FINAL

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HUDDLE PARK WETLAND DELINEATION VERIFICATION

Prepared for:

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Executive Summary

Introduction

Ixhaphozi Enviro Services (I.E.S.) were contracted by Strategic Environmental Focus (SEF) to conduct wetland boundary verification on the Huddle Spruit Wetland, Huddle Golf Club.

Scope of work

Wetland verifications for the Huddle development (Appendix A):

- The south – western corner of the development (roughly shown on the map in Appendix A), where the 32m buffer around the seasonal wetland encroaches on the development.
- Verify the northern section of the wetland (and its boundaries) (roughly shown on the map in Appendix A), as some services will cross the wetland here. An assessment of the Present Ecological State and Ecological Importance & Sensitivity were done for this part of the wetland.

Methodology

The wetland was previously delineated by SEF in 2006, refined by Imperata Consulting in 2007 and verified by I.E.S in 2008. At that time signs in wetness in the soils were used as the main indicator due to the fact that the Huddle Golf Course has transformed most of the wetlands natural character. This situation is still relevant and using soils to verify the 2008 delineation was considered the best option. The Present Ecological Status (PES) method was used to establish the integrity of the wetland. The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the guidelines as developed by DWAF.

Conclusion

From the verification exercise the wetland delineation by SEF and Imperata Consulting are accepted as accurate. The wetland has a low PES and EIS rating and the proposed Huddle Development should have little impact on the system if due diligence is paid during the different stages of development. Mitigation measures should focus on stormwater control, preventing water pollution, erosion and sedimentation.

Contents

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2 SCOPE OF WORK

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Due to the degraded state of the wetland vegetation (as a result of the golf course) it was necessary to focus on a soil survey to verification the wetland boundaries.

3 LIMITATIONS OF THIS INVESTIGATION

The following was assumed for the purposes of this wetland ecosystem assessment:

- The information supplied by the client was correct at the time that fieldwork commenced.

The following limitations were placed on the wetland verification study of this project:

- A single baseline assessment and a soil survey were conducted;
- Accuracy of the maps, aquatic ecosystems, routes and desktop assessments were made using the current 1:50 000 topographical map series of South Africa;
- Delineations and related spatial data generated will be supplied in GIS (kml file) format only and will be for use in conceptual planning purposes only and not detailed design. If the client requires that data be accurate to the level of detailed design this will be negotiated and budgeted for separately.
- Accuracy of Global Positioning System (GPS) coordinates were limited to 15m accuracy in the field;
- Whilst every care is taken to ensure that the data presented are qualitatively adequate, inevitably conditions are never such that that is possible. In the circumstances it must be pointed out that the nature of the vegetation (an old established golf course), the time of year, human intervention and the like limit the veracity of the material presented".

4 THE STUDY AREA

The site is located in the Huddle Golf Club, Linksfied, Gauteng approximately 2km west of the N3 (Figure 1). It is located towards the headwaters of the Huddle Spruit, a tributary of the Jukskei River) with a prominent quartzite ridge (Linksfield Ridge) to the south. The underlying geology is dominated in the wetland area by Halfway house granites. The wetland has been transformed into a golf course and is located within an urban environment.

Figure 1. Map indicating the locality of the study area: Place mark A (from Google Map)

5 METHODOLGY

The wetland was previously delineated by SEF in 2006, refined by Imperata Consulting in 2007 and verified by I.E.S in 2008 (Grundling, 2008) (Figure 2). At that time signs in wetness in the soils were used as the main indicator due to the fact that the Huddle Golf Course has transformed most of the wetlands natural character. This situation is still relevant and using soils to verify the 2007 delineation was considered the best option.

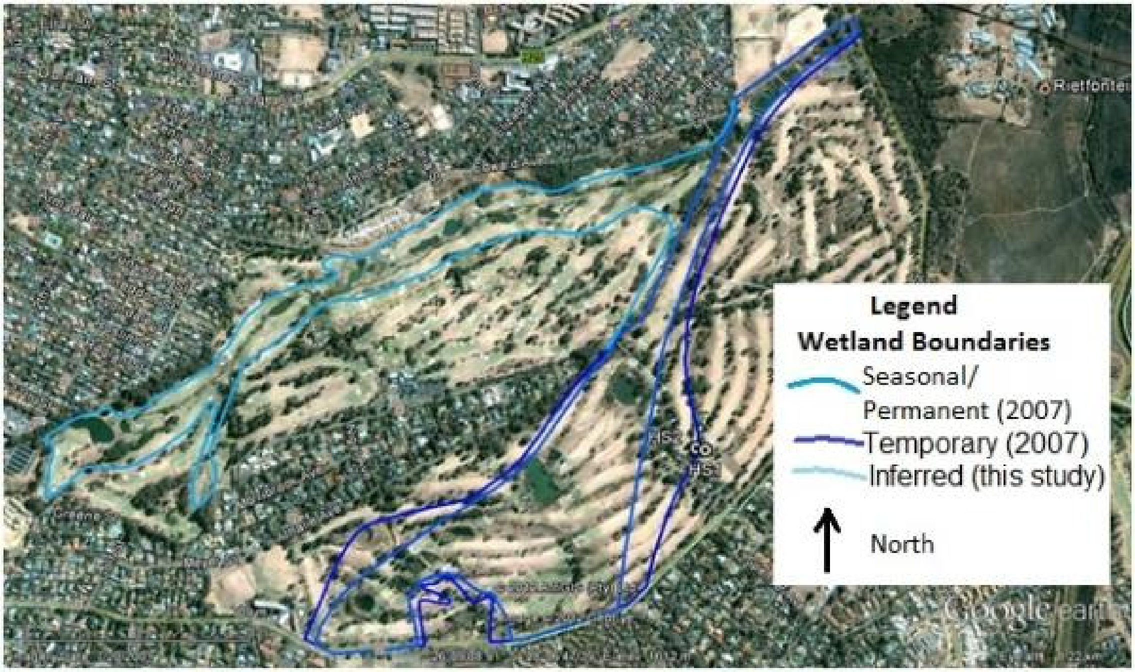

Figure 2. Wetland boundaries as delineated by Imperata Consulting 2007

5.1 BACKGROUND – THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled "A practical field procedure for identification and delineation of wetland and riparian areas" (DWAF, 2005). The "…manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries." The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- "**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 50cm of the soil."

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.

- Soil Form Indicator. A number of soil forms (as defined by The Soil Classification Working Group, 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of "bleaching" and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use of soils (soil form and wetness) as the criteria for the delineation of wetlands.

5.2. THEORETICAL BACKGROUND

In order to discuss the procedures followed and the results of the wetland delineation exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

5.2.1 Pedogenesis

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely:

- Parent material
- Climate
- Topography
- Living Organisms
- Time

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as iron (Fe) and manganese (Mn). Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

5.2.2 Water Movement in the Landscape

Water movement in a landscape is subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. Figure 3provides a simplified schematic representation of an idealised landscape. The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape. The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil. In a landscape there is a cumulative effect as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. Figure 4 illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile.

