Glencore Lanxess Stormwater Passive Wetland Conceptual Design

Rustenburg Municipality, Bojanala Platinum District Municipality, North West Province, South Africa

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Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, Amended. We have no conflicting interests in the undertaking of this activity and have no interest in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science.

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1 Introduction

1.1 Background

The Biodiversity Company was commissioned to provide a conceptual passive wetland design for the discharge of clean water from the proposed Glencore Kroondal Mine Infrastructure on Portion 11 of the Farm Rietfontein 338 JQ (Western Chrome Mines) near Rustenburg, North West Province (Figure 1-1).

Glencore Western Chrome Mines (WCM) is in the process of acquiring a portion of the mining and surface rights from the Clover Alloys Rustenburg Chrome Mine (RCM) to reduce the time taken to travel to the face at its Kroondal Mine and increase the mining facetime which will in turn increase productivity. In addition to utilizing the existing infrastructure at Clover Alloys RCM, the applicant wishes to develop additional facilities to use in the life of mine. Stormwater management will be necessary for the development will now incorporate a constructed wetland system, designed to enhance passive treatment, water quality improvement, and ecological function.

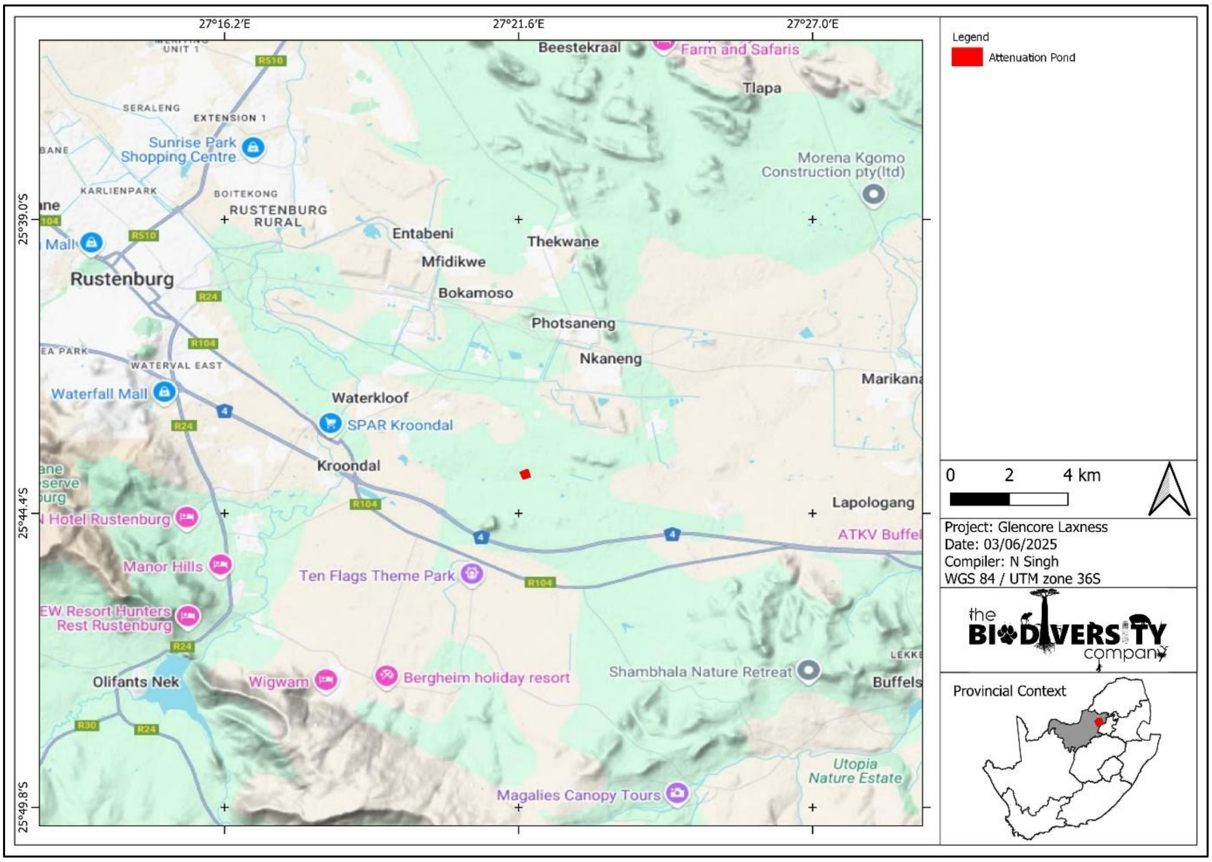

Figure 1-1 Location of the proposed Lanxess Stormwater project

1.2 Scope of Work

The following tasks were completed in fulfilment of the terms of reference for this assessment:

- The design of an artificial wetland, which will include the following:
- A layout sketch for the designed system;
- Designated excavation or intercept locations;
- Recommended plant and / or seed mixes; and

- Recommended structure measures.

1.3 Assumptions and Limitations

The following assumptions were considered for the design of the artificial system:

- The site will be reshaped according to the final approved plans for the new infrastructure layout for the Glencore Kroondal Mine Infrastructure project, which will provide a uniform and controlled environment for the constructed wetland;
    - The topography and soil conditions will be modified or engineered to support wetland vegetation and hydrology;
- The hydrological inputs into the wetland (e.g., inflow rates, water levels) will be consistent with the stormwater design specifications for the Glencore Kroondal Mine Infrastructure and will not exceed its limits;
- The quality of stormwater released into the constructed wetland will be of an acceptable standard given that the receiving area is from the clean water catchment;
- Given the assumed periodicity of flows due to the nature of the feature being reliant on stormwater input, it is presumed that seasonal and temporary wetland conditions will be dominant in the outflow wetland; and
- Given that the constructed wetland forms part of the Glencore Kroondal Mine Infrastructure project, it is assumed that all regulatory requirements from the relevant authorities have been applied or accounted for during the suitable application phases for the Glencore Kroondal Mine Infrastructure project.

