APPENDIX K

Stormwater Management Plan

STORMWATER MANAGEMENT PLAN

The proposed construction of a service road on a portion of Erf 30475 (Public Open Space), Bloemfontein

Proponent: B&L Trust
MDA Ref No: 40732
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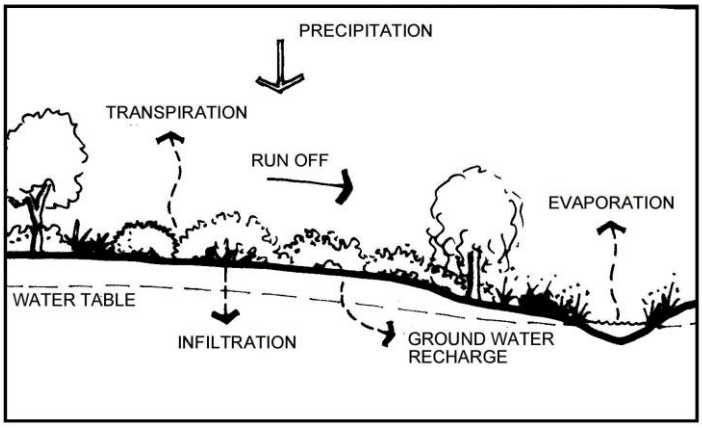
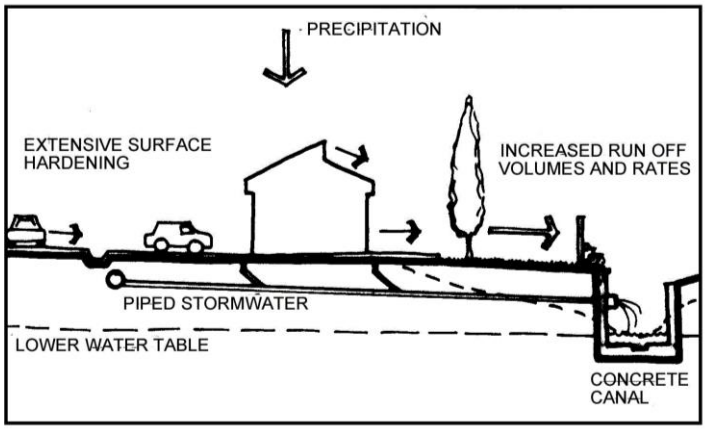
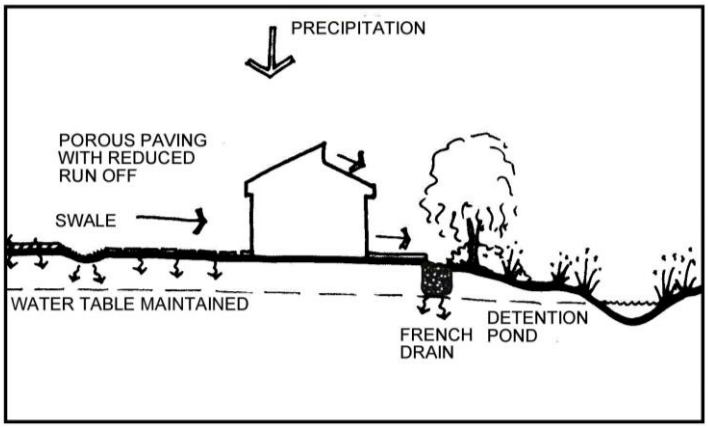
Stormwater Management Objectives

1.1. Minimising effect of proposed project on environment

The aim of the stormwater management plan is to minimise the effect of the proposed project on the environment (Figure 1.1).

Figure 1.1: Indication of effect of stormwater management in a developed area

Nr	Description	Drawing
1	Natural Environment	
2	Developed Area, without sufficient stormwater mitigation measures being implemented	
3	Developed Area, with sufficient stormwater mitigation measures being implemented	

1.2. Minimise the Threat of Flooding

The minimisation of the possibility of flooding remains a key objective of any stormwater management system. However the challenge when contemplating design of stormwater management systems is to consider the following:

- To mimic pre-development responses to storms
- To reduce the volume of runoff by promoting infiltration
- To reduce the peak flows and increase the time-to-peak through detaining the runoff and releasing it at a gradual rate
- Where necessary, to construct means to contain flood waters and safely convey them out of the urban area

1.3. Protection of Receiving Water Bodies

The receiving water body is not necessarily the system into which stormwater is discharged directly, but can also be a natural system located further downstream in the catchment. Every endeavour should be made to achieve the following as far as possible:

- Maintain natural flow regimes and seasonality
- Prevent deterioration in water quality
- Prevent erosion or sedimentation of natural wetlands or rivers
- Preserve natural river channels, wetlands and vegetation, and preclude engineering interventions that may alter their physical and ecological characteristics.

