



City of Ekurhuleni Wetland and Watercourse Rehabilitation Planning within the Kaalspruit Catchment

Engineering Conceptual Designs and Basic Assessment Report

By:

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TABLE OF CONTENTS

1	INTRODUCTION.....	7
1.1	Purpose of this report	7
1.2	Approach	7
1.3	Study area	7
2	HIGH LEVEL FLOOD LINE ANALYSIS	10
2.1	Flood lines methodology	10
2.2	Hydrological analysis	10
2.3	Discussion and limitations	14
3	CONCEPTUAL MASTER PLAN.....	14
3.1	Rehabilitation Zones	14
3.2	Development of rehabilitation strategy	16
3.3	Soft interventions	16
3.3.1	Parks and green spaces	17
3.4	Hard interventions	18
3.4.1	Instream structures	18
3.4.1.1	Existing instream interventions.....	20
3.4.1.2	Proposed instream interventions.....	21
4	RISK ASSESSMENT	28
4.1	Approach	28
4.2	Findings	28
4.2.1	Proposed activities	28
4.3	Impact identification	30
4.3.1	Activities outside of wetland boundaries but within 500m of wetland habitat	30
4.3.2	Activities within wetland habitat	31
4.4	Mitigation measures	32
5	GN 509 RISK ASSESSMENT.....	34
6	HIGH LEVEL COST ESTIMATES.....	41
6.1	Approach/methodology	41
6.2	Limitations with respect to costing	41
6.3	Costing	41
7	GENERIC CONSTRUCTION METHOD STATEMENT	42

7.1	Occupational health and safety	42
7.2	Soil movement, backfilling and levelling:	43
7.3	Revegetation of disturbed areas:	43
7.4	Removal of alien vegetation:	43
7.5	Instream structure construction	44
7.5.1	Phasing	44
7.5.2	Site setup	44
7.5.3	Structure setting out	44
7.5.4	Vegetation and topsoil stripping	44
7.5.5	Flow diversion	45
7.5.6	Structure pit excavation and soil stockpiling	45
7.5.7	Excavation dewatering (if applicable)	46
7.6	Weir Construction and Placement:	46
7.6.1	Concrete structure – construction notes (Ignore if not applicable):	46
7.6.2	Approval and signing off	48
7.6.3	Rehabilitation of main channel (Excluding impoundment and diversion trench)	48
7.6.4	Removal of diversion impoundment	48
7.6.5	Rehabilitation of the diversion trench:	48
7.6.6	Rehabilitation of remaining working areas:	49
8	WAY FORWARD	49
9	CONCLUSION	50
9.1	Rehabilitation strategy	50
9.2	Rehabilitation measures	50
9.3	Risk assessment	50
9.4	Cost estimates	51
9.5	Way forward	52
10	APPENDICES	53

TABLE OF FIGURES

Figure 1: Map showing Kaalspruit catchment in relation to the CoE Boundary	9
Figure 2: 1:100-year flood lines for targeted wetlands in Kaalspruit catchment.....	13
Figure 3: Kaalspruit rehabilitation zones.....	15
Figure 4: Existing and proposed structures in Kaalspruit catchment	19
Figure 5: Armorflex and or MacMat Channels	22
Figure 6: Low-level berm with MacMat	23
Figure 7: Concrete Weirs.....	23

Figure 8: Concrete weir with walkway.....	24
Figure 9: Concrete weir box and or round-inlet.....	25
Figure 10: Kaalspruit litter traps.....	27

TABLE OF TABLES

Table 1: The extent of the study catchment area in relation to the DWS quaternary catchment.	8
Table 2: Recommended 24 hour rainfall storm depths for different recurrence intervals.....	10
Table 3: Sub-Catchment characteristics.....	11
Table 4: Existing structures within the targeted wetlands area in Kaalspruit Catchment.....	20
Table 5: Proposed structures within the targeted wetlands area in Kaalspruit Catchment.....	21
Table 6. Risk rating scale utilised (as per amendment GA for section 21 (c) and (i) water uses which was published in the Government Gazette (No 40229 Pg 105 Notice 509) on 26 August 2017).....	28
Table 7: Summarised results of the risk assessment for the proposed activities.....	34
Table 8: High level costing for soft interventions.....	42
Table 9: High level costing for hard interventions.....	42

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1 INTRODUCTION

GreenGAB, along with Wetland Consulting Services (WCS), was appointed by Environmental Impact Management Services (EIMS) on behalf of the City of Ekurhuleni (CoE), to develop a master plan for wetland rehabilitation, as well as open green space integration, to be implemented within the Kaalspruit catchment. This catchment was selected by the CoE as a priority catchment to be focused on in this master plan.

The Kaalspruit catchment is located within heavily developed areas, consisting of informal settlements and urban developments, associated infrastructures and subsistence agricultural areas. All of these land uses could lead to typical water quality and quantity impacts. These impacts may range from failing of sewer infrastructure and direct discharge of sewage into watercourses, increased stormwater flows off hardened surfaces (resulting in erosion and deterioration of natural watercourses) and agricultural return flows containing a variety of pesticides and fertilisers which negatively affect water quality in the receiving watercourses. Wetland rehabilitation within this catchment provides a potential opportunity to address some of these, and other, impacts.

As part of the planning regime for the wetland rehabilitation, a high-level master plan, along with high-level conceptual designs and layout of the various “hard and soft” engineering measures were developed. The thinking and rationale behind the various interventions are described in this report.

1.1 PURPOSE OF THIS REPORT

The purpose of this report is to convey the rationale behind the development of the master plan for hard and soft interventions in and around the targeted wetlands within the Kaalspruit catchment. This will include conceptual maps, drawings and high level Bill of Materials (BoM) for the proposed interventions.

1.2 APPROACH

The following approach was followed for the compilation of this master plan:

- A desktop assessment of the available information was undertaken to inform master plan;
- A field survey of the targeted wetland areas was undertaken;
- A high-level hydrological analysis was developed;
- A conceptual master plan for the Kaalspruit catchments was developed;
- The hard and soft interventions were conceptualised;
- A risk assessment of the various hard and soft interventions was undertaken;
- A high-level BoM for the hard and soft interventions was developed; and
- A generic construction method statement for the intervention was developed.

1.3 STUDY AREA

The study area is the catchment of the Kaalspruit River within the CoE boundary, as indicated in Figure 1. The catchment falls within the Department of Water and Sanitation (DWS) quaternary catchment A21B. The extent of the specific catchment targeted for this CoE project is also shown in Figure 1. The catchment was delineated based on 5m contours, with the outlet point of the major

river system placed on the edge of the CoE boundary. The extent of the study catchment area in relation to the quaternary catchment is detailed in Table 1.

Table 1: The extent of the study catchment area in relation to the DWS quaternary catchment.

Sub-Catchment	Catchment Area (km ²)	Catchment Area within CoE (km ²)	% Quaternary catchment within CoE
Kaalspruit/Hennops (A21B)	527	157	30

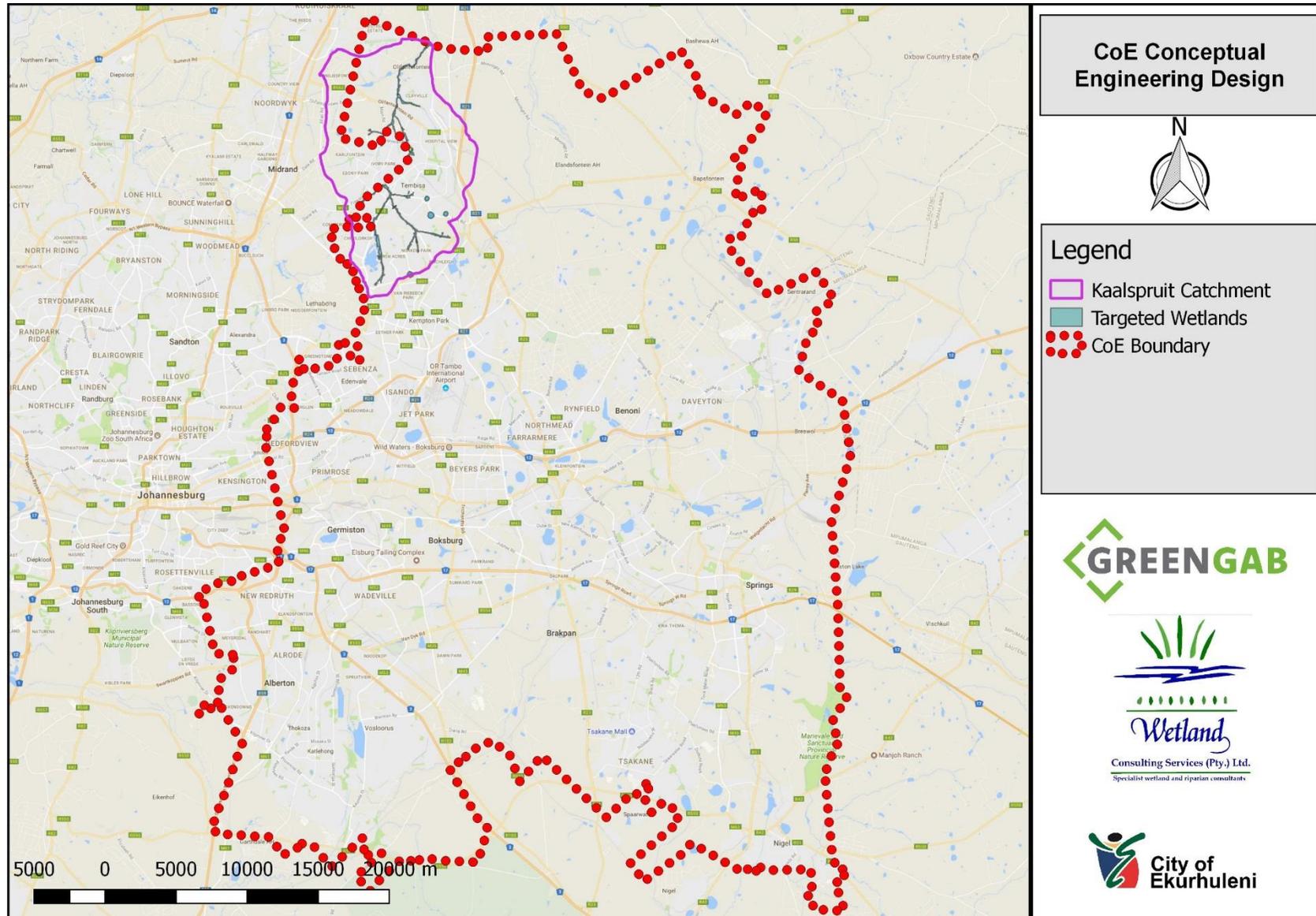


Figure 1: Map showing Kaalspruit catchment in relation to the CoE Boundary

The Kaalspruit catchment is located in the Crocodile (West) Marico Water Management Area in quaternary catchment A21B within the Hennops River Catchment. The rivers in the study area include the Kaalspruit and Olifantspruit Rivers, which drain into the Hennops River. Figure 1 indicates the location of the study catchment in relation to the CoE boundary. The Kaalspruit and Olifantspruit Rivers originate in Kempton Park and Tembisa and flow north to join the Hennops River in Centurion. There are serious pollution problems in these systems and these issues are attributed to human settlements and agricultural activities.

2 HIGH LEVEL FLOOD LINE ANALYSIS

2.1 FLOOD LINES METHODOLOGY

The approach used for the floodline (flood risk) analysis can be summarised as follows:

- The Light Detection and Ranging (LiDAR) survey data, as well as the high-resolution aerial imagery from CoE, were converted into a DTM (Geotif), with a resolution of 2m;
- Site visits were undertaken to the various catchments and, more specifically, to the major river systems within the catchments. During these site visits, special attention was given to potential changes in river roughness coefficients (Manning n);
- Hydrological analysis for the catchment was determined using literature land use of the area;
- The hydrological catchments and sub-catchments were then delineated using the DTM, with limited ground truthing during the site visit. The hydrological attributes of each sub-catchment were determined through high-resolution imagery and Google Earth, depending on the date of the high-resolution imagery;
- A flood peak analysis was undertaken to determine the recurrence interval flood peaks for the various watercourses. (The main watercourses within the catchments). The peak flood analysis was done with the Rational Method as well as PCSWMM (advanced modelling software for stormwater management); and
- The flood lines were then plotted and mapped using the available software.

2.2 HYDROLOGICAL ANALYSIS

The 24-hour rainfall depths for the 2-, 5-, 10-, 20-, 50- and 100-year recurrence interval events were determined using the Design Rainfall Estimation in South Africa package (Smithers and Schulze, 2003). The rainfall data recorded at the six (6) closest rainfall stations to Kaalspruit were used to determine the 24-hour rainfall events. The 24-hour rainfall depths are presented in Table 2.

Table 2: Recommended 24 hour rainfall storm depths for different recurrence intervals

Return Period (years)	1:2	1:5	1:10	1:20	1:50	1:100
Rainfall Depth (mm)	57.2	79.0	95.5	113.0	138.6	160.0

The return period depths shown in Table 2 were then used in conjunction with the SCS-SA (Schulze) method, to determine the storm flow depths. This took into consideration soil group, soil water retention and initial losses.

PCSWMM software was used to determine the hydrographs for the various return periods. The catchment characteristics used in PCSWMM as well as the computed peak runoff are listed in Table 3.

Table 3: Sub-Catchment characteristics

Name	Area (ha)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	Zero Imperv (%)	Peak Runoff (m ³ /s)
S1	46.6637	1942.549	2.515	0	0.018	0	3.87
S2	180.85	1737.476	4.518	0.398	0.029	0	14.46
S3	136.048	1786.337	4.749	0	0.025	0	11.97
S4	273.098	2934.005	3.669	2.783	0.022	0.264	19.27
S5	31.895	619.196	5.814	0.618	0.029	0	5.55
S6	57.98	1733.799	4.696	1.423	0.019	0	6.71
S7	25.0725	499.409	8.454	0	0.033	0	5.09
S8	3.95625	418.605	3.836	25.968	0.027	0	1.49
S9	1.3125	180.716	4.836	26.653	0.025	0	0.69
S10	201.09	2554.696	4.723	12.571	0.022	0	27.55
S11	37.995	939.124	4.707	61.422	0.016	0	19.12
S12	8.5375	549.425	5.212	6.434	0.031	0	1.82
S13	24.7387	1117.52	3.073	18.54	0.017	0	6.18
S14	41.2225	1003.088	5.431	16.374	0.026	0	9.62
S15	50.32	966.231	4.063	1.498	0.025	0	6.82
S16	39.2012	1181.577	3.85	31.656	0.021	0	11.62
S17	43.68	1045.539	3.217	0.82	0.017	0	6.53
S18	429.99	3086.067	4.064	55.094	0.017	0	118.95
S19	86.4888	1757.754	4.18	3.925	0.025	0.277	8.77
S20	348.607	3091.639	3.93	11.629	0.018	19.293	44.2
S21	73.81	1647.965	3.56	28.107	0.018	0	18.72
S22	36.62	798.441	5.908	58.918	0.017	0	19.48
S23	156.94	2311.544	3.331	5.236	0.021	0	14.88
S24	30.1512	1155.395	4.338	34.383	0.018	6.878	10.3
S25	117.775	2442.187	4.16	2.685	0.022	1.296	9.81
S26	429.74	3244.67	4.436	9.128	0.024	0	42.31
S27	49.565	1615.797	5.079	1.952	0.024	0	5.37
S28	78.115	1679.699	3.922	48.112	0.017	2.306	26.26
S29	37.3438	1322	5.656	29.202	0.022	0	10.83
S30	382.01	3993.623	3.614	73.568	0.014	0	111.61
S32	16.6362	410.816	4.319	31.67	0.025	0	13.44
S33	79.6663	1778.943	7.361	17.896	0.025	0	16.09
S34	223.075	4087.585	4.094	63.355	0.016	0	59.43
S35	136.174	2173.53	3.719	84.26	0.009	2.644	170.39
S36	19.0112	1444.248	2.61	84.211	0.011	2.264	9.08
S37	315.584	4077.956	3.293	74.415	0.009	12.24	195.31
S38	464.52	3841.935	3.145	73.11	0.011	2.584	148.06
S39	315.022	3316.852	5.368	72.366	0.011	2.9	118.26
S40	875.794	8846.132	3.458	57.297	0.012	12.189	166.95
S41	2020.01	10953.86	3.014	17.228	0.02	6.235	151.59
S42	2013.46	7347.453	4.961	57.214	0.015	6.139	415.93
S43	22.6838	1404.387	5.169	70.498	0.014	0.85	11.01

S44	64.88	1315.378	5.234	68.6	0.013	1.56	32.97
S45	8.61625	694.378	5.629	73.326	0.011	11.34	5.57
S46	18.94	681.597	5.44	58.837	0.009	16.948	12.01
S47	3.76875	381.272	4.819	40.657	0.01	15.245	2.29
S48	365.051	2988.19	4.96	67.786	0.011	8.341	138.61
S49	22.965	523.123	5.263	64.458	0.012	9.275	14.83
S50	13.985	736.997	5.705	67.64	0.014	3.218	8.34
S51	4.9625	475.714	5.826	80.048	0.013	0	3.38
S52	7.2275	456.207	5.047	19.325	0.022	10.239	2.71
S53	34.7938	1323.864	6.785	79.74	0.01	3.455	20.59
S54	48.83	944.216	6.094	82.497	0.008	3.209	32.39
S55	38.03	1089.374	6.215	74.964	0.01	1.327	23.15
S56	34.4862	1147.499	6.153	60.056	0.01	11.384	19.49
S57	41.16	1091.036	5.567	27.445	0.016	12.544	14.41
S58	31.39	928.091	6.458	64.642	0.009	5.899	19.63
S59	104.61	1582.753	4.976	71.628	0.01	2.135	54.79
S60	65.22	1158.072	5.335	22.999	0.02	8.106	18.55
S61	110.47	2087.81	4.205	67.193	0.014	0.489	42.53
S62	195.146	2117.45	3.482	29.949	0.016	2.313	47.55
S63	256.58	3214.68	4.705	70.769	0.009	8.327	103.67
S64	37.6988	1100.126	6.243	67.834	0.013	0	20.84
S65	51.48	1735.079	4.924	63.605	0.014	5.531	21.94
S66	83.11	1662.399	4.936	40.856	0.015	1.231	29.17
S67	107.59	2115.088	4.259	65.969	0.014	0.086	41.04
S68	60.52	1299.041	4.565	0	0.022	0	7.3
S69	96.89	2111.07	4.736	69.772	0.011	2.083	43.07
S70	86.3163	967.904	3.55	0.481	0.028	0	10.05
S71	50.0537	1878.586	4.472	0.858	0.015	2.098	6.22
S72	77.955	1760.212	4.642	46.046	0.013	0	29.54
S73	122.36	2272.982	3.69	0.382	0.012	0.48	14.34
S74	45.8138	961.86	3.808	0.786	0.02	1.406	6.86
S75	43.7	740.772	2.712	1.442	0.025	0	6.15
S76	606.561	3564.062	4.53	10.879	0.013	1.474	85.04
S77	74.91	1467.436	4.686	4.646	0.015	0	12.26
S78	225.605	2307.17	5.307	22.913	0.014	9.105	54.97
S79	65.475	1607.487	4.684	0.347	0.012	0	10.29
S80	150.38	2559.651	5.457	12.882	0.016	14.008	25.36
S81	24.785	1276.87	6.601	3.128	0.019	22.148	4.02
S82	47.055	1554.782	5.133	9.932	0.015	39.388	9.45
S83	134.975	1635.531	4.553	5.727	0.012	1.411	24.68
S84	36.5537	1083.858	4.517	17.009	0.013	41.095	11.07
S85	83.3662	1239.696	4.275	13.018	0.015	13.388	19.78
S86	18.99	892.293	3.677	29.396	0.017	15.102	6.66

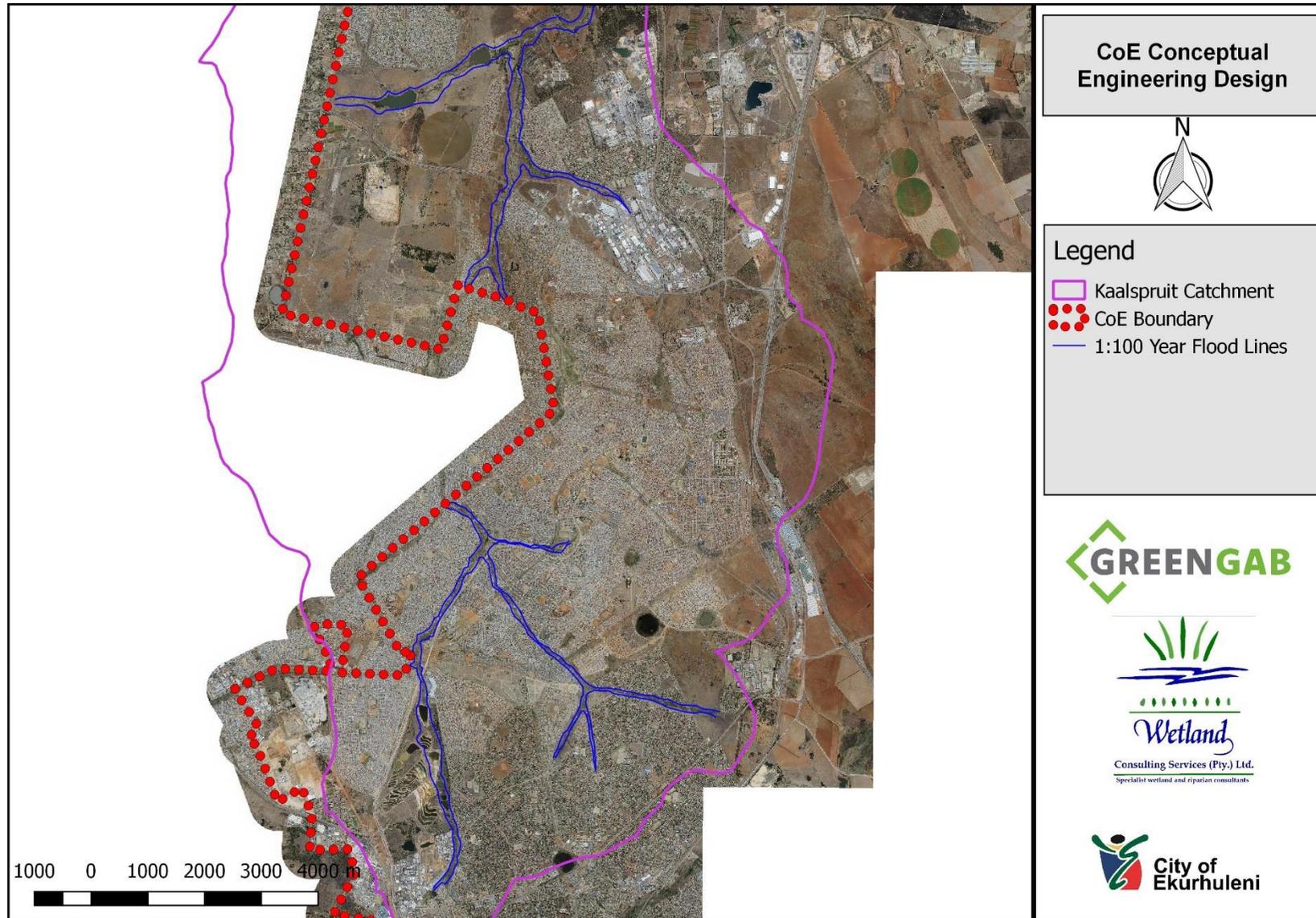


Figure 2: 1:100-year flood lines for targeted wetlands in Kaalspruit catchment

2.3 DISCUSSION AND LIMITATIONS

The following limitations should be considered regarding the floodline determinations:

- The survey information received from CoE was more than 5 years old at the time of this report. While every effort was made to predict the current topography surface as accurately as possible, designers should allow for significant error, as is the norm in hydrological calculations. This is due to a number of factors, including the accuracy of the DTM, of which 2m contour was used in this report.
- The topographical cross section through the watercourses in question was only taken at 1 in every 200m, due to the size of the catchment relative to the high-level floodline analysis;
- No river crossing bridges and culverts were modelled in this high -level floodline analysis. There for no flooding effects of localised infrastructure was taken into account;
- No flow and rainfall data against which the runoff calculation could be calibrated were available. This could leave uncertainties regarding the flow data. Therefore, the floodline was only calibrated to empirical norms and standards for runoff coefficient and standard rational method;
- The Manning's n coefficient was estimated (based on literature land use of the area); and
- Limited field verification of the floodline results was done.

It is recommended that the floodline be used as a high level analysis to predict possible problem areas. Once the problem areas are highlighted, a more detailed localised 100 year floodline analysis can be undertaken.

3 CONCEPTUAL MASTER PLAN

3.1 REHABILITATION ZONES

Due to the extensive nature of the wetland areas within the Kaalspruit catchment, a simplified approach was adopted to assess the areas within the project area. The study catchment area was subdivided into **seven Kaalspruit rehabilitation zones**. Subdivision of the study area into a number of rehabilitation zones has the following benefits:

- Sharpening the focus on the environmental problems encountered in each of the seven zones;
- Reducing the scale of the problems to be addressed, to those encountered within each zone;
- Ensuring community participation in the benefits of the rehabilitation process by addressing the rivers'/wetlands' problems within the geographic boundaries of each community; and
- Ensuring as far as reasonably possible, that each community passes on water of acceptable quality to its downstream neighbours.

The subdivision is merely based on the point of confluence of tributaries in order to ensure manageable small catchments upstream. Figure 3 indicates the proposed rehabilitation zones of the wetlands considered for further rehabilitation planning.

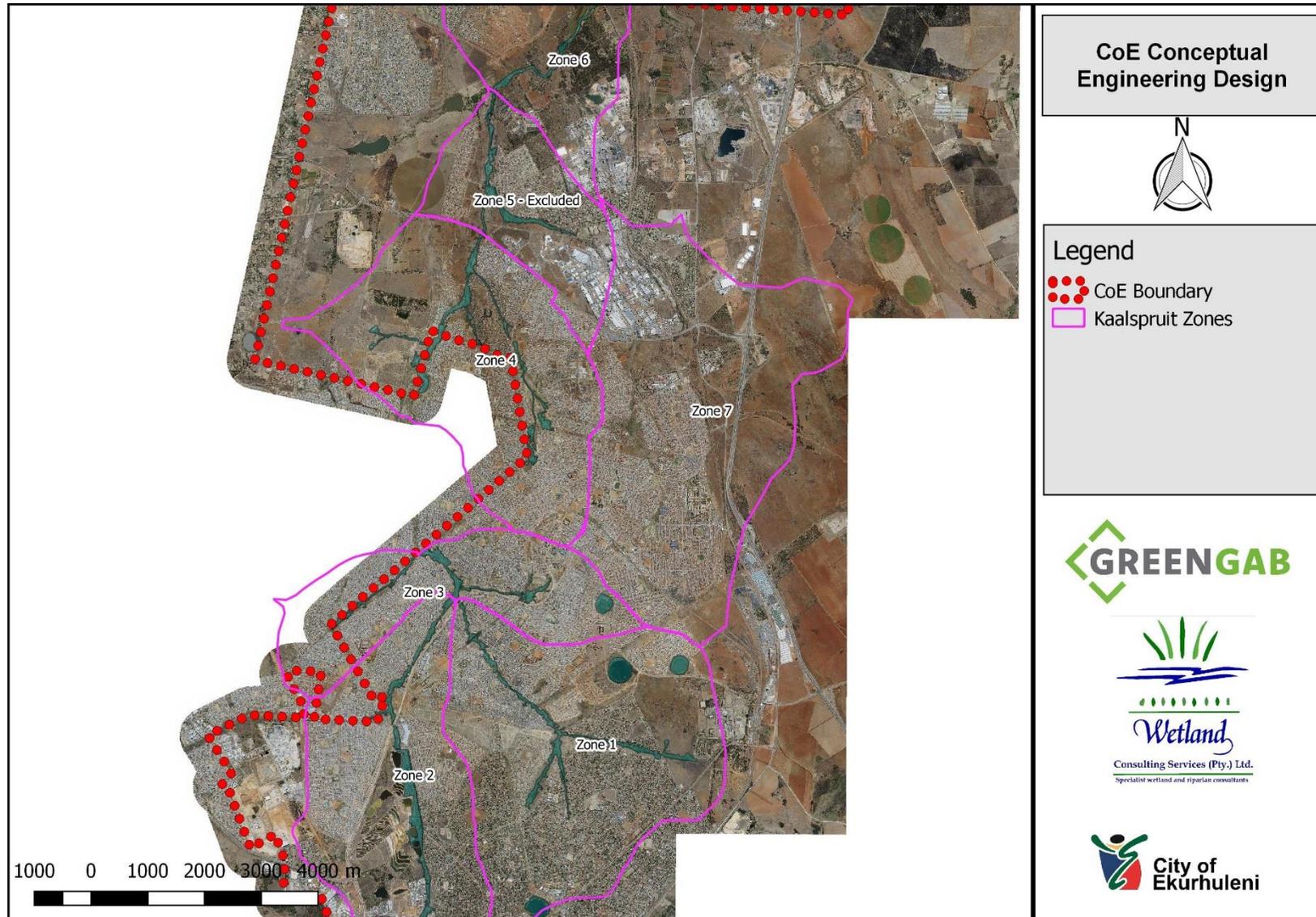


Figure 3: Kaalspruit rehabilitation zones

3.2 DEVELOPMENT OF REHABILITATION STRATEGY

The master plan rehabilitation strategy was developed in a three-phase process, including:

- Identification of the problems compromising wetland ecological integrity;
- Setting rehabilitation objectives based on an analysis of the problems and the feasible extent of addressing them to make ecological improvements; and
- Formulating solutions aimed at achieving the set objectives.

A range of problems undermining wetland ecological integrity were identified during the site visits. Addressing these impacts forms the underlying goal of the proposed master plan and wetland rehabilitation strategy. Rehabilitation inherently implies a concession that it will not be possible to reinstate all of the driving ecological processes within the wetlands, because:

- The hydrology of the catchment has been fundamentally altered; or
- The physical impact within the wetland will be too costly to reverse.

Only those processes that were realistically achievable were therefore considered and used to form the basis of the rehabilitation objectives. Under the current scenario, the goal of rehabilitating the wetlands to functional systems in some places was considered realistic.

The rehabilitation interventions are split into two categories, namely hard and soft interventions:

- Soft engineering wetland rehabilitation interventions: These relate to all ancillary measures used to improve the overall wetland condition, contributing to the success of the rehabilitation effort. Soft interventions are typically measured in terms of which are easier, quicker and less invasive to implement within the wetland system. For example, the removal of alien vegetation. As part of the soft intervention, various parks and greenspaces were also highlighted; and
- Hard engineering wetland rehabilitation interventions: These relate to specific side slope or in-stream measures that have specific functions, given their respective locations. These interventions are used to improve the overall wetland condition. Hard wetland rehabilitation interventions are typically designed to solve a specific pre-identified issue such as head-cut, erosion gully and so forth. Hard interventions typically require Water Use Licences (WUL) () and are more complex to construct. An example of this is concrete weirs.

3.3 SOFT INTERVENTIONS

Some examples of soft wetland rehabilitation interventions include, but are not limited to, the following:

(For a more comprehensive list of impacts, rehabilitation objectives and rehabilitation activities please see Wetland Consulting Services' report entitled *Situation Assessment Report*, [May 2018]):

- Small earthwork: General earthwork which can be done using a small, unskilled labour force, to reshape uneven ground to allow for a more natural ground slope;
- Small breached dam removal: Undertaken to allow more flow in the wetland's small "dam-like" structure;
- Re-vegetation of stabilised areas: Undertaken to re-instate the natural bio-diversity with appropriate wetland and riparian species;

- Fencing of sensitive areas: Done to protect the sensitive areas from unmanaged grazing;
- Pushing back of agriculture: Where possible, agriculture will be pushed out of the wetland boundary;
- Informal road removal: Undertaken to allow normal flow of water in the wetland. Informal roads crossing the wetland could be removed where possible, linking the up- and down-stream wetlands together;
- Plug and fill channels/trenches in the wetland: Done to reduce the risk of danger, as well as to allow for free movement of water through the wetland. Plugging artificial drainage channels created by development or historical agricultural practices will be undertaken;
- Removal of alien vegetation: Done to reinstate natural bio-diversity and functional vegetation communities back into the wetland system; and
- Litter clean-up: Undertaken to reduce general pollution of the wetland as well as to prevent physical blockage in culverts

3.3.1 PARKS AND GREEN SPACES

The landscape design for the parks was mainly centered around creating usable public spaces that are fit for their intended purpose, while being aesthetically appealing. The primary landscape principles of movement facilitation and place-making were used to define the layout of the parks, within which specific elements are provided to facilitate use by different people groups. In this way, the following was done:

- Access points were positioned in logical locations and walkways aligned as indicated by existing movement patterns into and through the park. This was done to ensure that these features are actively used and that ad-hoc movement via other entry points and routes do not deteriorate the park over time;
- Spaces for different intended active and passive uses were defined along the various movement routes and throughout the park using a simple combination of form-giving vertical and horizontal elements, such as trees, paving and lawn areas. These were purposefully located in different parts of the park to ensure that they are intentionally and optimally used by different people groups;
- The various spaces created within the parks are simple and versatile to be as low-maintenance as possible, and are provided with robust and durable landscape furniture, play and outdoor gym elements. In this manner, appealing places are created that each have defined uses and a distinct sense of place, while forming a contingent part of the overall park aesthetic;
- The robust layouts were also purposefully created such that further improvements and addition of other use areas can easily be accommodated in the future, without detracting from the overall character and appeal of the parks;
- Indigenous, water-wise and low-maintenance plant species are used throughout, to contribute to the ecological functionality, sustainability of appeal of the parks; and
- The various spaces and overall character of the landscape design is one of openness and accessibility, which will ensure that the parks will be safe and allow communal monitoring, while being inviting and retaining a sense of inclusion.

3.4 HARD INTERVENTIONS

Site visits were conducted by project team members to proposed rehabilitation areas, in order to provide rehabilitation objectives. Once the wetland interventions were conceptualised and their locations confirmed with the wetland specialist, the conceptual engineering design drawings of the interventions were completed. Attention was given to at least the following so that they would meet the requirements for wetland rehabilitation:

- Legislative requirements as far as engineering requirements, especially the latest Norms and Standards; and
- The practicality of design to ensure minimal wetland disturbances during construction.
- Construction materials for the proposed interventions was selected based on a range of site specific criteria, including expected velocities, availability of materials and maintenance requirements;

Hard wetland rehabilitation interventions typically include but are not limited to the following:

- Earth berms with MacMat overlay: To slow water velocity and spread flow across a larger area;
- Concrete or masonry weirs: These structures will act as settling ponds, reducing the velocity of water to allow for sedimentation above the structure. These structures will also raise the water table of the localised area and disperse the overflow water in a controlled manner to reduce erosion;
- Concrete or concrete canvas structures: To stabilise head-cut or other erosion and to prevent gullies; and
- Litter traps: to capture litter in the rivers.

3.4.1 INSTREAM STRUCTURES

For the Kaalspruit catchment, there are two types of instream interventions:

- Existing instream interventions: These are interventions already designed and constructed by other consultants; and
- Proposed interventions: These are new interventions

Figure 4 shows all of the existing and proposed interventions for the targeted wetlands in Kaalspruit Catchment.