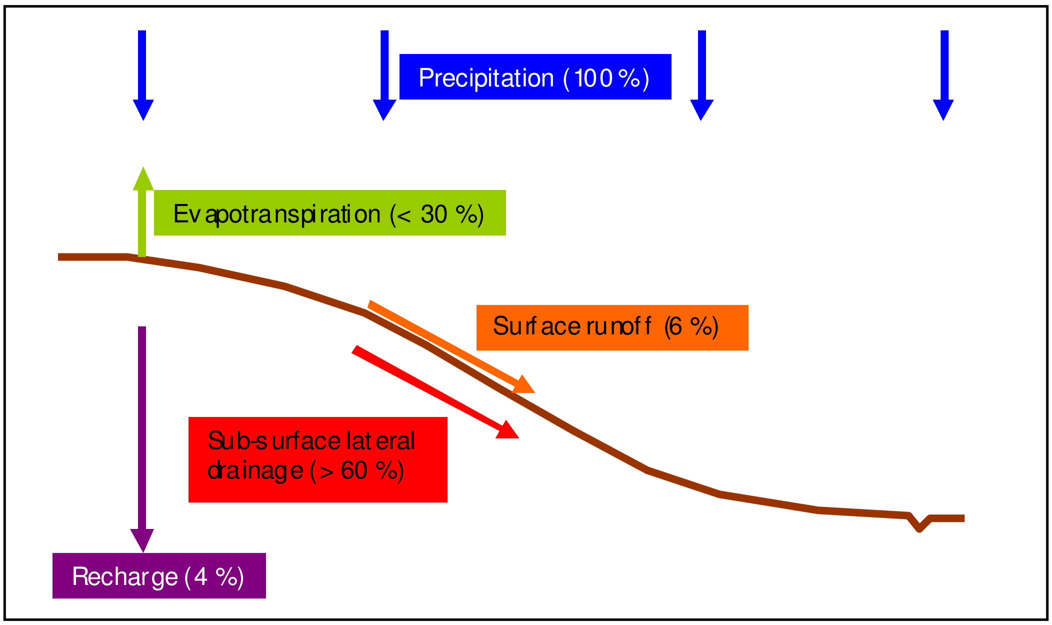

Figure 3. Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %). Note the upland recharge area.

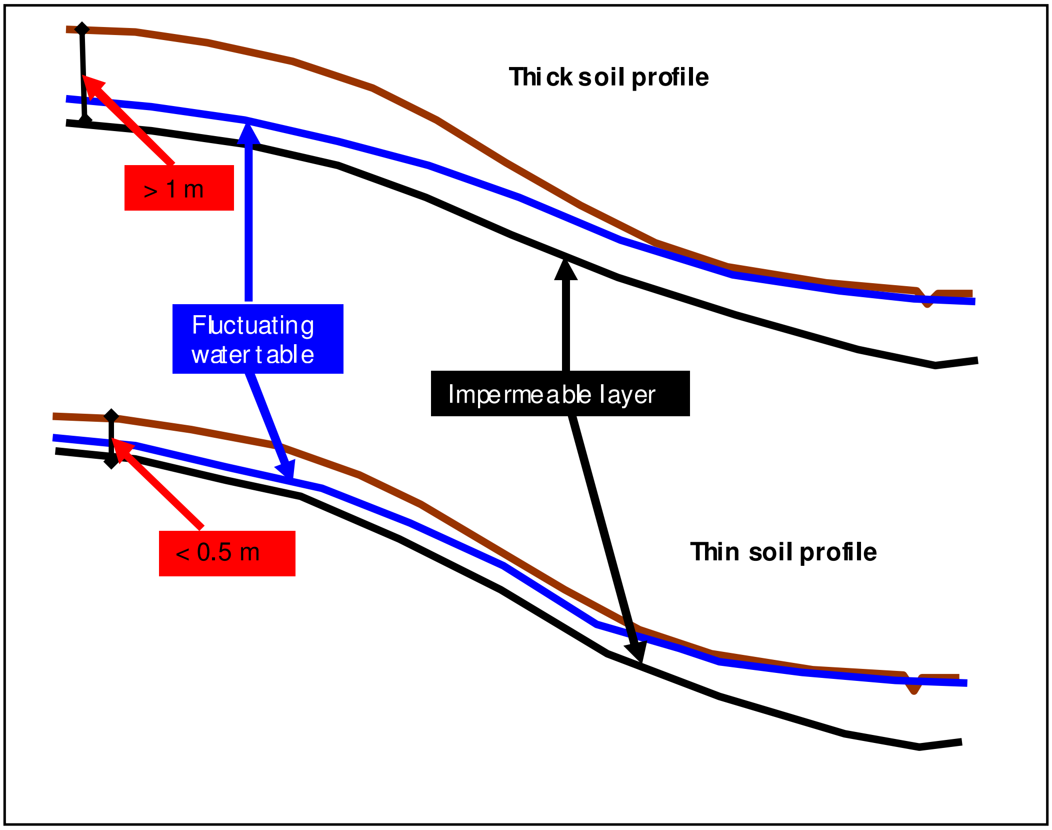

Figure 4. The difference in water flow between a dominantly thick and dominantly thin soil profile.

5.2.3 The Catena Concept

Here it is important to take note of the "catena" concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. Figure 5 illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peatland).

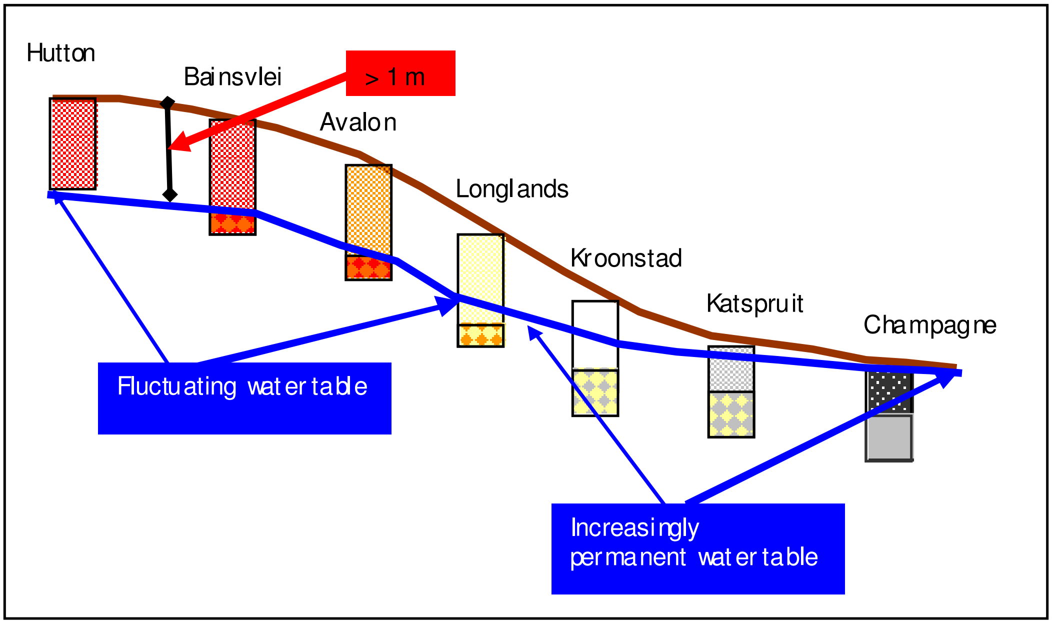

Figure 5. Idealised catena on a quartz rich parent material.

5.2.4 The Halfway House Granite Catena

The typical catena that forms on the Halfway House granite differs from the idealised one discussed above in that the landscape is an old stable one, the parent material is relatively hard and therefore resistant to weathering as well as that it has a very low Fe content/"reserve". The implication is that the whole catena is dominated by bleached sandy soils with a distinct and shallow zone of water fluctuation. This zone is often comprised of a high frequency of Fe/Mn concretions and sometimes exhibits feint mottles. In lower lying areas the soils tend to be deeper due to colluvial accumulation of sandy soil material but then exhibit more distinct signs of wetness (and pedogenesis). Figure 6 provides a schematic representation of the catena.

