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

Engineering Conceptual Designs and Basic Assessment Report

By:

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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 Rietvlei catchment. This catchment was selected by the CoE as a priority catchment to be focused on in this master plan.

The Rietvlei 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 rational 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 Rietvlei catchment. This will include conceptual maps, drawings and high level Bill of Quantities (BoQ) 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 Rietvlei 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 BoQ 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 Rietvlei River within the CoE boundary as indicated in Figure 1 below. The catchment falls within the Department of Water and Sanitation (DWS) quaternary catchment A21A. The extent of the specific catchment targeted for this CoE project is shown in the figure below. This 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
Rietvlei/Hennops (A21A)	482	282	59

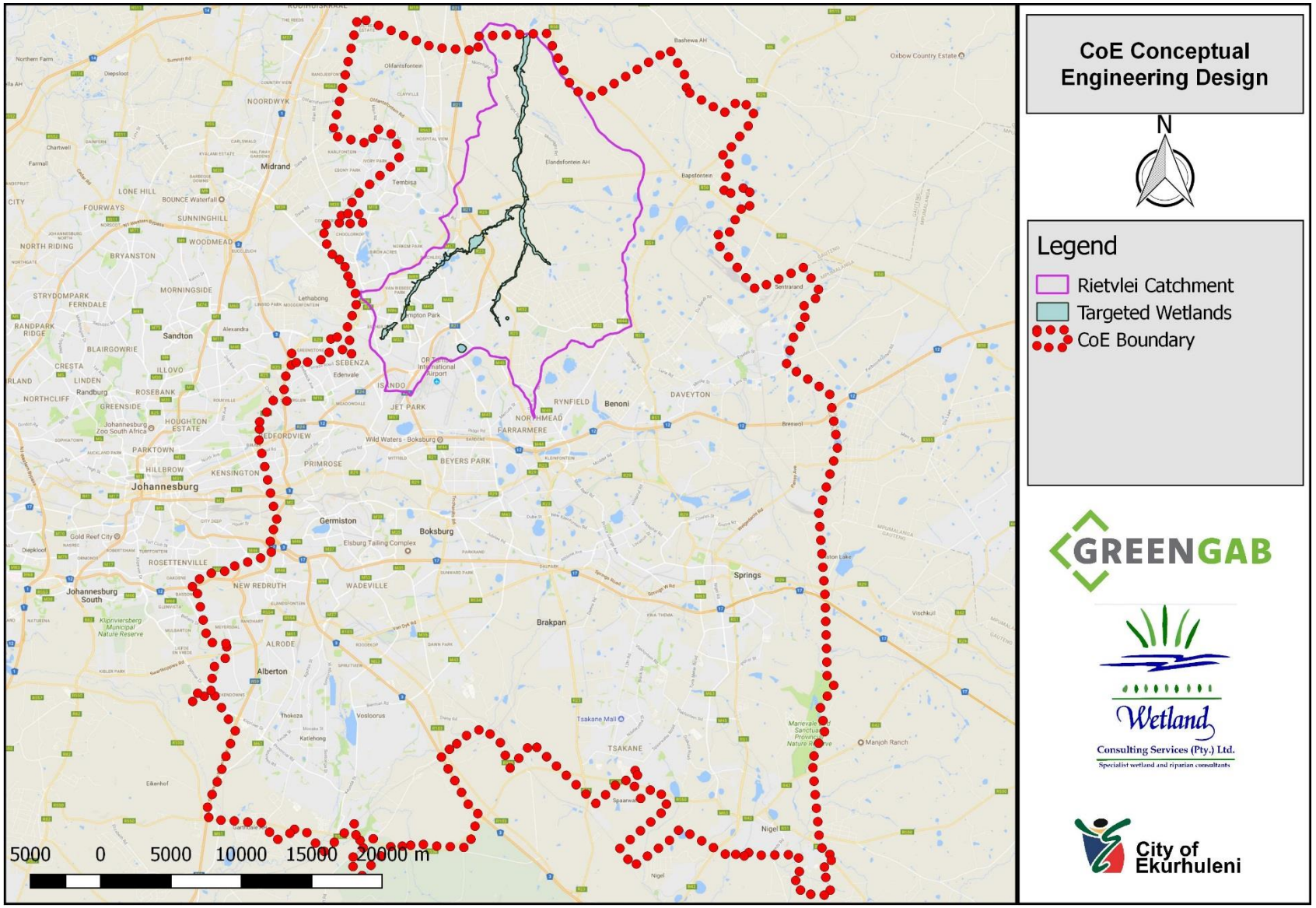


Figure 1: Map showing Rietvlei catchment in relation to the CoE Boundary

The Rietvlei catchment is located in the Crocodile (West) Marico Water Management Area in quaternary catchment A21A within the Hennops Catchment. The river in the study area consists of the Rietvlei River and associated smaller, first order tributaries draining into the Hennops River. Figure 2 below indicates the location of the study catchment in relation to the CoE Boundary. The Rietvlei system starts in the small-holdings area of Kempton Park and flows northwards past O.R. Tambo International Airport to Rietvlei Dam. Rietvlei Dam is an important contributor of water supply in the Tshwane Metropolitan Municipality. The primary supply of this water originates from agricultural and industrial surface run-off and is also fed by a tributary - the Grootvlei River - which originates from the Bapsfontein area. Sewage works situated at Kempton Park are responsible for serious pollution. A series of wetlands between the sewage works and the dam are anticipated to play a role in filtering some of the pollution carried by the rivers. The Tshwane Metropolitan Municipality also operates an extensive filtering plant at the dam. The landuse within the catchment is urban development around the Kempton Park area and agricultural activities towards the lower reaches of the river.

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 Rietvlei catchment 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)	61.5	84.9	102.7	121.6	149.1	172.1

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	438.5363	3892.24	3.886	21.869	0.011	37.819	123.26
S2	252.095	3739.249	3.053	70.924	0.014	0.357	97.25
S3	607.7225	2906.922	2.324	50.4	0.014	3.533	220.12
S4	512.105	4355.642	2.965	70.333	0.013	0.316	189.54
S5	271.7075	6093.448	2.351	70.324	0.011	3.906	87.84
S6	315.2037	3359.265	3.7	10.487	0.007	67.635	92.29
S7	327.2588	4072.898	3.606	30.056	0.011	23.336	100.1
S8	324.155	2308.578	2.599	55.29	0.014	0.25	135.76
S9	10.8312	667.778	4.056	9.708	0.021	0.007	4.23
S10	564.69	3515.902	2.17	55.343	0.015	2.518	187.47
S11	588.885	3762.492	2.91	5.921	0.02	12.891	71.45
S12	166.865	2142.423	2.613	68.662	0.013	3.106	245.92
S13	348.37	2857.642	2.556	75.349	0.013	0	149.53
S14	282.005	2991.168	2.49	14.836	0.011	24.56	69.47
S15	181.96	1581.792	3.296	64.546	0.014	0.219	101.06
S16	215.965	3480.491	3.575	49.797	0.012	15.824	138.01
S17	532.21	2851.455	2.717	61.761	0.015	2.511	209.38
S18	285.9588	2959.695	3.044	29.281	0.017	0.252	79.7
S19	42.21	857.124	2.852	46.73	0.013	11.512	26.72
S20	89.4762	1246.706	3.005	34.619	0.018	0	38.95
S21	47.8375	1258.052	3.387	1.252	0.024	0.741	9.27
S22	47.93	837.722	4.661	77.367	0.013	0	36.39
S23	99.2162	1961.93	2.966	56.013	0.017	2.478	42.48
S24	254.965	2828.225	3.119	6.016	0.014	2.63	46.36
S25	474.6038	3606.564	3.573	47.607	0.013	8.938	172.66
S26	528.0962	3576.753	2.007	79.248	0.012	2.477	206.08
S27	105.2312	1576.913	3.524	82.022	0.013	0	63.21
S28	629.8725	3079.725	3.296	4.315	0.014	2.376	104.81
S29	129.4188	2086.678	3.031	80.55	0.012	0	69.46
S30	229.6087	2589.824	2.392	67.28	0.013	0.986	98.4
S31	628.93	3922.559	3.157	14.62	0.014	6.756	126.05

S32	20.1925	548.126	3.668	79.722	0.012	6.24	16.53
S33	246.82	3078.563	3.101	3.709	0.012	5.853	43.59
S34	20.6375	466.693	5.944	76.581	0.014	0.285	17.48
S35	90.595	1298.553	4.774	0	0.015	4.661	24.18
S36	1083.396	6488.271	2.366	29.282	0.018	0.285	191.54
S37	139.4462	2012.572	2.976	67.893	0.013	0	71.21
S38	213.3138	2321.81	3.169	18.376	0.015	3.976	59.07
S39	75.55	1054.09	2.909	28.902	0.022	0	29.96
S40	0.9088	195.756	2.242	0.929	0.01	0	0.61
S41	93.415	1665.721	2.338	51.471	0.013	1.809	45.26
S42	307.5	3039.051	4.356	4.799	0.015	3.753	54.75
S43	35.4175	958.283	3.328	3.426	0.01	0	14.11
S44	88.845	1520.86	3.381	7.187	0.022	1.912	18.74
S45	81.13	1519.888	4.42	2.282	0.023	0	15.97
S46	100.1387	1726.873	2.949	2.772	0.016	0	20.34
S47	70.865	1622.439	2.323	44.337	0.016	0	29.79
S48	51.1012	1317.516	2.577	16.527	0.017	0	16.18
S49	103.5387	1333.479	6.623	12.43	0.017	0	37.92
S50	68.515	1224.52	3.591	5.156	0.017	0.175	18.16
S51	537.6937	3370.931	3.39	0.385	0.022	1.379	51.93
S52	115.3487	2258.484	2.178	12.739	0.018	1.404	23.11
S53	71.7925	1851.307	5.637	0.241	0.028	0	11.14
S54	633.91	3831.604	2.979	0.043	0.021	0	53.1
S55	181.925	1581.823	4.364	4.548	0.016	0.964	44.82
S56	92.8275	1310.084	3.284	0.206	0.019	0	19.66
S57	25.7862	1030.483	1.976	1.105	0.018	0	5.69
S58	47.235	852.418	4.37	0	0.031	0	10.47
S59	142.3913	2612.108	2.967	0	0.019	0	17.75
S60	33.8275	966.116	3.279	1.203	0.02	0.002	8.41
S61	24.0775	459.296	6.335	5.635	0.028	0	10.18
S62	129.1713	1302.53	4.865	5.232	0.024	0	29.74
S63	76.9713	1031.099	4.245	0	0.024	0	17.58
S64	152.2575	1730.774	3.197	0.183	0.02	0.791	25.71
S65	212.5487	3276.54	2.997	1.735	0.017	0.859	26.08
S66	111.8025	1941.883	3.494	0.483	0.018	0	19.5
S67	8.255	864.545	3.611	0	0.025	0	1.94
S68	232.83	2945.633	2.874	1.121	0.02	1.559	26.23
S69	289.8187	2460.601	2.156	1.64	0.018	0	37.17
S70	465.3937	3579.318	2.037	0	0.021	0	34.96
S71	457.0563	3243.588	2.955	2.938	0.021	0.965	50.99
S72	189.615	2934.393	2.434	0.149	0.021	0	18.39
S73	18.8475	450.77	3.13	0	0.024	0	6.32
S74	90.6712	1747.858	2.579	0	0.024	0	12.2
S75	143.945	2256.362	2.76	5.194	0.022	2.918	21.42
S76	35.865	1016.854	1.831	0	0.029	0	5.53
S77	258.0175	2396.342	2.708	0.864	0.018	0	35.7
S78	69.2175	1511.357	1.811	0	0.027	0	8.28
S79	134.0075	1772.396	6.742	8.927	0.018	0	37.41
S80	261.0513	2737.399	1.802	0.001	0.019	0	25.54