The need to design appropriate stormwater management systems for new developments should be seen as an opportunity to preserve or, if possible, improve natural freshwater ecosystems that have suffered degradation as a result of past activities, and in some cases to create additional freshwater habitats that will contribute to the availability of appropriate, high quality river and wetland habitat that mimics the natural condition.

1.4. Promote Multi-Functional Use of Stormwater Management Systems

Resources such as land and water are becoming increasingly scarce and multiple uses of these must be strived for. Stormwater systems provide a wide range of opportunities for multi-functionality. These can have significant implications on:

- The initial and long term costs of development (e.g. Instead of constructing a detention pond and a sportsfield, these uses could be combined)
- The quality of the natural and urban environment [e.g. the pressure of private development requirements on land for public land use, conservation, etc. can be alleviated by combining compatible land uses such as conservation, recreation and stormwater systems (including wetlands, vleis, dams and rivers) enabling an improved natural and urban environment]
- Maintenance efficiency (e.g. instead of meeting the maintenance requirements of stormwater systems and public open space separately, they could be combined and could include walking/bicycle trails and parks)

1.5. Development of Sustainable Environments

The long-term involvement with the project and consideration of the sustainability of the stormwater management system that is to be implemented should be kept in mind. All relevant factors that will impact on future operation and maintenance should be taken into account.

Environmental policies such as promoting the use of locally indigenous vegetation in planting programmes will also reduce the long-term maintenance requirements of the development.

2. Stormwater Planning Regarding the Proposed Project

Adequate planning is crucial to the success of the project as a whole.

2.1. Need of Multi-disciplinary Expertise

To maximise opportunities to manage stormwater, the input from various design teams are necessary (Table 2.1).

Table 2.1. Indication of the role that various team members play

Nr	Team member		Role
1	Civil Engineer		An engineer skilled in the design of stormwater systems should determine runoff flows for the required recurrence intervals and proposed land uses and design appropriate measures to attenuate peak flows and safely convey the runoff.
2	Environmental Consultant		Alert the engineer at the conceptual stage of the development to crucial aspects of the environment, which are fulfilling an important role with respect to stormwater and should be taken into consideration, as well as opportunities for enhancement or rehabilitation of existing natural features.
3	If required	Freshwater Ecologist	Provide insight regarding the functioning of natural rivers, streams and wetlands and advice regarding the ecological aspects of the design of the components of the system, including water quality enhancement and the land needed for the system to function.
		Landscape Architect	Provide a holistic site analysis of the existing natural and man-made landscape and advice on the opportunities, constraints and implications of the site on the development planning and design.

Project:

Inputs regarding the opportunities to manage stormwater was received from the civil engineers, environmental consultant and ecologist associated with the proposed project.

2.2. Incorporation of Existing Information into Planning Stage

The following information (where relevant) should be investigated, during the planning stage and used to feed into more detailed site assessment:

- Catchment area in which the site is located
- Catchment or river management plans (overall management objectives and recommended key management actions with respect to runoff quantity, quality and other associated environmental and social issues, where such plans exist for the catchment in question, must be met in the design stage)
- Stormwater management master plan (identifies bulk infrastructure, including stormwater flow routes, required within developing areas and may identify particular issues such as pollution which must be addressed at a local level). The existence of a stormwater management master plan which covers the area to be developed should be established and its recommendations applied to the design.
- Existing reports relating to the sensitivity of known wetlands / rivers / other natural ecosystems on or associated with the study area.

Interdependencies exist between the various water related services such as water supply, sanitation and stormwater management. Thus, consideration of the impact of effluent discharges (if any) into or water abstraction from stormwater management systems should be taken into account.

Project:

The site is located in Drainage Region C25G, within the Water Management Area 13 (Upper Orange).

No current land use occurs on the site other than the power line and associated dirt track. No other structures or buildings occur on the site. Littering on the site is common. Grazing and browsing of the vegetation is absent due to the site being isolated by urban areas and not forming part of any farming area. The mammal populations on the site will also be diminished due to the condition of the site, isolation from surrounding natural areas and proximity of urban areas.