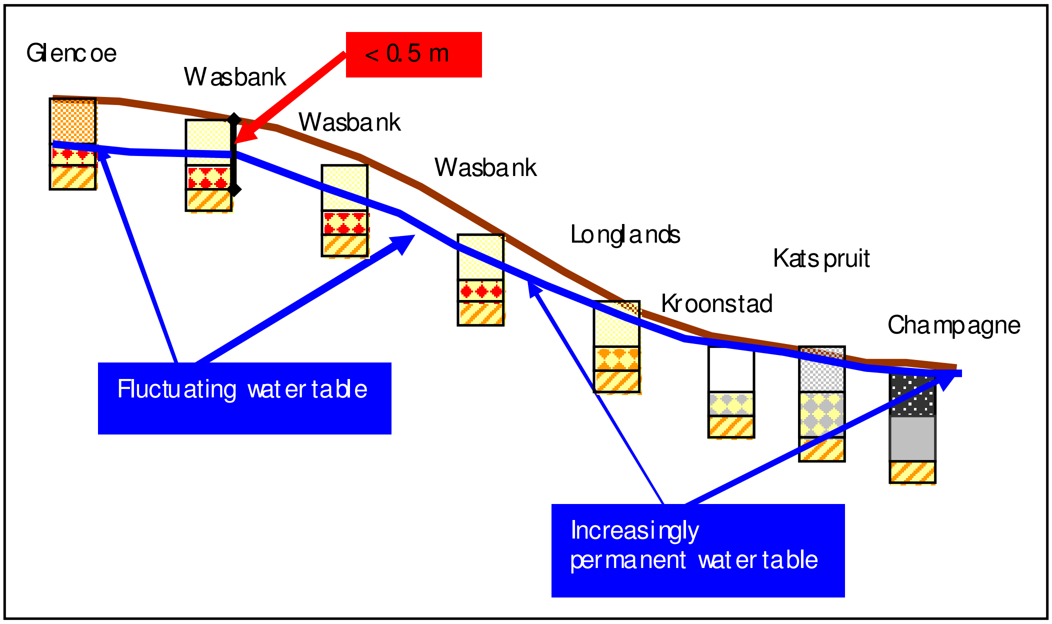

Figure 6. Schematic representation of a Halfway House granite catena.

The essence of this catena is that the soils are predominantly less than 50 cm thick and as such have a fluctuating water table (mimicking rainfall events) within 50 cm of the soil surface. One of the main criteria used during wetland delineation exercises as stipulated by the guidelines (DWAF, 2005) is the presence of mottles within 50 cm of the soil surface (temporary and seasonal wetland zones). Even from a theoretical point of view the guidelines cannot be applied to the above described catena as soils at the crest of the landscape would already qualify as temporary wetland zone soils (upon request many such examples can be supplied). The practical implication of this statement as well as practical examples will be discussed in the next section.

5.2.5 Convex Versus Concave Landscapes in the Halfway House Granite Catena

An additional factor of variation in the Halfway House granites is the shape of the landscape along contours. Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of “dryer” soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of “signs of wetness” such as grey colours, organic matter and subsurface clay accumulation. Figure 7presents the difference between these landscapes in terms of typical soil forms encountered on the Halfway House granites. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the midslope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E-horizons). In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions.

Note: In some cases the HHGD has influences of what appears to be dolerite/diabase. Under these circumstances the typical catena as described does not occur and a typical red/yellow-brown/dark soil sequence is observed from crest to valley bottom. Under the influence of dolerite/diabase the clay contents of the soils are also much higher than the granite derived soils.

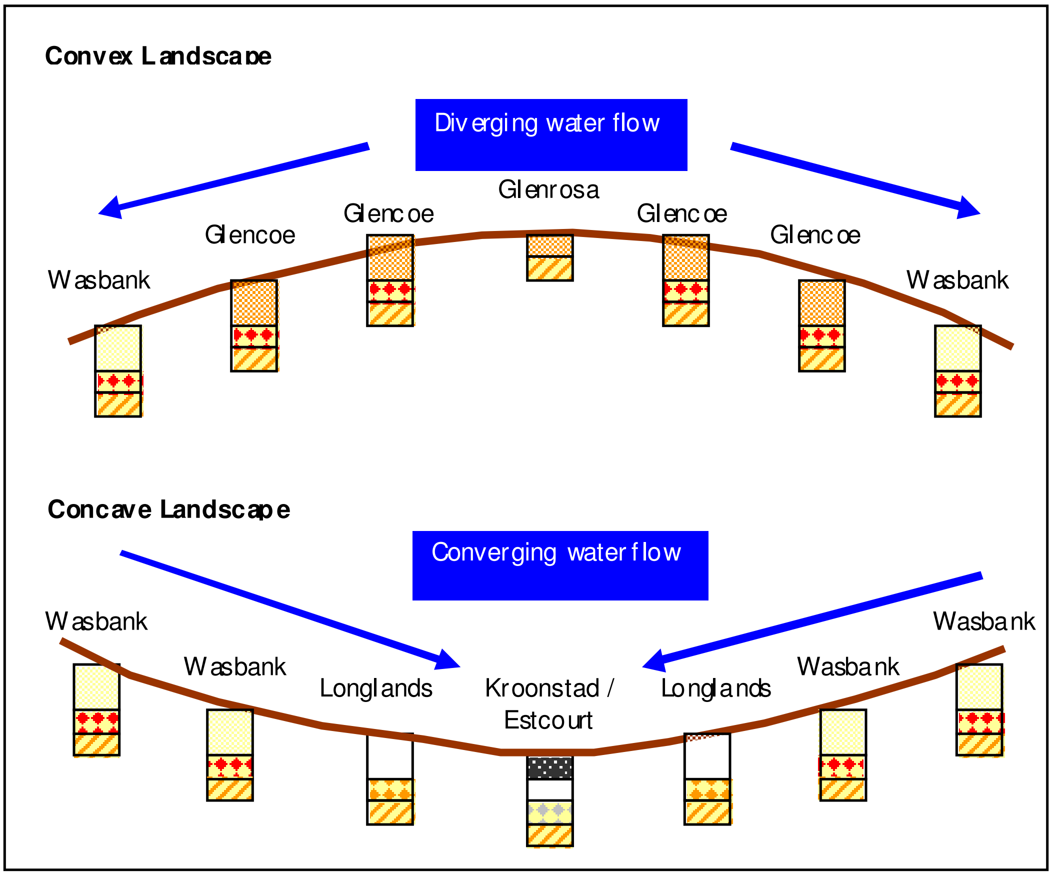

Figure 7.Schematic representation of the soils in convex and concave landscapes in the Halfway House granite catena.

5.2.6 Implications for Wetland Delineation and Application of the Guidelines

When the 50 cm criterion is used to delineate wetlands in the Halfway House granite environment, the soils in convex positions often "qualify" as temporary wetland soils due to their relatively thin profile and the presence of concretions (often weathering to yield "mottles") within this zone. In conjunction with a low Fe content in the soils and subsequent bleached colours (as defined for E-horizons) in the matrix a very large proportion of the landscape "qualifies" as temporary wetland zones. On the other hand, the soils in the concave environments, especially in the centre of the drainage depression, tend to be thicker and the 50 cm criterion sometimes does not flag these soils as being wetland soils due to the depth of the signs of wetness (mottles) often occurring only at depths greater than 80 cm. Invariably these areas are always included in wetland delineations due to the terrain unit indicator flagging it as a wetland area and drainage feature.