The following limitations were considered for the design of the artificial system:

- Due to the development of the area entailing largescale reshaping of the topography and alterations to the natural local flow regime, the site-specific conditions for the constructed wetland area may be altered resulting in the design of the feature requiring adjustments prior to the final implementation phases;
- Due to the nature and stage of the proposed constructed wetland project (i.e. Conceptual Design) no bill of quantities, cost estimates and timeframes have been included for the construction phase therefore, the financial feasibility of the project was not examined; and
- The assumption of uniform site conditions may not hold true once the site is developed and fully operational as the conditions may vary due to unforeseen factors such as grading inconsistencies or construction constraints potentially affecting the performance and effectiveness of the constructed wetland.

2 Project Area

The project area is characterised by the following attributes (The Biodiversity Company, 2025):

- Vegetation – Marikana Thornveld;
- Climate – Warm-temperate with summer rainfall (October–April);
- Mean Annual Precipitation – 654 mm;

- Quaternary Catchment – A22H;
- Water Management Area (WMA) – Limpopo-Olifants; and
- The North West Conservation Plan (Aquatic) – Biodiversity of the area is classified as an Ecological Support Area.

3 Site Selection

As previously mentioned, the constructed passive wetland forms part of the Glencore Kroondal Mine Infrastructure project. The site has been selected based on the positioning of the attenuation dam as per the stormwater design for the project as displayed in Figure 3-1. The attenuation pond will be designed to promote wetland conditions within the main basin and downslope of the basin and therefore act as a passive wetland system.

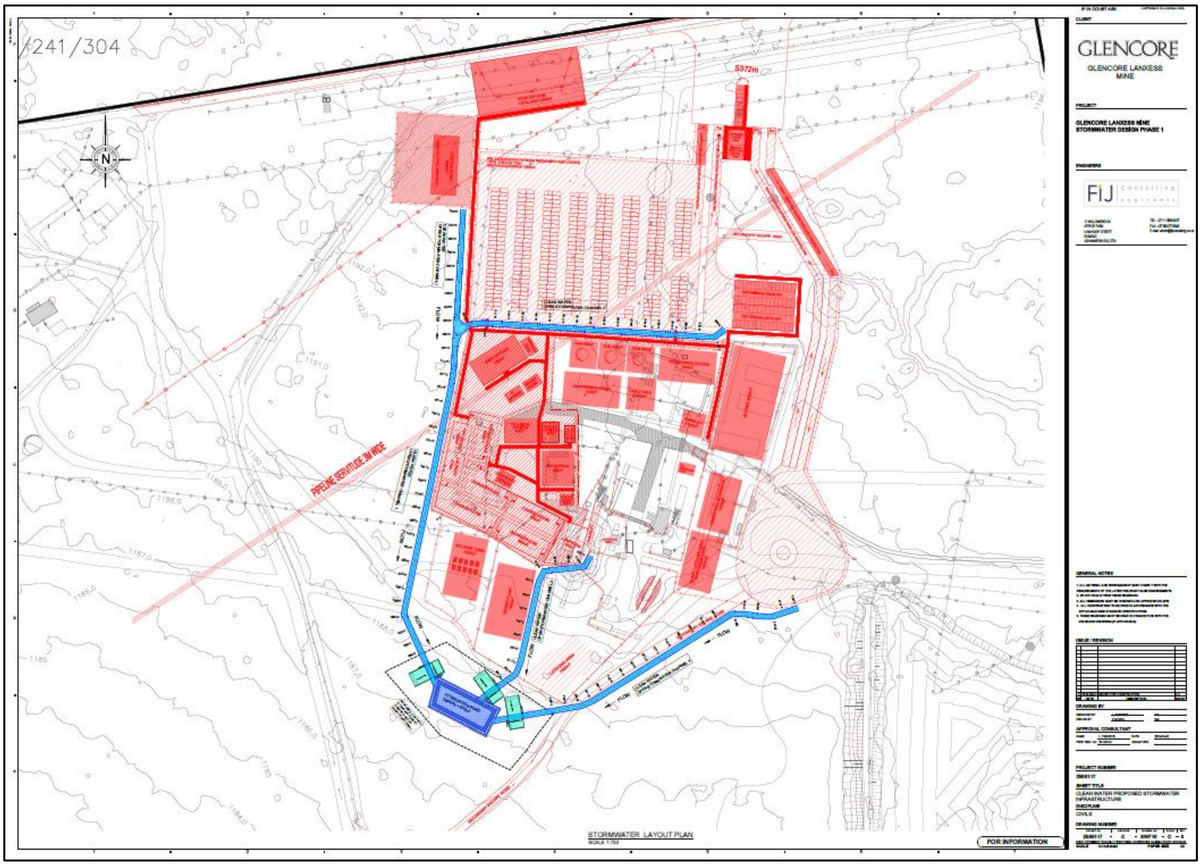

Figure 3-1 Proposed stormwater design for the proposed development (FIJ Consulting Engineers, 2025)

3.1 Location

The proposed site for the main basin of the passive wetland will be located at the discharge points for the clean stormwater channels with the outflow area of the wetland extending downslope. Figure 3-2 indicates the area for which the passive wetland will occur.

