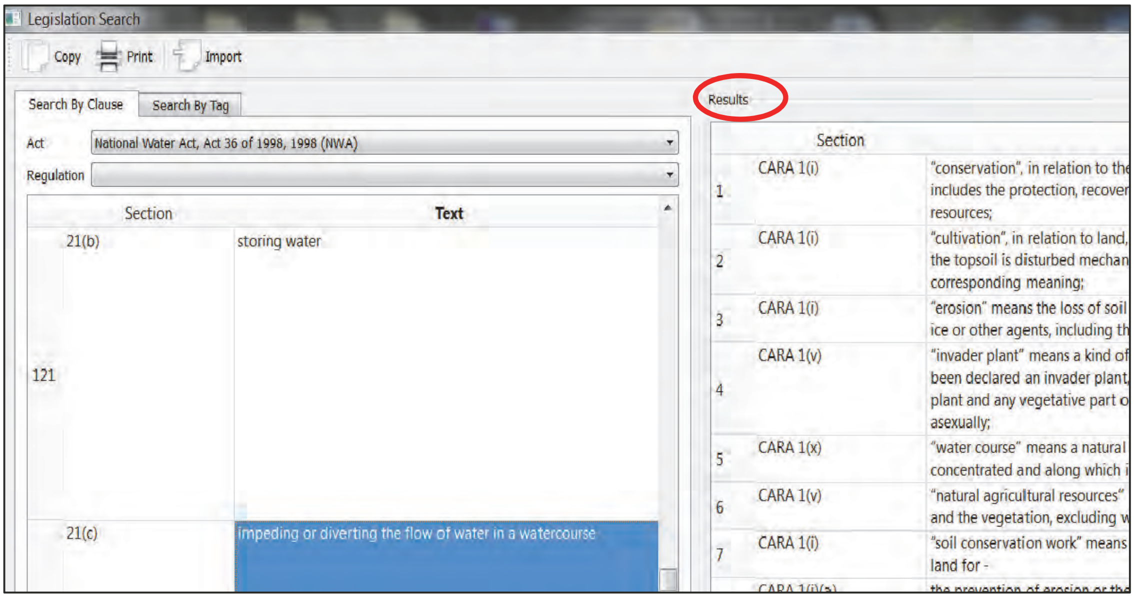


Figure 4-4 Click on particular section, and results appear on the right pane

In the second search type – by tag, Figure 4-5, the user "clicks" on the Tag search label, then selects the appropriate word from the list of words on the left hand pane. Once selected, the relevant sections of legislation to the selected word will appear in the right hand pane Figure 4-6.

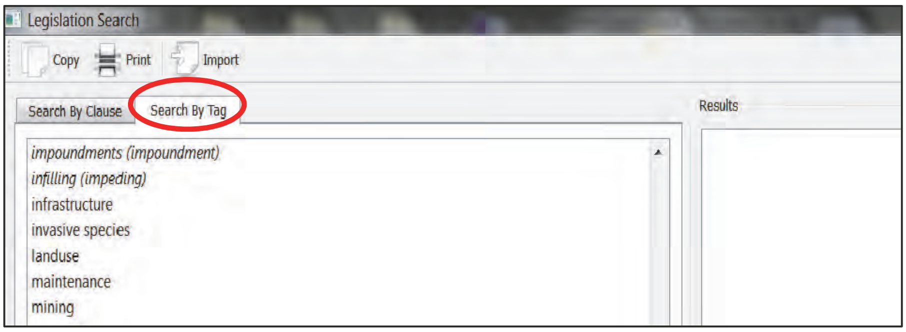


Figure 4-5 Search by tag words

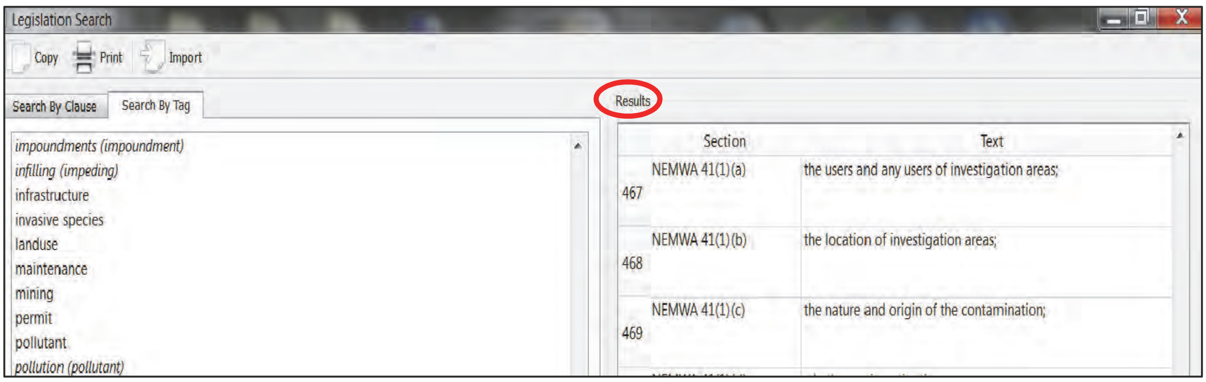


Figure 4-6 Click on tag word and results appear on right pane.

In both search options the right hand pane can be expanded in size and the user can scroll through the columns. The information presented includes the particular Act, the section number, the section text, other search word tags that are linked to that particular section, as well as the sphere of government responsible for that particular section of legislation. The search results can be printed.

A detailed user manual is included in the Guideline Document, which is included in Appendix 2.

4.1.3 Implementation

Two programmes were developed for this tool. The first programme provides for the capturing and editing of legislation (Legislation Edit). The second programme conducts the search of the database (Legislation Search). The editing programme will be provided to the institution that takes ownership for the programme and will be responsible for the maintenance and updating of the database. This will prevent different edited versions of the database being used by different institutions. The search (Legislation Search) programme will be made available to all users. Users may be required by the owning organisation to register on a database for the tool. This is in order to collect contact details, when the database is updated, the updated version could be circulated to the existing registered users. There are no licence or operating system requirements to run both of the programmes. The user requires a basic computer. The installation instructions are included in the Guideline Document.

4.2 Site Assessment Form (SAF)

When conducting site inspections, there is a Standard Operating Procedure (SOP) for Environmental Management Inspectors (EMIs). 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 develop 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. Further 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.

4.2.1 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. This involves completing the Site Assessment Form while inspecting the activities on site. Additional notes (including photos, 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. 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 and request the necessary specialist studies to be carried out to inform the rehabilitation plan.

4.2.2 Developing the Site Assessment Form

Using the arguments presented in this research, the site assessment tool needs to be compiled in the context of several criteria:

- Assess river function rather than river health;
- Be suitable to use by officials with no background in aquatic sciences or ecology, in other words not too technical or full of jargon;
- Be usable across the spectrum of enforcement officials.

The first step in developing the Site Assessment tool was to conduct a review of the existing river assessment tools for suitability of use to the context required. Thereafter, a process to determine the necessary criteria and indicators for assessment was undertaken.

4.2.2.1 Review of river assessment guidelines

Norris and Thoms (1999:199) observe that "(m)uch emphasis is being placed on rapid biological assessment in Australia, United States and the United Kingdom, particularly using indices such as the Index of Biotic Integrity (IBI; Karr, 1981) and the benthic-IBI (B-IBI; Plafkin *et al.*, 1989; Kerans & Karr, 1994), AUSRIVAS (Australian River Assessment System; Simpson *et al.*, 1996), and RIVPACS (River Invertebrate Prediction and Classification Scheme; Wright, 1995)." Further, Maddock (1999:374) notes that "(s)ome river restoration initiatives aim to improve the water quality (Jordan, Gilpin & Aber, 1987) whereas others aim to improve the ecological integrity of river systems (RRP, 1993).” In contrast, the aim of this assessment needs to assess impacts to river function, in order to set appropriate rehabilitation objectives.

An assessment form to be used by enforcement officials in the current context of environmental enforcement in South Africa, needs to be easily understood by a “layman”, should provide a basic characterisation of the site, and should ideally link to the detailed tools developed in terms of the National Water Act, Act 36 of 1998 for river classification, e.g. the EcoClassification modules. Further, the assessments need to provide sufficient information to support the officials to make reasonable decisions in determining the rehabilitation objectives and activities.

There are many guideline documents and manuals available from around the world for riverine rehabilitation or riverine management, however these are predominately based on Initiative Driven Rehabilitation using river health as the guiding objective rather Enforcement driven rehabilitation and assess river function. Table 4.2 provides a summary of these guidelines.

A review was conducted of existing riverine assessment methods to determine their suitability for use for the enforcement officials. The existing methods were reviewed based on the following criteria:

- Assessment of riverine functions versus ecosystem health;
- Suitability for use by a layperson (e.g. a person with no background in aquatic science);
    - Complexity of use;
    - Limited mathematical based methodology;
    - Limited detailed/complicated terminology;
- Suitability for site/erf specific assessment;
- Limited technical sampling requirements/ measurements needed;
- Ability to indicate specific functions or aspects requiring rehabilitation.

Table 4.2 Summary of available riparian rehabilitation guidelines and manuals (updated from Schoeman and Quinn, 2003).

Country	Title	Urban /Rural	Initiative Driven/ Enforced Rehabilitation
Australia	**A Rehabilitation Manual for Australian Streams.** Rutherfurd, I., Jerie, K., and Marsh, N. (2000). Cooperative Research Centre for Catchment Hydrology, Monash University.	Both	Initiative Driven
United States	Urban Subwatershed Restoration Manual Series. **An Integrated Framework to Restore Small Urban Watersheds.** Schueler, T. (2005). Center	Urban	Initiative Driven

	for Watershed Protection. U.S Environmental Protection Agency.		
	Stream Corridor Restoration: Principles, Process and Practices. Federal Interagency Stream Restoration Working Group (1998) www.usda.gov/stream_restoration/	Both	Initiative Driven
	Restoring Streams in Cities. A guide for planners, policymakers and Citizens. Riley, A. (1998). Island Press, Washington D.C.	Urban	Initiative Driven
	Visual surveys and assessments: an overview River voices **12**(4) 2002, Oregon, USA	Urban	Both
United Kingdom and Ireland	**River Restoration Manual of Techniques.** Vivash and Murphy (1999). The River Restoration Centre, United Kingdom.	Both	Initiative Driven
	River Habitat Quality. River Habitat Survey. Raven, P.J., Holmes, T.H., Dawson, F.H., Fox, P.J.A., Everard, M., Fozzard, I.R., and Rouen, K.J. (1998). Environment Agency	Both	Initiative Driven
	Green City Guidelines. Advice for the protection and enhancement of biodiversity in medium to high-density urban developments. Brennan, C and O'Connor, D. (2008) UCD Urban Institute Ireland.	Urban	Biodiversity Management
South Africa	**A decision support system for rehabilitation and management of riparian systems.** Quinn, N. (2003). Water Research Commission, Pretoria. 1064/1/03.	Rural	Initiative Driven
	Wetland Fix. Assessment, Management and Restoration of South African Wetlands. Wyatt, J (1997). Rennies Wetland Project	Rural	Initiative Driven
	WET-Tools	Wetlands	**Both**
	River Maintenance Guidelines. A practical Guide to Good Practice. City of Cape Town, Transport, Roads & Stormwater Directorate. (2002)	Urban	Maintenance

Seven existing assessment methods or protocols were reviewed, six of which are specifically designed for river restoration or rehabilitation. These examples are from both South Africa and international and included:

i. EcoClassification (South Africa)
ii. Quinn Assessment (SA)
iii. Environmental Reconnaissance Checklist (South Africa)
iv. River Habitat Survey (UK)
v. Stream Planning Procedure (Australia)
vi. Stream Visual Assessment Protocol (US)
vii. FISRWG Describing conditions in the stream corridor (US)

i. River Health Programme and EcoClassification (South Africa)(DWAF, 1994)

In 1994, the Department of Water Affairs and Forestry (DWAF) initiated the River Health Programme (RHP) with the intention of serving as a source of information regarding the overall ecological status of river ecosystems in the country. “Biological monitoring of the RHP also uses EcoClassification to assess data in terms of the severity of change. However, the RHP focuses primarily on biological responses as an indicator of ecosystem health, with only a general assessment of the cause-and-effect relationship between the drivers and the biological responses” (Kleynhans and Louw, 2008:A1-11). The RHP is a tool used to assess the health of South African rivers by making use of biological indicators such as fish communities, riparian vegetation and aquatic invertebrate fauna. “The rationale for using biological monitoring is that the integrity of biota inhabiting river ecosystems provides a direct holistic and integrated measure of the integrity or health of the river as a whole.” (RHP, 2008).

The EcoClassification Modules are an in-depth methodology for determining the Present Ecological Status (PES) for river health. This process is far too complicated, complex, time consuming and costly to meet the needs of the enforcement context. However, it provides a suitable and appropriate methodology for the specialists to follow where detailed specialist studies are requested in the enforcement process. In developing the site assessment tool, the criteria should align where possible with the EcoClassification modules.

ii. Assessing Riparian Habitat (South Africa) (Quinn, 2003)

The process is a habitat assessment approach suitable to the South African context that maps riparian habitat assets and problems. The assessment procedure is fairly complex and incorporates mathematical formula, which reduces the usability by a layperson. While it included a detailed assessment of habitat integrity, it does not include an assessment of water quality or species occurrence, in particular invertebrates, to confirm the habitat assessment. The land use component is very basic and doesn’t look at particular impacts as a result of the adjacent land use. The assessment does provide a good scoring mechanism for its evaluation. The assessment can be applied on a site scale or a reach scale.

iii. Environmental Reconnaissance Checklist (South Africa) (DWAF, 2004)

The Environmental Reconnaissance Checklist forms part of the Environmental Decision Support System, developed by the South African Department of Water Affairs and Forestry in 2004, Integrated Environmental Management Series 1 (IEMS).

The Environmental Reconnaissance Checklist was designed to assist the Department of Water Affairs officials to incorporate environmental issues when considering the conceptualisation phase of a development application. This falls within the ambit of initiative driven rehabilitation rather than enforcement driven rehabilitation. Further, the checklist is based on a desktop review of the development documents and does not include a site characterisation prior to the development, e.g. a as baseline characterisation against which to measure impacts.

iv. **River Habitat Survey (RHS) (United Kingdom) (EA, 1998)**

The RHS was developed in conjunction with the Environment Agencies of the United Kingdom. "The River Habitat Survey is a system for assessing the character and quality of rivers based on their physical structure; it has been developed to help the conservation and restoration of wildlife habitats along rivers and their floodplains" (EA, 1998: x). This inherently suggests that it is initiative driven. The survey is well laid out, very basic and suitable for "layman" use. However it is very long and requires 10 assessments at different transects of the reach. While this provides a comprehensive assessment of the reach of river, it is not necessarily appropriate for the enforcement context which is usually site specific and only a short reach of river. The completed survey form provides a detailed characterisation of the site.

v. **Procedure for Stream Rehabilitation (Australia) (Rutherfurd *et al.*, 2000)**

The Australian manual outlines a 12-step procedure for stream rehabilitation. The first step is to develop a vision and goals, then to share the vision e.g. garnering support, and only third to describe the stream condition. This procedure supports initiative driven rehabilitation, rather than enforcement driven rehabilitation, which requires the objectives and goals of the rehabilitation be set as a priority. Unlike the previous assessments, the procedure for determining the stream condition provides a list of attributes to be described in order to develop a characterisation of the site. In order to compile this description requires an understanding of the different elements, as well as research into the various elements. This does not suit "layman" use or the tight timeframes of enforcement procedures. Unlike the previous assessments the list of attributes does include animals and water quality to be described.

vi. **Stream Visual Assessment Protocol (United States) (USDA, 1998)**

The Stream Visual Assessment Protocol provides a basic level of stream health evaluations. "It can be successfully applied by conservationists with little biological or hydrological training" (USDA, 1998:1), this make this protocol usable by laypersons. The protocol has a very easy to follow layout which is good for layman use. It includes good context questions, such as weather on the day of assessment and 2 days prior. The protocol is also the only one to include a site layout diagram. The methodology provides a good narrative per score as well as good layman's guidance for observing the indicators. However, the completed sheet only includes the numerical score, and one needs to look up each of the reference scores to determine the site characterisation. The method provides a good record of assessment but no interpretation what the assessment means in terms of river function or river health. Similar to the previous assessments, the protocol includes no assessment of river function.

vii. **Problem and Opportunity Identification (United States) (FISRWG, 2001)**

The FISRWG report provides a list of Measurable Attributes for Describing Conditions in the Stream Corridor. Similar to the Australia Procedure for Stream Rehabilitation, the list of attributes are characteristics to be reviewed when describing the site conditions. The attributes need to be described by personal with some understanding of the different attributes and is not suitable for laypersons. Further the attributes do not include a scoring mechanism to indicate what characteristics should be of concern. The characteristics do include water quality and species occurrence but excludes land use characteristics and specific river function.

