Watercourse Investigation for the Hartswater Landfill Site (LFS), Northern Cape Province

Specialist Report

Prepared For: SE Solutions

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Date: November 2015

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Wetlands • Ecology • Responsibility

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Suggested Citation: Grobler, L.E.R.2014. Watercourse Investigation for the Hartswater Landfill Site (LFS), Northern Cape Province. Specialist report for SE Solutions. Pretoria.

Approach and Disclaimer

This report provides a brief description of watercourses, as defined by the National Water Act (NWA), Act No. 36 of 1998, that are present within the study area, including wetlands present within a 500m radius of the study area. The latter is undertaken at a secondary level of detail through a mainly desktop approach with limited site surveying. The study area is located in the northwestern part of the town of Hartswater on property belonging to the Phokwane Local Municipality, in the Northern Cape Province. The investigation furthermore provides a description of selected aspects of the study area and identifies potential project related impacts, recommended mitigation measures and an impact assessment table.

This study does not provide detailed descriptions of the local geology, agricultural potential, climatic conditions, hydrology of the aquatic environments(including volumes and flow patterns), surface and ground water quality, aquatic and terrestrial flora and fauna, or a detailed review of the legal constraints associated with potential project related impacts on the environment. It has been assumed for the purposes of this report that these aspects have been the subject of separate specialist studies should they be required as part of the environmental authorisation process.

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1. Introduction

1.1. Background and Terms of Reference

SE Solutions appointed Imperata Consulting to conduct a watercourse specialist investigation for an old landfill Site (LFS) in Hartswater, in the Phokwane Local Municipality in the Northern Cape Province. The landfill site is located in the north-western part of Hartswater, east of the N18 Highway, but has recently been replaced by a new LFS and is therefore no longer operational.

The study was undertaken by Mr. L.E.R Grobler from Imperata Consulting who compiled the report on the findings of the commissioned watercourse assessment, which included a desktop component as well as a fieldwork survey component. The terms of references for the specialist study include the following:

- The delineation and assessment of wetlands and other watercourses present within the study area, including the delineation of wetlands within a 500m radius around the property (henceforth referred to as the 500m study area buffer or 500m buffer). The delineation of wetlands within the 500m buffer will be undertaken at a secondary level of detail through a mainly desktop approach with limited site surveying.
- Watercourses identification will be based on definitions specified in the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Watercourse definitions used as part of the investigation include:
  - A river or spring.
  - A natural channel in which water flows regularly or intermittently.
  - A wetland, lake or dam into which, or from which, water flows.
- The description and classification of delineated wetlands into corresponding hydro-geomorphic (HGM) units according to Ollis *et al.* (2013).
- Present Ecological State (PES) assessment of identified wetlands within the LFS study area. PES assessments for wetlands and other watercourses located outside of the study area, but inside the 500m buffer, are excluded from this study.
- Ecological Importance and Sensitivity (EIS) assessment of identified wetlands present within the LFS study area. EIS assessments for wetlands and other watercourses located outside of the study area, but inside the 500m buffer, are excluded from this study.
- The identification of potential project-related impacts along with an impact assessment and the recommendation of appropriate mitigation measures.

1.2. Experience of the author

Mr. Grobler has undergraduate majors in Botany (UP) and Soil Science (UP), an honours degree in Botany from the University of Pretoria (cum laude), and a MSc (cum laude) from the Department of Plant Sciences (UP) with a focus on peatland wetland systems. He is a registered Pr. Sci. Nat professional natural scientist in the fields of Botanical Science and Ecological Science (Reg. no. 400097/09). He has been working as a consultant based in Pretoria, with work experience in Gauteng, Mpumalanga, North-West, Eastern Cape, Northern Cape, Free State, Limpopo and KwaZulu-Natal Provinces over the last eight years. Areas of specialisation include wetland, riparian and headwater drainage line assessments, with a special interest in peat wetlands.

1.4. General assumptions

- This study assumes that the project proponents will always strive to *avoid, mitigate* or *offset* potentially negative project related impacts on the environment, with impact avoidance being considered the most successful approach, followed by mitigation and offset. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.
- Spatial GIS shapefiles received from the client were used to demarcate the landfill site boundaries are deemed accurate.
- The project proponents will commission an additional study to assess the impact(s) if there is a change in the size and/or extent of the study area or proposed infrastructure that is likely to have a potentially significant and/ or unavoidable impact on watercourses (e.g. wetlands).

1.5. Overview of wetlands and riparian habitat

1.5.1. What are wetlands?

In terms of the Ramsar Convention on Wetlands (Iran 1971), to which South Africa is a contracting party, "… wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs" (Ramsar Convention Secretariat 2007).