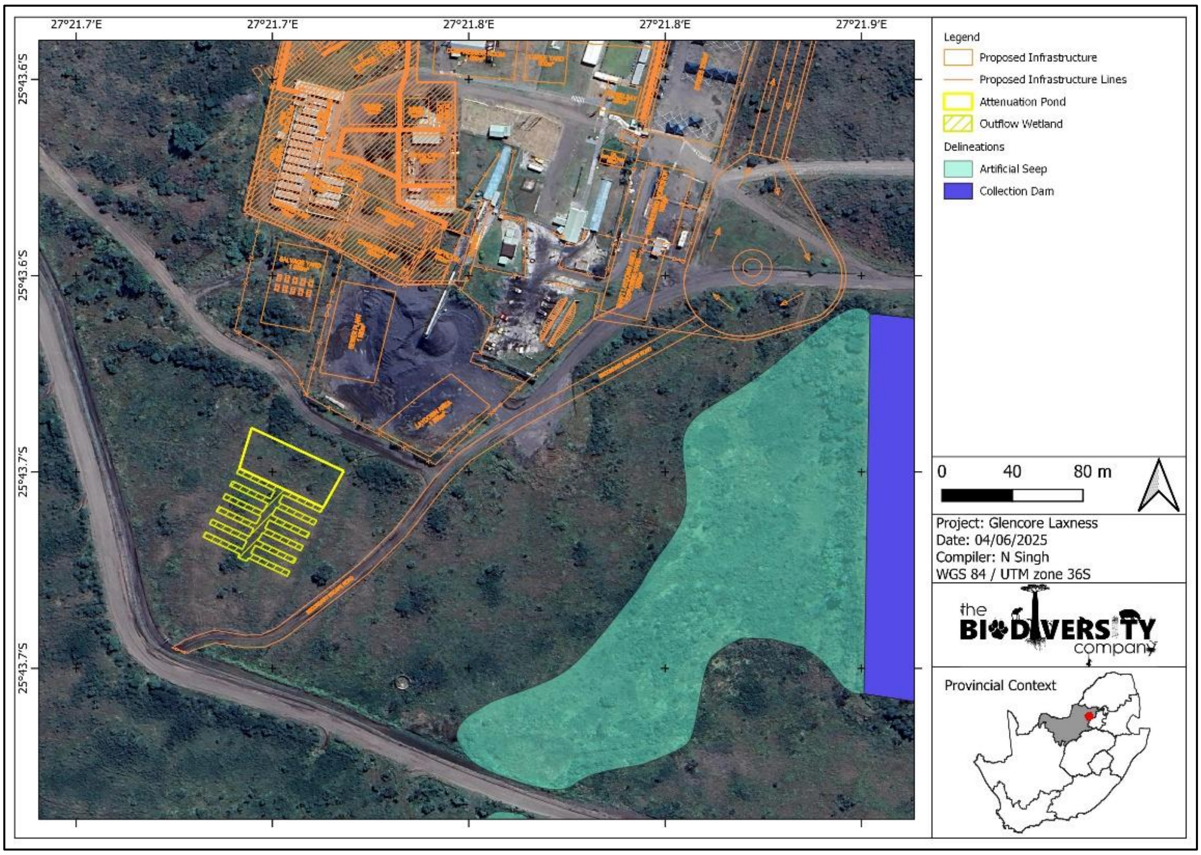

Figure 3-2 Approximated location of the passive wetland

3.2 Site Characteristics

As noted in the Terrestrial Biodiversity Assessment (The Biodiversity Company, 2025), the area proposed for the passive wetland is characterised by disturbed thornveld. Hydromorphic soils and a natural presence of hydrophilic vegetation, typical of wetlands is therefore naturally lacking and would need to be considered in the design. The general slope of the land from the expected area for stormwater discharge, across the passive wetland site and towards the southern secondary escape road is marked by a 1.73% change in elevation over 171 m (Figure 3-3). The relatively gentle slope will support the design of the passive wetland as it would minimise the amount of excavation required and will promote gravity flow.

Figure 3-3 Google Earth elevation profile of the constructed wetland area

4 Design Objectives

The passive wetland will be conceptually designed with the primary purpose of increasing water retention and promoting low velocity flows, which thereby reduces erosion. The secondary objectives of the constructed wetland are the:

- Improvement in water quality of discharge received from the clean water catchment; and
- The provision of a transitional habitat that is integrated with the environment to encourage and support local wildlife.

5 Design Aspects

The design will focus on the primary objective of reducing the potential erosion and incorporate features that support the secondary objectives benefits where necessary. In achieving the primary objective, the secondary objectives will inevitably be reached attributed to the cascading effect of having an artificial system that mimics a natural setting.

5.1 Rudimentary Literature

Constructed wetlands are engineered systems designed to treat wastewater by utilizing natural processes involving wetland vegetation, soils, and microbial assemblages. They mimic the processes of natural wetlands within a controlled environment and can be classified according to their dominant hydrological flow pattern (Vymazal, 2010).

Two main constructed wetland types exist, namely a Vertical Flow (VF) and Horizontal Flow (HF) wetland (Figure 5-1). According to the UN-HABITAT (2008) vertical flow wetlands are characterised by wastewater which is fed from the top and then gradually percolates down through the bed and is collected by a drainage network at the base. Whereas horizontal flow wetlands are characterised by wastewater that is fed in at the inlet and thereafter flows slowly through the porous substrate under the surface of the bed in a predominant horizontal path until it reaches the outlet zone.