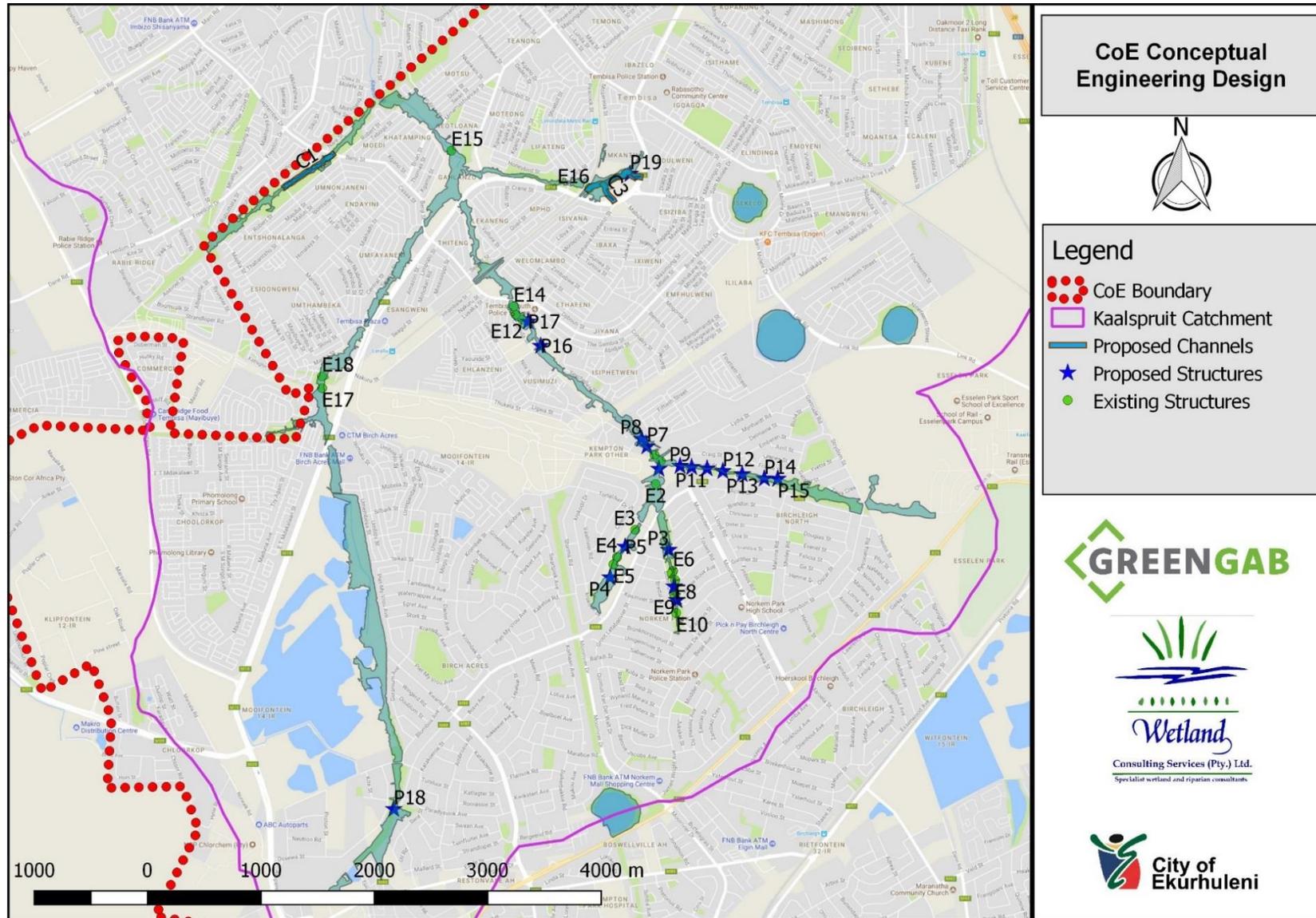


Figure 4: Existing and proposed structures in Kaalspruit catchment

3.4.1.1 EXISTING INSTREAM INTERVENTIONS

Throughout the Kaalspruit Catchment, there are various existing interventions. These interventions are in need of maintenance, to protect the current investment. Table 4 shows a list of the existing interventions within the targeted areas, as well as the condition of these interventions and the maintenance measures proposed for the interventions.

Table 4: Existing structures within the targeted wetlands area in Kaalspruit Catchment

Structure	Latitude	Longitude	Comment	Maintenance
E1	-26.037398	28.21964	Concrete weir, good condition	Extend wingwall a further 10m with reinforced concrete wall
E2	-26.039679	28.219735	Large gabion structure, good condition	Cap gabions with concrete, add right wingwall further 10m
E3	-26.043281	28.217932	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on both sides of structure
E4	-26.045433	28.216335	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on both sides of structure
E5	-26.045998	28.216012	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on both sides of structure
E6	-26.046516	28.221269	Concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure
E7	-26.046697	28.221142	Gabion stormwater channel, poor condition	Replace gabions with Armoflex channel
E8	-26.047243	28.221443	Gabion stormwater channel, poor condition	Replace gabions with Armoflex channel
E9	-26.048462	28.221418	Concrete weir, poor condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure
E10	-26.049828	28.221544	Large gabion structure with walkway, fair condition	Concrete cap gabions as well as reinforce foundations
E11	-26.037877	28.22019	Concrete weir, poor condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure
E12	-26.026751	28.207989	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E13	-26.026366	28.207391	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E14	-26.025717	28.207225	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E15	-26.013464	28.201733	Large low water crossing, fair condition	General concrete repairs
E16	-26.016409	28.213894	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on one sides of structure

E17	-26.032144	28.190333	Large concrete weir, good condition	General concrete repairs and extend wingwalls a further 2m on both sides
E18	-26.031217	28.190328	Bridge, good condition	Currently under construction 2018

3.4.1.2 PROPOSED INSTREAM INTERVENTIONS

Throughout the targeted wetland area, various hard instream interventions were conceptualised. Some examples of hard instream interventions include, but are not limited to, the following:

- Armorflex and or MacMat Channels;
- Low level berms with MacMat;
- Concrete weirs;
- Concrete weir with incorporated walkways;
- Concrete weir with box inlet;
- Concrete weir with round inlet; and
- Litter traps.

Table 5 shows a list of the proposed interventions within the targeted areas, as well as the proposed sizes of the interventions. (For more details of the interventions, consult the drawings in the appendix of this report):

- PX: Proposed structure and number;
- LX: Proposed litter trap and number; and
- CX: Proposed channel and number.

Table 5: Proposed structures within the targeted wetlands area in Kaalspruit Catchment

Structure	Latitude	Longitude	Length (m)
P1	-26.048820	28.221608	65
P2	-26.047747	28.221371	16
P3	-26.044872	28.220895	25
P4	-26.047032	28.215723	16
P5	-26.044625	28.217050	16
P6	-26.038496	28.220022	30
P7	-26.036724	28.218970	30
P8	-26.036132	28.218499	30
P9	-26.038270	28.221891	20
P10	-26.038363	28.222911	20
P11	-26.038467	28.224276	20
P12	-26.038675	28.225659	20
P13	-26.038922	28.227367	20
P14	-26.039260	28.229319	20
P15	-26.039281	28.230501	16
P16	-26.028830	28.209602	30

P17	-26.026916	28.208499	30
P18	-26.065250	28.196652	30
P19	-26.015302	28.217478	30
L1	-26.017148	28.202292	n/a
L2	-26.019288	28.199386	n/a
L3	-26.016343	28.213249	n/a
C1 start point	-26.016284	28.187074	580
C1 end point	-26.013745	28.191269	
C2 start point	-26.015526	28.218400	600
C2 end point	-26.016538	28.213775	
C3 start point	-26.017358	28.216008	200
C3 end point	-26.016113	28.215095	

Armorflex and or MacMat

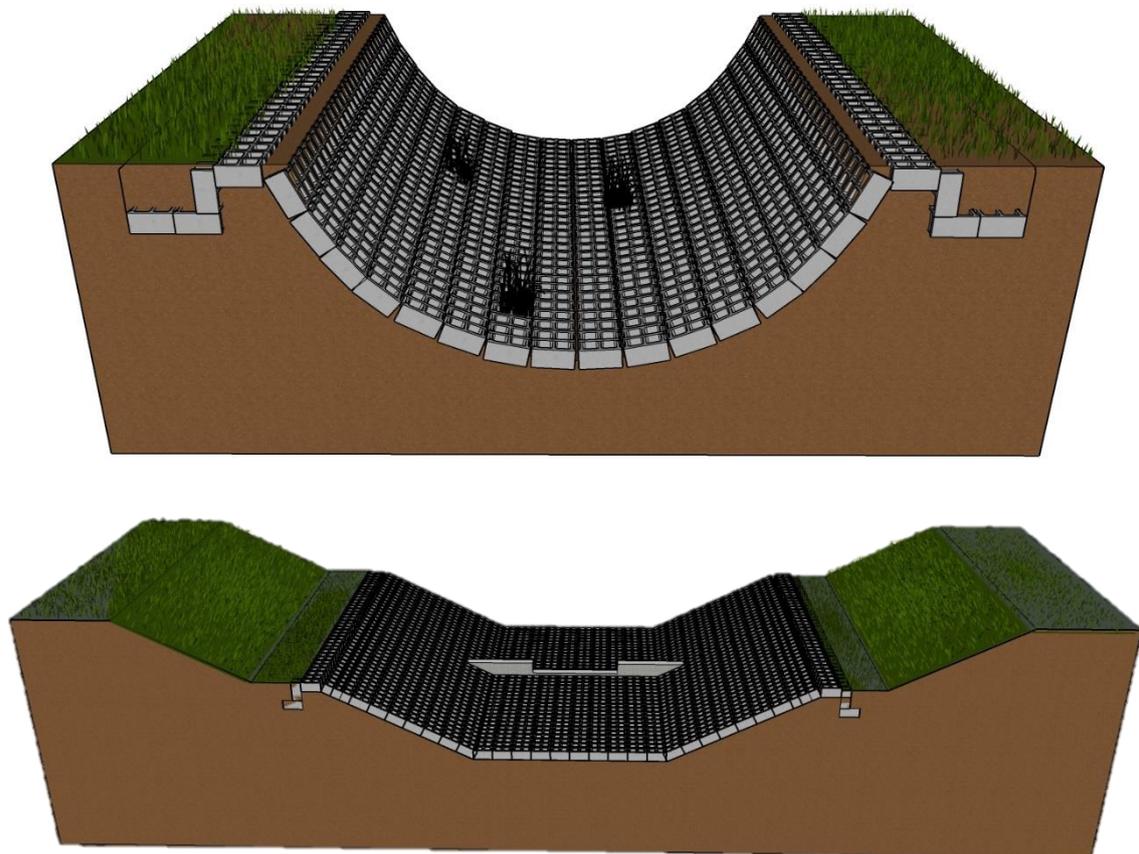


Figure 5: Armorflex and or MacMat Channels

Armorflex and or MacMat channels are proposed in areas where stormwater channels have high velocities and current channels are severely incised. Armorflex allows for larger velocities than MacMat, however MacMat allows for better vegetational growth within the channel; therefore, careful consideration should be given in the detailed design, to the final material used. Both materials should be anchored in trenches within the cement stabilised soil. In areas with extremely high velocities, small low-level weirs could be constructed in cooperation with Armorflex or MacMat, to slow down water velocity at various stages within the channel.

The main purpose of this intervention is to slow down water velocity and prevent further gully erosion.

Low level berms with MacMat

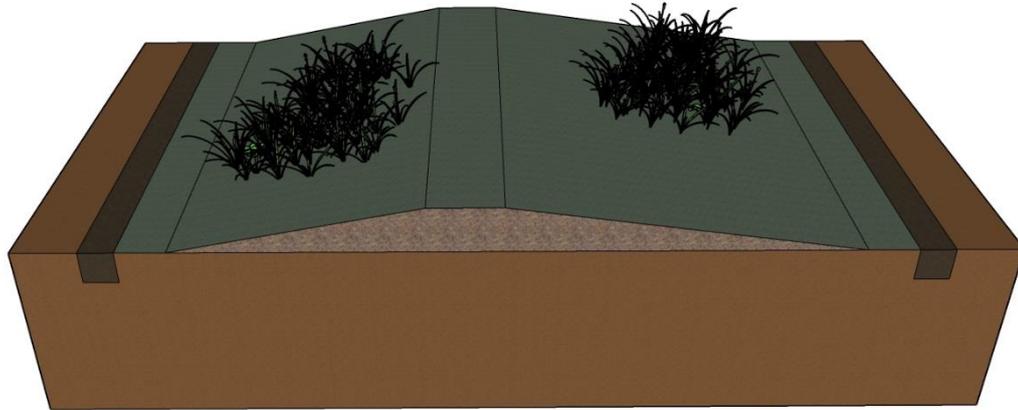


Figure 6: Low-level berm with MacMat

Low level berms with MacMat are proposed in areas where the wetland is not severely incised. These berms are typically only 0.5m in height. The side slope is 1:5 in the upstream and the side slope is 1:7 in the downstream. Typically, these berms have a lower spillway zone which is protected with rock. Large flows move over the top of the berms. MacMat should be anchored in trenches, within cement stabilised soil, on either side of the berm.

The main purpose of this intervention is to slow down water velocity and gather a small amount of water, to allow for wetland vegetation to establish around the berm.

Concrete weirs

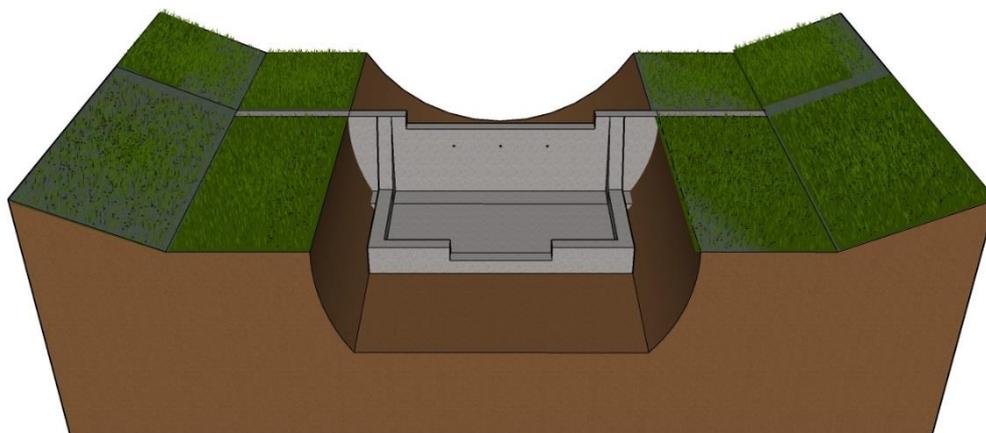


Figure 7: Concrete Weirs

The concrete weirs are proposed in the incised valley bottom wetlands. These weirs will raise the water table yet allow sufficient water to move through the weir to avoid cutting off the water source completely. The concrete weir structure allows energy dissipation in the plunge pool; thereafter it spills over back into the valley bottom wetland. This in turn slows water velocity in the valley bottom.

All concrete weirs are designed with a footing, as well as long wingwalls, to ensure that no cutting occurs around the interventions. The soil around the wingwalls should be cement stabilised and compacted to the engineering specifications.

Concrete weirs with incorporated walkways

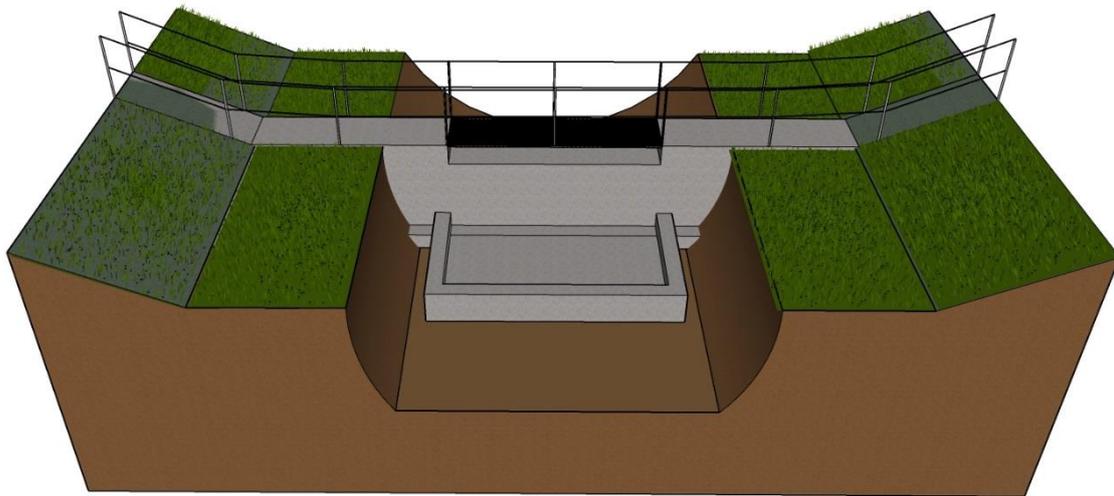


Figure 8: Concrete weir with walkway

Just as with the normal weirs, the concrete weirs with incorporated walkways are proposed in the incised valley bottom wetlands. These weirs will raise the water table yet allow sufficient water to move through the weir to avoid cutting off the water source completely. The concrete weir structure allows energy dissipation in the plunge pool; thereafter it spills over back into the valley bottom wetland. This in turn slows water velocity in the valley bottom.

All concrete weirs are designed with a footing, as well as long wingwalls, to ensure that no cutting occurs around the interventions. The soil around the wingwalls should be cement stabilised and compacted to the engineering specifications.

The weirs also have an increase top width to allow for pedestrian walkway. This walkway has hand rails on either side. This allows easy crossing of the stream during low-flow periods. Signage should be installed to warn people that in high-flow periods, water will move over the weir and crossing is not prohibited.

Concrete weir box and or Round inlets

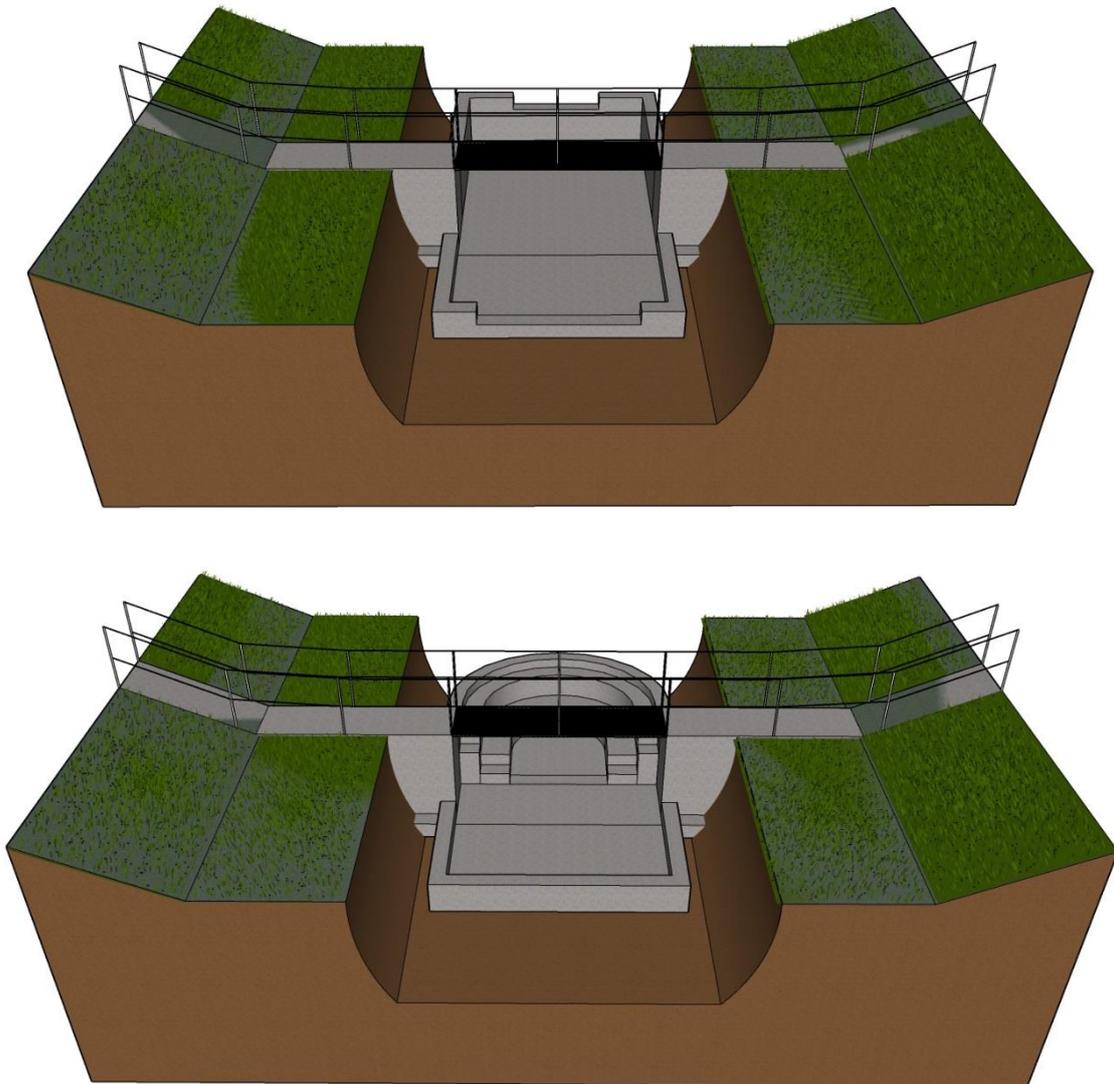


Figure 9: Concrete weir box and or round-inlet

The concrete weirs with box- and/ or round-inlets, are proposed in the incised valley bottom wetlands, just like the normal weir. These weirs will raise the water table while allowing sufficient amounts of water to move through the weir so as not to cut off the water source completely. The concrete weir structure allows energy dissipation in the plunge pool; thereafter it spills over back into the valley bottom wetland. This in turn slows water velocity in the valley bottom.

All concrete weirs are designed with a footing, as well as long wingwalls, to ensure that no cutting occurs around the interventions. The soil around the wingwalls should be cement stabilised and compacted to the engineering specifications.

The weirs also have an increased top width to allow for pedestrian walkway. This walkway has hand rails on either side. This allows for easy crossing of the stream during low-flow periods. Signage should be installed to warn people that in high-flow periods, water will move over the weir and crossing is not prohibited.

The box- and/ or round- inlets are for areas with increased flow, where the standard spillway length is insufficient to pass the volume of water.

Litter traps

Litter traps are proposed at various points in the target wetlands. The proposed litter traps are special nets, called “StormX nets,” which are fitted to pipe or normal culverts. These nets will need to be cleaned periodically for them to function optimally. These nets have been chosen as they can be retro-fitted to existing infrastructure; this is important, as most of the areas proposed are extremely built-up and more formal litter traps will not have enough space. Figure 10 shows the placement of three litter traps. It is important to note that this will only remove litter up to a certain size; smaller particles will move through the nets.

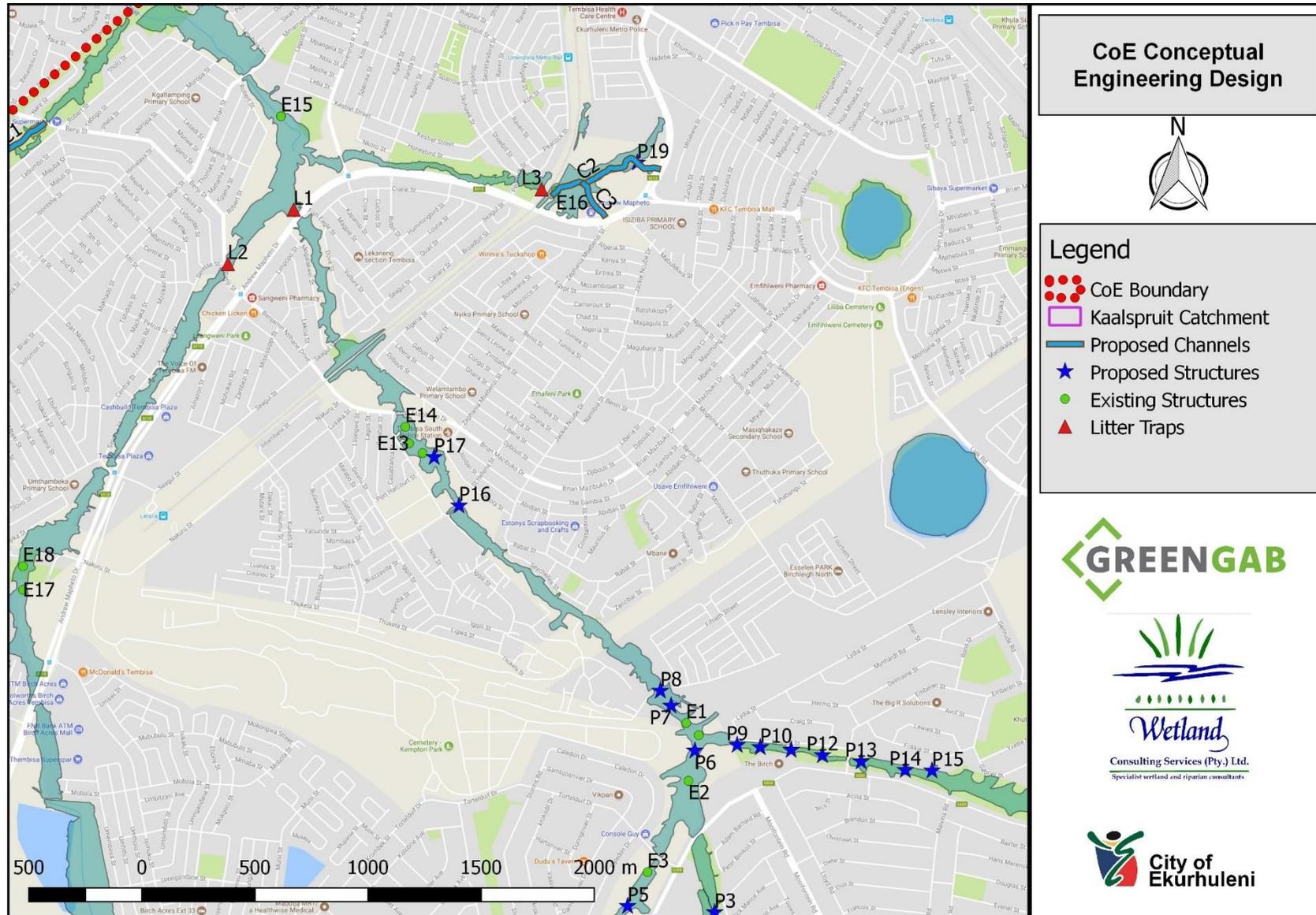


Figure 10: Kaalspruit litter traps

4 RISK ASSESSMENT

As part of the planning regime for wetland rehabilitation to be implemented within the Kaalspruit catchment, it was considered necessary to undertake a Water Use License (WUL) risk assessment for the broad rehabilitation and other activities proposed within the wetland boundaries and/or within the regulated area (within 500 metres of a wetland boundary), to determine the appropriate authorisation process requirements for different activities.

The purpose is to provide a summary of the risk assessment of activities located within 500m of the wetland boundaries, or within the wetlands themselves, and to assess the risk posed by the proposed activities on the identified wetlands in terms of Section 21 (c) and (i) water uses. A number of the proposed activities are located within the delineated wetland boundaries, while others are located outside the delineated wetlands but within the 500m regulated area surrounding the wetland.

WCS has undertaken delineation and assessment (PES and IS) of the wetlands within the Kaalspruit catchment as part of the larger rehabilitation planning project for CoE. The baseline information from the Kaalspruit catchment wetland assessment and management report has been used for this risk assessment (WCS and GreenGab, 2018).

4.1 APPROACH

A risk assessment was undertaken using the spreadsheet developed as part of the amendment GA for section 21 (c) and (i) water uses which was published in the Government Gazette (No 40229 Pg 105 Notice 509) on 26 August 2016 to invite public comment. This methodology has now been formally adopted by the authorities (DWS) and provides a useful outline for assessing the risk to water resources in terms of Section 21 (c) and (i) water uses. The rating scale for this risk assessment is provided in Table 6. A low risk class must be obtained for all activities to be considered for a GA.

Table 6. Risk rating scale utilised (as per amendment GA for section 21 (c) and (i) water uses which was published in the Government Gazette (No 40229 Pg 105 Notice 509) on 26 August 2017).

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands may be excluded.
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Wetlands are excluded.
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.

4.2 FINDINGS

4.2.1 PROPOSED ACTIVITIES

As part of the proposed wetland rehabilitation, a number of rehabilitation activities have been proposed to address identified impacts and integrate the wetlands into improved public open spaces and parks that encourage better utilisation of the wetlands and adjacent open spaces. A number of wetland systems have been prioritised for rehabilitation and, depending on the nature of the impacts, one or more of a number of typical rehabilitation activities or interventions have been proposed. This section details the types of activities and interventions that are likely to be implemented, though it must be noted that not all activities/interventions detailed below will necessarily be implemented in every target wetland system. The activities that need to be assessed and which are associated with the proposed wetland rehabilitation and integration into improved public open spaces can be summarised as follows:

1. Activities/Interventions within Wetland Habitat

- a. Repair of existing instream rehabilitation structures (gabion and concrete structures) to improve performances (Extending key walls to prevent erosion around structures and/or cement capping existing gabion structures to address rusting and uneven gabion levels)
- b. Construction of new instream structural interventions (gabions or concrete structures) to stabilise channel erosion
- c. Alien vegetation clearing and management
- d. Removal of litter, rubble and infill
- e. Landscaping and revegetation of bare or disturbed areas
- f. Installation of bricked walkways

2. Activities/Interventions outside of but within 500m of Wetland Habitat

- a. Alien vegetation clearing and management
- b. Removal of litter, rubble and infill
- c. Landscaping and revegetation of bare or disturbed areas
- d. Installation of litter collection facilities (refuse bins)
- e. Establishment of communal subsidence agricultural plots
- f. Establishment of grassed sports fields
- g. Installation of play and outdoor gym facilities and/or braai facilities, table and benches
- h. Installation of bricked walkways

A number of the activities listed above are purely for rehabilitation purposes, namely, improving overall wetland integrity by addressing identified impacts or problems, such as the presence of alien, invasive vegetation, dumped infill, rubble and litter and disturbed or cleared areas within or adjacent to the wetlands, channel and bank erosion, and poorly performing or deteriorating existing rehabilitation structures. Other proposed activities are primarily aimed at encouraging low impact utilisation of the wetlands and adjacent open spaces by the local communities through the establishment of park and recreational areas. This includes the installation of park facilities, such as braai facilities, tables and benches, refuse bins, outdoor gym and children's play areas and equipment, installation of bricked walkways for pedestrian traffic through the parks, and establishment of sports fields (outside of wetland habitat only). In addition, current impacts, such as use of wetland habitat for subsidence farming will be addressed by established demarcated communal subsidence agricultural plots outside of the wetland habitat only, thus allowing the local community to continue subsidence farming activities on which they depend, while also reducing the future impact to wetland habitat.

4.3 IMPACT IDENTIFICATION

All of the activities and interventions listed above have the potential to impact the wetlands within which or adjacent to which they are proposed. In terms of Section 21 (c)¹ and (i)² water uses, it is therefore clear that the activities proposed within the delineated wetland habitat could lead to:

- Temporary impedance of flow in a watercourse;
- Temporary diversion of flow in a watercourse; and/or
- Alteration of the bed, banks, course and characteristics of the watercourses.

It will also be important to determine if activities proposed within the 500m regulated area around the wetlands (but outside of the wetland boundaries) could lead to a change in the characteristics of the wetlands and a degradation of the resources quality.

In order to determine possible impacts to the characteristics of the wetlands, the impact of the proposed activities on the drivers (and responders) of the adjacent wetland habitats need to be considered. Where the proposed activities alter wetland drivers, it can be assumed that the wetland habitat will respond to such changes, possibly leading to a deterioration of wetland health and functionality. For the purpose of this assessment, the categories as considered in WET-Health have been utilised.

4.3.1 ACTIVITIES OUTSIDE OF WETLAND BOUNDARIES BUT WITHIN 500M OF WETLAND HABITAT

Hydrology

The primary negative impacts to wetland hydrology that may result from the proposed activities are associated with construction activities, which may lead to the compaction of soils and the formation of preferential flow pathways, thus decreasing infiltration in favour of surface runoff and encouraging concentrated rather than diffuse flows. **The biggest risk is posed by ruts caused from vehicle access to the construction areas.** Such ruts could lead to the formation of preferential flow paths that concentrate flow and increase flow velocities, leading to channel incision along the ruts. **Implementation of mitigation measures and post construction rehabilitation measures will be important to address this risk.**

Another potentially negative impact to wetland hydrology may occur as a result of irrigation of grassed sports fields and communal subsidence agricultural plots, which could increase flow volumes and velocities into the downslope wetlands leading to increased erosion risk and an altered saturation regime within adjacent wetland habitat. In order to limit these impacts it is important that appropriate mitigation measures be put in place, such as the inclusion of contour berms in agricultural plots to slow flows and limit the erosion risk, and reducing the water volumes required for irrigation by using plant species with low water requirements and irrigating at night or during the cooler parts of the day.

Aside from the potential negative impacts addressed above, several of the rehabilitation activities are expected to have a positive impact on wetland hydrology. Removal of alien vegetation, particularly stands of Eucalyptus and Black Wattle trees (species with high water demands), will

¹ (c) impeding or diverting the flow of water in a watercourse;

² (i) altering the bed, banks, course or characteristics of a watercourse;

increase flow to the wetlands and increase levels of saturation. Removal of infill and rubble will remove impediments to flow and encourage more diffuse surface flow into the wetlands downslope.

Geomorphology

Outside of the delineated wetland habitat, the required construction activities will have no impact on the wetland topography or on the passage of sediments through the wetland. Disturbance of construction areas could theoretically expose bare soils to erosion and increase sediment inputs to the wetlands. However, in most cases the grassland vegetation between the construction footprints and the wetland habitats will act as a sediment trap, trapping sediments prior to flows entering the wetlands. However, additional mitigation measures are proposed in Section 4.4 to further reduce the likelihood of any impacts.

Aside from the potential negative impacts addressed above, certain rehabilitation activities are expected to have a positive impact on geomorphology. For example, landscaping and revegetation of bare or disturbed areas will reduce the likelihood of flow concentration and limit the risk of erosion and sediment mobilisation into downslope wetlands.

Water Quality

Construction activities could lead to an impact on water quality through leaks and spillages from machinery and materials used on site entering wetlands. Leaks and spills are likely to be limited to small hydrocarbon spills. This impact is only expected to occur where construction occurs within or in very close proximity to wetlands.

The application of herbicides during the clearing of alien vegetation, the installation of bricked walkways and within the agricultural plots could have a negative impact on water quality if such chemicals are washed into the downslope wetlands.

In order to address this impact, mitigation measures are proposed in Section 4.4 to prevent and minimise any impacts to water quality.

Vegetation

Where the proposed activities are located outside the delineated wetland edge, no direct impacts to the wetland vegetation are expected.

4.3.2 ACTIVITIES WITHIN WETLAND HABITAT

Hydrology

The primary negative impacts to wetland hydrology that may result from the proposed activities are associated with construction activities, particularly of instream rehabilitation structures which may require the diversion or impoundment of instream flows. All construction of instream structures will be undertaken towards the end of the dry season to limit the necessity for flow diversion or impoundment.

In addition, general construction activities may lead to the compaction of soils and the formation of preferential flow pathways, thus decreasing infiltration in favour of surface runoff and encouraging concentrated rather than diffuse flows. The biggest risk is posed by ruts caused from vehicle access to the construction areas. Such ruts could lead to the formation of preferential flow paths that concentrate flow and increase flow velocities, leading to channel incision along the ruts.

Implementation of mitigation measures and post construction rehabilitation measures will be important to address this risk.

Aside from the potential negative impacts addressed above, several of the rehabilitation activities are expected to have a positive impact on wetland hydrology. Repairing of existing instream structures and placement of additional structures where necessary will address ongoing channel erosion and improve flows through the wetlands. Removal of alien vegetation, particularly stands of Eucalyptus and Black Wattle trees (species with high water demands), will increase flows within the wetlands and increase levels of saturation. Removal of infill and rubble will remove impediments to flow and encourage more diffuse surface flow within the wetlands.

Geomorphology

Construction activities may have an impact on the wetland topography and on the passage of sediments through the wetland. Disturbance associated with construction activities will expose bare soils to erosion and increase sediment inputs to the wetlands, while excavations and top soil stockpiles that remain in place could lead to the impoundment and diversion of flows respectively.

Implementation of mitigation measures and post construction rehabilitation measures will be important to address this risk, especially within the permanently saturated area of the wetlands.

Water Quality

Construction activities could lead to an impact on water quality through leaks and spillages from machinery and materials used on site entering the wetlands. Leaks and spills are likely to be limited to small hydrocarbon spills. This impact is only expected to occur where construction occurs within or in very close proximity to wetlands.

The application of herbicides during the clearing of alien vegetation and the installation of bricked walkways could have a negative impact on water quality if such chemicals are washed into the wetlands.

In order to address this impact, mitigation measures are proposed in Section 4.4 to prevent and minimise any impacts to water quality.

Vegetation

Where construction activities are located within the delineated wetland habitat, vegetation disturbance is likely to occur as a result of machinery driving into the wetlands and within the actual footprints of infrastructure (gym and play equipment, bricked walkways). The disturbance is likely to be temporary in nature outside of installed infrastructure footprints but could lead to the establishment of pioneer and/or invasive species within the wetland, including alien species. Where activities lead to erosion, more long-term impacts to vegetation could be expected.

Aside from the potential negative impacts addressed above, certain rehabilitation activities are expected to have a positive impact on vegetation. For example, landscaping and revegetation of bare or disturbed areas and removal of alien vegetation will reduce the likelihood of flow concentration and limit the risk of erosion and sediment mobilisation within the wetlands and will improve the vegetation community composition and diversity in favour of indigenous species.

