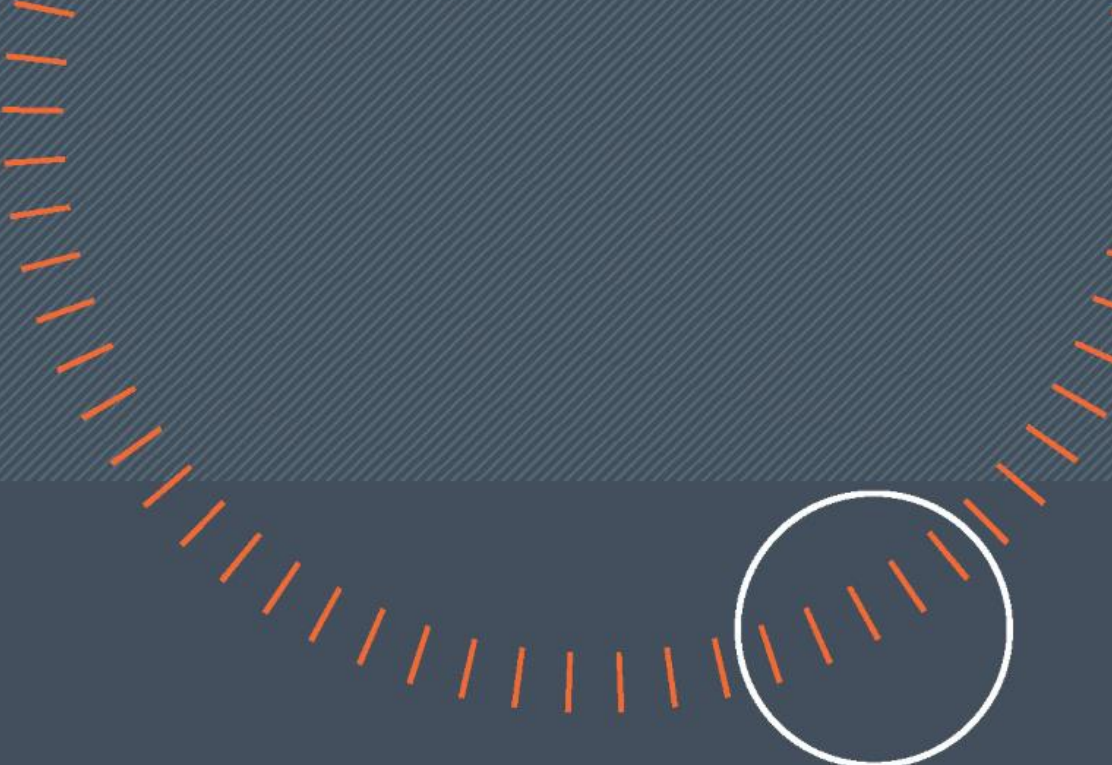




City of Cape Town

Philippi Opportunity Area Stormwater Study Conceptual Proposal Report

7527

March 2023



DOCUMENT VERIFICATION

Title: Philippi Opportunity Area Stormwater Study: Conceptual Proposal Report
--

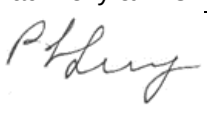
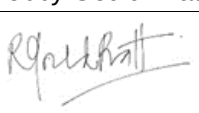
Project No: 7527	Report No: REP-7527-700-8003 Rev D
-------------------------	---

Date: 10 March 2023	Report Status: Final
----------------------------	-----------------------------

Compiled By: HHO Consulting Engineers 14th Floor, The Towers South 2 Hertzog Boulevard Cape Town 8001 Tel: (021) 425 2870	Client: City of Cape Town 44 Wale Street Cape Town 8000
---	--

Authors: Fred de Villiers & Bobby Gould-Pratt	Client Contact: Lorraine Nzimande & Gideon Brand
--	---

Synopsis: Integrated Conceptual proposal report for the Philippi Opportunity Area Stormwater Study

Quality Verification:						
Rev	Date	Prepared by	Checked by	Approved by	Description	Status
A	01/11/2022	Mark Bollaert & Paul Levy	Ruan Piek	Fred de Villiers		Draft
B	12/12/2022	Paul Levy & Trish Naidu	Bobby Gould-Pratt	Fred de Villiers		Final Draft
C	20/02/2023	Paul Levy & Trish Naidu	Bobby Gould-Pratt	Fred de Villiers		Updated Final Draft
D	10/03/2023	Paul Levy & Trish Naidu	Bobby Gould-Pratt	Fred de Villiers		Final
						

Design Specialist Contact Details			
Role	Contact Person	E-mail	Telephone No.
Project Leader	Fred de Villiers	fred@hho.co.za	021 425 2870
Project Manager	Megan Woodward	megan@hho.co.za	021 425 2870
Hydrologist	Mark Bollaert	mark@hydrologic.consulting	072 239 0974
Civil Engineer	Paul Levy	paul_levy@hho.co.za	021 425 2870
Principal Urban designer	Bobby Gould-Pratt	bobby@ctn.gapp.net	021 424 2390
Urban designer	Trish Naidu	trish@ctn.gapp.net	021 424 2390

Copyright

This report has been prepared by HHO in their professional capacity in accordance with the scope of their appointment. Any assumptions, advice or recommendations in this report are based upon the information provided to HHO at the date of this report as well as current country specific standards, codes, technology & industry practices. HHO accepts no liability for any use of this document other than by the client and only for the purposes for which it was prepared and provided.

TABLE OF CONTENTS

Section No.	Description	Page No
	TABLE OF CONTENTS.....	i
	LIST OF TABLES	ii
	LIST OF FIGURES.....	ii
	LIST OF APPENDICES	iv
	EXECUTIVE SUMMARY	v
1	INTRODUCTION	1
1.1	Background	1
1.2	Study Area	2
1.3	Problem Definition	2
1.4	Project Objectives	4
1.5	Planning Informants	5
1.5.1	POA Regeneration Framework	5
1.5.2	Sheffield Road Review Study	7
1.5.3	City of Cape Town- Housing Initiatives in the POA	8
1.5.4	Private Development Indicatives in the POA	9
2	STATUS QUO HYDROLOGY & HYDRAULIC MODELLING	9
2.1	Existing Site Information	9
2.1.1	Review of Previous Reports	9
2.2	GIS and LIDAR data	10
2.2.1	Existing Services	10
2.2.2	Existing Ground Levels	10
2.3	Site Condition Assessment	10
2.4	Topographic Survey of Ponds	10
2.5	Status Quo Hydrology	11
2.5.1	Rainfall	11
2.5.2	Terrain Data	11
2.5.3	Hydrological Setting	11
2.5.4	Groundwater	12
2.5.5	Soil Runoff Potential And Land-Cover	12
2.5.6	Status Quo Hydraulic Modelling	15
2.5.7	Water Quality Assessment	24
2.5.8	Status Quo Conclusions & Recommendations	29
3	PROPOSED CONCEPT	31
3.1	SECTION A: Proposed Conceptual Stormwater Management Interventions & Results	31
3.1.1	Stormwater Model Setup	31
3.1.2	Stormwater Model Concepts and Results	32
3.1.3	Graphical Summary of Results	47
3.2	Summary of Concept Proposal Results	51
3.2.1	Zone 1	51
3.2.2	Zone 2	51
3.2.3	Zone 3	51
3.2.4	Zone 4	51
3.2.5	Zone 5	52
3.2.6	Zone 6	52

3.2.7	Zone 7	52
3.3	SECTION B: Integrated POA Open Space and Stormwater Concept.....	53
3.3.1	Conceptual Approach.....	53
3.3.2	Integrated POA Open Space and Stormwater Concept and its components.....	55
3.3.3	Stormwater Pond Design Guidelines	59
4	RECOMMENDATIONS AND WAY FORWARD	66
4.1	Recommendations	66
5	REFERENCES	68
6	CLIENT APPROVAL	68
6.1	Approval	68

LIST OF TABLES

Description	Page No
Table 2.1: 24-hour design Rainfall Depth (mm)	11
Table 3.1: Zone 1 Pond Characteristics.....	34
Table 3.2: Zone 2 Pond Characteristics.....	35
Table 3.3: Zone 3 Pond Characteristics.....	38
Table 3.4: Zone 4 Pond Characteristics.....	40
Table 3.5: Zone 5 Pond Characteristics.....	42
Table 3.6: Zone 6 Pond Characteristics.....	44
Table 3.7: Zone 7 Pond Characteristics.....	47

LIST OF FIGURES

Description	Page No
Figure 1.1: Extent of the Philippi Opportunity Area.....	2
Figure 1.2: POA Regeneration Framework.....	5
Figure 1.3: An integrated and multifunctional green network	7
Figure 1.4: Sheffield Street Road Review- Draft Street character definition map	8
Figure 1.5: POA Housing Project Figure 1.6: Sheffield Road Housing Project	9
Figure 2.1: Hydrological Setting	13
Figure 2.2: Groundwater Influence.....	13
Figure 2.3: Land-Cover	14
Figure 2.4: Model Setup.....	16
Figure 2.5 Model Results (Overall)	18
Figure 2.6: Model Results (Zone 1).....	18
Figure 2.7: Model Results (Zone 2).....	19

Figure 2.8: Model Results (Zone 3).....	19
Figure 2.9: Model Results (Zone 4).....	20
Figure 2.10: Model Results (Zone 5).....	20
Figure 2.11: Model Results (Zone 6).....	21
Figure 2.12: Model Results (Zone 7).....	21
Figure 2.13: Illegal dumping in a stormwater swale	24
Figure 2.14: Poor water circulation	25
Figure 2.15: Plant growth on water surface	25
Figure 2.16: Evidence of grey and black water	26
Figure 3.1: Concept Proposal Model Setup	31
Figure 3.2: Concept Proposal Model Results (Overall).....	32
Figure 3.3: Concept Proposal Model Results (Zone 1)	33
Figure 3.4: Outflow Hydrograph H1	33
Figure 3.5: Head and volume comparison for Pond – P1.....	34
Figure 3.6: Concept Proposal Model Results (Zone 2)	35
Figure 3.7: Concept Proposal Model Results (Zone 3)	36
Figure 3.8: Outflow Hydrographs for ‘H2’	37
Figure 3.9: Outflow Hydrographs for ‘H3’	37
Figure 3.10: Concept Proposal Model Results (Zone 4).....	39
Figure 3.11: Inflow Hydrograph at Pond D2.....	39
Figure 3.12: Concept Proposal Model Results (Zone 5)	41
Figure 3.13: Inflow Hydrograph at Pond P7	41
Figure 3.14: Concept Proposal Model Results (Zone 6)	43
Figure 3.15: Outflow Hydrographs for ‘H4’	43
Figure 3.16: Head and volume comparison for Pond – D2.....	44
Figure 3.17: Concept Proposal Model Results (Zone 7)	45
Figure 3.18: Outflow Hydrographs for ‘H5’	46
Figure 3.19: Head and volume comparison for Pond – P7	46
Figure 3.20: 1:2 Year Storm Event Comparison	47
Figure 3.21: 1:5 Year Storm Event Comparison	48
Figure 3.22: 1:10 Year Storm Event Comparison	48
Figure 3.23: 1:20 Year Storm Event Comparison	49
Figure 3.24: 1:50 Year Storm Event Comparison	49
Figure 3.25: 1:100 Year Storm Event Comparison	50
Figure 3.26: Comparison of Flooded Area	50
Figure 3.27: Percentage Reduction in Flooded Area	51
Figure 3.28: Application of the guiding concepts in existing and new development areas.....	54
Figure 3.29: Integrated Open Space and stormwater Concept	55
Figure 3.30: Green Streets and Linear Parks	56
Figure 3.31: Hierarchy of green streets- living street	57

Figure 3.32: Active Stormwater Ponds.....	57
Figure 3.33: Active Stormwater ponds	58
Figure 3.34: Supporting positive frontage onto open space	58
Figure 3.35: Proposed development in the POA	59
Figure 3.36: Pond P7 vision	61
Figure 3.37: Pond 20 vision (Erf 5268)	63
Figure 3.38: Pond P1 vision	63
Figure 3.39: Wynberg Park landscape masterplan.....	65
Figure 4.1: Proposed Phase 1 Implementation.....	67

LIST OF APPENDICES

APPENDIX A: DETENTION POND SURVEY

APPENDIX B: PCSWMM DATA OUTPUT

APPENDIX C: PCSWMM GRAPHICAL OUTPUT

EXECUTIVE SUMMARY

The City of Cape Town (CCT) Spatial Planning and Environment Directorate, Urban Catalytic Investment Department (UCI), required a review and assessment of the stormwater system serving the Philippi Opportunity Area (POA) with related master planning. The UCI department is working in close collaboration with the Catchment and Stormwater Management Department.