The strict application of the wetland delineation guidelines in the Halfway House granite area often leads to the identification of 70 % or more of a landscape as being part of a wetland. For this reason a more pragmatic approach is often followed in that the 50 cm criterion is not applied religiously. Rather, distinctly wet horizons and zones of clay accumulation within drainage depressions are identified as distinct wetland soils. The areas surrounding these are assigned to extensive seepage areas that are difficult to delineate and on which it is difficult to assign a realistic buffer area. The probable best practice is to assign a large buffer zone in which subsurface water flow is encouraged and conserved to lead to a steady but slow recharge of the wetland area, especially following rainfall events.

5.3. SITE ASSESSMENT AND WETLAND DELINEATION

Due to the current state of the site in terms of road construction activities as well historic impacts that have led to changes in vegetation and the appearance of head-cuts in the stream canal a dedicated soil based delineation of the wetland on the site was conducted.

5.3.1 Methods of Investigation

The wetland on the site was investigated and assessed on the basis of the wetland indicators as described in the wetland delineation guidelines (DWAF, 2005).As a basis for the soil indicators the land type data for the site and surrounding area was also investigated to provide a baseline reference. Sample sites are listed in Appendix B.

5.3.2 Land Type data and Terrain Unit Indicator

Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System (MacVicar et al., 1977). The soil data was interpreted and re-classified according to the Taxonomic System (The Soil Classification Working Group, 1991).

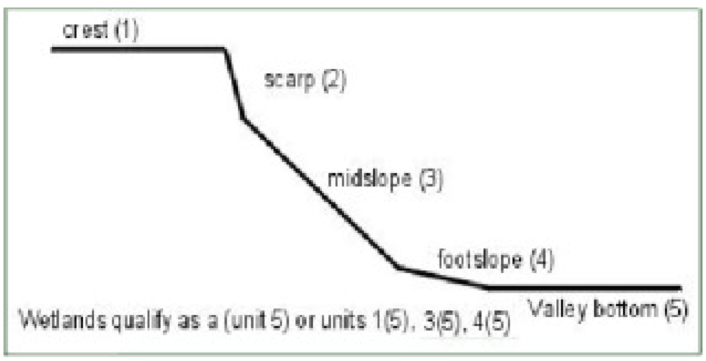

Figure 8. Terrain units

Wetlands usually occur in landscape positions (Figure 8) where slopes are shallower such as valley bottoms or even crests in certain conditions. However wetlands are often found on steeper slopes where discharge of intermediate (subsurface) flow or groundwater is forced to the surface by geological or geomorphological features, and it often noted at slope changes such between the midslope and the footslope. Slope changes were noted infield and correlated with imagery on Google Earth. High resolution satellite images as well as 2 m contours for the site were used to identify the specific terrain units where the wetland occurs. This data was correlated with the land type data and descriptions for the purposes of the discussion later in the report.

5.3.3 Soil Form and Soil Wetness Indicators

Soils were classified along five (5) transects across the delineated wetland (Figure 9). The classification was conducted through auguring with a hand soil auger and the identification of soil morphological properties. These include texture, structure, soil colour, presence of mottles, etc. The presence and types of mottles were used as an indication of "signs of wetness" in the soil horizons. "Signs of wetness" refer to the morphology of redox accumulations and redox depletions as expressed in soil due to the dominant water regime.

Figure 9. Position of the transects on Huddle Park Golf Course

5.3.3 Vegetation Indicator

A vegetation survey was not conducted by this author as it had been conducted due to the fact that the whole site is a golf course and mostly covered with lawn.

5.4 WETLAND INTEGRITY ASSESSMENTS

5.4.1 Present Ecological Status (PES)

The Present Ecological Status (PES) method (Kleynhans, 1999) was used to establish the integrity of the wetland. This method is based on the modified Habitat Integrity approach (Table 1) developed by Kleynhans (DWAF 2005). Anthropogenic modification of the criteria and its attributes can have an impact on the ecological integrity of a wetland.

Table 1. Habitat integrity assessment criteria for wetlands (Adapted from Kleynhans, 1999)	
Criteria and Attributes	***Relevance***
Hydrologic	
Flow Modification	Consequence of abstraction, regulation by impoundments or increased run-off from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to or from a wetland.
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.
Water Quality	
Water Quality Modification	From point or diffuse sources. Measured directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.
Hydraulic/Geomorphic	
Canalization	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other disruptive activities to the substrate which reduce or change the inundation patterns of wetland habitat directly.
Biota	
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases in potential for erosion.
Invasive Plant Encroachment	Affects habitat characteristics through changes in biotic community structures and water quality changes (oxygen reduction and shading).
Alien Fauna	Presence of alien fauna affecting indigenous faunal community structure.
Over utilization of Biota	Overgrazing, over fishing, etc.
Attributes above are rated and scored as follows: Natural/Unmodified 5 Largely Natural 4 Moderately Modified 3 Largely Modified 2 Seriously Modified 1 Critically Modified 0	

The Present Ecological Status Class (PESC) of the wetlands was based on the available information for each of the criteria listed in **Error! Reference source not found.**2 and the mean score determined for each wetland as reflected in Table 2. This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the PESC (Kleynhans, 1999).

Table 2. Guidelines for the determination of the Present Ecological Status Class (PESC) (after Kleynhans, 1999).		
Class Boundary	**Class**	**Class Description**
Within generally acceptable range		
>4	Unmodified (A = Very High)	Unmodified or approximated natural condition.
>3 and <=4	Largely Natural (B = High)	Largely natural with few modifications, but with some loss of natural habitat.
>2 and <=3	Moderately Modified (C = Moderate)	Moderately modified, but with some loss of natural habitat.
2	Largely Modified (D = Low)	A large loss of natural habitat and basic ecosystem function has occurred.
Outside generally acceptable range		
>0 and <2	Seriously Modified (E = Very Low)	The loss of natural habitat and basic ecosystem function are extensive.
0	Critically Modified (F = Non-Existent)	Modifications have reached a critical level and the system has been modified completely with almost complete loss of natural habitat.

5.4.2 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the guidelines as discussed by DWAF (1999). Here DWAF defines "ecological importance" of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. "Ecological sensitivity", according to DWAF (1999), refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. In the method outlined by DWAF, a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 3), where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to determine the EIS of the wetland unit (Table 4.).

Table 3. Score sheet for determining Ecological Importance and Sensitivity (DWAF, 1999)
Determinant
Primary determinants
Rare and endangered species
Species/taxon richness
Diversity of habitat types or features
Migration route/breeding and feeding site for wetland species
Sensitivity to changes in the natural hydrological regime
Sensitivity to water quality changes
Flood storage, energy dissipation and particulate/element removal
Modifying determinants
Protected status
Ecological integrity

Table 4. Ecological Importance and Sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF, 1999)		
Range of Median	**EIS Category**	**Category Description**
>3 and <=4	**Very High**	Wetlands that are considered to be ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers.
>2 and <=3	**High**	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water in major rivers.
>1 and <=2	**Moderate**	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers.
>0 and <=1	**Low/ Marginal**	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers.

The above approach has been adapted to include and assess the Biodiversity and Ecology, Hydrological and Water Quality, and Direct Human Benefits separately, this according to Rowntree & Malan (2010).

6 RESULTS AND DISCUSSION

6.1 WETLAND SOILS

6.1.1 Land type data and Terrain Unit Indicator

The wetland, no more than 100 to 150m wide was confined to the valley bottom position in the northern part of the site but broadens upstream to a width of 500 – 600 m where hillslope seepages occur more extensively. The wetland slopes along its Thalweg 1 – 2 %, being steeper upstream and more gentle downstream. The hillslope seepage occurs on convex slopes, mostly at slope changes with hill slopes varying from 2.5 – 3.6% upstream to 8.5 – 10.7% downstream.