4.4 MITIGATION MEASURES

The following mitigation measures are recommended to reduce the impact of the proposed activities on wetlands:

- Undertake initial clearing of vegetation during dry season.
- Vegetation clearing should be limited to the actual construction footprint. Prior to the commencement of any construction, the required disturbance footprint should be demarcated and all activities should be located within the demarcated area. No vegetation disturbance, clearing or excavation to take place outside the demarcated area.
- No heavy vehicles should be permitted in wetland habitat, unless absolutely necessary and existing access routes and disturbed areas should be utilised as far as possible to access intervention locations. Where no existing tracks are available, a single access track to each intervention location should be used.
- Access tracks through wetland areas should ideally run parallel to the contour to limit the formation of preferential flow paths that could lead to erosion. Accessing intervention locations along tracks perpendicular to the contour should be avoided.
- Surface runoff along the access tracks should not lead to erosion. Where ruts have formed and remain following completion of construction activities, these should be plugged with regular shallow soil berms to prevent a preferential flow paths forming along the vehicle ruts. All vehicle ruts must be rehabilitated following completion of activity.
- Apply best practice management to storage of materials and preparation and pouring of concrete, i.e.: remain outside of wetland habitat, do not store or mix cement and concrete (or other materials) directly on the ground, store and prepare on liner on a bunded area, dispose of all visible remains of excess cement and concrete after the completion of tasks, dispose of in the approved manner (solid waste concrete may be treated as inert construction rubble, but wet cement and liquid slurry, as well as cement powder must be treated as hazardous waste).
- No servicing or cleaning of vehicles/machinery to take on site.
- No storage of fuel and diesel on site.
- On completion of construction the site should be left clean and free from all debris, hydrocarbons and waste, and all excavations filled appropriately and as soon as possible.
- Undertake construction or repair associated with instream rehabilitation structures towards the end of the dry season when flows are low – it may then not be necessary to divert flows, and temporary impoundment may be sufficient.
- Apply best practice to the diversion/impoundment of flows and the rehabilitation of disturbed wetland areas.
- Minimise construction period to limit opportunity for erosion and mobilisation of sediment
- Agricultural plots to be limited to designated areas outside of wetland habitat only.
- Implementation of soil management measures within communal subsidence agricultural plots, i.e.: contour berms to prevent sediment mobilisation into adjacent wetland habitat.
- All alien vegetation clearing should be undertaken according to WfWetlands alien vegetation management protocols.

- Only manual removal of alien vegetation should be permitted and should be limited to use of hand tool.
- To ensure areas cleared of alien vegetation and areas that have been disturbed or revegetated remain free of alien and weed vegetation, ongoing management of alien vegetation should be implemented.
- Only approved, low impact herbicides to be used for initial clearing of vegetation, along bricked walkways and during ongoing alien vegetation management. the use of broad spectrum herbicides should be avoided, application should be limited to target individuals rather than being applied to a general area, and application should be avoided during periods of high rainfall when herbicides may be washed into downstream water resources. Working for Wetlands should be consulted for further information on the most appropriate products.
- All disturbance footprints should be rehabilitated, including ploughing/ripping (in instances where the soils have become compacted), landscaping to the natural landscape profile, application of topsoil if necessary, and revegetation with appropriate, indigenous plant species.
- Wherever possible, as part of either revegetation activities or for use as grass cover on the sports fields, indigenous grass species with low watering requirements, should be used.
- Limit irrigation volumes required on sports fields by timing irrigation during cooler hours/overnight.
- All refuse bins installed should be regularly emptied and waste removed to appropriate refuse disposal sites.

5 GN 509 RISK ASSESSMENT

A water use risk assessment as per the methodology detailed in GN509 of 2016 was applied to the proposed activities. For the risk assessment the activities were grouped as follows:

- Activities located within delineated wetland habitat; and
- Activities located within 500m of delineated wetland habitat

The location of some of the activities within wetland habitat has a significant bearing on the outcome of the water use risk assessment, as the methodology of the risk assessment prescribes the highest severity rating for activities located within wetland habitat.

The risk assessment was undertaken by Shavaughn Davis, SACNASP Pr. Sci. Nat. Registration 115025.

The risk assessment results are summarised in Table 7 below. The full risk assessment results are provided at the end of this section.

Table 7: Summarised results of the risk assessment for the proposed activities.

No.	Activity	Significance	Risk Rating
ACTIVITES WITHIN WETLAND HABITAT			
1	Alien Vegetation Clearing & Management	120	M
2	Removal of Litter, Rubble, Infill	70	M

No.	Activity	Significance	Risk Rating
3	Landscaping and Revegetation of Bare or Disturbed Areas	70	M
4	Repair of Existing Instream Rehabilitation Structures (gabion and concrete structures) to Improve Performances (Extending key walls to prevent erosion around structures and/or cement capping existing gabion structures to address rusting and uneven gabion levels)	108	M
5	Construction of New Instream Structural Interventions (gabions or concrete structures) to Stabilise Channel Erosion	108	M
6	Installation of Bricked Walkways	108	M
ACTIVITIES WITHIN THE REGULATED AREA (500M OF WETLAND HABITAT) BUT OUTSIDE OF WETLAND BOUNDARY			
1	Alien Vegetation Clearing & Management	68.75	M
2	Removal of Litter, Rubble, Infill	32.5	L
3	Landscaping and Revegetation of Bare or Disturbed Areas	30	L
4	Installation of Litter Collection Facilities (Refuse Bins)	24	L
5	Establishment of Communal Subsidence Agricultural Plots	112	M
6	Establishment of Grassed Sports Fields	59.5	M
7	Installation of Play and Outdoor Gym Facilities and/or Braai facilities, Table and Benches	40	L
8	Installation of Bricked Walkways	66	M

It should be noted that GN 509 allows for borderline Low/Moderate rating classes to be considered for authorisation under a GA where the significance score is less or equal to 80 (a maximum of 25 points more than a Low Risk Rating of 55).

From the results of the water use risk assessment it is evident that certain activities should be considered for authorisation under a General Authorisation either because they represent a **Low Risk** (activities highlighted in **GREEN** in Table 7) or because they are borderline **Low/Moderate Risk** with a significance score of 80 or less (activities highlighted **YELLOW** in Table 7). Activities with significance scores of over 80 (activities highlighted in **ORANGE** in Table 7) potentially pose a **Moderate Risk** and are likely to require authorisation via the Water Use Licence process unless the rehabilitation purpose of certain activities is taken into account in potentially adjusting the severity scores. It is recommended that in such instances, further guidance should be sought from DWS to establish whether the severity scoring currently applied to certain rehabilitation activities could be adjusted downwards, particularly for activities considered within wetland habitat

For those activities that received a borderline Low/Moderate Risk score it is recommended that authorisation for these activities be considered under a GA for the following reasons:

- The overall purpose of activities such as alien vegetation clearing, removal of litter, rubble and infill and landscaping and revegetation of bare or disturbed areas is to contribute towards rehabilitation of currently disturbed wetland habitat. Therefore, although there is a low to moderate risk of negative impact to the wetlands over the short term, primarily during the construction phase, the impact to the wetlands in the long term will be positive and is expected to contribute towards an improvement in the overall integrity of the wetlands.
- In the case of activities proposed within the regulated area, such as the establishment of grassed sports fields, installation of bricked walkways and alien vegetation clearing,

additional mitigation measures are suggested to address those activity aspects that have contributed to raising the overall risk of these activities, as follows and as applicable:

- Use of herbicides increases risk as if it is released into the water resource it can impact over a larger special scale and it may be harder to detect any impact caused. Therefore, for activities where the use of herbicides may be required to manage alien or weed vegetation, it is recommended that only relatively low impact herbicides be used, i.e.: the use of broad spectrum herbicides should be avoided, application should be limited to target individuals rather than being applied to a general area, and application should be avoided during periods of high rainfall when herbicides may be washed into downstream water resources. Working for Wetlands should be consulted for further information on the most appropriate products.
- Ongoing irrigation of grassed sports fields into the operational phase increases risk as there is a greater potential for such additional flows to lead to erosion and sedimentation downslope and increased flows to the wetlands could alter the flow characteristics into downslope wetlands. Therefore, it is recommended that indigenous grass species with low watering requirements be used on the sports fields to limit the need for irrigation and any irrigation that is required should be undertaken during cooler periods of the day or preferably at night to limit evaporation and thus limit the water volumes required.
- Full implementation of the proposed mitigation measures should limit impact to Low significance.

ACTIVITIES WITHIN WETLAND HABITAT																						
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control Measures	PES and IS of Watercourse
1	Full Lifecycle	Alien Vegetation Clearing & Management	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Accessing alien vegetation (foot traffic) Manual clearing (felling or pulling) of alien vegetation Removal of cut plant material Application of herbicides <p>OPERATION</p> <ul style="list-style-type: none"> Pulling of emerging juveniles as needed Application of herbicides as needed 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments Water quality deterioration (spillages and leaks from machinery and equipment) Water quality deterioration (Herbicides) <p>POSITIVE</p> <ul style="list-style-type: none"> Improved flow into wetlands Improvement in habitat quality 	5	5	5	5	5	3	2	10	1	3	5	3	12	120	M	Moderate	<ul style="list-style-type: none"> All clearing according to WfWetlands alien vegetation management protocols Only manual removal of vegetation (limited to use of hand tools) Only approved, low impact herbicides to be used No heavy vehicles in wetland habitat. Existing access routes to be used as far as possible 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
2		Removal of Litter, Rubble, Infill	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Vehicle (TLB and/or Truck) access to and from Litter/Rubble/Infill Earthworks (TLB removal of material) <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Creation of preferential flow paths in vehicle ruts Exposure of bare soils to increased risk of erosion Mobilisation of sediments Flow concentration Water quality deterioration (spillages and leaks from machinery and equipment) <p>POSITIVE</p> <ul style="list-style-type: none"> Possible water quality improvement after removal of litter/waste Improved surface runoff characteristics 	5	5	5	5	5	1	1	7	1	3	5	1	10	70	M	Moderate	<ul style="list-style-type: none"> Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Rehabilitate (landscape & revegetate) disturbance footprint 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
3		Landscaping and Revegetation of Bare or Disturbed Areas	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Vehicle access to and from disturbed areas Earthworks (scarifying/ploughing, levelling soil surface) Application of top soil (if necessary) Placement of grass sods or seeding (manual or hydro-seeding) Irrigation of revegetated areas (if necessary) <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Creation of preferential flow paths in vehicle ruts Exposure of bare soils to increased risk of erosion Mobilisation of sediments Flow concentration Water quality deterioration (spillages and leaks from machinery and equipment) <p>POSITIVE</p> <ul style="list-style-type: none"> Improved surface runoff characteristics Improved vegetation composition and cover 	5	5	5	5	5	1	1	7	1	3	5	1	10	70	M	Moderate	<ul style="list-style-type: none"> Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Management of alien vegetation 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
4		Repair of Existing Instream Rehabilitation Structures (gabion and concrete structures) to Improve Performances (Extending key walls to prevent erosion around structures and/or cement capping existing gabion structures to address rusting and uneven gabion levels)	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Earthworks – excavation of diversion channel and/or key walls Prepare (level and compact) subsoil to receive structures (extended key walls, etc.) Placement of gabion structure and/or cement capping of existing gabion structures Earthworks – backfilling of diversion channel and/or key wall excavations Landscaping disturbance footprint – level and shape Revegetate disturbed area <p>OPERATION</p> <ul style="list-style-type: none"> Structure maintenance 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to wetland vegetation Exposure of bare soils to increased risk of erosion Mobilisation of sediments Temporary diversion or impoundment of flow Water quality deterioration (spillages and leaks from machinery and equipment) Water quality deterioration (Concrete/cement) Creation of preferential flow paths in vehicle ruts <p>POSITIVE</p> <ul style="list-style-type: none"> Improved operation of structure resulting in improved flow within wetland Decreased risk of erosion around structure 	5	5	5	5	5	2	2	9	1	5	5	1	12	108	M	Moderate	<ul style="list-style-type: none"> Apply best practice management to storage of materials and preparation and pouring of cement/concrete Apply best practice to the diversion of flows and the rehabilitation of disturbed wetland areas Undertake construction towards the end of the dry season when flows are low – it may then not be necessary to divert flows, and temporary impoundment may be sufficient Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Rehabilitate (landscape & revegetate) disturbance footprint 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate

ACTIVITES WITHIN WETLAND HABITAT																						
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control Measures	PES and IS of Watercourse
5		Construction of New Instream Structural Interventions (gabions or concrete structures) to Stabilise Channel Erosion	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Earthworks – excavation of diversion channel Prepare (level and compact) subsoil to receive structures Placement of gabion/concrete structure Earthworks – backfilling of diversion channel and around structures Landscaping disturbance footprint – level and shape Revegetate disturbed area <p>OPERATION</p> <ul style="list-style-type: none"> Structure maintenance 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to wetland vegetation Exposure of bare soils to increased risk of erosion Mobilisation of sediments Temporary diversion or impoundment of flow Water quality deterioration (spillages and leaks from machinery and equipment) Water quality deterioration (Concrete/cement) Creation of preferential flow paths in vehicle ruts <p>POSITIVE</p> <ul style="list-style-type: none"> Improved flow within the wetland Stabilisation of bank erosion Decreased risk of erosion 	5	5	5	5	5	2	2	9	1	5	5	1	12	108	M	Moderate	<ul style="list-style-type: none"> Apply best practice management to storage of materials and preparation and pouring of cement/concrete Apply best practice to the diversion of flows and the rehabilitation of disturbed wetland areas Undertake construction towards the end of the dry season when flows are low – it may then not be necessary to divert flows, and temporary impoundment may be sufficient Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Rehabilitate (landscape & revegetate) disturbance footprint 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
6		Installation of Bricked Walkways	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Earthworks (Digging foundation) Prepare (level and compact) subsoil Placement of interlocking concrete pavers placed on PVC and 50 mm rolled sand base Application of weed killer (herbicide) as needed <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Exposure of bare soils to increased risk of erosion Mobilisation of sediments Altered flow characteristics due to soil compaction and placement of sand/PVC/concrete pavers Water quality deterioration (herbicide) 	5	5	5	5	5	3	1	9	1	3	5	3	12	108	M	Moderate	<ul style="list-style-type: none"> Limit vegetation clearing and earthworks to actual footprint Minimise construction period to limit opportunity for erosion and mobilisation of sediment Apply best practice management to storage of materials, i.e.: remain outside of wetland habitat, do not store materials directly on the ground, store and prepare on liner on in bunded area, dispose of all visible remains of excess materials after the completion of tasks, dispose of in the approved manner Only approved, low impact herbicides to be used 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate

ACTIVITIES WITHIN THE REGULATED AREA (500M OF WETLAND HABITAT) BUT OUTSIDE OF WETLAND BOUNDARY

No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control Measures	PES and IS of Watercourse
1	Full Lifecycle	Alien Vegetation Clearing & Management	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Accessing alien vegetation (foot traffic) Manual clearing (felling or pulling) of alien vegetation Removal of cut plant material Application of herbicides <p>OPERATION</p> <ul style="list-style-type: none"> Pulling of emerging juveniles as needed Application of herbicides as needed 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments Water quality deterioration (spillages and leaks from machinery and equipment) Water quality deterioration (Herbicides) <p>POSITIVE</p> <ul style="list-style-type: none"> Improved flow into wetlands Improvement in habitat quality 	1	2	1	1	1.25	3	2	6.25	1	2	5	3	11	68.75	M	Moderate	<ul style="list-style-type: none"> All clearing according to WfWetlands alien vegetation management protocols Only manual removal of vegetation (limited to use of hand tools) Only approved, low impact herbicides to be used No heavy vehicles in wetland habitat. Existing access routes to be used as far as possible 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
2		Removal of Litter, Rubble, Infill	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Vehicle (TLB and/or Truck) access to and from Litter/Rubble/Infill Earthworks (TLB removal of material) <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Creation of preferential flow paths in vehicle ruts Exposure of bare soils to increased risk of erosion Mobilisation of sediments Flow concentration Water quality deterioration (spillages and leaks from machinery and equipment) <p>POSITIVE</p> <ul style="list-style-type: none"> Possible water quality improvement after removal of litter/waste Improved surface runoff characteristics 	1	2	1	1	1.25	1	1	3.25	1	2	5	2	10	32.5	L	Moderate	<ul style="list-style-type: none"> Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Rehabilitate (landscape & revegetate) disturbance footprint 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
3		Landscaping and Revegetation of Bare or Disturbed Areas	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Vehicle access to and from disturbed areas Earthworks (scarifying/ploughing, levelling soil surface) Application of top soil (if necessary) Placement of grass sods or seeding (manual or hydro-seeding) Irrigation of revegetated areas (if necessary) <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Creation of preferential flow paths in vehicle ruts Exposure of bare soils to increased risk of erosion Mobilisation of sediments Flow concentration Water quality deterioration (spillages and leaks from machinery and equipment) <p>POSITIVE</p> <ul style="list-style-type: none"> Improved surface runoff characteristics Improved vegetation composition and cover 	1	1	1	1	1	1	1	3	1	2	5	2	10	30	L	Moderate	<ul style="list-style-type: none"> Use existing roads and disturbed areas as access routes as far as possible. Access tracks to run parallel to contour to prevent formation of preferential flow path. Rehabilitate vehicle ruts following completion of activity. Management of alien vegetation 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
4		Installation of Litter Collection Facilities (Refuse Bins)	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Prepare (level and compact) soil surface Placement of concrete/steel litter bins <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments <p>POSITIVE</p> <ul style="list-style-type: none"> Improved waste disposal, resulting in reduction of fugitive litter 	1	1	1	1	1	1	1	3	1	1	5	1	8	24	L	Moderate	<ul style="list-style-type: none"> Limit vegetation clearing and earthworks to actual footprint Minimise construction period to limit opportunity for erosion and mobilisation of sediment Ensure regular emptying of refuse bins 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate

ACTIVITIES WITHIN THE REGULATED AREA (500M OF WETLAND HABITAT) BUT OUTSIDE OF WETLAND BOUNDARY

No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control Measures	PES and IS of Watercourse
5		Establishment of Communal Subsidence Agricultural Plots	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Landscaping and levelling of surface Ploughing and preparation for planting <p>OPERATION</p> <ul style="list-style-type: none"> Watering of crop Application of fertiliser/herbicide/insecticide Harvesting of crop Ploughing and preparation for planting Increased frequency of burning 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments Altered surface runoff characteristics Water quality deterioration (Fertiliser/Herbicides/Insecticides) Establishment of alien vegetation 	2	2	2	2	2	2	3	7	5	3	5	3	16	112	M	Moderate	<ul style="list-style-type: none"> Implementation of soil management measures, i.e.: contour berms Undertake initial clearing during dry season Control of alien vegetation Waste disposal and removal Agricultural plots to be limited to designated areas Limit irrigation volumes by timing irrigation during cooler hours/over night 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
6		Establishment of Grassed Sports Fields	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Landscaping, scarifying and levelling of surface Planting of grassed lawn <p>OPERATION</p> <ul style="list-style-type: none"> Irrigation of grassed sports field 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments Altered surface runoff characteristics (due to irrigation) 	2	1	1	1	1.25	1	2	4.25	4	3	5	2	14	59.5	M	Moderate	<ul style="list-style-type: none"> Limit vegetation clearing to actual footprint Minimise construction period to limit opportunity for erosion and mobilisation of sediment Use indigenous grass species with low watering requirements Limit irrigation volumes by timing irrigation during cooler hours/over night 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
7		Installation of Play and Outdoor Gym Facilities and/or Braai facilities, Table and Benches	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Earthworks (Digging foundation) Prepare (level and compact) subsoil to receive in-situ concrete base Construct appropriate 75 mm in-situ concrete base for play surface/gym equipment/braai area/table and benches <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Exposure of bare soils to increased risk of erosion Mobilisation of sediments Altered flow characteristics due to soil compaction and concrete infrastructure Water quality deterioration (Concrete/cement) 	1	1	1	1	1	2	1	4	1	2	5	2	10	40	L	Moderate	<ul style="list-style-type: none"> Limit vegetation clearing and earthworks to actual footprint Minimise construction period to limit opportunity for erosion and mobilisation of sediment Apply best practice management to storage of materials and preparation and pouring of concrete, i.e.: remain outside of wetland habitat, do not store or mix cement and concrete directly on the ground, store and prepare on liner on in banded area, dispose of all visible remains of excess cement and concrete after the completion of tasks, dispose of in the approved manner (solid waste concrete may be treated as inert construction rubble, but wet cement and liquid slurry, as well as cement powder must be treated as hazardous waste) 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate
8		Installation of Bricked Walkways	<p>CONSTRUCTION</p> <ul style="list-style-type: none"> Clear vegetation Earthworks (Digging foundation) Prepare (level and compact) subsoil Placement of interlocking concrete pavers placed on PVC and 50 mm rolled sand base Application of weed killer (herbicide) as needed <p>OPERATION</p> <ul style="list-style-type: none"> None 	<p>NEGATIVE</p> <ul style="list-style-type: none"> Disturbance to vegetation Exposure of bare soils to increased risk of erosion Mobilisation of sediments Altered flow characteristics due to soil compaction and placement of sand/PVC/concrete pavers Water quality deterioration (herbicide) 	2	2	2	2	2	3	1	6	1	2	5	3	11	66	M	Moderate	<ul style="list-style-type: none"> Limit vegetation clearing and earthworks to actual footprint Minimise construction period to limit opportunity for erosion and mobilisation of sediment Apply best practice management to storage of materials, i.e.: remain outside of wetland habitat, do not store materials directly on the ground, store and prepare on liner on in banded area, dispose of all visible remains of excess materials after the completion of tasks, dispose of in the approved manner Only approved, low impact herbicides to be used 	Majority of Wetlands in the following categories: PES=D to F IS=Low/Marginal to Moderate

6 HIGH LEVEL COST ESTIMATES

6.1 APPROACH/METHODOLOGY

Initial/conceptual rehabilitation intervention measures were devised. These measures were refined in consultation with a wetland specialist, civil engineer and landscape architect to achieve the targeted rehabilitation outcomes.

The costs were based on the following suite of information:

- Google earth imagery;
- Site visit to the required intervention areas;
- Contour data DTM of the on-site area;
- High-level hydrological analysis;
- Conceptual engineering designs; and
- Discussion with various professionals.

Given the limited information available for the costing, the assigned accuracy was taken as -20% and +30%, reflecting the nature of the uncertainty associated with the costing. This accuracy range was applied to the predicted quantities for each item in the high-level bill of quantities.

High-level costs were determined based on previous experience and/or rates from potential suppliers. The high-level costs of the different areas are attached to this report, in the form of summary cost tables.

6.2 LIMITATIONS WITH RESPECT TO COSTING

The cost estimates were based on limited information, at best reflecting the costs that could be assigned to the conceptual designs. The following limitations are noted:

- Only conceptual level designs where completed;
- High-level hydrological analysis;
- Contractor site establishment and health and safety requirements are not costed for;
- Maintenance cost for the intervention are not costed for;
- Purchase of land or service agreements were not considered;
- Litter traps were not costed at this point as no reliable costs could be ascertained for the litter traps;
- Exact placement of structures/ interventions might need to be altered in the next phase of the project. This will affect the costing of the current structures; and
- Soil conditions and geo-hydrology for the target areas are unknown.

6.3 COSTING

The high level costing was done for each rehabilitation zone as well as split into two categories, hard and soft interventions as explained in Section 3.3 and 3.4. The assigned accuracy was taken

as -20% and +30%, reflecting the nature of the uncertainty associated with the costing. Table 8 highlights the cost for the soft intervention and Table 9 indicates the cost for the hard interventions.

Table 8: High level costing for soft interventions

Soft Interventions			
Rehabilitation Zone	Lower Range (-20%)	Median	Upper Range (+30%)
Zone 1	39.5	49.4	64.2
Zone 2	10.9	13.6	17.7
Zone 3	14.2	17.8	23.1
Zone 4	29.1	36.4	47.3
Zone 6	1.3	1.6	2.1
Zone 7	20.5	25.6	33.3
Total (in millions of Rands)	R 115.5	R 144.4	R 187.7

Table 9: High level costing for hard interventions

Hard Interventions			
Rehabilitation Zone	Lower Range (-20%)	Median	Upper Range (+30%)
Zone 1	21	26.2	34.1
Zone 2	1	1.2	1.6
Zone 3	34.4	43	55.9
Total (in millions of Rands)	R 56.4	R 70.4	R 91.6

7 GENERIC CONSTRUCTION METHOD STATEMENT

The generic construction method statement is a high level statement that is developed for the conceptual designed. This generic construction method statement will need to be elaborated upon in the next phase of the project.

7.1 OCCUPATIONAL HEALTH AND SAFTY

Occupational health and safety is a priority, all necessary precautionary measures must be undertaken to ensure safety of the team. Particular attention must be given to deep excavations

where gentle sloping back of soil or shoring must be applied to prevent possible soil collapse. Where risks are foreseen, these must be reported to the Occupational Health and Safety Agent and/or ECO employed by the CoE, who may need to seek further advice. In addition, no excavated earth or other materials should be stockpiled within a distance of one metre from the edge of any excavation. The one metre wide strip along the edges of all sides of an excavation should at all times be kept clear of objects such as lumps of clay, rocks or tools that could injure workers in the excavation if they were to fall in.

7.2 SOIL MOVEMENT, BACKFILLING AND LEVELLING:

- Movement of large volumes of soil must be undertaken using a light excavator/grader;
- This is applicable for backfilling drains and/or trenches, levelling of excavated areas and soil dumps;
- A dumpy level must be used to work out the cut and fill levels and moving the soil onsite, pegs must be placed to ensure that the grader moves soil appropriately;
- It must be ensured that the grader/machinery move uniformly onsite starting from inside wetland impacted areas toward the outer edge of the wetland area;
- Plugs may need to be placed (as per engineer specification) at interval within the trenches to ensure there is no preferential flow path that develops upon completion of back filling;
- No haphazard driving of machinery must be allowed onsite;
- 100mm layer of topsoil should be placed on the surface of the backfill material in order to promote the establishment of vegetation;
- Specifications for backfilling of impoundments/small farm dams on site should be provided by the design engineer, including volumes and appropriately detailed method statements that should be followed by the contractor on site; and
- Tractors must be used to disc plough and/or rip informal road areas and areas targeted for buffering wetlands prior to revegetation taking place.

7.3 REVEGETATION OF DISTURBED AREAS:

- Revegetation of rehabilitated areas, including ripped and/or ploughed areas must be done using local grass species adapted to the local climate and conditions. Where this is found not to be feasible then an appropriate seed mix must be used as per specification from the supplier; and
- A wetland specialist/botanist must assist during re-vegetation and must prescribe the suitable species for re-vegetation of disturbed wetland areas.

7.4 REMOVAL OF ALIEN VEGETATION:

- Hand chain saws must be used to cut down the trees, appropriate herbicides must be used to treat the cut stumps as per advise from Working for Water, or an alternative suitably qualified person; and

- Guidance on specific precautionary measures should be from Working for Water, or an alternative suitably qualified person, with respect to removal of alien vegetation instream and the use of herbicides.

7.5 INSTREAM STRUCTURE CONSTRUCTION

7.5.1 PHASING

1. Each structure must be constructed to completion and signed-off before starting the next structure;
2. Construction of the second structure may only be started in parallel to the first if there is a second construction team available on site.

7.5.2 SITE SETUP

1. The construction camp must be located and established outside of the wetland system and areas susceptible to potential flooding;
2. All access routes to the intervention construction sites/zones must be identified by the contractor with input by the wetland ecologist and Environmental Control Officer (ECO) prior to construction commencing. The access routes must be strictly single lane and must be demarcated;
3. Demarcate the construction site/zone for each structure. The construction footprint must be as small as possible and must be demarcated prior to construction commencing using orange plastic bonnox fencing. The construction zone must include:
 - a. Intervention construction area.
 - b. Material stockpile and storage area.
 - c. A designated topsoil and subsoil stockpile area must be identified with input by the wetland ecologist and/or ECO prior to construction commencing.
 - d. All areas outside of the demarcated access routes and construction footprint must not be disturbed and should be considered 'no-go' zones.

7.5.3 STRUCTURE SETTING OUT

1. Before any clearing and excavation takes place, the structures must be set out by the rehabilitation engineer. Following the excavation, the rehabilitation and resident engineers must re-check that the levels are correct and approve of the setting out; and
2. Check all dimensions on site to determine if any amendments to the designs are necessary. Note the required final height of the structure relative to the original ground level as specified in the construction notes for each intervention. The responsible engineer must be consulted before any changes are made to dimensions.

7.5.4 VEGETATION AND TOPSOIL STRIPPING

Where applicable, all topsoil and vegetation within the construction zone must be stripped and stockpiled for re-use in post-construction rehabilitation at the designated soil stockpile areas.

7.5.5 FLOW DIVERSION

1. The diversion trench must be established before the main channel is impounded where applicable;
2. The diversion trench must first be pegged out by the rehabilitation engineer before excavation. All diversion trenches must be aligned along contours as far as possible and must be aligned to feed into the nearest lateral drain;
3. The diversion trench must under no circumstances be aligned parallel or near-parallel to flow in the main channel. In general the diversion trenches should be two buckets wide ($\pm 2\text{m}$ wide) and 0.5m deep (this must be confirmed by the onsite engineer);
4. The trench must be excavated working from downstream to upstream (from the lateral drain to the main channel). Under no circumstances must the trench excavation start from the main longitudinal drain downstream of the proposed structure;
5. Once the diversion trench is established between the main and lateral drain, clayey subsoil material stockpiled adjacent to the main drain, must be used to block the channel (upstream and possibly downstream if back flooding is a problem) and divert water around the structure. Under no circumstances must topsoil or organic soil be used to plug the main channel;
6. The diversion plug must be located far enough upstream of the proposed intervention to allow for an excavator to cross the channel between the diversion plug and the structure i.e. the excavator may cross the dry portion of the channel downstream of the diversion plug; and
7. The impoundment must be high enough to effectively divert all flow along the diversion trench and away from the working area.

7.5.6 STRUCTURE PIT EXCAVATION AND SOIL STOCKPILING

1. Excavation must be carried out to the final levels;
2. Soil must be placed in areas best suited for re-use/replacement. The topsoil must be stockpiled separately from the subsoil;
3. The excavation floor on which the interventions are to be placed must be well compacted. As per the engineering design;
4. All intervention walls are to be founded on firm impermeable material;
5. Where weirs are used for the construction of keywalls, the trenches need to be dug wide enough so that sufficient access is available to properly backfill and compact all the way around them. Making the trench only wide enough to receive the baskets is not acceptable, as water will eventually find its way around the structures; and
6. Once the trench has been excavated in its entirety, the Resident Onsite Engineer (ROE) must inspect and ensure that the pit has been excavated according to the setting out levels, approved designs and/or instructions of the Wetland Ecologist (WE) and Resident Engineer (RE). If the ROE is satisfied that the pit has been excavated appropriately, the ROE must inform the WE and RE immediately and provide the WE and RE with pictures of the approved pit.

7.5.7 EXCAVATION DEWATERING (IF APPLICABLE)

Once the weir pit has been excavated, the working area will likely need to be dewatered using a suitable water pump. Water pumped from the working areas must be discharged onto adjacent intact portions of the wetland as far away as possible from the main channel in an attempt to reduce contamination of the clean water in the channel with sediment. An effort must be made to ensure that erosion resulting from the discharge of pumped water is minimised through managing the energy at the outlet e.g. discharging the water into a perforated drum or other suitable means to break the energy.

7.6 WEIR CONSTRUCTION AND PLACEMENT:

7.6.1 CONCRETE STRUCTURE – CONSTRUCTION NOTES (IGNORE IF NOT APPLICABLE):

1. Check all dimensions on site to determine if any amendments to the designs are necessary. Note the required final height of the structure relative to the original ground level. The responsible engineer must be consulted before any changes are made to dimensions;
2. Excavation must be carried out to the final levels. Soil must be placed in areas best suited for re-use, for example, when building an earthen diversion embankment, the soil excavated should be used immediately in building up the embankment (on condition the excavated soil is of suitable quality). The excavated soil should alternatively be stockpiled immediately upstream of the site of the proposed wall. The topsoil must be stockpiled separately from the subsoil;
3. Where soil is to be the foundation for non-soil structures (for example, berms and rafted weirs), all sand deposits must be removed and the floor well compacted while the soil is at optimum moisture content, as per engineering design;
4. In instances where the addition of Gypsum (CaSO_4) has been specified for the amelioration of a dispersive soil, mixing must be carried out off site, after which it must be transported to the construction site;
5. When the final level of the soil construction has been reached, the previously stockpiled topsoil must be added as an extra height and planted with suitable vegetation (unless other provision for protection of the structure has been specified);
6. When backfilling soil against concrete, extra care must be taken to ensure that a waterproof joint with the structure is, as far as possible, achieved. Compaction must be carried out in layers as specified by the engineer. Material containing organic matter must not be used for this backfilling purpose;
7. Ensure that the correct steel reinforcing, as specified, has been delivered to site. Ensure that the minimum cover, as specified by the engineer, is achieved at all times. All steel joints must have an overlap of at least 200mm and must be securely tied with 2mm building wire. At least three rings at 150mm spacing are required. Particular attention must be paid to ensure the correct placing of steel reinforcing (particularly steel mesh with different bar sizes);

8. Before placing concrete on a rock foundation, carefully chip away any loose surface layers and wash away all debris. New surfaces must be painted with a cement slurry prior to the placing of the concrete;
9. Ensure that all shuttering is strong and well supported. It is recommended that the concrete be placed in layers no greater than one metre per day. The shuttering must be well oiled on the inside to prevent the concrete from sticking. Spacers between shuttering must be placed every one metre, both vertically and horizontally, with a minimum of two in both directions;
10. Note that when mixing concrete it is preferable to use a full pocket of cement with each mix. The specified cement water ratio must be maintained at all times;
11. The poured concrete must be “rodded” to ensure proper compaction. Never add more than one metre height of concrete in any one day, and attempt to lay the concrete in even, horizontal layers throughout the length of any section. Check the specifications for any requirement of expansion joints. The shuttering should be left for at least two days before stripping. Wetting it while it is curing will make for a strong construction. Backfilling of soil against the completed structure may only be done after a period of at least seven days;
12. The use of “plums” in concrete: In some instances it may be feasible and economic to reduce the amount of concrete in mass volume structures, by replacing up to 33% of the volume by the judicious use of suitable hand sized quarried rock. Where this is specified the rocks (purchased as handstone) must be so placed that there is always a minimum cover of 50mm between the rock and the shuttering, as well as between any two adjacent rocks;
13. Where structures are to be built in dispersive soils, the following should be noted:
 - Impermeable cut off wall (at least 500mm deep) to be constructed under spillway section of the structure;
 - Key walls to be impermeable; and
 - Impermeable barriers to be constructed between key walls and spillway section of structures.
14. Sloping and vegetating gully banks where specified:

Where the gully is no more than approximately 1.0 metre deep, and the catchment area small (say ten hectares), the topsoil of the site immediately adjoining the channel is removed and stockpiled in a safe place nearby. The subsoil thus laid bare is excavated at a slope not less than 1:3 (V:H) and deposited in the gully. This deposit is carefully compacted while in a moist state. The topsoil is now returned to the sloped area, and spread as evenly as possible over it. Vegetation suitable to the site is planted. The additional advantage to this idea is that, as the channel cross section is made shallower and wider and established to vegetation, so the chances of floodwaters overflowing into the adjacent flood area will be that much greater. Note that the base of the modified channel should be planted to strong, hydrophitic plants while the outer edges will require plants more suited to drier regimes. It must be emphasised that the stockpiling of the topsoil and its replacement is vital, especially

where very erodible subsoil is present. Failure to do this will be tantamount to a waste of money and effort;

15. The orientation of all wetlands and interventions is to be taken facing downstream i.e. Left bank and right bank are to be identified facing downstream; and
16. The Bill of Quantities of the various rehabilitation interventions only included revegetation in those instances where the engineer considered the re-vegetation of the denuded area as important due to the size of the area affected or due to the risk associated with scouring and erosion.

7.6.2 APPROVAL AND SIGNING OFF

Each structure must be inspected by the WE and RE prior to backfilling against the completed work and after completion, unless agreed to otherwise.

7.6.3 REHABILITATION OF MAIN CHANNEL (EXCLUDING IMPOUNDMENT AND DIVERSION TRENCH)

1. Only once the structure is inspected by the WE and RE must rehabilitation of the main channel and the areas immediately surrounding the structure commence;
2. The bed and banks of the main channel (below impoundment) disturbed by the construction phase must be re-graded and re-shaped back to original levels. Where applicable, the soils must be ripped to mitigate the effects of compaction;
3. The WE and RE must inspect and sign-off on the reshaped areas; and
4. Thereafter, available *Typha capensis* plants must be transplanted along the top of the re-graded/shaped channel banks. These plants must be collected by the contractor.