In South Africa, wetlands are defined as "…land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil" (National Water Act, 1998 (Act No. 36 of 1998)). Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to the aforementioned will also be applicable to wetlands.

In addition, the NWA stipulates that "…reference to a watercourse includes, where relevant, its bed and banks…". This has important implications for the management of watercourses and encroachment on their boundaries, as discussed further on in this document.

The NWA defines riparian areas as "…the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized 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…" Note that this does not imply that the plant species within a riparian zone must be aquatic, only that the species composition of plant assemblages must be different within the riparian area and adjacent uplands.

In terms of the wetland delineation document available from the Department of Water Affairs and Forestry (DWAF), now known as the Department of Water and Sanitation (DWS), "wetlands must have one or more of the following attributes" (DWAF 2005):

- **Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation.
- The presence, at least occasionally, of **water loving plants (hydrophytes)**.
- A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.

It follows that the level of confidence associated with a specific area being considered as a wetland is proportionate to the number of confirmed indicators that positively correlate with wetland habitat. Not all indicators are always present within a specific biophysical and land use setting, while not all indicators are always reliable and/or useful under all conditions. The use of additional wetness indicators from different disciplines that are internationally applied therefore adds value and confidence in the identification and delineation of wetland habitats, especially in challenging environments. These types of environments include urban settings where disturbances to the natural soil and vegetation are common.

2. Methods

2.1.General

The following methods and approaches were applied as part of the wetland investigation:

- Existing spatial datasets that indicate potential watercourses an ecologically important areas were used as part of an initial desktop approach:
    - The 1:50 000 river and drainage line data of the study area and its surroundings was used, as illustrated on the relevant topographic map (2724DBTaung and 2724DD Jan Kempdorp).
    - The recently completed National Freshwater Ecosystem Priority Areas (NFEPA) spatial database was used to identify potential wetland areas within the study area and its immediate surroundings. This wetland layer has been formed by combing information from the National Land Cover 2000 data set (NLC 2000), 1:50 000 topographic maps and sub national data (Van Deventer et al. 2010).
    - The National Spatial Biodiversity Assessment (NSBA) spatial dataset, which is based on the DWA 1:500 000 rivers GIS layer (Driver et al. 2004). The GIS layer was obtained via the BGIS website hosted by the South African National Biodiversity Institute (SANBI).
- A wetland site survey was undertaken in October 2015.
- Watercourses were identified and delineated through the procedure described by the Department of Water and Sanitation (DWS; previously also known as DWAF and DWA) in their document entitled: "A Practical field procedure for the identification and delineation of wetlands and riparian areas" (DWAF 2005).
- Available wetland indicators that were investigated included hydromorphic (wetland soil) features, the presence of wetland plant species (e.g. hydrophytes), riparian species and vegetation features, alluvial soil features, and terrain unit indicators.
- The identification of hydromorphic features to identify and delineated wetland areas included the presence of the following features: mottling, gleying, localised iron depletion, low chroma matrix colours, and organic enrichment in the A horizon (DWAF, 2005; Nobel, 2005).
- The field survey primarily focussed on the delineation of watercourses within the study area, while selected areas were investigated within a 500 m radius of the site. The majority of wetland areas within the 500m buffer area were mainly delineated and classified through a desktop approach with restricted site surveying.

- Identified wetland areas and other watercourses were delineated into GIS polygon shapefiles, which were used for map creation.
- All natural wetlands identified within the study area were classified according to the recently completed 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' up to the hydrogeomorphic (HGM) unit level (Ollis *et al*. 2013).
- The HGM classification system is based on three key parameters pertaining to the wetland: the geomorphic setting of the wetland, the source of water inputs into the wetland, and its hydrodynamics (how does water move through the wetland), (Brinson 1993; Kotze *et al.* 2008).
- The Present Ecological State (PES) of any wetland that may occur within the study area was to be assessed according to the method developed by Kleynhans (DWAF 1999) or the Wetland IHI method developed by DWA (2007).
- The PES method compares the current condition of a wetland, or other watercourse type, to its perceived reference condition, in order to determine the extent to which the watercourse had been modified from its pristine (reference) condition.
- Results from the PES assessments are rated into one of six categories ranging from unmodified/ pristine wetlands (Class A) to critically/ totally modified HGM wetland units (Class F).
- An Ecological Importance and Sensitivity (EIS) assessment of any identified wetlands that may occur within the study area were undertaken to provide an indication of the conservation value and sensitivity of these watercourses. The applied EIS wetland assessment was based on the following criteria derived from the method proposed by Rountree& Malan (2010):
    - Habitat uniqueness
    - Species of conservation concern
    - Habitat fragmentation with regards to ecological corridors
    - Prominent ecosystem services

2.2.Limitations

The following refers to general limitations that affect the applicability of information represented within this report (also refer to the Approach and Disclaimer section):

- Wetland assessments are based on a selection of available techniques that have been developed through the Department of Water and Sanitation (DWS), as well as the Water Research Council (WRC) based on site conditions and applicability. These techniques are, however, largely qualitative in nature with associated limitations due to the range of interdisciplinary aspects that have to be taken into consideration.