An investigation into the possible use of detention ponds and other parts of the stormwater system as potential multifunctional spaces and to improve the public realm was required. The results of this investigation were published in a Status Quo report commissioned by the CCT, REP-7527-700-8002 Rev 02, Philippi Opportunity Area Stormwater Study: Final Status Quo Report. The contents of the Status Quo Report are contained in this report.

Subsequent to the publication of the Status Quo report, HHO Consulting Engineers and GAPP Architects and Urban Designers were appointed by the CCT under Contract 375C/2018/19 to propose conceptual stormwater management interventions for the POA which would alleviate or mitigate the effects of flooding in the precinct.

This report and the associated stormwater modelling by HHO and the informed urban design exploration by GAPP Architects and Urban Designers presents the 'Concept Proposal' for the stormwater management and urban integration of the study area.

The PCSWMM model which was used to simulate the Status Quo scenario was modified to incorporate various proposed stormwater management interventions, including the provision of new stormwater detention ponds, modifications to or consolidation of existing ponds, and the provision or modification of new underground stormwater conduits. These modifications comprised the Concept Proposal scenario.

The model was set up to simulate the stormwater response of the study area once the above interventions are implemented focusing on the storage areas (including formal ponds) and the primary stormwater network draining them. The overall level of detail intended, was below that of a stormwater master plan (i.e. a high-level model was developed). The PCSWMM model enabled the simulation of the 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year RI, 24-hour storm events.

The results of the simulation of these six (6No.) design events illustrate the approximate reduction in flooding extents associated with storage areas or overland flow paths that are necessary to convey stormwater (due to no known stormwater network or an insufficiently sized stormwater network). Results are for the maximum, and may therefore be highly transient, lasting only a few minutes. The percentage reduction is summarised in the figure below.

For all zones (refer to Figure 1.1 below) and recurrence intervals, a reduction in the extent of flooding or the height of flood waters was demonstrated (refer to Figure 3.27 below), and the ponds potentially suitable for future mixed-use facilities such as sports fields were identified.



Figure 1.1: Extent of the Philippi Opportunity Area

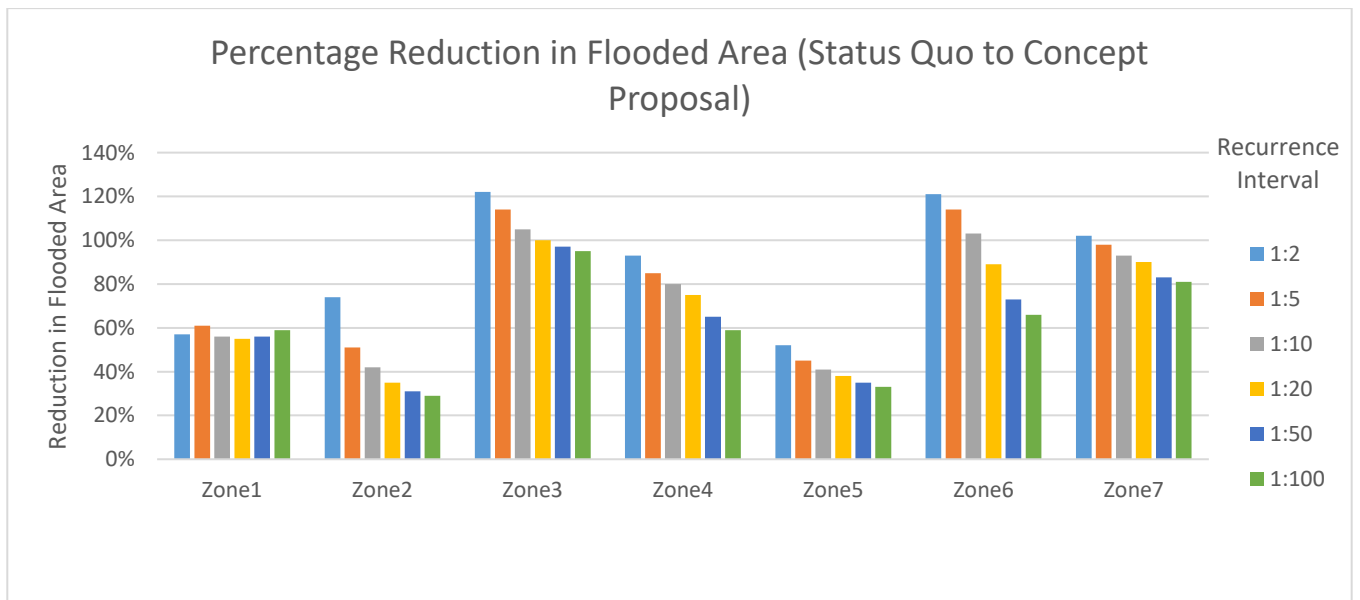


Figure 3.27: Percentage Reduction in Flooded Area

1 INTRODUCTION

1.1 Background

The City of Cape Town (CCT) Spatial Planning and Environment Directorate, Urban Catalytic Investment Department (UCI) appointed HHO Consulting Engineers and GAPP Architects & Urban Designers under Contract 375C/2018/19 to undertake a review, assessment and master planning of the stormwater system serving the Philippi Opportunity Area (POA). The focus of the study relates to the identification of possible conceptual stormwater management interventions for the POA which would alleviate or mitigate the effects of flooding in the precinct as well as support the improved functioning and optimisation of the open space network.

The need for a detailed review of the stormwater system was identified in the POA Regeneration Framework in order to confirm and test its proposals to improve the performance and character of green spaces and natural systems. This included the redevelopment of some existing detention ponds as multifunctional green spaces as well as proposals to develop the edges of these open spaces with infill development to create active frontages and improved surveillance to limit dumping and other antisocial behaviour forms that are prevalent in the POA.

Contract 375C/2018/19 was approved by the City of Cape Town as a transversal panel appointment contract over 7 years. The UCI Department has obtained due approval to appoint the required professional team members available through this contract for this project and is working in close collaboration with the relevant bulk services departments.

This report describes the conceptual stormwater management interventions proposed for the POA and presents the simulated results thereof. It provides a range of proposals to support the regeneration of the POA open space network into an integrated and multifunctional system that will better address the stormwater, recreation, amenity and access needs of the local community. The results of the stormwater investigations used to formulate the proposals in this report were published in a Status Quo report commissioned by the CCT, *REP-7527-700-8002 Rev 02, Philippi Opportunity Area Stormwater Study: Final Status Quo Report* (see Section 2 below).

This report describes the conceptual stormwater management interventions proposed for the POA and presents the results thereof. It is structured as follows:

- **Section One** provides an introduction to the project, confirms the study area and outlines the project objectives. Challenges regarding existing stormwater infrastructure and open spaces are discussed as well as confirming the project's planning informants.
- **Section Two** provides general site information, and the status quo hydrology and hydraulic information which was completed during an earlier stage of the project. It includes the conclusions and recommendations which arose from that study.
- **Section Three** is comprised of two sections. Section A outlines the proposed conceptual stormwater management interventions for the POA and presents the simulated results of these proposed improvements. Section B expands on the stormwater proposals outlined in Section A and provides an Integrated Open Space Concept to guide future stormwater infrastructure and open space improvements in the POA.
- **Section Four** outlines the conclusions and recommendations of the study.

1.2 Study Area

The Philippi Opportunity Area is located in Cape Town's Cape Flats Region. The area is bordered by the N2 to the north, the R300 to the east, Amsterdam Street to the west and the central railway line to the south. This is shown in **Figure 1.1** below. The study area covers the greater part of the POA, with a small portion in the north-west excluded. This portion forms part of a different catchment system and does not impact the rest of the POA and was therefore not considered significant for this study.



Figure 1.1: Extent of the Philippi Opportunity Area

1.3 Problem Definition

The POA forms part of the Philippi Catalytic Precinct which was identified as part of the City's Catalytic Land Development Programme (CLDP). The area is targeted for higher density mixed-use and compact Transit-Oriented Development (TOD). One aspect that was identified as a serious constraint and inhibiting factor that will prevent the POA from progressing towards its full potential is the inadequate stormwater management system in the area.

Existing stormwater ponds in the POA are currently treated as dumping spaces for litter and other waste products that inhibit optimal stormwater functions as well as leading to pollution of the ground water system. The open spaces with stormwater facilities are also dangerous spaces for the local community as a result of poor urban design. These open spaces are typically surrounded by blank boundary walls resulting in poor surveillance and a lack of activity in these spaces leading to antisocial behaviour.

The following specific problems relating to stormwater management have been identified:

- Periodic flooding;
- Degraded and damaged stormwater facilities;
- Poorly functioning detention ponds in terms of quality and amenity;
- Poor integration of detention ponds with nearby surroundings; and
- Health and safety risks associated with quality of water and illegal dumping.



Challenges relating to the public environment and open space within the POA are as follows:

- Flooding of streets and open spaces;
- Isolated and poorly integrated open spaces leading to inefficient use of limited available open spaces;
- Unsafe, dangerous and unhygienic open spaces, many of which are poorly defined and have an unclear function leading to antisocial behaviour or inappropriate use;
- Insufficient sporting, recreation and amenity spaces;
- Poor environmental quality of existing green (stormwater ponds) and recreational spaces (parks, sports fields and streets) which are poorly resourced and maintained; and
- Limited availability of vacant/underutilized open land to meet the growing and competing needs of the local community; there is a need for housing, sustainable livelihood development, and community, recreational and social facilities.





1.4 Project Objectives

Based on the problem definition, the following objectives have been identified:

- Develop a high-level concept plan which identifies interventions to improve the overall stormwater system and develop an integrated and resilient framework for the POA;
- Test initial concepts and proposals within the POA Regeneration Framework as illustrated below in Figure 1.2 to confirm approaches and options for;
 - The integration of the stormwater system with the open space network to form an integrated, safe and multifunctional green network that serves a range of functions (stormwater management, environment, amenity & sense of place);
 - The implementation of Sustainable Drainage Systems (SuDS) within the POA and how this relates to the guiding vision & conceptual approach proposed in the POA Regeneration Framework;
 - Modifications to selected facilities in the system which can become multifunctional community spaces as part of a functional and safe open space system through tested urban design concepts; and
 - The stormwater modelling of identified POA housing projects and proposed layouts.