7.6.4 REMOVAL OF DIVERSION IMPOUNDMENT

1. Only once the bed and banks of the main channel downstream of the impoundment have been re-graded and rehabilitated to the satisfaction of the WE and RE must the earthen impoundment be removed.
2. The earthen impoundment must be removed systematically by removing 500mm of earth at a time. Once removed, a temporary earthen berm should be established across the entrance to the diversion trench along the bank of the main channel. The ECO must be present to strictly monitor activities during the removal of the impoundment.
3. The earthen impoundment/berm must be maintained until the diversion trench is backfilled and rehabilitated as described below.

7.6.5 REHABILITATION OF THE DIVERSION TRENCH:

1. Once all flow has been diverted back along the main channel, the rehabilitation of the diversion trench must commence;
2. The diversion channel must be backfilled systematically in layers using selected clay material. Material containing organic matter must not be used to backfill the trench;

3. Each 150mm of backfill must be compacted until the natural ground level has been achieved;
4. Special attention should be paid to the entrance to the diversion trench. The material should be well compacted and the bank of the channel reinstated to the shape and levels that existed prior to the diversion being constructed;
5. Once backfilling is completed, the disturbed areas must be re-graded and revegetated;
6. Small diversion berms, 300mm high and constructed at 45 degrees facing away from the main channel are to be installed across the backfilled trench to prevent erosion of the backfill material from occurring;
7. The ROE must strictly monitor the diversion trench backfilling and re-grading; and
8. The rehabilitated trench area must be re-vegetated by the transplanting of *Typha capensis* plants at 500mm intervals. These plants must be collected by the contractor. Vegetation, mosaic harvested from the banks of the drains, is to be densely planted on the banks at the entrance point to the diversion.

7.6.6 REHABILITATION OF REMAINING WORKING AREAS:

Once the main channel and the diversion trench have been rehabilitated as above, the need for rehabilitation of soils within the construction zone and access routes must be assessed by the wetland ecologist. Areas affected by heavy compaction may need to be ripped to a depth of 200-300mm as the excavator is working backwards out of the wetland.

8 WAY FORWARD

The level of accuracy for this project is at a concept level. In order to take this work forward, the following work has to be done:

- Improve the understanding of the quality and quantity of water in the catchments. As such the following work should be done:
 - Gain a clear understanding of what effect the increased hard surface areas and underperforming sewer infrastructure will have on the proposed intervention measures;
 - Given the outcomes of the above, a full water balance for the entire catchment would need to be conducted, taking into consideration the surface water and groundwater;
- Improve the topographical and geotechnical understanding. As such, the following work should be done:
 - Once approval of the locations of interventions have been obtained from DWS, a topographical survey of each site needs to be conducted to inform the preliminary engineering going forward;
 - Conduct a detailed backwater calculation for all of the proposed interventions based on improved topographical surveys;
 - Conduct dedicated geotechnical investigation of the proposed intervention areas;

- Advance the project to a preliminary engineering stage. As such, the following work should be done:
 - Improve the details of all interventions, along with engineering design drawings;
 - Obtain a detailed DTM to guide weir placement, through the use of backwater modelling;
 - Refine the costing for the interventions as the designs are refined/improved;
 - Consider additional measures such as fish ladders if the intervention measures result in more “permanent” water bodies. These need to be considered even if no notable water bodies will form, as connectivity for fish migration should be maintained as much as possible; and
 - Formulate an appropriate monitoring plan to reflect on performance and success of the implemented interventions.

9 CONCLUSION

9.1 REHABILITATION STRATEGY

A phased rehabilitation implementation approach should be followed to allow for the learnings from the initial stage to be banked and applied to the wetland areas targeted in the remaining stages. This would increase the probability of success. In addition, a phased approach will provide a high amount of labour-intensive construction jobs over a prolonged period of time.

9.2 REHABILITATION MEASURES

The proposed engineering interventions are mainly aimed at raising the shallow/near surface groundwater levels (in a localised area) in the eroded valley bottom channels. Interventions are primarily designed to reduce the stream flow velocity/energy, spreading flow across a larger area and capture silt.

It is proposed that hard interventions be used in various locations in the wetlands, as the construction of direct interventions can be done manually with a reduced/limited impact on the surrounding environment/wetland, by obviating heavy construction equipment.

Soft interventions are just as important and will provide quick improvement, for a small amount of capital expenditure.

9.3 RISK ASSESSMENT

As part of a larger project aimed at designing a planning regime for rehabilitation within target wetlands within the Kaalspruit catchment, it was necessary to determine the appropriate authorisation process for various rehabilitation and other activities proposed through the application of the WUL risk assessment. This risk assessment was therefore undertaken to determine the risks associated with certain generic rehabilitation activities proposed within or adjacent to (within the 500m regulated area) one or more wetlands within the catchment.

The activities that need to be assessed and which are associated with the proposed wetland rehabilitation and integration into improved public open spaces include the following:

- Repair of existing instream rehabilitation structures (gabion and concrete structures) to improve performances;

- Construction of new instream structural interventions (gabions or concrete structures) to stabilise channel erosion;
- Alien vegetation clearing and management;
- Removal of litter, rubble and infill;
- Landscaping and revegetation of bare or disturbed areas;
- Installation of bricked walkways;
- Installation of litter collection facilities;
- Establishment of communal subsidence agricultural plots;
- Establishment of grassed sports fields; and
- Installation of play and outdoor gym facilities and/or braai facilities, table and benches.

The proposed activities above were considered in relation to possible impacts on wetland drivers, focusing on hydrology (surface flow, interflow and groundwater), geomorphology, water quality and vegetation (habitat and biota). Activities were grouped based on their location:

1. Activities within wetland habitat
2. Activities outside of but within 500m of wetland habitat

From the results of the water use risk assessment it is evident that certain activities should be considered for authorisation under a General Authorisation either because they represent a **Low Risk** or because they are borderline **Low/Moderate Risk**³ with a significance score of 80 or less. It is our opinion that the proposed activities should be authorised under a GA. Activities with significance scores of over 80 potentially pose a **Moderate Risk** and are likely to require authorisation via the Water Use Licence process unless the rehabilitation purpose of certain activities is taken into account in potentially adjusting the severity scores. It is recommended that in such instances, further guidance should be sought from DWS to establish whether the severity scoring currently applied to certain rehabilitation activities could be adjusted downwards, particularly for activities considered within wetland habitat

A number of mitigation and management measures have been proposed to ensure that all activities on site are undertaken in an environmentally sensitive and responsible manner. ***The method statements developed for the proposed activities should be amended to include these measures.***

9.4 COST ESTIMATES

The wetland rehabilitation measures were devised to sustain and improve the current wetland conditions of the Kaalspruit Catchment wetlands. The conceptual mean costs for the project are roughly **R 144.4 million for the soft interventions and R70.4 million for the hard interventions.**

As the cost estimates were primarily prepared for budgetary purposes of the master plan, these must be refined/improved as the project progresses and this would include improved engineering.

³ GN 509 allows for borderline Low/Moderate rating classes to be considered for authorisation under a GA where the significance score is less or equal to 80 (a maximum of 25 points more than a Low Risk Rating of 55).

Costs will improve once the individual physical interventions have been designed to a greater level of resolution.

9.5 WAY FORWARD

This report outlines the master plan for the Kaalspruit Catchment wetland remediation at a concept level. With the work going forward, the project details need to be reviewed and improved to allow for an improvement of the resolution of the proposed rehabilitation measures and associated costing.

10 APPENDICES

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 1

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
HGM 1.1 (Esselen Park Pan)			
1	Fence of pan area		Palisade fence is costed for with 8 entrances to the pan
1.1	Palisade fence 1.8m bolt on application	R 1 255 000	Fence in pan area
1.2	Palisade pedestrian gates	R 35 200	Palisade gates pedestrian
1.3	Palisade car gates	R 31 900	Palisade car gate 3m wide
2	Shape and level area around pan		
2.1	Clear and grub	R 776 910	General clearing of the area around the pan
2.2	Level and shape	R 1 155 000	Lots of shaping around the pan, create agricultural areas, as well as flatten area for sports field
3	Pedestrian walkways		
3.1	Bricked walkways	R 1 035 000	Concrete interlocking paving in and around the pan area
3.2	Construct vehicular and servicing area	R 577 500	
4	Sports field		
4.1	Sport field (120m by 70m wide)	R 252 000	Sport field just a grassed area
4.2	Irrigation for the sports field	R 100 000	Small pump along with 1 large sprinkler irrigation system.
5	Waste management		
5.1	Bins concrete	R 30 000	Bins scattered in and around pan area
5.2	Waste management area	R 120 000	A dedicated waste management area. Paved area with place for 2 large skips
6	Park miscellaneous		
6.1	Stormwater infrastructure	R 700 000	Formalised stormwater channels into the pan
6.2	Braai areas	R 100 000	20 small braai areas
6.3	Out door play equipment	R 80 000	10 pieces of equipment
6.4	Outdoor gym equipment	R 60 000	9 different outdoor gym machines
6.5	Outdoor gym flooring	R 320 000	Rubber flooring
6.6	Concrete bench and tables	R 60 000	20 concrete tables with benches
6.7	Trees and shrubs	R 1 500 000	Number of indigenous tress planted around the pan area
6.8	Landscaping	R 300 000	General landscaping in and around miscellaneous areas
6.9	Signage	R 30 000	Signage in and around pan area
Subtotal HGM 1.1 - Esselen Park Pan		R 8 518 510	
HGM 1.2 (Small pan area)			
1	Fence of pan area		Palisade fence is costed for with 6 entrances to the pan
1.1	Palisade fence 1.8m bolt on application	R 787 500	Fence in pan area
1.2	Palisade pedestrian gates	R 26 400	Palisade gates pedestrian

1.3	Palisade car gates	R	31 900	Palisade car gate 3m wide
2 Shape and level area around pan				
2.1	Clear and grub	R	219 000	General clearing of the area around the pan
2.2	Level and shape	R	330 000	Shaping around the pan, to ensure free drainage
3 Pedestrian walkways and parking				
3.1	Bricked walkways	R	1 240 750	Concrete interlocking paving in and around the pan area
3.2	Construct vehicular and servicing area	R	279 125	
4 Waste management				
4.1	Bins concrete	R	15 000	Bins scattered in and around pan area
4.2	Waste management area	R	120 000	A dedicated waste management area. Paved area with place for 2 large skips
5 Park miscellaneous				
5.1	Stormwater infrastructure	R	140 000	Formalised stormwater channels into the pan
5.2	Braai areas	R	50 000	10 small braai areas
5.3	Out door play equipment	R	40 000	5 pieces of equipment
5.4	Outdoor gym equipment	R	60 000	5 different outdoor gym machines
5.5	Outdoor gym flooring	R	180 000	Rubber flooring
5.6	Concrete bench and tables	R	30 000	10 concrete tables with benches
5.7	Trees and shrubs	R	900 000	Number of indigenous tress planted around the pan area
5.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
5.9	Signage	R	10 000	Signage in and around pan area
Subtotal HGM 1.2 - Small pan area		R	4 759 675	
HGM 1.3 (Channelled valley bottom)				
1	Fence of park area			Palisade fence is costed for with 6 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R	700 000	Fence in park area
1.2	Palisade pedestrian gates	R	26 400	Palisade gates pedestrian
1.3	Palisade car gates	R	15 950	Palisade car gate 3m wide
2 Shape and level area around pan				
2.1	Clear and grub	R	187 500	General clearing of the area around the valley bottom
2.2	Level and shape	R	330 000	Shaping around the park
3 Pedestrian walkways				
3.1	Bricked walkways	R	450 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R	279 125	
4 Waste management				
4.1	Bins concrete	R	15 000	Bins scattered in and around park area
4.2	Waste management area	R	120 000	A dedicated waste management area. Paved area with place for 1 large skips
5 Park miscellaneous				
5.1	Stormwater infrastructure	R	350 000	Formalised stormwater channels into the wetland
5.2	Braai areas	R	25 000	10 small braai areas
5.3	Out door play equipment	R	40 000	5 pieces of equipment
5.4	Outdoor gym equipment	R	60 000	5 different outdoor gym machines

5.5	Outdoor gym flooring	R	180 000	Rubber flooring
5.6	Concrete bench and tables	R	15 000	10 concrete tables with benches
5.7	Trees and shrubs	R	1 000 000	Number of indigenous tress planted around the park area
5.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
5.9	Signage	R	10 000	Signage in and around park area
	Subtotal HGM 1.3 - Channel valley bottom	R	4 103 975	
	HGM 1.4 (Channelled valley bottom)			
1	Fence of pan area			Palisade fence is costed for with 2 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R	1 650 000	Fence in park area
1.2	Palisade pedestrian gates	R	44 000	Palisade gates pedestrian
1.3	Palisade car gates	R	31 900	Palisade car gate 3m wide
2	Shape and level area around pan			
2.1	Clear and grub	R	1 290 000	General clearing of the area around the valley bottom
2.2	Level and shape	R	1 980 000	Lots of shaping around the park, create agricultural areas, as well as flatten area for sports field
3	Pedestrian walkways			
3.1	Bricked walkways	R	765 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R	279 125	
4	Sports field			
4.1	Sport field (120m by 70m wide)	R	504 000	Sport field just a grassed area
4.2	Irrigation for the sports field	R	200 000	Small pump along with 2 large sprinkler irrigation system.
5	Waste management			
5.1	Bins concrete	R	15 000	Bins scattered in and around park area
5.2	Waste management area	R	120 000	A dedicated waste management area. Paved area with place for 1 large skips
6	Park miscellaneous			
6.1	Stormwater infrastructure	R	70 000	Formalised stormwater channels into the park
6.2	Braai areas	R	25 000	10 small braai areas
6.3	Out door play equipment	R	40 000	5 pieces of equipment
6.4	Outdoor gym equipment	R	60 000	9 different outdoor gym machines
6.5	Outdoor gym flooring	R	320 000	Rubber flooring
6.6	Concrete bench and tables	R	15 000	10 concrete tables with benches
6.7	Trees and shrubs	R	1 250 000	Number of indigenous tress planted around the park area
6.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
6.9	Signage	R	20 000	Signage in and around park area
	Subtotal HGM 1.4 - Channel valley bottom	R	8 979 025	
	HGM 1.5 (Channelled valley bottom)			
1	Fence of pan area			Palisade fence is costed for with 6 entrances to the pan
1.1	Palisade fence 1.8m bolt on application	R	650 000	Fence in park area
1.2	Palisade pedestrian gates	R	26 400	Palisade gates pedestrian
1.3	Palisade car gates	R	15 950	Palisade car gate 3m wide
2	Shape and level area around pan			

2.1	Clear and grub	R	150 000	General clearing of the area around the valley bottom
2.2	Level and shape	R	726 000	Shaping around the park
3	Pedestrian walkways			
3.1	Bricked walkways	R	315 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R	279 125	
4	Waste management			
4.1	Bins concrete	R	10 000	Bins scattered in and around park area
4.2	Waste management area	R	120 000	A dedicated waste management area. Paved area with place for 1 large skips
5	Park miscellaneous			
5.1	Stormwater infrastructure	R	700 000	Formalised stormwater channels into the wetland
5.2	Braai areas	R	25 000	10 small braai areas
5.3	Out door play equipment	R	40 000	5 pieces of equipment
5.4	Outdoor gym equipment	R	60 000	5 different outdoor gym machines
5.5	Outdoor gym flooring	R	83 250	Rubber flooring
5.6	Concrete bench and tables	R	15 000	10 concrete tables with benches
5.7	Trees and shrubs	R	1 250 000	Number of indigenous trees planted around the park area
5.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
5.9	Signage	R	20 000	Signage in and around park area
	Subtotal HGM 1.5 - Channel valley bottom	R	4 785 725	
	HGM 1.6 (Channelled valley bottom)			
1	Park miscellaneous			
1.1	Stormwater infrastructure	R	693 000	Formalised stormwater channels into the park
	Subtotal HGM 1.6 - Channel valley bottom	R	693 000	
	Total Zone 1	R	31 839 910	
1	Additional allowances			
1.1	Preliminaries and general	R	7 959 978	Assume 25% of Total Zone 1
1.2	Contingencies	R	9 551 973	Assume 30% of Total Zone 1
	Subtotal 3 - Additional allowances	R	17 511 951	
	GRAND TOTAL	R	49 400 000	
-20%	LOWER RANGE	R	39 500 000	
+30%	UPPER RANGE	R	64 200 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 2

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
HGM 2.1 (Channelled valley bottom)			
1	Fence of Park area 1		Palisade fence is costed for with 4 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 800 000	Fence in park area
1.2	Palisade pedestrian gates	R 17 600	Palisade gates pedestrian
1.3	Palisade car gates	R 31 900	Palisade car gate 3m wide
2	Shape and level area around Park 1		
2.1	Clear and grub	R 198 000	General clearing of the area around the park
2.2	Level and shape	R 264 000	
3	Pedestrian walkways Park 1		
3.1	Bricked walkways	R 315 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R 577 500	
4	Waste management Park 1		
4.1	Bins concrete	R 15 000	Bins scattered in and around park area
4.2	Waste management area	R 60 000	A dedicated waste management area. Paved area with place for 1 large skips
5	Park 1 miscellaneous		
5.1	Stormwater infrastructure	R 350 000	Formalised stormwater channels into the park
5.2	Braai areas	R 25 000	10 small braai areas
5.3	Out door play equipment	R 80 000	10 pieces of equipment
5.4	Outdoor gym equipment	R 60 000	5 different outdoor gym machines
5.5	Outdoor gym flooring	R 180 000	Rubber flooring
5.6	Concrete bench and tables	R 15 000	10 concrete tables with benches
5.7	Trees and shrubs	R 1 250 000	Number of indigenous tress planted around the park area
5.8	Landscaping	R 300 000	General landscaping in and around miscellaneous areas
5.9	Alien tree removal	R 5 512	
5.1	Signage	R 20 000	Signage in and around park area
6	Fence of Park 2 area		Palisade fence is costed for with 2 entrances to the park
6.1	Palisade fence 1.8m bolt on application	R 400 000	Fence in park area
6.2	Palisade pedestrian gates	R 8 800	Palisade gates pedestrian
6.3	Palisade car gates	R 15 950	Palisade car gate 3m wide
7	Shape and level area around Park 2		
7.1	Clear and grub	R 114 000	General clearing of the area around the park
7.2	Level and shape	R 660 000	
8	Pedestrian walkways Park 2		
8.1	Bricked walkways	R 234 000	Concrete interlocking paving in and around the park area

8.2	Construct vehicular and servicing area	R	577 500	
9 Waste management Park 2				
9.1	Bins concrete	R	10 000	Bins scattered in and around park area
9.2	Waste management area	R	60 000	A dedicated waste management area. Paved area with place for 1 large skips
10 Park 2 miscellaneous				
10.1	Stormwater infrastructure	R	350 000	Formalised stormwater channels into the park
10.2	Braai areas	R	25 000	10 small braai areas
10.3	Out door play equipment	R	80 000	10 pieces of equipment
10.4	Outdoor gym equipment	R	60 000	5 different outdoor gym machines
10.5	Outdoor gym flooring	R	180 000	Rubber flooring
10.6	Concrete bench and tables	R	15 000	10 concrete tables with benches
10.7	Trees and shrubs	R	1 100 000	Number of indigenous tress planted around the park area
10.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
10.9	Signage	R	20 000	Signage in and around park area
Subtotal HGM 2.1 - Channelled valley bottom		R	8 774 762	
Total Zone 2		R	8 774 762	
1 Additional allowances				
1.1	Preliminaries and general	R	2 193 691	Assume 25% of Total Zone 1
1.2	Contingencies	R	2 632 429	Assume 30% of Total Zone 1
Subtotal 3 - Additional allowances		R	4 826 119	
GRAND TOTAL		R	13 600 000	
-20%	LOWER RANGE	R	10 900 000	
+30%	UPPER RANGE	R	17 700 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 3

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
	HGM 3.1 (Channelled valley bottom)		
1	Fence of Park area 1		Palisade fence is costed for with 8 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 900 000	Fence in park area
1.2	Palisade pedestrian gates	R 35 200	Palisade gates pedestrian
1.3	Palisade car gates	R 31 900	Palisade car gate 3m wide
2	Shape and level area around Park 1		
2.1	Clear and grub	R 465 000	General clearing of the area around the park
2.2	Level and shape	R 825 000	
3	Pedestrian walkways Park 1		
3.1	Bricked walkways	R 495 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R 577 500	
4	Sports field		
4.1	Sport field (120m by 70m wide)	R 252 000	Sport field just a grassed area
4.2	Irrigation for the sports field	R 100 000	Small pump along with 1 large sprinkler irrigation system.
5	Waste management Park 1		
5.1	Bins concrete	R 25 000	Bins scattered in and around park area
5.2	Waste management area	R 120 000	A dedicated waste management area. Paved area with place for 2 large skips
6	Park 1 miscellaneous		
6.1	Stormwater infrastructure	R 700 000	Formalised stormwater channels into the park
6.2	Braai areas	R 50 000	10 small braai areas
6.3	Out door play equipment	R 80 000	10 pieces of equipment
6.4	Outdoor gym equipment	R 60 000	9 different outdoor gym machines
6.5	Outdoor gym flooring	R 320 000	Rubber flooring
6.6	Concrete bench and tables	R 30 000	10 concrete tables with benches
6.7	Trees and shrubs	R 1 050 000	Number of indigenous trees planted around the park area
6.8	Landscaping	R 500 000	General landscaping in and around miscellaneous areas
6.9	Signage	R 20 000	Signage in and around park area
7	Fence of Park area 2		Palisade fence is costed for with 2 entrances to the park
7.1	Palisade fence 1.8m bolt on application	R 1 100 000	Fence in park area
7.2	Palisade pedestrian gates	R 17 600	Palisade gates pedestrian
7.3	Palisade car gates	R 15 950	Palisade car gate 3m wide
8	Shape and level area around Park 2		
8.1	Clear and grub	R 277 500	General clearing of the area around the park

8.2	Level and shape	R	264 000	
9 Pedestrian walkways Park 2				
9.1	Bricked walkways	R	495 000	Concrete interlocking paving in and around the park area
9.2	Construct vehicular and servicing are	R	577 500	
10 Waste management Park 2				
10.1	Bins concrete	R	10 000	Bins scattered in and around park area
10.2	Waste management area	R	60 000	A dedicated waste management area. Paved area with place for 1 large skips
11 Park 2 miscellaneous				
11.1	Stormwater infrastructure	R	87 500	Formalised stormwater channels into the park
11.2	Braai areas	R	25 000	10 small braai areas
11.3	Out door play equipment	R	80 000	10 pieces of equipment
11.4	Outdoor gym equipment	R	60 000	5 different outdoor gym machines
11.5	Outdoor gym flooring	R	180 000	Rubber flooring
11.6	Concrete bench and tables	R	15 000	10 concrete tables with benches
11.7	Trees and shrubs	R	1 250 000	Number of indigenous tress planted around the park area
11.8	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
11.9	Signage	R	20 000	Signage in and around park area
Subtotal HGM 3.1 - Channelled valley bottom		R	11 471 650	
Total Zone 3		R	11 471 650	
1 Additional allowances				
1.1	Preliminaries and general	R	2 867 913	Assume 25% of Total Zone 1
1.2	Contingencies	R	3 441 495	Assume 30% of Total Zone 1
Subtotal 3 - Additional allowances		R	6 309 408	
GRAND TOTAL		R	17 800 000	
-20%	LOWER RANGE	R	14 200 000	
+30%	UPPER RANGE	R	23 100 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 4

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
HGM 4.2 (Channelled valley bottom)			
1	Fence of Park area		Palisade fence is costed for with 8 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 1 550 000	Fence in park area
1.2	Palisade pedestrian gates	R 70 400	Palisade gates pedestrian
1.3	Palisade car gates	R 47 850	Palisade car gate 3m wide
2	Shape and level area around Park		
2.1	Clear and grub	R 300 000	General clearing of the area around the park
2.2	Level and shape	R 825 000	
3	Pedestrian walkways Park		
3.1	Bricked walkways	R 1 035 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R 577 500	
4	Sports field		
4.1	Sport field (120m by 70m wide)	R 504 000	Sport field just a grassed area
4.2	Irrigation for the sports field	R 200 000	Small pump along with 1 large sprinkler irrigation system.
5	Waste management Park		
5.1	Bins concrete	R 50 000	Bins scattered in and around park area
5.2	Waste management area	R 120 000	A dedicated waste management area. Paved area with place for 2 large skips
6	Park miscellaneous		
6.1	Stormwater infrastructure	R 612 500	Formalised stormwater channels into the park
6.2	Braai areas	R 100 000	10 small braai areas
6.3	Out door play equipment	R 80 000	10 pieces of equipment
6.4	Outdoor gym equipment	R 60 000	9 different outdoor gym machines
6.5	Outdoor gym flooring	R 320 000	Rubber flooring
6.6	Concrete bench and tables	R 60 000	10 concrete tables with benches
6.7	Trees and shrubs	R 1 400 000	Number of indigenous tress planted around the park area
6.8	Landscaping	R 500 000	General landscaping in and around miscellaneous areas
6.9	Signage	R 20 000	Signage in and around park area
Subtotal HGM 4.2 - Channelled valley bottom		R 8 432 250	
HGM 4.3 (Channelled valley bottom)			
1	Fence of Agri park		Palisade fence is costed for with 16 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 1 350 000	Fence in park area
1.2	Palisade pedestrian gates	R 70 400	Palisade gates pedestrian
1.3	Palisade car gates	R 63 800	Palisade car gate 3m wide
2	Shape and level area around Agri Park		
2.1	Clear and grub	R 990 000	General clearing of the area around the park
2.2	Level and shape	R 2 640 000	

3	Pedestrian walkways Agri Park		
3.1	Bricked walkways	R	1 575 000
3.2	Construct vehicular and servicing are	R	577 500
4	Waste management Agri Park		
4.1	Bins concrete	R	75 000
4.2	Waste management area	R	240 000
5	Agri Park miscellaneous		
5.1	Stormwater infrastructure	R	2 625 000
5.2	Concrete bench and tables	R	30 000
5.3	Paved area for fresh good market	R	3 000 000
5.4	Trees and shrubs	R	750 000
5.5	Landscaping	R	1 000 000
5.6	Signage	R	40 000
	Subtotal HGM 4.3 - Channelled valley bottom	R	15 026 700
	Total Zone 4	R	23 458 950
1	Additional allowances		
1.1	Preliminaries and general	R	5 864 738
1.2	Contingencies	R	7 037 685
	Subtotal 3 - Additional allowances	R	12 902 423
	GRAND TOTAL	R	36 400 000
-20%	LOWER RANGE	R	29 100 000
+30%	UPPER RANGE	R	47 300 000

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 6

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
	HGM 6.1 (Channelled valley bottom)		
1	Shape and level area around Park		
1.1	Clear and grub	R 240 000	General clearing of the area around the park
1.2	Level and shape	R 330 000	
2	Miscellaneous		
2.1	Alien tree removal	R 440 960	
2.2	Signage	R 20 000	Signage in and around park area
	Subtotal HGM 6.1 - Channelled valley bottom	R 1 030 960	
	Total Zone 6	R 1 030 960	
1	Additional allowances		
1.1	Preliminaries and general	R 257 740	Assume 25% of Total Zone 1
1.2	Contingencies	R 309 288	Assume 30% of Total Zone 1
	Subtotal 3 - Additional allowances	R 567 028	
	GRAND TOTAL	R 1 600 000	
-20%	LOWER RANGE	R 1 300 000	
+30%	UPPER RANGE	R 2 100 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION**

Site Name: Kaalspruit Catchment Zone 7

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
HGM 7.1 (Channelled valley bottom)			
1	Fence of Park area		Palisade fence is costed for with 8 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 600 000	Fence in park area
1.2	Palisade pedestrian gates	R 35 200	Palisade gates pedestrian
1.3	Palisade car gates	R 47 850	Palisade car gate 3m wide
2	Shape and level area around Park		
2.1	Clear and grub	R 154 500	General clearing of the area around the park
2.2	Level and shape	R 825 000	
3	Pedestrian walkways Park		
3.1	Bricked walkways	R 450 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R 577 500	
4	Sports field		
4.1	Sport field (120m by 70m wide)	R 252 000	Sport field just a grassed area
4.2	Irrigation for the sports field	R 200 000	Small pump along with 1 large sprinkler irrigation system.
5	Waste management Park		
5.1	Bins concrete	R 50 000	Bins scattered in and around park area
5.2	Waste management area	R 120 000	A dedicated waste management area. Paved area with place for 2 large skips
6	Park miscellaneous		
6.1	Stormwater infrastructure	R 1 050 000	Formalised stormwater channels into the park
6.2	Braai areas	R 100 000	10 small braai areas
6.3	Out door play equipment	R 80 000	10 pieces of equipment
6.4	Outdoor gym equipment	R 120 000	9 different outdoor gym machines
6.5	Outdoor gym flooring	R 640 000	Rubber flooring
6.6	Concrete bench and tables	R 60 000	10 concrete tables with benches
6.7	Trees and shrubs	R 1 150 000	Number of indigenous trees planted around the park area
6.8	Landscaping	R 500 000	General landscaping in and around miscellaneous areas
6.9	Signage	R 20 000	Signage in and around park area
Subtotal HGM 7.1 - Channelled valley bottom		R 7 032 050	
HGM 7.1 (Channelled valley bottom)			
1	Fence of Agri park		Palisade fence is costed for with 24 entrances to the park
1.1	Palisade fence 1.8m bolt on application	R 1 600 000	Fence in park area
1.2	Palisade pedestrian gates	R 105 600	Palisade gates pedestrian
1.3	Palisade car gates	R 95 700	Palisade car gate 3m wide
2	Shape and level area around Agri Park		
2.1	Clear and grub	R 666 000	General clearing of the area around the park
2.2	Level and shape	R 1 650 000	

3	Pedestrian walkways Agri Park			
3.1	Bricked walkways	R	900 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R	577 500	
4	Waste management Agri Park			
4.1	Bins concrete	R	75 000	Bins scattered in and around park area
4.2	Waste management area	R	240 000	A dedicated waste management area. Paved area with place for 2 large skips
5	Agri Park miscellaneous			
5.1	Stormwater infrastructure	R	1 050 000	Formalised stormwater channels into the park
5.2	Concrete bench and tables	R	30 000	10 concrete tables with benches
5.3	Paved area for fresh good market	R	270 000	Paved area for fresh food market
5.4	Trees and shrubs	R	1 150 000	Number of indigenous tress planted around the park area
5.5	Landscaping	R	1 000 000	General landscaping in and around miscellaneous areas
5.6	Signage	R	60 000	Signage in and around park area
	Subtotal HGM 7.1 - Channelled valley bottom	R	9 469 800	
	Total Zone 7	R	16 501 850	
1	Additional allowances			
1.1	Preliminaries and general	R	4 125 463	Assume 25% of Total Zone 1
1.2	Contingencies	R	4 950 555	Assume 30% of Total Zone 1
	Subtotal 3 - Additional allowances	R	9 076 018	
	GRAND TOTAL	R	25 600 000	
-20%	LOWER RANGE	R	20 500 000	
+30%	UPPER RANGE	R	33 300 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
HARD INTERVENTIONS**

Site Name: Kaalspruit Catchment Zone 1

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
HGM 1.3 (Channelled valley bottom)			
1	Pedestrian crossing and wetland structure		Weir with walkway P16
1.1	Clear and grub	R 6 500	
1.2	Bulk excavations	R 56 000	
1.3	Concrete, reinforcing and formwork	R 600 000	
1.4	Berms with MacMat	R 16 000	Rate include anchor trench for MacMat
1.5	Reestablishment of vegetation	R 80 000	
1.6	Metal grate	R 5 000	
1.7	Hand rail	R 20 000	
1.8	Signage	R 20 000	
2	Additional weir structures		additional weir structures P17
2.1	Clear and grub	R 3 250	
2.2	Bulk excavations	R 44 800	
2.3	Concrete, reinforcing and formwork	R 375 000	
2.4	Berms with MacMat	R 16 000	Rate include anchor trench for MacMat
2.5	Reestablishment of vegetation	R 4 000	
2.6	Signage	R 15 000	
3	Maintenance on current instream structures		5 instream structure need additional maintenance
3.1	Clear and grub	R 3 250	
3.2	Bulk excavations	R 56 000	
3.3	Concrete	R 44 000	Gabion structure must be concrete capped
3.4	Concrete, reinforcing and formwork	R 1 125 000	structures need to be enlarged water is cutting around structures
3.5	Berms with MacMat	R 40 000	Add berms on either side of concrete structures
3.6	Reestablishment of vegetation	R 4 000	
3.7	Signage	R 25 000	
4	Formalise channel		
4.1	Clear and grub	R 487 500	
4.2	General levelling and shaping	R 5 148 000	
Subtotal HGM 1.3 - Channel valley bottom		R 8 194 300	
HGM 1.4 (Channel valley bottom)			
1	Formalise stormwater channel into wetland		
1.1	Clear and grub	R 20 475	
1.2	General levelling and shaping	R 207 900	
1.3	Restricted excavations for anchor trench	R 23 520	

1.4	Supply and install Armoflex	R	289 800	
1.5	Dissipation energy rocks	R	57 500	
1.6	Reestablishment of vegetation	R	25 200	
2	Additional weir structures			additional weir structures P9 to P15
2.1	Clear and grub	R	22 750	
2.2	Bulk excavations	R	94 080	
2.3	Concrete, reinforcing and formwork	R	2 625 000	
2.4	Berms with MacMat	R	112 000	Rate include anchor trench for MacMat
2.5	Reestablishment of vegetation	R	28 000	
2.6	Signage	R	70 000	
	Subtotal HGM 1.4 - Channel valley bottom	R	3 576 225	
	HGM 1.5 (Channel valley bottom)			
1	Additional weir structures			additional weir structures P4 and P5
1.1	Clear and grub	R	6 500	
1.2	Bulk excavations	R	26 880	
1.3	Concrete, reinforcing and formwork	R	900 000	
1.4	Berms with MacMat	R	32 000	Rate include anchor trench for MacMat
1.5	Reestablishment of vegetation	R	8 000	
1.6	Signage	R	20 000	
2	Maintenance on current instream structures			3 instream structure need additional maintenance
2.1	Clear and grub	R	1 950	
2.2	Bulk excavations	R	20 160	
1.3	Concrete	R	105 600	Gabion structure must be concrete capped
1.4	Concrete, reinforcing and formwork	R	900 000	
1.5	Berms with MacMat	R	24 000	Add berms on either side of concrete structures
1.6	Reestablishment of vegetation	R	2 400	
1.7	Signage	R	30 000	
	Subtotal HGM 1.5 - Channel valley bottom	R	2 077 490	
	HGM 1.6 (Channel valley bottom)			
1	Maintenance on current instream structures			2 instream structure need additional maintenance
1.1	Clear and grub	R	1 300	
1.2	Bulk excavations	R	22 400	
1.3	Concrete	R	88 000	Gabion structure must be concrete capped
1.4	Concrete, reinforcing and formwork	R	600 000	structures need to be enlarged water is cutting around structures
1.5	Berms with MacMat	R	16 000	Add berms on either side of concrete structures
1.6	Reestablishment of vegetation	R	1 600	
1.7	Signage	R	20 000	
2	Formalise stormwater channel into wetland			11 stormwater entrances into the wetland system
2.1	Clear and grub	R	37 538	
2.2	General levelling and shaping	R	304 920	
2.3	Restricted excavations for anchor trench	R	43 120	
2.4	Supply and install Armoflex	R	531 300	
2.5	Dissipation energy rocks	R	80 500	
2.6	Reestablishment of vegetation	R	46 200	

3	Additional weir structures		additional weir structures P1 to P3
3.1	Clear and grub	R	9 750
3.2	Bulk excavations	R	40 320
3.3	Concrete, reinforcing and formwork	R	1 125 000
3.4	Berms with MacMat	R	48 000
			Rate include anchor trench for MacMat
3.5	Reestablishment of vegetation	R	12 000
3.6	Signage	R	30 000
	Subtotal HGM 1.6 - Channel valley bottom	R	3 057 948
	Total Zone 1	R	16 905 963
1	Additional allowances		
1.1	Preliminaries and general	R	4 226 491
			Assume 25% of sub total 1
1.2	Contingencies	R	5 071 789
			Assume 30% of sub total 1
	Subtotal 3 - Additional allowances	R	9 298 279
	GRAND TOTAL	R	26 200 000
-20%	LOWER RANGE	R	21 000 000
+30%	UPPER RANGE	R	34 100 000