- Wetland areas within transformed landscapes, such as urban, agricultural settings, or other areas with existing disturbances, such as landfill sites, are often affected by disturbances that restrict the use of available wetland indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of the dominance of alien vegetation, cultivation, hard surfaces, and dumping and infilling). Hence, a wide range of available indicators are considered, to help determine wetland boundaries more accurately.

3. Study Area Description

3.1. Location and existing land use

- The Hartswater landfill site (LFS), henceforth also referred as the study area or site, has a size of approximately 6.27 ha and is located in the northwestern section of Hartswater within the Phokwane Municipality in the Northern Cape Province (Figure 1).
- The site is located approximately 4.7 km south of the North West Province Border(coordinates 27°44 46.825"S and 24°47.58’.725”E) and approximately 1.25 Km east of the National Road (N18) and adjacent to concreted furrows and canal systems. It is located on slightly irregular plains and pan terrain morphology (Figure 1).
- Cultural features of importance overlapping with the 500 m study area buffer surrounding the site include the Vaalharts Irrigation Scheme and a Grave/Burial (Monument Site).
- The study area includes operational facilities for landfill site, such as access roads and dwelling units.
- The study area is located on a highly modified land use setting that consists of cultivated areas with irrigated lands, residential areas, orchard and vineyard plantations, open reservoirs (concrete dams), and concrete furrows and channels.
- The study area is surrounded by Somerlus, Maki-Saki, Eureka and Pokwane residential areas.