In summary each of the existing assessments reviewed had strengths and weaknesses. The context questions of the Stream Visual Assessment Protocol is important for putting the conditions observed on site on the day of assessment in context to the weather conditions of the previous days. This is important when considering turbidity and flow regime. Also the Protocol's inclusion of a site layout diagram provides a reference of observations for people reviewing the file without being on site themselves, as well as a reference when following up with inspections and evaluations. Many of the procedures included a comprehensive assessment of habitat integrity but did not include water quality as an element to habitat integrity and did not confirm the habitat assessment with an invertebrate assessment. In order to have a realistic "snapshot" of the river at the time of the assessment, the water quality is crucial. The first driver of change to a riverine system is the anthropogenic change to the catchment of the river system. This ultimately relates to a change in land use or anthropogenic activities, which was not covered in as much detail as biological integrity in the methodologies. These assessment methods focus on species specific aspects or requirements and not on the integrative aspect of ecosystem services and functions. Maddock (1999) observes that although these methods survey physical features, they do not necessarily identify their ecological value as specific functions; rather they record information on the physical features present and the geomorphological status of the channel and its surrounds. "A physical habitat assessment method must demonstrate that the physical features that are being measured are indeed of ecological significance" (Maddock, 1999:383).

Each of these existing assessment methods was developed with set objectives in mind, and all in the context of initiative-driven rehabilitation. While these methodologies are not directly applicable to the context of rehabilitation in the enforcement context, certain indicators or concepts from the different methods were drawn on in developing the Site Assessment Form.

4.2.2.2 Criteria, indicators and measures

In order to determine firstly whether activities, specifically non-compliant activities, have impacts on riparian habitats, and secondly what extent those impacts are, one needs to determine indicators of change. According to UNEP (2004) Indicators can be defined as being the measurements or statistical parameters that help us to present a meaningful picture of what is happening within the environment. This is useful to assist one to track changes over time and thereby identifying trends. In this manner indicators communicate important information to the audience. Selecting appropriate indicators for a given context is important. Gras et al. (1989), cited in Bockstaller and Girardin (2003:640) define an indicator as “a variable which supplies information on other variables which are difficult to access (….) and can be used as a benchmark to take a decision”. Bockstaller and Girardin (2003) go on to note that indicators serve two functions, one is informative in that they provide simplified information about complex systems, or “things” that are difficult to measure, and the other is as a decision- support function to achieve a certain set of objectives. Referring specifically to water management, Seager (2001) is of the opinion that indicators allow us to present scientific information to policy-makers who make decisions about water management, as well as to those who have to live with the consequences of the management decision. “For purposes of clarity, it needs to be fully understood that some indicators measure the physical, chemical or biological changes that have resulted from an intervention. Other indicators refer to the activities that lead to such changes (UNEP, 2004:28).” In relation to rivers and watercourses, indicators can be divided into multiple assemblages based on whether they generate an impact or whether they respond to an impact. The fundamental concept is that certain components affect change and are thus called “drivers” and then there’s the consequential result of the drivers - the effected components, e.g. the response indices (Kleynhans and Louw, 2008). Figure 4-7 illustrates the interaction between these components, e.g. between the impacts to system drivers and the resultant biological response. Similarly we can use indicators to determine the cause and impact to riverine functions.

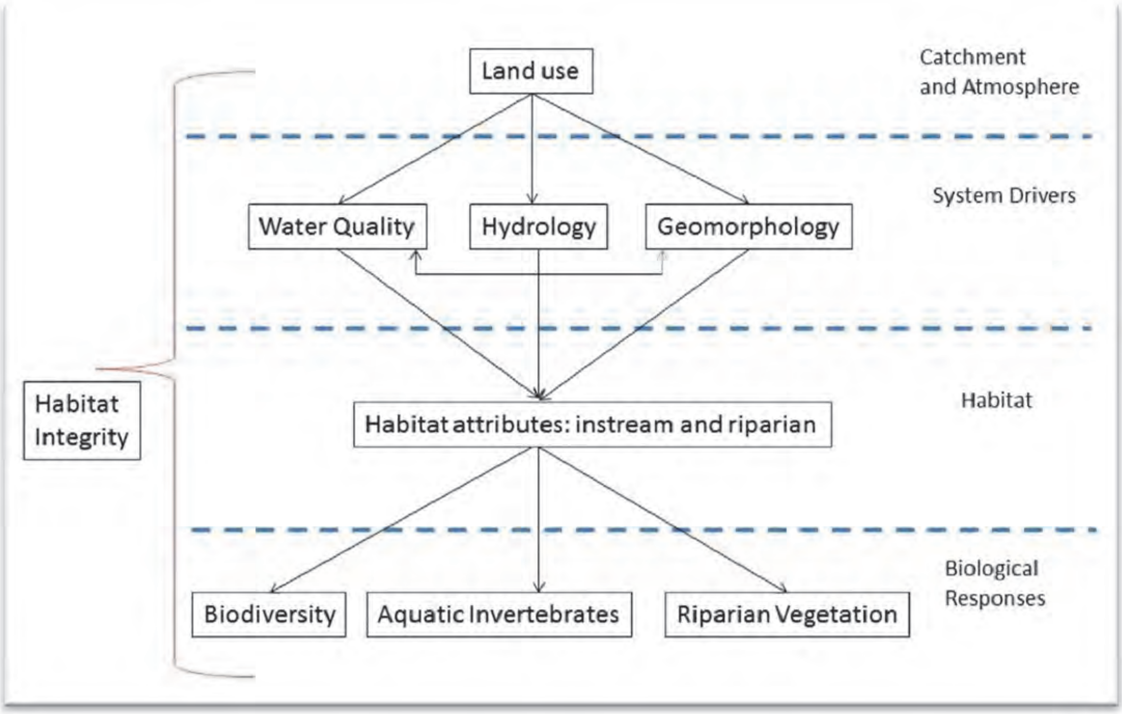


Figure 4-7 Interaction between drivers and biological responses. (Adapted: Kleynhans and Louw, 2008:A2-7)

Of particular interest are the anthropogenic (human-induced) activities in the riverine zone that drive the response changes in the riverine functions. In the context of this research, this means indicators of drivers and responses as activities and impacts on riverine functions. The use of indicators to determine impacts to the riverine functions provides a scientific-based input for determining rehabilitation requirements for compliance measures.

Walmsley (2009:8) suggests that the significance of the information collected by an indicator extends beyond that information directly associated with the indicator itself. He proposes that there are several classes and categories of indicators and their use depends on the context in which they provide information. These different types of indicators are listed in

Table 4.3.

In the context of this research, the proposed indicators would be classified as mainly process indicators, in that they review the impacts to riverine functions. It must be noted, that the aim is not to assess the river health, and therefore the actual assessment does not use quantitative indicators. However, for baseline reporting purposes there are qualitative indicators in the site description.

Table 4.3 Types of reporting and performance management indicators (Walmsely, 2009:8)

Type of indicator	Comment on usage and context
Qualitative indicators	Provide descriptive and contextual information
Quantitative indicators	Provide contextual and explanatory information based on numerical values that require data collection
Process indicators	Describe the qualitative and/or quantitative characteristics of a process. They measure ways in which services and goods are provided.
Input indicators	Measures resources, both human and financial, devoted to a particular program or intervention (i.e. number of workers, energy used). Input indicators can also include measures of characteristics of target populations (i.e. number of farmers receiving irrigation water).
Output indicators	Measure the quantity of goods and services produced and the efficiency of production (i.e. number of people served, speed of response to complaints)
Outcome indicators	Measure the broader results achieved through the provision of goods and services (e.g. economic and social benefits achieved through provision of irrigation water)
Agency-level indicators	Provide information on results for which the agency is responsible
Programme-level indicators	Provide information on results for which a programme, sub-programme or department is responsible
Performance indicators	Provide information about the achievements of an activity, a process or an organisation

When developing the indicators and measures associated with them, the following principles, from Walmsley (2004:10) were applied:

- Be clearly defined, with a concise and unequivocal interpretation
- Be quantifiable
- Constituent variables should be easily and reliably measured at a reasonable cost
- Contribute to the expression of the level of actual performance achieved in a certain area
- Be related to a specified geographical area (and, in the case of comparison analysis, it should be for the same geographical area)
- Be related to a specific time period (e.g. annual, quarterly)
- Allow for a clear comparison with targeted objectives and simplify an otherwise complex analysis
- Be verifiable and auditable
- Be simple and easy to understand
- Be objective and avoid any personal or subjective appraisal

Good indicators of river health and function should (www.watercentre.org):

- Reflect important ecological values and threats to these

- Provide easy outputs that are easy to interpret
- Respond predictably to damage caused by humans
- Relate to management goals for the specific river system
- Be cost effective to measure
- Be scientifically defensible
- Relate to appropriate scales of time and space.

By using some of the indicators from the existing methodologies, as well as indicators of activities affecting river function, a list of criteria and indicators were compiled. The initial list of indicators was discussed with various specialists including Mark Rowntree, a fluvial geomorphologist, Dr Mandy Uys, an aquatic ecologist, Nico Rossouw, a water quality specialist and Karl Renecke, a botanist. Based on the feedback from these specialists, the list of indicators was adjusted. The final list of criteria and indicators are shown in Table 4.4. The process of determining the indicators for the Site Assessment Form was an evolutionary one. The indicators used in the existing site assessment tools were used as a base set of indicators, which was then adapted and changed according to the suitability for enforcement inspection, level of simplicity and ability to measure based on observation only. The site assessment criteria were tested on several sites by enforcement officials, refer to Chapter 5: Case Studies, and adapted accordingly to the comments received from the officials, as well as review of the results.

The indicators were further broken down into measures and scores. Measures were assigned to each indicator to "measure" the level of impact of the indicator. These measures are based on descriptions, e.g. the official selects the best description that suits their assessment of that indicator on the site. Each of these "descriptions" has a hidden numerical value/score. The scoring is based on a 5-point Likert scale. These scores are hidden in the Dashboard Tool calculations to avoid bias and score-tampering. Although a numerical value is attached to the measures of the indicators, the Tools do not provide a numerical value output of the site. The tools are a basic rough assessment to guide the officials as to where the problem areas are, the specialist studies can then compile the detailed assessment.

Table 4.4 Breakdown of criteria into indicators

Indicator types	Criteria	Indicators
Qualitative indicators for reporting purposes	Site Description	• Land use and % cover • Ground cover o Type o % cover • Height of vertical banks (60°-90°) • Substrate description

		• Vegetation Composition o Type o % composition
Process indicators for assessment purposes	Site character	• Erosion on site • % Invasive vegetation • Continuity of the riverine zone • Dumping / rubble • Litter
	Erosion and armouring	• Macro channel bank erosion • Extent of erosion on S-bends • Bank armouring • Active channel bed erosion
	Hydrology	• State of discharge outlets • Canalisation / Channelling • Levees / flood prevention bank • Abstraction • Impoundments • Culverts / Bridges • Flood debris
	Water Quality	• Water Quality o Colour o Odour o Clarity o Temperature o Foam o pH o Oily sheen o Nutrients o Oxygen o Indication of life • Discharge Quality o Colour o Odour o Temperature o pH o Foam o Oily sheen

4.2.3 The Site Assessment Form (SAF) Indicators

The following sections describe the criteria, indicators and present the measures identified for the Site Assessment Form. The detailed description of the relevance of each indicator is included in the Guideline Manual in Appendix 2. When completing the Site Assessment Form, the left bank refers to the left hand side of the water course when looking upstream, e.g. against the flow of water.

Each of the proposed indicators is discussed further. The indicators are grouped according to criteria.

4.2.4 Site Description

4.2.4.1 Land Use

The indicators in this criteria look at the anthropogenic changes in the catchment and adjacent to the riparian corridor. As the land uses cannot be rehabilitated, these indicators are not measured/scored. The land use is recorded in the SAF for record purposes and to provide a site description. The land use activities may contribute to the degradation of ecosystem functions, and these can be remedied through an Operational Environmental Management Plan, but they do not necessarily constitute an “illegal” activity.

The City of Cape Town (2009b:5) 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 watercourses. Such impacts include “declining water quality, diminishing groundwater recharge and quality, stream channel degradation, increased overbank flooding, floodplain expansion, loss of ecosystem integrity and functionality and loss of biodiversity. Natural river restoration processes such as absorption; attenuation and quality improvement of runoff have also diminished,” as well as increased flow due to increased runoff and change in biodiversity abundance and composition. Many of the criteria and indicators still to be discussed in this section address these impacts. The indicators for land use include both the activity and the estimated percentage cover of the activity on the site. The land use activity is described according to Table 4.5.

Table 4.5 Description of land use activities

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. Waste Water 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 estimated percentage cover relates to the proportion of the site that is occupied by each of the land use classes and is described according to Table 4.6.

Table 4.6 Percentage coverage of land use activities

Measure	**Description**
0-20%	Little to no cover
21-50%	Some activity, less than majority of site
51-80%	Majority of site, with some areas excluded
81-100%	Almost to Full cover

4.2.4.2 Ground cover

"The greater the extent of hardened surfaces (e.g. roofs, parking lots, etc.) or area of bare soil in the catchment, the lower is the infiltration of storm-waters and therefore the greater the surface runoff and increase in flood peaks" (Macfarlane*, et al.*, 2008), as well as reduced infiltration and groundwater recharge. Figure 4-8 illustrates the relationship of increased runoff related to increased coverage by impervious surfaces. Note how as the percentage of impervious cover increases, that the rate of evapotranspiration and infiltration (both shallow and deep) decreases, while runoff increases. According to FISRWG (2001:3-23) as little as 10% increase in impervious surfaces can lead to stream degradation.

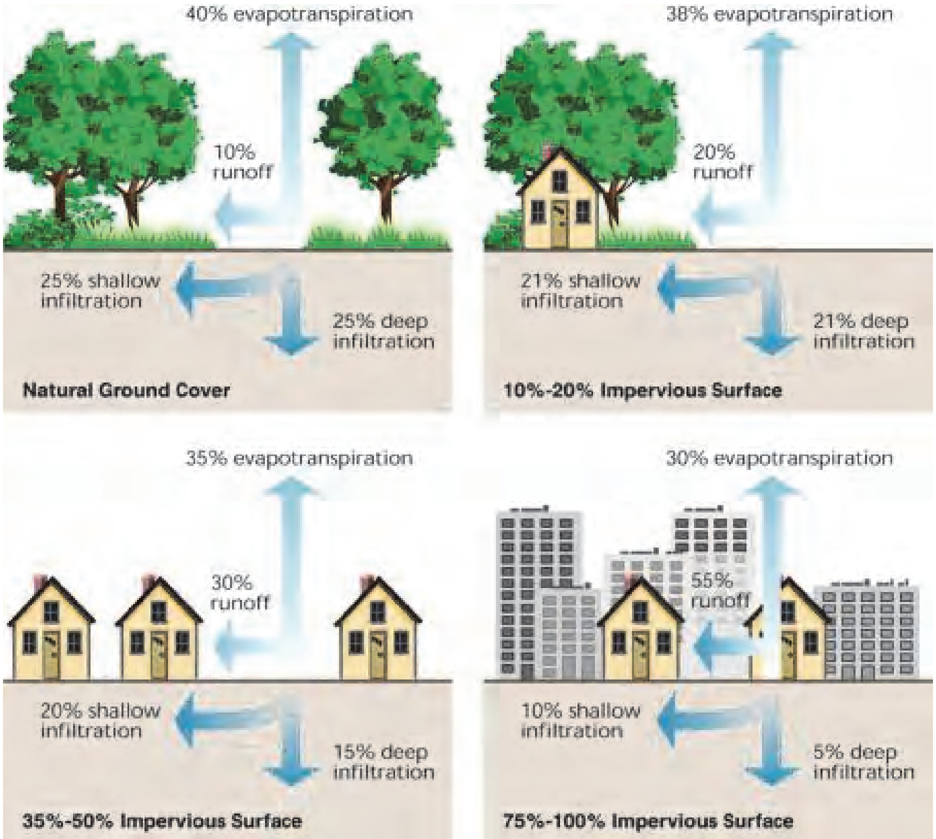


Figure 4-8 Relationship between change in ground cover and runoff. (FISRWG, 2001:3-23)

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 4.7 and Table 4.8.

Table 4.7 Type of ground cover

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

Table 4.8 Percentage coverage of ground cover

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

Ecological functions of flood attenuation, sediment trapping, carbon storage, water quality and habitat provision are all affected by activities impacting on or reducing the absorption of runoff on the site, e.g. impervious ground cover reduces vegetation cover and habitat and prevents sediment trapping.

4.2.4.3 Height of Vertical Banks (60°-90°)

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 floods to reach the flood plain or associated wetlands, which in turn can contribute to reducing the riparian zone and drying out the wetlands. The height of vertical banks is measured from the edge of the active channel to the height of the bank, and is described according to Table 4.9.

Table 4.9 Height of vertical 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 vertical banks

4.2.4.4 *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 description is measured according to Table 4.10.

Table 4.10 Substrate description measure code

Measure	Description
Fine	River bed is predominantly silt, mud, clay and sand (substrate materials < 2mm)
Gravel mix	River bed is predominantly gravel, pebbles & sand (substrate materials 2-100mm)
Coarse	River bed is predominantly gravel, cobbles & boulders (substrate materials >100mm)
No sediment	River bed is concrete bed, bed rock, no substrate materials or sediment.

Where the substrate types are classified according to the table below in Thirion (2008):

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

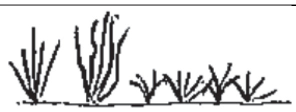
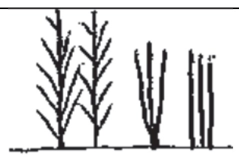
4.2.4.5 *Riverine vegetation composition*

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, but 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.