The vegetation structure on the site is comprised of a grass, dwarf shrub and shrub layers and a significant succulent / bulb element in shallow soils or where rock sheets occur. Although degraded the vegetation structure still resembles the natural condition. The dominant grass species on the site

include *Enneapogon cenchroides, Eragrostis lehmanniana, Aristida congesta, Themeda triandra, Heteropogon contortus* and *Digitaria eriantha*. Dominant shrubs and dwarf shrubs include *Diospyros austro-africana, Euryops empetrifolius, Searsia ciliata, Felicia muricata, Gymnosporia polycantha* and *Olea europaea* subsp. *africana*. The last also being a protected species. The Wild Olive (*O. europaea* subsp. *africana*) is the provincial tree of the Free State and a protected species. It is widespread and common and the specimens on the site is not of exceptional size or age and is therefore not of significant conservation value. Permits will however still have to be obtained to remove them from the site. Other herbs common on the site include *Heliophila suavissima* and *Dicoma macrocephala*. Succulent and bulb species occurring on the site include *Euphorbia mauritanica, Crassula nudicaulis, Albuca setosa, Chasmatophyllum muscullinum, Ruschia intricata, R. unidens, Stapelia grandiflora* and *Aloe grandidentata*. Of these the following are also listed as being protected: *E. mauritanica, S. grandiflora* and *A. grandidentata*. These are all widespread and relatively common. As protected species they retain a conservation value and due to their ease of establishment it is recommended that permits be obtain to transplant these to an area on or adjacent to the site where they will not be affected. The area proposed for the road is degraded due to its proximity to current land use surrounding it.

In conclusion the area is considered to have significant conservation value as the vegetation in the area is considered to be unique and containing a high species diversity. However, the specific site proposed for the access road has been degraded and the diversity of species is relatively low with areas of the site transformed from the natural condition. The site is isolated from surrounding natural areas and is not considered to represent a conservable portion of the vegetation type. However, the site still contains a few species which are protected. Protected succulent species should be transplanted to adjacent areas where they will not be affected by construction and permits should be obtained to remove the few specimens of Wild Olive on the site. It should be kept in mind that ongoing development within this vegetation type will contribute to the cumulative impact of decreasing this vegetation type and as a result continued development within the vegetation type will have to be done with increased care and sensitivity.

2.3. Site Analysis

The physical characteristics of the site reflect the existing course of runoff and stormwater. Working with the natural environment and environmental

processes has been found to be safer, more sustainable and easier to maintain in the long term, than more traditional engineering approaches aimed at controlling these processes.

On sites that have been substantially disturbed, consideration should be made of what the natural drainage and runoff conditions would have been, as well as the existing situation. This will enable potential problems, and opportunities, to be identified.

Project:

The vegetation in the study area consists of Bloemfontein Karroid Shrubland (Gh 8). The vegetation type is currently listed as being of Least Concern under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004). However, according to Brown & Du Preez (2014), the vegetation type must be regarded as endemic to the Free State Province and must be afforded a high conservation status and must be included as a Threatened Ecosystem. In this area it is under pressure for residential development. The area proposed for the road is however also degraded due to its proximity to current land use surrounding it.

2.3.1. Topography

The consideration of various topographical factors is important for the compilation of a stormwater management plan, due to the following:

- Gradients dictate the direction of flow and runoff/drainage routes can be plotted over land, identifying areas of ponding and concentration of loads
- In some areas which are very flat, earthworks may be required to provide sufficient grade for drainage
- Topography influences the potential for erosion to occur
- Topography informs the feasibility of different locations for stormwater routes, outlets and treatment areas; the main stormwater routes should be located along natural drainage routes
- In ecological terms, different habitats, some of higher conservation value than others, are frequently associated with changes in topography
- From an environmental and stormwater management perspective, as the slope increases, erf sizes should also increase to prevent excessive run-off and potential erosion

- Road and planning layouts should also reflect the topography of an area, to enable integrated stormwater design and management
- The commercial (and aesthetic) value of different sections of a development area is also frequently derived from different topographical characteristics.

Project:

The topography of the site consists of a plateau / ridge of higher elevation and slopes toward the north. The vegetation on the site consists of dwarf shrubs, shrubs and grassland and forms mosaic pattern of vegetation structure. The area is disturbed and contains a dirt track utilised for servicing the powerline on the site where vegetation is largely absent. Natural vegetation still remains on the site although it is notably degraded and not of as high diversity as portions of the surrounding vegetation type in natural condition. As mentioned a powerline also occurs on the site which has also contributed to degradation of the vegetation. Soils on the site are relatively shallow as is characteristic of this vegetation type. No discernible watercourse or wetland occurs on or near the site and runoff occurs primarily as sheetflow.