Figure 1.2: POA Regeneration Framework

1.5 Planning Informants

A range of planning informants have been referred to in the formulation of the urban design concept proposals. These include completed and or current projects in the POA. Reference to these studies has been integral to ensuring consistent, integrated and complementary proposals in the POA.

Key studies include:

1.5.1 POA Regeneration Framework

1.5.1.1 Overarching Guiding Principles

The POA Regeneration Framework was completed in August 2021 to provide an integrated and holistic approach to support future investment in the Philippi area. It provides a framework to set the POA on a path to a more inclusive, thriving and resilient future. To support integrated approaches to planning and design in the POA, the following overarching guiding principles, completed as part of this study, should inform all future work in the POA and are summarised below:

1. Flexible And Incremental Design Approach

- Formulated to guide expansion/ change and to be responsive to change- not to be a blueprint;
- Structured to Identify key structuring elements required to initiate change and to secure the key parts of the design; and
- Support a developmental approach which accommodates phased growth, while being always complete.

2. Integrate And Connect

- Support continuous connections with its surrounds;
- Prioritise NMT and linkages that connect public and community facilities and amenities; and
- Cluster and locate activities and public facilities in accessible and extroverted locations.

3. High Density and Multifunctional

- With limited space in the POA to adequately address various and competing demands between the various sectors, a collaborative approach with the identification of solutions that support the sharing of available land is required; and
- Optimisation of available land requires intense and high-density options to be prioritised.

4. Start small in the biggest way possible

- Consolidate and cluster new development around existing landmarks, nodes, industries and/or activities; and
- Build on and use what we have- reuse existing buildings, infrastructure, tree planting etc.

5. Always Designing for safety

- Adopt perimeter block typologies;
- Orientate buildings and locate uses to create activity and promote surveillance onto streets and open spaces;
- Create safe streets - provision of pedestrian lighting, generous sidewalks; and
- Open spaces to be activated and surrounded with uses that provide passive surveillance.

6. Resilient and Green

- Supporting Sustainable Urban Drainage Systems (SUDS) to manage stormwater runoff;
- Support the use of multifunctional and active open spaces- even if primary use is for ecological functions; and
- Support industries and activities that encourage sustainable use of resources.

7. Support Placemaking and Identity

- Support the making of vibrant, mixed use and active environments;
- Celebrate cultural and heritage sites, activities and events; and
- Identity and protect natural and built elements to provide an authentic sense of place and character.

1.5.1.2 Key Design Concepts

Key design concepts from the POA Regeneration Framework which should inform the POA stormwater study relate in particular to regeneration theme 8, which promotes the development of an integrated and multifunctional green network in the POA.



Figure 1.3: An integrated and multifunctional green network

Identified actions, as indicated in Figure 1.3 above, to support this include:

- **Developing an Integrated Movement Network** by integrating and connecting open spaces via a network of green streets;
- **Creating Active, Multifunctional and Quality Open Spaces** by adding value and activating all open space. Cluster and design outdoors spaces as multifunctional spaces that perform a range of functions; and
- **Redeveloping Sheffield Road as a Hybrid Green Spine (Living Street)** by optimising the existing clustering of retention ponds and vacant/ underutilised land along Sheffield Road to develop a hybrid Green Spine that functions as an integrated and multi-functional movement, stormwater and activity corridor.

1.5.2 Sheffield Road Review Study

A study is currently underway for Sheffield Road to confirm the best approach to:

- support the required mobility upgrades needed as part of the broader metropolitan movement network and MyCiTi expansion;
- enable improved NMT conditions at a local scale; and
- activate the underutilised road reserve area with a range of infill development, open space and SuDS improvements.

The vision is for Sheffield Road to function as a green spine or 'living green street' within the POA that supports an integrated and multi-functional network of retention ponds, sports, recreation spaces with active frontage along its length. It is closely linked to the POA stormwater study as many existing retention ponds occur along its length.

Although the study is not complete, initial recommendations are as follows:

- Road widening is required at key intersections including Stock Road, New Eisleben and Ingulube Drive;
- The remainder/left over servitude space should be developed to serve a specific purpose in order to stop illegal encroachment into the space. Suitable uses include NMT facilities, landscaping, recreation facilities, trading areas, and where possible infill housing opportunities; and
- Inclusion of new underground stormwater and sewer infrastructure within the road reserve:
 - Inclusion of generous open space and landscaping to promote the green character of the street;
 - The identification of a range of street character typologies, as indicated in Figure 1.4 below, along its length to inform approaches to public space improvements within the road reserve as well as guide positive street interface conditions along Sheffield Road.



Figure 1.4: Sheffield Street Road Review- Draft Street character definition map

1.5.3 City of Cape Town- Housing Initiatives in the POA

A range of City housing initiatives are relevant to the POA Stormwater project. These planned housing projects should be considered in the planning for future new retention ponds as well as being an informant for where open space will be available in the long term to locate new retention facilities.

- **POA Housing Study-** As indicated below in Figure 1.5, The POA Housing Study has identified several sites for new and infill mixed use housing in the POA area. A potential 8569 housing opportunities were identified for possible development on both green and brownfield sites. Some of these sites include developing the perimeter of existing retention ponds to support improved surveillance onto these spaces. These retention pond sites occur predominantly along Sheffield Road. Increased housing and intensification make the need for functional open space in the POA critical;
- **Sheffield Road Housing Project-** A new public housing project is currently being implemented on the corner of Sheffield and Icakatha Road. As indicated below in Figure 1.6, a large onsite retention facility has been provided on the south-western edge of the site. It has, however, not been designed to function as a multifunctional facility; and
- **Marikana informal settlement.** Parts of the Marikana informal settlement are in the process of being acquired by the City. This will allow reblocking and formalisation of the area to start. The planning process must proactively plan for sustainable stormwater management in the area as well as provide sufficient open space for recreation and amenity.

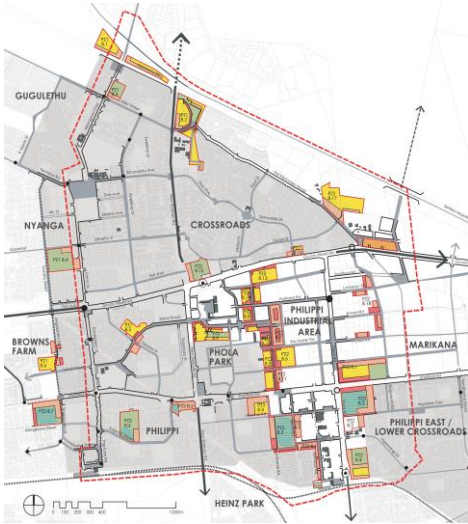


Figure 1.5: POA Housing Project

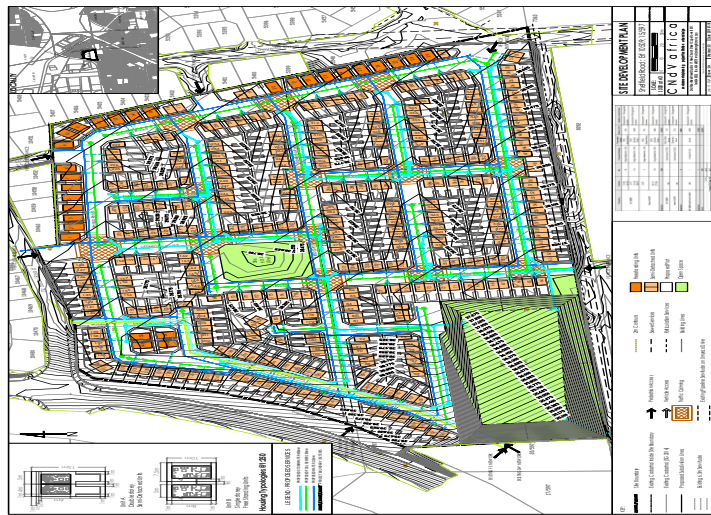


Figure 1.6: Sheffield Road Housing Project

1.5.4 Private Development Indicatives in the POA

Other known private development initiatives in the POA, include the future intensification of the Philippi Village property and a new proposed retail development on the north-eastern side of Sheffield Road.

Although plans were not available to be included in this report, the location and extent of new large-scale development in the POA will influence options to support improved stormwater management in the area.

2 STATUS QUO HYDROLOGY & HYDRAULIC MODELLING

2.1 Existing Site Information

2.1.1 Review of Previous Reports

2.1.1.1 Stormwater Master Plan

In October 2000, Phikon Engineers were appointed to prepare a stormwater master plan which included the whole of the Philippi East sub-catchment which drains into the Big Lotus River Canal. Included in the master plan, was the sizing of detention storage facilities in the Brown's Farm area. The sizing of these facilities was intended to be incorporated into the township designs which were also underway at the time.

The master plan made use of Visual Hydro SWMM stormwater analysis software and provided suggested capacities which would be required at existing and proposed detention facilities within the study to accommodate a 1:50-year return interval storm. It is unknown whether the City of Cape Town implemented these proposed storage facilities. This stormwater master plan is now 22 years old and the study area is likely to have changed during this time with the stormwater master plan now possibly redundant.

2.1.1.2 Phola Park – Philippi Stormwater Upgrade

During 2015 and 2016, the City of Cape Town undertook a project located in Phola Park, to improve the quality of stormwater and associated living conditions of residents adjacent to an existing stormwater channel. This 380m long channel drained into the stormwater system in Sheffield Road.

The project began with the implementation of several key interventions:

- Regular cleaning of the channel
- Increased service from the solid waste removal department

- Door-to-door awareness campaign with residents

Further interventions were identified for long-term implementation which included: lining the channel, including litter traps, increasing toilet facilities, dosing stormwater with bio enzymes etc.

The project team determined that the quality of water within the channel could not be improved if the channel remained as is, even with the more frequent cleaning. The operational costs associated with the additional cleaning were prohibitive and the localized pollution and dumping were an ongoing issue. Therefore, the Client opted to construct a closed system which prevented pollution from entering the system. A low-flow diversion was installed to divert grey and black water into the sewerage system instead.

The underground box culvert was designed to cater for a 1:100-year return period. This ensured additional capacity was available for any future development projects upstream.

2.2 GIS and LIDAR data

2.2.1 Existing Services

Existing services information was received from the City of Cape Town, specifically for the stormwater infrastructure within the study area. This information was in the form of as-built pdf drawings for past developments, as well as GIS data. The GIS included pipe sizes and levels for catch pits and manholes. However, it should be noted that data was missing or incomplete for many areas within the Philippi Opportunity Area. Consequently, some infrastructure likely remains unidentified.

2.2.2 Existing Ground Levels

In addition to the GIS data, LIDAR data based on a 5m x 5m grid interval was supplied by the City of Cape Town. It should be noted that the grid interval meant that terrain was not very detailed, and certain drainage elements were not visible.

2.3 Site Condition Assessment

Before the topographical survey was undertaken, HHO and Parker Surveys conducted a site assessment to determine the location and condition of important stormwater facilities within the study area. This assessment highlighted several common issues which were listed in Section 1.3, such as illegal dumping, flooding, poor quality water and unsafe areas.

Representatives from the Philippi Economic Development Initiative were also present and provided valuable insight into the various areas and flooding-prone zones.