S81	95.9813	1312.684	3.546	1.875	0.018	0	22.12
S82	104.7612	1845.963	3.265	3.863	0.027	0	15.59
S83	31.5788	753.522	3.069	0	0.023	0	8.01
S84	27.0325	808.392	1.215	0	0.034	0	3.77
S85	15.4375	758.021	2.125	2.264	0.033	0	2.98
S86	27.1275	407.524	4.449	2.675	0.026	0	10.92
S87	13.1725	444.637	4.874	0	0.032	0	4.26
S88	79.6225	1645.047	2.882	0.791	0.026	2.374	11.32
S89	28.3288	823.39	4.907	0	0.032	0	6.51
S90	38.2912	969.285	2.164	3.943	0.033	0	6.66
S91	422.235	3598.406	2.012	2.214	0.019	0	39.23
S92	73.215	1162.42	5.659	2.865	0.029	0	16.06
S93	255.7837	3066.603	2.56	3.414	0.024	0.493	26.4
S94	112.1725	1762.616	3.755	0.241	0.025	0.991	16.9
S95	52.6913	746.421	5.882	0	0.026	0	14.77
S96	61.9087	793.592	2.316	0.276	0.031	0	11.85
S97	457.7563	2540.287	3.002	0.67	0.019	0.524	60.06
S98	334.345	4686.04	2.328	0.876	0.022	0.441	21.61
S99	306.0075	4375.383	1.665	0.354	0.017	0.008	21.76
S100	57.2762	1050.47	2.216	0	0.033	0	8.41
S101	327.6638	2702.438	5.101	35.829	0.018	0	112.69
S102	467.3625	3393.662	1.575	0.25	0.02	0.462	34.88
S103	793.455	4578.972	2.416	2.512	0.022	0.161	60.6
S104	170.6812	2201.553	2.252	0.671	0.016	0.777	25.46
S105	40.5038	690.013	7.382	0	0.033	0	11.12
S106	127.8925	1604.82	5.321	0	0.032	0	25.03
S107	454.6725	3023.485	5.216	24.31	0.019	0	123.45
S108	415.6037	3166.853	3.15	2.057	0.019	0	49.75
S109	185.4688	2662.602	1.413	0.56	0.016	0	19.88
S110	539.0725	5834.317	1.371	6.571	0.017	0	47
S111	74.3612	1179.511	5.704	0	0.027	0	15.97
S112	128.2037	2820.429	2.289	0.491	0.018	0	14.44
S113	79.76	1231.152	3.251	2.431	0.02	0	17.71
S114	591.8575	5966.35	1.435	2.654	0.016	0	39.56
S115	33.2825	709.298	10.159	5.949	0.03	0	12.22
S116	602.9275	3172.774	3.565	0.045	0.021	0	77.77
S117	12.9463	461.64	3.953	0	0.03	0	3.97
S118	52.11	1067.893	5.153	2.418	0.02	0	14.03
S119	52.305	1462.435	3.256	2.554	0.024	0	9.38
S120	69.08	1201.712	3.186	0.389	0.024	0	13.26
S121	288.3163	1852.165	1.714	7.008	0.018	0	50.32
S122	99.665	1774.717	3.445	13.329	0.023	0	22.9
S123	30.985	1008.738	4.143	0	0.03	0	6.22
S124	104.62	1203.546	6.521	0	0.025	0	24.16
S125	234.465	2740.98	2.507	0.274	0.02	0	25.51

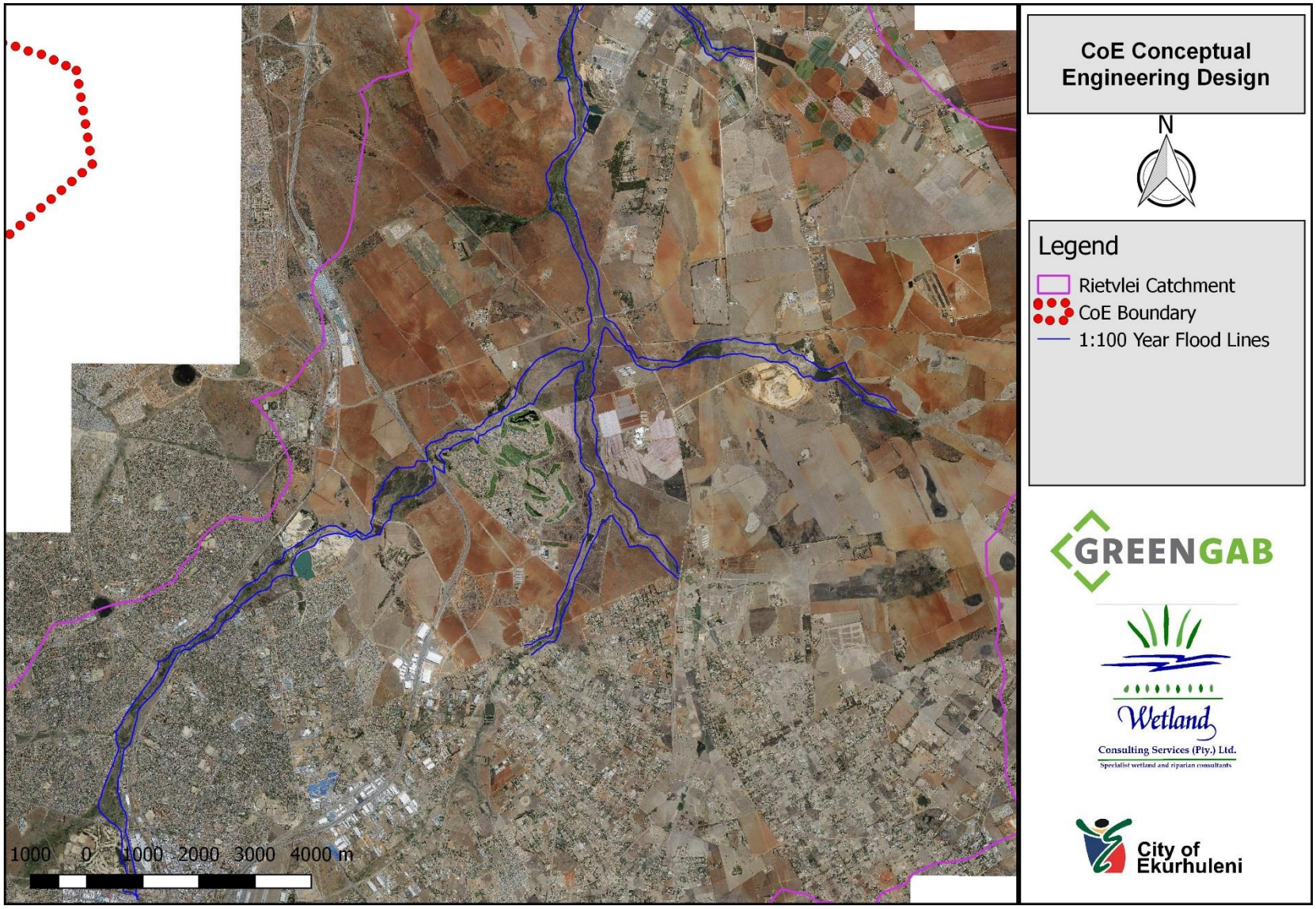


Figure 2: 1:100-year flood lines for targeted wetlands in Rietvlei catchment

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 Rietvlei catchment, a simplified approach was adopted to assess the areas within the project area. The study catchment area was subdivided into **four Rietvlei 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.

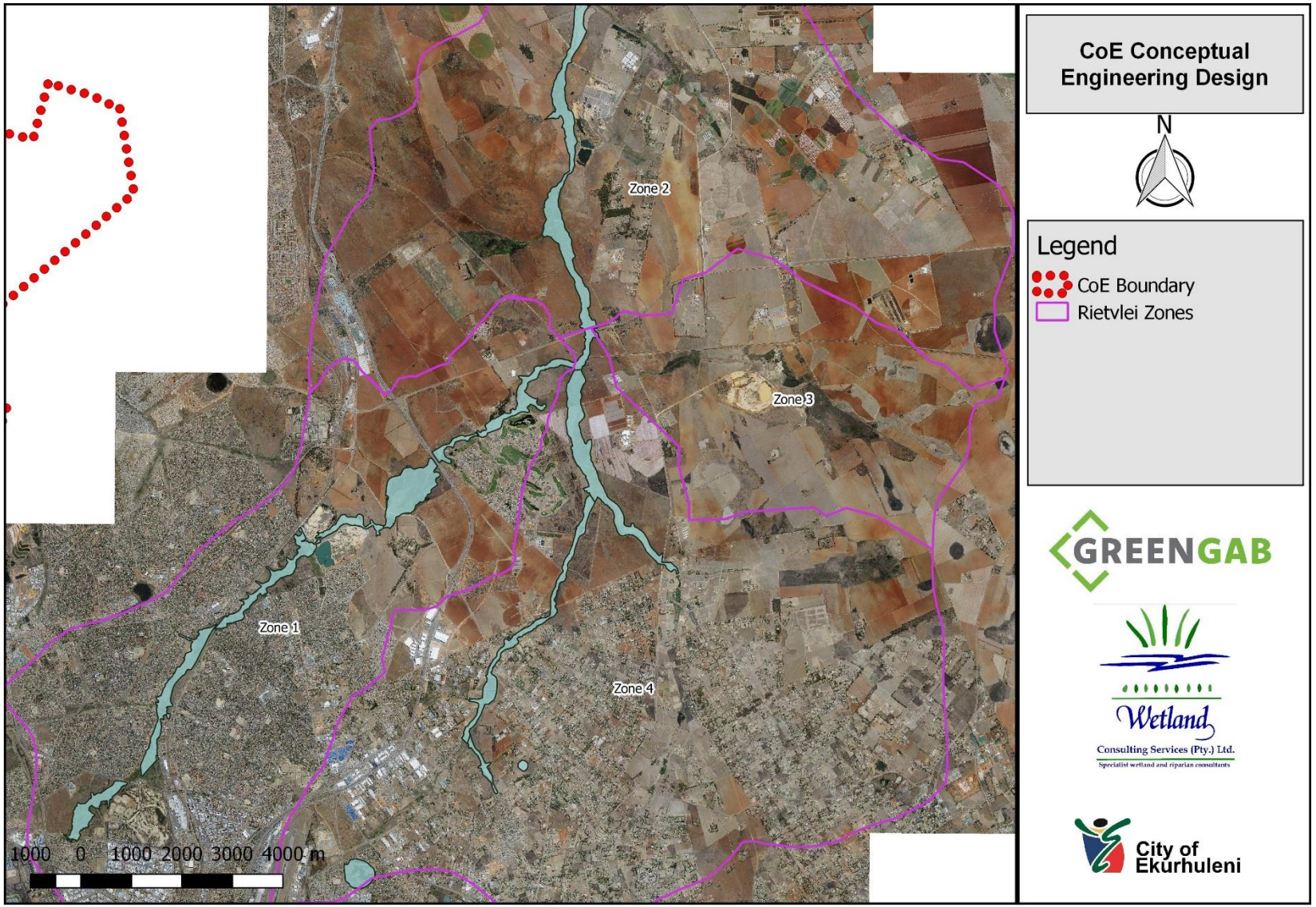


Figure 3: Rietvlei rehabilitation zones

3.2 DEVELOPMENT OF REHABILIATION 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 where also highlighted; and
- Hard engineering wetland rehabilitation interventions: These relate to specific side slope or instream 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 gulley 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

3.4.1 INSTREAM STRUCTURES

For the Rietvlei 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 Rietvlei Catchment.

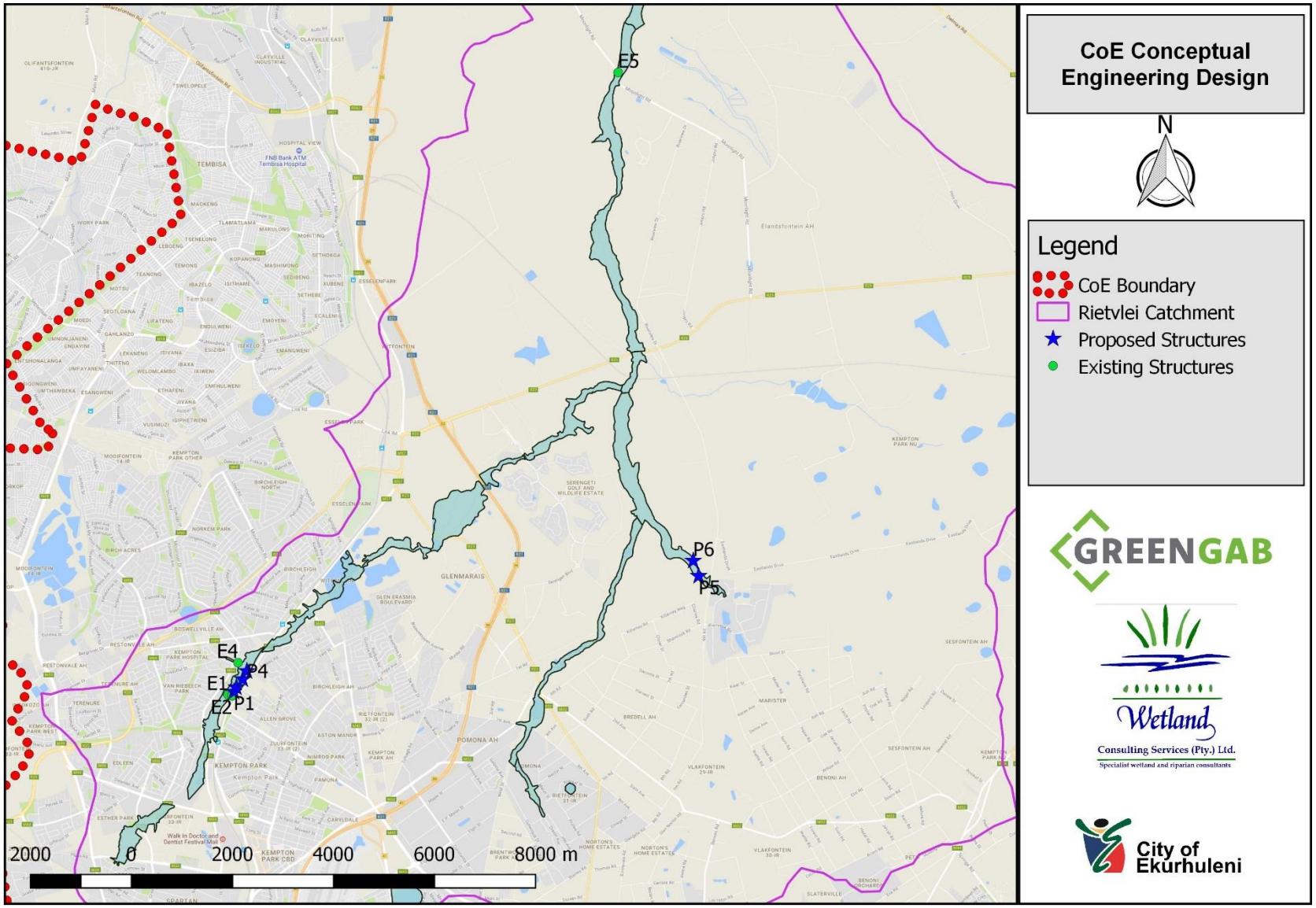


Figure 4: Existing and proposed structures in Rietvlei catchment

3.4.1.1 EXISTING INSTREAM INTERVENTIONS

Throughout the Rietvlei 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 Rietvlei Catchment