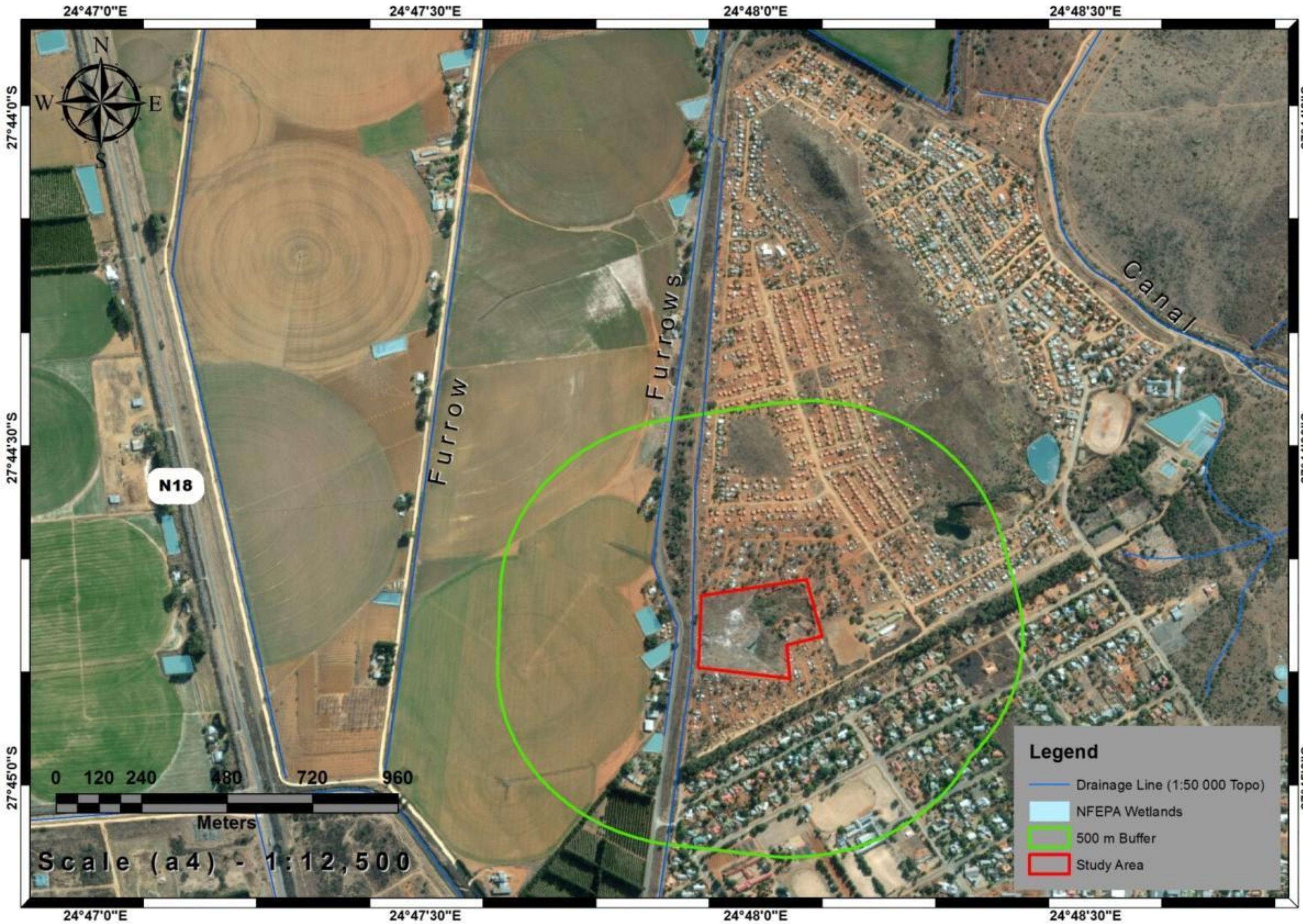

Figure 1: Locality map of the study area illustrating the study area boundary, sample points, 500 m study area buffer, furrows and canals from the 1:50 000 topographical map (2724DB & 2724DD), as well as wetlands from the NFEPA spatial dataset (2011).

3.2. Study Area catchment and surface hydrology

- The study area is located within the Lower Vaal Water Management Area (WMA) and falls within the Quaternary Catchment C33A.
- Quaternary Catchment C33A has a Moderate Conservation status and a Largely modified (Class D) Present Ecological State (PES), as indicated by Middleton & Bailey (2008).
- Quaternary Catchment C33A is associated with largely developed and modified land use including numerous small farm dams for irrigation and urbanized catchment with residential areas.
- Non-natural drainage features (furrows) are indicated to be flowing parallel to the study area into concrete dams that are used to irrigate cultivated lands.
- Smaller concrete furrows are connected to the main concrete canal, located northeast of the site, which contains diverted water from the Vaal River and forms part of the Vaalharts Irrigation Scheme. This irrigation scheme is the largest in the country and consists of a total of 1176 km of concrete-lined canals, while it provides water for the irrigation of a total of 39820 ha of land (http://vaalhartswater.co.za/).

3.4. Local climate, geology and regional vegetation

- The most recent vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006) indicates that the entire study area is located within the Savanna Biome and includes one bioregion (subgroup). The entire study area and its immediate surroundings fall within the Kimberley Thornveld vegetation unit, which forms part of the Eastern Kalahari Bushveld Bioregion. Furthermore, the vegetation is classified as Least Threatened even though there is transformation due to cultivation and a relatively low protection of the vegetation unit in nature reserves. According to Mucina & Rutherford (2006) almost 18% of the vegetation is already transformed by cultivation and erosion degradation is regarded as low.
- The average (MAP) of Kimberly Thornveld vegetation ranges from 300 mm in the southwest to about 500 mm in the northwest and mostly falls during summer, with very dry winters (Mucina& Rutherford, 2006).
- The study area does not overlap with any listed Threatened Ecosystem areas according to the 2011 Schedule (Government Gazette of December 2011) of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA).

- The study area falls within Land Type Ah21 and is associated with soils that have Red-yellow apedal, freely drained soils, with a high base status and usually with less than 15% clay.
- The geology of the study area and its surroundings are associated with the Hartswater Group of the Ventersdorp Supergroup, with Andesite, Tuff, Tillite, Chert and Conglomerate lithological features (Mucina& Rutherford, 2006).

4. Watercourse Delineation and Assessment

4.1. Delineated and classified watercourses

- The study area does not overlap with known wetland areas indicated on the NFEPA wetland spatial dataset. Three artificial wetlands in the form of concrete dams are present approximately 70 m west and 210 m southwest of the site. These dams are connected to concrete furrows that provide water to the dams as part of the Vaalharts Irrigation Scheme (Figure 1).
- No drainage line, furrow or canal, as indicated on the 1:50000 topographical map 2724DB, is present within the study area. Furrows are, however, present in the surrounding 500 m buffer, while larger canals are present approximately 660 m to the southwest and 1.15 km to the northeast (Figure 1). The nearest canal represents the Phokwane River, which flows westwards into the Harts River, approximately 88 km west of the study area.
- The site survey confirmed the presence of wetland conditions confined to an excavated area within the study area (Figure 2). Recorded wetland features include the dominance of the obligate hydrophyte species, *Typha capensis*, which covers most of the floor of the excavated area (Figure 3). *Phragmites australis,* is another obligate hydrophyte species that is common within the same area. Other recorded hydrophyte species include *Cyperus* cf. *textiles,* and the aliens *Melilotus alba* and *Juncus* cf. *excertus.*
- Only weathered saprolite and in wash material was recorded along the floor of the excavation with no distinct signs of hydromorphism. The absence of hydromorphic features can partially be attributed to the removal of topsoil and subsoil material in which wetland soil features typically form, as well as the unknown potential of the saprolitic material to buffer chemical change.
- The development of wetland conditions are not regarded as recent in spite of the absence of distinct hydromorphic features as the majority of the artificial wetland is dominated by obligate hydrophyte species, which indicate a prolonged period of soil saturation.