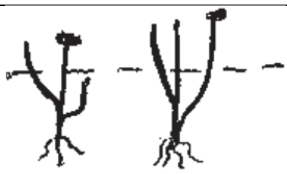
The riverine vegetation is composed of both the riparian vegetation e.g. on the flood banks and the aquatic vegetation e.g. in-stream in the active channel. DWAF (2005:16) explain that riparian areas represent the interface between aquatic and upland ecosystems; the vegetation in the riparian area may 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 4.11, whereas the vegetation type in the stream is measured according to Table 4.12**.** Vegetation composition refers to the presence of different types of vegetation on the site as well as their relative proportions (% cover) in the assemblage, as measured according to Table 4.13.

Table 4.11 Flood zone: dominant vegetation type.

Measure	**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

Table 4.12 In-stream: dominant vegetation type.

Measure	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.

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).

Table 4.13 Riparian vegetation composition: % (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 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 Form riverine vegetation composition is recorded as a description of the site rather than a measure of impact.

4.2.5 Site Character

4.2.5.1 Erosion on the site

This erosion refers to erosion taking place on the site, outside of the riverine area. Erosion in the riverine area is still to be addressed in later indicators. There are three types of erosion that can occur on site, that of sheet, rill and gully erosion.

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 occurs when the surface water forms fast flowing little rivulets that cut small channels in the soil. (Miller, 1998:553).

Gully erosion occurs when rivulets of fast flowing water join together and with each succeeding rain event cut the channels 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 occur where severe gully erosion has caused deep ditches, e.g. greater than 1 meter deep.

The erosion on site indicator is measured according to Table 4.14.

Table 4.14 Erosion on the site

Good	**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
Bad	Donga	Deep gullies forming dongas on site

Ecological function of flood attenuation increases due to greater channel width; however the other functions of sediment trapping, carbon storage, water quality and habitat provision are all affected and reduced by erosion taking place on the site.

4.2.5.2 Percentage invasive Vegetation

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 on the site and is recorded for both the flood banks as well as the active channel. Percentage invasive vegetation is measured using Table 4.15.

Table 4.15 % (percentage) invasive vegetation

Good	**Measure**	**Description**
	unknown	Not sure of the alien or invader plant 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.
Bad	41 – 60% AIP	Concentrated patches alien and/or invader species.
	60 – 100% AIP	More alien and/or invader species than indigenous.

Many enforcement 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 Guideline Document and where available images of these plants have also been provided**.**

Alien and invasive vegetation reduces habitat provision for indigenous and endemic species. However, at the same time it increases flood attenuation by slowing floodwaters, and trapping sediment. The vegetation material and sediment trapping contribute to carbon storage. Alien and invasive plants species such as black wattle can be used as fuel wood for burning.

4.2.5.3 Continuity of Riverine Zone

This indicator refers to the continuity of both the riparian corridor between the site and 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-instream zone), e.g. 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, and so on, 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 4.16.

Table 4.16 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 riparian corridor and/or zone on the site.

According to USDA (1998:9), "(a) healthy riparian zone is one of the most important elements for a healthy stream ecosystem. The quality of the riparian zone increases with the width and complexity of the woody vegetation within it. This zone:

- Reduces the amount of pollutants that reach the stream in surface runoff;
- Helps control erosion;
- Provides microclimate that is cooler during the summer providing cooler water for aquatic organisms;
- Provides large woody debris from fallen trees and limbs that form in-stream cover, create pools, stabilize the streambed, and provide habitat for stream biota;

- Provides fish habitat in the form of undercut banks with the ceiling held together by roots of woody vegetation;
- Provides organic material for stream biota that form the base of the food chain in lower order streams;
- Provides habitat for terrestrial insects that drop in the stream and become fish food, and habitat and travel corridors for terrestrial animals;
- Dissipates energy during flood events; and
- Often provides the only refuge areas for fish during out-of-bank flows (behind trees, stumps, log, etc.)."

4.2.5.4 Dumping in the River Channel

Dumping is considered the disposal of solid waste on the specific site. The solid waste may vary in composition, including garden refuse, building rubble, product waste, household waste, and so on. 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. Dumping in the river channel is measured according to Table 4.17.

Table 4.17 Dumping / Rubble

Good	**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.
Bad	=>50%	Dumping affects / covers more than half or the majority of the riverine area.

Dumping reduces flood attenuation and habitat provision and can contribute negatively to the water quality function. Dumping prevents the subsistence/cultural use of the river and reduces the aesthetic appeal at that point.

4.2.5.5 Litter in the River Channel

For the purpose of this research, 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. The litter is measured according to Table 4.18.

Table 4.18 Litter

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

4.2.6 Erosion and armouring

4.2.6.1 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. Macro-bank erosion measured according to Table 4.19.

Table 4.19 Macro-channel bank erosion

Good	**Measure**	**Description – Bank and site erosion**
	None	No erosion or cutting of macro-channel bank length
	>5%	>5% of macro-channel bank length
	>20%	>20% of macro-channel bank length
Bad	>50%	>50% of macro-channel bank length

Erosion in the macro-channel reduces habitat provision, reduces carbon storage, reduces provision of subsistence resources and reduces the aesthetic appeal of the river.

4.2.6.2 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 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 wasting events. The erosion around a cut bank can be exaggerated by increased flows and site clearing resulting in the cut bank extending further than the river bend and causing the river bank to become unstable. Cut banks are 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 Table 4.20.

Table 4.20 Extent of erosion n 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

Increased area of cut banks results in increased flood attenuation from a wider channel, increases sediment load from bank collapse, reduces carbon storage because of the banks eroding away, reduces habitat provision, reduces the water quality function by increased sediment load, reduces the subsistence and cultural utilization of the river bank and makes the river less aesthetically appealing.

4.2.6.3 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 of channels to stop lateral cutting usually leads to more problems (especially downstream). Watercourse and bank interaction are threatened by armouring such as by gabions, stacked tyres, shuttering, walls and berms. Armouring can be of differing levels of interference in the river system. For example, engineered armouring 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 also reduces the bank-watercourse interaction, although during flood events there may still be some interaction. Exposed soil or bank collapse still provides for some bank-watercourse interaction but has reduced habitat provision, and carbon and sediment trapping. By contrast, toe-armouring or vegetated banks still promote bank-watercourse interaction but still stabilise the watercourse bank from erosion. The indicator for bank modification is measured according to Table 4.21.

Table 4.21 Bank armouring

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

4.2.6.4 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. Active channel bed erosion or active down cutting is measured according to Table 4.27.

Table 4.22 Active channel bed erosion

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

4.2.7 Hydrology Indicators

4.2.7.1 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. In addition, discharge points introduce point source pollutants into the watercourse e.g. swimming pool back-wash. For these criteria the state of the discharge structure is assessed. The quality of discharge is assessed in the water quality criteria. The discharge outlet indicator is measured according to Table 4.23.

Table 4.23 State of discharge outlet structures

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

Discharge outlets contribute additional contaminants to the water quality. Where structures are in good condition they provide a small interruption habitat provision, whereas structures that have collapsed or eroded provide a larger interruption to habitat provision. Outlet structures offer no flood attenuation, carbon storage, subsistence or cultural resource, or aesthetic appeal. For recreational fishing, some discharge outlets may provide increased access to fish feeding in the warmer water from the discharge outlet.

4.2.7.2 Canalisation / Channelling

The act of intentional channelling or canalising of a watercourse is a process of straightening a watercourse and directing its flow according to human want rather than natural choice. Channelling can also occur naturally 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. Formal canalisation includes formal concrete canals for a reach of river. Informal canalisation includes erosion gullies and piecemeal straightening or retraining of the reach of river. The canalisation/channelling indicator is measured according to Table 4.24.

Table 4.24 Canalisation / Channelling

Good	**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
Bad	Straightened	Complete artificial channel or river course straightening

Canalising or channelling of the watercourse reduces flood attenuation and sediment trapping, as well as carbon storage, water quality function, habitat provision, provision of subsistence and cultural resources, and in many cases also reduces recreational use of the river.

4.2.7.3 Levees / Flood prevention banks

Where there are large floodplains, many land owners construct flood prevention banks (levees) in order to reclaim the land for utilisation. 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. 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, reduced riparian habitat provision, reduced carbon storage, reduced sediment trapping but increased subsistence utilisation. Where historic levees occur, the river system would have adapted to the change in regime, however the construction of levees is now a listed activity in terms of the National Water Act, Act 36 of 1998. Naturally occurring levees are not common in South Africa; however manmade levees are common especially in agricultural areas. A levee also constitutes infilling/dumping/impeding the flow within a watercourse. A levee can be a simple earthen embankment or more formal like stacked tyres. A levee causes canalising of the river. Levees are measured using Table 4.25.

Table 4.25 Levees or flood prevention banks measure card

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

4.2.7.4 Abstraction

There are two scales to abstraction, the first being abstraction for domestic use, e.g. 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. Should a schedule 1 activity draw commercial gain, e.g. the sale of vegetables from a small garden, this would then be considered a section 21(a) use requiring a water use license.

Without a flow-meter or other technical equipment, it is difficult for an official to measure the volume of abstraction. 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 infrastructure is usually smaller in size and capacity. Whereas abstraction on a larger, commercial scale usually involves larger and more permanent infrastructure such as a pump house or a diversion weir and channel. 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. The record of abstraction on a site is measured according to Table 4.26.

Table 4.26 Abstraction measure code

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

4.2.7.5 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. 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 (1998:12) 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., (2008:74) highlight that one of "the main threats to floodplains is the damming of streams upstream of or located within the floodplain. 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. The indicator for impoundments is measured according to Table 4.27.

Table 4.27 Impoundment measure code

	Measure	Description
Good	None	None
	Temporary	Small, temporary e.g. with 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
Bad	Large, permanent	Large, permanent diversion e.g. permanent dam such as Emmarentia dam, Bruma Lake

4.2.7.6 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 of the culvert. In peak flows, where the opening of the culverts is not sufficient, the water can back-up upstream of the culvert causing damage to the river banks, and even over-topping the culvert. Flood debris also accumulates on the culvert edges which in turn also affects the flow regime. Culverts and bridges are measured according to Table 4.28.

Table 4.28 Culverts and bridges measure code

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

4.2.7.7 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 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 flood debris indicator is measured according to Table 4.29.

Table 4.29 Accumulated flood debris measure code

Good	**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.
Bad	Accumulated	Accumulated woody and flood debris obstacles e.g. fallen trees/branches blocking flow of water and accumulating other debris.

4.2.8 Water Quality Indicators

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.

4.2.8.1 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. The presence of a colour that is different from the surrounding soil colour may indicate the presence of a chemical pollutant. Brightly coloured water usually indicates acid mine drainage or other chemical contaminants. The indicator for water quality colour is measured using Table 4.30.

Table 4.30 Water quality: Colour measure code

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

4.2.8.2 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. The odour indicator is measured using Table 4.31.

Table 4.31 Water quality: Odour measure code

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

4.2.8.3 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. Likewise, clarity affects aquatic fauna and their ability to see food or predatory threats. 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. For the purpose of the site assessment, clarity is scored by observation. The clarity indicators are measured using Table 4.32.

Table 4.32 Clarity: Observed measure code.

Good	**Measure**	**Description**
	Transparent	Completely transparent. No suspended material in the water.
	Clearish	Some suspended material in water. Slightly turbid.
	Opaque	Dirty water
	Dirty	Milky. Some turbidity.
Bad	Poor clarity	Extremely muddy. High turbidity.
	Not observed	Water clarity was not observed on site.

4.2.8.4 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.
- Discharge of heated 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 indicator is measured using Table 4.33.

Table 4.33 Water quality: Temperature measure code

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

4.2.8.5 Foam

The presence of foam on the water surface may *indicate* the presence of industrial foaming agents 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 measured using Table 4.34.

Table 4.34 Water quality: Foam measure code

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

4.2.8.6 pH

According to Marlborough, rain water is naturally acidic at about 5.6pH 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. 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.

In the Guideline manual the pH indicator is measured using an HTH dipstick, but any method for measuring pH will apply. The pH indicator is measured using Table 4.35.

Table 4.35 Water Quality: pH measure code

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

4.2.8.7 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 rare occasions, and usually in the autumn, a noticeable but small oily sheen can be the result of the decomposition of fallen leaves. The oily sheen indicator is measured using Table 4.36.

Table 4.36 Water Quality: Oily sheen measure code

Good	**Measure**	**Description**
	None	No oily sheen
	Small	Relatively small patches of sheen
	Sheen	Large or regular occurrence of oily sheen
Bad	Not observed	No observation made on site.

4.2.8.8 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. The nutrient indicator is measured using Table 4.37.

Table 4.37 Nutrient measure code

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

4.2.8.9 Oxygen

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.” The oxygen indicator is measured using Table 4.38.

Table 4.38 Oxygen measure code

Good → Bad	Measure	Description
Good	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 and some fish gapping at the surface.
Bad	Not observed	No observation made on site.

4.2.8.10 Indication of life

Dead fish, lack of aquatic animal life, lack of insects are indicators of poor oxygen content in the water body, and is likely to be linked with toxic contamination of the water, poor pH or algal growth. The indication of life indicator is measured using Table 4.39.

Table 4.39 Indication of life measure code

Good → Bad	Measure	Description
Good	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.
Bad	Not tested	No observation made

4.2.9 Discharge Quality

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. The scores are indicated in

Table 4.40 to Table 4.5.

.

Table 4.40 Discharge quality: Colour

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

Table 4.41 Discharge quality: Odour

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

Table 4.42 Discharge quality: Temperature

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

Table 4.43 Discharge quality: pH

	Measure	Description
Good	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
Bad	Not Tested	pH was not tested on site.

Table 4.44 Discharge quality: Foam

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

Table 4.45 Discharge quality: Oily sheen

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

4.2.10 Site Assessment Form

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

4.2.11 Section 1: Record of Inspection

These are the details of the assessment, Figure 4-9, 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.

SITE ASSESSMENT FORM

Section 1: Record of Inspection				
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 4-9 Site Assessment Form Section 1: Record of Inspection

4.2.12 Section 2: Site Description

The Site Description provides a record of the description of the site, per 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 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.

The site description, Figure 4-10, 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.

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 and % cover	**Land use type**	**Measure**	**% cover**		**Measure**	**% 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 4-10 Site Assessment Form Section 2: Site Description

4.2.13 Section 3: Activities on the Site

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 4-11 Site Assessment Form Section 3: Activities on the site

The third section, Figure 4-11, 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.

4.2.14 Section 4: Site Assessment

Section 4, Figure 4-12, 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 4.2.3 The Site Assessment Form Indicators.

Section 4: Site Assessment

Indicators		Left Flood Bank	Active Channel	Right Flood Bank
Site character	4.1 Erosion on site (out the channel)			
	4.2 % vegetation is invasive			
	4.3 Continuity of riverine zone			
	4.4 Dumping / rubble			
	4.5 Litter			

		Left Flood Bank	Active Channel	Right Flood Bank
Erosion and armouring	4.6 Macro-channel bank erosion (flood bank)			
	4.7 Extent of erosion on S-bends			
	4.8 Bank armouring			
	4.9 Active channel bed erosion			

		Left Flood Bank	Active Channel	Right Flood Bank
Hydrology	4.10 State of discharge outlets			
	4.11 Canalisation / channelling			
	4.12 Levees / Flood prevention bank			
	4.13 Abstraction from watercourse			
	4.14 Impoundments			
	4.15 Culverts / bridges			
	4.16 Flood debris			

		In stream
In stream water quality	4.17 Colour	
	4.18 Odour	
	4.19 Clarity	
	4.20 Temperature	
	4.21 Foam	
	4.22 pH	
	4.23 Oily sheen	
	4.24 Nutrients	
	4.25 Oxygen availability	
	4.26 Indication of life	

		Left Flood Bank	Right Flood Bank
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		

Figure 4-12 Site Assessment Form Section 4: Site Assessment

4.2.15 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.

Refer to the Guideline Document in Appendix 2 to complete the Site Assessment Form.

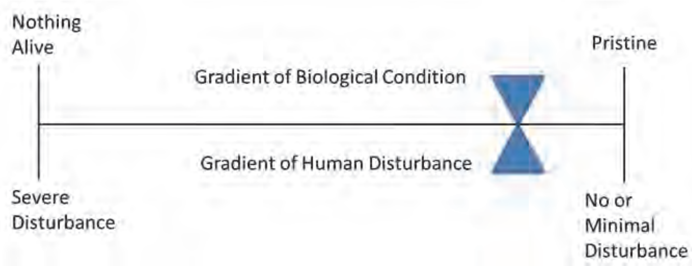
4.2.16 Comments

The indicators identified in this chapter provide a basic character assessment of the site. The criteria and indicators described here provide a basic baseline and site characterisation, more than whether the activity is compliant or not. The detailed studies once identified and conducted by specialists, will provide more detailed information about the river health, and responses of ecosystems on the site. The Site Assessment Form provides an initial indication of the impacts and response to the ecosystem functionality as a result of activities on the site.

4.3 Dashboard Tool (DT)

"By measuring biological condition and evaluating the result as a divergence from baseline biological integrity, we can thus focus on the most integrative, biological endpoint." (Karr, 1999:225) By measuring the ability of the site to provide ecosystem services/functions as a divergence from the baseline, we can focus on the most impacted riverine functions for rehabilitation. Rapport (1989) in Norris and Thoms (1999:199) suggests that "health is commonly taken to be the absence of detectable symptoms of pathology. From this viewpoint it may only be necessary to define symptoms and their indicators." The DT thus measures the disturbance of ecological functions as an indicator of the impacts of activities or deviation from the baseline.