Structure	Latitude	Longitude	Comment	Maintenance
E1	-26.079714	28.223742	Dam wall with gabion spillway, good condition	Concrete cap gabion, general shaping around dam wall
E2	-26.079892	28.224541	Large concrete weir, good condition	General concrete repairs and extend wingwalls a further 5m on both sides
E3	-26.077848	28.225996	Gabion weir, poor condition	Reconstruct weir with reinforced concrete
E4	-26.074020	28.225736	Gabion channel, fair condition	Replace gabions with Armoflex channel
E5	-25.968940	28.300997	River crossing, fair condition	Upgrade the river crossing

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;
- Concrete weirs;
- Concrete weir with incorporated walkways;
- Concrete weir with box inlet;
- Concrete weir with round inlet; and

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;

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

Structure	Latitude	Longitude	Length (m)
P1	-26.079198	28.224909	25
P2	-26.078436	28.225403	25
P3	-26.07699	28.226669	25
P4	-26.075524	28.227507	25
P5	-26.058601	28.316939	28
P6	-26.055891	28.31587	20

Armorflex and or MacMat

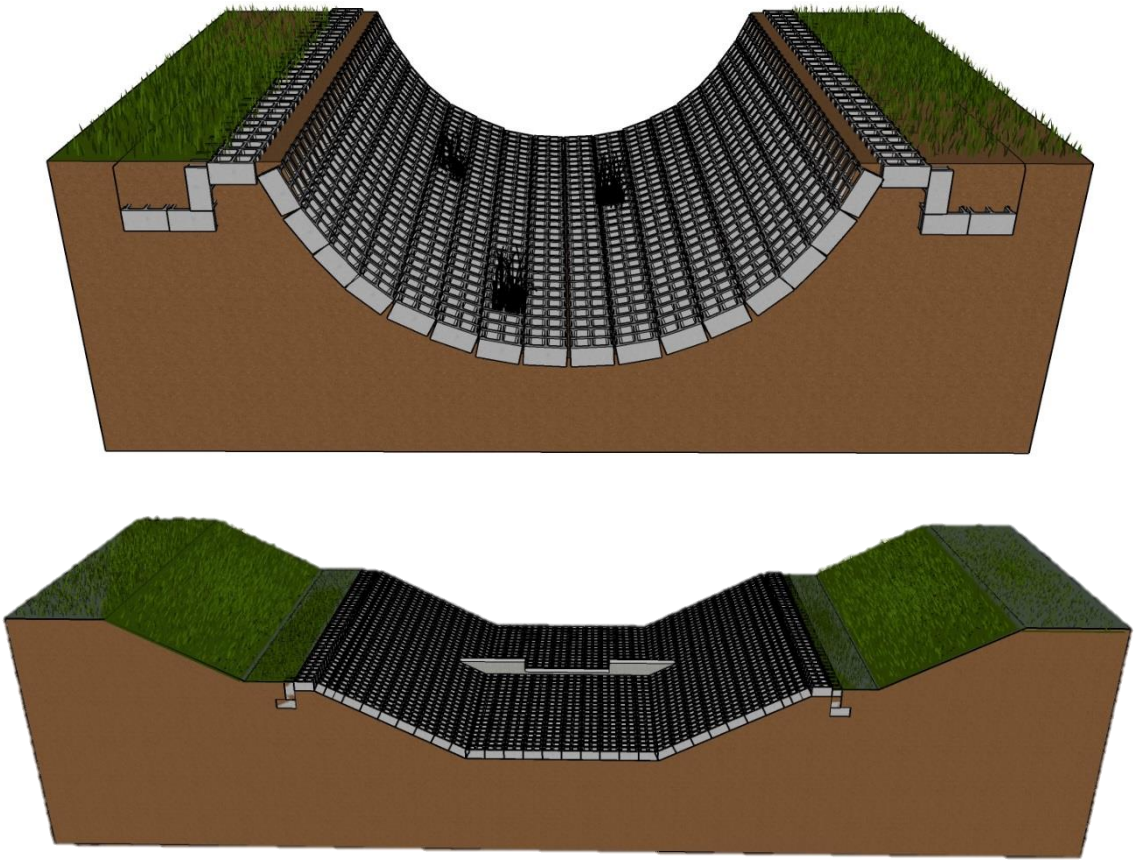


Figure 5: Armorflex and or MacMat Channels

Armoflex and or MacMat channels are proposed in areas where stormwater channels have high velocities and current channels are severely incised. Armoflex 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.

Concrete weirs

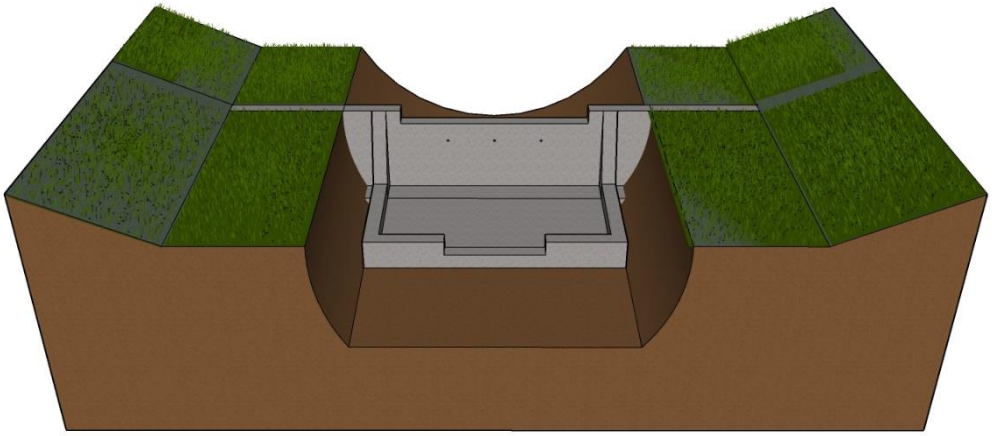


Figure 6: Concrete Weirs

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

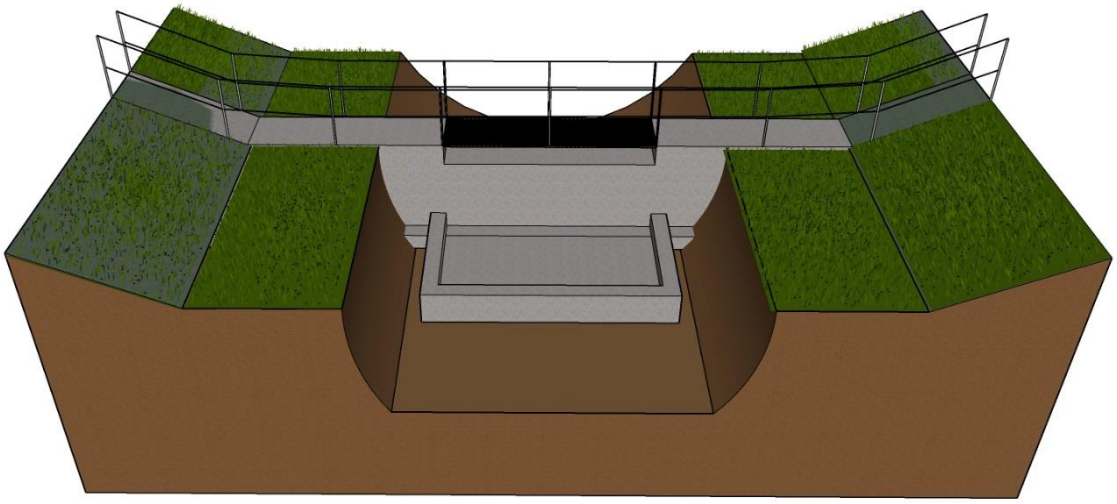


Figure 7: Concrete weir with walkway

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

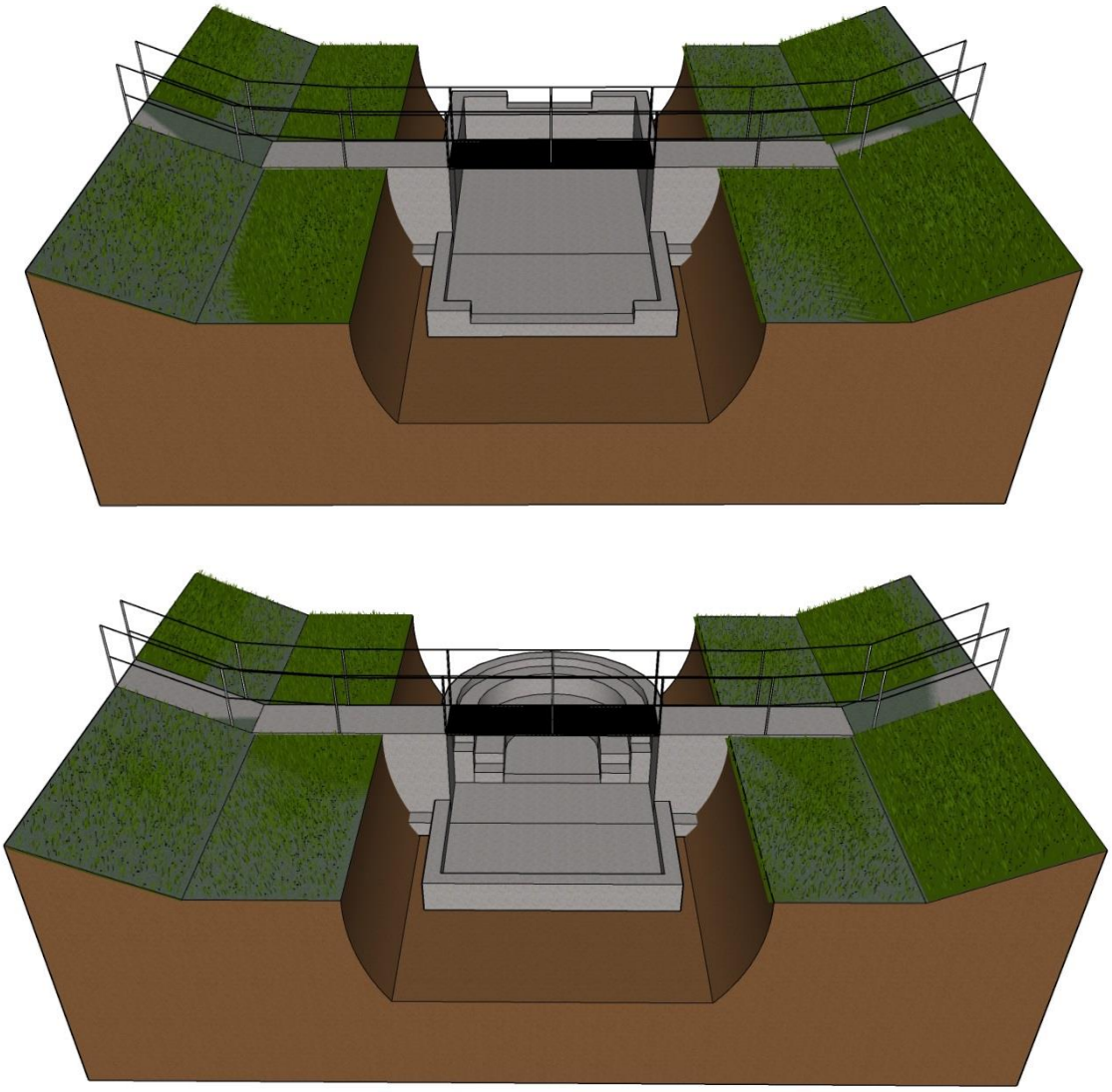


Figure 8: Concrete weir box and or round-inlet

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.