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
HARD INTERVENTIONS**

Site Name: Kaalspruit Catchment Zone 2

Knowledge Base for Assessment

1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
	HGM 2.1 (Channelled valley bottom)		
1	Pedestrian crossing and wetland structure		1 pedestrian crossings
1.1	Clear and grub	R 650	
1.2	Bulk excavations	R 11 200	
1.3	Concrete, reinforcing and formwork	R 525 000	
1.4	Berms with MacMat	R 16 000	Rate include anchor trench for MacMat
1.5	Reestablishment of vegetation	R 800	
1.6	Signage	R 5 000	
2	Maintenance on current instream structures		1 large instream structure need additional maintenance
2.1	Clear and grub	R 10 156	
2.2	Bulk excavations	R 11 200	
2.3	Concrete	R 11 000	Gabion structure must be concrete capped
2.4	Concrete, reinforcing and formwork	R 150 000	1 structures need to be enlarged water is cutting around structures
2.5	Berms with MacMat	R 8 000	Add berms on either side of concrete structures
2.6	Reestablishment of vegetation	R 12 500	
2.7	Signage	R 5 000	
	Subtotal HGM 2.1 - Channel valley bottom	R 766 506	
	Total Zone 2	R 766 506	
1	Additional allowances		
1.1	Preliminaries and general	R 191 627	Assume 25% of sub total 1
1.2	Contingencies	R 229 952	Assume 30% of sub total 1
	Subtotal 3 - Additional allowances	R 421 578	
	GRAND TOTAL	R 1 200 000	
-20%	LOWER RANGE	R 1 000 000	
+30%	UPPER RANGE	R 1 600 000	

**CoE KAALSPRUIT CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
HARD INTERVENTIONS**

Site Name: Kaalspruit Catchment Zone 3

Knowledge Base for Assessment

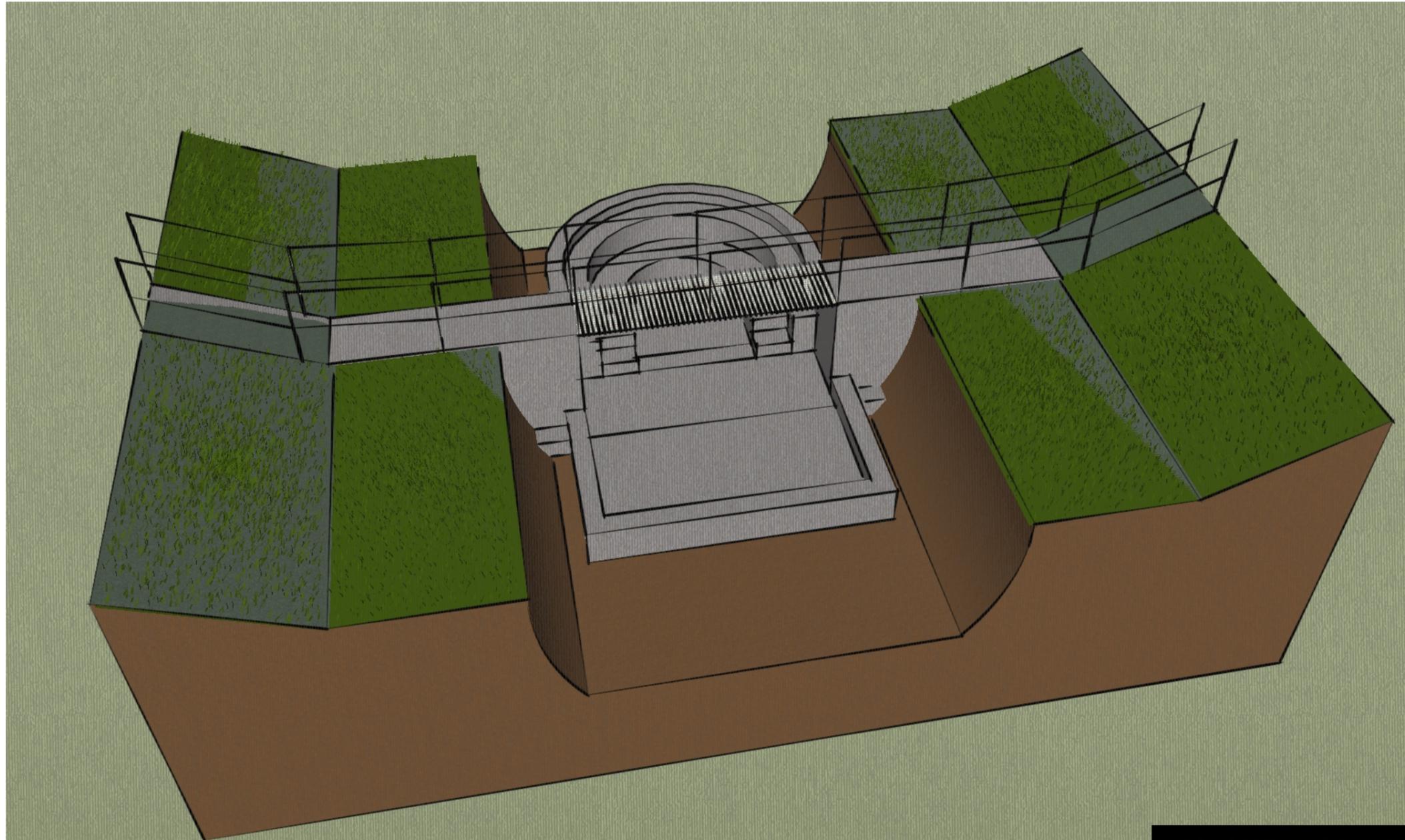
1. Google Earth imagery
2. Site Visit Conducted
3. Concept Level Design
4. DTM and aerial imagery

CONCEPT LEVEL REHABILITATION COSTS

No	Description	Total	Notes/Assumptions
	HGM 3.1 (Channelled valley bottom)		
1	Pedestrian crossing and wetland structure		1 pedestrian crossings
1.1	Clear and grub	R 650	
1.2	Bulk excavations	R 11 200	
1.3	Concrete, reinforcing and formwork	R 525 000	
1.4	Berms with MacMat	R 16 000	Rate include anchor trench for MacMat
1.5	Reestablishment of vegetation	R 800	
1.6	Signage	R 10 000	
2	Maintenance on current instream structures		1 large instream structure need additional maintenance
2.1	Clear and grub	R 10 156	
2.2	Bulk excavations	R 11 200	
2.3	Concrete	R 11 000	Gabion structure must be concrete capped
2.4	Concrete, reinforcing and formwork	R 300 000	1 structures need to be enlarged water is cutting around structures
2.5	Berms with MacMat	R 8 000	Add berms on either side of concrete structures
2.6	Reestablishment of vegetation	R 12 500	
2.7	Signage	R 10 000	
3	Formalise channel		
3.1	Clear and grub	R 585 000	
3.2	General levelling and shaping	R 4 752 000	
3.3	Restricted excavations for anchor trench	R 72 000	
3.4	Supply and install Armoflex	R 8 280 000	
3.5	Reestablishment of vegetation	R 720 000	
3.6	Structures to slow water velocity	R 750 000	
	Subtotal HGM 3.1 - Channel valley bottom	R 16 085 506	
	HGM 3.3 (Channelled valley bottom)		
1	Formalise channel		Formalise degraded channel
1.1	Clear and grub	R 390 000	
1.2	General levelling and shaping	R 3 696 000	
1.3	Restricted excavations for anchor trench	R 48 000	
1.4	Supply and install Armoflex	R 5 520 000	
1.5	Reestablishment of vegetation	R 480 000	
1.6	Structures to slow water velocity	R 1 500 000	
	Subtotal HGM 3.3 - Channel valley bottom	R 11 634 000	
	Total Zone 3	R 27 719 506	
	1 Additional allowances		
1.1	Preliminaries and general	R 6 929 877	Assume 25% of sub total 1
1.2	Contingencies	R 8 315 852	Assume 30% of sub total 1
	Subtotal 3 - Additional allowances	R 15 245 728	

GRAND TOTAL	R	43 000 000
-20% LOWER RANGE	R	34 400 000
+30% UPPER RANGE	R	55 900 000

KAALSPRUIT CATCHMENT CONCEPTUAL ENGINEERING DRAWINGS CITY OF EKURHULENI



CONCEPTUAL DRAWING

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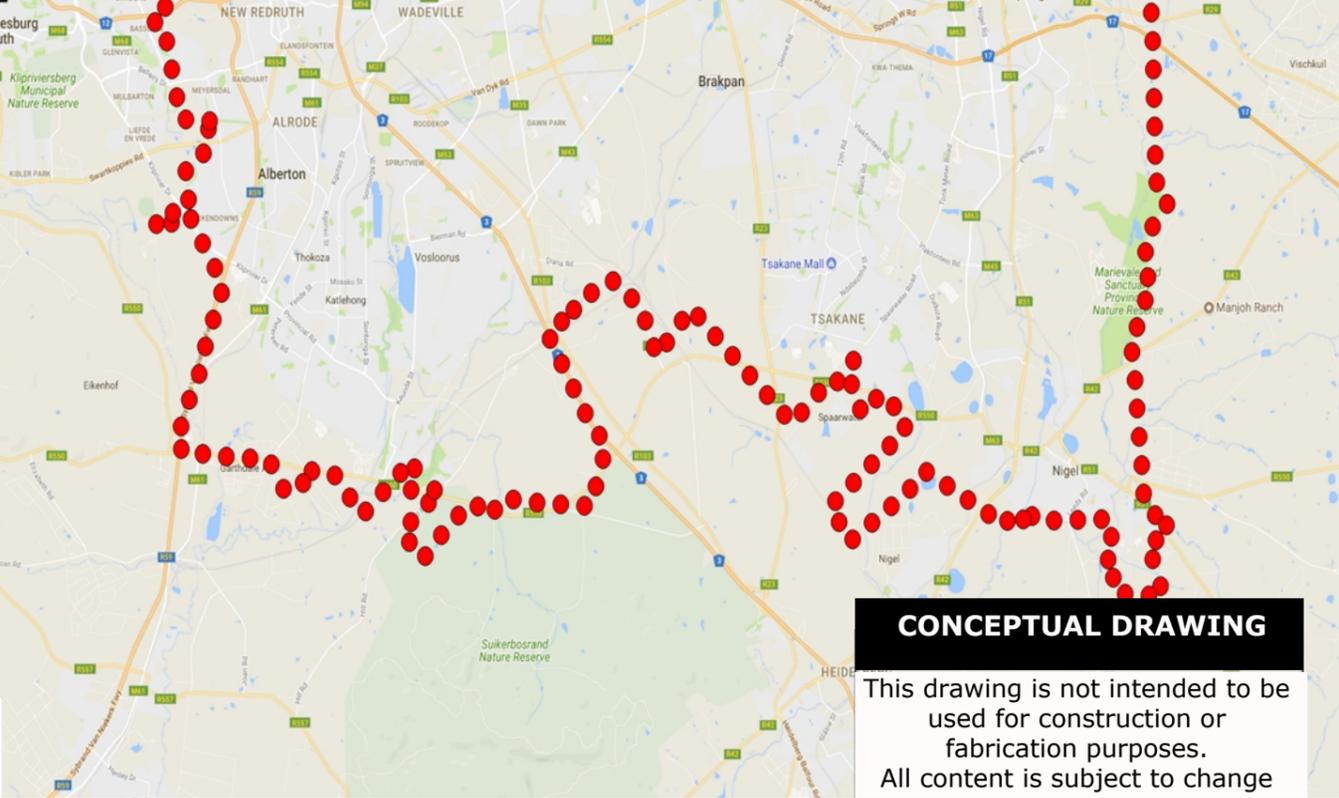
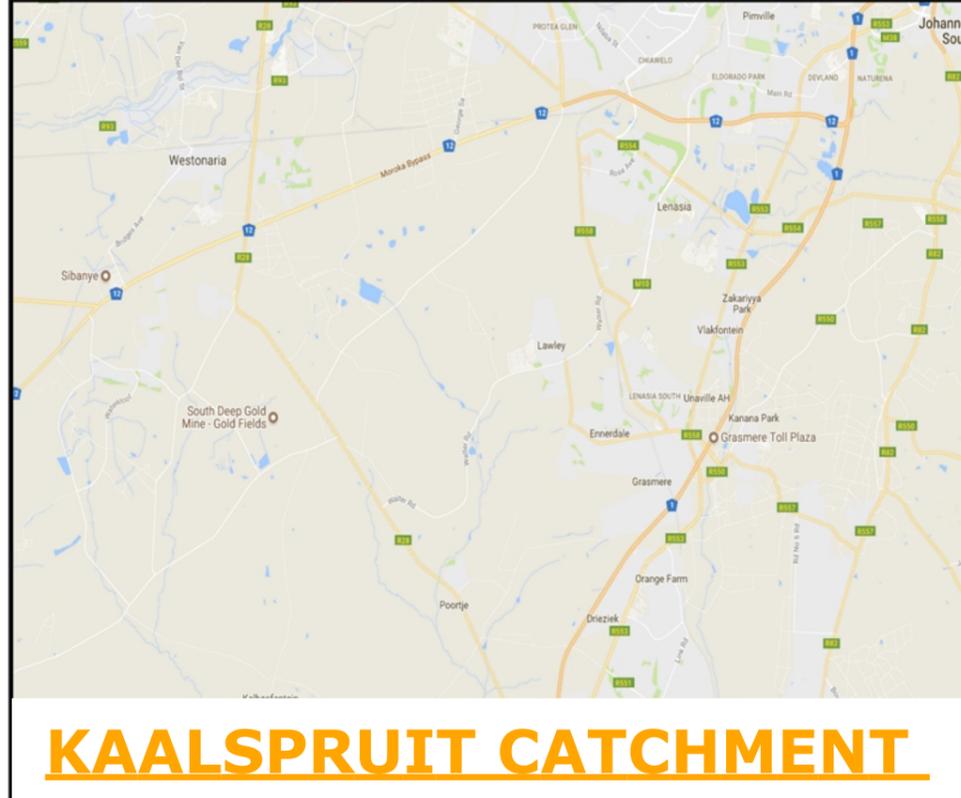
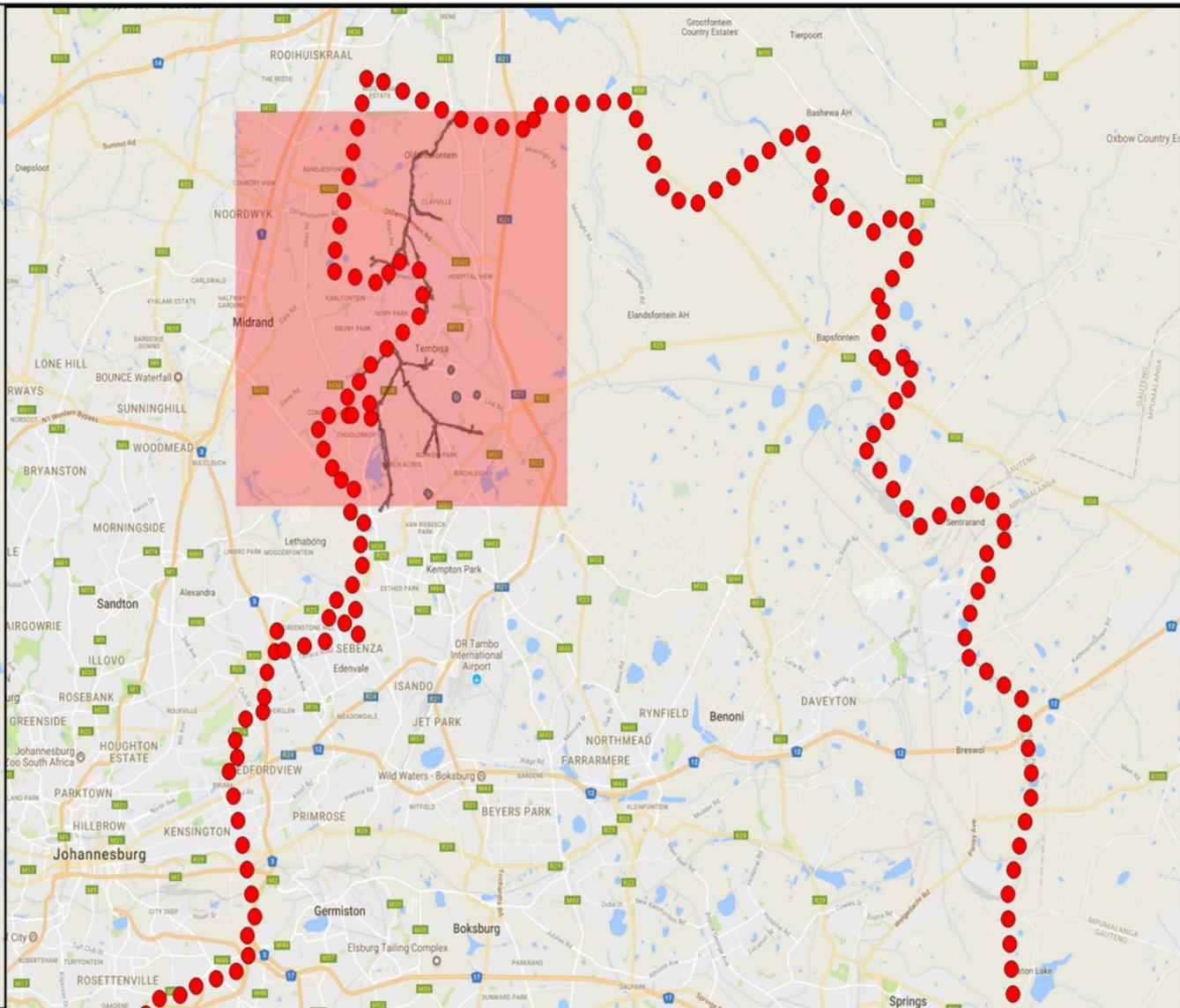
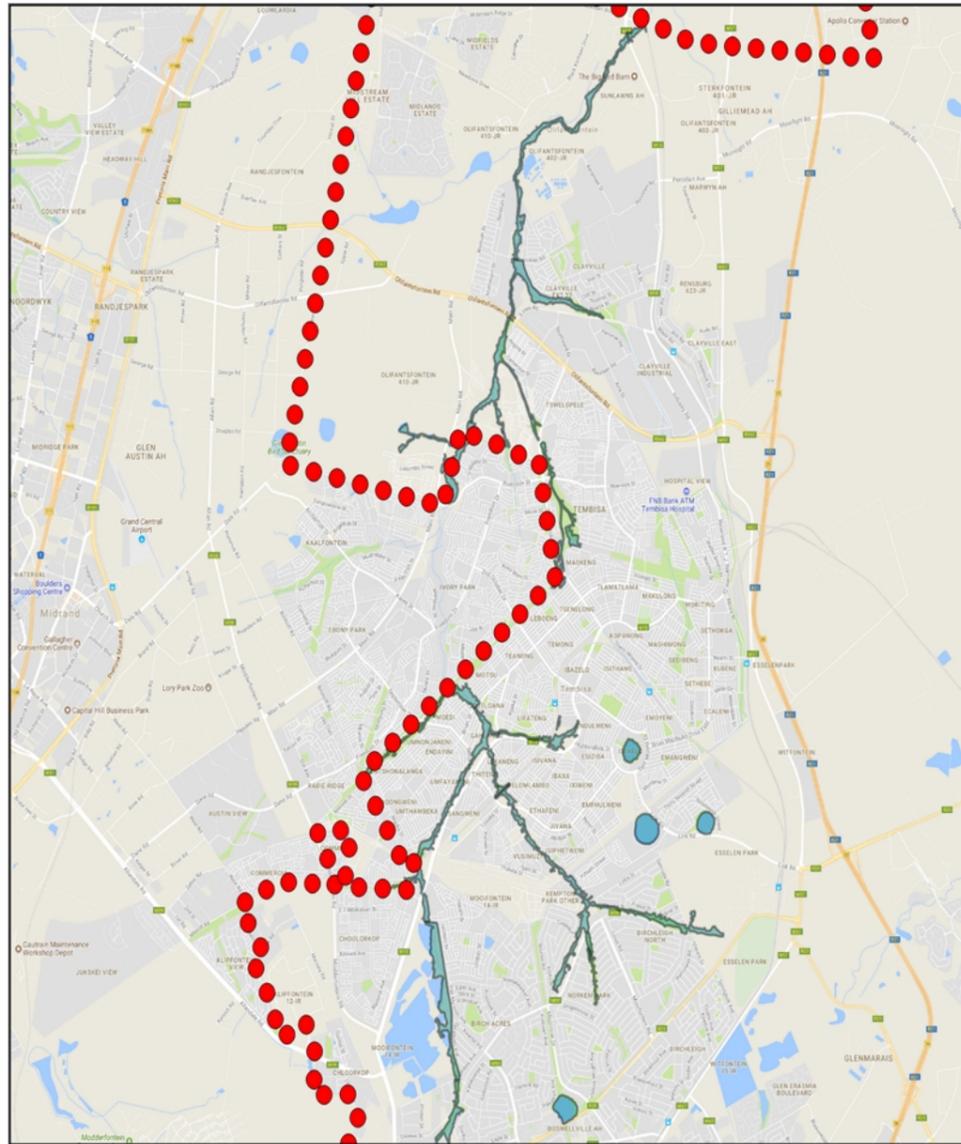
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Cover Page

July 13, 2018

A.01



KAALSPRUIT CATCHMENT

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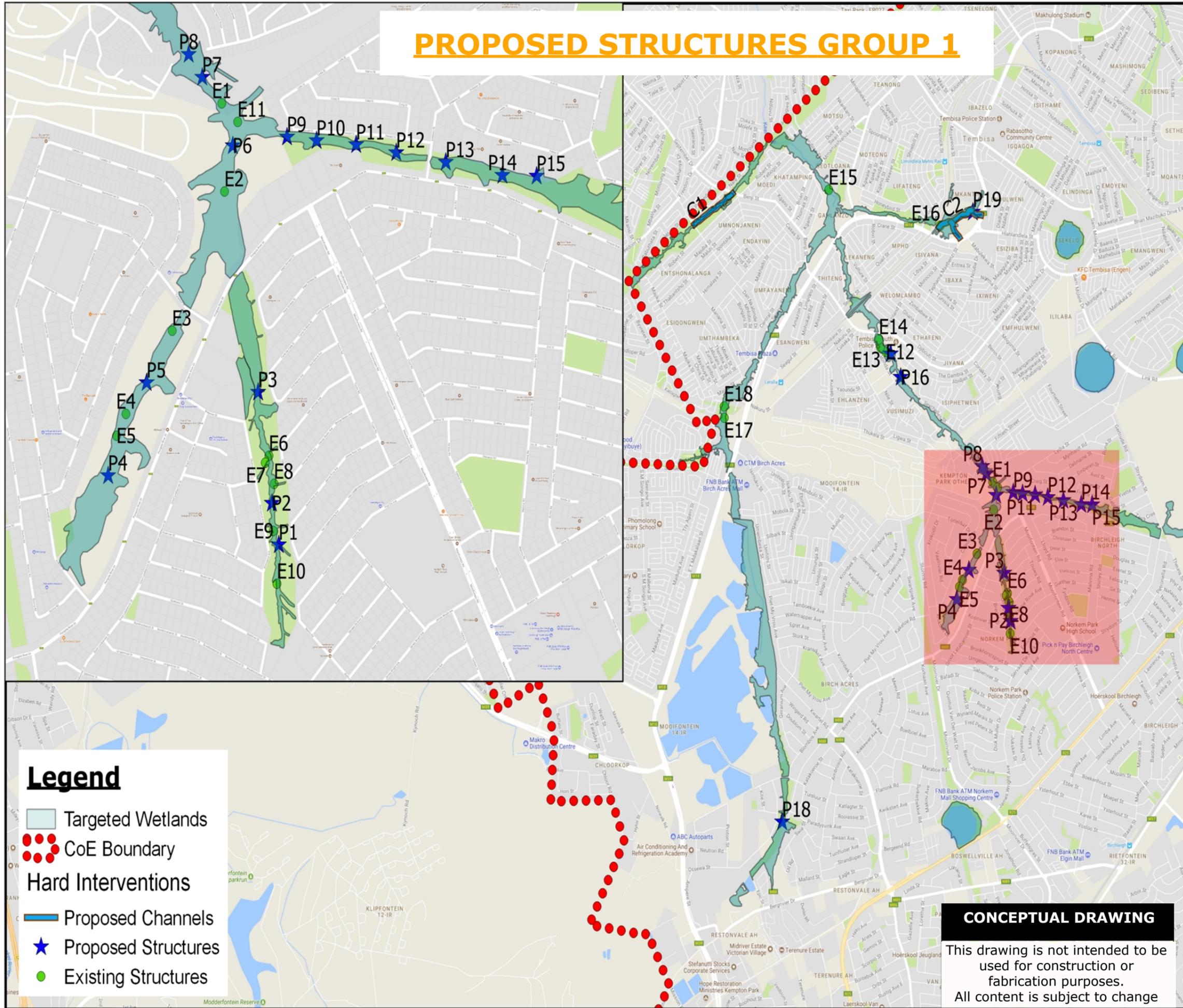


General Arrangement

July 13, 2018

A1.01

PROPOSED STRUCTURES GROUP 1



Legend

- Targeted Wetlands
- CoE Boundary
- Proposed Channels
- Proposed Structures
- Existing Structures

CONCEPTUAL DRAWING

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Proposed and Existing
Structures Group 1
 July 13, 2018

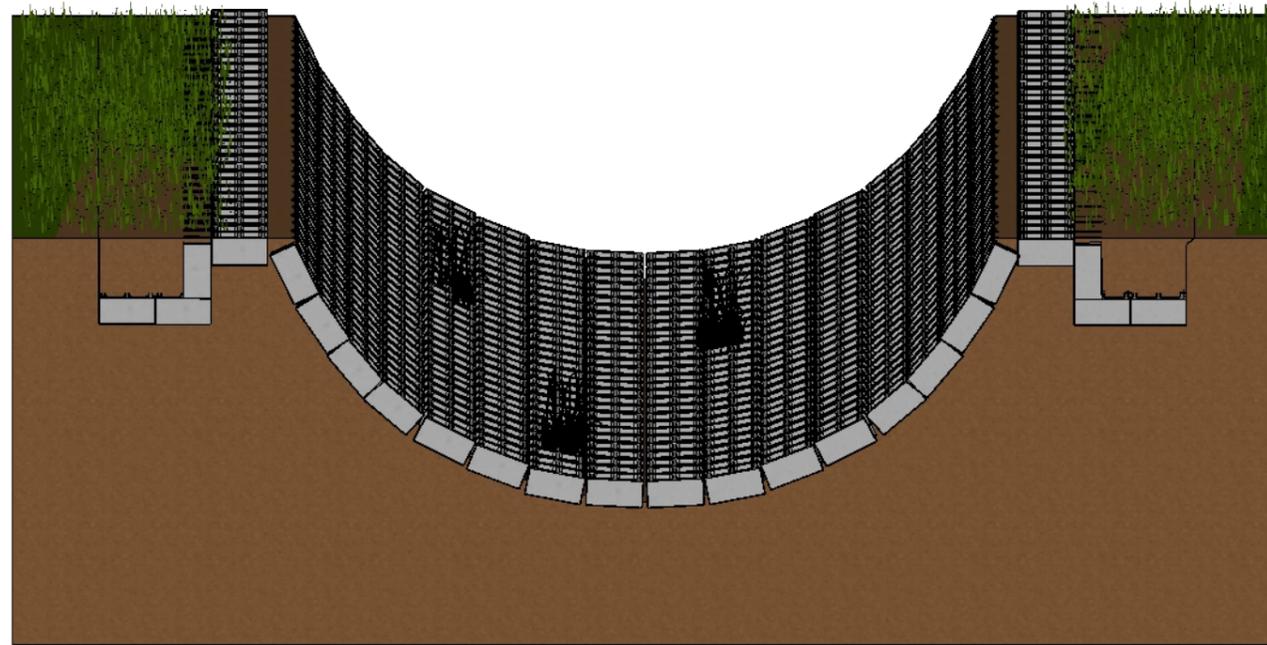
A2.01

ARMORFLEX AND OR MACMAT CHANNEL

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P1	-26.048820	28.221608	65

Notes:

All the stormwater channels entering the main wetland systems should be formalise to Armorflex channels. Sufficient energy dissipation measure should be constructed before stormwater enters the wetland system. Design connecting the current stormwater outlet and the Armorflex channel should be carefully considered.



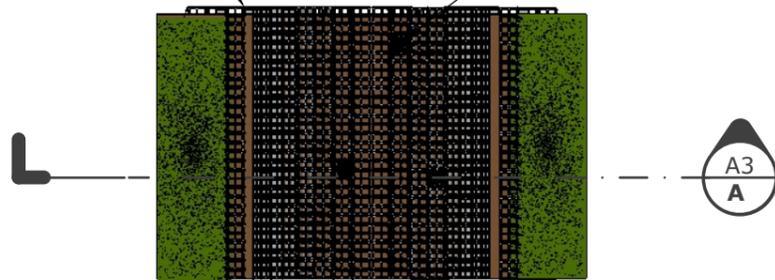
ARMORFLEX CHANNEL

scale: 1:50



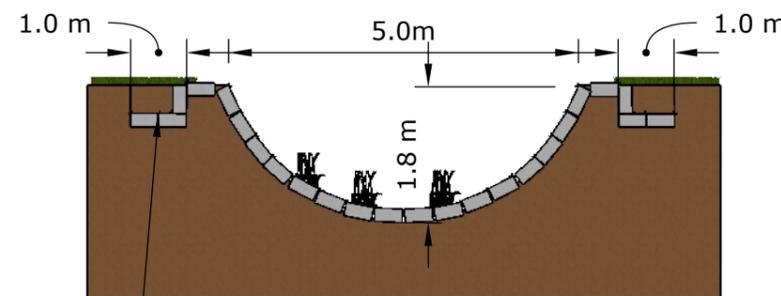
Channel length is approximately 60m

Armorflex block should be seeded



PLAN VIEW

scale: 1:100



CROSS SECTION

scale: 1:100



Anchor trench to be filled with cement stabilised soil and compacted at 95% MOD AASHTO

CONCEPTUAL DRAWING

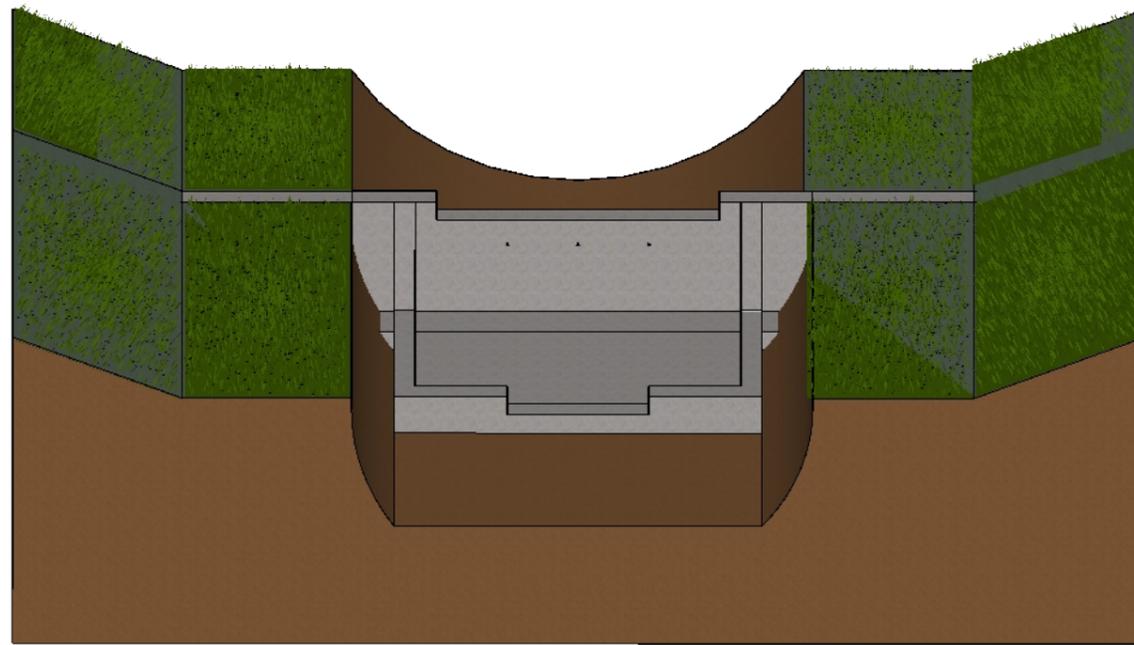
This drawing is not intended to be used for construction or fabrication purposes. All content is subject to change

CONCRETE WEIR

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P2	-26.047747	28.221371	16
P11	-26.038467	28.224276	20
P12	-26.038675	28.225659	20
P13	-26.038922	28.227367	20
P15	-26.039281	28.230501	16

Notes:

These weirs are not designed for low water pedestrian walkway. Please note that in high flows the water is designed to move over the entire structure and at such time the walkways will not be safe to use. Clear signage should be installed to highlight this. Structure can be optimised during the detailed engineering design phase of the project. Concrete weirs will need to be scaled for each individual point. These sizes should be confirmed in the detailed design.