2.3.2. Geology, Soils and Groundwater

The infiltration potential of the site is mostly determined by the geology, soil and groundwater conditions of the area. The following factors should be considered, where possible:

- Soil types affect surface permeability and hence rate of runoff
- The mapping of geology and soils will indicate areas of potential groundwater recharge
- Geology and soils influence the potential for erosion to occur
- Soil types should be identified, along with the characteristics of the different soils, such as levels of infiltration, permeability and their water-bearing capacity
- The presence of contaminated soils, which may pose a threat to surface and groundwater quality should be identified and plotted
- Areas of high groundwater levels can limit the possibilities and/or desirability of groundwater recharge and filtration methods.
- It should be noted that large-scale removal of certain vegetation types, such as Port Jackson (*Acacia saligna*) and Bluegums (*Eucalyptus sp.*), that consume large volumes of water, might significantly raise groundwater levels

- Need to determine seasonal and longer term trends in groundwater level fluctuation
- Soil types indicate the likely occurrence of particular plant communities, some of which may play a role in the stormwater management plan
- Assessing soils can also indicate the presence of both existing and even historic wetlands
- Seasonal variation of groundwater levels should be taken into account
- The geology and soils of a site will inform the feasibility of different locations for stormwater treatment areas and the potential for groundwater recharge
- Different habitats (some with high conservation value) are associated with specific geological features and soils

2.3.3. Climate

The following climatic factors should be considered, where necessary:

- Storm rainfall parameters are major design factors and must be carefully determined
- The general climatic characteristics of an area will also impact on the site and stormwater systems implemented, i.e. whether the site is generally waterlogged or dry and if evaporation levels are high or low
- Microclimate conditions can inform the spatial layout of water treatment and attenuation, particularly those associated with specific planting and multifunctional uses

Project:

Bloemfontein normally receives about 407mm of rain per year, with most rainfall occurring mainly during summer. Bloemfontein receives the lowest rainfall (2mm) in June and the highest (68mm) in January. When the monthly distribution of average daily maximum temperatures are taken into consideration, it is evident that the average midday temperatures for Bloemfontein range from 16°C in June to 29.2°C in January. The region is the coldest during July when the mercury drops to 0°C on average during the night.

2.3.4. Natural Ecosystems, Flora and Fauna

The site should be assessed in terms of the natural ecosystems and habitat types that it supports. The following factors should be considered:

- Conservation (or improvement) of bio-diversity and ecosystem function must be one of the objectives of a management plan
- Some habitats are afforded protection by existing legislation and guideline (e.g. wetlands; buffers around rivers and wetlands)
- Where the site intercepts natural corridors of movement between ecologically important areas, stormwater management should seek to retain or recreate such corridors
- Endangered or threatened vegetation, animals and/or habitats should be identified and their opportunities and constraints for stormwater management assessed
- Vegetation and animals that have roles or functions that can improve water quality, amelioration and/or infiltration should be identified, and their natural status and integrity determined
- Healthy, diverse and/or relatively undisturbed natural systems should be identified and assessed in terms of their habitat integrity and importance (environmentally, socially and culturally), and, wherever possible, be accommodated within the future planning and development of the site
- The presence of invasive alien animals (e.g. fish, birds) or plants should be discouraged from any developments
- Alien flora or fauna associated with habitats created or maintained for the management of stormwater from a site should not be allowed to pass into any downstream or associated water bodies

Project:

Due to the degraded condition of the site as well as the urban proximity of dwellings it is considered unlikely that any species of concern will occur on the site. The mammal population on the site is likely to be diminished from the natural condition.
Habitat diversity on the site is moderate and degraded. As a result the species diversity is also moderate in contrast to the natural condition where it should have been relatively high. The habitat consists of dwarf karroid shrubland with a mosaic vegetation pattern of grass, dwarf shrubs and shrubs.

No rare or endangered species occur on the site although a few protected species were noted to occur. These are the succulent species *E. mauritanica, S. grandiflora*, *A. grandidentata* and the tree species *Olea europaea* subsp. *africana* (Wild Olive). All the above species are relatively widespread and common and are therefore not of significant conservation concern.

However, the succulent species are easily transplanted and permits should be obtained to transplant them to adjacent areas where they will not be affected by construction. The Wild Olives trees are present on the site as juvenile shrubs and are therefore not of significant size or age. Permits should be obtained to remove these.

The ecological function of the site is largely intact although degraded to some extent. The habitat provided by the site is degraded and due to the proximity and isolation from natural areas its function as habitat for fauna will be decreased. The functioning as part of the catchment and providing runoff will have to be accommodated by the access road in the form of storm water drainage.

The vegetation in the study area consists of Bloemfontein Karroid Shrubland (Gh 8). The vegetation type is currently listed as being of Least Concern under the National List of Threatened Ecosystems (Notice 1477 of 2009)(National Environmental Management Biodiversity Act, 2004) (Map 2). However, according to Brown & Du Preez (2014), the vegetation type must be regarded as endemic to the Free State Province and must be afforded a high conservation status and must be included as a Threatened Ecosystem. In this area it is under pressure for residential development. The area proposed for the road is however also degraded due to its proximity to current land use surrounding it. Its conservation value is therefore decreased and considered only moderate.