The land type identified for the site is Bb1 (Figure 10). From the field survey (reported on later in the report) it was clear that the site consisted of two very distinct soil areas, the one having formed on granite of the HHGD and the other having an influence of distinctly more clay forming minerals in the parent material. This aspect is ascribed to the presence of the Ab11 and Ib41 land types in close proximity. Since the land type data was generated at scales of 1:50 000 upwards and reported at a scale of 1:250 000 it is distinctly possible that the eastern section of the investigation site could have fallen into the Ab11 land type but that the boundaries on the map erroneously did not indicate such. The description of the soils later in the report will allude to this aspect as the difference between the Bb1 and Ab11 land types is large enough to cause large wetland delineation and land management challenges.

The Bb1 land type is as described in section 5.2 above. The Ab11 land type is dominated by high clay content red (structured and apedal) soils in upland positions and structured and high clay content dark coloured soils in lower lying positions. The latter may have swelling properties. Due to the very distinct difference in clay content as well as dominant colours of the soils it is found that wetlands are often delineated as very large in the Bb1 land type and very narrow and limited in the Ab11 land type. This aspect generally does not pose a problem when one works exclusively in one land type but it can lead to large challenges regarding wetland delineation and functional assessments when these land types start overlapping – as is the case on the investigation site.

A contour map (2m) of the survey site and its surrounding area is provided in Figure 11. From the contours it is evident that a distinct drainage depression and channel exists. This feature corresponds adequately with the historic wetland delineation that is superimposed on the contour data (Figure 12). For ease of reference a digital elevation model with contours and wetland delineation is provided in Figure 13.

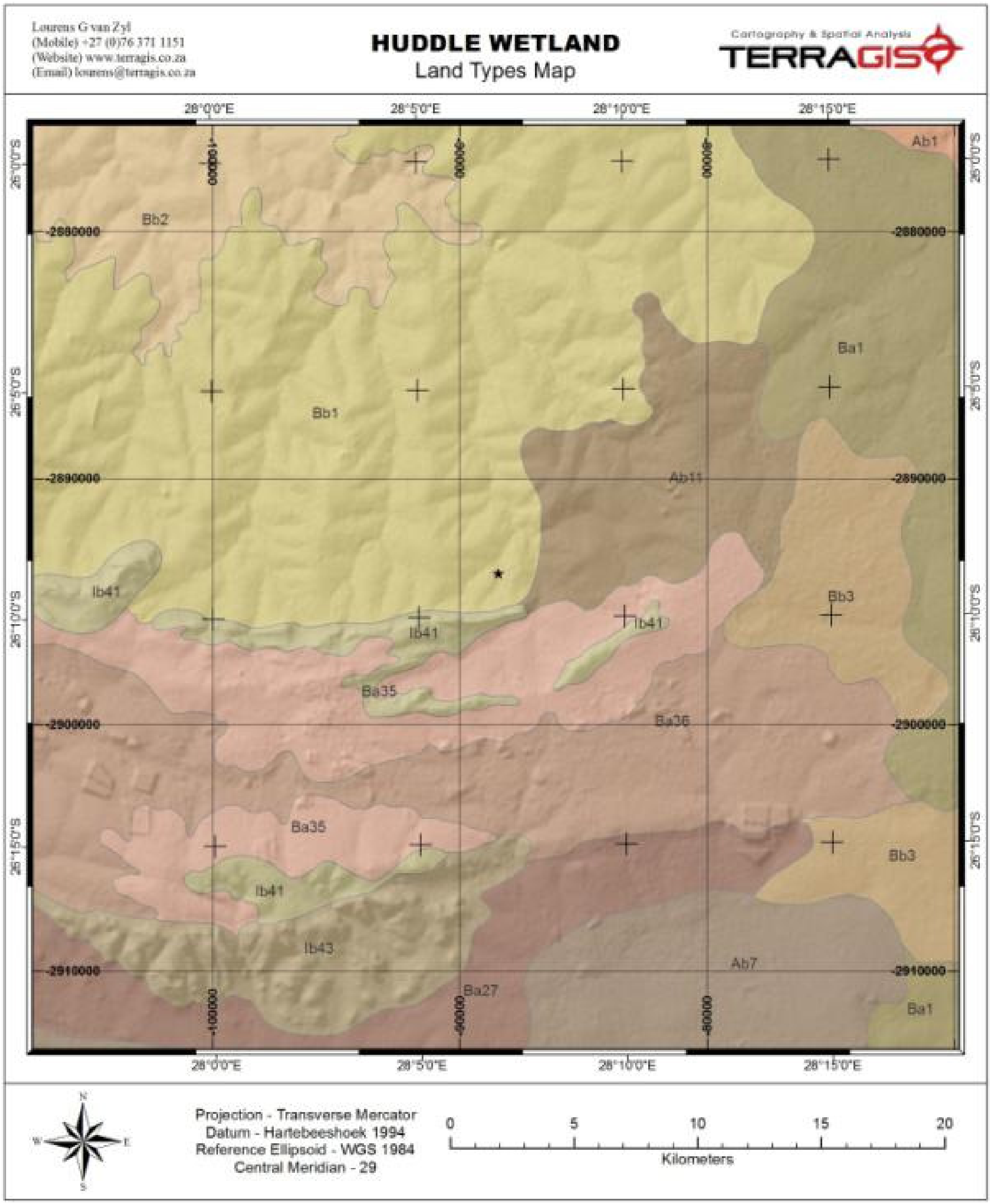

Figure 10. Land type map for the investigation area

Figure 11. Satellite image with 2 m contours of the survey site and surrounding area

Figure 12. Satellite image with 2 m contours with a historic wetland delineation result superimposed on the image