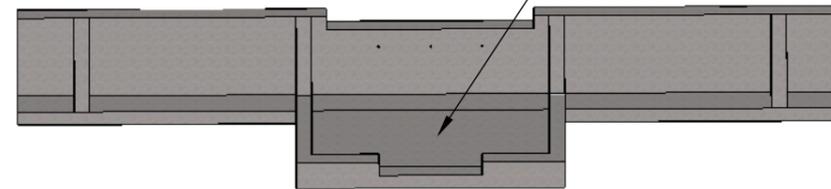


CONCRETE WEIR

scale: 1:100

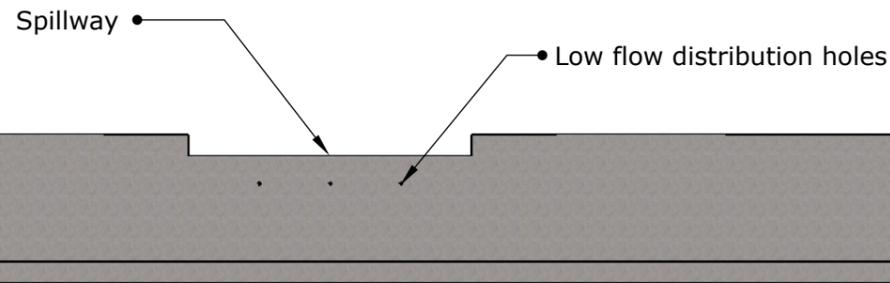


Plunge pool to help dissipate energy



CONCRETE VIEW

scale: 1:NA

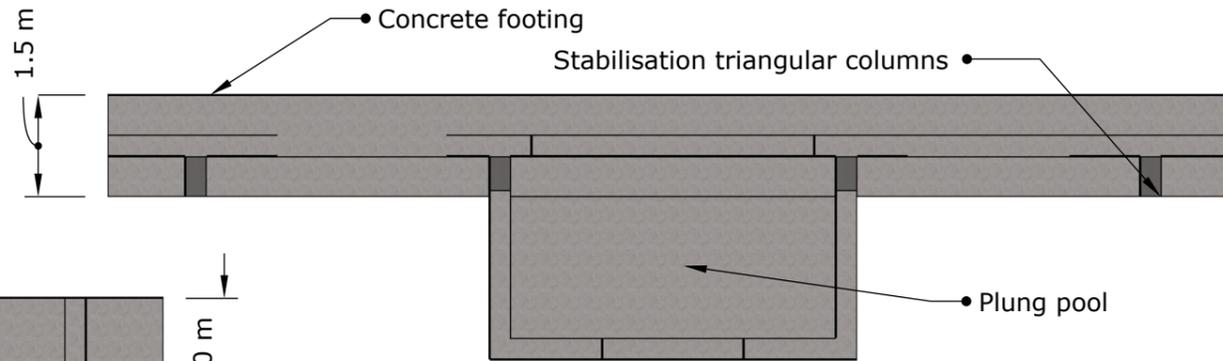


CROSS SECTION (UPSTREAM)

scale: 1:100

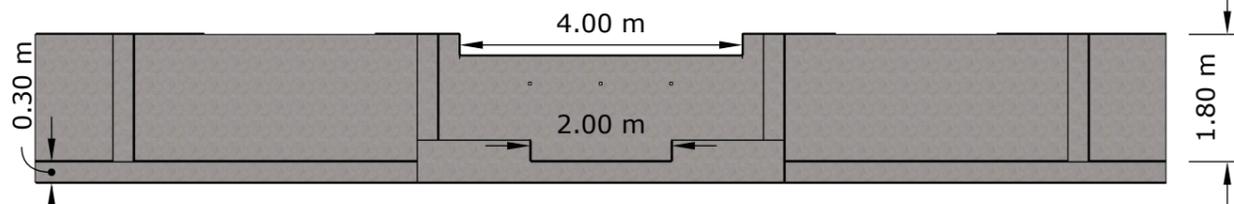


Footing foundation needs to be confirmed by geotechnical engineer



PLAN VIEW

scale: 1:100



CROSS SECTION (DOWNSTREAM)

scale: 1:100



CONCEPTUAL DRAWING

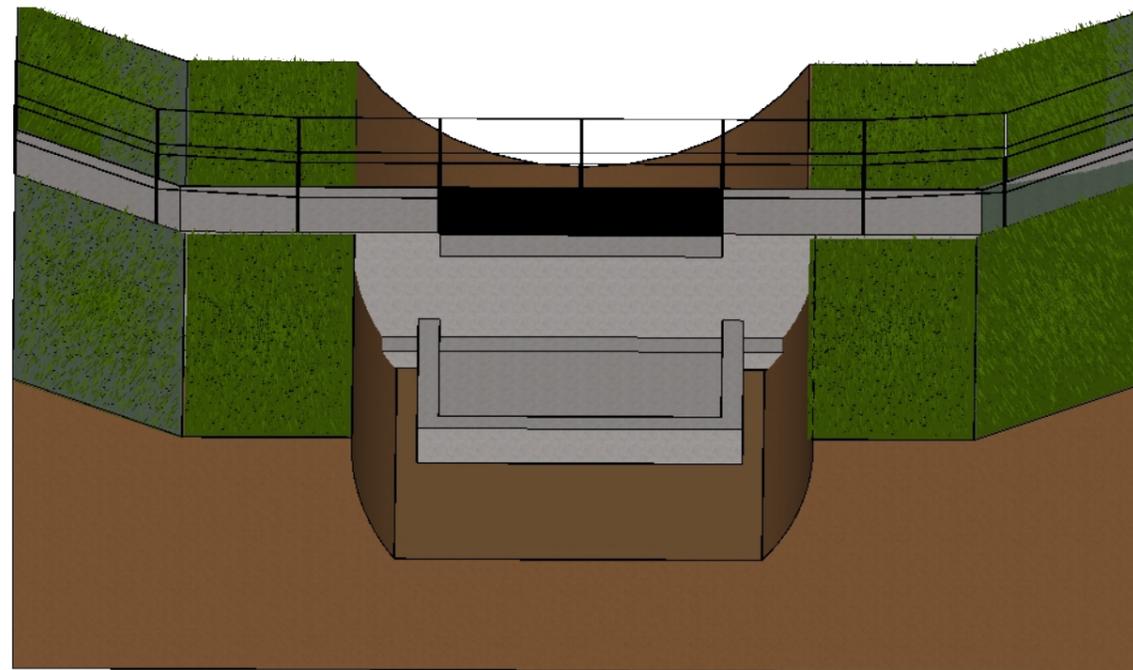
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CONCRETE WEIR WITH WALKWAY

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P3	-26.044872	28.220895	25
P4	-26.047032	28.215723	16
P5	-26.044625	28.217050	16
P14	-26.039260	28.229319	20

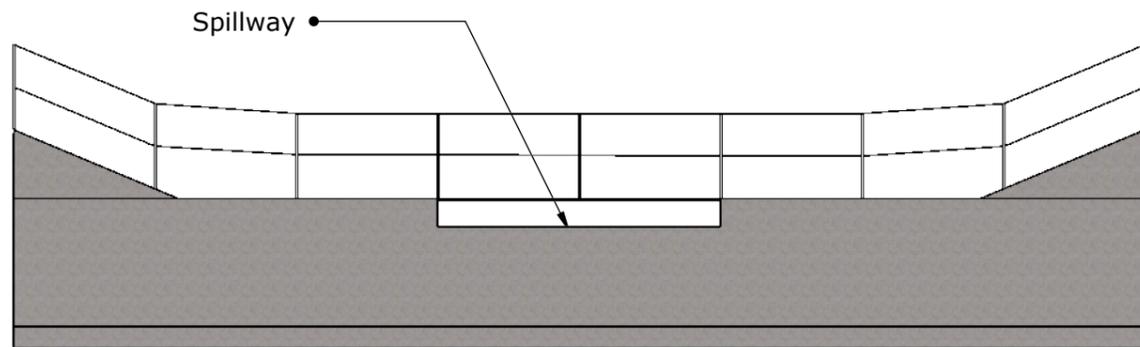
Notes:

All Concrete weir doubles up as a low water pedestrian walkway. Please note that in high flows the water is designed to move over the entire structure and at such time the walkways will not be safe to use. Clear signage should be installed to highlight this. Structure can be optimised during the detailed engineering design phase of the project. Concrete weirs will need to be scaled for each individual point. These sizes should be confirmed in the detailed design.



CONCRETE WEIR WITH WALKWAY

scale: 1:100

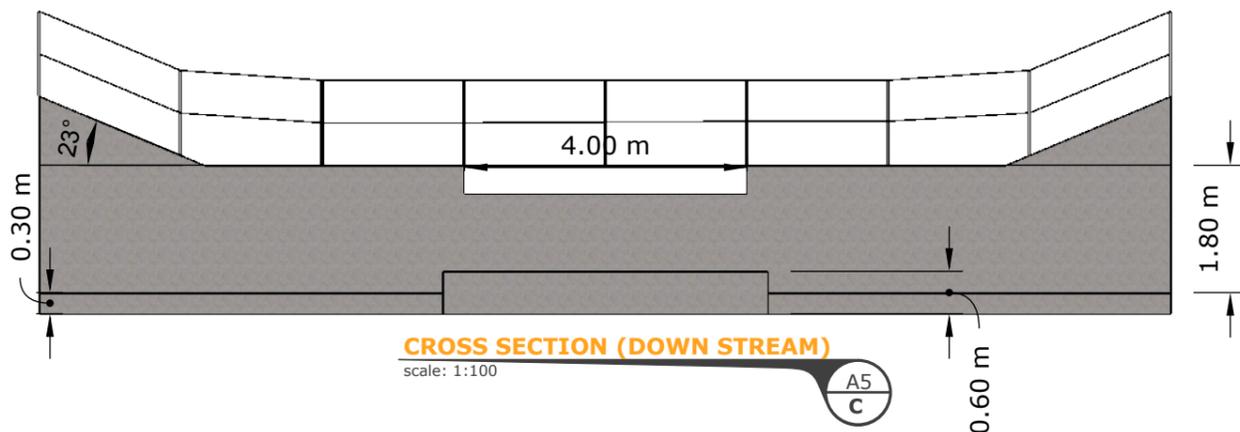


CROSS SECTION (UPSTREAM)

scale: 1:100

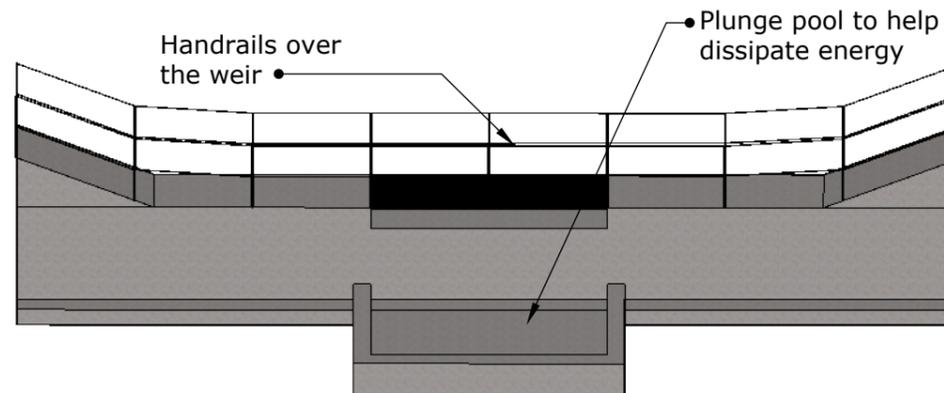


Footing foundation needs to be confirmed by geotechnical engineer



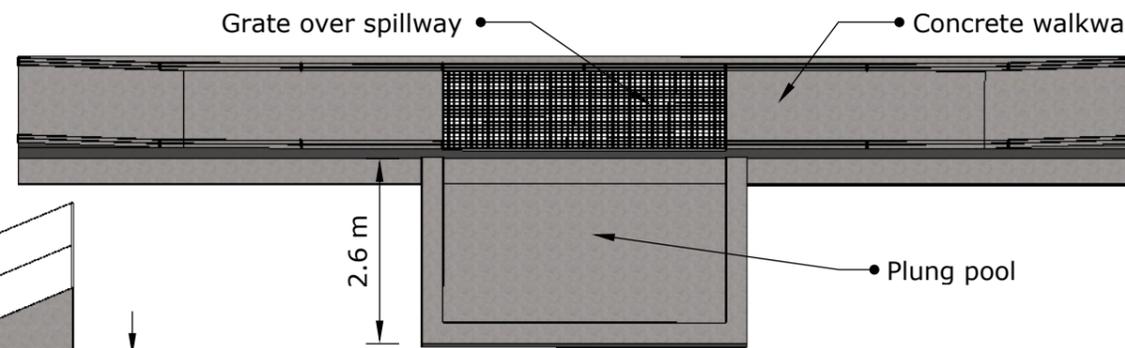
CROSS SECTION (DOWN STREAM)

scale: 1:100



CONCRETE VIEW

scale: 1:NA



PLAN VIEW

scale: 1:100



CONCEPTUAL DRAWING

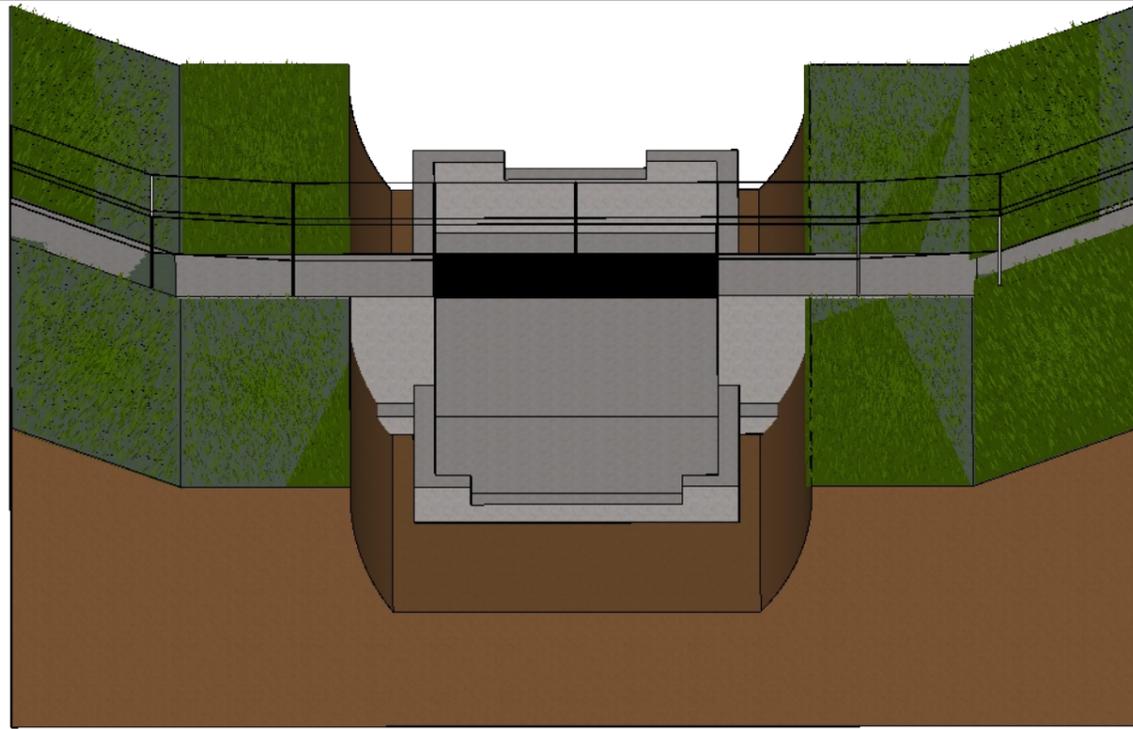
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CONCRETE WEIR WITH WALKWAY AND DROP INLET

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P6	-26.038496	28.220022	30
P7	-26.036724	28.218970	30
P8	-26.036132	28.218499	30
P9	-26.038270	28.221891	20
P10	-26.038363	28.222911	20

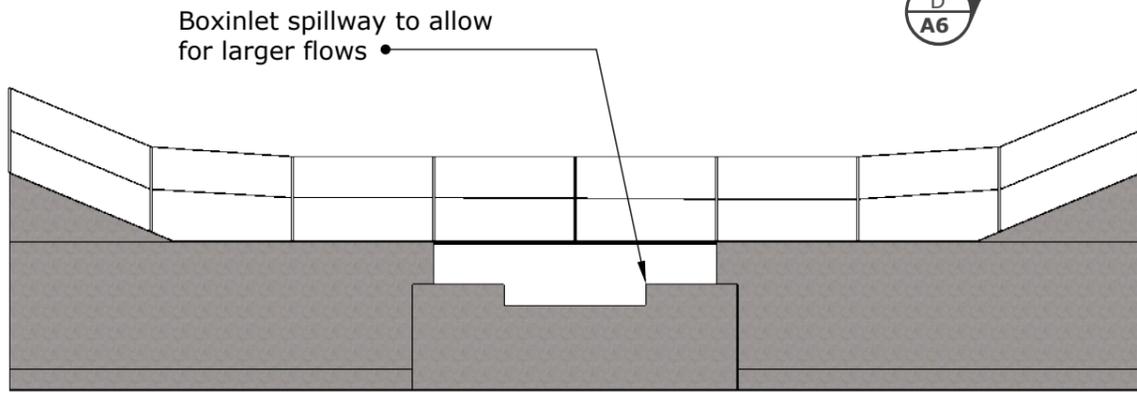
Notes:

All Concrete weir doubles up as a low water pedestrian walkway. Please note that in high flows the water is designed to move over the entire structure and at such time the walkways will not be safe to use. Clear signage should be installed to highlight this. Structure can be optimised during the detailed engineering design phase of the project. Concrete weirs will need to be scaled for each individual point. These sizes should be confirmed in the detailed design.



CONCRETE WEIR WITH WALKWAY

scale: 1:100

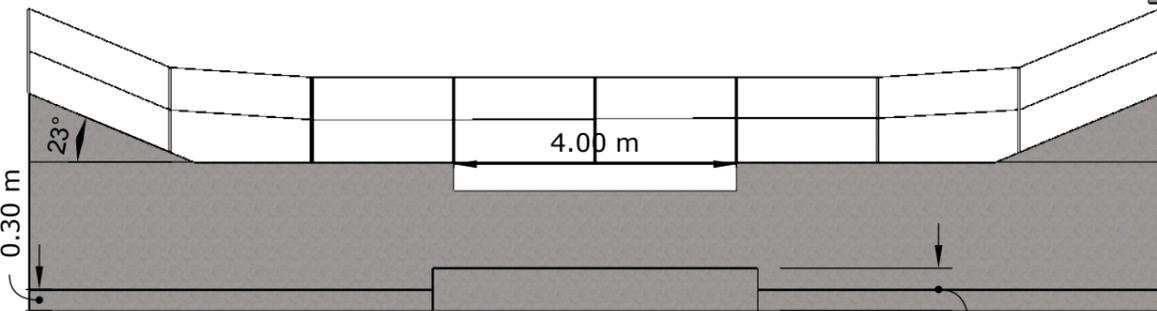


Boxinlet spillway to allow for larger flows

CROSS SECTION (UPSTREAM)

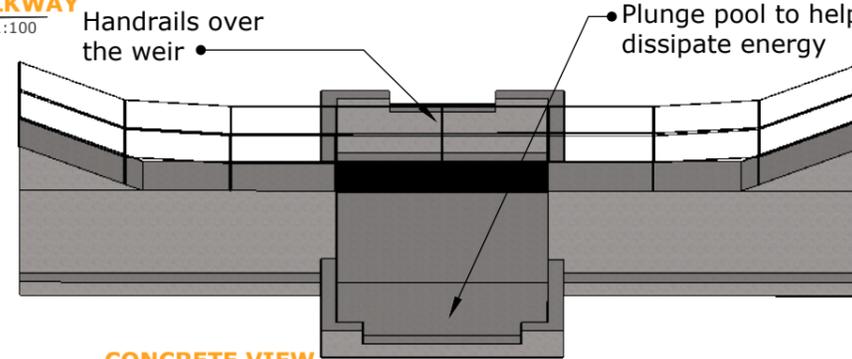
scale: 1:100

Footing foundation needs to be confirmed by geotechnical engineer



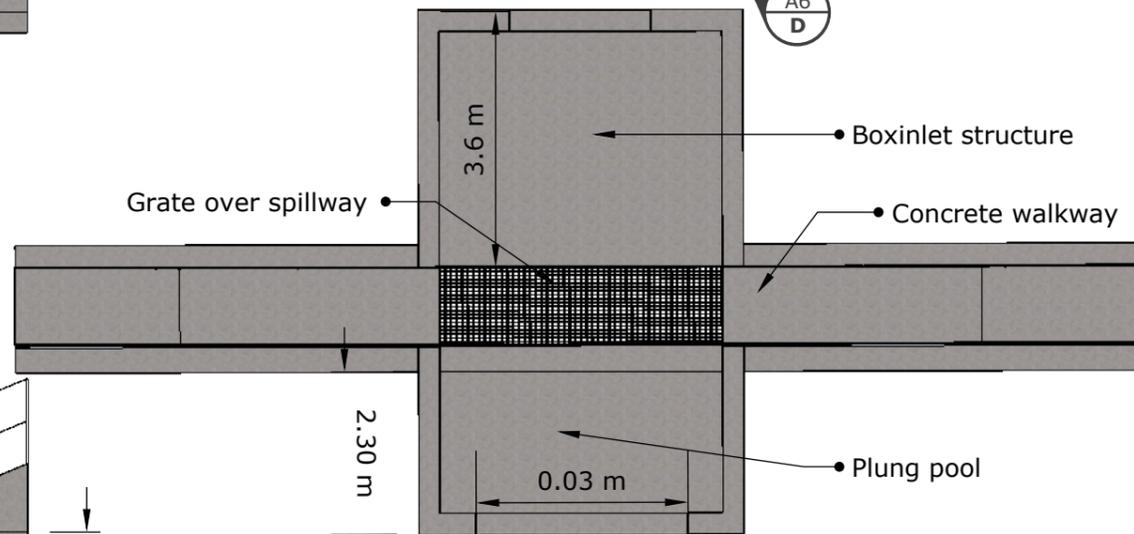
CROSS SECTION (DOWN STREAM)

scale: 1:100



CONCRETE VIEW

scale: 1:NA



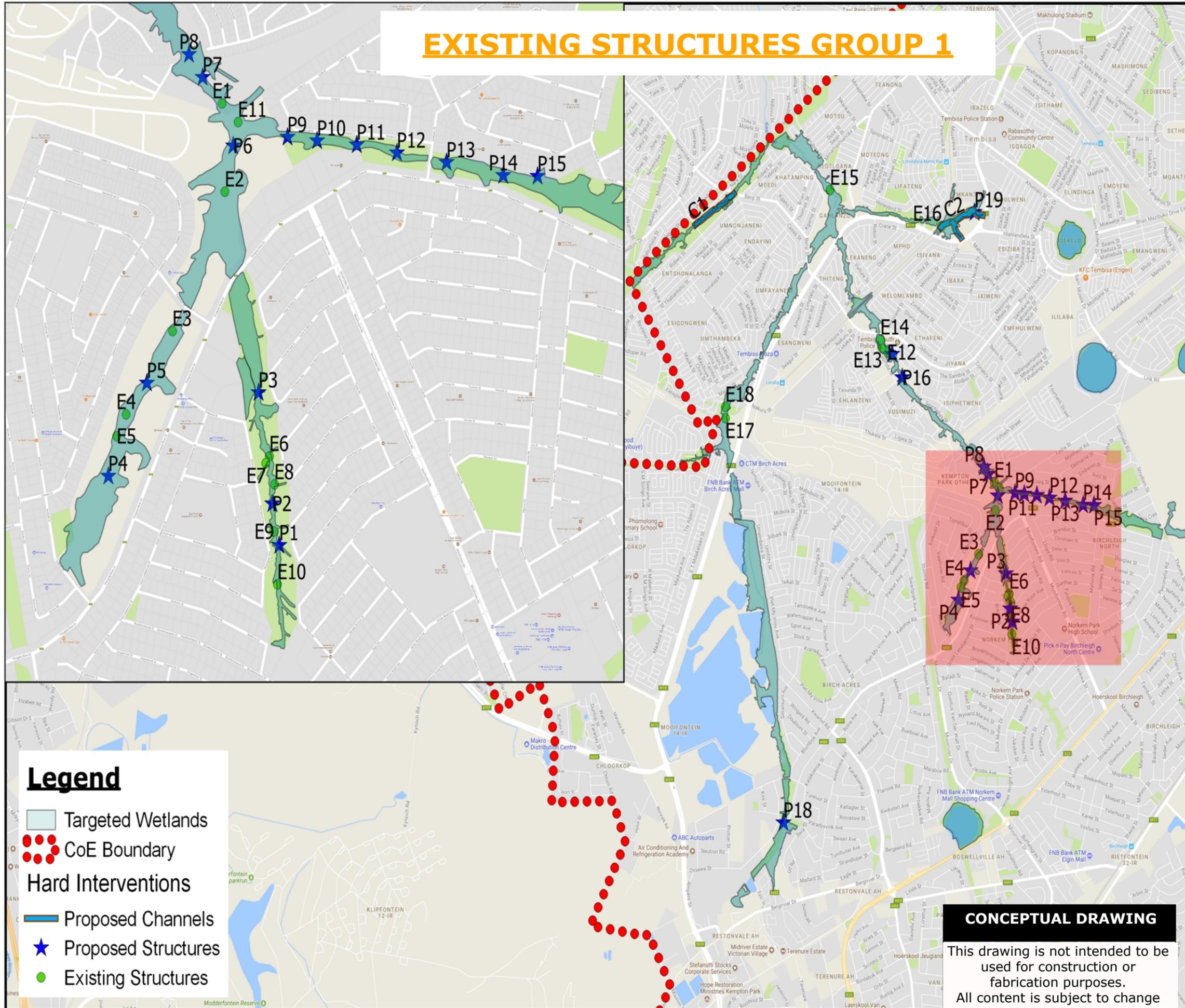
PLAN VIEW

scale: 1:100

CONCEPTUAL DRAWING

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EXISTING STRUCTURES GROUP 1



Legend

- Targeted Wetlands
- CoE Boundary
- Hard Interventions
- Proposed Channels
- Proposed Structures
- Existing Structures

CONCEPTUAL DRAWING

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Existing Structures
Group 1
 July 13, 2018

A7.01

EXISTING STRUCTURES MAINTENANCE GROUP 1



STRUCTURE	LATITUDE	LONGITUDE	COMMENT	MAINTENANCE
E1	-26.037398	28.219640	Concrete weir, good condition	Extend wingwall a further 10m with reinforced concrete wall
E2	-26.039679	28.219735	Large gabion structure, good condition	Cap gabions with concrete, add right wingwall further 10m
E3	-26.043281	28.217932	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on boths sides of structure
E4	-26.045433	28.216335	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on boths sides of structure
E5	-26.045998	28.216012	Gabion structure, fair condition	Concrete cap gabion baskets add wing walls 5m on boths sides of structure
E6	-26.046516	28.221269	Concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure
E7	-26.046697	28.221142	Gabion stormwater channel, poor condition	Replace gabions with Armoflex or MacMat channel
E8	-26.047243	28.221443	Gabion stormwater channel, poor condition	Replace gabions with Armoflex or MacMat channel
E9	-26.048462	28.221418	Concrete weir, poor condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure
E10	-26.049828	28.221544	Large gabion structure with walkway, fair condition	Concrete cap gabions as well as reinforce foundations
E11	-26.037877	28.220190	Concrete weir, poor condition	Extend wingwall a further 5m with reinforced concrete wall on both side structure

Notes:

All existing structure where designed by other consultants. In the next phase of the project detailed designs of the existing stuctures with the maintenance measure should be undertaken to get exact construction volumes. Not all intervencion could be found. Some areas had access issues and arge portion of intervention where never constructed.

CONCEPTUAL DRAWING

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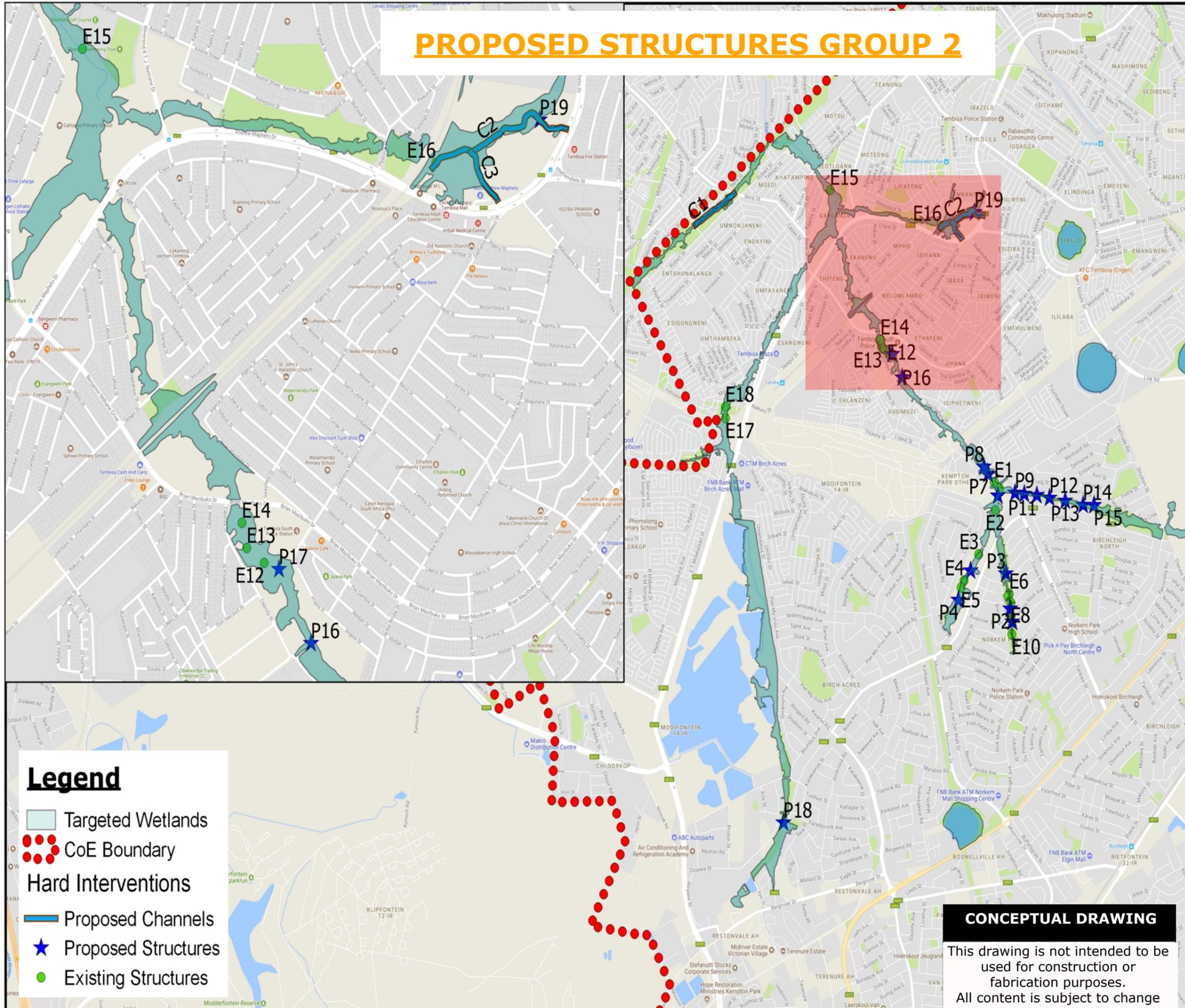
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Existing Structures
Maintenance Group 1
July 13, 2018

A8.01

PROPOSED STRUCTURES GROUP 2



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Proposed and Existing
Structures Group 2
 July 13, 2018

A9.01

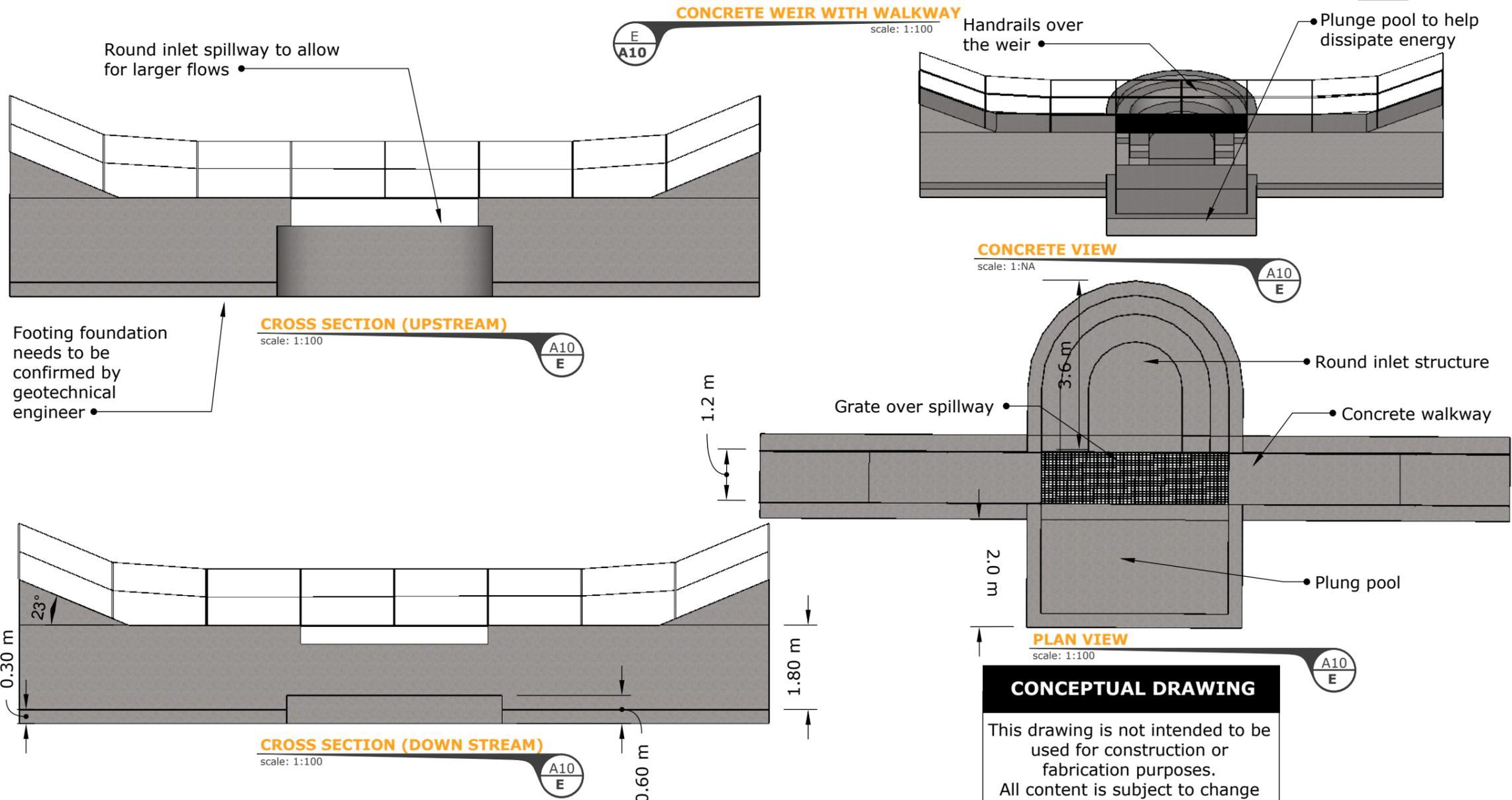
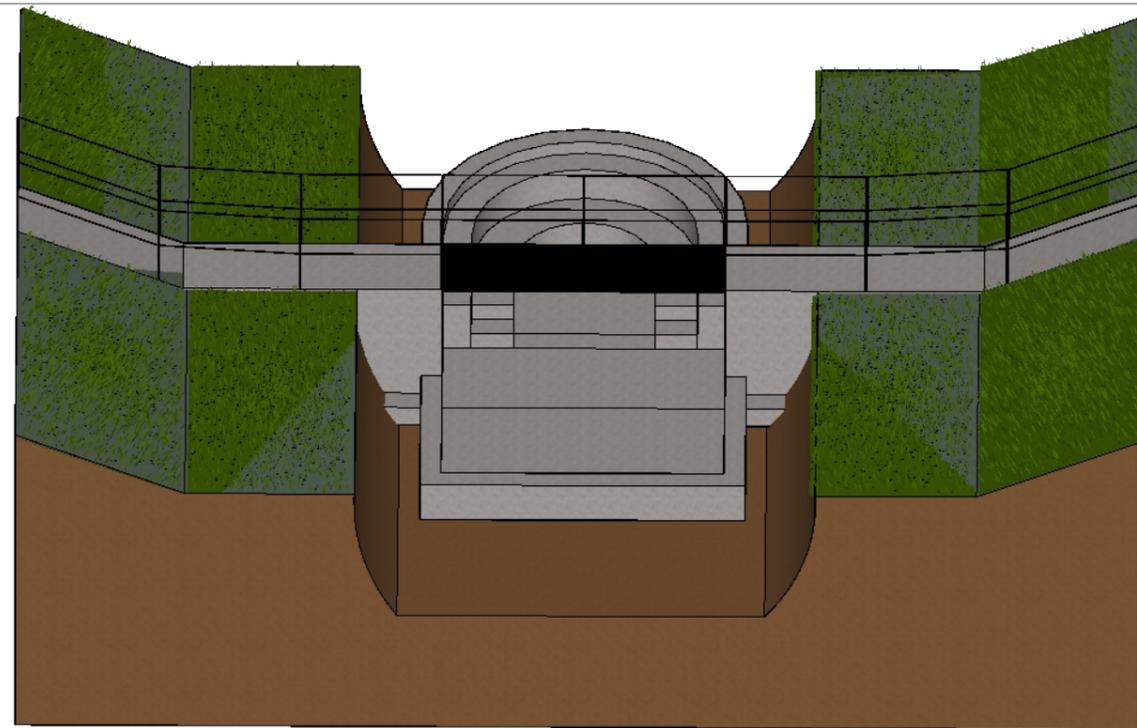
CONCEPTUAL DRAWING
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CONCRETE WEIR WITH WALKWAY AND ROUND DROP INLET

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P16	-26.028830	28.209602	30
P17	-26.026916	28.208499	30
P19	-26.015302	28.217478	30

Notes:

All Concrete weir doubles up as a low water pedestrian walkway. Please note that in high flows the water is designed to move over the entire structure and at such time the walkways will not be safe to use. Clear signage should be installed to highlight this. Structure can be optimised during the detailed engineering design phase of the project. Concrete weirs will need to be scaled for each individual point. These sizes should be confirmed in the detailed design.