4 RISK ASSESSMENT

As part of the planning regime for wetland rehabilitation to be implemented within the Rietvlei 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 Rietvlei catchment as part of the larger rehabilitation planning project for CoE. The baseline information from the Rietvlei 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***.

[1] *(c)* impeding or diverting the flow of water in a watercourse;
[2] *(i)* altering the bed, banks, course or characteristics of a watercourse;

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 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
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.

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
1	Full Lifecycle	Alien Vegetation Clearing & Management	CONSTRUCTION • Accessing alien vegetation (foot traffic) • Manual clearing (felling or pulling) of alien vegetation • Removal of cut plant material • Application of herbicides OPERATION • Pulling of emerging juveniles as needed • Application of herbicides as needed	NEGATIVE • 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) POSITIVE • Improved flow into wetlands • Improvement in habitat quality	5	5	5	5	5	3	2	10	1	3	5	3	12	120	M	Moderate	• 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=C to E IS=Moderate
2		Removal of Litter, Rubble, Infill	CONSTRUCTION • Vehicle (TLB and/or Truck) access to and from Litter/Rubble/Infill • Earthworks (TLB removal of material) OPERATION • None	NEGATIVE • 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) POSITIVE • 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	• 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=C to E IS=Moderate
3		Landscaping and Revegetation of Bare or Disturbed Areas	CONSTRUCTION • 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) OPERATION • None	NEGATIVE • 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) POSITIVE • 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	• 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=C to E IS=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)	CONSTRUCTION • 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 OPERATION • Structure maintenance	NEGATIVE • 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 POSITIVE • 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	• 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=C to E IS=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	CONSTRUCTION • 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 OPERATION • Structure maintenance	NEGATIVE • 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 POSITIVE • 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	• 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=C to E IS=Moderate
6		Installation of Bricked Walkways	CONSTRUCTION • 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 OPERATION • None	NEGATIVE • 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	• 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=C to E IS=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	CONSTRUCTION • Accessing alien vegetation (foot traffic) • Manual clearing (felling or pulling) of alien vegetation • Removal of cut plant material • Application of herbicides OPERATION • Pulling of emerging juveniles as needed • Application of herbicides as needed	NEGATIVE • 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) POSITIVE • 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	• 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=C to E IS=Moderate
2		Removal of Litter, Rubble, Infill	CONSTRUCTION • Vehicle (TLB and/or Truck) access to and from Litter/Rubble/Infill • Earthworks (TLB removal of material) OPERATION • None	NEGATIVE • 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) POSITIVE • 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	• 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=C to E IS=Moderate
3		Landscaping and Revegetation of Bare or Disturbed Areas	CONSTRUCTION • 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) OPERATION • None	NEGATIVE • 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) POSITIVE • 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	• 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=C to E IS=Moderate
4		Installation of Litter Collection Facilities (Refuse Bins)	CONSTRUCTION • Clear vegetation • Prepare (level and compact) soil surface • Placement of concrete/steel litter bins OPERATION • None	NEGATIVE • Exposure of bare soils to increased risk of erosion • Mobilisation of sediments POSITIVE • 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	• 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=C to E IS=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	CONSTRUCTION • Clear vegetation • Landscaping and levelling of surface • Ploughing and preparation for planting OPERATION • Watering of crop • Application of fertiliser/herbicide/insecticide • Harvesting of crop • Ploughing and preparation for planting • Increased frequency of burning	NEGATIVE • 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	• 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=C to E IS=Moderate
6		Establishment of Grassed Sports Fields	CONSTRUCTION • Clear vegetation • Landscaping, scarifying and levelling of surface • Planting of grassed lawn OPERATION • Irrigation of grassed sports field	NEGATIVE • 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	• 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=C to E IS=Moderate
7		Installation of Play and Outdoor Gym Facilities and/or Braai facilities, Table and Benches	CONSTRUCTION • 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 OPERATION • None	NEGATIVE • 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	• 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 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)	Majority of Wetlands in the following categories: PES=C to E IS=Moderate
8		Installation of Bricked Walkways	CONSTRUCTION • 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 OPERATION • None	NEGATIVE • 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	• 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=C to E IS=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;
- Upgrade of the road crossing was not costed as it is a reginal road and falls under the stormwater and roads department;
- 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;
- 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	19.8	24.7	32.1
Zone 2	1.4	1.8	2.3
Zone 4	20	25	32.5
Total (in millions of Rands)	**41.2**	**51.5**	**66.9**

Table 9: High level costing for hard interventions

Hard Interventions			
Rehabilitation Zone	Lower Range (-20%)	Median	Upper Range (+30%)
Zone 1	10.4	13	16.9
Zone 4	1.3	1.6	2.1
Total (in millions of Rands)	**11.7**	**14.6**	**19**

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 (±2m 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 join 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 joins 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 Rietvlei 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 Rietvlei Catchment wetlands. The conceptual mean costs for the project are roughly ***R 51.1 million for the soft interventions and R14.6 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 Rietvlei 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 RIETVLEI CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION

Site Name: Rietvlei 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 (Channelled valley bottom)			**Large upper park area (corner M32 and M39) most of cost concentrated to the north east corner of the M90**
1	**Fence of large upper park**			Palisade fence is costed for with 8 entrances to the pan
1.1	Palisade fence 1.8m bolt on application	R	2 350 000	Fence in park area
1.2	Palisade pedestrian gates	R	52 800	Palisade gates pedestrian
1.3	Palisade car gates	R	63 800	Palisade car gate 3m wide
2	**Shape and level area around pan**			
2.1	Clear and grub	R	660 000	General clearing of the area around the park
2.2	Level and shape	R	3 300 000	Lots of shaping around the park edges as well as flatten area for sports field
3	**Pedestrian walkways**			
3.1	Bricked walkways	R	540 000	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	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**			
5.1	Bins concrete	R	60 000	Bins scattered in and around pan area
5.2	Waste management area	R	240 000	A dedicated waste management area. Paved area with place for 2 large skips
6	**Park miscellaneous**			
6.1	Stormwater infrastructure	R	770 000	Formalised stormwater channels into the park area
6.2	Braai areas	R	100 000	Small concrete 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	1 000 000	Number of indigenous tress planted around the pan area
6.8	Landscaping	R	500 000	General landscaping in and around miscellaneous areas. More to the north east area
6.9	Signage	R	60 000	Signage in and around pan area
	Subtotal HGM 1.1 - Large upper park area	**R**	**11 498 100**	
	HGM 1.1 (Channel valley bottom)			**Rietvlei Park running parallel to the M84**
1	**Fence of pan area**			
1.1	Palisade fence 1.8m bolt on application	R	750 000	Fence in park 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	150 000	General clearing of the area around the park
2.2	Level and shape	R	165 000	Shaping around the park, to ensure free drainage
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	577 500	
4	**Waste management**			
4.1	Bins concrete	R	20 000	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	350 000	Formalised stormwater channels into the channel valley bottom
5.2	Braai areas	R	50 000	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	30 000	10 concrete tables with benches
5.7	Trees and shrubs	R	950 000	Number of indigenous tress planted around the pan area
5.8	Tree removal	R	5 512	Alien tree removal
5.9	Landscaping	R	300 000	General landscaping in and around miscellaneous areas
5.1	Signage	R	20 000	Signage in and around pan area
	Subtotal HGM 1.1 - Rietvlei Park	**R**	**4 316 312**	
	HGM 1.1 (General alien tree removal)			**General alien tree removal in Zone 1**
1	**Shape and level area around Park**			
1.1	Clear and grub	R	6 000	General clearing of the area around the park
1.2	Level and shape	R	66 000	20% of alien tree area
2	**Miscellaneous**			
2.1	Alien tree removal	R	55 120	
	Subtotal HGM 1.6 - Channel valley bottom	**R**	**127 120**	
	Total Zone 1	**R**	**15 941 532**	
1	**Additional allowances**			
1.1	Preliminaries and general	R	3 985 383	Assume 25% of Total Zone 1
1.2	Contingencies	R	4 782 460	Assume 30% of Total Zone 1
	Subtotal 3 - Additional allowances	**R**	**8 767 843**	
	GRAND TOTAL	**R**	**24 700 000**	
-20%	**LOWER RANGE**	**R**	**19 800 000**	
+30%	**UPPER RANGE**	**R**	**32 100 000**	

CoE RIETVLEI CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION

Site Name: Rietvlei 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 2.3 (Channelled valley bottom)			
1	**Shape and level area around Park**			
1.1	Clear and grub	R	90 000	General clearing of the area around the park
1.2	Level and shape	R	990 000	20% of alien tree area
2	**Miscellaneous**			
2.1	Alien tree removal	R	82 680	
	Subtotal HGM 2.3 - Channelled valley bottom	**R**	**1 162 680**	
	Total Zone 2	**R**	**1 162 680**	
1	**Additional allowances**			
1.1	Preliminaries and general	R	290 670	Assume 25% of Total Zone 2
1.2	Contingencies	R	348 804	Assume 30% of Total Zone 2
	Subtotal 3 - Additional allowances	**R**	**639 474**	
	GRAND TOTAL	**R**	**1 800 000**	
-20%	**LOWER RANGE**	**R**	**1 400 000**	
+30%	**UPPER RANGE**	**R**	**2 300 000**	

CoE RIETVLEI CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
SOFT INTERVENTION

Site Name: Rietvlei 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)			**Park area on the corner of 6th road in HGM 4.2**
1	**Fence of Park area**			
1.1	Palisade fence 1.8m bolt on application	R	1 050 000	Fence in park 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 Park**			
2.1	Clear and grub	R	156 000	General clearing of the area around the park
2.2	Level and shape	R	1 716 000	
3	**Pedestrian walkways Park**			
3.1	Bricked walkways	R	675 000	Concrete interlocking paving in and around the park area
3.2	Construct vehicular and servicing area	R	577 500	
4	**Waste management Park**			
4.1	Bins concrete	R	25 000	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 2 large skips
5	**Park miscellaneous**			
5.1	Stormwater infrastructure	R	210 000	Formalised stormwater channels into the park
5.2	Braai areas	R	50 000	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	9 different outdoor gym machines
5.5	Outdoor gym flooring	R	320 000	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 park area
5.8	Landscaping	R	500 000	General landscaping in and around miscellaneous areas
5.9	Signage	R	40 000	Signage in and around park area
	Subtotal HGM 4.2 - Channelled valley bottom	**R**	**6 567 800**	
	HGM 4.2 (Channelled valley bottom)			**Park around dam on corner of Pomona and High road**
1	**Fence of Park area**			
1.1	Palisade fence 1.8m bolt on application	R	1 050 000	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	60 000	General clearing of the area around the park
2.2	Level and shape	R	660 000	
3	**Pedestrian walkways Park**			
3.1	Bricked walkways	R	765 000	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**			
5.1	Bins concrete	R	30 000	Bins scattered in and around park area
5.2	Waste management area	R	240 000	A dedicated waste management area. Paved area with place for 2 large skips
6	**Park miscellaneous**			
6.1	Stormwater infrastructure	R	420 000	Formalised stormwater channels into the park
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	1 000 000	Number of indigenous tress planted around the park area
6.8	Landscaping	R	800 000	General landscaping in and around miscellaneous areas
6.9	Signage	R	60 000	Signage in and around park area
	Subtotal HGM 4.3 - Channelled valley bottom	**R**	**6 717 550**	
	HGM 4.3 (Pan)			**Clean up around pan area Lanseria Road**
1	**Shape and level area around pan**			
1.1	Clear and grub	R	150 000	General clearing of the area around the pan
1.2	Level and shape	R	1 650 000	Shaping around the pan, to ensure free drainage
2	**Waste management**			
2.1	Bins concrete	R	15 000	Bins scattered in and around pan area
2.2	Waste management area	R	120 000	A dedicated waste management area. Paved area with place for 2 large skips
3	**Park miscellaneous**			
3.1	Stormwater infrastructure	R	910 000	Formalised stormwater channels into the pan
3.2	Signage	R	10 000	Signage in and around pan area
	Subtotal HGM 1.2 - Small pan area	**R**	**2 855 000**	
	Total Zone 4	**R**	**16 140 350**	
1	**Additional allowances**			
1.1	Preliminaries and general	R	4 035 088	Assume 25% of Total Zone 4
1.2	Contingencies	R	4 842 105	Assume 30% of Total Zone 4
	Subtotal 3 - Additional allowances	**R**	**8 877 193**	
	GRAND TOTAL	**R**	**25 000 000**	
-20%	**LOWER RANGE**	**R**	**20 000 000**	
+30%	**UPPER RANGE**	**R**	**32 500 000**	

CoE RIETVEI CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
HARD INTERVENTIONS