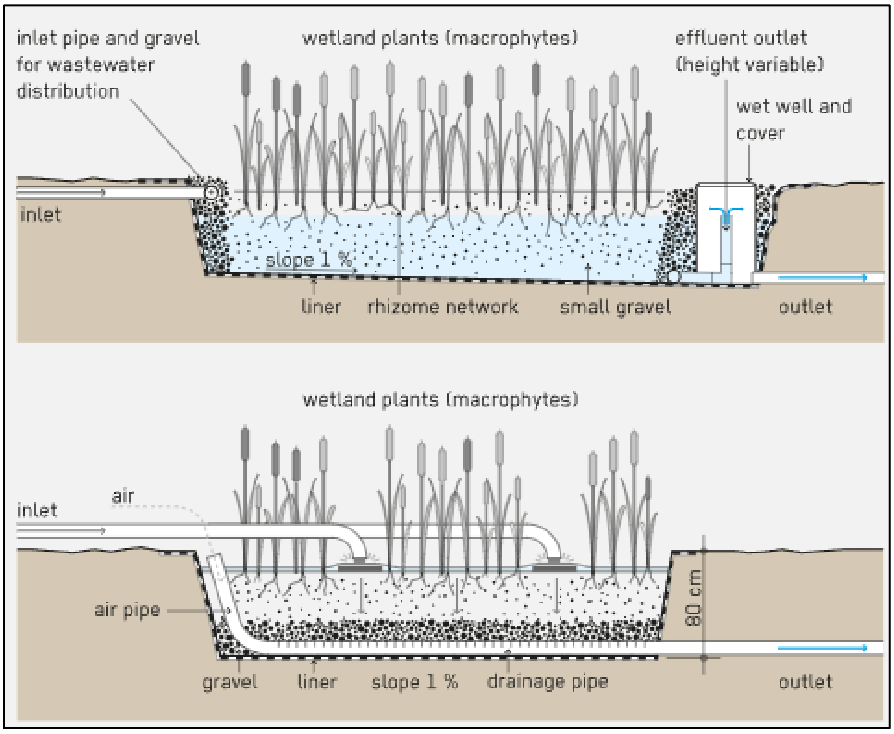

Figure 5-1 Cross sectional representation of constructed wetland types. Top: Horizontal Flow. Bottom: Vertical Flow (Sanitation Technologies in Emergencies, 2025)

5.2 Type

It should be noted that the substrate of constructed wetlands can rapidly be filled with debris, solids and grit from raw sewerage discharge which would prevent the wetland from functioning. It is therefore imperative that only 'clean' water that is free of contaminants and solid waste and meets the targets as set out in the Target Water Quality Guidelines (DWS, 1996) be released into the passive wetland.

Given the general topography of the site and the design objectives a combination of an aerobic free surface water and HF constructed wetland system is deemed to be suitable for the proposed project. The overall shape of the free surface water wetland will conform to a rectangular channel-basin system. The main design concept will be a constructed shallow channel-basin that is sealed with an impermeable liner and is filled with suitable grades of gravel and other substratum which the 'clean' stormwater influent will diffusely be spread across, travelling through the wetland (Figure 5-1) and be released into the outflow HF wetland once the basin capacity is reached. Given the expected periodicity of flows, the outflow wetland will be characterised by seasonal and temporary wetland conditions and will consist of a main channel and interceptor channels. A seasonal die-off of vegetation is therefore expected for the entire wetland system, and this is presumed to result in a seasonal drying of vegetation which could be beneficial for nutrient cycling, habitat diversity, and organic matter accumulation.

5.3 Design Considerations

Under typical conditions the requisite size of the passive wetland is largely dependent on the discharge rate of the influent released into the constructed system and Hydraulic Retention Time (HRT) that the influent spends in the constructed wetland. Given that this system is designed for stormwater control and not a daily or constant release of water, it is anticipated that the discharge rate will fluctuate. Furthermore, given that water will not be constantly released into the system and only flow through the wetland during rainfall events, the outflow will not be positioned at the bottom and will rather be located at the top to promote a higher HRT in the main basin and subsequently the sustenance of wetland vegetation within the main basin. By rule of thumb, a larger surface area in relation to the depth of the feature will be required to effectively reduce the flow velocity. According to the stormwater design report (FIJ Consulting Engineering, 2025) the proposed volumetric size of the passive wetland main basin is 876 m^3. The approximated dimensions resulting in the volumetric size are a depth of 0.7 m, and sides of 53 m by 23 m which are deemed sufficient for the passive wetland design.

The main channel of the outflow wetland will be characterised by a width of 5 m, a length of 45 m and a depth of 0.5 m. The interceptor channels will be characterised by a width of 48 m (the width of the main basin), a length of 3 m and a depth of 0.5 m. The space between each interceptor feature can vary but should aim to be spaced approximately 8 m between their centres, with the first interceptor being located at the end of the main wetland basin. With the above spacing, a total of 6 interceptor channels.

5.3.1 Bed and Wall Slope

A 1% slope is required for the bed of the main basin in the constructed wetland in order to allow for water to slowly move through the substrate. The front (inflow side) and back wall (outflow side) of the basin should ideally have a 100% slope (45˚). Sloping the sidewalls of the feature is not deemed to be necessary.

The front and back wall slopes of the main basin will be sealed with an impervious liner; however, slope stabilisation may be required and can consist of geotextiles or riprap fitted on the outsides of the impervious liner.

Similarly, the desired wall slopes for the interceptor trenches and main channel of the outflow wetland are 100% (45°). The bed slopes for both the interceptor trenches and main channel should follow the slope of the land. If necessary and, to be confirmed during the final design stages, the bed slope of the interceptor trenches should be gentle and orientated to flow towards the main channel.

A conceptual schematic indicating the required slopes for the main basin is displayed in Figure 5-2.