Karr (1999:223) suggests that "at one end of a continuum of human influence on biological condition, severe disturbance eliminates all life; at the other end of the gradient are pristine, or minimally disturbed living systems (Figure 4-13, top). A parallel gradient, Figure 4-13 bottom, from integrity towards nothing alive, passes through healthy, or sustainable, conditions or activities. Below a threshold defined by specific criteria, the conditions or activities are no longer healthy or sustainable in terms of supporting living systems." These changes such as human activities in the watershed alter the river's biota and thus the entire biological context of the river, causing it to diverge from integrity.



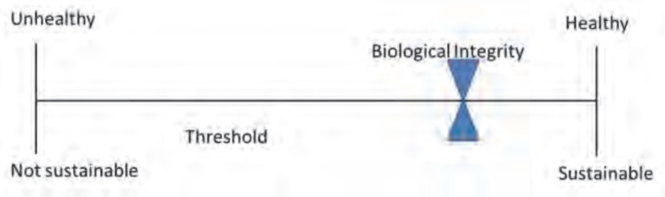


Figure 4-13 Continuum of human influence (Karr, 1999:223)

Therefore the Dashboard is based on Karr's concept, where healthy ecosystem functions is set as the baseline, and disturbance is measured along the gradient away from the baseline, based on the indicators of the SAF.

The purpose of the Dashboard Tool is to provide environmental enforcement officials with a visual indication of the impacts to the riverine ecosystem functions as a result of activities on the site, and thereby determine areas for rehabilitation.

4.3.1 How it works

The calculations in the DT are a "back-office" function of the tool, and do not require the user to carry out any calculations. The official completes the Site Assessment Form on site and when back in the office, then captures it into the DT in the Impact Form (which is identical to the Field Form), and then reviews the produced graphs in the Dashboard.

The enforcement official is required to describe which activities are taking place on the site, from a prescribed list of activities. The prescribed list is based on activities that require authorisation in the environmental legislation (e.g. the NEMA, NWA and CARA).

The DT starts with completing the Site Assessment Form. Using the SAF completed on site, the official then completes the Impact Form in the DT on their computer. This is completed by selecting the appropriate "answers" or descriptions from the drop-down lists that best describe the site for each of the indicators as observed on site. The full definition or description of these "measures" is discussed in Section 4.2.3 Site Assessment Form indicators and the Guideline Document.

A summary of the criteria, indicators and measures are presented in Table 4.46. Each indicator is answered from a list of potential measures. The river is assessed in terms of left bank (looking downstream), active channel and right bank. Each of the measures is allocated a numerical value based on a scale between 0 to 5, with 0 being the highest and indicating a good condition and 5 being the lowest and representing a poor condition or severe impact.

A matrix indicating the relation between indicators and the various activities was compiled. The matrix includes a weighting per indicator per activity in relation to the indicator-activity matrix. The weighting is based on the reliability of the indicator as well as the contribution of the indicator as an impact on the activity. This first weighting matrix of the indicators to the activities is illustrated in Table 4.47. The matrix is automatically populated with the scores from each of the indicator measures from the completed Impact Form. The scores of the weighted matrix are then summed to give a total score per activity in the left bank, active channel and right bank.

Table 4.46 Summary of Criteria, Indicators and Measures

Natural 0 → 5 **Degraded**

Site Description	Ground cover	Vegetated	Kikuyu grass	Pervious	Compacted soil	Paved/ impervious		Factor by % cover: 0-30% = 0.2 30-60% = 0.5 60-100% = 1
Site Character	Site erosion	None	Sheet	Rill	Gully		Donga	
	Alien Vegetation	no AIP		1-10%AIP	11 – 40% AIP	41 – 60% AIP	60 – 100% AIP	
	Riparian zone	Contiguous			Fragemented		None	
	Dumping & rubble	None	0-10%	10-25%	25-50%	>50%		
	Litter	None	10 pieces		10-50 pieces		>50 pieces	
Erosion and armouring	Macro-Channel bank	None	>5%		>20%		>50%	
	Extent of cut bank	None		<10%	11-50%		>50% of macro	
	Bank armouring	Vegetated	Toe	Occassional		Armoured	Exposed soil Engineered	
	Bed erosion	None		Some incision			Deep incision	
Hydrology	Discharge outlet	None		Good			Poor	
	Canalisation	Natural		Occassional	Straightened	Deeply eroded		
	Levees	None	0-1m	>1m			>2m	
	Abstraction	None		Domestic			Large	
	Impoundments	None	Temporary	Low flow	Small, permanent		Large, permanent	
	Culverts/bridges	None		Bridge	Intermediate	Culvert/drift		
	Flood debris	Scattered		None	Accumulated			
In-stream water quality	Colour	Colourless Tea	Brown	Uunatural			Milky Black Green	
	Odour	Earthy No odour					Sewerage Pesticide Hydrocarbon	
	Clarity	Transparent	Clearish	Cloudy		Dirty	Poor clarity	
	Temperature	Normal					Cold Warm	
	Foam	None		Small			Large	
	p.H	Neutral					Alkaline Acidic	
	Oily sheen	None	Small				Sheen	
	Nutrients	None	Occassional				Excessive	
	Oxygen availability	Oxygen available	Some anoxia				Anoxic conditions	
	Indication of life	Life			None observed		Dead	
Discharge quality	Colour	Colourless Tea	Brown	Uunatural			Milky Black Green	
	Odour	Earthy No odour					Sewerage Pesticide Hydrocarbon	
	Foam	None		Small			Large	
	Oily sheen	None		Small			Sheen	
	p.H	Neutral					Alkaline Acidic	
	Temperature	Normal					Cold Warm	

Table 4.47 Weighting 1: Indicators to activities

Indicator-Activity Relation		Flood Zone / bank											Active Channel										
		Alien vegetation infestation	Vegetation / site clearing	Excavation /erosion	Infilling / encroachment / impeding	Discharge	Bank stabilising	Abstraction	Impoundments	Diverting	Structures	Canalising / levess	Alien vegetation infestation	Vegetation / site clearing	Excavation /erosion	Infilling / encroachment / impeding	Discharge	Bank stabilising	Abstraction	Impoundments	Diverting	Structures	Canalising / levess
	Ground cover		80	20			10																
	Erosion on site			10																			
	% invasive vegetation	100											100										
	Continuity riparian zone		20				10							20				20					10
	Dumping & rubble				30				10	20		10				50				10	20		10
	Litter					10											10						
	Macro channel erosion			30			20					30											
	Extent S-bend erosion			30			10					10											
	Bank armouring				20		30					10						20					
	Bed erosion														80			40					30
Hydrology	Discharge outlet					10	5																
	Canalisation/ chanelling				20		10			35		30				10		20			20		40
	Levees				20		5		10	20	10	10											
	abstraction																		100		10		
	impoundments				5				80	10	10					20				80	20	10	
	culverts/bridges				5					10	80					10				10	10	90	10
	flood debris			10						5					20	10					20		
Water Qua	colour																5						
	odour																10						
	clarity: observed																10						
	temperature													80			5						
	foam																10						
	Ph																20						
	oily sheen																5						
	nutrients																10						
	oxygen																5						
	indication of life																10						
Discharge	colour					10																	
	odour					20																	
	foam					10																	
	oily sheen					10																	
	p.H					20																	
	temperature					10																	
	Total Score	*100*	*100*	*100*	*100*	*100*	*100*	*0*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Table 4.48 Weighting 2: Activity to ecosystem function

	Services / Impact activities	Vegetation / Site clearing (creation of lawns)	Excavation and erosion	Infilling, impeding and encroachment	Discharge	Bank stabilising	Abstraction	Impoundments (and decreased sediment loads)	Diverting	Structures Bridges, jetties, etc.)	Canalising and levees	Alien vegetation infestation
Left Flood zone	Flood attenuation	-20	-20	-15	0	-10	0	30	0	10	-20	20
	Sediment trapping	-20	-20	-15	0	-10	0	30	0	10	-20	20
	Habitat provision	-20	-20	-20	0	-10	0	-20	-10	-10	-20	-20
	Water Quality				-100							
	Carbon storage	-20	-10	-10	0	-10	0	10	0	0	-10	-20
	Aesthetic/recreational / cultural use	20	-10	10	0	10	0	20	10	10	0	-30
	Subsistence	-40	-10	-10	20	-10	0	-20	-10	-10	-10	-10
Active Channel	Flood attenuation	0	-20	-10	0	-10	0	30	0	10	-20	20
	Sediment trapping	0	-20	-10	0	-10	0	30	0	10	-20	20
	Water Quality	0	-10	-10	-100	0	-10	-10	0	0	0	-10
	Aquatic habitat provision	0	-20	-20	-20	-10	-10	-50	-10	-10	-20	-20
	Aesthetic/recreational / cultural use	10	-10	-10	0	10	-10	20	10	20	10	-10
	Subsistence	-10	-10	-10	-50	-10	-20	40	-10	-10	-10	-10
Right Flood Zone	Flood attenuation	-20	-20	-15	0	-10	0	30	0	10	-20	20
	Sediment trapping	-20	-20	-15	0	-10	0	30	0	10	-20	20
	Habitat provision	-20	-20	-20	0	-10	0	-20	-10	-10	-20	-20
	Water Quality				-100							
	Carbon storage	-20	-10	-10	0	-10	0	10	0	0	-10	-20
	Aesthetic/recreational / cultural use	20	-10	10	0	10	0	20	10	10	0	-30
	Subsistence	-40	-10	-10	20	-10	0	-20	-10	-10	-10	-10

Using the resultant activity score of the first weighting, the second weighting, Table 4.48, is based on whether the impact of the activities will positively (+) or negatively (-) impact on the ecosystem functions. The numerical value of the weighting is based on the severity of impact the activity will have on the ecosystem functions. The final score of this matrix is used to populate the Dashboard graphs. The results do not provide a numerical value of the ecosystem health but rather an indication of disturbance away from the baseline, where the baseline would be full function. The disturbance can be positive or negative. The graph indicates each activity's impact on the riverine functions at the site.

Addressing subjectivity:

When determining the measures of the indicators a coarse-scale approach was used. As the officials have varying backgrounds, varying experience and interpretations of the indicators, it was decided that a fine-scale of measures would lead to a greater variability in the resultant graphs which would reduce the repeatability of a particular site or case. Subjective interpretation of the observations on the site will still take place. The "score" for each of the activities is based on the sum of several indicator scores. These indicator scores are weighted per activity on the relevance or contribution of information the indicator has to the particular activity, as well as per flood zone or active channel which accommodates subjectivity to a limited degree. The weighting of indicator scores further accommodates subjectivity in the final graphs. Some subjectivity is still maintained as each official has a different understanding of each site, the activities and impacts as well as the indicators in the Site Assessment Form.

An example of this variability and subjectivity was observed in the Case Study 3 to test subjectivity of the SAF. Eleven officials completed Site Assessment Forms for the same site, and a control form was also completed. The variability of the responses as to the identified listed activities taking place on the site is indicated in Table 4.49.

Table 4.49 Example of variability between officials about listed activities on the same site

Listed Activities on site	Control	Yes	No
Vegetation / Site clearing	Yes	3	9
Excavation / erosion (dredging, removal, etc.)	Yes	6	5
Infilling, impeding, encroachment (depositing, dumping, storage)	Yes	5	6
Discharge	Yes	5	6
Bank stabilising / channel straightening	Yes	8	3
Abstraction/ stream flow reduction / transfers	No	3	9
Impoundments (includes storage of water, dams, etc.)	No	5	6
Diversions	No	6	5
Structures (bridges, jetties, piers, stormwater outlets, etc.)	Yes	10	1
Canalising / levees	No	2	9
Alien vegetation infestation	No	5	6

4.3.2 The Dashboard Graphs

The Dashboard screen, Figure 4-14, 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. 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.

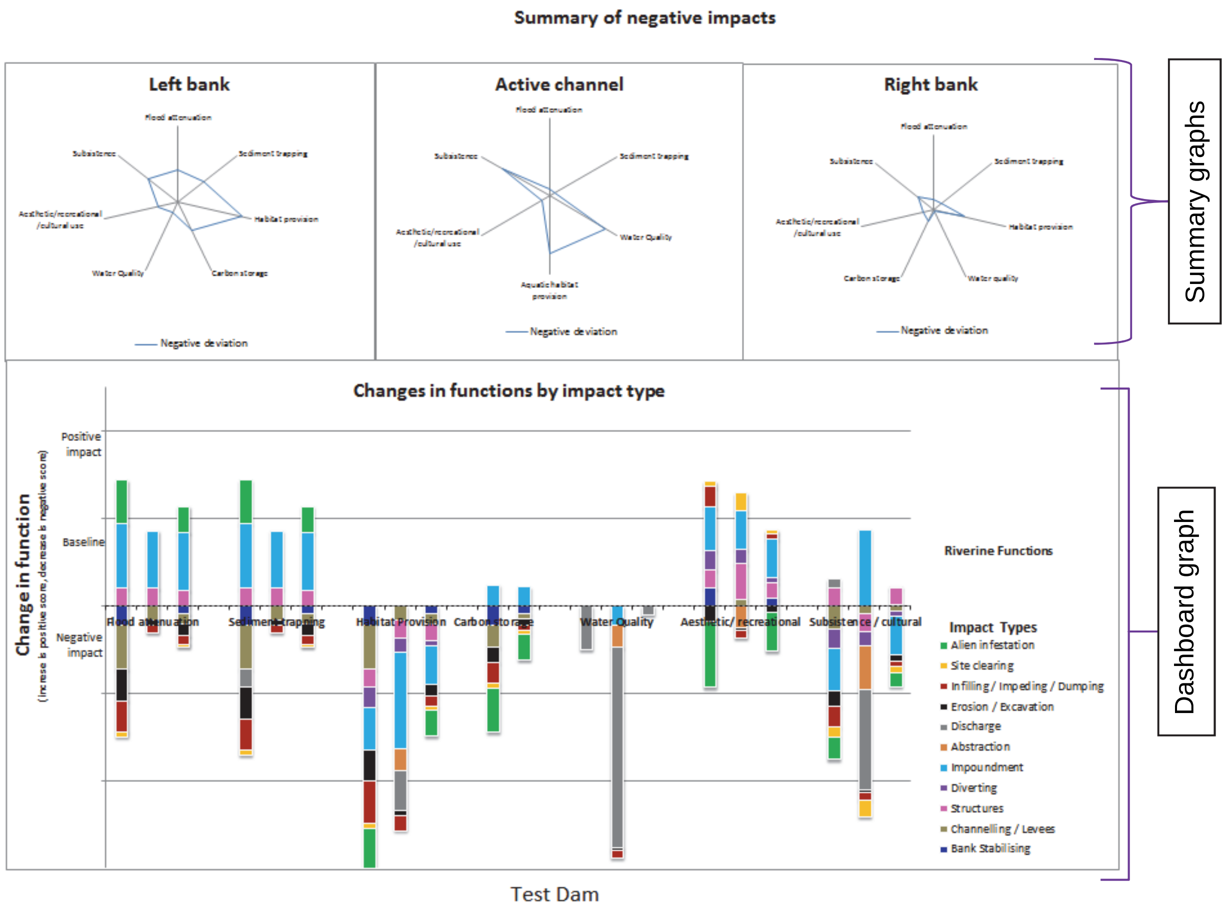


Figure 4-14 The Dashboard graphs

4.3.3 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 centre of the radial graph indicates a baseline or no impact to the riverine functions. 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 is close to the centre of the radial graph there is little or no impact to that particular riverine function. The further outwards the blue line is, e.g. away from the centre of the graph, the greater the negative impact to the riverine function. Figure 4-15 provides an indication of the different aspects of the summary graphs.