The Free State Biodiversity Plan indicates the site to form part of an Ecological Support Area 1 which functions in maintaining the integrity of Critical Biodiversity Areas.

A rough estimate of the percentage of vegetation condition on the site is considered as 20% near natural, 60% degraded and 20% transformed vegetation in comparison to natural vegetation of the region in pristine condition with no impacts.

The percentage ground cover is considered as low. The natural condition is only considered moderate due to the arid habitat conditions created by shallow soils. However, degradation on the site has caused the percentage ground cover to be decreased. The vegetation structure is largely natural consisting of a dwarf karroid shrub layer, grass and shrub layers.

The site contains only limited exotics although it is considered likely that annual weed species establish annually after rains. Grazing by domestic stock is absent from the site. Erosion is considered as moderate due to clearing of vegetation along the dirt track.

Due to the degraded condition of the site as well as the urban surroundings and proximity of dwellings it is considered unlikely that any species of concern will occur on the site. The mammal population on the site is likely to be diminished from the natural condition.

2.3.5. Cultural and Historical Landscapes and Archaeological Sites

Areas, routes, vegetation and landmarks that have a cultural and/or historical use or significance should be identified. Development and stormwater planning should avoid disturbing these areas where possible. Where possible they should generally be incorporated within the public open space of a development. This contributes a further function to the public open space system, and should be integrated into a network of public open space.

Project:

A heritage impact assessment was conducted for the construction of a service road on a portion of Erf 30476, Bloemfontein, Free State Province. The proposed footprint will be a linear development covering about 7350 m2 of open veld on declared public open space near the corner of Christo Groenewald Street and Olympus Drive. The proposed footprint is located on dolerite intrusions that are not palaeontologically significant or sensitive. A foot survey revealed no evidence of in situ archaeological remains, ancient structures, graves or historical buildings older than 60 years. The probability of impact by the development on intact fossil remains is considered non-existent, and it is considered unlikely that the proposed development will result in any archaeological impact at the site. The terrain in general is regarded as of low archaeological significance and is assigned a rating of Generally Protected C (GP.C).

2.3.6. Development Requirements

The public open space and pedestrian access requirements of a development should be incorporated into the stormwater management planning of the site. The integration of public open space and access requirements with the spatial requirements of stormwater management not only reduces the conflict of pressure on land, but also enables the amalgamation of maintenance requirements, and maximises the use of resources. The following factors should be considered (where necessary):

- Land use planning should be done in relation to the natural context and characteristics of the site. The appropriate placement of land uses will enhance the multi-functionality of the stormwater systems and their use as an amenity by residents in the area.
- Innovative opportunities exist for future stormwater management systems to link-up and add value to educational initiatives (outdoor classroom), ownership (friends groups adopting the system), and water saving (re-use of stormwater/treated effluent for irrigation).
- These opportunities are also area specific and need to be identified up front, rather than as a nice-to-have-after-thought
- The need for a safe environment must be taken into account (e.g. avoid of potential hiding places for criminal elements; do not create unnecessary hazards in the selection of stormwater management options).
- The cost of stormwater implementation, management and maintenance, as well as flood risk, can be greatly reduced by identifying, retaining and enhancing the natural areas along which runoff and natural habitat retain ecological integrity. The advantages of this approach are not limited to stormwater, but can increase the visual, amenity and ecological value of a development.

Project:

The proposed project entails the construction of a service road. The need for a safe environment during the construction phase will be taken into account. The construction activities will be undertaken in such a manner that the possibility of health, safety and visual impacts will be taken into consideration.