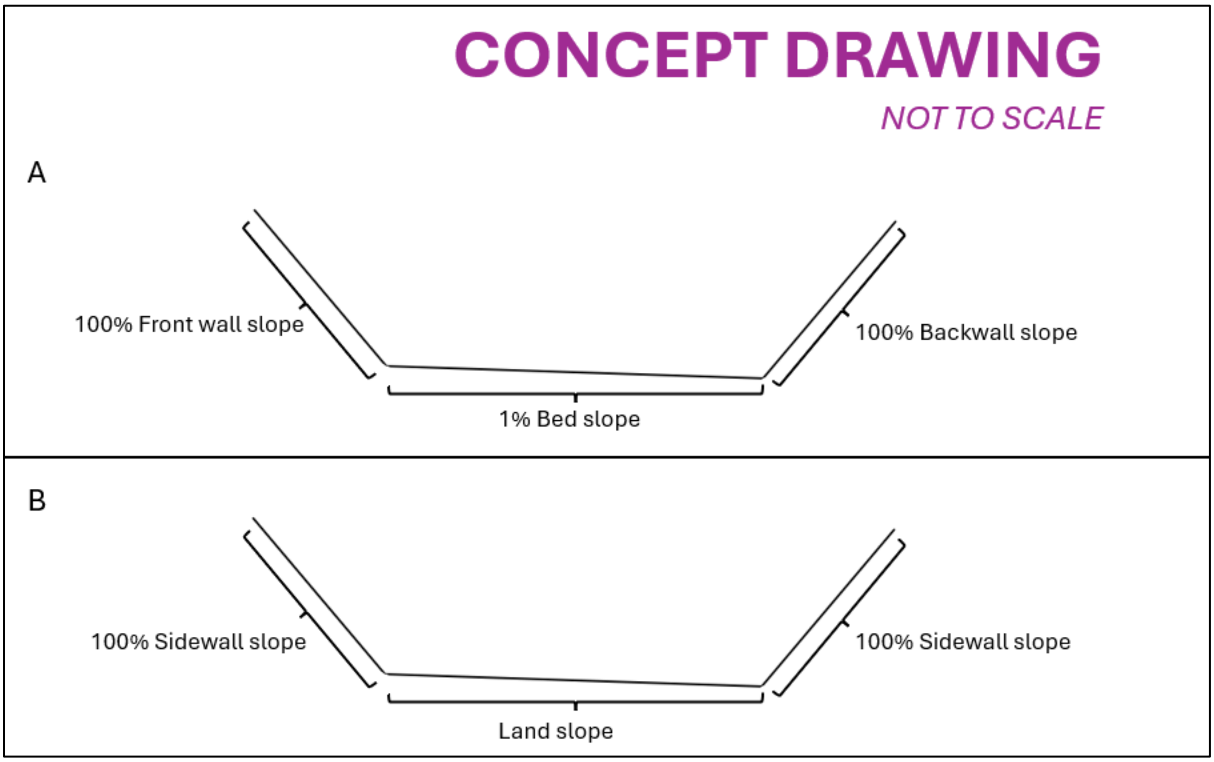

Figure 5-2 Conceptual schematic for the required bed and wall slopes of the passive constructed wetland. A) Main basin and; B) Main and Interceptor Channels

5.3.2 Substrate

Experimental studies indicate that shallow substrate depths were more effective than deep substrate depths in HF wetlands (Garcia et al., 2004). An approximate bed depth of 0.35 – 0.4 m is commonly used in the United States (Steiner and Watson, 1993), whereas a bed depth of is 0.5 – 0.8 m commonly used in Europe (Cooper et al., 1996). An important factor in deciding the depth of the constructed wetland is the rooting depth of the plants that will be required.

Given the above the suitable substrate depth for a HF constructed wetland is 0.5 m. This depth is presumed to increase the hydraulic retention time and promote a reduction in the outflow rate. Furthermore, a freeboard of 0.2 m (30 %) has been incorporated into the design to buffer for stormflows and act as a factor of safety, bringing the total depth of the feature to 0.7 m which is consistent with the approximated depth presented in the stormwater design report.

Different substrate media are necessary for the different zones of the constructed systems as the soil properties influence the contact time of the influent in the wetland and the subsequent ability to remove pollutants and prevent erosion (Yang et al., 2022).

The following substrate material specifications are required for the HF constructed wetland and the typical arrangement of the substrate in the wetland is provided in Figure 5-3:

- The entire excavation of the HF wetland must be fitted with an impervious liner. A synthetic liner made of Polyvinyl chloride (PVC); Polyethylene (PE) or Polypropylene is recommended;
- Gravel of between 40 – 80 mm must be used in the inlet and outlet zones of the wetland. A 1.5 m fill width is recommended for each zone. The depth of the fill must be 0.5 m;
- A mixture of 20 – 25 mm grade gravel and pea gravel of 10 mm for the treatment zone. The fill area will be 20 m in width and 0.5 m in depth; and
- Addition of wood chips on the surface of the treatment zone over the pea gravel substrate to promote healthy microbial activity.

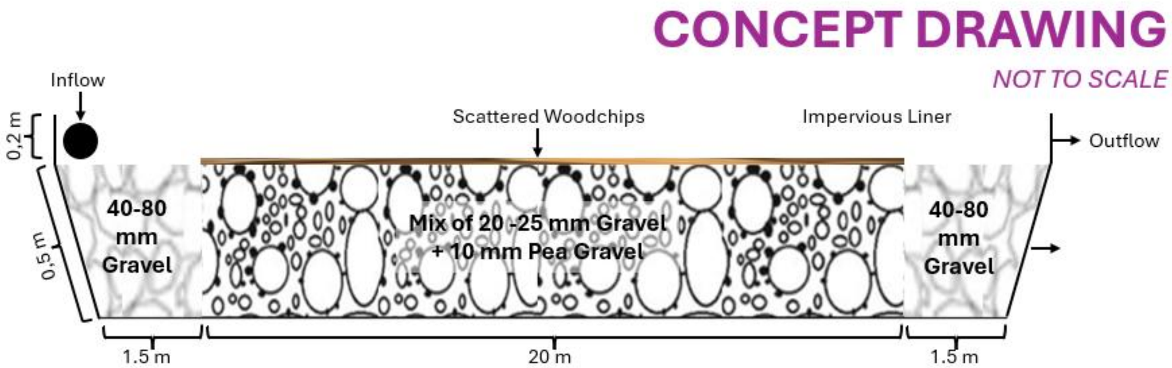

Figure 5-3 Conceptual arrangement of the substrate in the passive HF constructed wetland

The following substrate material specifications are required for the outflow wetland and the typical arrangement of the substrate in the wetland is provided in Figure 5-4. The substrate fill must be for the entire area of the channels:

- A base of 30-60 mm round washed gravel to a depth of 0.15 m;
- A layer of 12 mm round washed gravel to a depth of 0.1 m;

- A 6 mm washed pea-gravel layer to a depth of 0.15 m; and
- A layer of sand to a depth of 0.1 m.