Figure 2: Delineated artificial wetlands and dams within the study area and its 500 m buffer.

- The wetland is regarded as an artificial wetland based on the following:
    - Wetland habitat is only localised along the floor of the excavated area, which is deeper than 2 m in several areas.
    - The surrounding soils that border the wetland are deep and well drained sandy-loam red soil (deep red apedal soil horizons), which contain no signs of hydromorphism (Figure 4).
    - The surrounding vegetation outside of the excavated area is terrestrial and characterised by terrestrial species, such as *Vachellia erioloba* (previously known as *Acacia erioloba*) trees.
    - Another excavated area, located approximately 400 m upslope and northeast of the site, also contains artificial wetland habitat (Figures 2 & 5).It differs from the study area as it is not as wet with less open water and a sparser vegetation cover. The area is also shallower compared to the artificial wetland within the study area.
- The development of wetland conditions within the excavated area in the landfill site is contributed to rainwater collection and poor drainage based on findings in the groundwater study (Naidoo & Burger, 2015).
- The artificial wetland has a size of 1.39 ha and occupies 22.17 % of the 6.27 ha study area (Figure 2). The combined artificial wetland habitat delineated within the 500 m study area is 2.63 ha (excluding delineated dams).

Figure 3: Illustrates a dense stand of obligate hydrophytes in the form of *Typha capensis* and *Phragmites australis* within the artificial wetland.

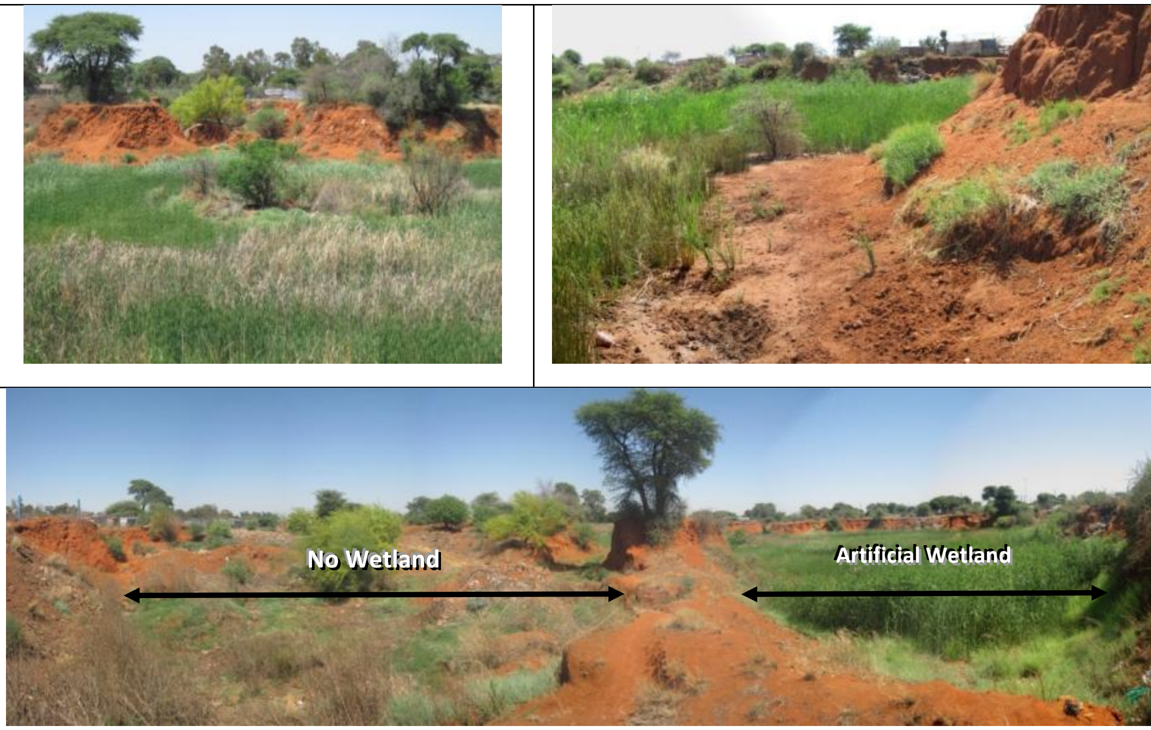

Figure 4: Illustrates deep profiles of well-drained red terrestrial soils that have been excavated with artificial wetland habitat along the bottom of the excavation. Only excavations of a sufficient depth have resulted in the formation of artificial wetland habitat (bottom row).