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Proposed Structure
Group 2.1
July 13, 2018

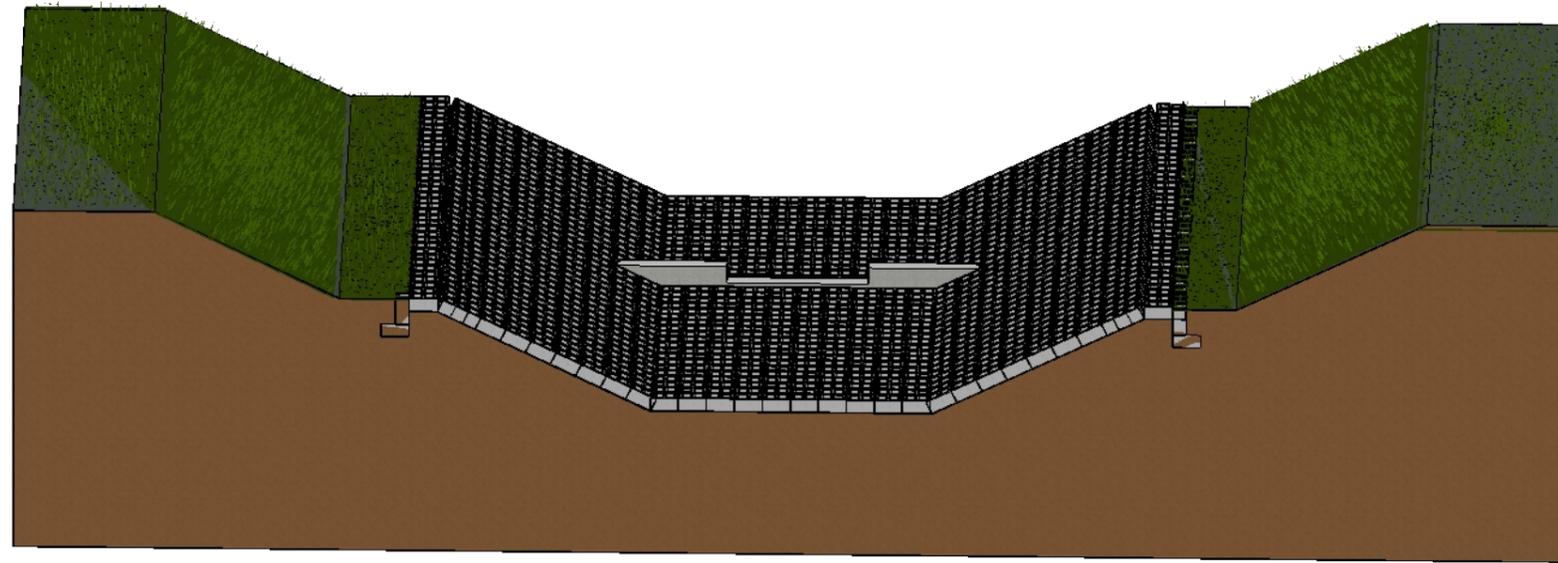
A10.01

ARMORFLEX AND OR MACMAT CHANNEL TWO STEPED LEVELS

STRUCTURE	LENGTH (m)
C2	600
C3	200

Notes:

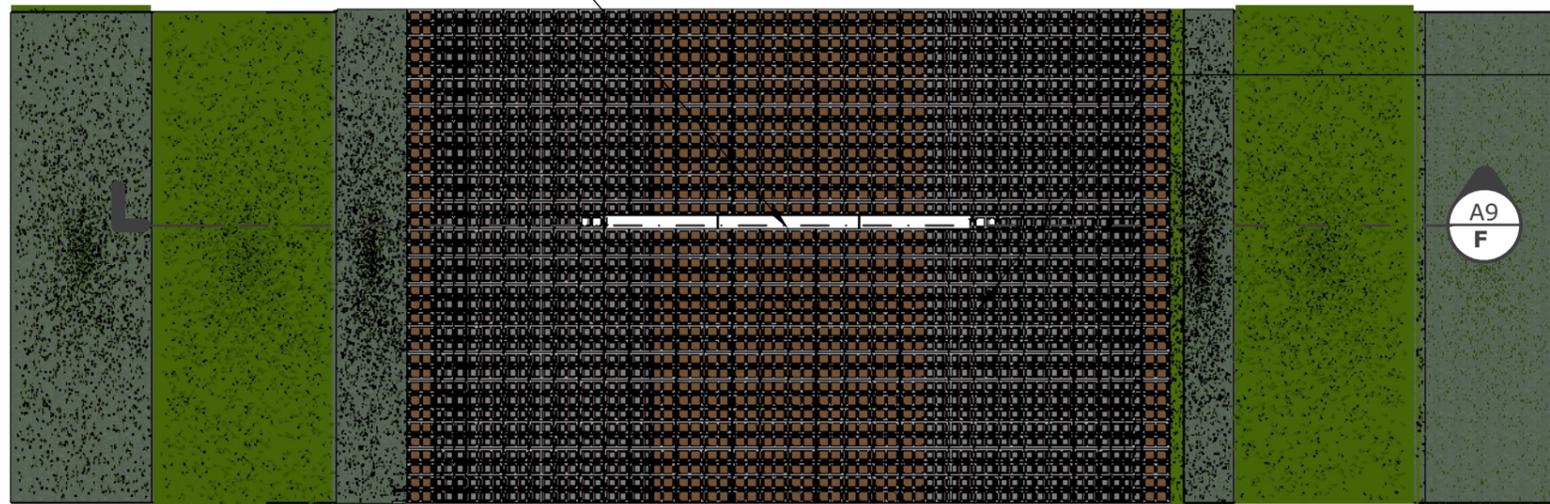
All the stormwater channels entering the main wetland systems should be formalise to Armorflex channels. Sufficient energy dissipation measure should be constructed before stormwater enters the wetland system.



ARMORFLEX CHANNEL

scale: 1:50

Small weirs to reduce flow velocity



Armorflex block should be seeded



CONCEPTUAL DRAWING

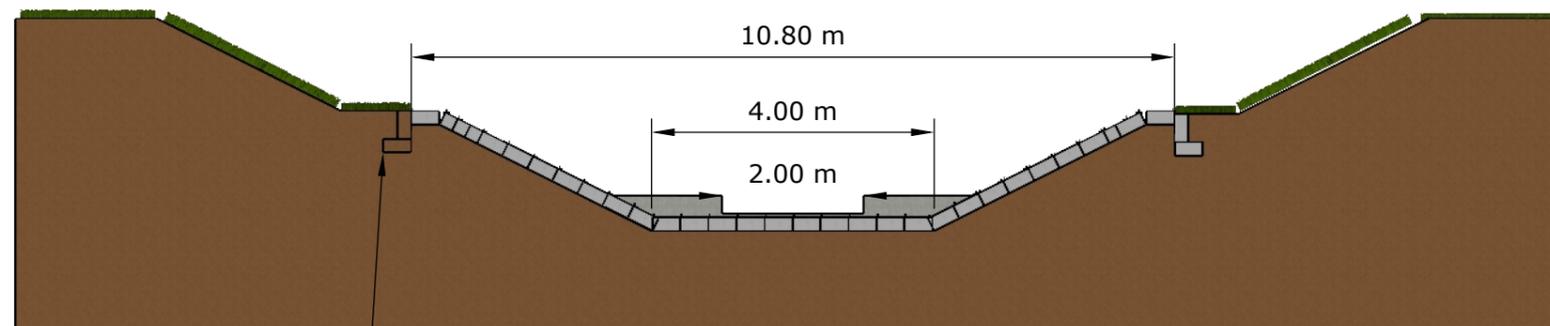
This drawing is not intended to be used for construction or fabrication purposes. All content is subject to change

PLAN VIEW

scale: 1:100



Anchor trench to be filled with cement stabilised soil and compacted at 95% MOD AASHTO



CROSS SECTION

scale: 1:100

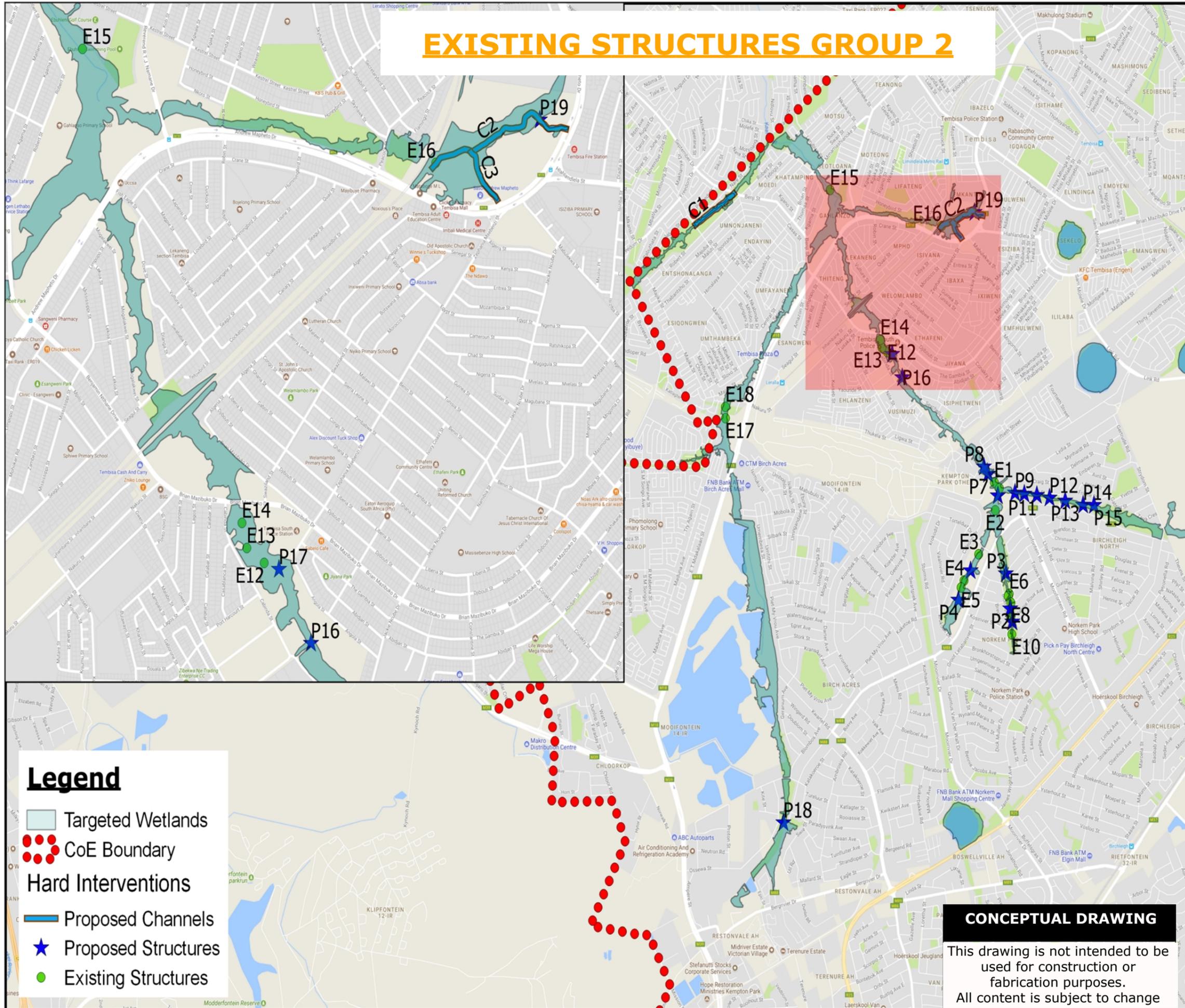


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Proposed Structure
Group 2.2
 July 13, 2018

EXISTING STRUCTURES GROUP 2



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Existing Structures
Group 2
 July 13, 2018

A12.01

EXISTING STRUCTURES MAINTENANCE GROUP 2

STRUCTURE	LATITUDE	LONGITUDE	COMMENT	MAINTENANCE
E12	-26.026751	28.207989	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E13	-26.026366	28.207391	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E14	-26.025717	28.207225	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on both sides of structure
E15	-26.013464	28.201733	Large low water crossing, fair condition	General concrete repairs

Notes:

All existing structure where designed by other consultants. In the next phase of the project detailed designs of the existing structures with the maintenance measure should be undertaken to get exact construction volumes. Not all intervention could be found. Some areas had access issues and large portion of intervention where never constructed.

CONCEPTUAL DRAWING

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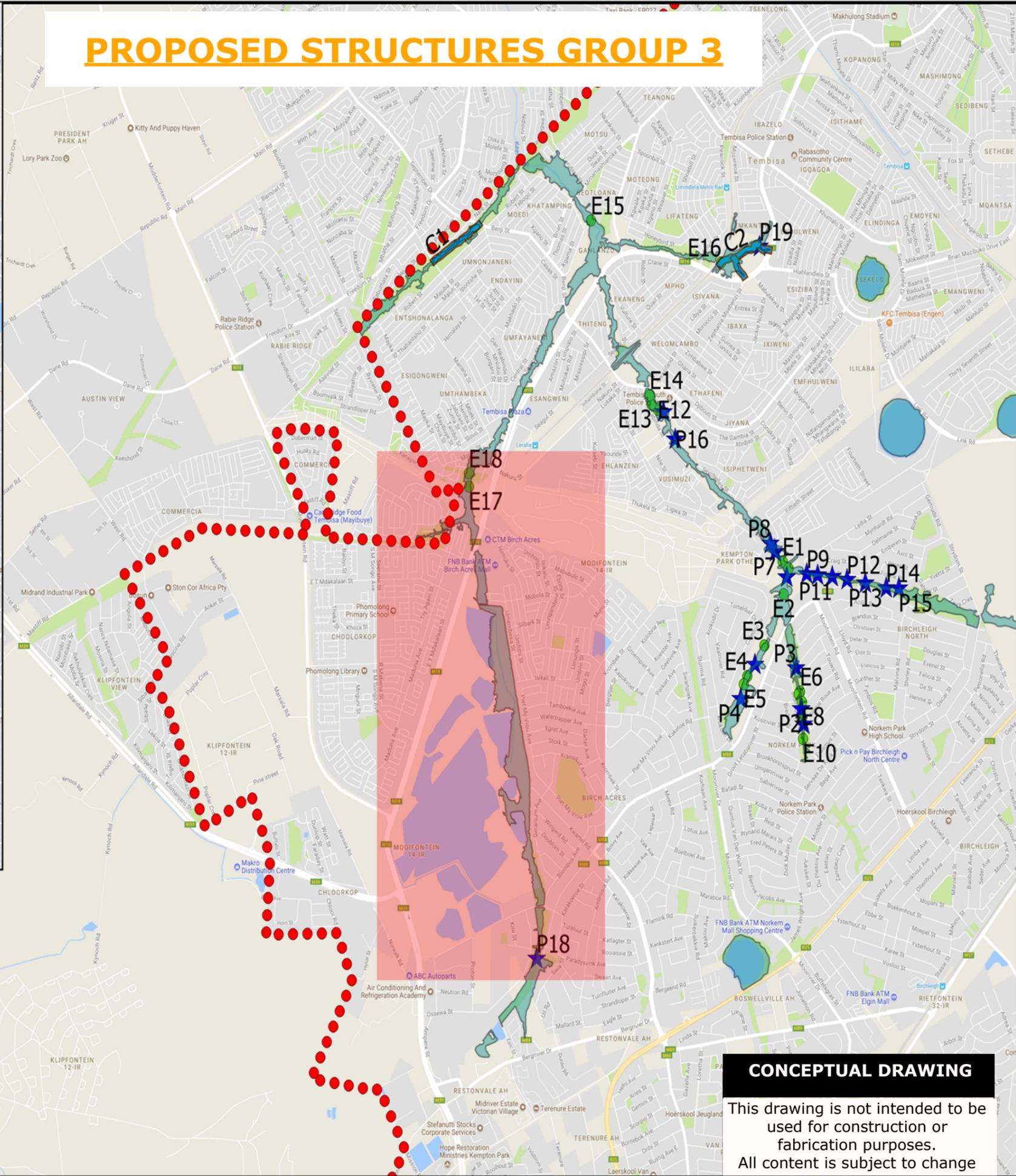
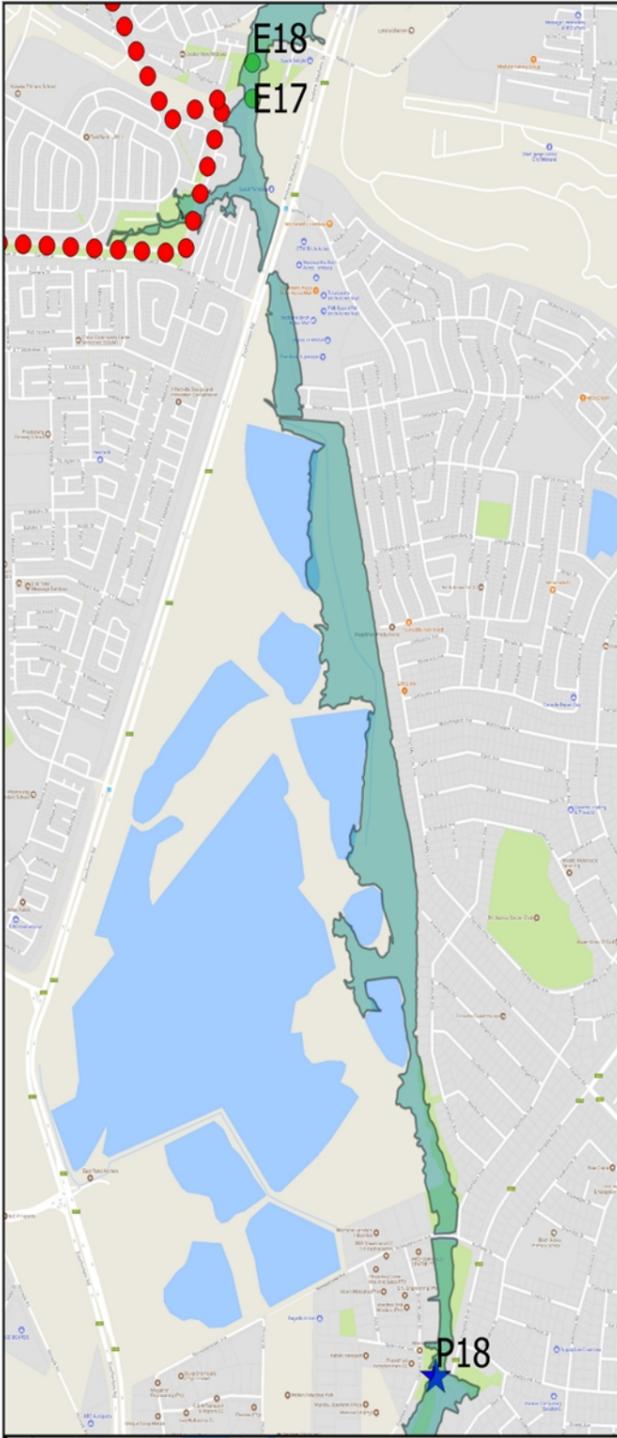
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Existing Structures
Maintenance Group 2
July 13, 2018

A13.01

PROPOSED STRUCTURES GROUP 3



- Legend**
- Targeted Wetlands
 - CoE Boundary
 - Hard Interventions
 - Proposed Channels
 - Proposed Structures
 - Existing Structures

CONCEPTUAL DRAWING
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Proposed and Existing Structures Group 3
 July 13, 2018

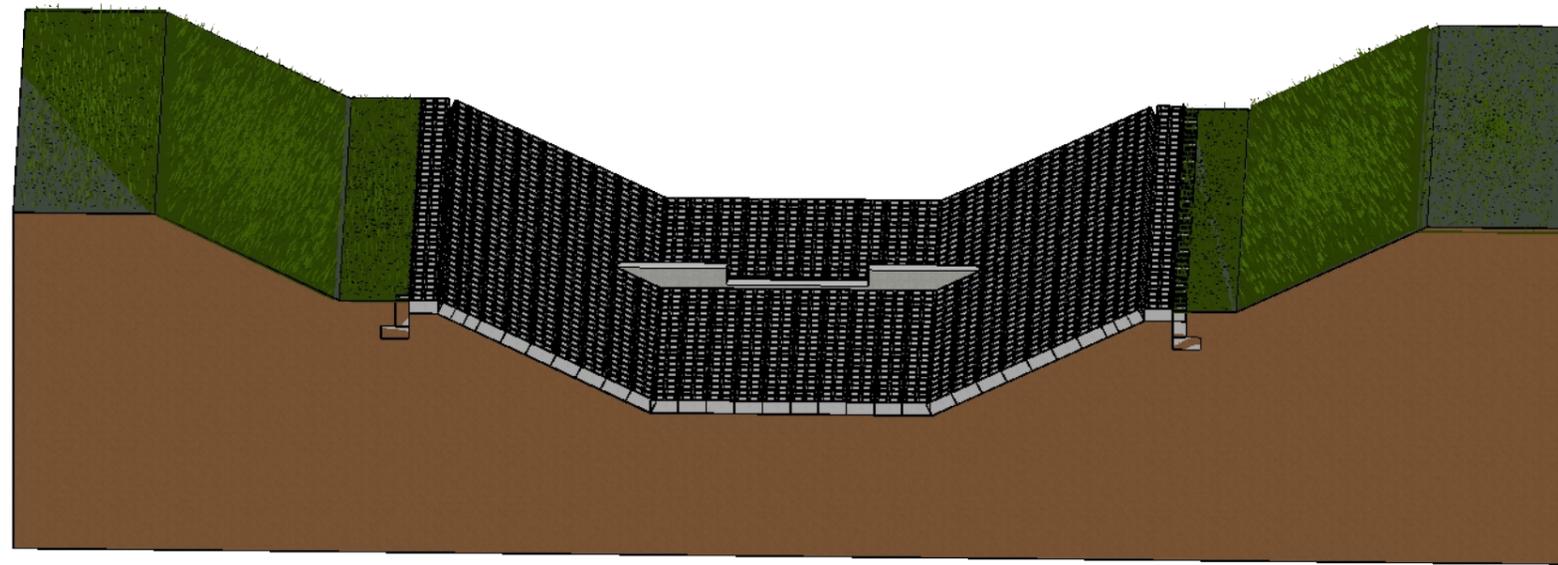
A14.01

ARMORFLEX AND OR MACMAT CHANNEL TWO STEPED LEVELS

STRUCTURE	LENGTH (m)
C1	580

Notes:

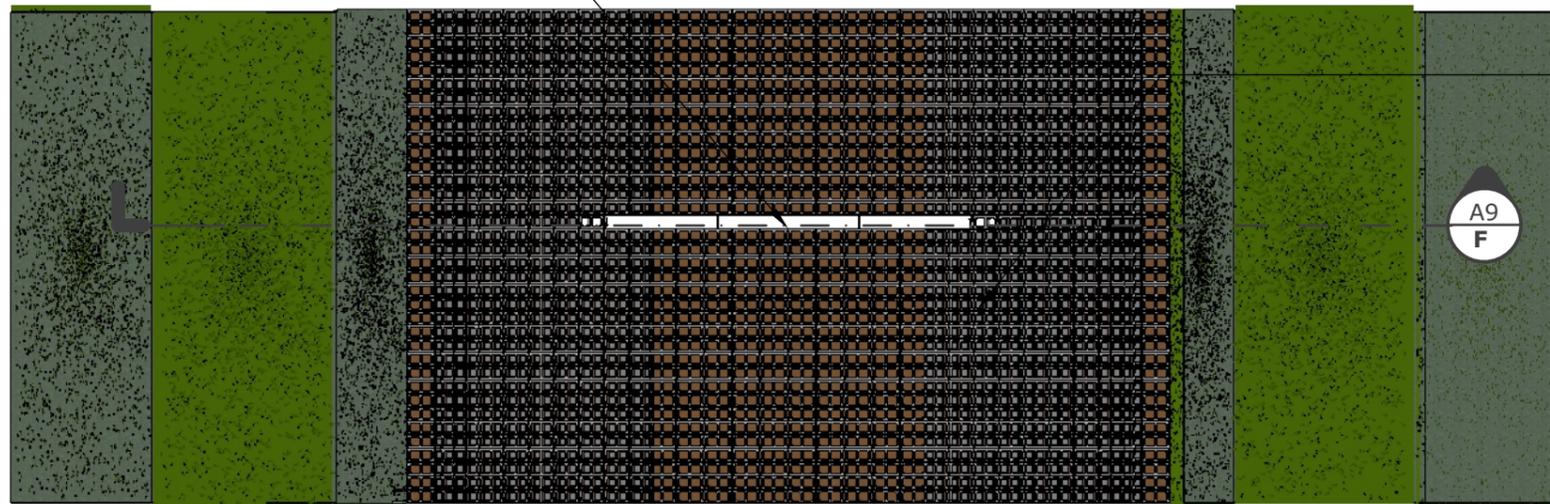
All the stormwater channels entering the main wetland systems should be formalise to Armorflex channels. Sufficient energy dissipation measure should be constructed before stormwater enters the wetland system.



ARMORFLEX CHANNEL

scale: 1:50

Small weirs to reduce flow velocity



Armorflex block should be seeded



CONCEPTUAL DRAWING

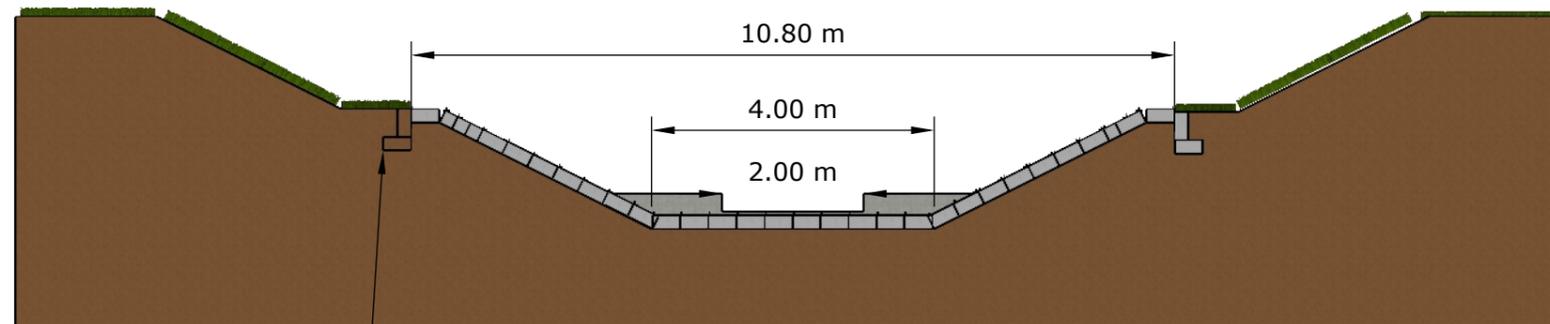
This drawing is not intended to be used for construction or fabrication purposes. All content is subject to change

PLAN VIEW

scale: 1:100



Anchor trench to be filled with cement stabilised soil and compacted at 95% MOD AASHTO



CROSS SECTION

scale: 1:100



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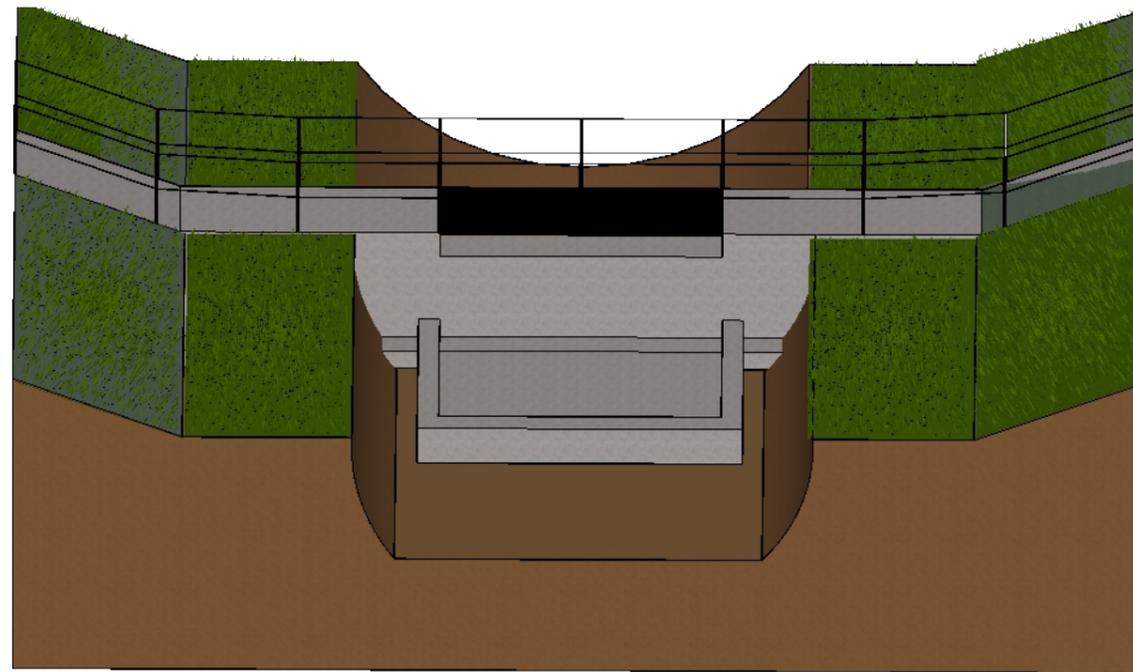
Proposed Structure
Group 3.1
 July 13, 2018

CONCRETE WEIR WITH WALKWAY

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P18	-26.065250	28.196652	30

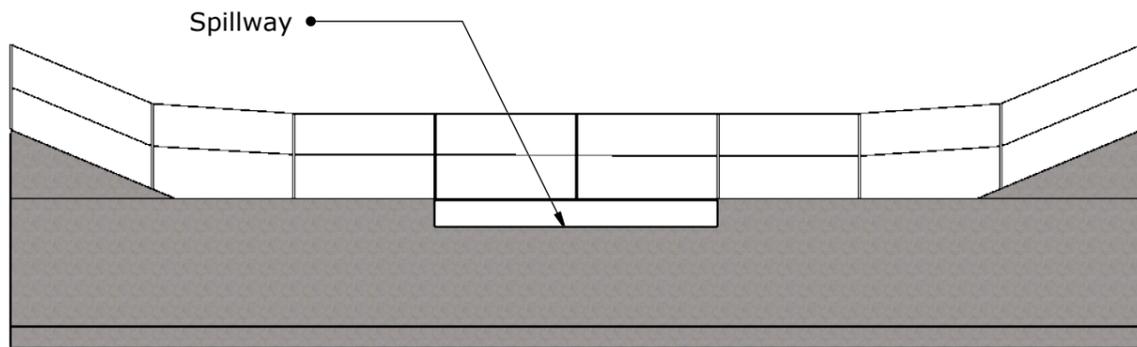
Notes:

All Concrete weir doubles up as a low water pedestrian walkway. Please note that in high flows the water is designed to move over the entire structure and at such time the walkways will not be safe to use. Clear signage should be installed to highlight this. Structure can be optimised during the detailed engineering design phase of the project. Concrete weirs will need to be scaled for each individual point. These sizes should be confirmed in the detailed design.



CONCRETE WEIR WITH WALKWAY

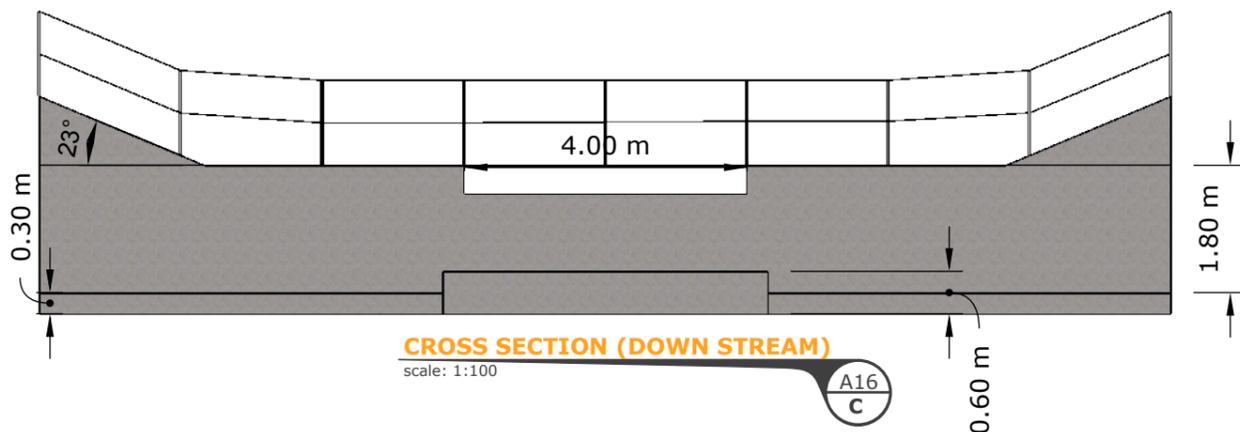
scale: 1:100



CROSS SECTION (UPSTREAM)

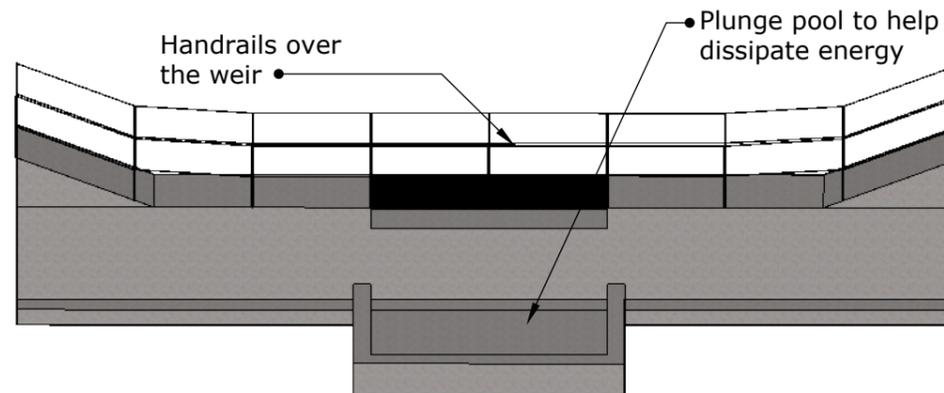
scale: 1:100

Footing foundation needs to be confirmed by geotechnical engineer



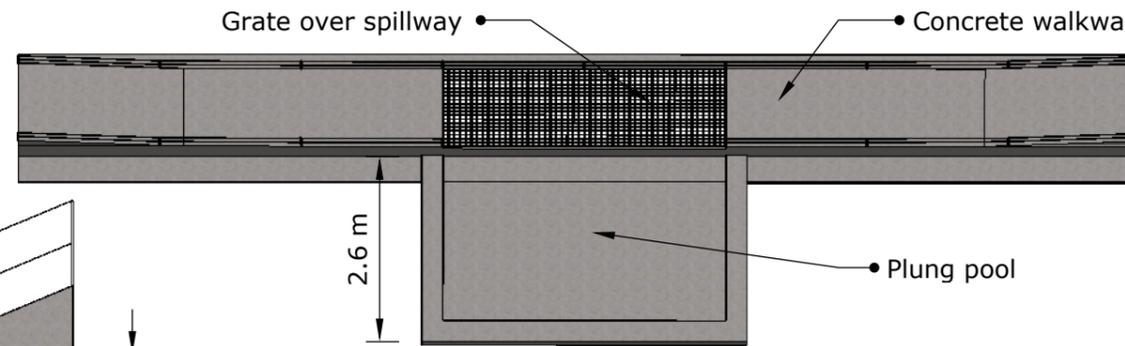
CROSS SECTION (DOWN STREAM)

scale: 1:100



CONCRETE VIEW

scale: 1:NA



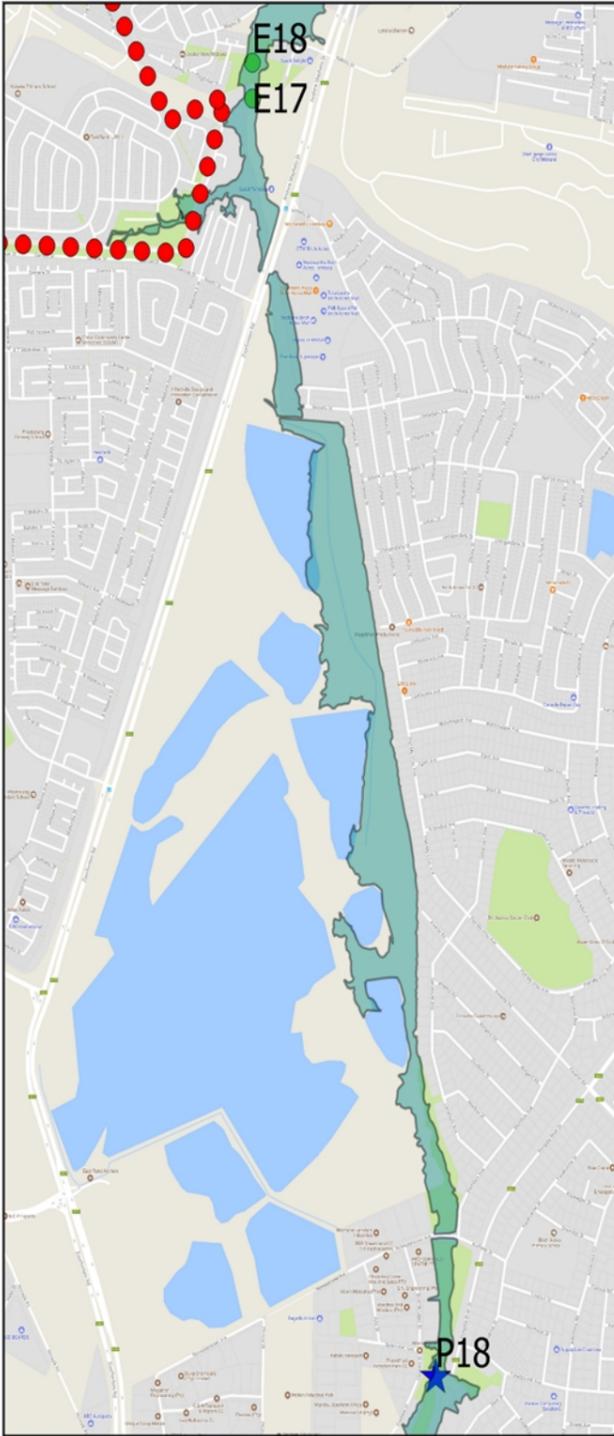
PLAN VIEW

scale: 1:100

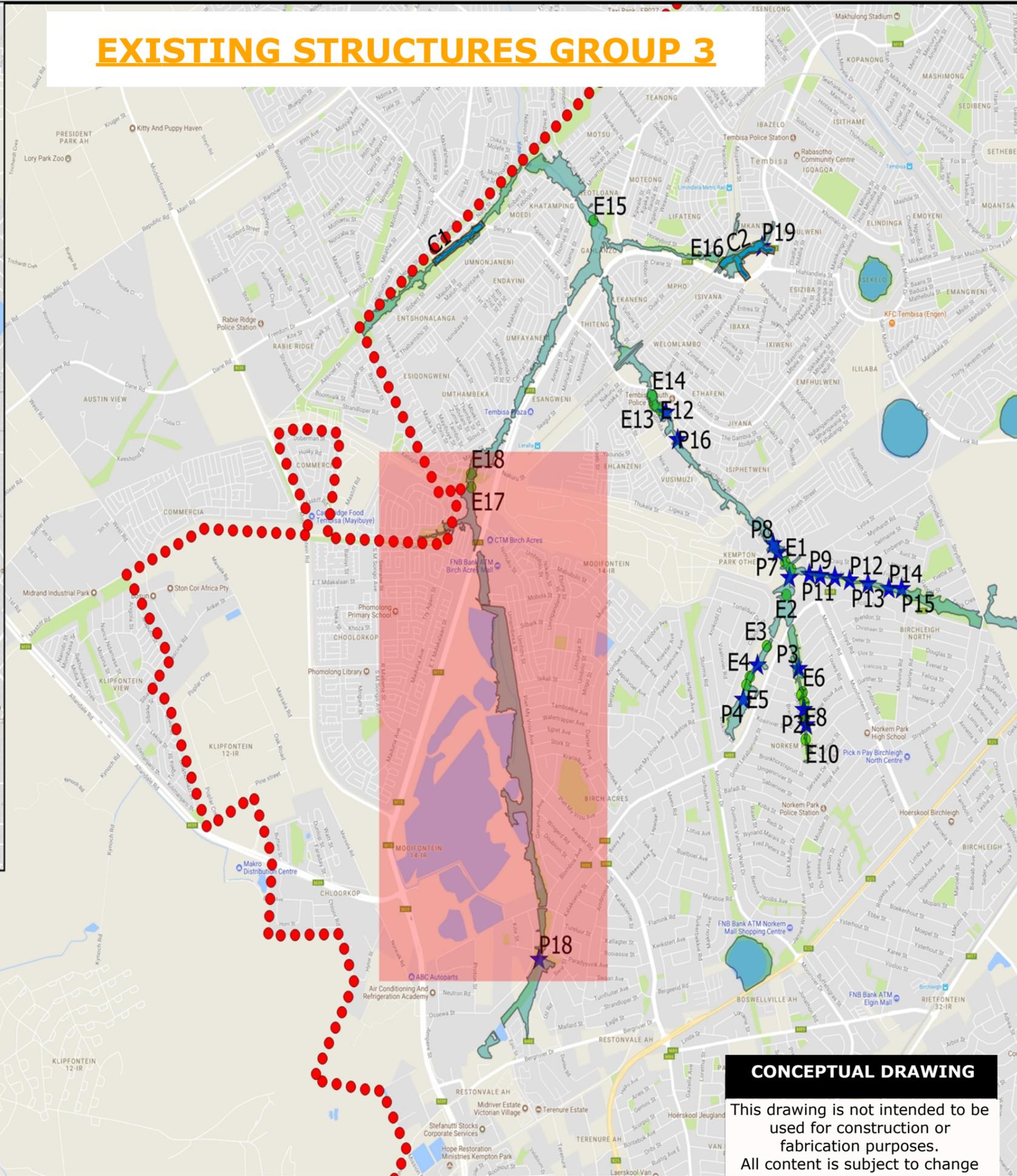
CONCEPTUAL DRAWING

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EXISTING STRUCTURES GROUP 3



- Legend**
- Targeted Wetlands
 - CoE Boundary
 - Hard Interventions
 - Proposed Channels
 - Proposed Structures
 - Existing Structures



CONCEPTUAL DRAWING

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Existing Structures
Group 3
 July 13, 2018

A17.01

EXISTING STRUCTURES MAINTENANCE GROUP 3



STRUCTURE	LATITUDE	LONGITUDE	COMMENT	MAINTENANCE
E16	-26.016409	28.213894	Large concrete weir, good condition	Extend wingwall a further 5m with reinforced concrete wall on one sides of structure
E17	-26.032144	28.190333	Large concrete weir, good condition	General concrete repairs and extend wingwalls a further 2m on both sides
E18	-26.031217	28.190328	Bridge, good condition	Currently under construction 2018

GreenGAB (Pty) Ltd
Environmental Engineering
Consultants

36 Normandie at Alto Villa
Estate
Moreleta Park
Pretoria
0181



Existing Structures
Maintenance Group 3
July 13, 2018

Notes:

All existing structure where designed by other consultants. In the next phase of the project detailed designs of the existing stuctures with the maintenance measure should be undertaken to get exact construction volumes. Not all intervetion could be found. Some areas had access issues and arge portion of intervention where never constructed.