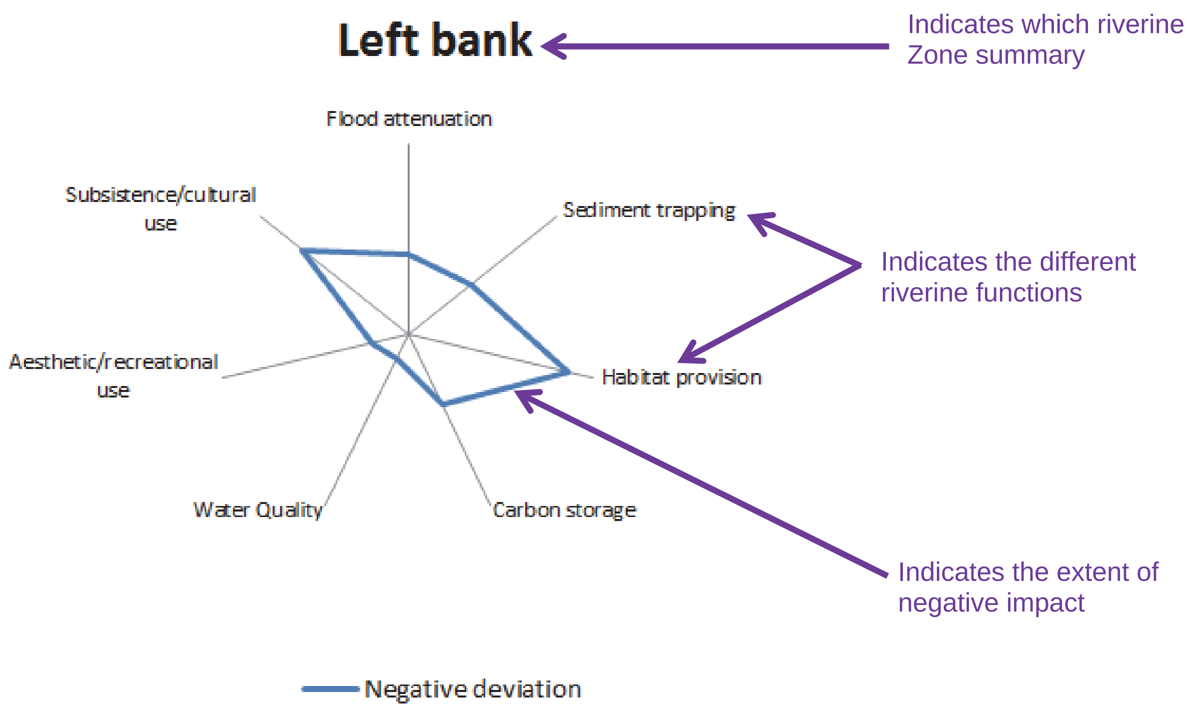


Figure 4-15 Reading the summary graphs

4.3.4 Dashboard Graph

Figure 4-16 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, inFigure 4-16, the red bars indicate Alien infestation, the pink bars indicate erosion or excavation, the brown bars indicate channelling or levees, etc.

4. The baseline indicates no change. The stacked graphs indicate the change in function. Some activities will have positive impacts, e.g. above baseline, and some will have negative impacts e.g. below the baseline. The total length e.g. both positive and negative impacts, of the stacked bar should be considered, when determining which functions have been most impacted by

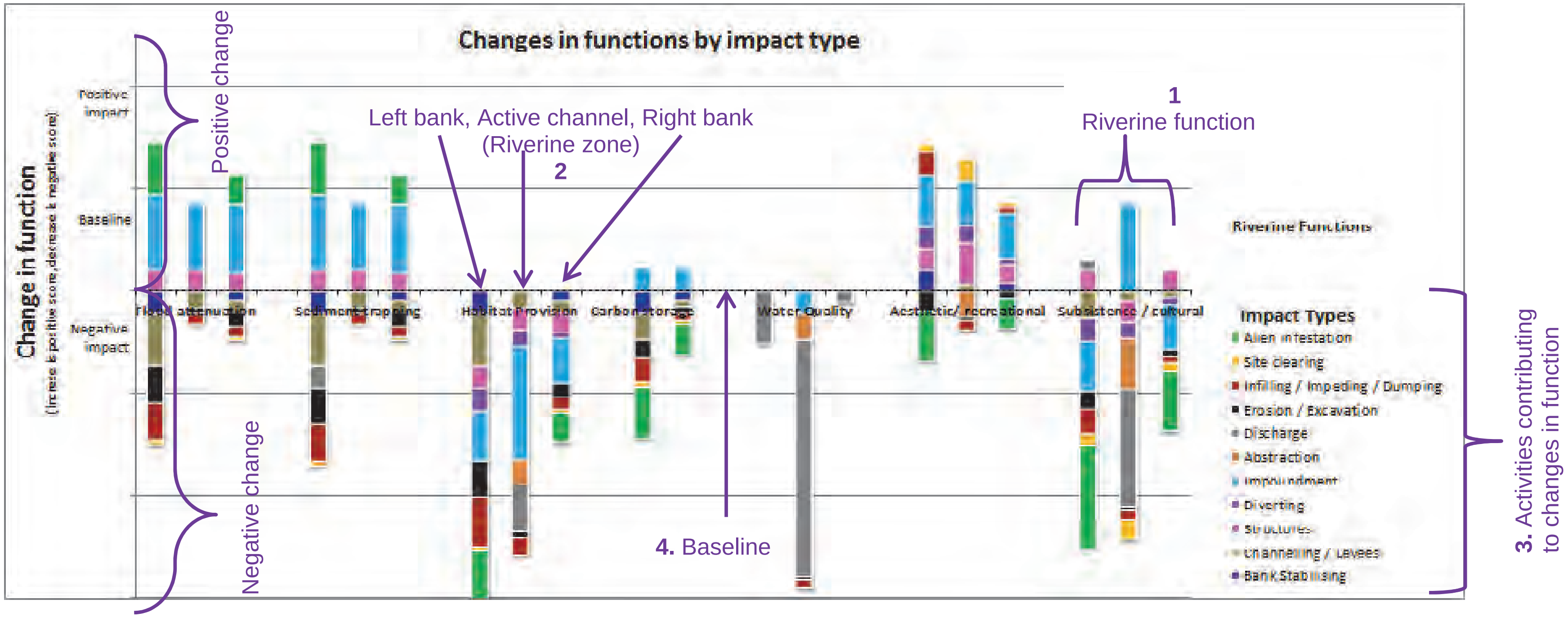


Figure 4-16 Reading the Dashboard graph

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 4-16, Habitat provision, subsistence/cultural are the two most negatively impacted functions, followed by sediment trapping, flood attenuation, water quality and carbon storage. Aesthetic/recreational has the least negative change in function. This means that rehabilitation objectives of this site should focus on rehabilitating habitat provision as a priority.

4.4 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:

- iv. The function(s) to be rehabilitated and any necessary specialist studies;
- v. Environmental Management Plan / Programme;
- vi. 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:

- iv. 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.
- v. Environmental management plan - must recognise 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; no toilets or storage of substance within the buffer of- or the riparian zone; delineate the riparian zone and clearly indicate that it is a sensitive environment.
- vi. 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 actions.

4.4.1 Specialist studies

The fundamental aim of EcoClassification is to determine the cause and origin of the deviation (impact) of the 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 4-17. These specialist studies can be applied according to which function(s) has been identified in the Dashboard.

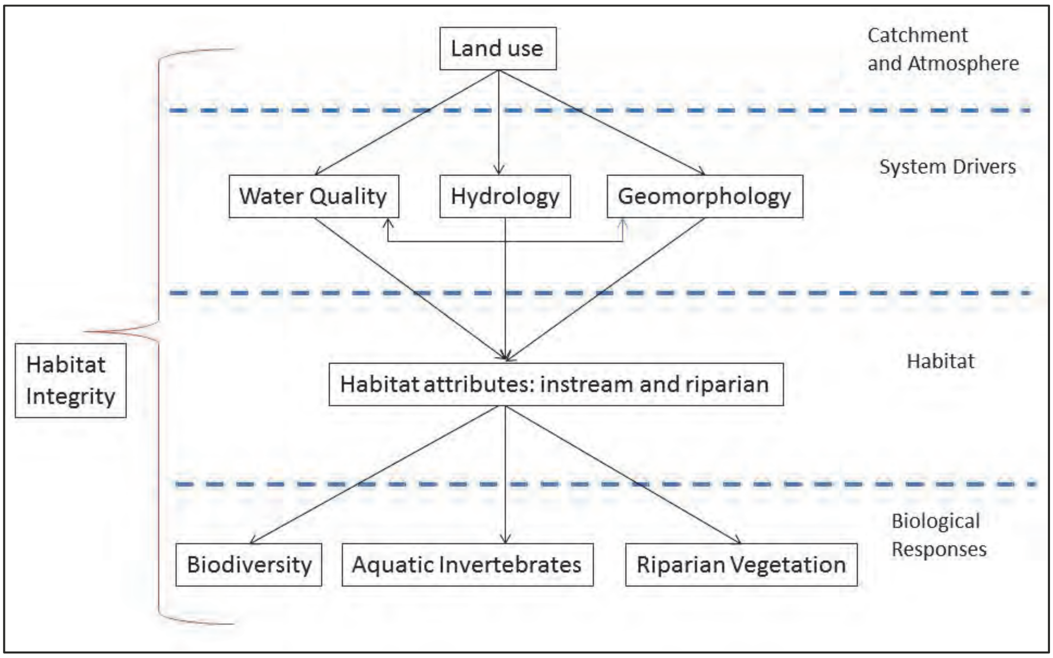


Figure 4-17 Interaction between drivers and biological responses (Adapted: Kleynhans and Louw, 2008:A2-7)

4.4.1.1 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 instream biota created by the interaction of the physical structure of the channel (the geomorphology) and the flow regime (discharge pattern over time). Table 4.50 summarises the various component and metrics (aspects) that affect habitat integrity.

Table 4.50 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 freshets
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 4.50 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.

4.4.1.2 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.

4.4.1.3 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, 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).

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

4.4.2 Environmental Management Plan (EMP)

The Environmental Management Plan, like formal Environmental Authorisations, must identify the potential impacts of all 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 activities on site.

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, or signage. 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.

4.4.3 Monitoring

According 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 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.

5 CASE STUDIES

Case studies were used in development and refinement of the Site Assessment Form indicators and the adjusting of the Dashboard calculations and weightings. The case studies presented in this report outline this development and refinement process. The first case study presents a status quo of how environmental compliance is currently conducted. The case studies thereafter provide different testing scenarios of the Site Assessment Form and “tuning” of the Dashboard. These testing case studies have been completed to adjust the tools to the current capability of environmental enforcement officials and to ensure the tools are suited to a range of site characteristics.

5.1 Case Study 1: Status Quo

5.1.1.1 Site Assessment and Dashboard Result

The most significant impact on the site was a result of the erosion due to the increasing stormwater runoff and the widening of the stream channel. However these impacts were “lost” in the process as the process focused on the legal box-ticking. As an example of how the tool could have guided the process better, a Site Assessment Form was completed at the site of the severe gully erosion and a Dashboard graph, Figure 5-1, was produced for the site.

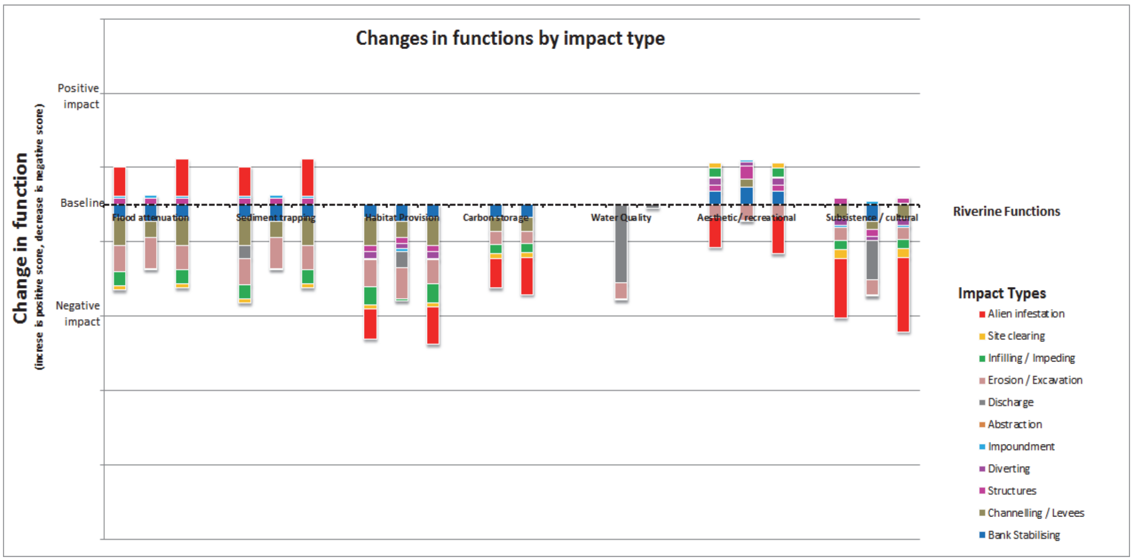


Figure 5-1 Dashboard of Cycle Park erosion gully

Based on the graphs in the Dashboard, the function of Habitat Provision has been the most impacted function followed by flood attenuation and sediment trapping (i.e. the cumulative lengths of the bar graphs are the longest for these functions). The socio-economic function of subsistence/cultural functions have also been impacted on the site, although the site is not used for subsistence/cultural purposes. Removal of the wooden bridges or receiving authorisation for the bridges will not remediate these functions. However addressing the erosion on site would remediate these functions. By identifying the negative impact to habitat provision as the objective of the rehabilitation, would have guided the Cycle Park and its specialists more constructively in developing the rehabilitation plan, rather than just the legalising issue of the activities. The legal aspect of the bridges and excavation could still have been dealt with, but would not have been the focus of the rehabilitation plan.

Of interest, the Dashboard indicates which activities on the site are impacting on the various riverine functions. The structures e.g. culverts, pipelines and wooden structures, have a minimal impact (**fucia** blocks) whereas erosion (**pink** box), channelling (**brown** boxes), and alien vegetation (**red** boxes) have the most impact.

5.1.1.2 Discussion

This example is being used to illustrate how the enforcement process is focused on the legislative box-ticking of the activity and not on preventing pollution or ecological degradation and the rehabilitation thereof. For clarity, a discussion with the complainant identified that they "only wanted the gabions to be fixed to prevent further erosion in the stream and wetland and weren't concerned about the wooden structures" (Personal correspondence).

The GDARD compliance notice identifies the appropriate specialists, however the guidance given by the Department as to what the specialists should focus on, only deals with the removal of the wooden structures and "the areas affected by the unlawful activities" (GDARD, 2011). This would rectify the illegality of the activity, but does not address the ecological degradation occurring on the site due to the on-going erosion.

It is likely that a compliance official with more experience or better understanding of ecological processes and, therefore, the ecological degradation as a result of the impacts of illegal or non-compliant activities, would have addressed the issues at the Cycle Park in a more sustainable, coordinated and comprehensive manner. The cumulative impacts of not only the wooden structures and the widening of the stream channel, but also of the un-attenuated and increasing storm water, the overflowing sewer manholes and the concrete encased pipelines traversing the stream would require a coordinated approach between the role-players. Consequently this would require a more detailed assessment of the site and the impacts on the ecological services provided by the wetland and stream on the site. Such an assessment would enable the compilation of a more comprehensive rehabilitation plan in order to achieve the sustainable rehabilitation of the site. Alternatively, a set of administrative tools to inform the current capability of enforcement officials of the critical issues on the site and guidelines towards remedying these issues would also improve the accountability and reasonableness of the official's decision making.

5.2 Case Study 2: Testing subjectivity of the SAF and Dashboard: Western Cape

On Monday 22 April 2013, a workshop was held with officials from the Western Cape Regional office of the Department of Water Affairs, the City of Cape Town Metropolitan Municipality, Drakenstein Municipality and CapeNature. A copy of the attendance register is included in the Appendix 1. At the workshop the Site Assessment Form and Dashboard Tool were presented and explained in detail to the officials. The officials then selected sites where they could test the tool. The sites selected would be tested by at least two of the enforcement officials. This was done to test the subjectivity of completing the site assessment and therefore the results of the Dashboard Tool.

The following case studies present the results from the various sites and discuss the outcomes of the results.

5.2.1 Site 1: Macassar Low Level Bridge

This site was assessed by two different officials in order to assess the subjectivity of the Site Assessment Form and the results from the Dashboard.

5.2.1.1 Site location

The site is located upstream of a small bridge over the Kuils River, in Macassar in the Western Cape. The upper catchment flows through residential, commercial and industrial land uses. Upstream of the site, the river flows through informal settlements and then through a Palmiet wetland system before reaching the site, which is surrounded by low density residential and agricultural land use. At the downstream boundary of the site is a low-level crossing with culverts. The site assessment was conducted in April 2013.

Figure 5-2 Macassar: Upstream showing right bank

Figure 5-3 Macassar: Upstream showing left bank

5.2.1.2 Activities

The activities on the site include the construction of a wall along the right river bank within the riparian zone.