Site Name: Rietvlei 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 (Channelled valley bottom)		
1	**Additional weir structures**		additional weir structures P1 to P4
1.1	Clear and grub	R 40 625	
1.2	Bulk excavations	R 89 600	
1.3	Concrete, reinforcing and formwork	R 1 800 000	
1.4	Berms with MacMat	R 64 000	Rate include anchor trench for MacMat
1.5	Reestablishment of vegetation	R 50 000	
1.6	Signage	R 40 000	
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 33 600	
2.3	Concrete	R 26 400	Gabion structure must be concrete capped
2.4	Concrete, reinforcing and formwork	R 900 000	3 structures need to be enlarged water is cutting around structures
2.5	Berms with MacMat	R 24 000	Add berms on either side of concrete structures
2.6	Reestablishment of vegetation	R 2 400	
2.7	Signage	R 30 000	
3	**Formalise channel**		
3.1	Clear and grub	R 195 000	
3.2	General levelling and shaping	R 1 584 000	
3.3	Restricted excavations for anchor trench	R 24 000	
3.4	Supply and install Armoflex	R 2 760 000	
3.5	Reestablishment of vegetation	R 240 000	
3.6	Structures to slow water velocity	R 450 000	
	Subtotal HGM 1.3 - Channel valley bottom	**R 8 355 575**	
	Total Zone 1	**R 8 355 575**	
1	**Additional allowances**		
1.1	Preliminaries and general	R 2 088 894	Assume 25% of sub total 1
1.2	Contingencies	R 2 506 673	Assume 30% of sub total 1
	Subtotal 3 - Additional allowances	**R 4 595 566**	
	GRAND TOTAL	**R 13 000 000**	
-20%	**LOWER RANGE**	**R 10 400 000**	
+30%	**UPPER RANGE**	**R 16 900 000**	

CoE RIETVLEI CATCHMENT - HIGH LEVEL COST ESTIMATE BOQ
HARD INTERVENTIONS

Site Name: Rietvlei Catchment Zone 4

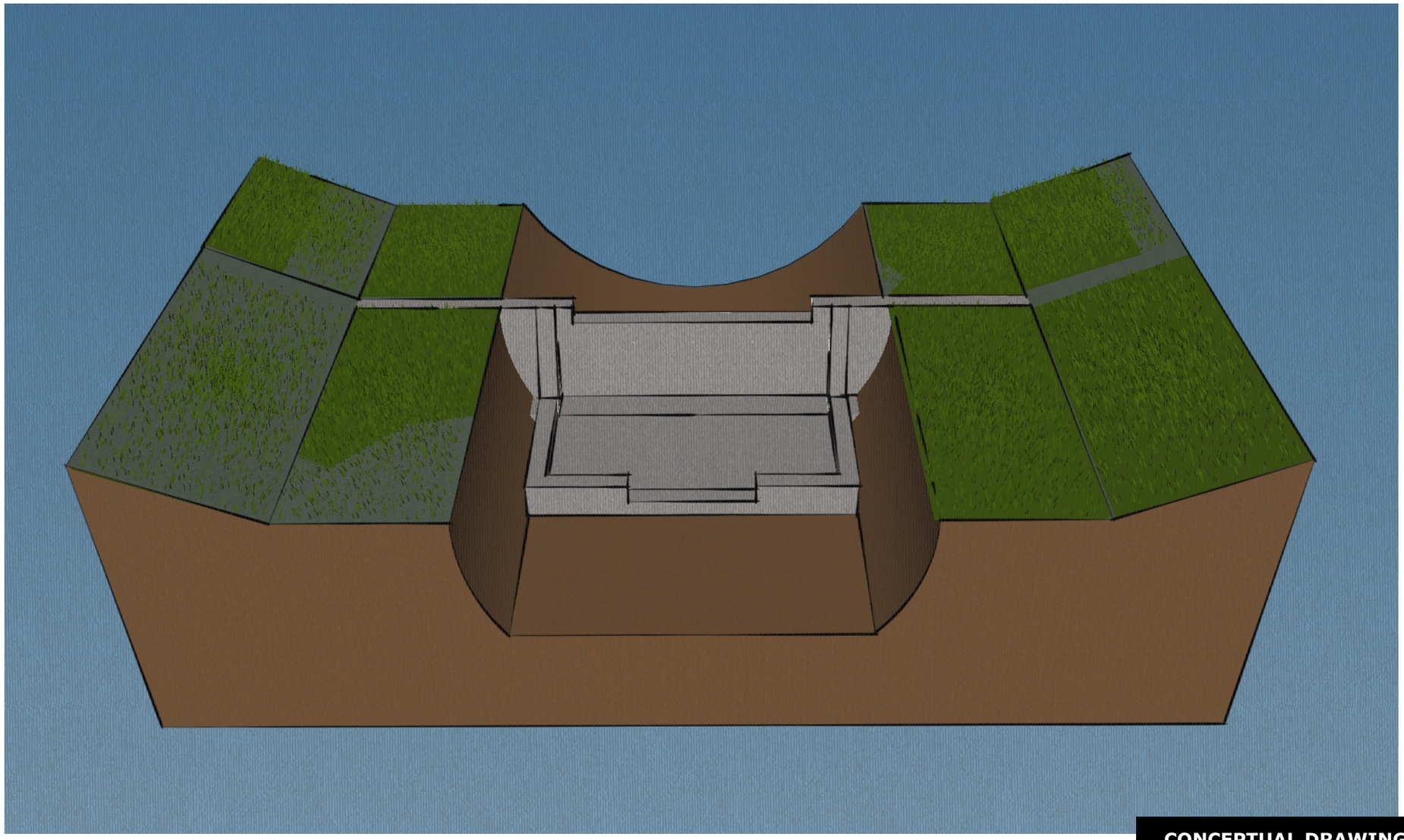
Knowledge Base for Assessment

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 4.1 (Channelled valley bottom)			
1	**Additional weir structures**			additional weir structures P5 to P6
1.1	Clear and grub	R	20 313	
1.2	Bulk excavations	R	44 800	
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	25 000	
1.6	Signage	R	20 000	
	Subtotal HGM 4.1 - Channel valley bottom	**R**	**1 042 113**	
	Total Zone 3	**R**	**1 042 113**	
1	**Additional allowances**			
1.1	Preliminaries and general	R	260 528	Assume 25% of sub total 1
1.2	Contingencies	R	312 634	Assume 30% of sub total 1
	Subtotal 3 - Additional allowances	**R**	**573 162**	
	GRAND TOTAL	**R**	**1 600 000**	
-20%	**LOWER RANGE**	**R**	**1 300 000**	
+30%	**UPPER RANGE**	**R**	**2 100 000**	

RIETVLEI CATCHMENT CONCEPTUAL ENGINEERING DRAWINGS
CITY OF EKURHULENI



CONCEPTUAL DRAWING

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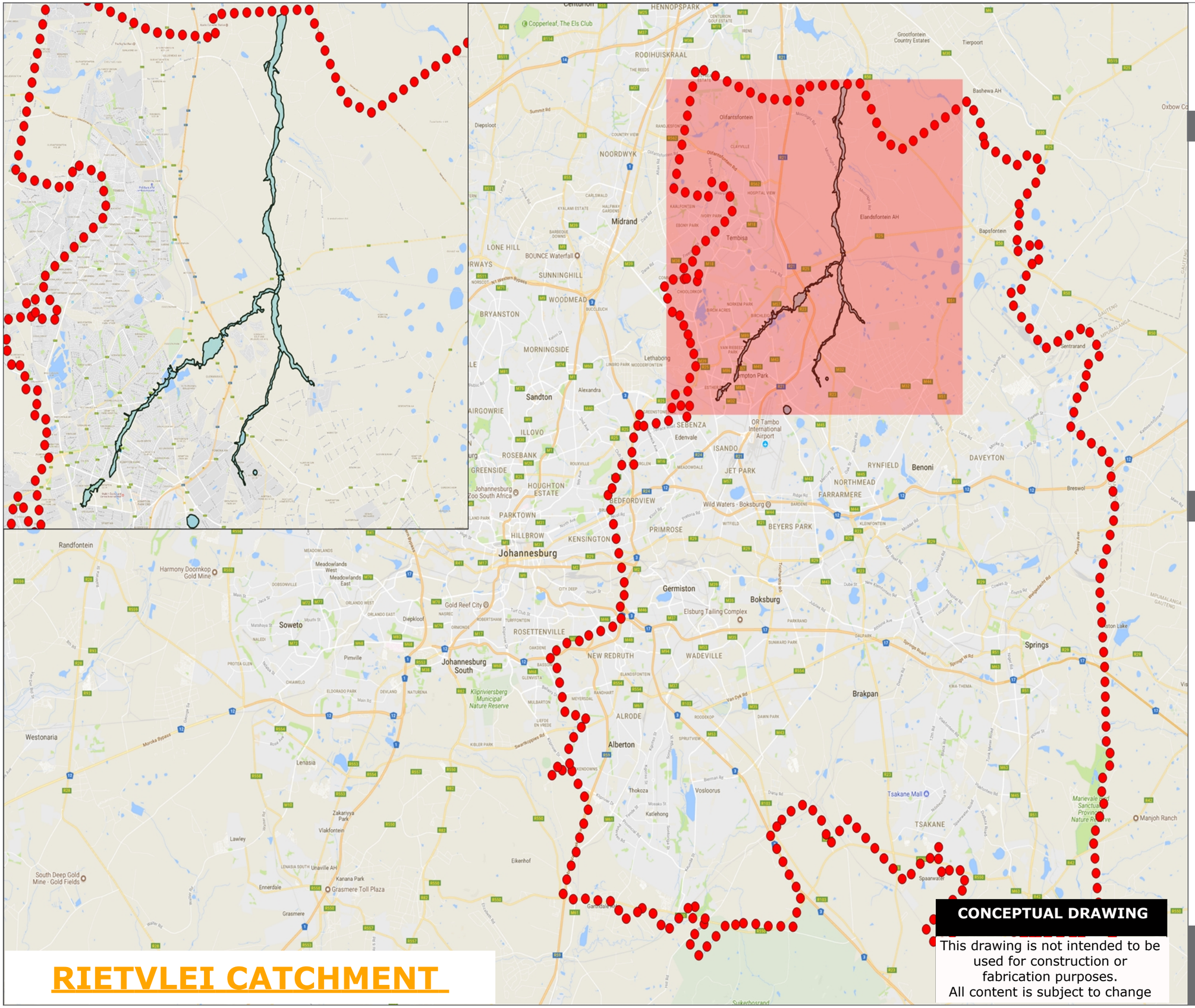
City of Ekurhuleni

Cover Page

July 13, 2018

A.01



RIETVLEI CATCHMENT

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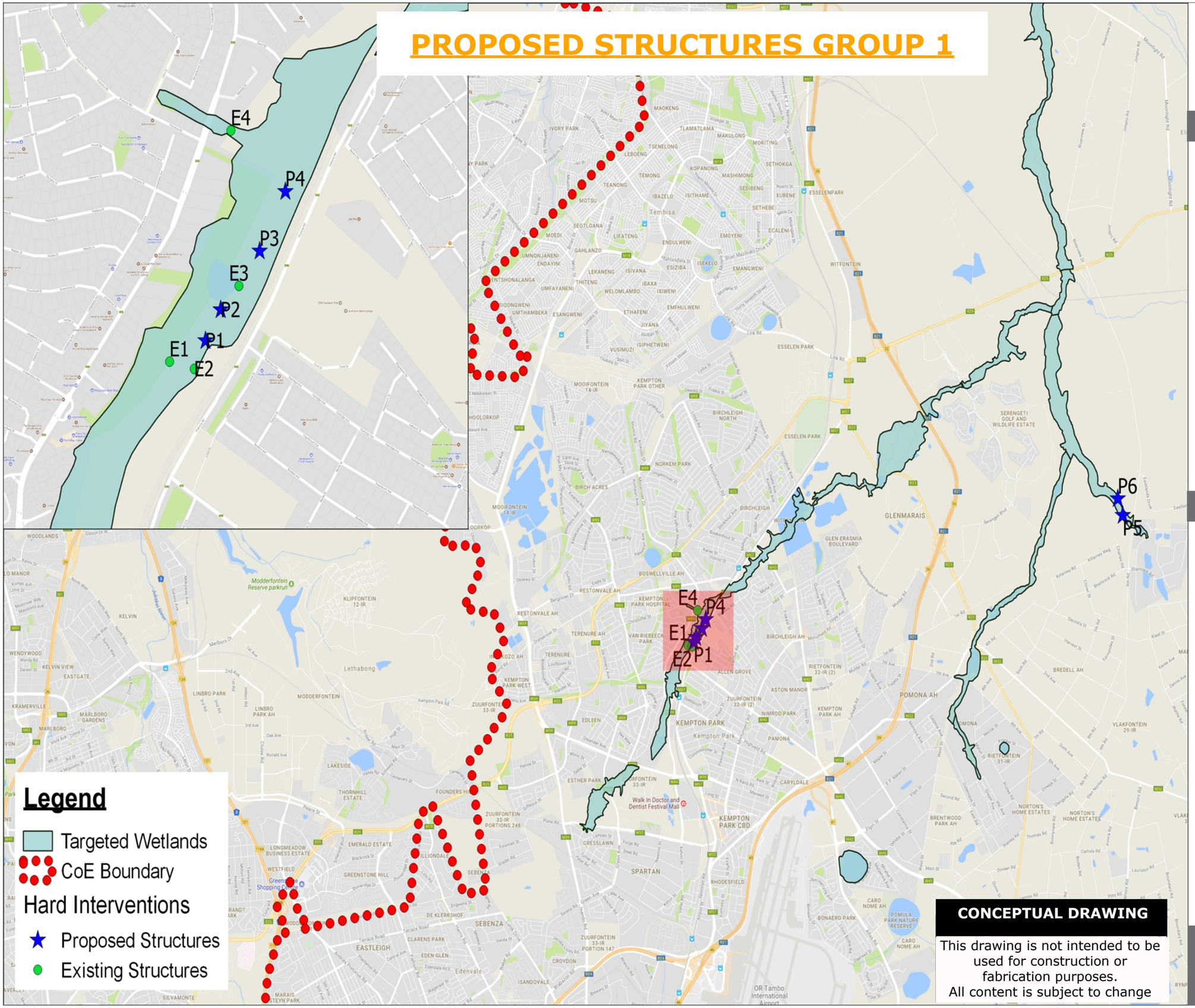
City of Ekurhuleni