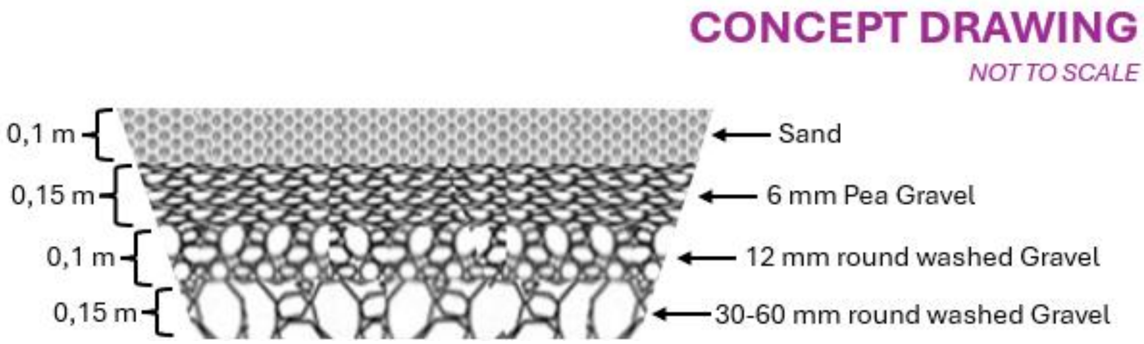

Figure 5-4 Conceptual arrangement of the substrate in the Secondary HF wetland

5.3.3 Flow Path

The main flow path of the influent into and through the constructed wetland system is indicated below.

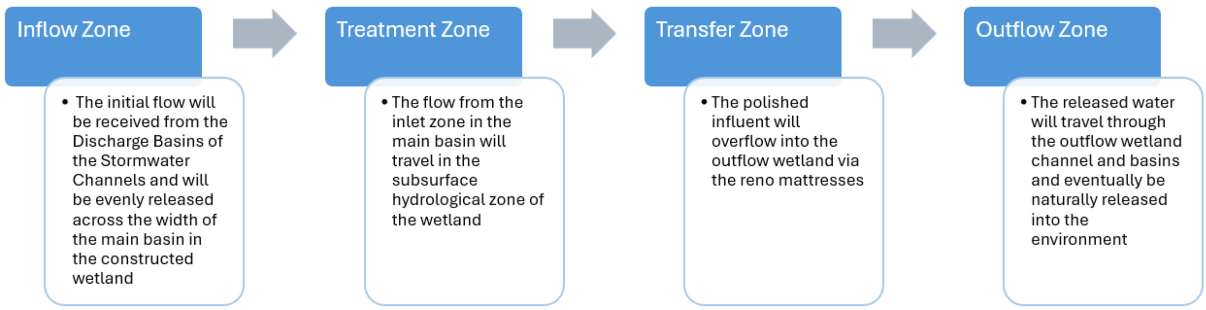

Figure 5-5 Flow path of the passive constructed wetland system

5.3.4 Inlet and Outlets

Inlet and outlet structures or pipes will be required to support the flow of the influent of the constructed passive wetland system. The main pipes and structures required are:

- Discharge Basins for stormwater inflow channels;
  - These structures may already be planned for in the Stormwater Design Report (FIJ, 2025) with a stipulated design. The minimum design requirement to support the inflow into HF wetland is to have a pipe culvert structure with baffles/dissipators/diffuser structures to support the in-feeding sewer network pipe and diffusely spread the flow across the HF constructed wetland, respectively. It is imperative that the baffles are designed and orientated for a diffuse outflow. A typical example is displayed in Figure 5-6.
- Main Inlet Pipe System from Discharge Structure (If required);
  - A piping system to diffusely release water into the HF wetland should be incorporated into the design if the baffle system to diffusely spread flow across the HF constructed wetland is not presumed to suit the design. This system will likely consist of a main pipe, a T-piece connector and a slotted or perforated pipe of suitable dimension for the expected flow rate. The material of the pipes will likely be PVC unless more durable

materials that offer the same functionality are identified and sought. Examples of these pipes and a concept plan for their placement is indicated in Figure 5-6.

- Outlet from main basin into outflow wetland (Compulsory);
  - The site will require inevitable reshaping to accommodate for the HF constructed wetland with a depth of 0.7 m and an average channel bed slope of 1 %. A balance of cut and fill excavation (area can only be confirmed on site) immediately after the backwall of the main basin, for the width and size of the outlet must be shaped to match the natural gradient of the land. The outflow point must be located above the substratum layer of the main basin and to allow for an increased retention in the HF wetland an impermeable liner will have to seal the basin and walls of the main wetland. Reno mattress that follows the natural gradient of the land are recommended for the outlet into the outflow wetland area (Figure 5-6).