Figure 5: Illustrates an excavation approximately 400 m northeast (upslope direction) of the study area that also contains artificial wetland conditions. Wetland conditions are expressed at a shallower depth in this excavation compared to the one within the study area.

4.2.Present Ecological State & Ecological Importance and Sensitivity Assessments

A Present Ecological State (PES) assessment for an artificial wetland is technically not possible, as the reference condition of such a system is terrestrial. In other words, no wetland existed in the delineated wetland area prior to excavation activities that lead to the creation of artificial wetland conditions. In general ecological terms the wetland area within the study area can be described as a transformed system that is impacted by soil sedimentation from the steep banks, litter dumping and infill from the surrounding landfill site, and expected low water quality inputs as a result of leachate from solid waste material into the wetland (Figure 6).

The Ecological Importance and Sensitivity (EIS) of the wetland is regarded as moderate based on available information. *Typha capensis* and *Phragmites australis* provide foraging and roosting habitat for the weaver *Euplectes orix* (Southern Red Bishop) within the wetland, while the steep and deep excavated banks are used by *Merops apiaster* (European Bee Eater) for burrowing sites (Figure 7).Both of these species are common and are therefore not regarded as species of conservation concern.

Figure 6: Illustrates dumping and infilling of solid waste (litter) within the wetland and the risk of leachate from litter into the wetland.

Figure 7: Illustrates habitat utilised by European Bee Eaters, and potentially other bird species, to create numerous burrows within the vertical banks of excavations in the study area; many of which are located above artificial wetland habitat.

5. Discussion and Impact Assessment

5.1. General discussion

- No natural wetlands or other natural watercourses are present within the study area.
- An artificial wetland of approximately 1.39 ha is associated with a deep excavation within the study area and surrounding landfill site, which occupies approximately 22.17 % of the site.
- Rainwater collection and poor drainage in the excavated area is regarded as the driver of wetland conditions within the landfill site (Naidoo & Burger, 2015).
- The artificial wetland is regarded as transformed with impacts that include sedimentation, solid waste infill and dumping, as well as expected leachate from litter material within and adjacent to the wetland.
- The delineated wetland, viewed as a separate entity from the surrounding landfill site, has some functionality as it provides habitat for birdlife and possess more aesthetic appeal compared to its unsightly surroundings. The aesthetic value of an area is a subjective interpretation and falls outside the scope of this report. It is, however, mentioned, as the vegetated within area within the artificial wetland and the vertical walls with burrows, are regarded more appealing compared to solid waste that dominates the rest of the study area.
- The artificial wetland has been buffered by 32 m buffer as a general means of impact mitigation (Figure 8). The 32 m buffer also demarcates an area in which several 'listed activities', as defined by the National Environmental Management Act,1998 (Act No. 107 of 1998) (NEMA), are identified as requiring legal authorization prior to commencement of activities within this buffer area.
- NEMA lists specific activities for which environmental authorization should be obtained when located within a watercourse, 32m of a watercourse or in some cases even within 100 m of a watercourse. Details pertaining to restrictions associated with different listed activities have been recently updated under sections 24(5) and 44 of the NEMA as set out in the Schedule under Government Gazette Notice 38282 date 4 December 2014.
- The artificial wetland does not provide ecological functionality apart from the created bird habitat. Its future existence is therefore not regarded as an essential consideration as part of the rehabilitation and closure of the landfill site.
- Features related to created bird habitat, such as sections with vertical slopes that are used as borrows, can be retained where it is practically possible and where there is no risk to groundwater pollution.

Figure 8: Illustrates delineated artificial wetlands within the study area and surroundings along with a 32 m buffer zone.

- It is therefore recommended that other aspects, such as the risk of groundwater pollution described by Naidoo & Burger (2015), should received priority during the rehabilitation and closure phases of the landfill site even if it may impact negatively on the artificial wetland.

5.2. Project-related impact identification

- The assessed Hartswater LFS is to be closed as a new LFS is in operation in the area. A Waste Management License is therefore being applied for to formally close the site.
- Closure and rehabilitation activities will therefore have to be undertaken and are expected to impact on the wetland.
- An impact assessment rating for each identified impact is provided in Table 1, while impact descriptions and mitigation measures are discussed below. The impact assessment method is based on the template received from SE Solutions and can be made available on request.
- Possible wetland impacts as a result of recommendations for the rehabilitation and closure of the LFS, as set out in the groundwater report by Naidoo & Burger (2015), are considered as part of the impact assessment of this report. Recommendations made in the groundwater report regarding the rehabilitation, closure and monitoring of the LFS should also be referred to for a more detailed description of these activities (Naidoo & Burger, 2015).