General Arrangement

July 13, 2018

A1.01

PROPOSED STRUCTURES GROUP 1



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City of Ekurhuleni

Proposed and Existing Structures Group 1

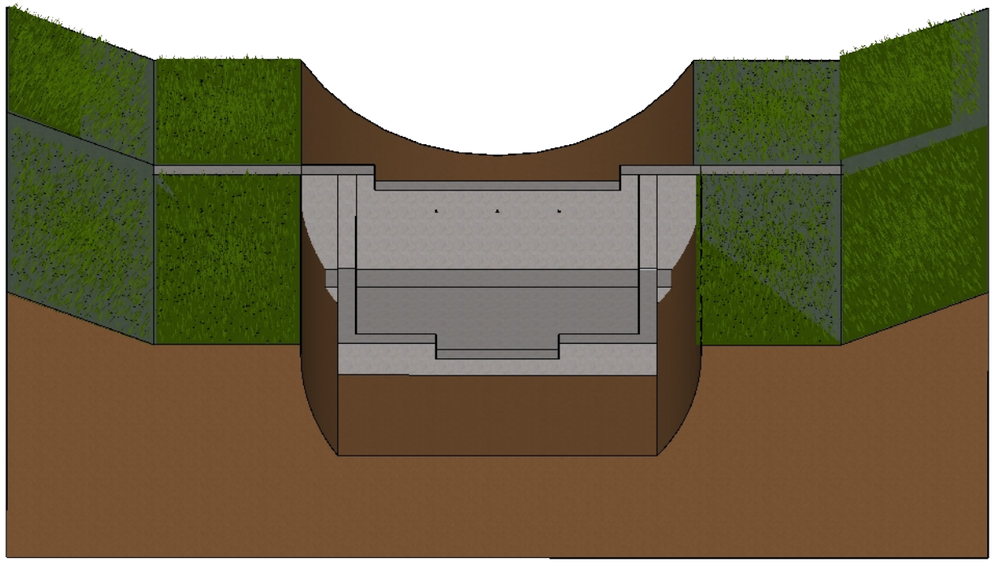
July 13, 2018

A2.01

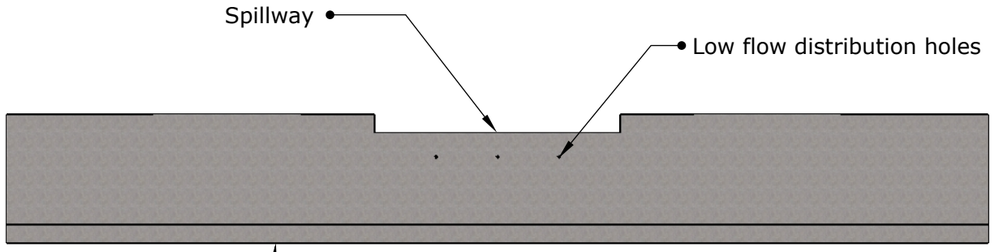
CONCRETE WEIR

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P1	-26.079198	28.224909	25
P2	-26.078436	28.225403	25
P3	-26.076990	28.226669	25
P4	-26.075524	28.227507	25

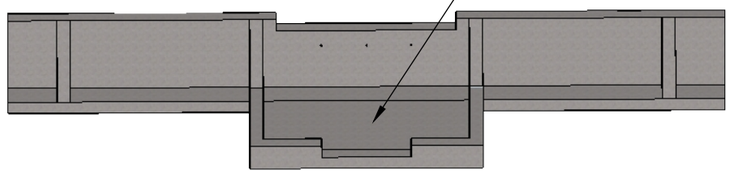
Notes:
Structure can be optimised during the detailed engineering design phase of the project.
Concrete weirs will need to be scaled for each individual point.
These sizes should be confirmed in the detailed design.



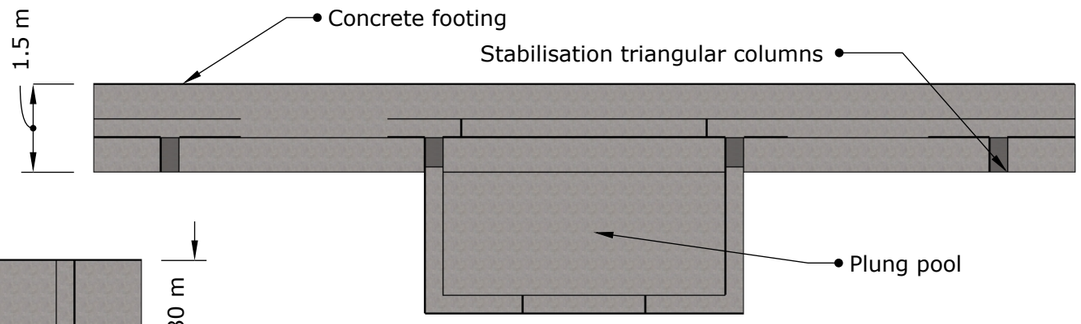
CONCRETE WEIR
scale: 1:100
B / A3



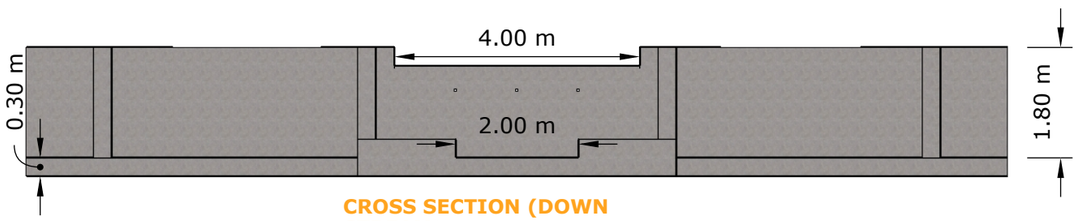
CROSS SECTION (UPSTREAM)
scale: 1:100
A3 / B



CONCRETE VIEW
scale: 1:NA
A3 / B



PLAN VIEW
scale: 1:100
A3 / B



CROSS SECTION (DOWN STREAM)
scale: 1:100
A3 / B

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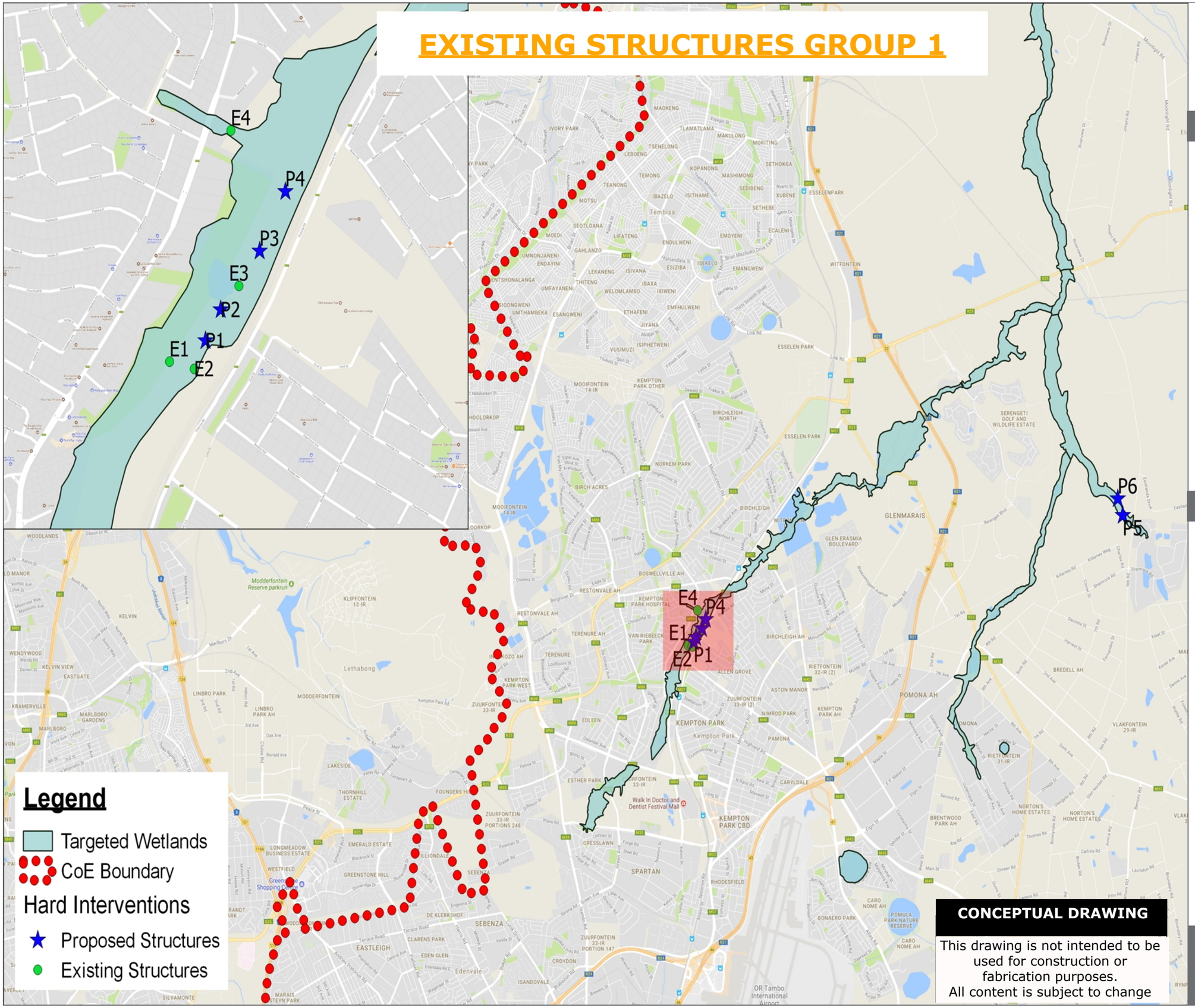
City of Ekurhuleni

Proposed Structure
Group 1.1
July 13, 2018

A3.01

EXISTING STRUCTURES GROUP 1



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City of Ekurhuleni

Existing Structures
Group 1
July 13, 2018

A4.01

EXISTING STRUCTURES MAINTENANCE GROUP 1

STRUCTURE	LATITUDE	LONGITUDE	COMMENT	MAINTENANCE
E1	-26.079714	28.223742	Dam wall with gabion spillway, good condition	Concrete cap gabion, general shaping around dam wall
E2	-26.079892	28.224541	Large concrete weir, good condition	General concrete repairs and extend wingwalls a further 5m on both sides
E3	-26.077848	28.225996	Gabion weir, poor condition	Reconstruct weir with reinforced concrete
E4	-26.074020	28.225736	Gabion channel, fair condition	Replace gabions with Armorflex channel

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.