5.2.1.3 Results

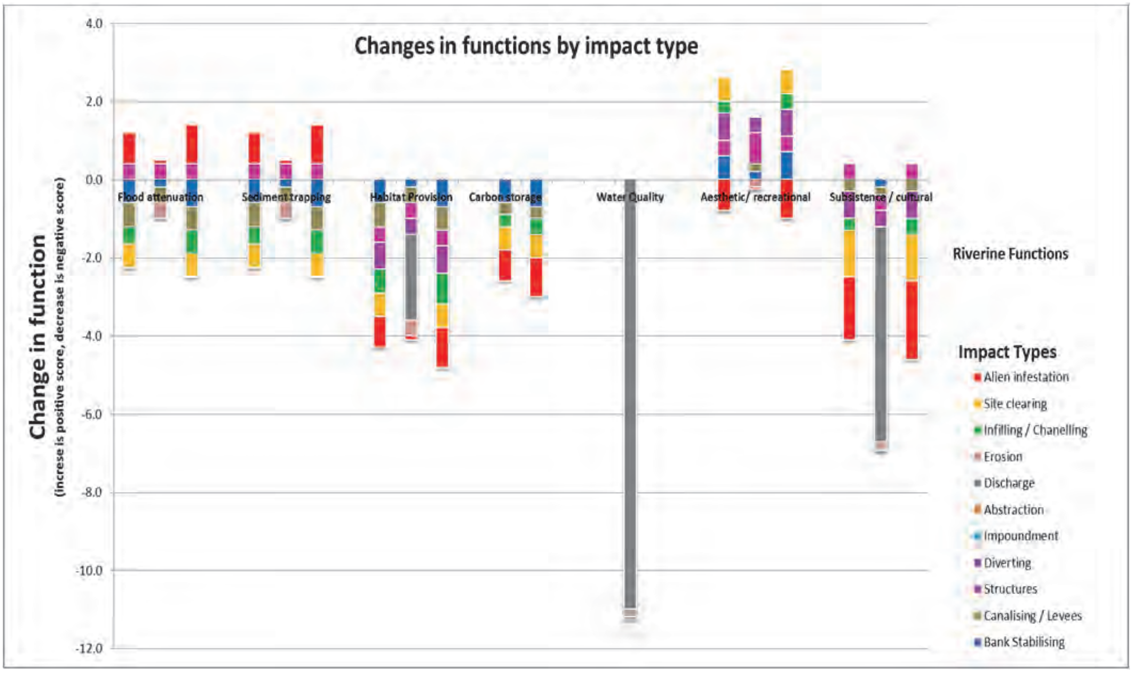


Figure 5-4 Sample 1 - Macassar site assessment Dashboard

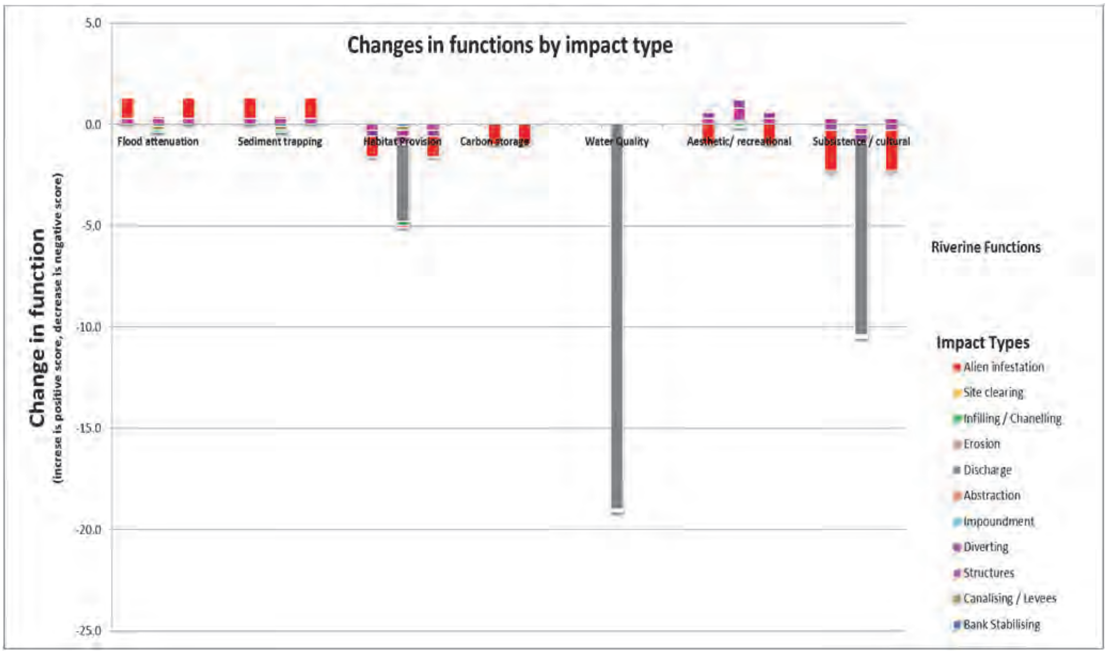


Figure 5-5 Sample 2 - Macassar site assessment Dashboard

A site assessment was completed by two different enforcement officials. The officials have differing tertiary education. The one official had 15 years of experience while the other only had 2 years of experience. This difference in background influenced the selection of answers to describe the site in the Site Assessment Form, this is noted in the level of detailed captured between the two forms, e.g. in sample one most of the indicators were answered, whereas in sample 2 many of the indicators were left as unobserved. The result is indicated in the Dashboard by contribution of activities to the impacts on the site, e.g. in sample 1 there are many contributing activities, while in sample 2 there are fewer contributing activities due to the fewer indicators being answered. However, despite the difference in the “completeness” of the Site Assessment Form, the trends in the result Dashboard still indicate the same functions as being impacted, e.g. Water Quality, Habitat Provision and Subsistence/Cultural. This difference in experience and background has been accommodated by simplifying the terminology in the Site Assessment Form, as well as providing more explanation to the terminology and indicators in the Guideline Document.

At the time water quality had the most indicators and therefore the results were biased towards water quality. After this site assessment, the activity-indicator weighting was added to the Dashboard calculations. Furthermore, the scale on the vertical axis of the dashboard was fixed as a qualitative scale rather than a numerical scale. The updated Dashboard is presented in Figure 5-6 and Figure 5-7.

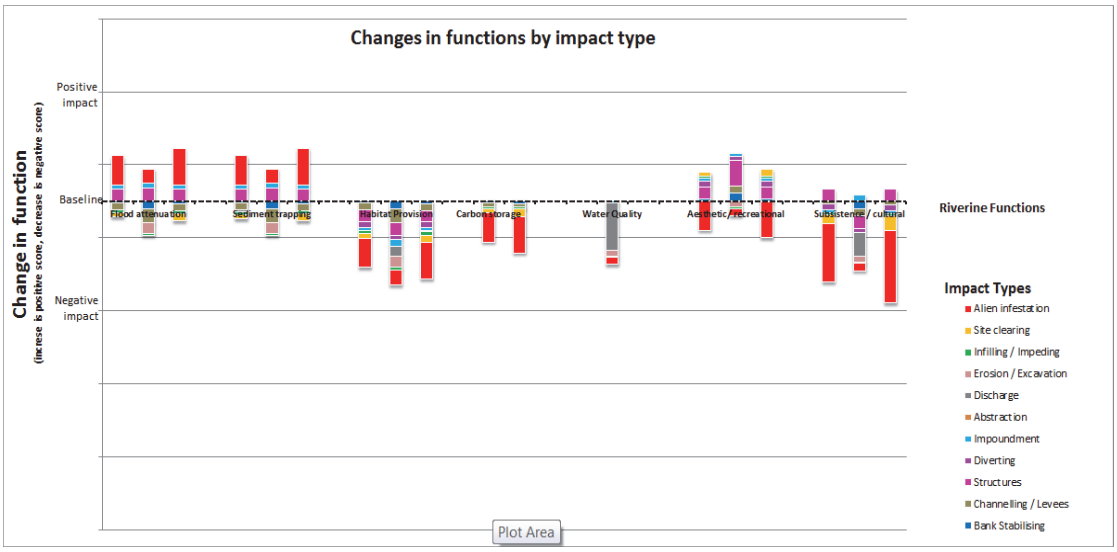


Figure 5-6 Sample 1 - Macassar site assessment Dashboard updated

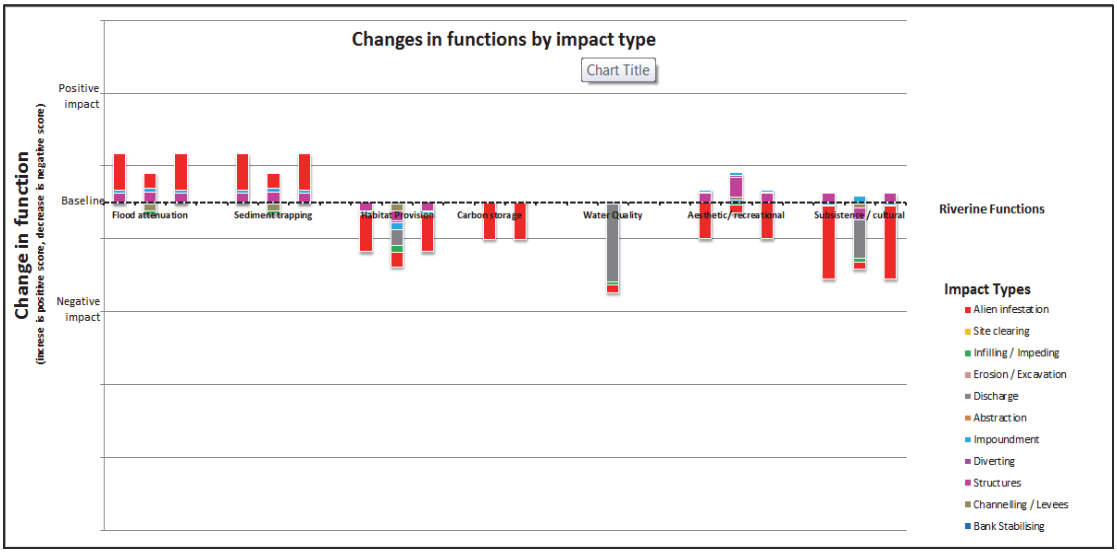


Figure 5-7 Sample 2 - Macassar site assessment Dashboard updated

In the updated version of the Dashboard, after the activity-indicator weighting has been added to the dashboard calculations, the similarity in the trends between the two samples is more noticeable. This indicates that the Tool adequately accommodates the difference in experience and training of the officials.

5.2.2 Site 2: Liesbeek River

This case study was used to test the subjectivity of the Site Assessment Form. The same site was assessed by two different officials.

Figure 5-8 Liesbeek River: Right bank - stormwater outlet depicted

Figure 5-9 Liesbeek River: Left bank

Figure 5-10 Liesbeek River: Discharge into the river with oily sheen

Figure 5-11 Liesbeek River: Milky discharge in stormwater outlet

5.2.2.1 Site location

The site is located on the lower sections of the Liesbeek River catchment. Land uses in the catchment in the vicinity of the site include residential, light industrial, commercial and recreational. Upstream of the site is a low-flow weir. The site includes a stormwater outlet. The site assessment was conducted in June 2013.

5.2.2.2 Activities

There was a pollution discharge into the river from the stormwater outlet located on the right bank in the riparian zone.

5.2.2.3 *Results*

The updated version of the Dashboard calculations, with the activity-indicator weighting included was used to derive the results presented in Figure 5-12 to Figure 5-14.

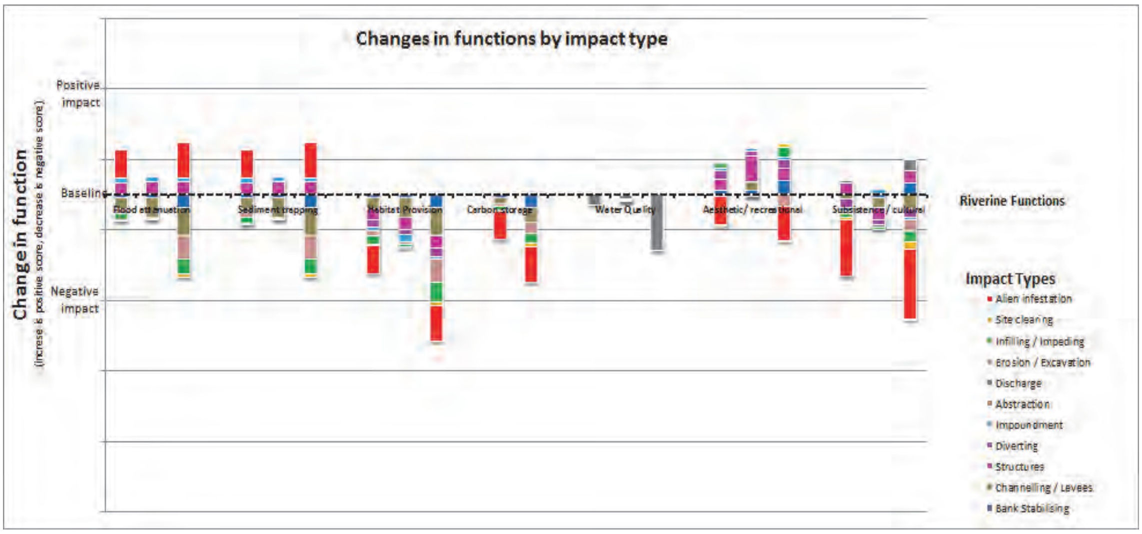


Figure 5-12 Sample 1 - Liesbeek River discharge site assessment Dashboard

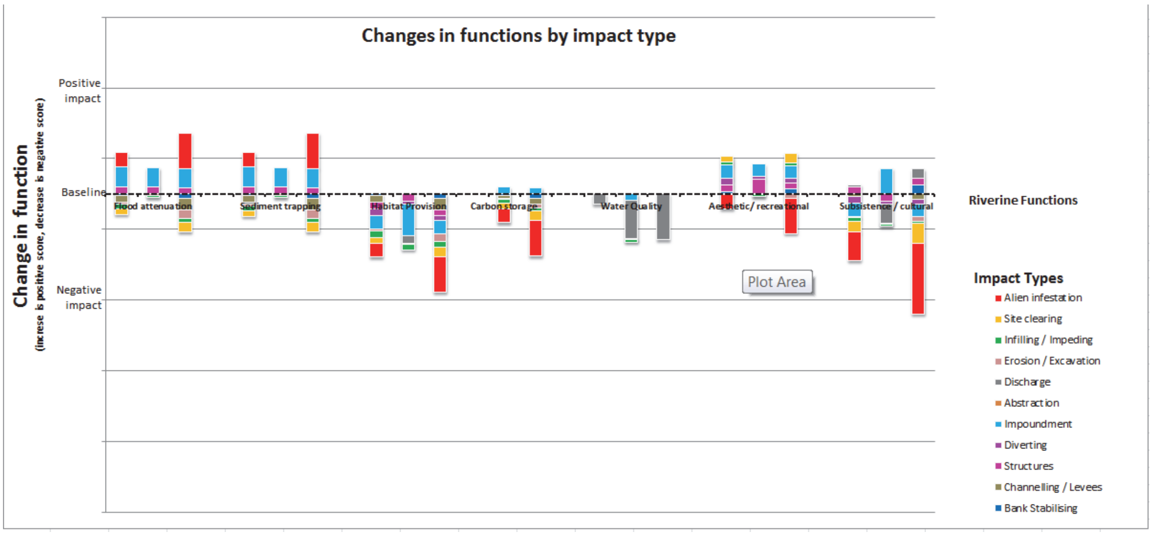


Figure 5-13 Sample 2 - Liesbeek River discharge site assessment Dashboard

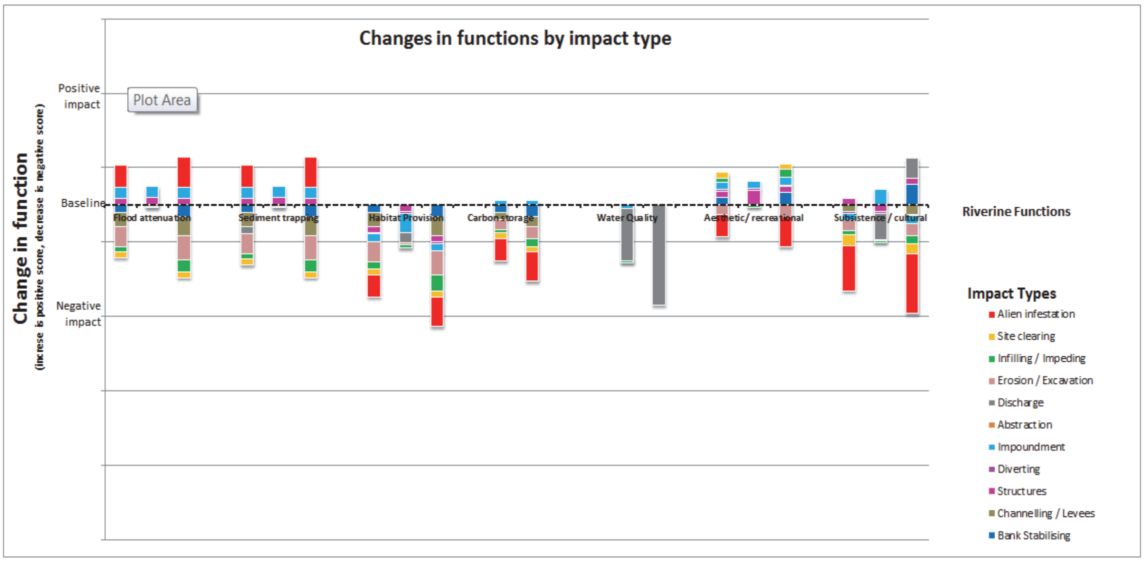


Figure 5-14 Control sample - Liesbeek River discharge site assessment Dashboard

The trends of the Dashboard graphs are similar. All three sets of results identified the functions of Habitat Provision, Flood Attenuation and Sediment Trapping as being impacted. In terms of water quality, the discharge on the right river bank was clearly identified as contributing a negative impact. Similarly, the invasive alien vegetation, erosion and channelling on the site were also identified as contributing negatively to the riverine functions on the site.

The exact size of the coloured bars in the graphs does not need to be exactly identical between the results, given the inevitably subjective interpretation by each official completing the Site Assessment Form as to the scale of the % coverage of the activity or indicator on the site. This subjectivity will not be mitigated; however, what is important is that the trends of the graphs correspond, which they do.