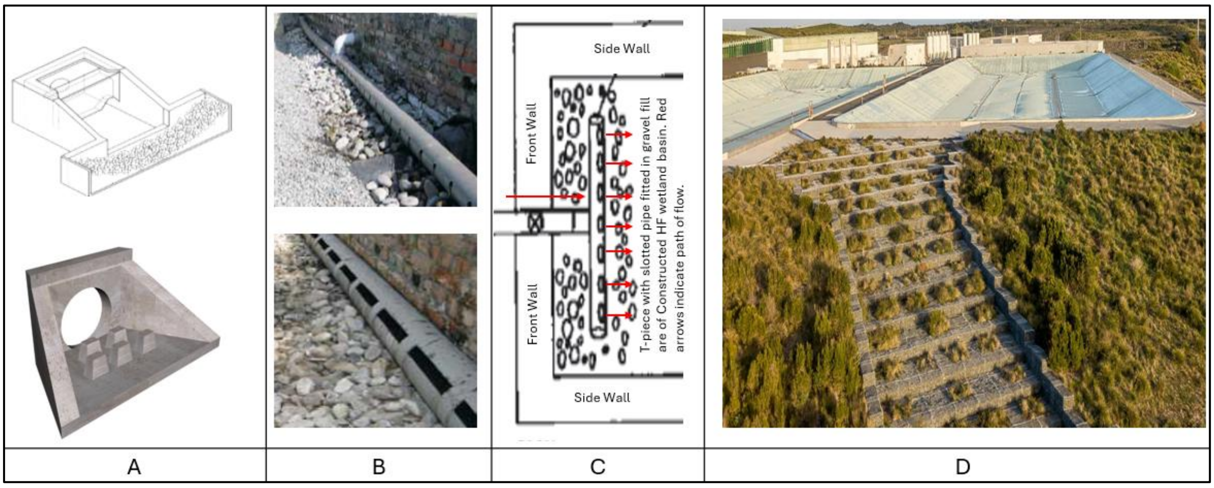

Figure 5-6 Desing concepts for Inlets and Outlets, A) Example of discharge structures from stormwater channels; B) Examples of perforated (top) and slotted pipes (bottom); C) Concept for inflow into the HF wetland using pipes instead of a discharge structure and; D) Example of outlet from main basin

No formal outlet structure is required for the discharge from the outflow wetland into the environment as the main channel will accommodate for the downslope movement of water with the interceptor channels promoting subsurface hydrological regimes and a sub-surface return.

5.3.5 Vegetation

The proposed planting model for the constructed wetlands is designed to optimize ecological function, enhance water treatment efficiency, and support biodiversity. By selecting specific plant species for different zones, the model aims to create a balanced and effective wetland ecosystem. The planting model will entail:

- Planting cattails or reeds from the Typha and Phragmites genus in the main basin of the wetland;
- Planting sedges and rushes from the Cyperus, Schoenoplectus and Juncus and Scirpoides genus in the outflow wetland; and
- Planting moist grass species in the areas surrounding the constructed wetlands.

Typha and Phragmites are preferred for vegetating the Main Basin of the Passive Wetland based on:

- Water treatment efficiency - Cattails (Typha) and reeds (Phragmites) are known for their robust root systems, which enhance nutrient uptake and provide extensive surface area for microbial growth, crucial for breaking down pollutants;
- Erosion control - These plants stabilize the substrate, reducing erosion and maintaining the structural integrity of the wetland; and
- Habitat provision - They offer habitat and food for various wildlife species, promoting biodiversity within the wetland.

Cyperus, Schoenoplectus, Juncus, and Scirpoides are preferred for vegetating the Outflow Wetland based on:

- Filtration and sediment trapping - Sedges and rushes are effective at trapping sediments and filtering water, improving water quality as it moves through the system;
- Adaptability - These species thrive in varying water levels, making them ideal for interceptor trenches and channels where water flow may fluctuate; and
- Biodiversity support - They provide habitat diversity, supporting a range of aquatic and terrestrial species.

Grass Species are preferred for vegetating the surrounding of the wetlands based on:

- Buffer zone creation - Moist grass species act as a buffer, reducing runoff and preventing pollutants from entering the wetland.
- Aesthetic and recreational value - Grasses enhance the visual appeal of the area, providing opportunities for recreation and education.
- Soil stabilization - They help stabilize the soil around the wetland, preventing erosion and maintaining landscape integrity.

6 Conceptual Design

The conceptual design (Figure 6-1) presents the main basin of the constructed wetland system, emphasizing its structural and functional components. As earlier indicated the wetland dimensions are 53 m by 23 m, with a total depth of 0.7 m, including a 0.2 m freeboard and a 0.5 m active zone. An impermeable lining sealing the HF constructed ensures water containment, while a reno mattresses provides stability and facilitates effective release of water from the feature. The main basin system is designed with a 1% slope to guide water from the discharge basins through the wetland to the outflow point where flow will diffusely be released into the outflow wetland once the basin capacity is reached.

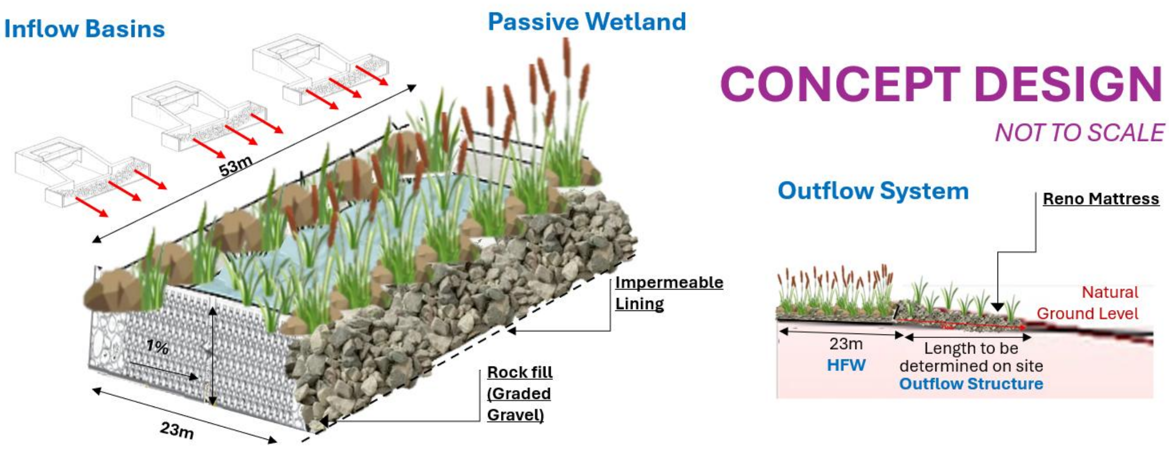

Figure 6-1 Conceptual design for main basin of the constructed wetland

The outflow wetland includes a main and several interceptor channels, positioned at 8 m centres, with a depth of 0.5 m and a bed slope that matches the natural land gradient to manage water distribution that mimics the natural setting and to enhance infiltration across the wetland. The conceptual design for the interceptor and main channel of the outflow wetland is provided in Figure 6-2.