CONCEPTUAL DRAWING

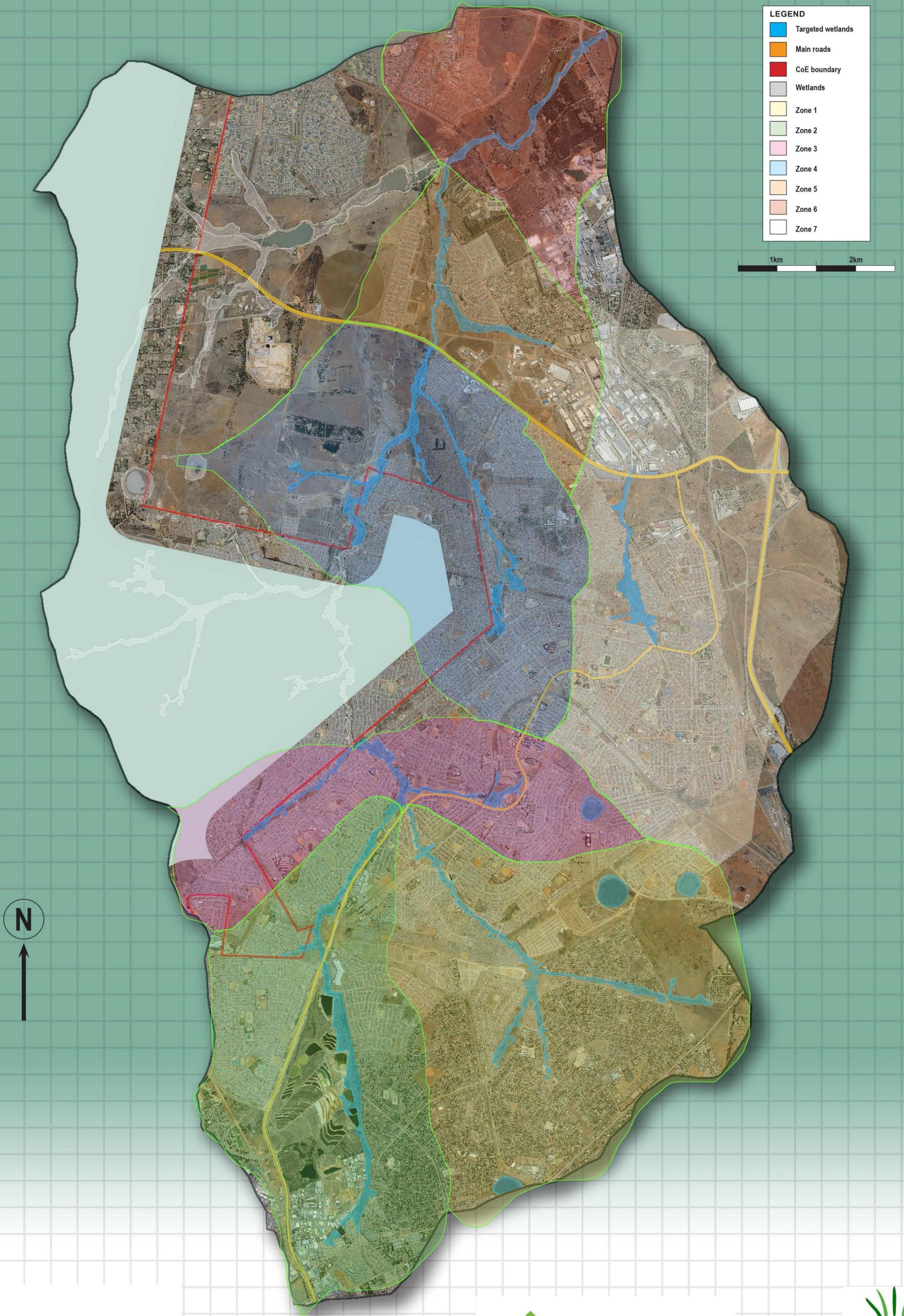
This drawing is not intended to be used for construction or fabrication purposes. All content is subject to change

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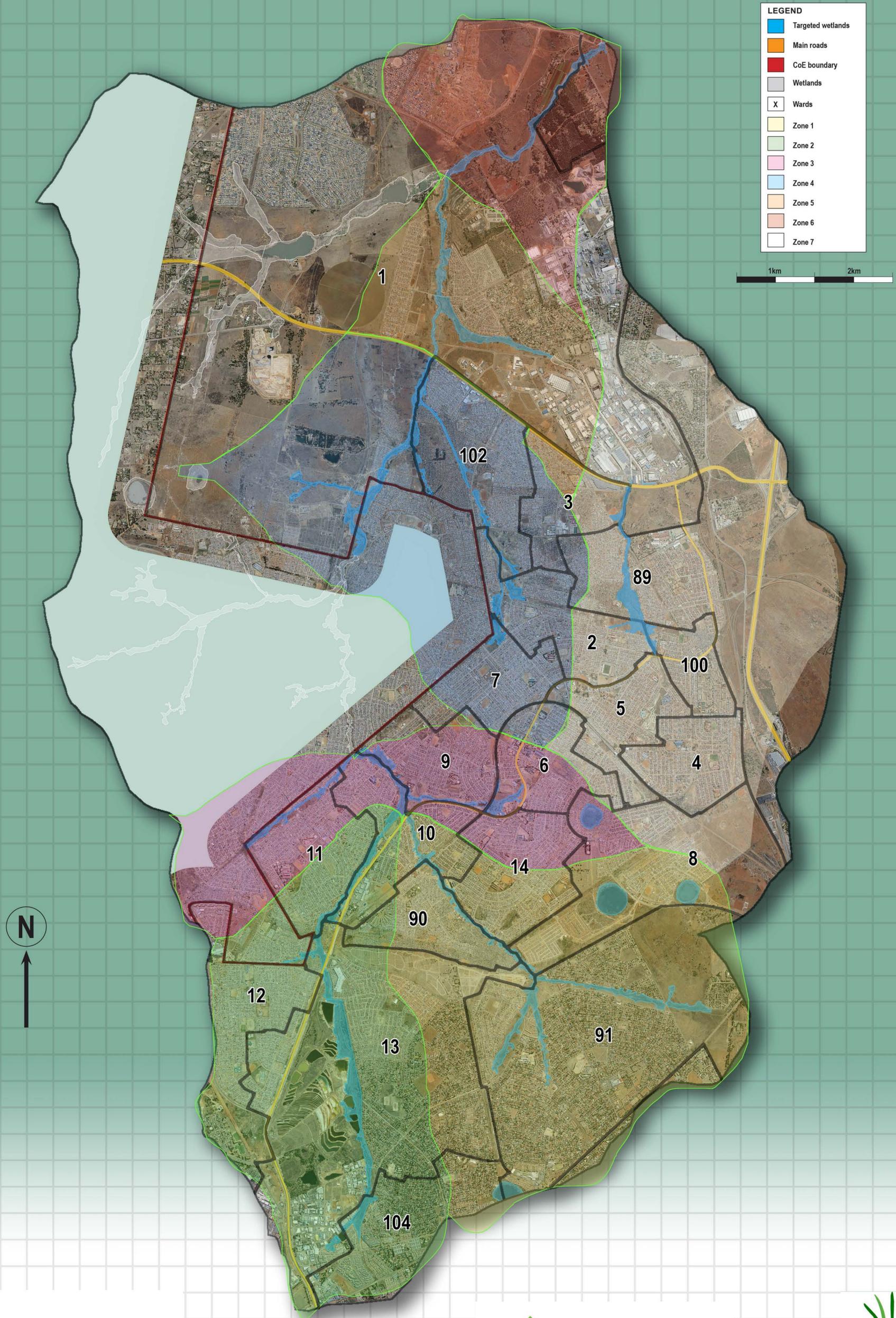
KAALSPRUIT CATCHMENT



KAALSPRUIT CATCHMENT



KAALSPRUIT CATCHMENT

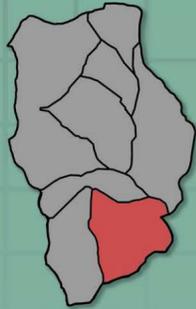


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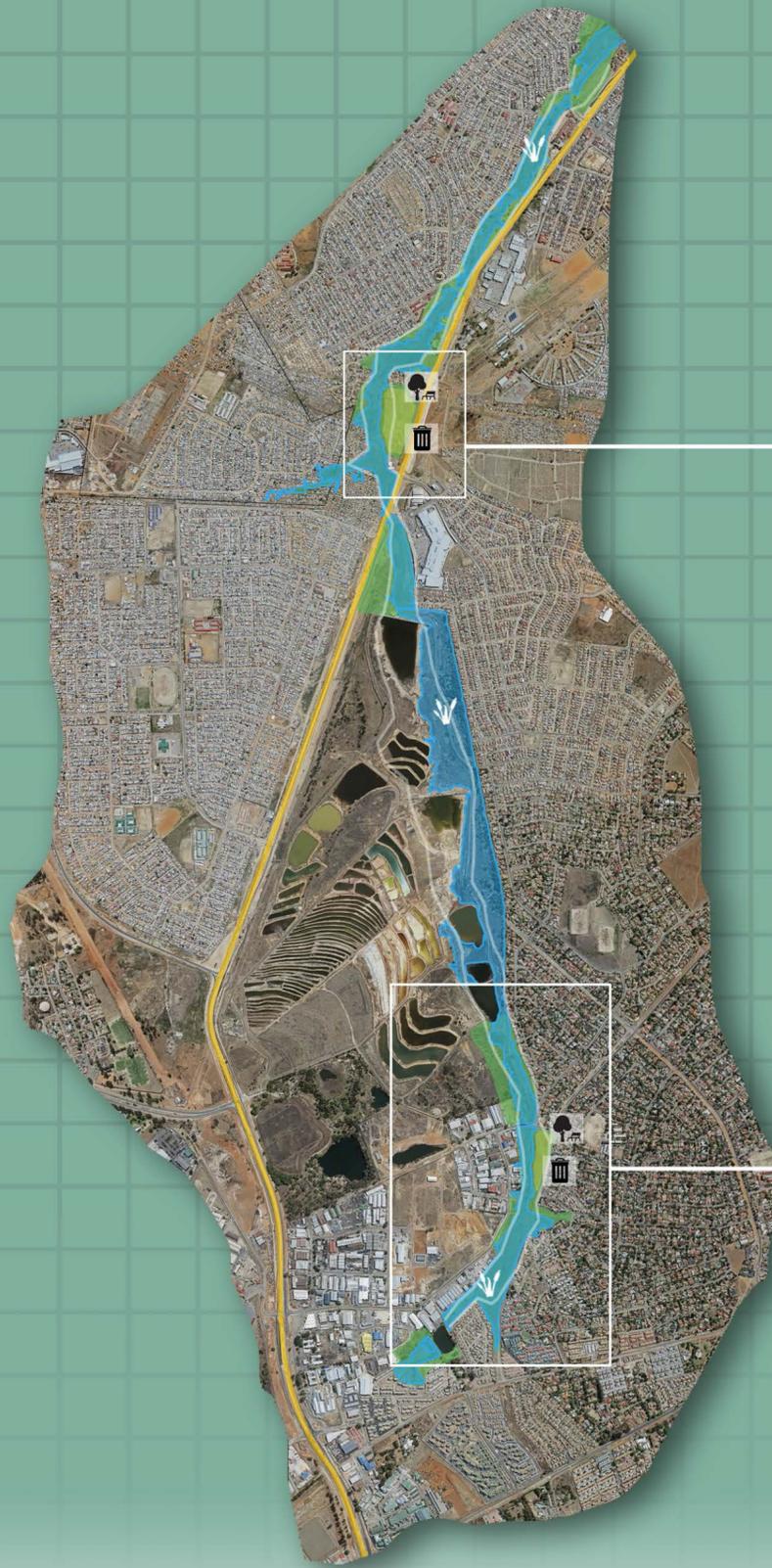


Legend

-  Walk ways
-  Waste management point
-  Agricultural fields
-  Parks
-  Sports fields
-  Instream structures
-  Wetlands
-  1 in 100 year floodlines

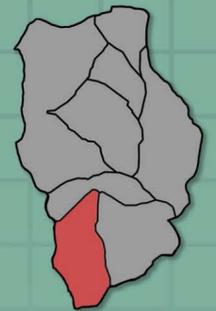


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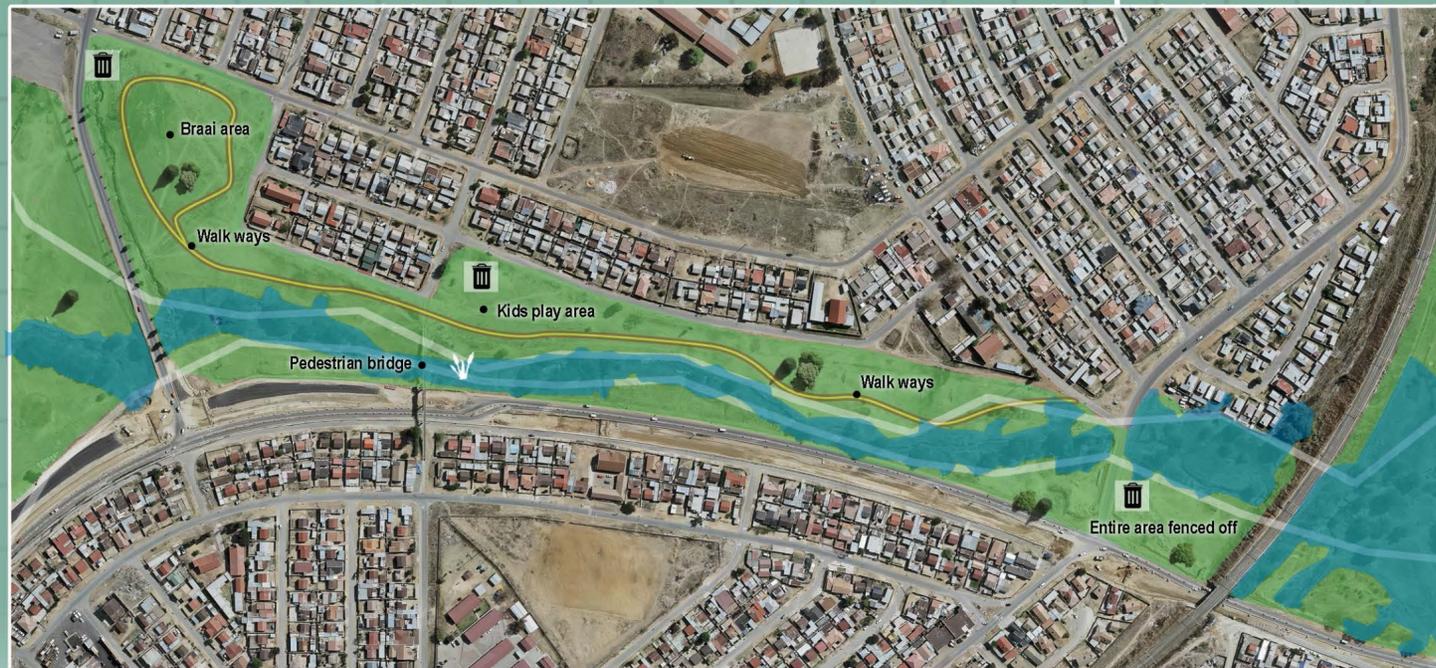
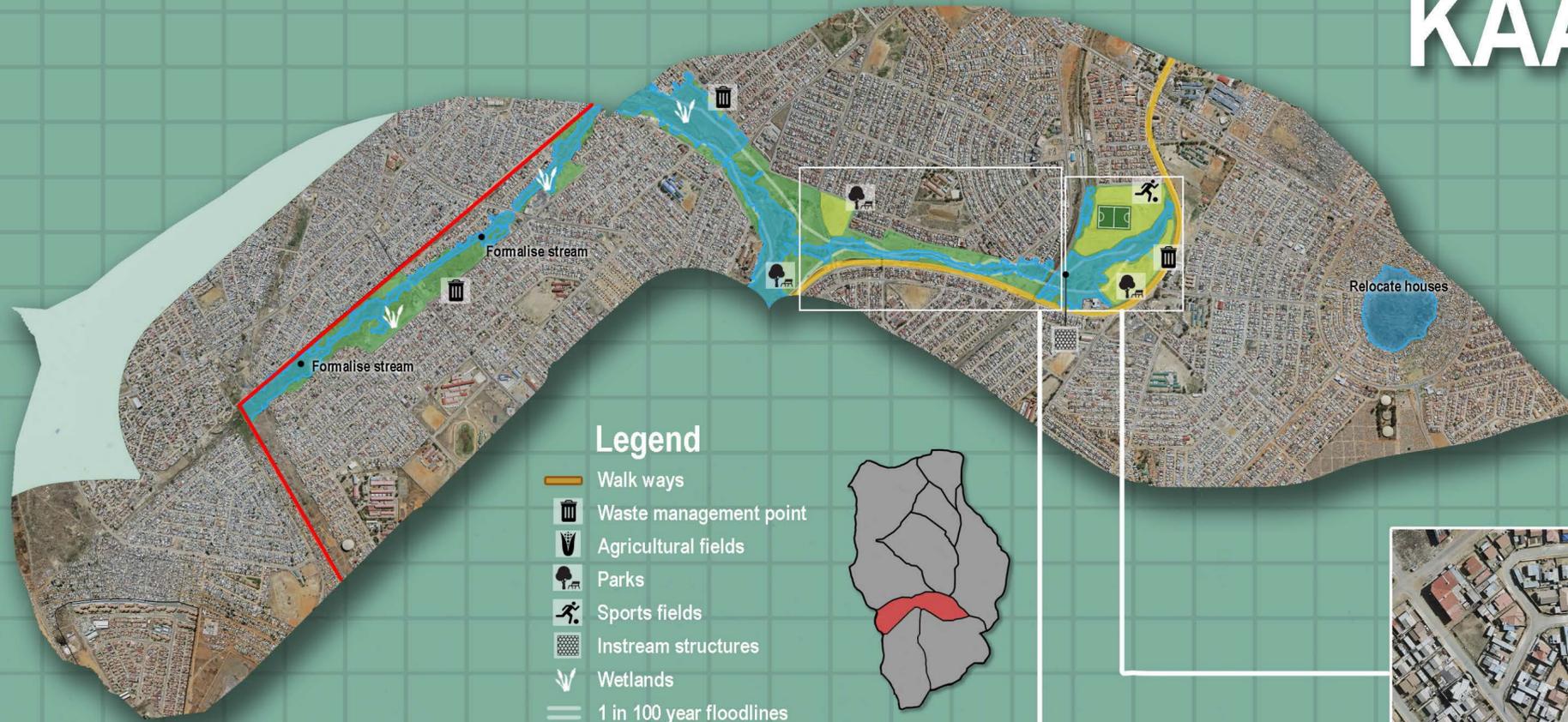


Legend

-  Walk ways
-  Waste management point
-  Agricultural fields
-  Parks
-  Sports fields
-  Instream structures
-  Wetlands
-  1 in 100 year floodlines
-  Roads



KAALSPRUIT ZONE 3

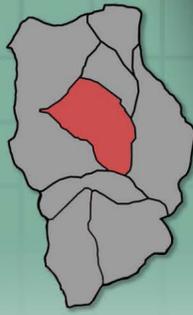


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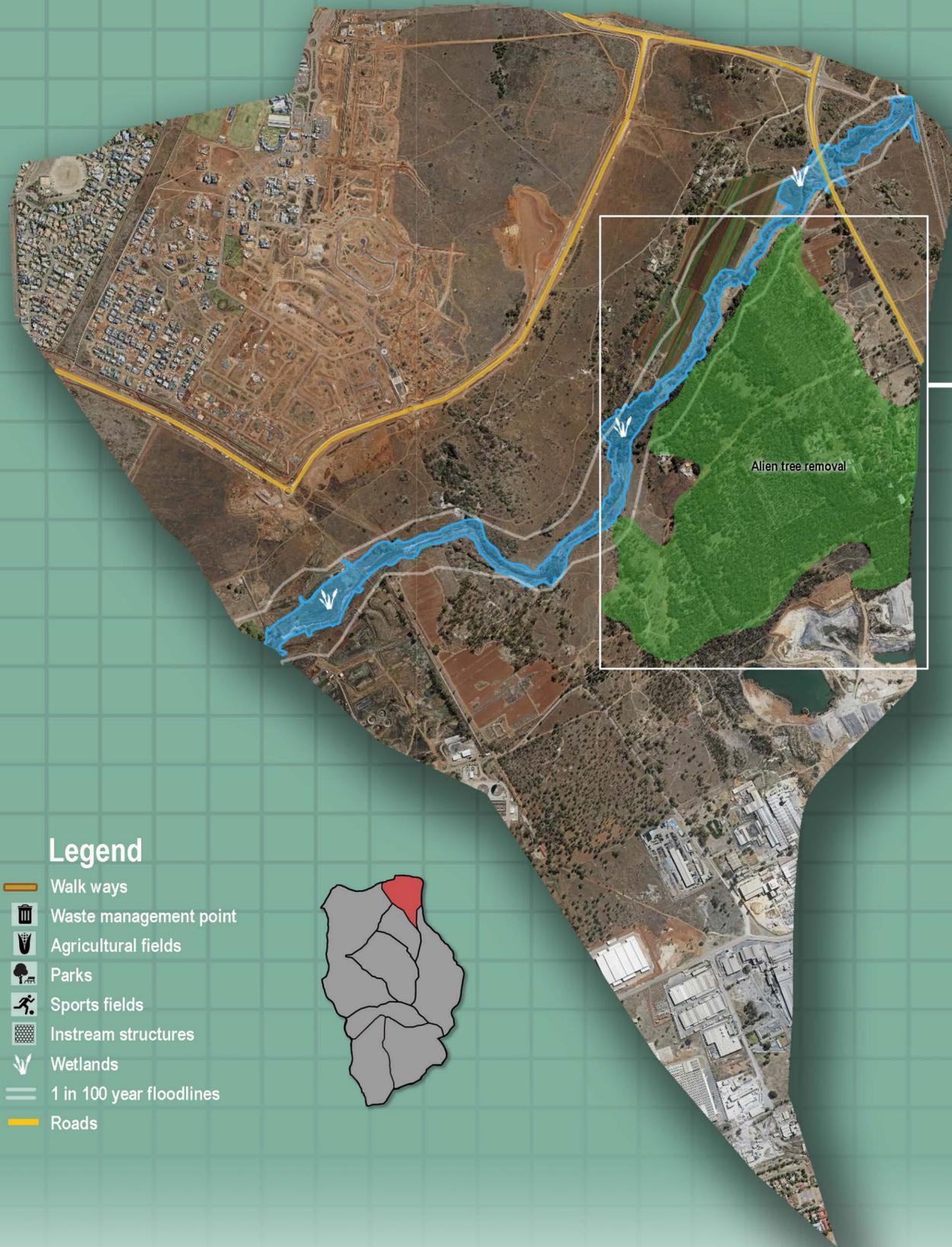


Legend

- Walk ways
- Waste management point
- Agricultural fields
- Parks
- Sports fields
- Instream structures
- Wetlands
- 1 in 100 year floodlines
- CoE boundary
- Road

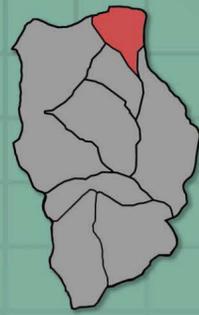


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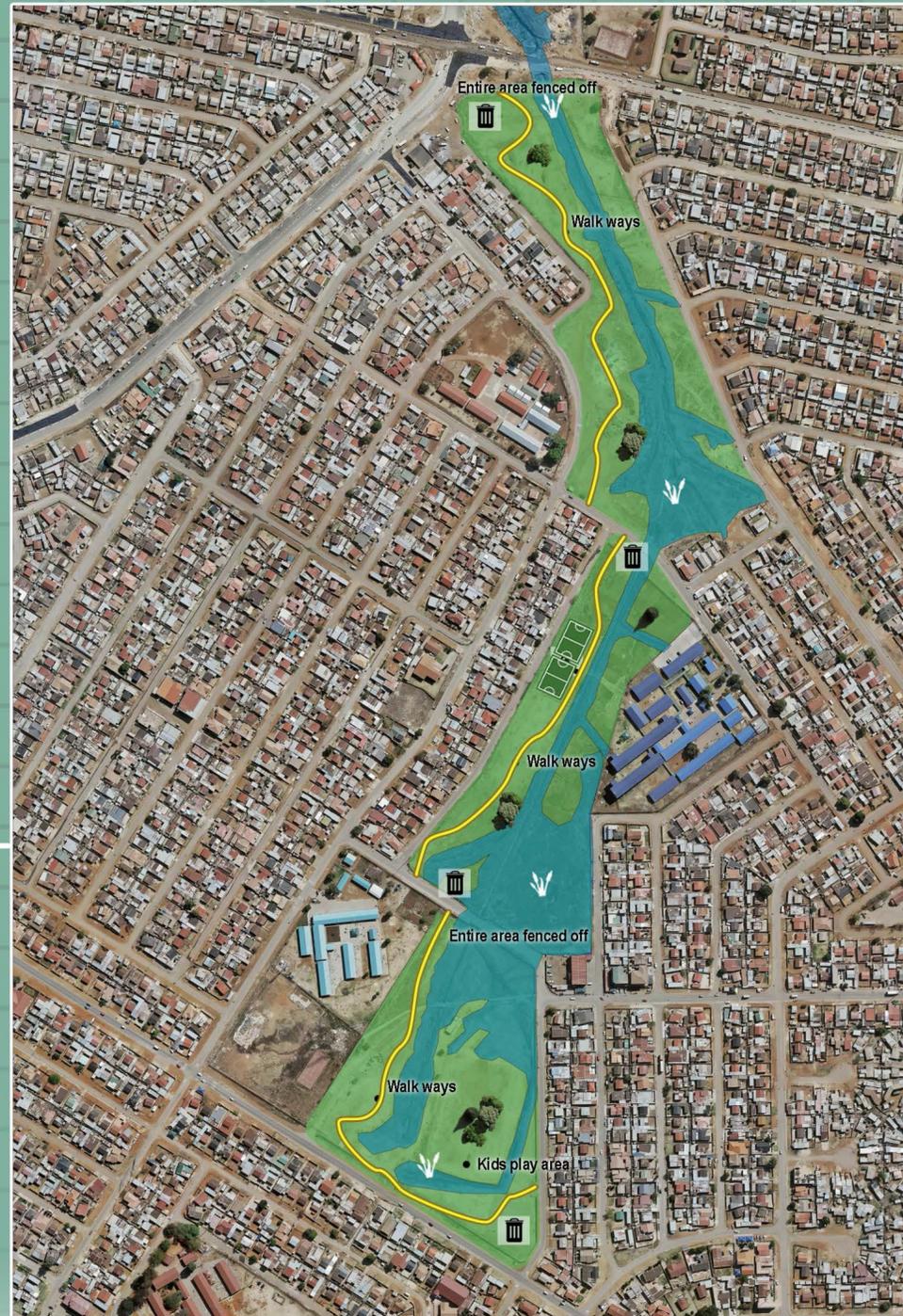
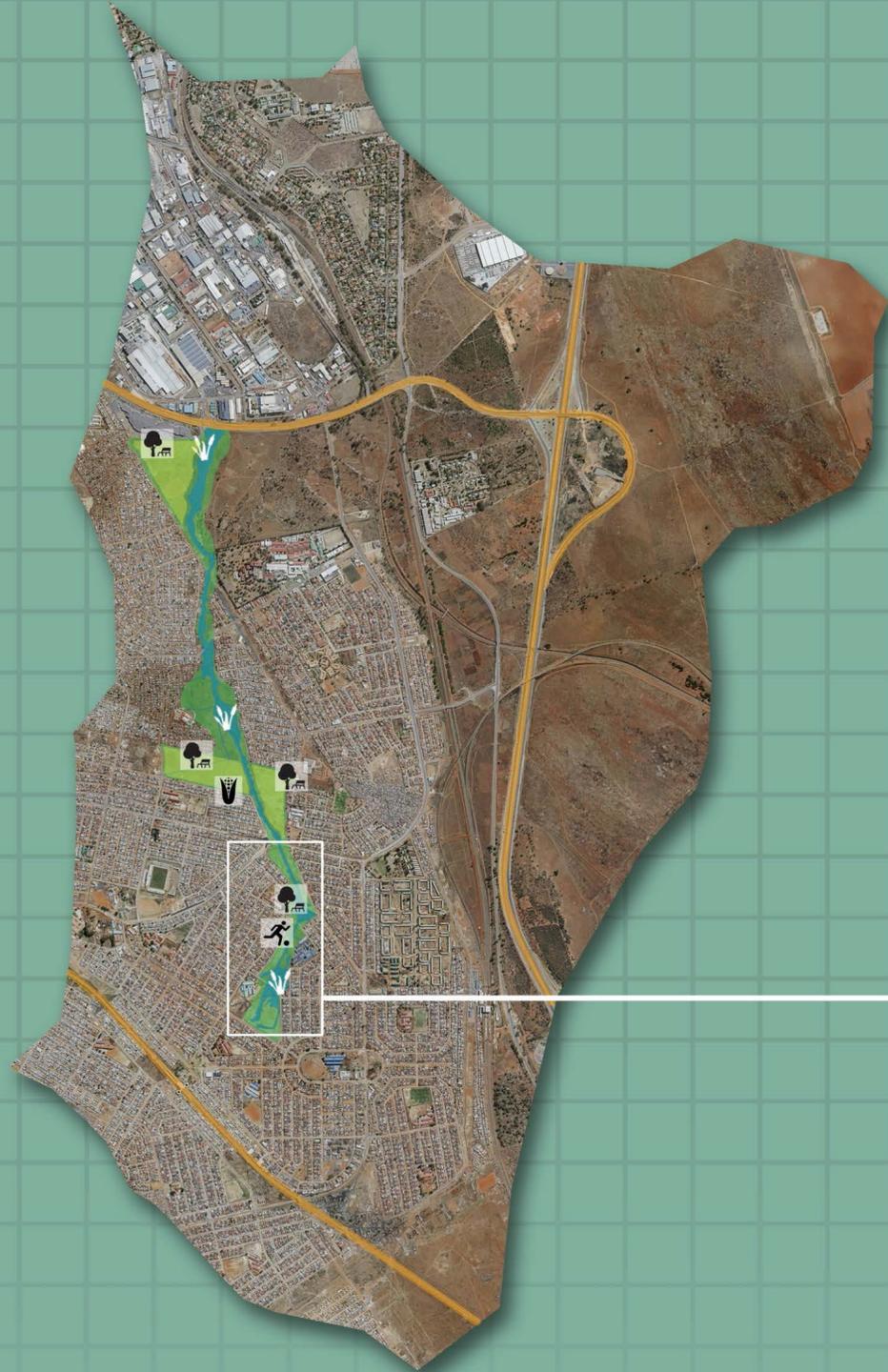


Legend

- Walk ways
- Waste management point
- Agricultural fields
- Parks
- Sports fields
- Instream structures
- Wetlands
- 1 in 100 year floodlines
- Roads



KAALSPRUIT ZONE 7



Legend

-  Walk ways
-  Waste management point
-  Agricultural fields
-  Parks
-  Sports fields
-  Instream structures
-  Wetlands
-  1 in 100 year floodlines
-  Roads