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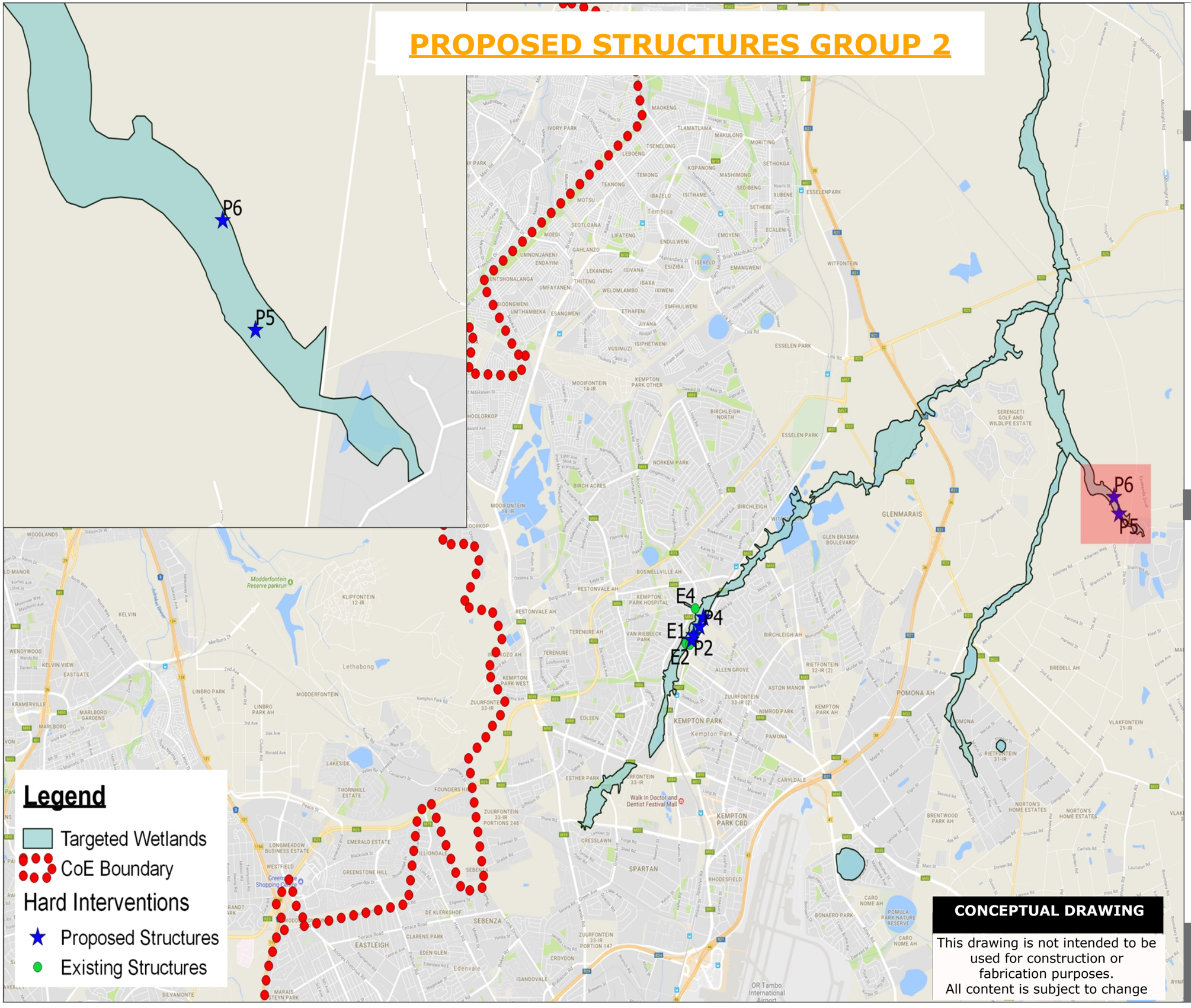
City of Ekurhuleni

Existing Structures Maintenance Group 1
July 13, 2018

A5.01

PROPOSED STRUCTURES GROUP 2



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City of Ekurhuleni

Proposed and Existing Structures Group 2

July 13, 2018

A6.01

CONCRETE WEIR

STRUCTURE	LATITUDE	LONGITUDE	LENGTH (m)
P5	-26.058601	28.316939	28
P6	-26.055891	28.315870	20

Notes:
Structure can be optimised during the detailed engineering design phase of the project.
Concrete weirs will need to be scaled for each individual point.
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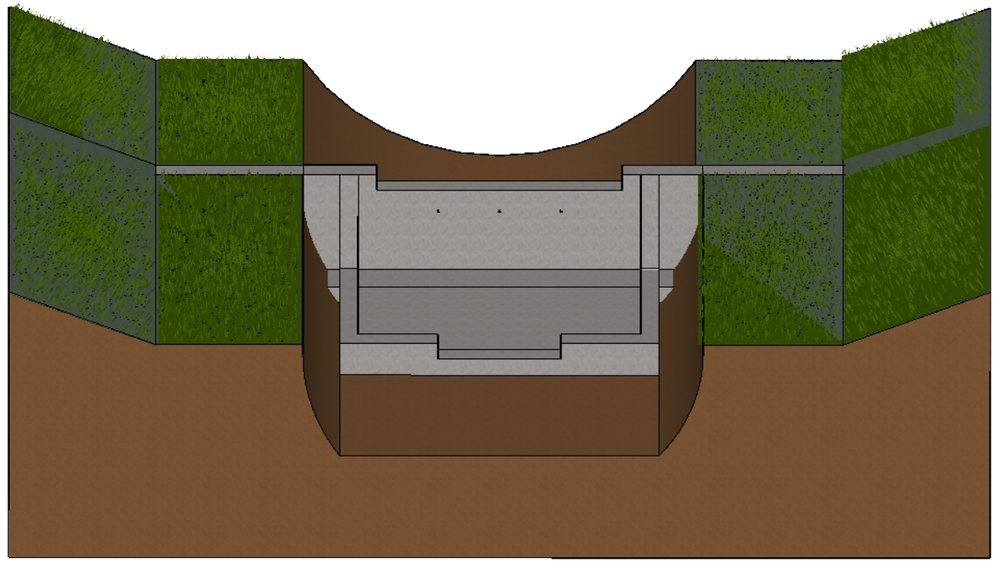
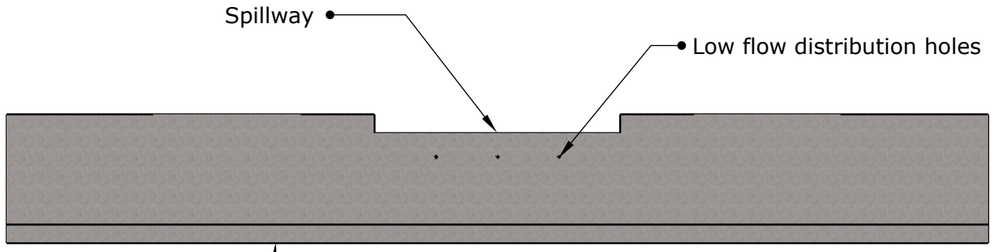
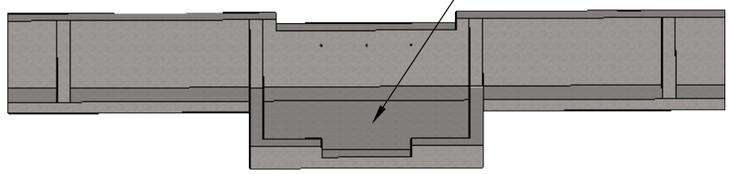


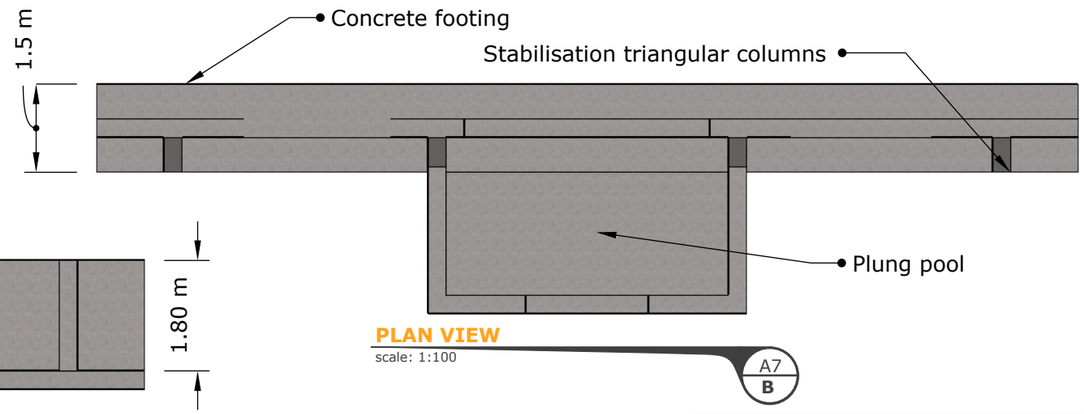
CONCRETE WEIR
scale: 1:100
B / A7



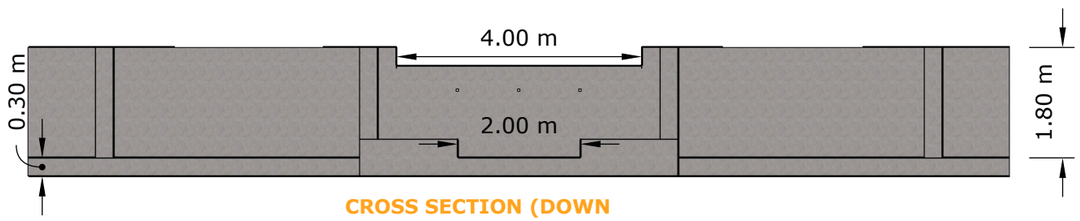
CROSS SECTION (UPSTREAM)
scale: 1:100
A7 / B



CONCRETE VIEW
scale: 1:NA
A7 / B



PLAN VIEW
scale: 1:100
A7 / B



CROSS SECTION (DOWN STREAM)
scale: 1:100
A7 / B

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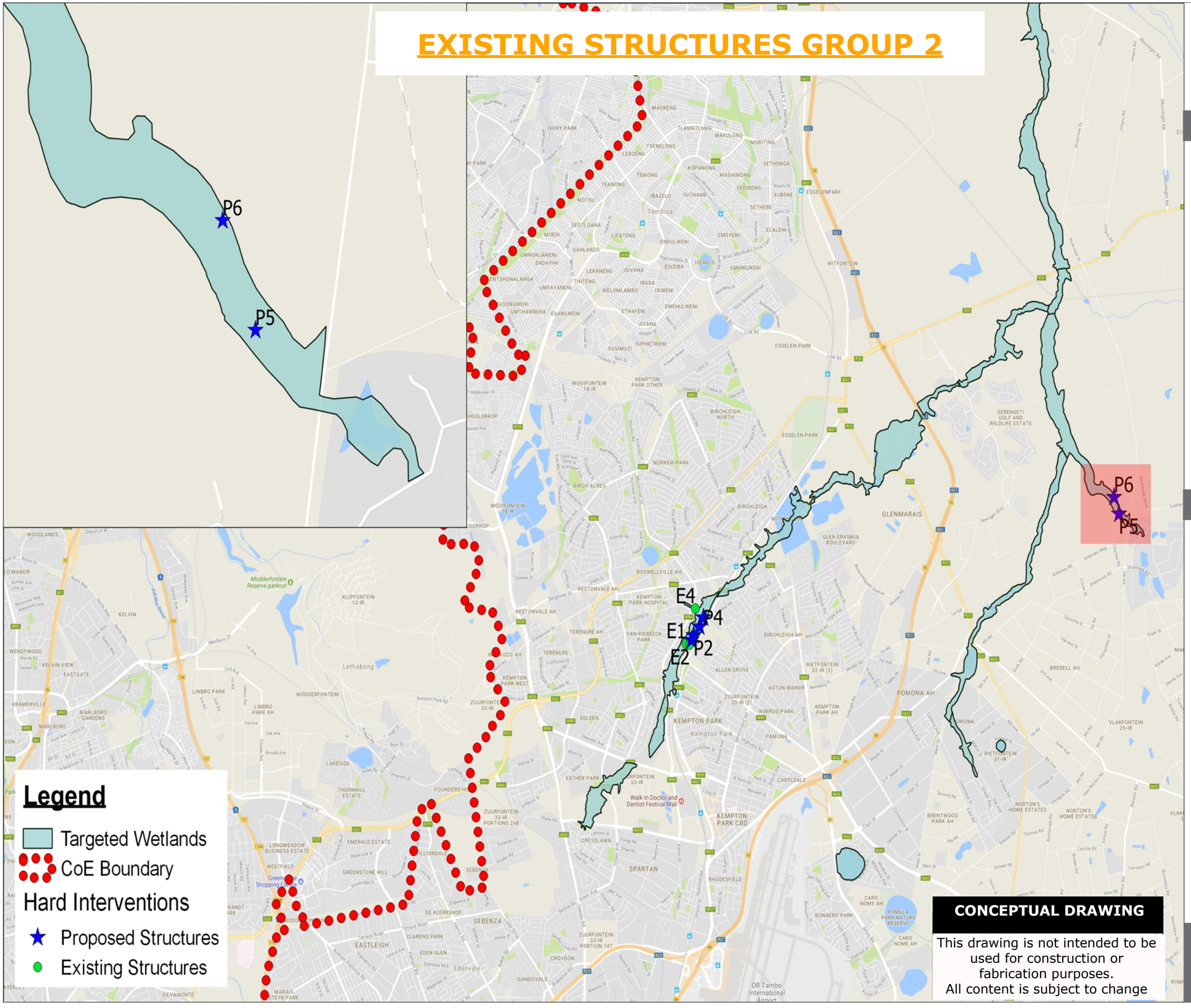
City of Ekurhuleni

Proposed Structure
Group 2.1
July 13, 2018

A7.01

EXISTING STRUCTURES GROUP 2



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City of Ekurhuleni

Existing Structures
Group 2
July 13, 2018

A8.01

EXISTING STRUCTURES MAINTENANCE GROUP 2

STRUCTURE	LATITUDE	LONGITUDE	COMMENT	MAINTENANCE
E5	-25.968940	28.300997	River crossing, fair condition	Upgrade the river crossing

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.