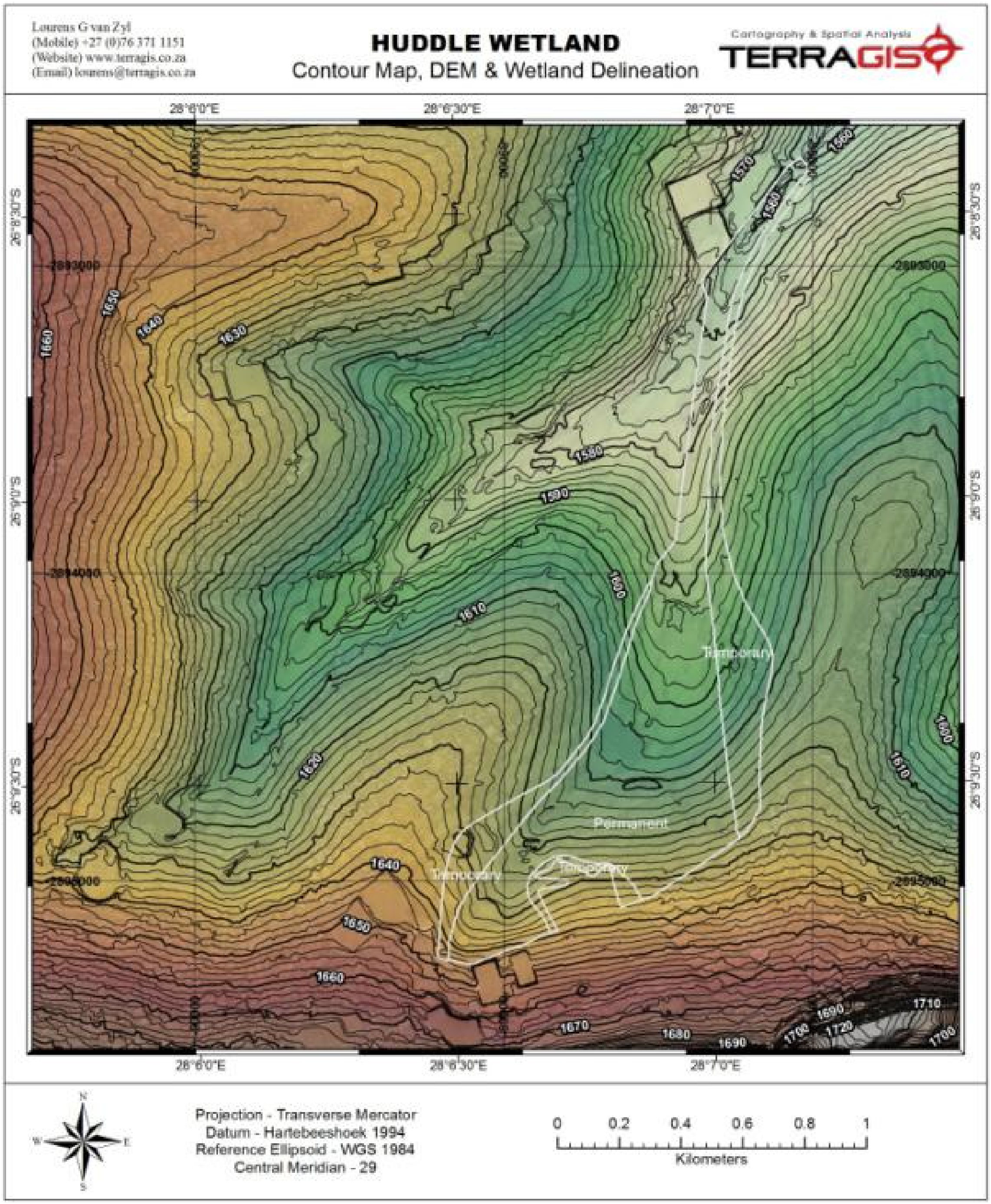

Figure 13. Digital elevation model of the site with 2 m contours and the historic wetland delineation result superimposed on the image

6.1.2 Soil Form and Soil Wetness Indicators

Transect 1

The delineation of the wetland along transect 1 was based on the presence of mottles within 50 cm of the soil surface in the soils. The sequence of soils encountered along Transect 1 was Longlands (Orthic A-horizon / E-horizon /. Soft Plinthic B-horizon) at the highest point of investigation (Figure 14 and Figure 15); Glencoe (Orthic A-horizon / Yellow-brown Apedal B-horizon / Hard Plinthic B-horizon) on the midslope position (Figure 16 and Figure 17); Avalon (Orthic A-horizon / Yellow-brown Apedal B-horizon / Soft Plinthic B-horizon) in the midslope/footslope position (Figure 18 and Figure 19); deep Longlands in the footslope position (Figure 20 and Figure 21) and permanent zone wetland soils in the valley bottom position. These soils are typical of the HHGD. The soils further down the slope indicated varying degrees of mottling and bleaching – also an aspect that is typical of the HHGD.

Figure 14. Auger profile of a Longlands soil form

Figure 15. Mottling in the soft plinthic B-horizon of the Longlands soil form

Figure 16. Yellow-brown apedal soil of the Glencoe form in the mislope position

Figure 17. Concretions in the yellow-brown apedal soil of the Glencoe form in the midslope position

Figure 18. Yellow-brown apedal soil of the Glencoe form in the midslope position. Note the dark coloured orthic A-horizon.

Figure 19. Mottles below the yellow-brown apedal horizon of the Avalon soil form

Figure 20. Soil of the Longlands form in the footslope position.

Figure 21. Dark coloured A-horizon in the Longlands soil form**.**

Transect 2

Along transect 2 it was evident that the upslope area was influenced by dolerite/diabase. The soils therefore did not follow the regular HHGD pattern but rather exhibited signs of good drainage as expressed in high chroma colours. The wetland zone was characterised by grey soils dominated by sandy materials (Figure 22). Within the drainage line soils with prismatic structure occur.

Figure 22. Sandy A-horizon overlying an prismatic B-horizon within the drainage depression

Transects 3 to 5

Along transects 3 to 5 the wetland area is very narrow as 1) the landscape becomes more V-shaped and 2) the soils are derived from mixed materials (granite and diabase). The transition between the terrestrial zone and the wetland zone therefore becomes very distinct as exhibited through textural and colour changes in the soils. The terrestrial soil exhibited high chroma colours and were of the Hutton and Clovelly forms (Figure 23). In this part of the landscape the typical sequence of soils from crest to valley bottom is Hutton (Orthic A-horizon / Red Apedal B-horizon / Unspecified); Clovelly (Orthic A-horizon / Yellow-brown Apedal B-horizon / Unspecified); Valsrivier (Orthic A-horizon / Pedocutanic B-horizon / Unconsolidated material without signs of wetness); Oakleaf (Orthic A-horizon / Neocutanic B-horizon / Unspecified) and Dundee (Orthic A-horizon / Stratified Alluvium). The Dundee soil form usually has grey colours indicative of prolonged saturation and could in some cases grade into eroded soils of the Kroonstad (Orthic A-horizon / E-horizon / G-horizon) or Katspruit (Orthic A-horizon / G-horizon) form. The only soils here that classify as wetland soils are Dundee, Kroonstad and Katspruit. The wetland channel has been altered through historical human activities and influences and exhibits soils with distinct stratification.

Figure 23. Profile of a Hutton soil in the terrestrial zone.

6.2 Present Ecological Status (PES) and Ecological Importance and Sensitivity (EIS) of the wetland areas assessed

The identified service crossings are heavily disturbed with the following impacts evident:

- A golf course infringing into the permanent zone on both banks of the wetland.
- Infilling and landscaping associate with the golf course took place in the wetland.
- 2 dams present in this area, with drains and more dams upstream.
- Infilling of dams by sediment is evident.
- Very little natural vegetation present with exotic invasive species in and adjacent to the dams.

This wetland scored a Very Low (E = 1.5) Present Ecological State indicating that the wetland is seriously modified (Table 5), with extensive loss of natural habitats and basic ecosystem functions. This is mainly due (for 60 years) to the effects of the golf course development and associated practices such damming, draining, canalization, removal of indigenous species, establishment of lawns, fertilising, as well urbanization of the catchment.

- The EIS of the wetland is considered to be "D" (1.7), which means the wetland has low ecologically important and sensitive rating. The biodiversity of this wetland is degraded and only a few remaining elements are potentially sensitive to changes in water quality and the hydrological regime.
- The Hydrological Functioning and Importance of this wetland is considered to be Very Low "D' (1.5); thus the wetland plays a minor role in moderating the quantity and quality of water in water courses downstream. However, the dams in the wetland do have some flood attenuation capacity.
- Direct Human Benefits obtained from this wetland is considered to be Moderate, a "C" (2.0). This favorable rating is mainly related to the historic use of this open space as a golf course in a highly urbanized setting.

Table 5. Present Ecological State, Ecological Importance & Sensitivity, Hydro-functional Importance and Direct Human Benefits of the selected wetlands.

		EIS		
Wetland	**PES**	**Ecological Importance & Sensitivity**	**Hydro-Functional Importance**	**Direct Human Benefits**
Huddle	**1.5 D**	**1.7 D**	**1.6 D**	**2.0 C**

6.3 Development and encroachment

The development area in the southern part does not encroach on the wetland area save for a small area in the 30 m buffer zone (south-western corner – Figure 24) that is earmarked for "soft" development (landscaping and gardens), thus the specific impact of encroachment into the buffer zone is negligible. However, the main impact of the development as a whole, while not encroaching on the wetland, has the potential for altered storm water runoff patterns into the wetland which has implication for erodible soils on the slope. On site mitigation measures should be implemented such as those listed in Appendix C.