5.3 Case Study 3: Testing subjectivity of the SAF and Dashboard: Gauteng

A workshop was held with enforcement officials from the Gauteng institutions on 19 June 2013. The group comprised officials from the Department of Water Affairs: Gauteng Regional Office and the City of Johannesburg Metropolitan Municipality. A copy of the workshop attendance register is included in Appendix 1. The workshop included an explanation of how to complete the Site Assessment Form, and the officials were tasked with assessing a tributary of the Braamfontein Spruit as a practical. Many of the officials worked in pairs, and 10 Site Assessment Forms were submitted at the end of the exercise. The officials used printed copies of the Site Assessment Form and a copy of the descriptions.

Figure 5-15 Enforcement officials in Gauteng completing the Site Assessment Form on a tributary to the Braamfontein Spruit

5.3.1.1 Site location

The river reach assessed is located downstream of the Emmarentia dam in Johannesburg, approximately 200m in length. The land use surrounding the site includes medium-density residential, open park and recreational uses.

Figure 5-16 Tributary to the Braamfontein Spruit

5.3.1.2 Activities

Activities on the site included the installation of gabion baskets for bank stabilisation along the left river bank in the riparian zone and the erection of a pedestrian bridge across the river. The site surrounding the river reach is landscaped park area.

5.3.1.3 Results

The Dashboard results of the ten samples and the control sample are presented in Figures 5.23 to 5.33.