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Existing Structures Maintenance Group 2
July 13, 2018

A9.01

RIETVLEI CATCHMENT

City of Ekurhuleni

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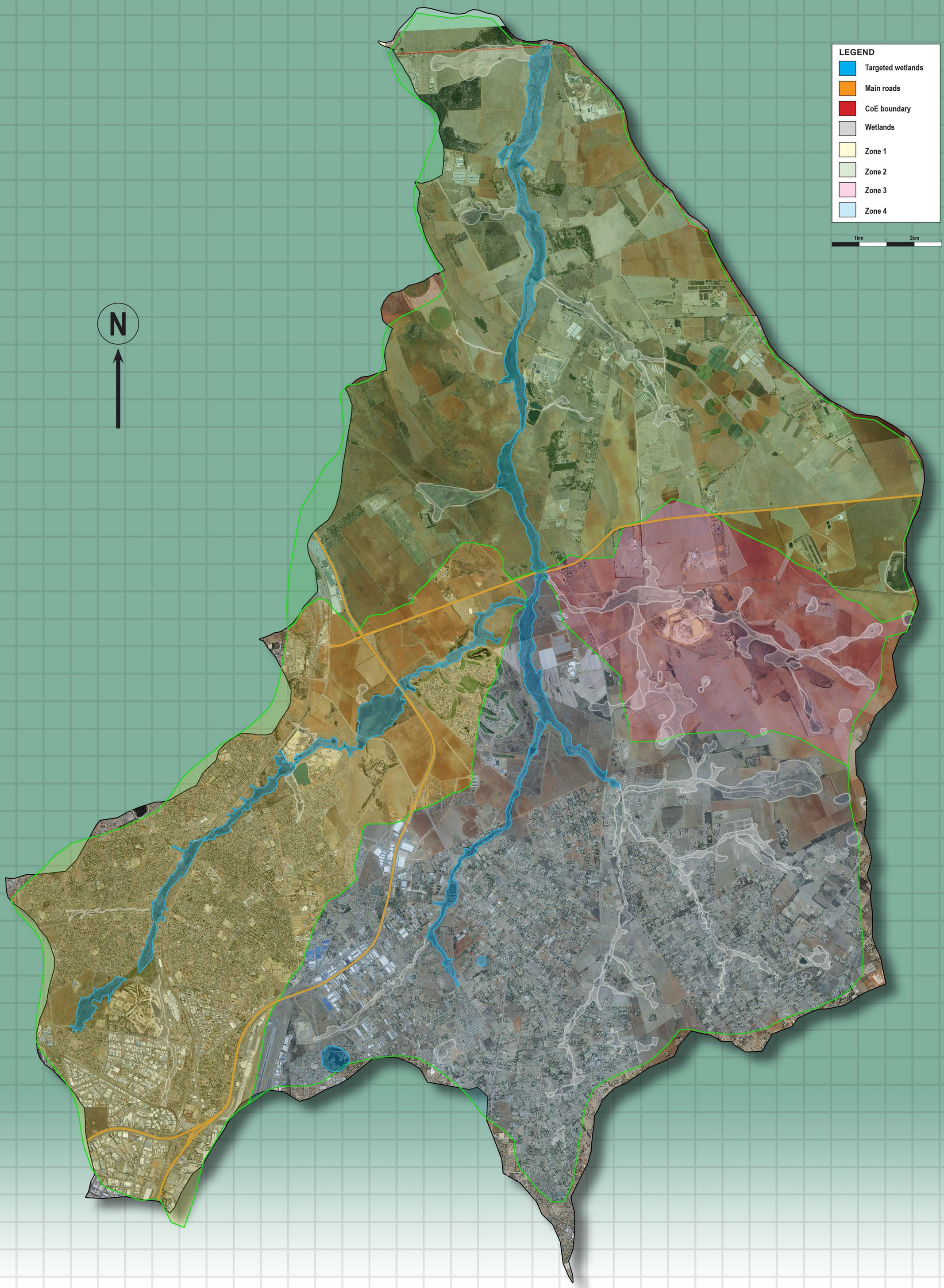
RIETVLEI CATCHMENT



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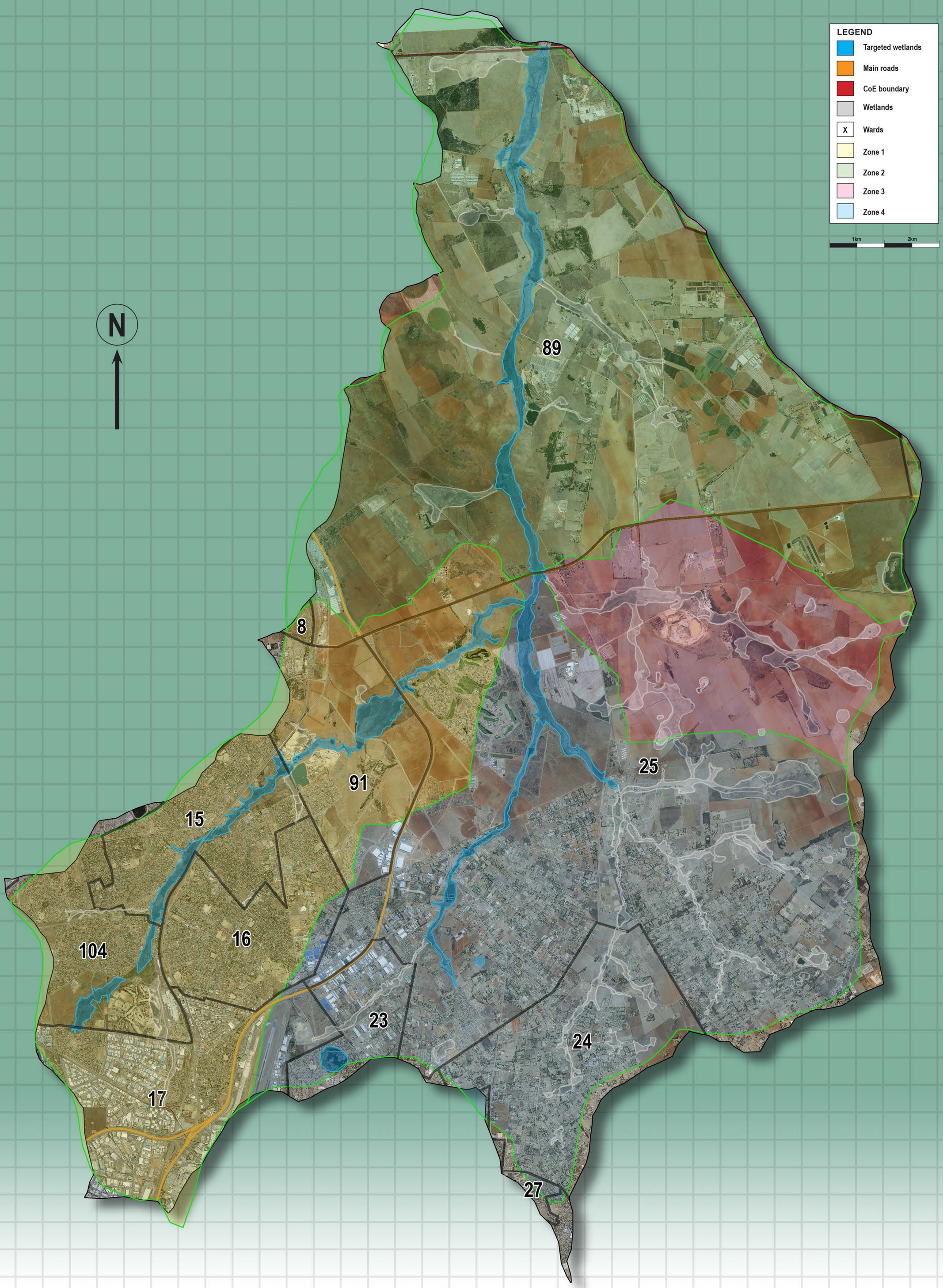
RIETVLEI CATCHMENT



City of Ekurhuleni

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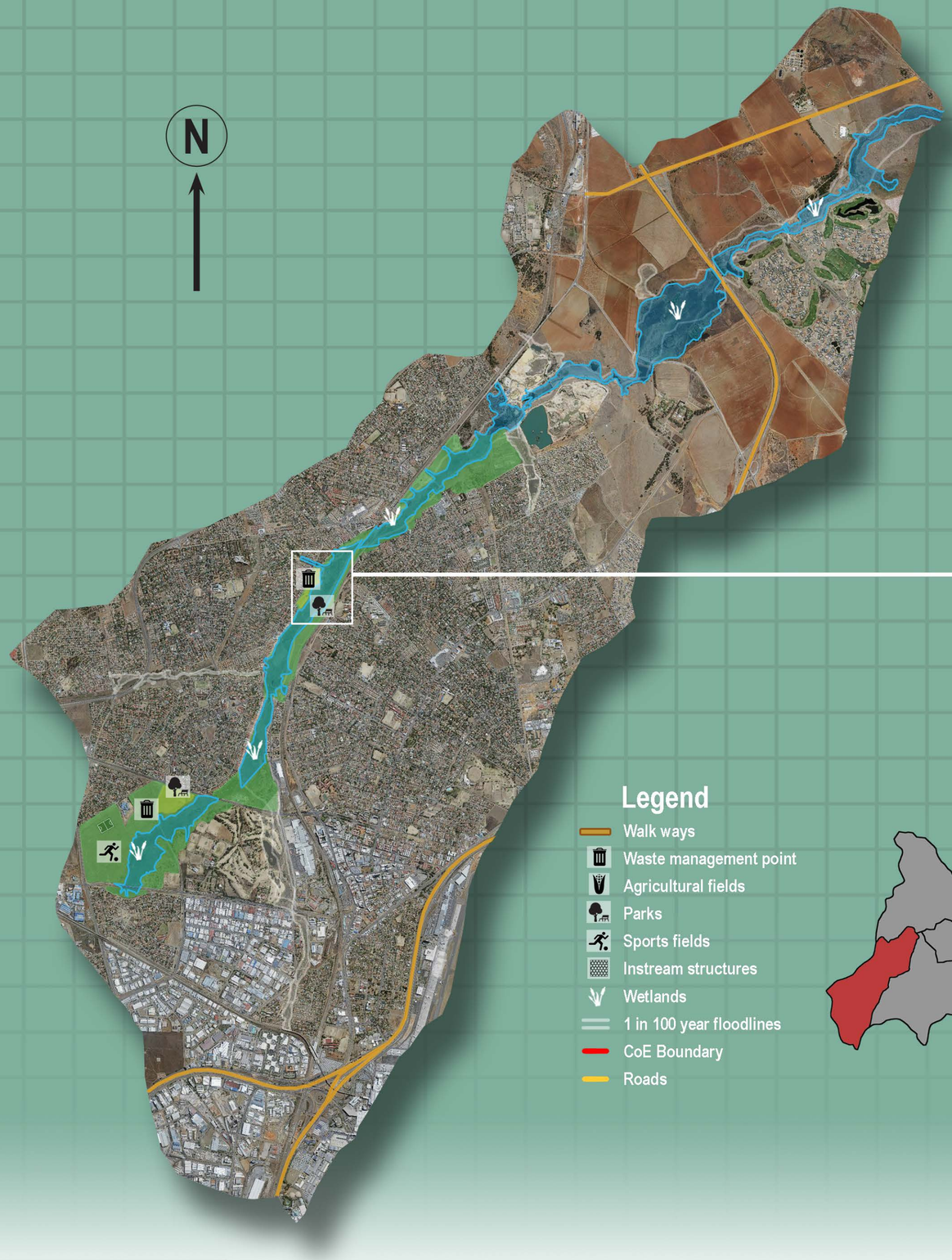
RIETVLEI ZONE 1



Legend

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

City of Ekurhuleni

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RIETVLEI ZONE 2

City of Ekurhuleni

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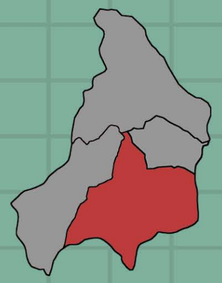
RIETVLEI ZONE 4

Legend

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



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