2.4. Site Planning

2.4.1. Site Analysis

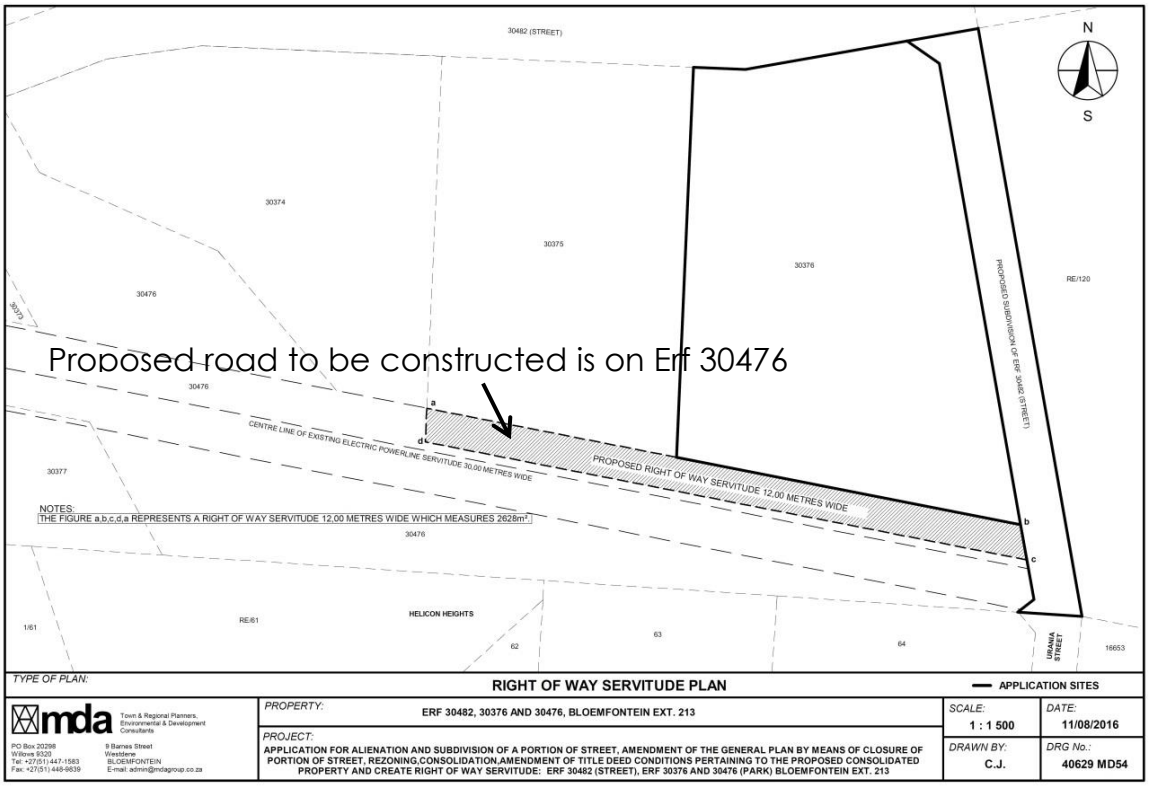
The developer should take the information stipulated in Section 2.3 into consideration during the Site Analysis Process.

Project:

Please refer to Section 2.3 for more information.

2.4.2. Conceptual Layout

A general concept plan for the site layout should be developed, taking into account the legal and physical aspects of the site as developed through the site analysis process.



3. Design Phase

3.1. Appropriate Stormwater Management Facilities and Techniques associated with the project

Various stormwater management facilities and techniques were evaluated in terms of engineering, ecological, health, safety, aesthetic, social, construction and maintenance design objectives.

Various facilities and techniques may be utilised to manage stormwater runoff from the development.

3.1.1. Conveyance

Conveyance can be summarised as the use of natural or artificial channels, natural or artificial wetlands or pipes and culverts for stormwater conveyance as well as the prevention of erosion.

In general terms, the developer should consider the following aspects when selecting designs for stormwater conveyance:

- The slopes of the development area – stormwater design on steep slopes will need to incorporate methods for reducing erosion.
- Soil type and stability in the development area – the former will affect infiltration rates, as well as the potential for establishment of different kinds of plant communities in unlined conveyance structures; the latter will affect the degree of stabilisation that may be necessary.
- Seasonal changes in water table height – groundwater should not be exposed by unlined conveyance structures during summer, as this will promote drainage of the groundwater resource; infiltration capacity will be reduced if the water table is above an unlined channel base during winter.
- The cost of land – where land is at a premium, use of large areas for stormwater conveyance may be prohibitively expensive. Nevertheless, the increase in aesthetic and other forms of amenity value that may be gained from sensitive and imaginative stormwater designs may make the use of such space more economically feasible.
- The anticipated quality of stormwater runoff – severely polluted water may constitute a health hazard to downstream residents and an ecological hazard to downstream aquatic ecosystems. Consideration should be given to the conveyance of such water off-site, and directly to

water purification works, at least during low-flow periods when water quality is likely to be most impacted.
- Presence of natural water bodies that would lend themselves to the conveyance of stormwater
  - Habitat integrity, priority ranking and/or ecological importance and sensitivity of the system should be considered
  - Sensitive systems should be protected from, rather than incorporated into stormwater conveyance design.
- The volume of expected stormwater runoff, during within-year flood events, and during larger storm events.
- The availability of open space for stormwater conveyance – large areas of open public or private space often lend themselves to the creation of wide, artificial waterways, which may also have ecological, recreational and aesthetic value in addition to providing a stormwater function.
- The presence of litter and sediment which would result in blockages.