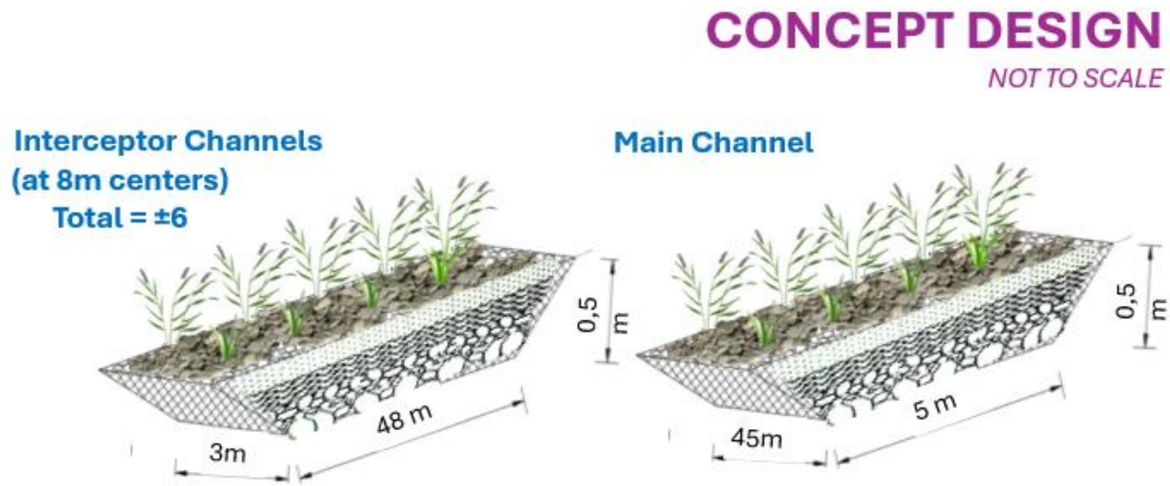

Figure 6-2 Conceptual design for main and interceptor channels of the constructed secondary HF outflow wetland

The aerial layout for the passive wetland is indicated in Figure 6-3.

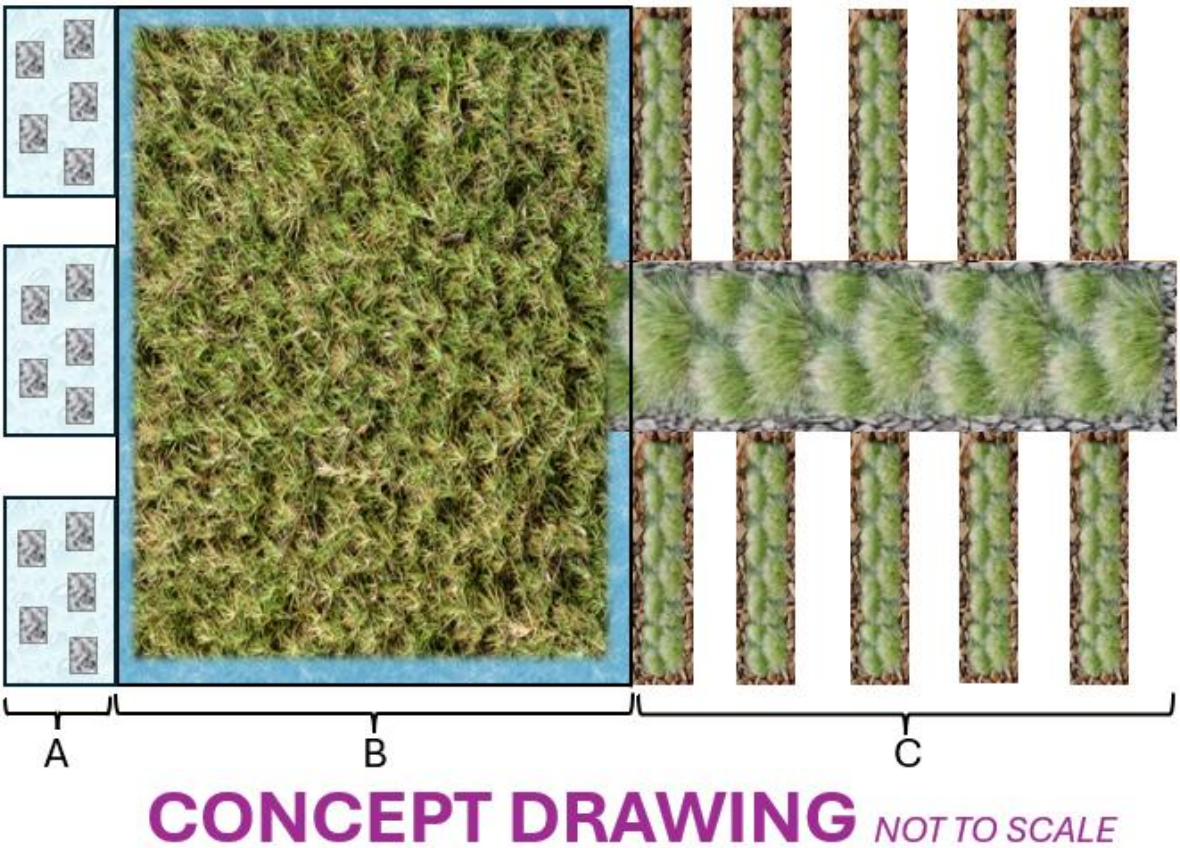

Figure 6-3 ***Aerial view of conceptual design for the passive wetland, A) Stormwater discharge structures leading into constructed wetland; B) Constructed HF wetland; C) Outflow wetland.***

The conceptual layout sufficiently meets the design objectives; however, a final civil design should be completed by the engineering team to aid construction.

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