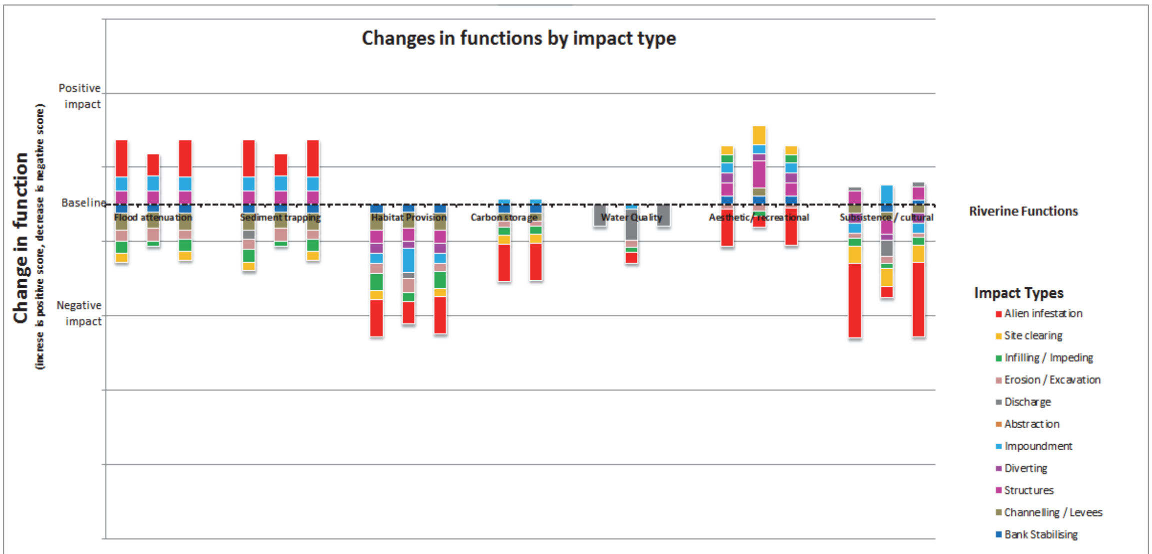


Figure 5-17 Sample 1 - Braamfontein Spruit site assessment Dashboard

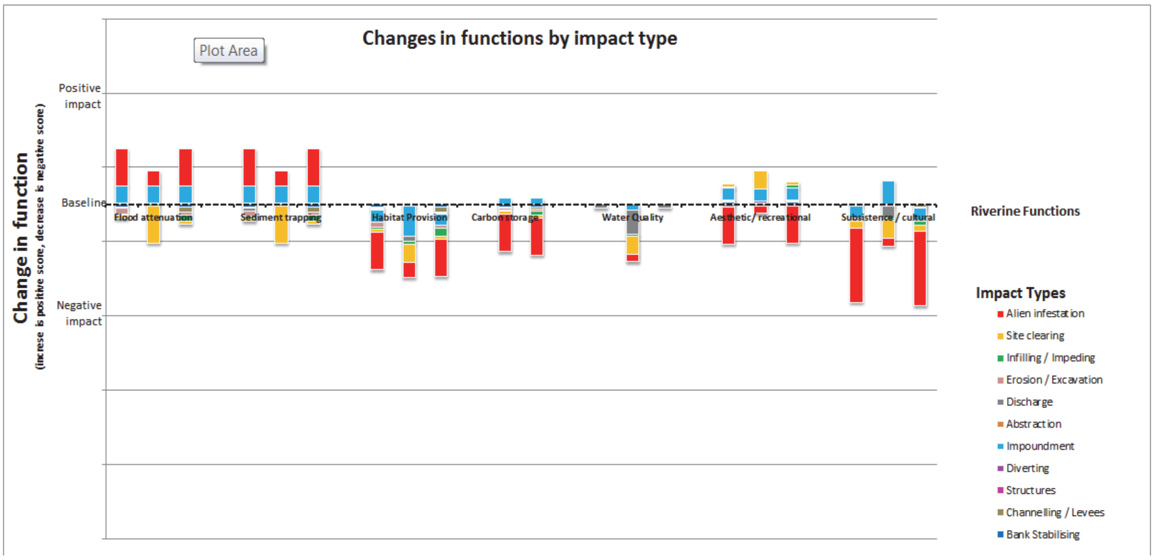


Figure 5-18 Sample 2 - Braamfontein Spruit site assessment Dashboard

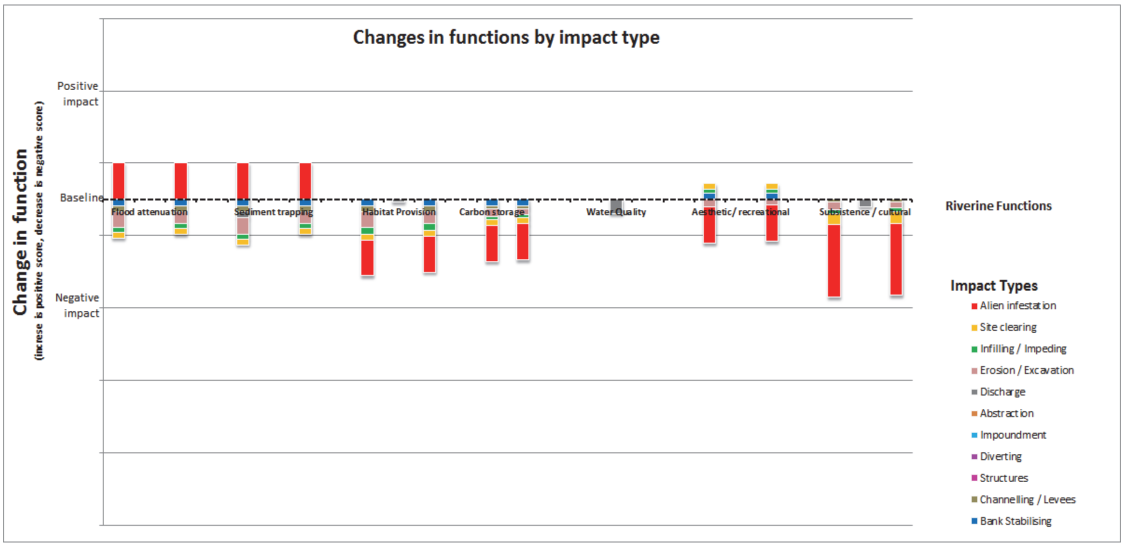


Figure 5-19 Sample 3 - Braamfontein Spruit site assessment Dashboard

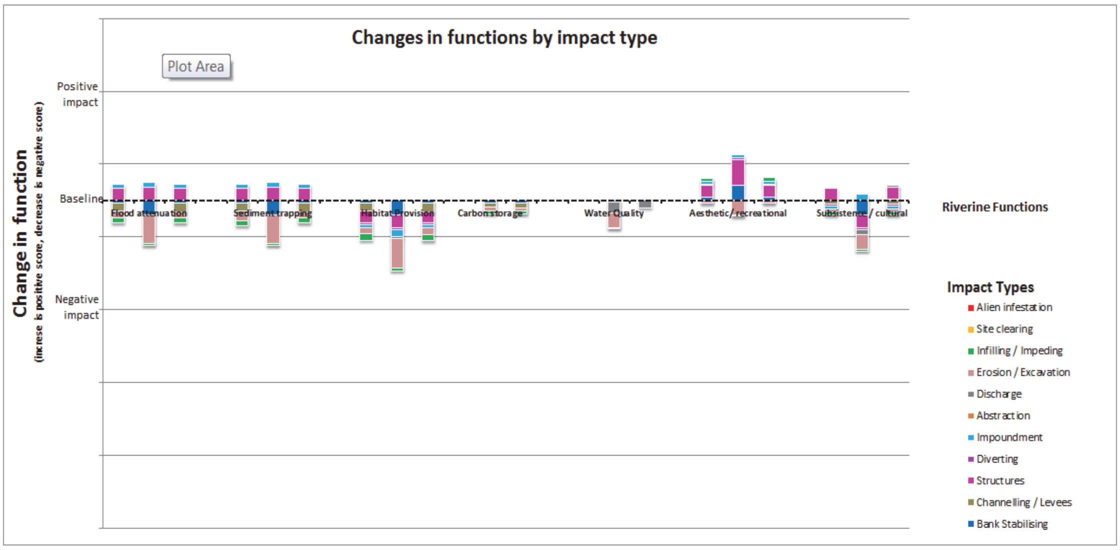


Figure 5-20 Sample 4 - Braamfontein Spruit site assessment Dashboard

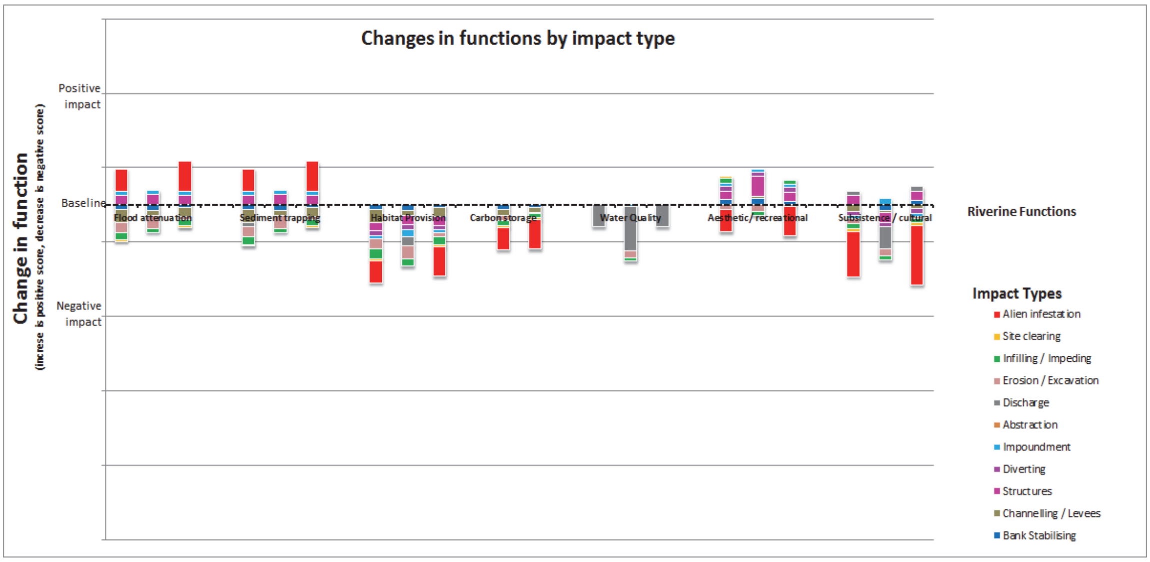


Figure 5-21 Sample 5 - Braamfontein Spruit site assessment Dashboard

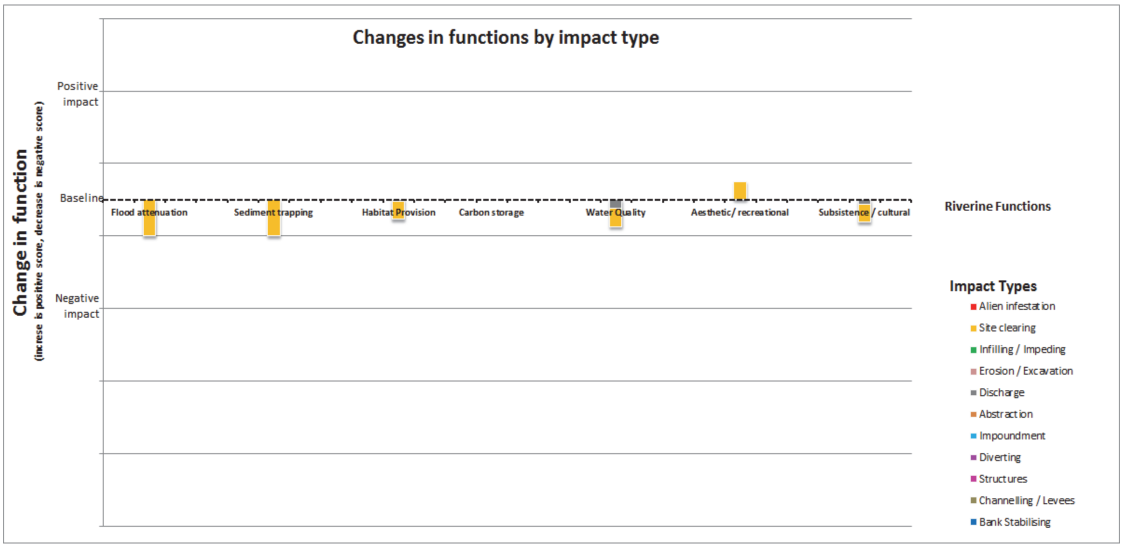


Figure 5-22 Sample 6 - Braamfontein Spruit site assessment Dashboard

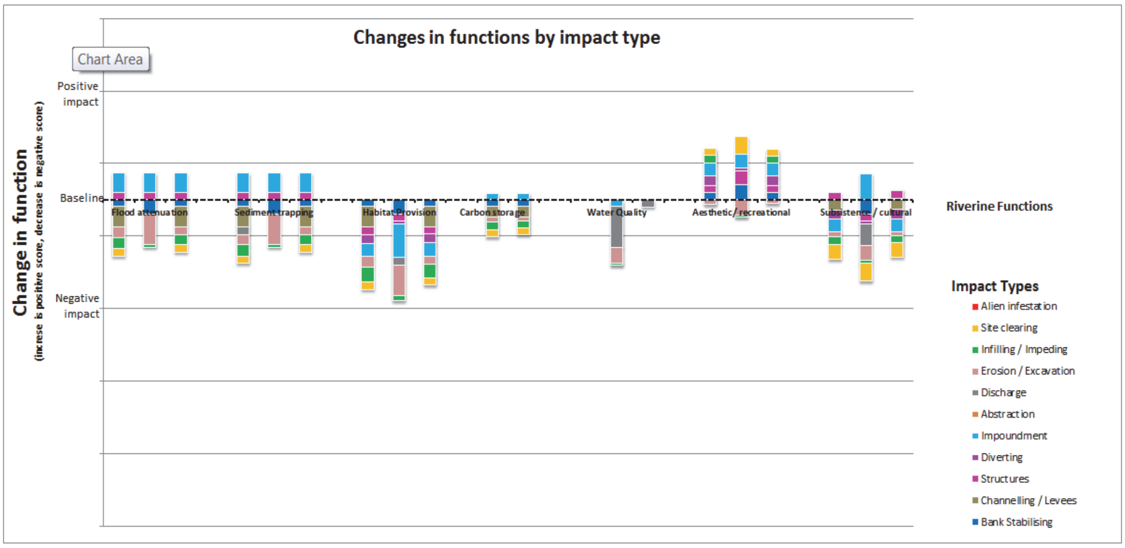


Figure 5-23 Sample 7 - Braamfontein Spruit site assessment Dashboard

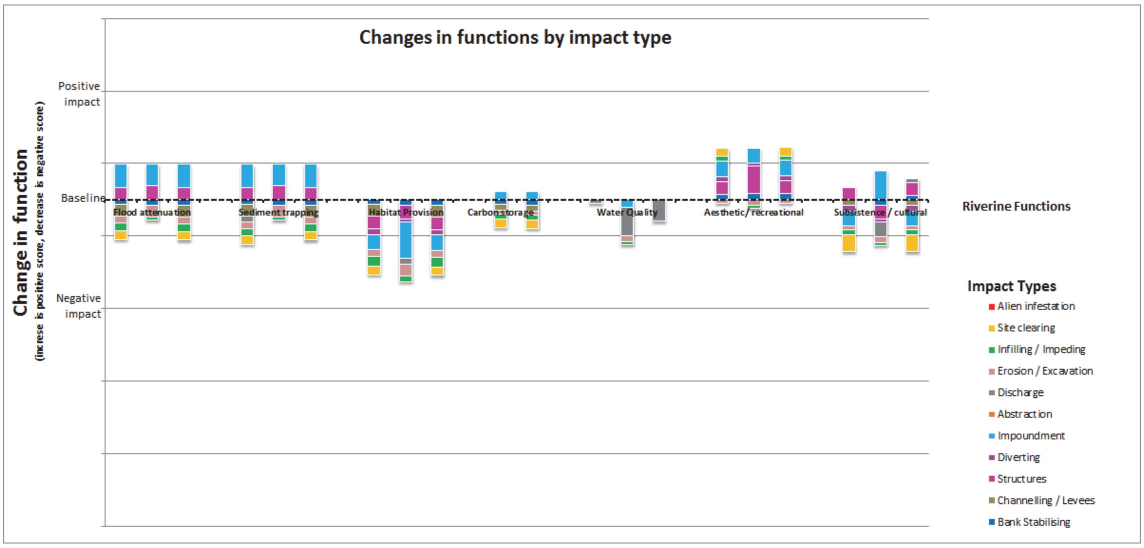


Figure 5-24 Sample 8 - Braamfontein Spruit site assessment Dashboard

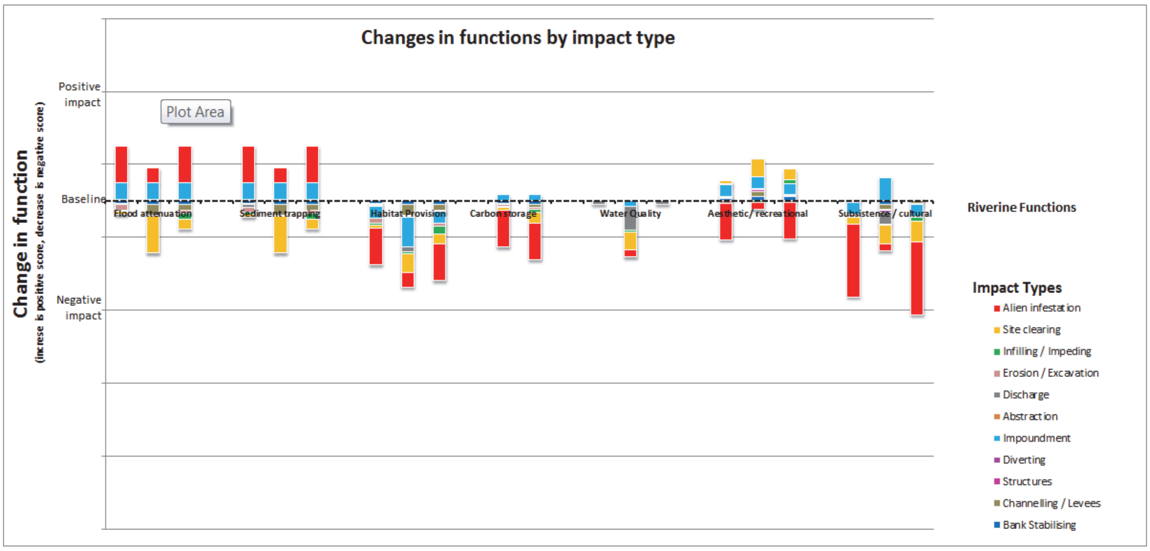


Figure 5-25 Sample 9 - Braamfontein Spruit site assessment Dashboard

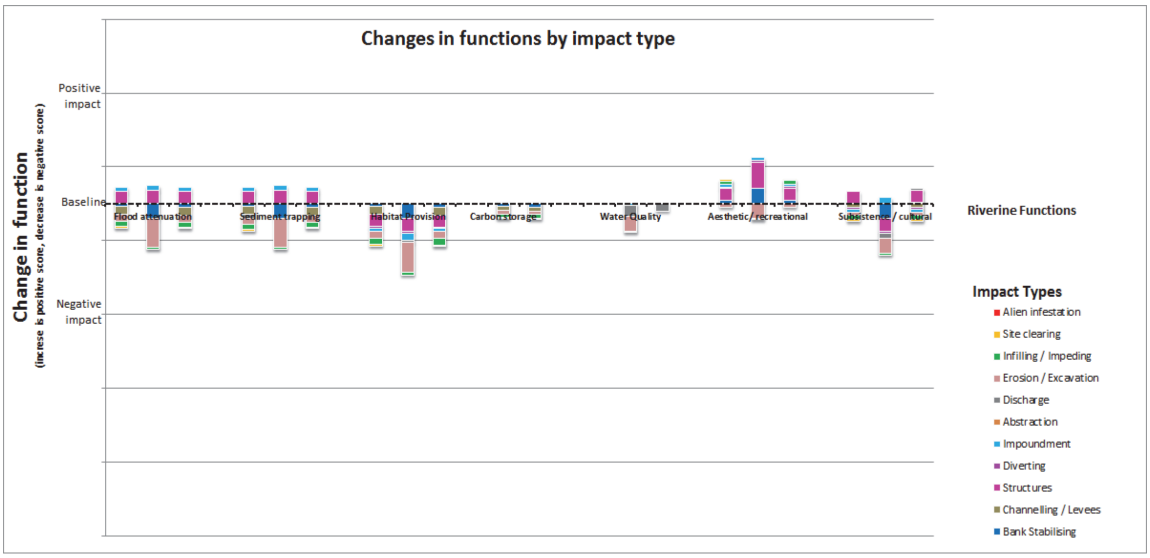


Figure 5-26 Sample 10 - Braamfontein Spruit site assessment Dashboard

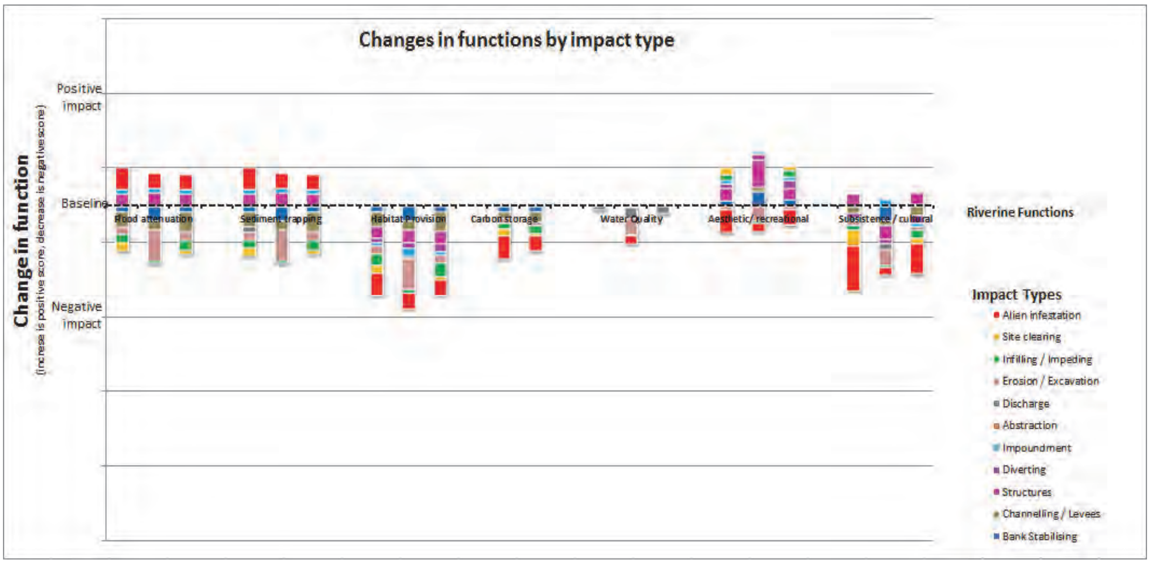


Figure 5-27 Control sample - Braamfontein Spruit site assessment Dashboard

The trends in the Dashboard graphs are similar. The particular activities resulting in the trends are based on subjective interpretation of the site and activities at the site. In many cases many of the Site Assessment Forms were not completed in full. This was mainly as a result of the officials being unfamiliar with completing the Site Assessment Form in Excel which requires all the indicators to be completed for the Dashboard calculations.

Many of the officials worked in pairs to complete the Site Assessment forms, this is noticeable in the Dashboard results, for example, samples 7 and 8; samples 4 and 10; and samples 2 and 9. The trends of the Dashboard graphs identified Habitat Provision as the primary function being impacted by activities on the site, as well as impacts to Flood Attenuation and Sediment Trapping. Similar to the sites in Case Study 2, the assessment of particular activities contributing to the impacts are influenced the officials' subjective interpretation of the site. However, despite this subjectivity, the Tool still indicates the impacts to corresponding riverine functions.

5.4 Discussion and Findings

The case studies illustrated the need for such a tool to guide enforcement officials in determining rehabilitation objectives, as illustrated in Case Study 1. The Site Assessment Form and Dashboard Tools that have been developed were successfully tested in the field, as illustrated in Case Studies 2-3. A general trend was noted from the Case Studies that the Habitat Provision function tended to be the dominant function negatively impacted. It was considered that this may be as a result of the activity-function weighting used in the Dashboard calculations, as these weightings are not evenly allocated across the functions, e.g. the total weight per function (and in the flood zone and active channel) differed. However, this has not been remedied, as the predominant function in urban rivers that is impacted by activities in the riverine zone is usually the habitat provision function and the current weightings highlight this. It was further considered whether the socio-economic functions included in the Dashboard were necessary in the Tool. As the activities in urban rivers are usually to improve these functions, it was decided to leave them in the Dashboard.

Comments received back from the officials as well as from the case studies suggested minor adjustments in the Tools, mainly regarding terminology. This has been accommodated both in the Guideline Document, as well as in the structure of the Site Assessment Form, e.g. the measure options are now also included on the paper version of the Form, negating the need for the officials to carry the detailed descriptions with them on site. In the testing of the Tool in the Case Studies the selection of indicators used was also slightly adjusted, again based on the results and comments from the officials. For example, measuring of water quality clarity was initially included, but as no officials measured the water clarity, given that they do not have the necessary equipment, this indicator was removed from the Tool.

In general the comments and feedback received on the tools were highly positive, and that the Tools will be very useful to the officials.

The Provincial Departments of Environmental Affairs were invited to the different workshops; however no officials participated in either workshop. This is a pity, as these are the primary officials the Tool was developed for.

Future development of the Tool could further test the score-allocations of the indicators, as well as the weightings of the activities to indicators, and the activities to functions. However for the purpose of this research, the testing of the Tool has confirmed its usability.

6 CONCLUSIONS

Chapter 2 of this research highlighted the concept of enforcement driven rehabilitation, as opposed to initiative driven rehabilitation, where enforced rehabilitation refers to a contravention that a person is then directed by an administrative notice to rehabilitate. Within this concept of enforcement driven rehabilitation Chapter 3 identified several problem areas. These included the myriad of environmental legislation that officials must operate within, but they are tied to operating within the jurisdiction of their own legislation, e.g. although the National Water Act, Act 36 of 1998 (NWA) overlaps in several areas with the Conservation of Agricultural Resources Act, Act 38 of 1983 (CARA), an official from the Department of Agriculture can only operate within the mandate of the CARA and not within the NWA. Similarly, the guidance provided by the legislation in the formal authorising processes is very prescriptive and detailed, whereas there is no similar guidance in the sections pertaining to enforcement. Further, the administrative and accountability requirements and capacity and capability constraints further hinder the enforcement officials and the enforced rehabilitation process.

With these problems in mind this research set out to develop an initial set of tools to assist environmental enforcement officials to determine the appropriate rehabilitation objectives in their administrative notices. This was done to ensure that rehabilitation activities target impacts to the urban riverine functions and not simply legalising a contravention. In developing these tools, existing assessment methodologies were considered, however many focused on river health rather than river function, whereas river function was presented as being more holistic and relevant. The tools developed included:

- *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 impact of the contravening activity on the riverine environment. 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.

The process of developing the tools was an interactive and evolutionary one. Workshops with the target audiences were held during the development stages, in order to ensure the tools were tailored to the official's requirements. This also provides buy-in and support for the utilisation of the tools in the future.

Although this research does not resolve the problems identified in environmental enforcement, this needs to be driven by the sector and institutions themselves. However the aim of the research was to develop tools to assist the existing officials in bridging these gaps. Based on the feedback from the officials, and the results of the case studies, the aim of the research has been achieved.

6.1 Notes on the Tools

6.1.1 Legislation Search Tool

The LST database currently only captures the national environmental legislation. However provincial/ geographic specific legislation and regulations may also still be applicable as well as municipal by-laws. These were purposefully excluded from the scope of the initial tool development. However further future development of the tool should include this detail as well.

The legislation is regularly being updated, and the listed activities identified in the different statutes, especially the NEMA, are regularly being amended. This will require the continued maintenance of the database to ensure it is kept up-to-date with any amendments in the legislation. At the time of developing the tool, it was recommended to the Department of Environmental Affairs to take ownership of this maintenance. This has not been confirmed to date.

6.1.2 Site Assessment Form

When considering the criteria and indicators to be included in the SAF aquatic invertebrates was initially considered as well as diatoms, however due to the complexity of assessing the invertebrates and the time and cost in analysing diatoms, it was decided to remove these criteria from the Site Assessment Tool, but that they should rather be available as specialist studies should they be required.

The indicators and measures used in the SAF were drawn from existing assessment methodologies and easily observable indications on a site. The Guideline Document in Appendix 2 explains the different indicators and includes pictures to illustrate the difference in measures. These indicators and measures were discussed with various specialists such as water quality specialist, botanist, aquatic ecologist and fluvial geomorphologist, and adjusted appropriately.

The SAF provides a detailed site assessment report, which can be easily understood by various officials, including those not having seen the site. This is particularly important, where there is staff-turnover, to ensure continuity of the rehabilitation objective.

6.1.3 Dashboard Tool

The scores attached to the measures, and the various weightings attached to the indicators and activities were derived from the literature and existing methodologies. These were adjusted based on the outcomes of the case studies and testing. The Tool was designed to provide a rough indication as to the impacts to riverine functions, and a more fine-tuned assessment would result from the specialist studies. This tool successfully provides that indication. Future work could test this tool in broader context and refine the weightings a little bit more.

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APPENDIX A: IMPACTS OF EFFLUENT DISCHARGE TO WATER COURSES

Table A.1 and **Table A.2** lists the impacts of pathogenic organisms known to occur in domestic sewer effluents, and the toxic substances found in industrial effluents, respectively.

Table A.1 Pathogenic organisms known to occur in sewerage effluents associated with sewerage treatment (Hellawell, 1986)

Organism	Disease or Condition	Comments
Viruses		
Polio virus	Poliomyelitis	Found in effluents, but not proven to be water-borne transmission.
Infectious hepatitis virus	Infectious hepatitis	Only virus for which water route has been proven, epidemiologically.
Bacteria		
Salmonella typhi.	Typhoid fever	Common in sewerage and effluents in epidemics
Salmonella paratyphi.	Paratyphoid fever	
Shigella spp.	Bacterial dysentery	Source of infection, mainly polluted water.
Bacillus anthracis	Anthrax	Spores resistant
Brucellosis spp.	Contagious abortion in livestock, undulant or Malta fever in man.	Infection normally from contact or infected milk but sewerage suspected also.
Mycobacterium tuberculosis	Tuberculosis	Isolated from Sewerage? Possible mode of transmission.
Vibrio cholerae	Cholera	Transmission by polluted water
Leptospira icterohaemorrhagiae	Leptospirosis, Leptospiral jaundice (Weil's Disease)	Carried by rats in sewers
Protozoa		
Entamoeba hystolytica	Amoebic dysentery	Contaminated water, tropical countries
Metazoa		
Schistosoma spp.	Bilharzia	Spread by application of sludge as agricultural fertiliser
Taenia spp.	Tape worms	
Ascaris spp.	Nematode worms	

Table A.2 Toxic substances present in industrial effluents (Adapted from Hellawell, 1986)

Substance	Potential Environmental Effect (DWAF, 1996)	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; *http://www.atsdr.cdc.gov/mmg/mmg.asp?id=216&tid=39*	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

Substance	Potential Environmental Effect (DWAF, 1996)	Source
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 *http://www.e-b-i.net/ebi/contaminants/nickel.html*	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

APPENDIX B: ATTENDANCE REGISTERS OF WORKSHOPS

Workshop in Pretoria on 29 May 2012 with officials to discuss applicable sections of legislation and Legislation Search Tool database:

aurecon

WATER RESEARCH COMMISSION
Water Linked Ecosystems
Legal Workshop on Determining Procedures for Enforced Rehabilitation Activities in Urban River Reaches

ATTENDANCE REGISTER

Project No: K5/2036 Date of meeting: 29/05/2012

Venue: Aurecon Centre, Lynnwood Bridge Office Park, 4 Daventry Street, Lynnwood Manor, Ground floor Meeting room 3

Chairman:

Surname & Initials	Company	Member / Project Team	Tel Number	Fax Number	E-mail address	Signature	For office use Cap
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28 May 2012

Workshop in Cape Town on 22 April 2013 with officials in the Western Cape to test Site Assessment Form and Dashboard Tools:

WRC WORKSHOP - 22 APRIL 2013

ATTENDANCE REGISTER

NAME	INSTITUTION	CONTACT DETAILS	SIGNATURE
Cindy Winter	Drakenstein Mun	Cindy.Prins@drakenstein.gov.za 021 807 4731	
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Workshop in Johannesburg on 19 June 2013 with officials in Gauteng to test Site Assessment Form and Dashboard:

aurecon

ATTENDANCE REGISTER

WORKSHOP : WRC Site Assessment Tool Workshop 2

VENUE : Dabulamanzi Canoe Club, Emmarentia Dam, Johannesburg

DATE : 19 June 2013

TIME : 13:30

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