Erosion is unfortunately often associated with development as areas become disturbed or as stormwater runoff is concentrated at outlets. In order avoid these problems, options such as stabilisation, energy dissipation and the design of stormwater management systems, which do not concentrate flows, are recommended. A number of structures incorporated into stormwater design play a role in the dissipation of energy required to prevent erosion at outlet and inlet points, and at various points in different conveyance structures. This section provides brief commentary on the ecological, engineering and aesthetic function of each of these.

Soil which has been disturbed or from which the vegetation has been removed, should be stabilised to prevent erosion due to wind or runoff. Such erosion could cause the stormwater system to block, thereby resulting in the flooding of properties. Stabilisation would be short term, for the duration of the construction phase, followed by long term on completion of construction. Particular care should be taken of areas where development will not take place immediately on completion of the construction phase, e.g. wide verges in the road reserve which have been acquired to accommodate future road widening, or erven reserved for unspecified local authority use.

Project:

- Erosion control measures will be implemented, where necessary.
- Soil type and stability of the development area will be taken into consideration.

- The impact of the proposed activities should be minimalized by the implementation of best practices.
- The anticipated stormwater quality is fairly good, as it can be summarised as rainwater within natural / manmade channels.

4. Construction

4.1. Civil Engineering Specifications

All materials and workmanship shall comply with the SABS Specifications.

4.2. Environmental Management Programme

Please refer to Appendix G of the fBAR for a copy of the EMPr.

4.3. Protection of Stormwater Systems during the Construction Phase

The proposed construction activities will be undertaken in the dry season (winter months), where possible in order to limit impacts on the flow of stormwater. The above will also be included in the documentation to the contractor.

4.4. Vegetation and Stabilisation

Structures that rely on infiltration for their efficacy should not come into operation until their runoff areas have been stabilised, following construction. This will prevent the need for early and costly maintenance of structures.

If stabilisation by planting is envisaged, plants should be established before the onset of the winter rains. A phased approach to construction should be considered, where the extent of the water course is such that planting of the whole area will take too long for stabilisation to be effective, or where construction activities are likely to take longer than the period between the end of the wet season and the end of the dry season, when planting should take place.

In some cases, delays in the design or tender stages of a project result in delaying construction such that plants are unlikely to be established before the start of the rainy season. Planting during the rainy season is likely to result in the costly loss of plants, due to washout, as well as the erosion of banks, often resulting in the destruction of careful landscaping of bank slopes and profiles. In such cases, it is suggested that planting be delayed until after the end of the rainy season – either until spring, or until the following autumn. Planting in late spring would allow a longer period for the establishment of plants before the next rainy season. However, for all zones except for

permanently wetted zones, frequent irrigation would be necessary to ensure the survival of the plants over summer.

Delays in planting are likely to have cost implications for the project as a whole: survival of pre-ordered, potted plants is often not good over a whole year; in addition, regarding and shaping of eroded banks may be necessary. Nevertheless, it should also be noted that there are advantages to such delays in planting – for one thing, it allows water levels and rates of flow to be observed over one year, and these observations can be used to guide plant zonation.

It is strongly recommended that any planting programmes carried out in stormwater management systems make use of locally indigenous plant species. Indigenous species tend to require less costly nurturing than do exotics. Moreover, they are often less prone to disease and, from an ecological perspective, can also provide areas of indigenous habitat, potentially linking areas of natural indigenous habitat, across the development area.

Project:

- The proposed access road is situated adjacent to the Northridge Mall in Bloemfontein and is adjacent to a residential area. It is situated on Park Erf 30476, Extension 213. The extent and length of the road of the road is approximated at 200 m in length and 12 m in width.

- Weed eradication should be done during construction.

- After construction has ceased all construction materials should be removed from the area and no dumping of rubble or waste may occur on or around the site.

- Protected succulent species occurring on the site are *E. mauritanica*, *S. grandiflora* and *A. grandidentata*. As protected species they retain a conservation value and due to their ease of establishment it is recommended that permits be obtain to transplant these to an area on or adjacent to the site where they will not be affected.

- A few juvenile specimens of the protected Wild Olive (*O. europaea* subsp. *africana*) occur on the site. Permits must be obtained to remove them from the site.