5.2.1. Loss of wetland habitat and indigenous species

The artificial wetland habitat on the landfill site has been transformed through dumping, which includes historical formal dumping and litter infill when the site was used as an operational landfill site. Continued informal dumping still occurs within the study area as surrounding residents making use of the area as a disposal site for household waste, while activities associated with the rehabilitation and closure of the LFS is likely to include capping on all areas where no further waste deposition will take place (including the artificial wetland), with vegetation establishment to follow (Naidoo & Burger, 2015). Capping of the artificial wetland is expected to result in a drier wetland. Vegetation establishment after capping may still have wetland characteristics, but can differ from the dominant stands of *Typha capensis* that are currently present. The impact is considered to be Negative and of Medium-High significance in spite of mitigation (Tables 1 & 2).

Table 1: Impact assessment table for the delineated artificial wetland within the Hartswater LFS study area (post closure assessment without mitigation WOM).

Nature	Extent	Duration	Intensity	Probability	Status	Significance	Confidence	Reversibility	Replaceability
Loss of wetland habitat and indigenous species	Site	Long term	Medium - High	Highly-likely	Negative	Medium - High	Medium	Partially reversible	Moderate - High
Groundwater pollution mitigation and changes in wetland hydrology	Site	Permanent	High	Highly-likely	Negative	Medium - High	Medium	Irreversible	High
Erosion and Sedimentation	Site	Permanent	High	Highly-likely	Negative	Medium - High	Medium	Partially reversible	Low - Moderate

Table 2: Impact assessment table for the delineated artificial wetland within the Hartswater LFS study area (post closure assessment with mitigation WM).

Nature	Extent	Duration	Intensity	Probability	Status	Significance	Confidence	Reversibility	Replaceability
Loss of wetland habitat and indigenous species	Site	Long term	Medium - High	Highly-likely	Negative	Medium - High	Medium	Partially reversible	Moderate - High
Groundwater pollution mitigation and changes in wetland hydrology	Site	Permanent	High	Highly-likely	Negative	Medium - High	Medium	Irreversible	High
Erosion and Sedimentation	Site	Long term	Medium	Likely	Negative	Medium	Medium	Partially reversible	Low - Moderate

Mitigation:

- No further landfill activities should occur within the delineated artificial wetland and its buffer. The new landfill site in Hartswater should be used as an alternative.
- The fence around the wetland and LFS should be repaired. It is, however, unlikely to keep local residents out. It is suggested that signage in local languages are used on fence sections near the wetland to encourage residents to utilise the non-wetland portions of the study area for household waste disposal. Avoidance of the artificial wetland by residents also has an added safety value as the area contains open water that may pose a drowning risk. An intact fence around the wetland area is therefore recommended to prevent pedestrian movement into or near the wetland prior to the rehabilitation and closure of the site.
- Capping on the artificial wetland may be unavoidable as part of mitigation measures to reduce the risk of groundwater pollution. If the artificial wetland area is not regarded as an essential area to be capped then capping can be restricted to the area outside of the wetland. The buffer area can also be capped as part of this approach as it is largely made up of infill waste material. The possibility to exclude or restrict capping within the artificial wetland will only become clear during the finalisation of a rehabilitation and closure plan for the site. It is currently expected that capping in the wetland area will occur.

5.2.2. Groundwater pollution mitigation and changes in wetland hydrology

The spreading of litter prior to the rehabilitation and closure of the LFS can lead to water pollution in the artificial wetland. Liquid leachate from the landfill site is another source of potential pollution that is expected to result in decreased water quality within the artificial wetland. This includes the risk of groundwater pollution as water within the artificial wetland can contaminate the underlying aquifer (Naidoo & Burger, 2015). The following extracts have been obtained from the groundwater assessment regarding the risk of groundwater pollution and recommended mitigation measures that are expected to impact negatively on the artificial wetland (Naidoo & Burger, 2015):

> The unlined landfill (source) may leach contaminated water into the underlying aquifer (pathway) during rainfall events. This contaminated groundwater may then move downgradient towards private boreholes surrounding the site or the Phokwane River (receptors).
>
> Pollution source management should be based on passive management principles, i.e. the need for ongoing intervention and active management is minimal, but not zero. Examples of passive measures include storm water diversion berms and drains, lining of pollution control dams, finger drains under ash disposal facilities and toe paddocks around such facilities, etc.

All covered surfaces on the landfill must be so graded as to promote run-off to prevent ponding.

Limit the ingress of surface water and groundwater into the pits.