2.4 Topographic Survey of Ponds

Parker Surveys conducted a topographical survey of 20 existing detention ponds and abutting stormwater infrastructure between December 2021 and April 2022. The ponds varied in size from $\pm 2,000\text{m}^2$ to $\pm 40,000\text{m}^2$. This data was used in the analysis of the stormwater system and is presented in Appendix A.

2.5 Status Quo Hydrology

2.5.1 Rainfall

The scope of work relates to design event rainfall and daily or monthly rainfall was consequently not necessary to assess.

2.5.1.1 24-hour Design Rainfall Depths

For the management of stormwater, design rainfall is the most important rainfall variable to consider as it is the driver behind peak flows.

Design storm estimates for various recurrence intervals (RI) and storm durations were sourced from the CoCT design rainfall grid which was developed by Professor Jeff Smithers of the University of KwaZulu-Natal. Professor Smithers was also responsible for the development of the Design Rainfall Estimation Software for South Africa (DRESSA), (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm (RLMA) in conjunction with a Scale Invariance approach to provide site-specific estimates of design rainfall (depth, duration and frequency), based on surrounding station records. WRC Report No. K5/1060 (WRC, 2002) provides more detail on the verification and validation of the method. The approach to the development of CoCT's design rainfall grid and the DRESSA software is understood to be the same. An increase in design rainfall estimates of approximately 15% has however been applied to the CoCT grid (to account for potential rainfall increases due to climate change).

Two grid cells cover the majority of the study area. From these two cells, the cell with the greater rainfall depths (western cell) was used as the source of design rainfall for this study. Table 2.1 presents the 24-hour design rainfall depths applicable to the study area.

Table 2.1: 24-hour design Rainfall Depth (mm)

Recurrence Interval (Years)	Design Rainfall (mm)
2	52.2
5	70
10	83
20	96.6
50	115.6
100	131.1

2.5.2 Terrain Data

Two datasets were primarily used to assess the terrain of the study area and its surrounds, namely:

- A 5m Digital Terrain Model (DTM), interpolated from a 5m Lidar dataset provided by the CoCT; and
- 5m CoCT contours to enable a generalised understanding of terrain (useful for visualisation purposes).

The topographic survey of the ponds (see Section 2.4) was also used in some instances relating to location-specific detail.

2.5.3 Hydrological Setting

Figure 2.1 presents the hydrological setting of the study area. No open watercourses (per the CoCT dataset) are present within the study area. Numerous water bodies are, however, present. The topographic survey informed the location of these water bodies, which have been referred to as ponds in this study. While numerous ponds are presented, the flat landscape of the study area has resulted in various depressions or storage areas. These storage areas (ponds included) were identified using the 5m DTM, which was processed to define all storage areas with a volume larger than 1,000m³ (and a depth greater than 0.2m and an area greater than 100m²).

This resulted in 62 storage areas being defined with a volume ranging from 1,087m³ to 159,280m³ (Pond P11 per the survey). The storage volume is not indicative of pond design volume (where relevant), but rather the spill level of the pond (e.g. the point where water crests low-lying area around a pond and runs down the road towards the next pond). The result is a pond storage area that is typically larger than the HHO survey (which defines the formal pond boundary), however, this larger storage area is relevant given the potential for ponds to flood beyond their intended limits. For each storage area, a depth/area volume curve was derived from the 5m DTM and was used in subsequent modelling.

The stormwater network of the study area is complex given the number of storage areas (formal and informal), and the urban setting including many stormwater conduits servicing properties, roads etc. For this study, only the stormwater network associated with storage areas was necessary to include (due to the intended level of modelling detail). This stormwater network (where present), drains the ponds drawing down their water level during and after storm events, or as a result of groundwater level rise.

2.5.4 Groundwater

To account for the possible influence of groundwater on storage areas (including ponds), a contour dataset of the maximum water levels recorded in the area surrounding the Philippi area was provided by Umvoto¹. This dataset was interpolated into a continuous raster dataset which enabled comparison with the 5m DTM. The outcome of this comparison is presented in Figure 2.2 and illustrates the maximum depth of standing groundwater in a storage area (without considering the draw-down influence of the stormwater network where relevant). This depth of standing groundwater was used as an initial water level for the storage areas in the subsequent modelling.

2.5.5 Soil Runoff Potential And Land-Cover

In considering the most detailed soil dataset available at the time of the study, (Soil Conservation Service for South Africa - SCS-SA dataset), soils are classified as being within hydrological soil group A/B (low to moderately low runoff potential). This hydrological soil group classification informed subsequent infiltration losses in the modelling.

Land-cover of the study area is illustrated in Figure 2.3 which utilised the Department of Environmental Affairs (DEA) 2020 land-cover dataset. The map clarifies the highly urbanised setting of the study area which is predominantly a mix of formal and informal housing. A high-level estimate of the percentage of impervious areas related to subcatchments of interest (detailed in Section 3.6) was performed using aerial imagery and rounding to the nearest 10%. The result was impervious estimates ranging from 10% to 80%. Areas not covered by impervious hardstanding were associated with pervious landscape in a poor to fair condition (on a scale of poor, fair and good).