It is important to note that the 30 m buffer area in this part of development remains important for this system as a recharge area. The importance of recharge for this landscape type was discussed in section 5.2.2 (please refer to Figure 3). Figure 24clearly illustrates the recharge concept along transect 1.A concave slope occurs from HS0 to HS2 with a clear slope change at HS1. The upland area between HS0 and HS1 (within the development and buffer zone) serves as a recharge area with discharge taking place at HS2 forming the seep zone and thus the edge of the temporary zone. A convex slope occurs between HS2 and HS3 forming a througflow zone after which water discharge in the concave slope between Hs3 and HS4 (the lowland area), forming the permanent and seasonal wet zone.

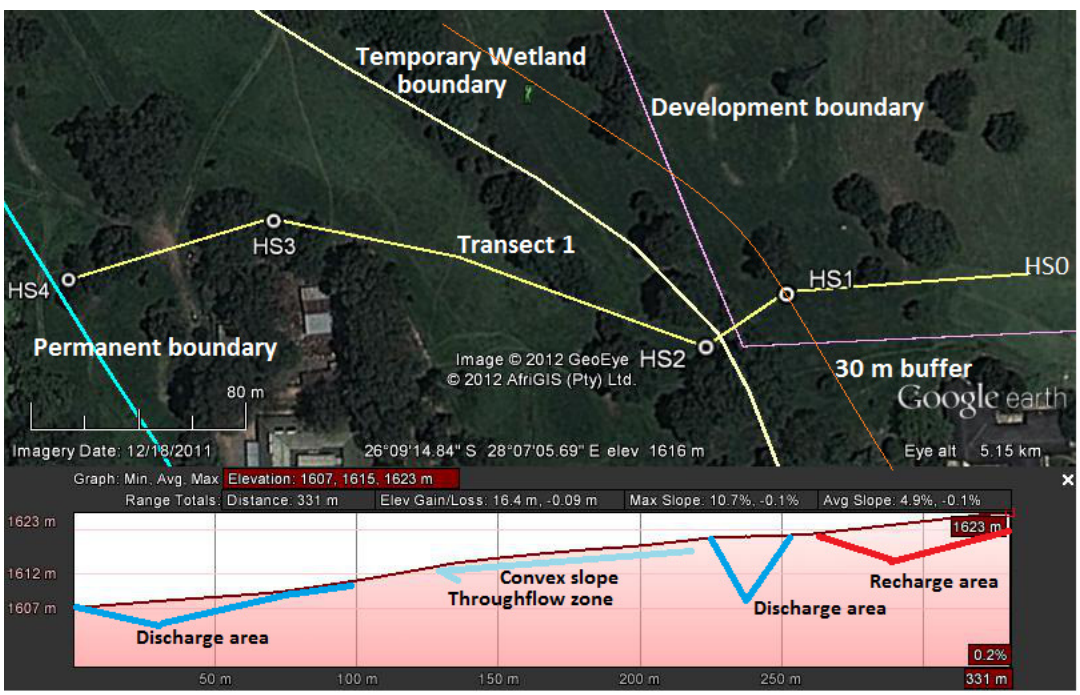

Figure 24. Google Earth Elevation Profile of transect 1 indicating recharge and discharge areas

7 CONCLUSION AND RECOMMENDATION

- From the verification exercise the wetland delineation by SEF (2006) and Imperata Consulting (2007) is accepted as accurate;
- The delineation result is a function of the variable geology in the area that has given rise to two very distinct and different soil environments regarding water regime and signs of wetness;
- The area to be developed (outside of the delineated wetland) consists of stable soils (regarding erosion potential) that exhibit few to no signs of wetness due to the dominance of high clay content forming and high Fe content parent materials;
- The area within the wetland consists of granite derived soils that have variable profiles with widespread signs of wetness in sandy and erosion prone soils;
- The development area does not encroach on the wetland area save for a small area that encroaches into the 30m buffer, that is earmarked for "soft" development (landscaping and gardens);
- The main impact of the development, while not encroaching on the wetland, has the potential for altered storm water runoff patterns into the wetland which has implication for erodible soils on the slope;
- The wetland has a low PES and EIS rating and the planned services crossing the northern portion should have little impact on the system if due diligence is paid during the different stages of development; and
- Mitigation measures should focus on preventing water pollution, erosion and sedimentation. The following aspects are strongly recommended for the development:

1. A dedicated storm water management strategy has to be drawn up in order to minimise impacts on down-slope erodible soils in the wetland area.
2. The management of storm water on the site should include the following:
    a. Retardation and containment of water on site in numerous containment structures that have permeable swales or walls to allow for slow but constant release of water into down-slope structures;
    b. Consideration of storm water structure integration with landscaping on the development; and

c. Release of water from storm water structures into down-slope structures that have been planned in conjunction with the Huddle Park Golf Course.

3. All storm water management structures and strategies to be generated in conjunction with a dedicated plan for the management of water throughout the Huddle Park Golf Course site. This is crucial as erosion pressures are immense at the lowest part of the golf course site. The minimisation of these pressures is dependent on integrated storm water management in the catchment. The current approach of including soft engineering containment structures that are vegetated (and that double as additional artificial wetland areas) is strongly advised.

8 REFERENCES AND FURTHER READING

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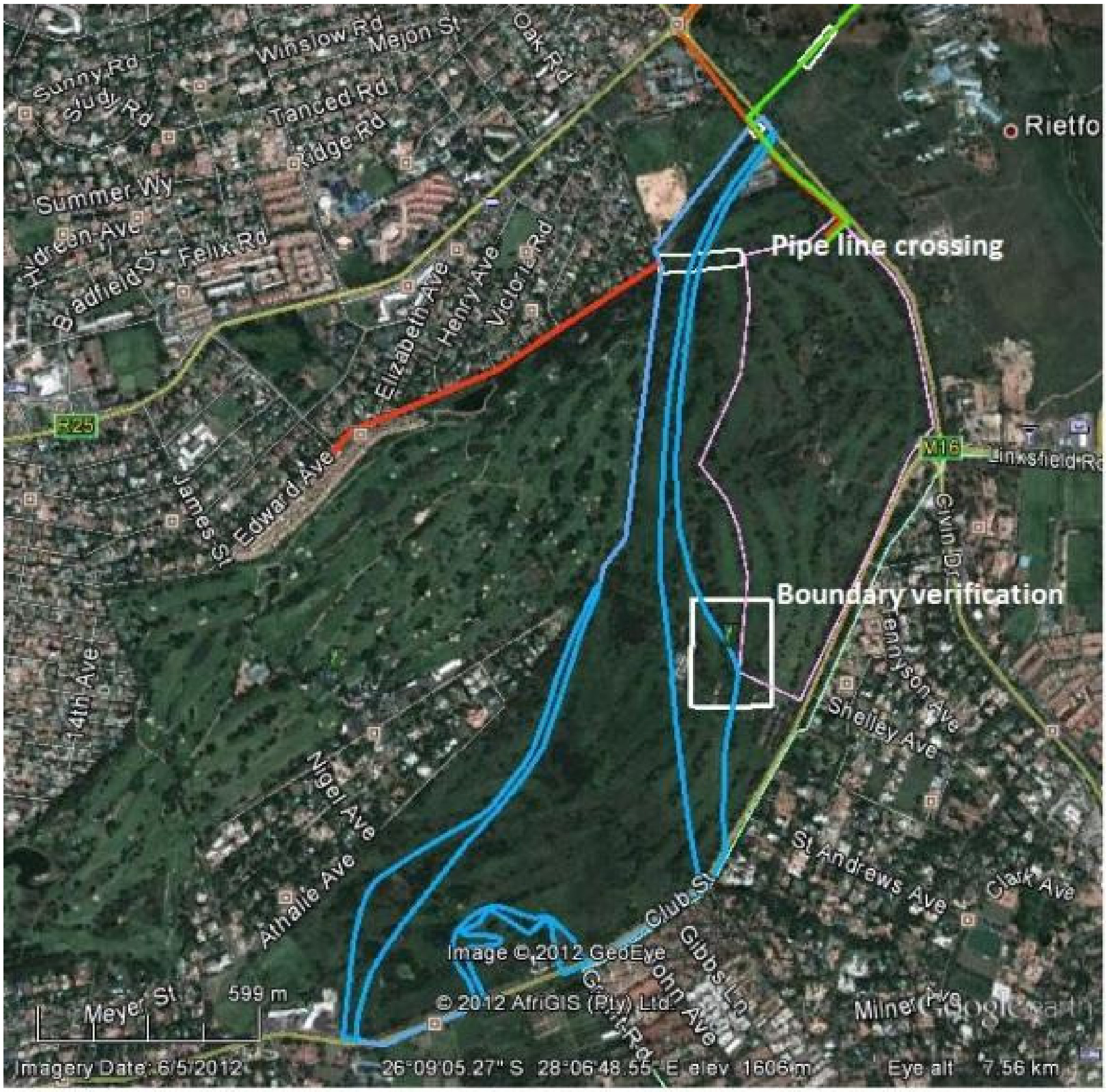
APPENDIX A: STUDY SITE WITH FOCUS AREAS