The expected lining of the LFS, including the artificial wetland, will reduce the risk of aquifer pollution, but it will also prevent possible groundwater discharge into the artificial wetland. Naidoo & Bester (2015) regards rainfall and poor internal drainage to be the main drivers of wetland conditions within the artificial wetland excavation, but the possibility remains that groundwater flow into the excavation may also play a role. This is based on the following:

- Water ponding was present during the end of the dry season within the artificial wetland (September & October 2015) in spite of a high Mean Annual Evaporation (MAE) of 2070 mm compared to a Mean Annual Precipitation (MAP) of 432 mm for Quaternary Catchment C33A (Middleton & Bailey, 2008)
- The presence of obligate hydrophytes, such as *Typha capensis* and *Phragmites australis*, across the artificial wetland, which indicate prolonged conditions of soil saturation and/or inundation.
- Mention of a minimum groundwater table of 2.5 m deep (less than the maximum excavated depth of sections in the artificial wetland), located north of the site (Naidoo & Burger, 2015).

Implementation of a lined surface in the artificial wetland can therefore cause drier conditions within the wetland, and in the worse case, may even result in the eventual disappearance of the wetland, if the system is more dependent on groundwater discharge compared to rainwater collection.

Creation of berms and trenches to capture runoff are likely to reduce surface water input into the wetland, which is regarded as an important source of water input into the artificial wetland (Naidoo & Burger, 2015).

Ponding in pits, depressions and excavations are to be prevented to restrict the risk of surface water ingress through landfill material into the underlying aquifer. The maintenance of artificial wetland conditions is therefore regarded as being undesirable in the light of groundwater pollution risks. This reshaping approach, along with the lining of the LFS and the use of berms and trenches, are therefore expected to result in the disappearance of the artificial wetland. This is most likely an unavoidable result of the proposed groundwater pollution mitigation measures. The combined impact of the different mitigation measures are Negative and of Medium-High significance with and without mitigation (Tables 1 & 2). More detailed information regarding the risks, impacts and effective mitigation of water quality impacts, especially groundwater quality impacts, are provided in the groundwater study (Naidoo & Burger, 2015).

Mitigation:

- No further landfill activities should occur within the delineated artificial wetland and its buffer prior to the rehabilitation and closure of the LFS. The new landfill site in Hartswater should be used as an alternative.
- Waste material can be removed from the artificial wetland, either manually or through the use of machinery.
- Groundwater pollution mitigation measures recommended by Naidoo & Bester (2015) are likely to have an unavoidable impact on the artificial wetland and it is expected that the wetland will seize to exists as a result of these mitigation measures. The final rehabilitation and closure plan can investigate opportunities to retain elements of the wetland on the condition that they do not pose a risk to groundwater pollution, which appears to be impractical based on available information.

5.2.3. Erosion and sedimentation

Sedimentation as a result of erosion along the steep banks of the excavation were recorded within the artificial wetland. Further erosion of excavation activities can result in sediment mobilisation and influx into the wetland system, which is not regarded as a major threat to the wetland. Reshaping of the excavated and vertical banks to create new slopes that are not steeper than 1 in 2.5 (Naidoo & Bester, 2015), will destroy habitat for bird burrows along the artificial wetland. The overall impact is considered to be Negative and of Medium significance with mitigation (Tables 1 & 2).

Mitigation:

- Not all of the vertical banks along the artificial wetland should be reshaped. Portions with a high density / number of burrows should be retained as far as practically possible. This should, however, be done in a manner that does not contribute to an increase groundwater pollution risk through the maintenance of excavations and depressions where water can collect and ingress into the underlying aquifer.

5.3. Water Use License requirements

- Wetlands and other watercourses are protected water resources in terms of the NWA. Development or transformation of the watercourses is regarded as a *water use*, which can only be allowed through an approved Water Use License, irrespective of the condition of the affected watercourse.
- The implication is that authorization will have to be obtained from DWS before water use activities can be initiated in demarcated wetlands and other watercourses.
- Section 21 of the NWA defines different types of water use in a watercourse. Examples of water use activities that may be applicable to the artificial wetland in the study area include the following

  (c) impeding or diverting the flow of water in a watercourse.

  (i)altering the bed, banks, course or characteristics of a watercourse.
- Opportunities to rehabilitate the wetland and ensure its maintenance are limited as a result of the risk it poses to groundwater pollution. The wetland is expected to decrease in size and wetness, and may even disappear completely due to the proposed groundwater pollution mitigation measures (Naidoo & Bester, 2015; also see Section 5.2). It therefore seems likely that a Water Use license (WUL) will have to be obtained t implement the recommended groundwater mitigation measures.
- A DWS stipulation published in Government Gazette No 32805 (December 2009) also require that a Water Use License should be applied for when any wetlands are present within a 500 m radius (buffer) of Section 21 *(c)* and/or Section 21 *(i)* water use activities.

6. References and Further Reading

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