¹ Email from David McGibbon - Wed 08/06/2022

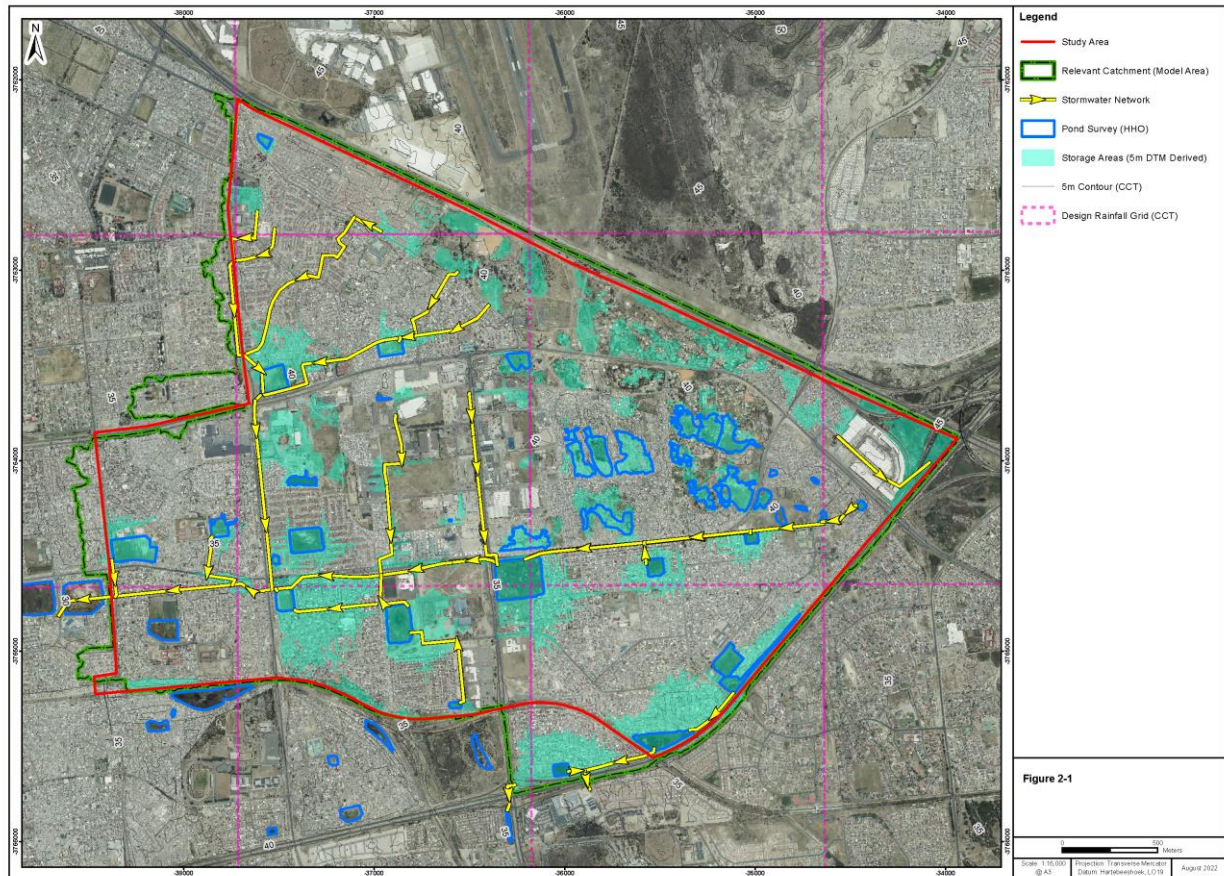


Figure 2.1: Hydrological Setting

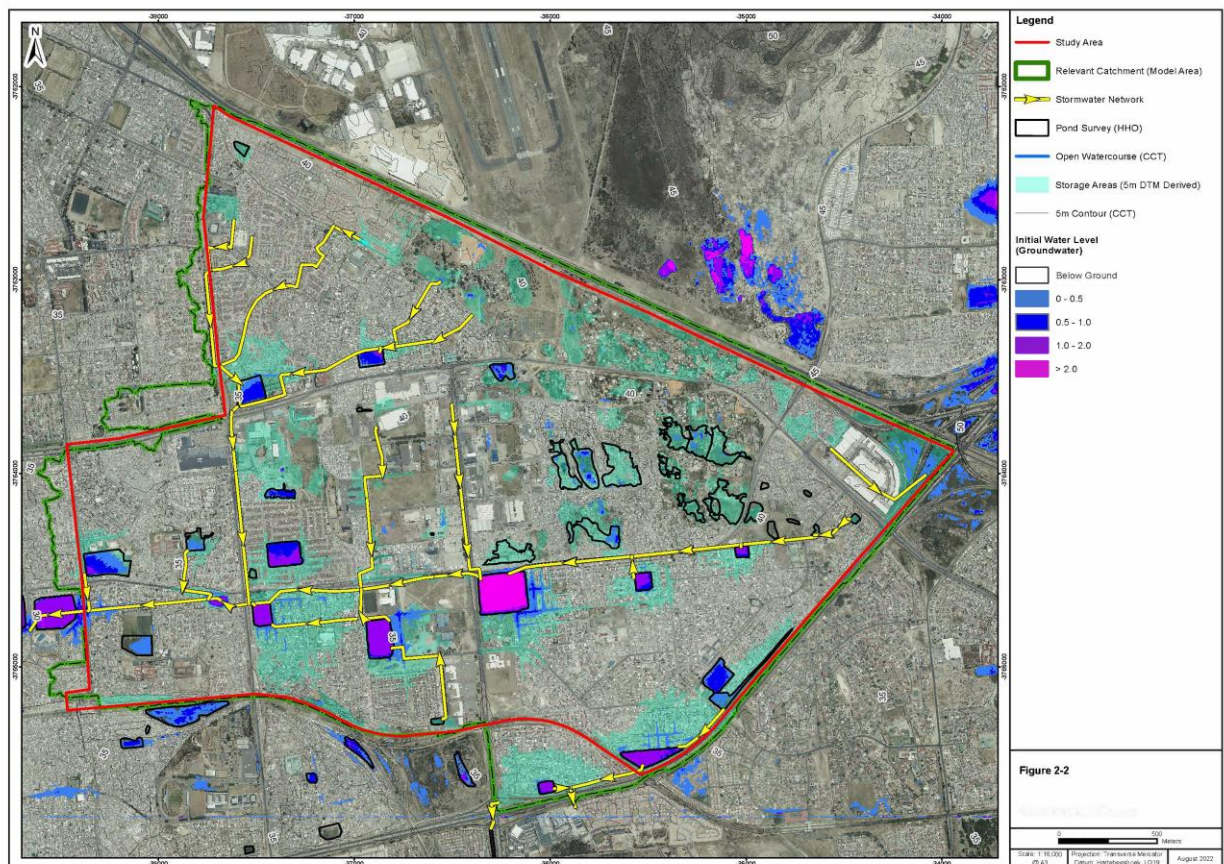


Figure 2.2: Groundwater Influence

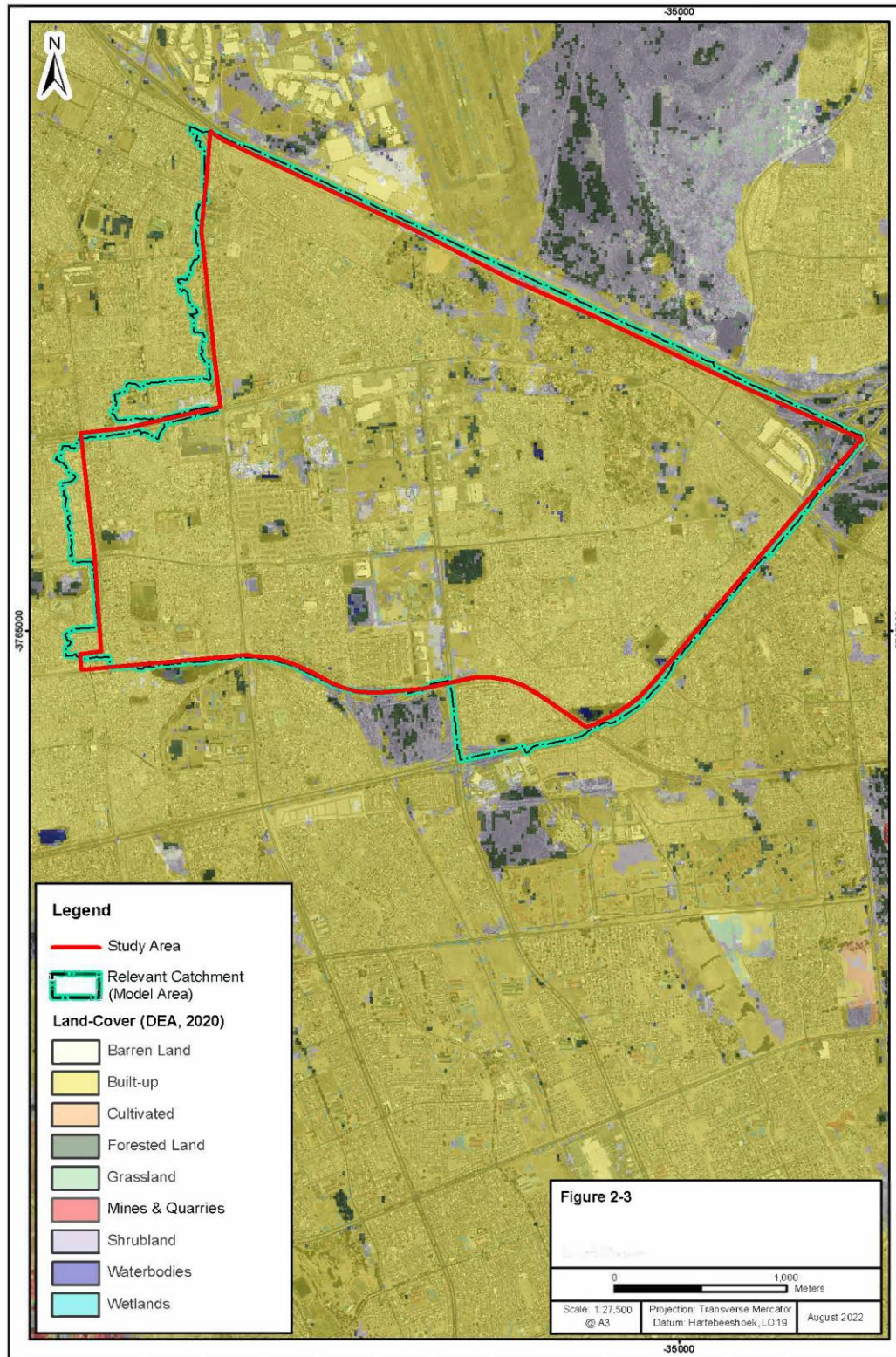


Figure 2.3: Land-Cover

2.5.6 Status Quo Hydraulic Modelling

This section outlines the setup of a PCSWMM model to simulate the stormwater response of the study area, focusing on the storage areas and the primary stormwater network draining them. The remaining stormwater network directing flows into a storage area was consequently not explicitly modelled, instead becoming part of the estimate of the stormwater response of the containing subcatchment.

The overall level of detail intended, was below that of a stormwater master plan. This aim needed regular consideration since there was a tendency towards increasing model detail during development. This point underscores the potential detail that is still possible to add detail to the model.

2.5.6.1 Model Setup

Figure 2.4 presents the setup of the PCSWMM model. Previous PCSWMM models available were reviewed but were not found to adequately cover the study area or did so with highly limited detail making them irrelevant to the task at hand. A new PCSWMM model was subsequently developed.

The 62 storage areas are represented by storage 'nodes' (the related model element) and are labelled according to the pond survey (e.g. P14) or with a prefix of 'D' where no pond number was provided. Pond 9 and 10 were combined into a single pond (P9_10) as they were associated with a single storage area. Depth/Area curves were used to simulate the increasing volume and depth of a storage area that enabled it to subsequently be related to elevation (utilised in the reported results).

For some storage areas, survey data showed a stormwater conduit draining them, however, in many instances, no conduit was noted (in the available data). Without a stormwater network defined (in the data), there is no means by which storage areas can drain. The implication is that the starting water level of a storage area if relevant (set according to groundwater levels as outlined in Section 3.4) remains steady rather than drawing down to the stormwater conduit invert before simulation of the design storm response. In addition, the subsequent rainfall-runoff response directs flows into storage areas and fills the area until its maximum spill level, which typically sees excess water flowing out of the storage area and into an overland flow path (e.g. the street). The influence of an absent stormwater conduit from the data, but one that does exist in actuality, is consequently substantial. This point is noted in the results discussed in the following section. Missing survey data for many of the storage areas meant that invert levels for ponds were set according to the available Lidar data. Lidar cannot penetrate water, and any standing water during the lidar survey would affect the accuracy of the assumed invert levels.

With storage areas and associated storage nodes defined, subcatchments were delineated based on the stormwater network and terrain directing flows into a storage area. Subcatchments were parametrised with relevant details including land-cover (e.g. impervious percentage) and soil type (i.e. hydrological soil group A/B).

The definition of storage areas (represented by storage nodes) and subcatchments enabled simulation of the hydrological component of the model which subsequently informed the relevance of overland flow paths for storage areas unable to drain via a stormwater conduit. These flow paths were added to the model where needed, along with the primary stormwater network draining storage areas. The result is a cascading system where runoff entering a storage area is detained/retained (depending on whether a stormwater conduit is present) with flow moving through the stormwater network or overland. This occurs in a generalised north-east to south-west direction with flows building up within the stormwater network (and pipe sizes thereby typically increasing in the same direction along with the primary network). Stormwater conduits were generally limited to 600mm in size (the smallest size adopted for the primary stormwater network), however, there were instances of 450mm conduits being used for some pond outlets.

Orifices and weirs simulated storage area outlets or overland flow paths respectively and were associated with typical energy loss coefficients. Aside from these energy losses, no other energy losses were factored into the simulation (e.g. losses occurring in a catch pit). This approach is commensurate with the level of intended detail. Outfalls are present at the downstream ends of the model and mark the termination point of the simulated stormwater network or overland flow path.

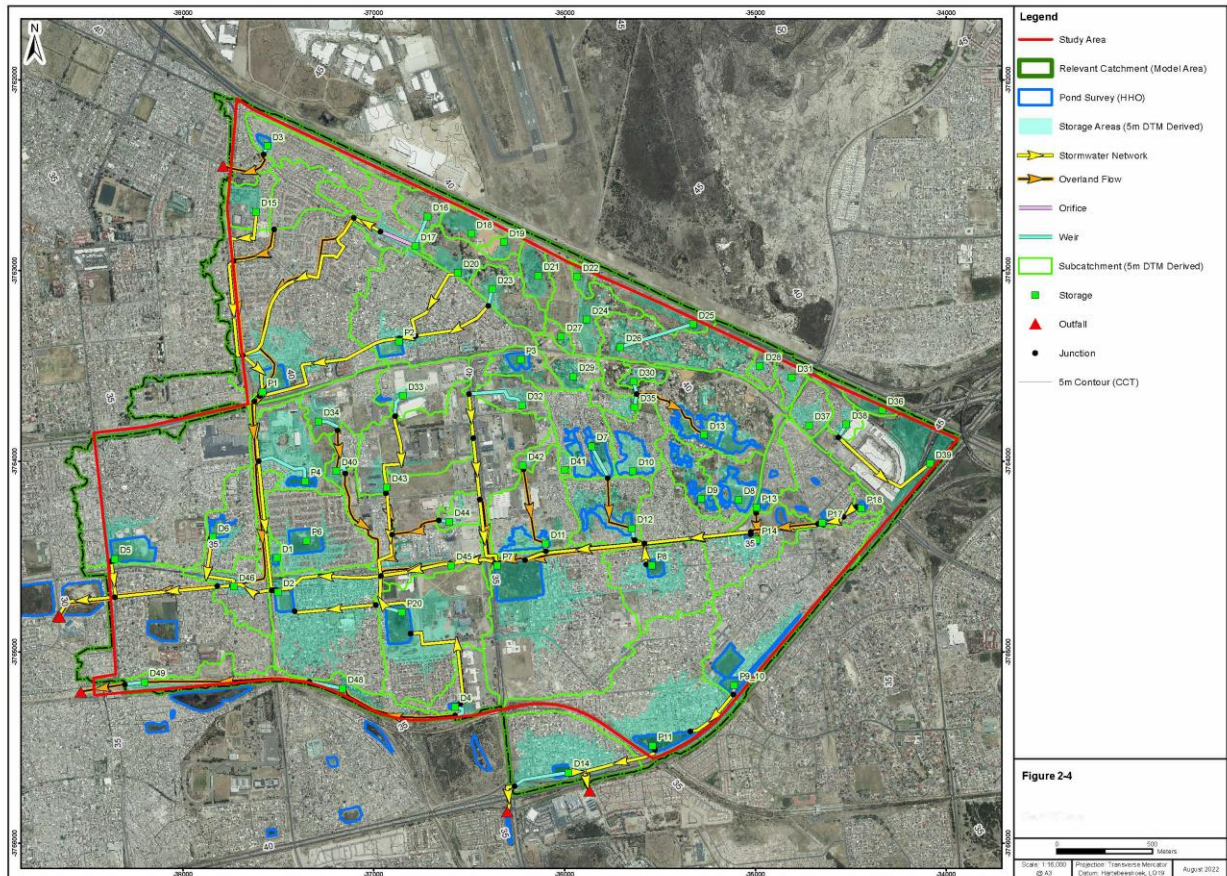


Figure 2.4: Model Setup

2.5.6.2 Model Results

The setup of a PCSWMM model enabled the simulation of the 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year RI, 24-hour storm events. The results of the simulation of these six design events have been presented in Figure 2.5 which illustrates the approximate extent of flooding associated with storage areas or overland flow paths that are necessary to convey stormwater (due to no known stormwater network or an insufficiently sized stormwater network). Results are for the maximum, and may therefore be highly transient, lasting only a few minutes.