5. Summary of stormwater mitigation measures to be implemented

5.1. Prevent concentration of stormwater flow at any point where the ground is susceptible to erosion.
5.2. Reduce stormwater flows as far as possible by the effective use of attenuating devices (such as swales, berms, silt fences). As construction progresses, the stormwater control measures are to be monitored and adjusted to ensure complete erosion and pollution control at all times.
5.3. Minimse the area of exposure of bare soils to minimse the erosive forces of wind, water and all forms of traffic.
5.4. Ensure that development does not increase the rate of stormwater flow above that which the natural ground can safely accommodate.
5.5. Ensure that all stormwater control works are constructed in a safe and aesthetic manner in keeping with the overall development.
5.6. Design culvert inlet structures to ensure that the capacity of the culvert does not exceed the pre-development stormwater flow at that point.
5.7. Design outlet culvert structures to dissipate flow energy. Any unlined downstream channel must be adequately protected against soil erosion.
5.8. Permits will be obtained for the removal / transplantation of protected species (if any) that are located within the proposed road route where no alternatives are possible. Care will be taken to prevent unnecessary damage to vegetation near to construction activities.
5.9. The necessary Environmental Authorisation will be obtained before any activities listed in the Regulations (Regulations 982, 983, 984 and / or 985 of 2014) are undertaken.
5.10. Proper sanitation, potable water and waste facilities will be in place before construction activities are undertaken.
5.11. Care will be taken to prevent unnecessary damage to vegetation near to construction activities.
5.12. Potable water will be made available daily to workers on site.
5.13. No activities will be undertaken within 32 m of a watercourse / within the 1:100 year floodline, without the necessary authorisations (for example from DESTEA and DWS).
5.14. Emergency plans will be in place in case of spillages into the water resource(s).
5.15. All no-go areas will be demarcated under guidance of the Environmental Control Officer (ECO).
5.16. All chemicals used during the development, including fuel for the construction vehicles, will be stored in a proper storeroom or protected area to prevent pollution.

5.17. Vehicles will be serviced at designated areas. No oil, diesel or other chemicals may be spilled or discharged anywhere.
5.18. Where applicable, the contractors will ensure that all relevant national, regional and local legislation regarding storage, transport, use and disposal of petroleum, chemical, harmful or hazardous substances and materials are adhered to, where necessary.
5.19. Cement and concrete mixing, if applicable, will only take place within the construction site. No concrete will be mixed directly on the ground.
5.20. All environmental problems occurring on the site such will be reported to the ECO. The ECO should implement best practices to rectify the impacts thereof on the environment.
5.21. The contractor is responsible for the removal of construction waste.
5.22. Construction activities will be limited to designated construction areas to prevent peripheral impacts on surrounding natural habitats. Construction vehicles will also keep to constructed roads where possible, so that natural vegetation is not destroyed unnecessarily.
5.23. All human movement and activities will be contained within designated construction areas in order to prevent peripheral impacts on surrounding natural habitat.
5.24. Erosion management is important. Rehabilitation of disturbed areas will be undertaken to help the recovery of the vegetation.
5.25. Removed topsoil will be stockpiled in an area where it will not be disturbed by vehicles.
5.26. Stockpiled material will be protected from washing away during rainstorms. For example, one layer of bricks or stones can be placed around the stockpiled material.
5.27. Stockpiled material will be placed on the cleared areas once construction is completed. Re-spreading of topsoil is preferably to be done to a maximum of 10 cm, depending on the natural depth.
5.28. An alien control and monitoring programme will be developed starting during the construction phase and will be carried over into the operational phase.
5.29. Any proclaimed weed or alien species that germinates during the contract period will be cleared by hand / approved chemicals before flowering thereof.
5.30. Imported fill material will be monitored during and after construction for the presence of any alien species. Any such species will be removed immediately.
5.31. The total depth of excavation will be kept to a minimum, i.e. follow the slope of the natural ground surface and a minimum cover of approximately 1 m over the pipe is proposed, where possible.

5.32. Species, especially grasses, trees and shrubs occurring in the region will be used to rehabilitate disturbed areas.
5.33. An alien plant control and monitoring programme will be implemented.
5.34. Re-vegetation of disturbed areas will be undertaken with site indigenous species.
5.35. Soil erosion occurrences will be attended to immediately.
5.36. The applicant will ensure that the contractors adhere to the recommendations of the EMPr and conditions of the Environmental Authorisation during construction.
5.37. An Environmental Control Officer (ECO) will be appointed to monitor the construction phase. Note that the ECO may be appointed separately or can be part of the contractor's team.
5.38. Regular monitoring and / or spot inspections at least every two weeks during the construction phase is recommended.
5.39. Inspections should be documented and any shortcomings addressed immediately.
5.40. An independent ECO will be appointed to monitor the construction phase. A report will be provided to the contractor upon completion thereof. The findings thereof should be made available to DESTEA, should it be requested.
5.41. The drainage system for the site should be designed to specifications that can adequately deal with a 1:50 year intensity rainfall event or more to ensure sufficient capacity for carrying storm waters around and away from infrastructure.
5.42. Procedures for storm water flow through a project site need to take into consideration both normal operating practice and special circumstances. Special circumstances in this case typically include severe rainfall events.