APPENDIX B: FIELD NOTES

Huddle Park field Notes

Ref no	Suid-grens	Lat ; Long	Description	Soil from	Wetness zone
S4	HS1	S26 º9'16.5"E28º7' 7.9'	On slope, disturbed, 0.3m deep, concretions, hard plintite, red matrix no mottling	Glencoe/Avalon	Terrestrial
B	HS2	S26 º9'16.6"E28º7' 6.8'	Slope change? 0 -0.2m: dark to light grey, cutanic; 0.2 – 0.4m: bit clayey, sand grains indicating bleaching. Yellow E; 0.4 – 0.5 m: yellow mottles and concretions.	Avalon/Longlands	Temporary
SB1	HS3	S26 º9'15.2"E28º7' 5.0'	Convex landscape. Disturbed soil, recharge soil. Red soil, a bit clayey	Glencoe	Terrestrial
SB2	HS4	S26 º9'13.3"E28º7' 2.9'	0-0.4m: darkened A horizon, slightly disturbed; 0.4 -0.6m: becoming yellow; 0.6-0.7m: signs of wetness, bleaching and mottles; 0.7m transition to hard plintite.	Glencoe?	Terrestrial
SB3	HS4	S26 º9'12.8"E28º7' 0.2'	Inflection point. 0-0.2m: Ortic A; 0.2 -0.5m: E – 50% course sand ; 0.5-0.7msoft plinite; 0.7m plintic – non-diagnostic G.	Longlands	Seasonal ?
SA1	HSN1	S26 º8'56.9"E28º7' 1.9'	Convex landscape. Blood red soil. Increase in clay. Quartz grains (from weathering granites) .geology - Diabase?	Hutton	Terrestrial
SA2	HSN2	S26 º8'56.9"E28º7' 0.5'	Inflection point. Grey subsoil. Exposed by earth works	?	Seasonal/Permanent
	Noord grens				
N31	HNS1	S26 º8'56.9"E28º7' 0.5'	Convex. Inflection point. Clay. Infilled	Vals rivier	Terrestrial, edge 10m downslope
N31e	HNS1E	S26 º8'42.9"E28º7' 1.2'	Wetland Edge. 10m downslope of HNS1.	Dundee/Kroonstad/Kats pruit	Seasonal/Permanent
N32	HNS2	S26 º8'44.2"E28º7' 3.5'	Recharge area. Shallow gravel. Shallow gravel maker	Shallow hutton/Rooi Glenrosa	Terrestrial

Nn31	HN1	S26 °8'37.9"E28°7' 3.9'	Inflection point. Clay. Infilled on slope?	Dundee/Kroonstad/Katspruit	Seasonal/permanent
Nn32	HN1	S26 °8'38.2"E28°7' 0.7'	0-0.3m:sand; 0.3-0.5m: dark grey clay with sand and mottling	?	Seasonal
N1	HNN1	S26 °8'34.4"E28°7' 6.0'	Red soil, on slope	Hutton	Terrestrial
N2	HNN2	S26 °8'34.0"E28°7' 5.8'	Clay and sand	Valsrivier	Terrestrial
N3	HNN3	S26 °8'33.7"E28°7' 5.2'	recent sediment	sediment	Riparian

APPENDIX C: MITIGATION MEASURES

6.2 Stormwater management

***(from the 2008 report:* HUDDLE PARK WETLAND DELINEATION AND FUNCTIONALASSESSMENT FOR THE PROPOSED RESIDENTIAL GOLFCOURSE DEVELOPMENT, ON A PORTION OF BEDFORD 68IR,LINKSFIELD, GAUTENG, compiled by P. Grundling)**

A well-designed stormwater management plan will be required to attenuate flood peak events and prevent excessive erosion. It is recommended that the storm water management systems be designed in such a way that the natural flow regime (velocity of the water) of the wetlands are not exceeded by 50% in the event of a 1:10 year flood to prevent the possibility of erosion in the wetland (*pers. comm.* M Lizamore).

Stormwater should not be allowed to enter directly into the protected wetland areas, but must be well buffered by vegetation and accompanied by energy dissipating interventions. Stormwater flow from outlets should therefore not be concentrated, but be spread out as far as possible. Sheet-like water flow would complement the wetland's hydrology, especially inside HGM unit 2 that receives water from the upper catchment and has been severely affected by hydrological modifications associated with development in the upper catchment. New dams are advised against being constructed within the protected wetland area as they have a negative impact on the wetlands' hydrology. Existing dams should however be upgraded and modified to help function as water retention structures during flooding events. Upstream development has been permitted without any onsite attenuation and the need therefore exists to attenuate these flows. Upgrading the dams for attenuation will help address this need and with the necessary engineering design input it could be possible to reduce the flow exiting the site to a level comparable with the predevelopment flow of the catchment. The modification of dams to include different levels of depth, vegetated by a diversity of obligated and facultative wetland species will create an array of habitats and attract different wetland dependant faunal species.

During the wet season water levels should not be at full capacity, but remain at lower levels to ensure that additional runoff water can be attenuated. Upgrading dams in wetland area is not the only option to attenuate floods. Alternative means for temporarily storing stormwater runoff in swales and/or large open spaces, such as parking areas and sections of golf course within the surrounding landscape should be considered as well. Specific stormwater attenuation structures outside of the protected wetland area on developed areas including residential areas (eg. Erven, public buildings, parks and golf course) can include:

- Soakaways/storage tanks;
- Filter drains;
- Permeable surfaces, such as porous pavements;
- Parking lot detention basins;
- Shallow detention basins;
- Grass swales; and
- Establishment of bulk services in wetland areas, especially those running parallel to the Thalweg of the wetlands should be avoided at all cost.