Figure 2.5 summarizes the status quo by providing a single snapshot for all events of relevance. Illustrated results should consider that where an overland flow path is shown (i.e. linear results), the underlying (larger) design events also apply. As such, an overland flow path illustrated as activating in the 1:20 year RI event will also activate in the 1:50 and 1:100 year RI events. The activation of overland flow paths implies flooding regardless of the degree of flooding (even if associated with a flow as little as $0.001\text{m}^3/\text{s}$). Overland flow paths activating illustrate the potential need for either a larger stormwater conduit/s or a new stormwater conduit if none is present. Larger storage areas may also be relevant. In the upper reaches of the model, the stormwater management is largely a function of the cascading storage areas, with the stormwater network gaining importance further downstream as flows accumulate. The model is conceptual and overland flow paths may intersect buildings in locations.

Storage area results should typically demonstrate a 'rainbow' effect since larger storm events would lead to a wider area of flooding, particular where pond capacity is exceeded and flooding spreads into the greater storage area. In some instances, this rainbow effect is not evident. One example is storage area P20. This storage area's flooding is shown to reach the full extent of the storage area (defined by the transparent blue colour in preceding maps) for the 1:2 year event (and therefore all events simulated). The reason for this occurrence was investigated and found to be a result of the initial water level included in the simulation. Per the simulation, groundwater levels were extracted from those provided by Umvoto (see Section 3.4). These groundwater levels often didn't have an influence if below minimum storage area inverts or if a storage area was drained by a stormwater conduit. The reason for the latter was the

use of a 7-day 'drawdown' of the storage area by the relevant stormwater conduit if present. In the case of P20, there is no stormwater conduit noted that can drawdown groundwater or route stormwater away from the pond. The result is an initial water level of 1.934m (groundwater emergence) out of the maximum depth of 2.434m available (before spilling into an overland flow path). The resulting rainfall-runoff response into the pond consequently causes the pond to fill and then spill, in all design events simulated.

The use of 600mm pipes as a minimum sizing (in general) means that the smaller stormwater conduit network is excluded. This limitation means that the rainfall-runoff response time is not as well simulated as it might be.

Appendix B presents the storage area (node) results for the design events of interest. Of importance is the initial water level (possible groundwater influence if not draining), the total inflow volume (i.e. the runoff volume from the design event) and the maximum percent full (relative to the full storage area and not just the formal pond volume).

No calibration or verification of the PCSWMM model has been undertaken given the absence of suitable observed data. The results of the simulations performed are consequently expected to approximate reality.

A final key consideration in the model setup and associated results is that no blockages were considered. Any blockages would likely exacerbate the flooding simulated and could substantially alter results.

Figures 2.6 to 2.12 present the results for Zones 1 to 7 respectively.

Model results are summarised at a high level (for each zone) in the following sections. The reader is, however, cautioned that the results (as simulated) will have inaccuracies due to various assumptions in the model build. This inaccuracy is also likely compounded by the cascading system of storage areas and associated conduits (e.g. inaccuracy at one storage area affects the downstream storage areas). Recommended improvements to the model are proposed in Section 4.3.

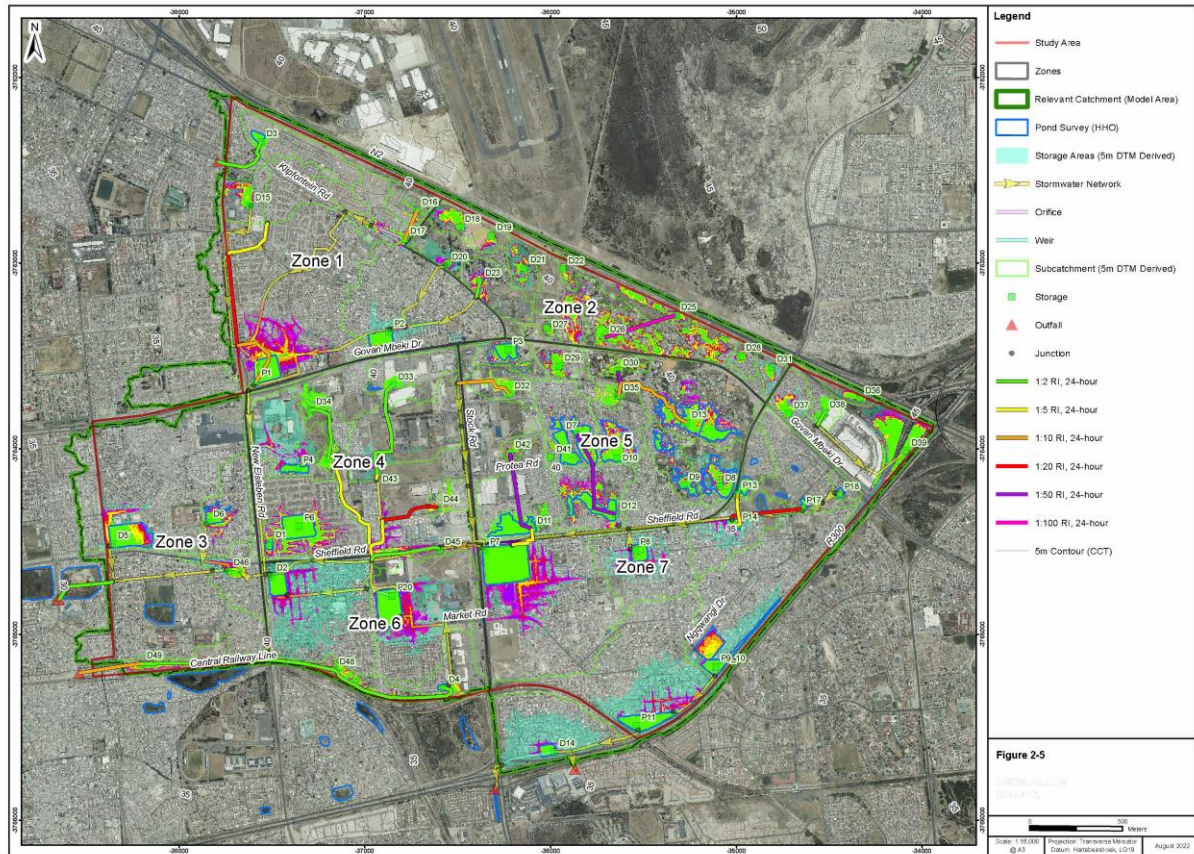


Figure 2.5 Model Results (Overall)

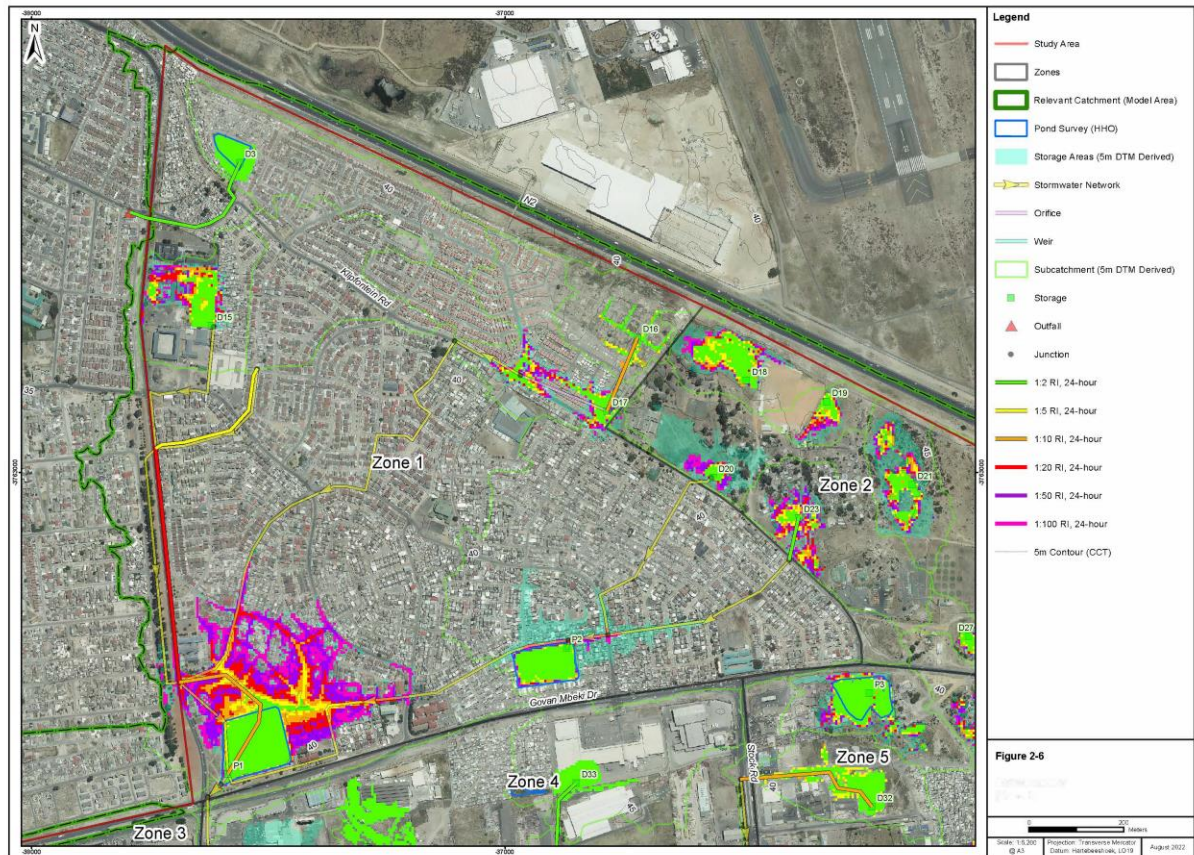


Figure 2.6: Model Results (Zone 1)

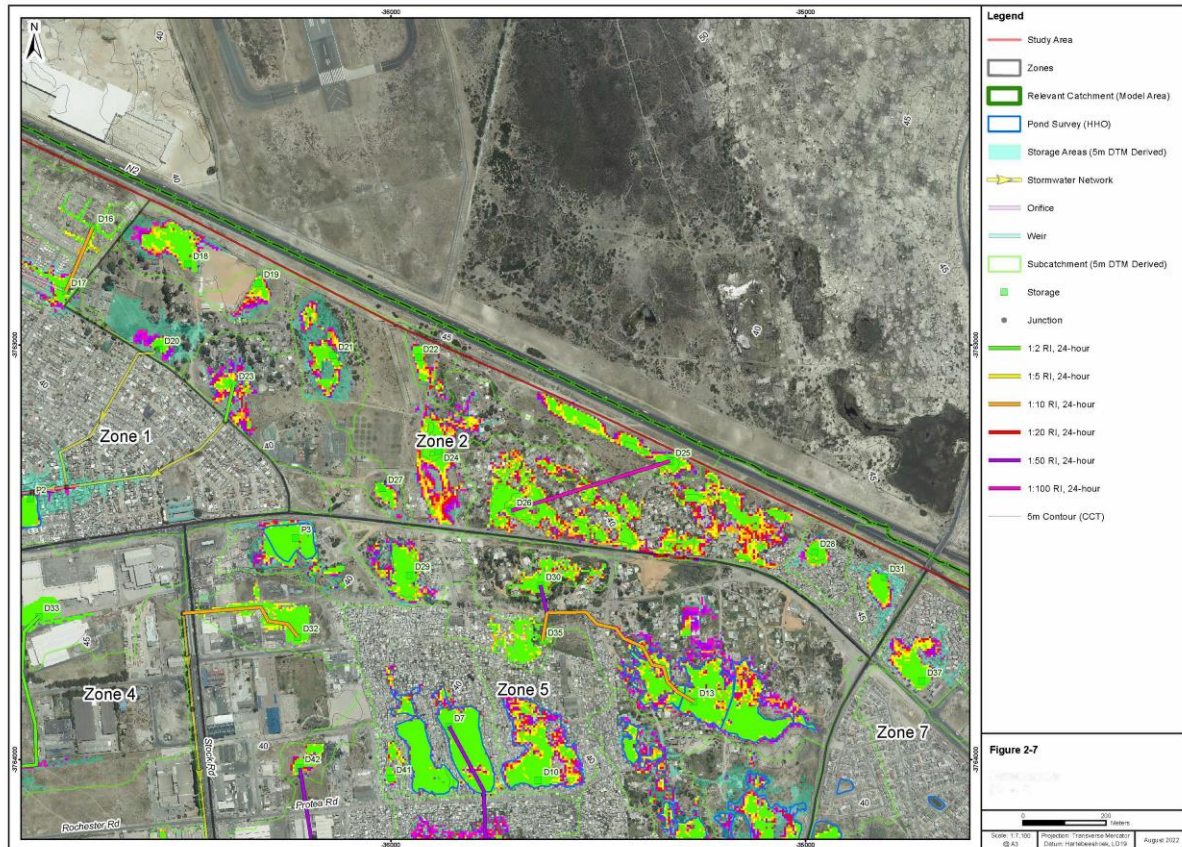


Figure 2.7: Model Results (Zone 2)

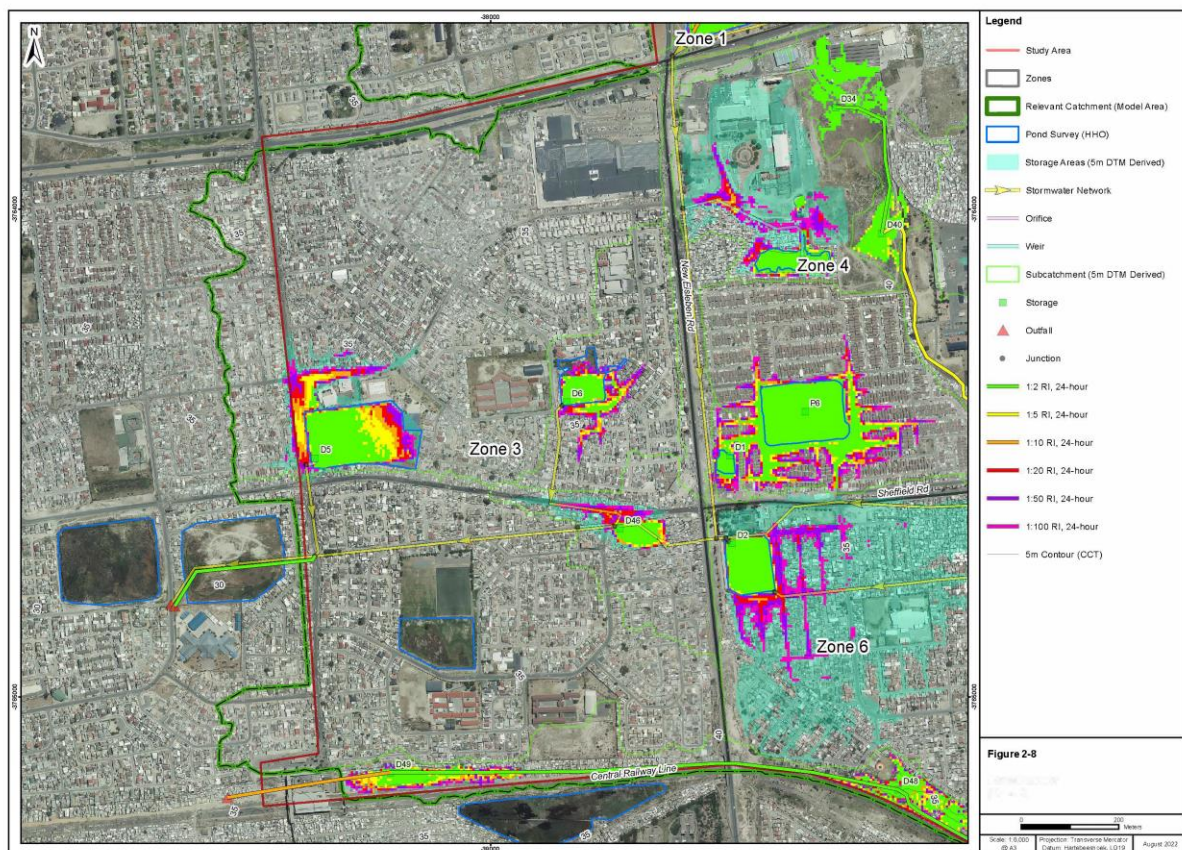


Figure 2.8: Model Results (Zone 3)

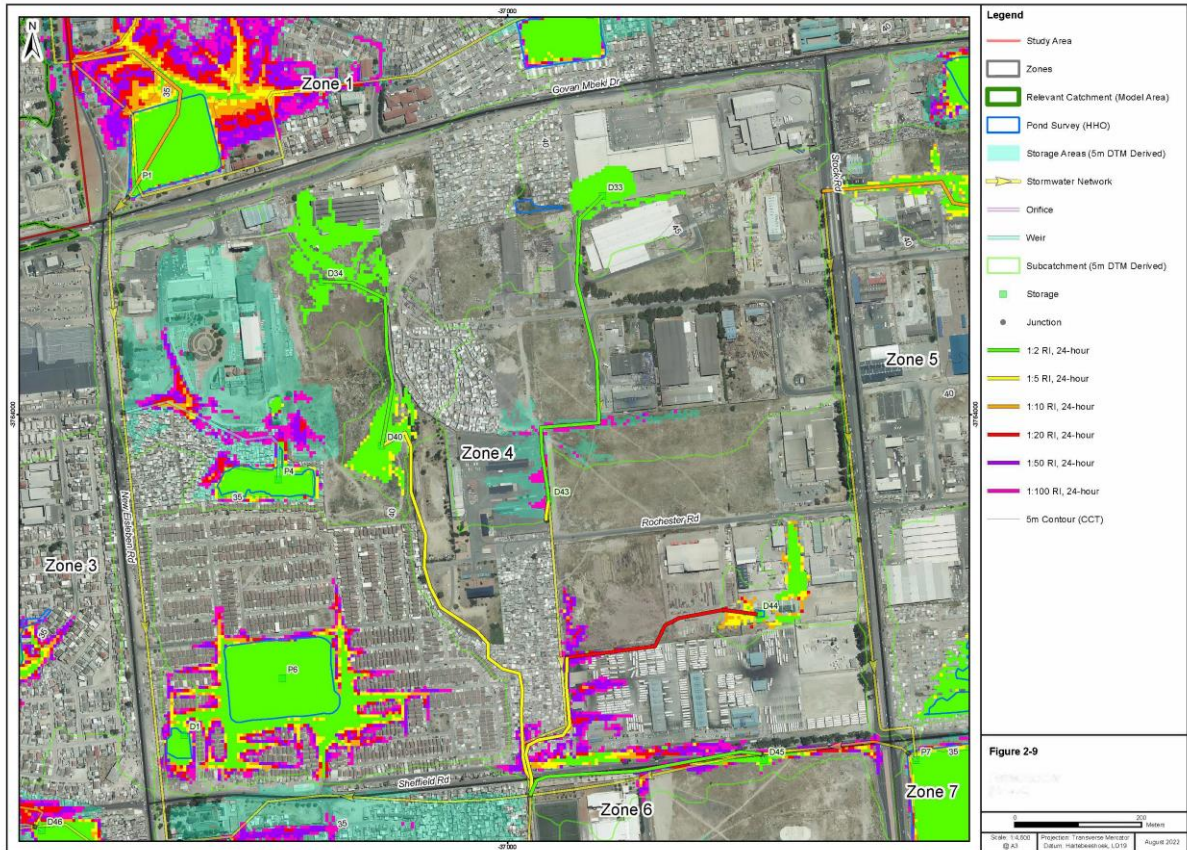


Figure 2.9: Model Results (Zone 4)

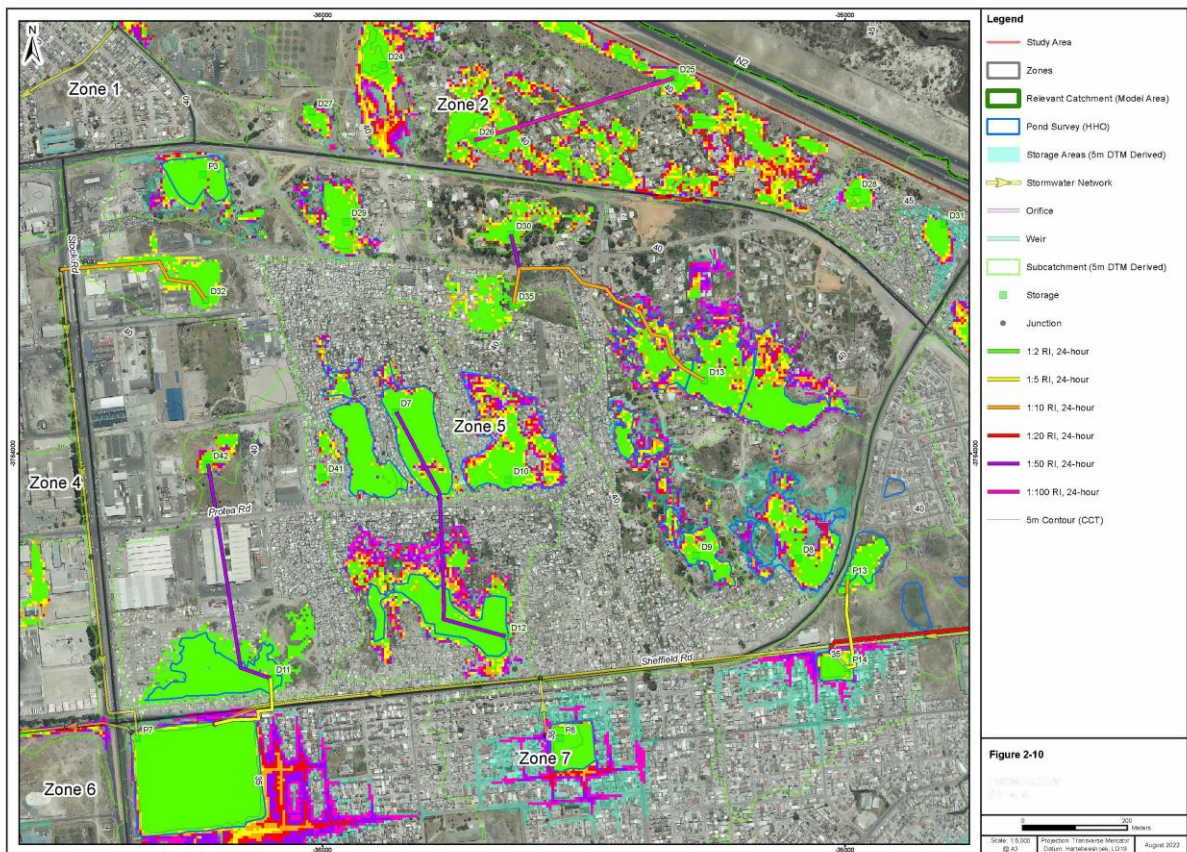


Figure 2.10: Model Results (Zone 5)

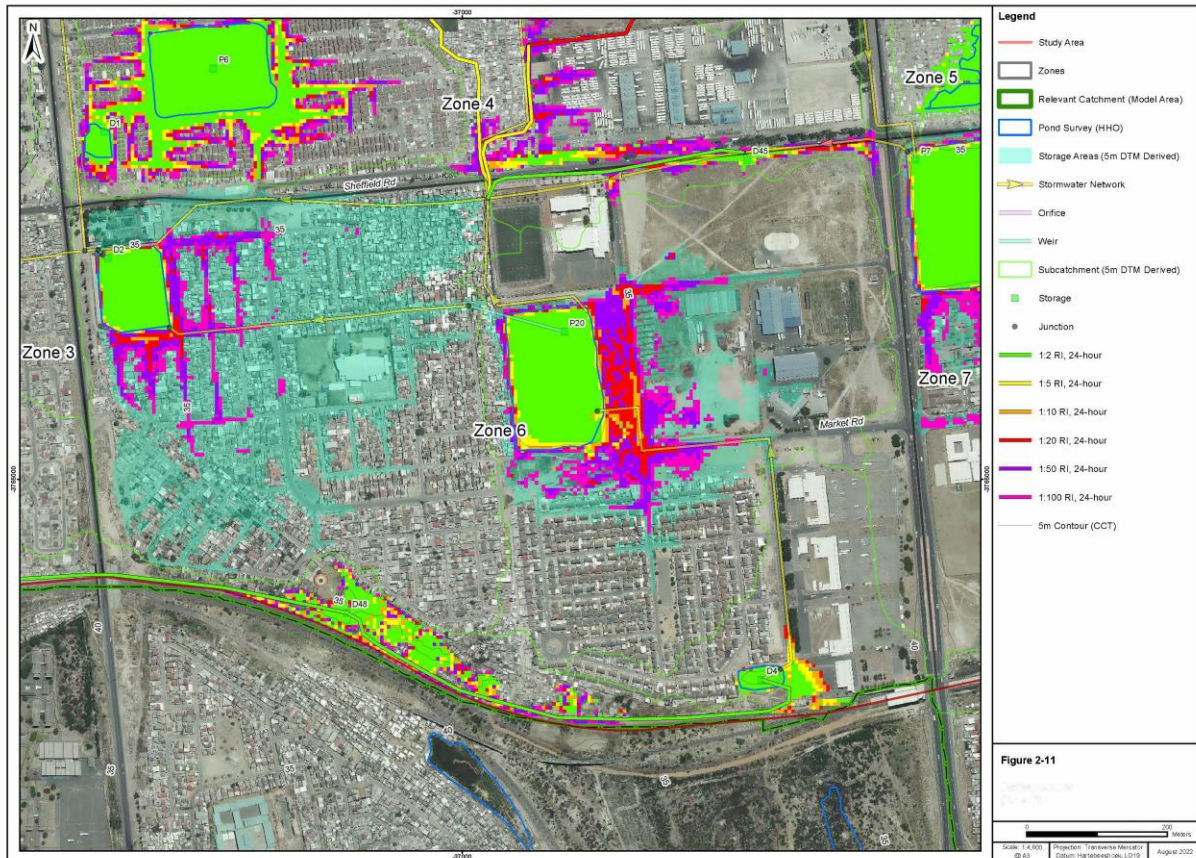


Figure 2.11: Model Results (Zone 6)

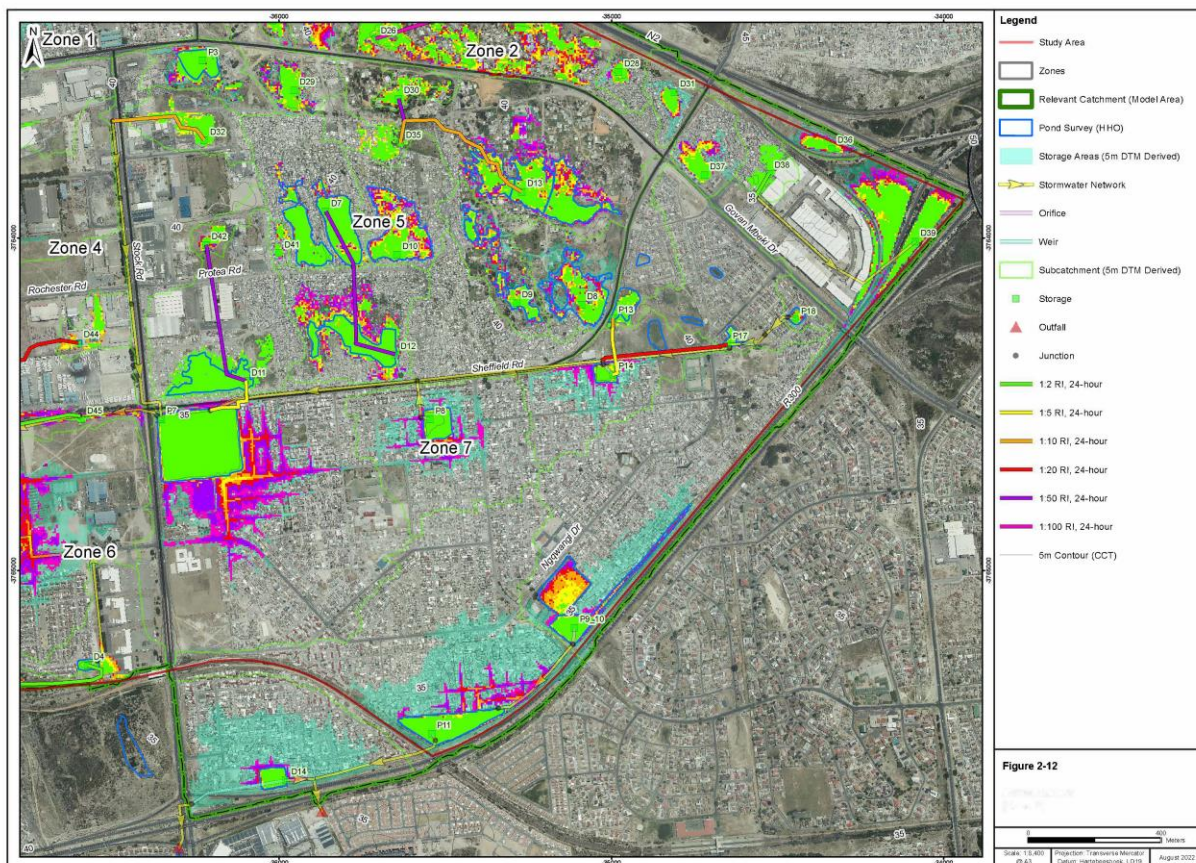


Figure 2.12: Model Results (Zone 7)

2.5.6.2.1 Zone 1

Zone 1 is a largely formalised urban area consisting of three formal storage areas (ponds) and three informal storage areas. The informal storage areas (D15, D16 and D17) are associated with surface flooding due to inadequate (or no) drainage by the underlying stormwater network. D16 and D3 have no stormwater conduit draining them (landlocked) and flooding is consequently expected to remain, with an overland flow path activating for the 1:2 year RI event and above (D3) and the 1:10 year RI event and above (D16). Additional overland flow paths activate towards P1, however, this is due to capacity limits in the underlying stormwater network. P2 is the better performing pond within this Zone with limited flooding beyond its defined boundary. P1 sees events beyond the 1:2 year RI, spilling into the adjacent neighbourhood creating a typical rainbow effect due to a greater extent of flooding per increasing RI events.

2.5.6.2.2 Zone 2

Zone 2 is a largely informal urban area consisting of 12 storage areas, with none of these defined as formal ponds. D20 is tied into the stormwater network to a degree and thereby does have associated drainage. The remaining 11 storage areas are all landlocked filling to greater depths with increasing RI events, with a few able to retain runoff without activating overland flow paths. Those that do activate overland flow paths include D25 and D26 (isolated spill to D26 alone) and D23 (but only up to the start of the stormwater network).

2.5.6.2.3 Zone 3

Zone 3 is a largely formalised urban area consisting of two formal storage areas (ponds) and two informal storage areas. The informal storage area D49 is associated with surface flooding due to no associated stormwater network. D46 has a stormwater network, however, the limited capacity of the system does result in temporary flooding. D5 and D6 are formal ponds that have a similar response, able to almost contain the 1:2 year RI event, with greater RI events leading to greater flooding of the surrounding neighbourhood. A single sports field towards the south is identified as a formal pond, however, its storage capacity was beneath the 1,000m³ threshold (per Lidar analysis) and it was consequently not included in the model. An outfall of the model west of Zone 3 includes an overland flow path that activates in the 1:2 year RI event (and above), indicating capacity limits in the underlying stormwater network. This overland flow path intersects a formal pond outside of the study area, which was not included in the model and the simulated overland flooding is consequently highly conceptual.

2.5.6.2.4 Zone 4

Zone 4 is a largely formalised urban and industrial area consisting of three formal storage areas (ponds) and six informal storage areas. Zone 4 was near 'blank' with regards to the available layout of the stormwater network and drainage of the storage areas is missing except for D43 and D45 (whose overland flow paths indicates capacity limits in the underlying stormwater network). The remaining storage areas (formal and informal) only drain via overland flow paths and is consequently not surprising to see some filling even in the smaller 1:2 year RI event. The landlocked nature of these storage areas means that groundwater has a potential influence on storage with this influence particularly noted for P6, which starts with ~25,000m³ of potential storage lost to groundwater emergence. This loss in storage exacerbates flooding at P6 which at a point becomes joined with flooding from D1 both of which add to the flooding of the surrounding neighbourhood. Where storage areas are unable to drain via a stormwater network fill, overland flow paths are activated (for differing RI events). A formal pond is also present to the west of D33t, however, its storage capacity was beneath the 1,000m³ threshold (per Lidar analysis) and it was consequently not included in the model.

2.5.6.2.5 Zone 5

Zone 5 is a mix of formalised industrial areas to the west and informal urban areas to the east. 12 storage areas are present, seven of which are formal storage areas (ponds) and five of which are informal storage areas. The available layout of the stormwater network is similar to Zone 4 in that it is largely missing. The result is consequently the same as with Zone 4 whereby most storage areas can only fill with some overtopping into associated overland flow paths associated with various RI events. It is consequently not surprising to see the 1:2 year RI event filling many of the formal pond areas. Groundwater likewise influences storage, reducing the available capacity of D12 and D13 (by ~2,000m³), P3 (by ~4,000m³) and D7 (by ~8,000m³). Of the formal ponds noted, some are partitioned as is the case with D13. All pond

storage areas have been defined by Lidar and individual ponds are consequently combined into one where applicable.

2.5.6.2.6 Zone 6

Zone 6 is a largely formalised urban and industrial area consisting of three formal storage areas (ponds) and one informal storage area. D45 has been associated with Zone 4 to the north. D2 is able to accommodate up to the 1:5 year RI event, with the 1:50 and 1:100 year RI events seeing spilling into the surrounding neighbourhood. A similar response is seen at P20, however, significant spilling occurs sooner (from the 1:20 year RI event onwards). Groundwater influences the two smaller storage areas with a reduction in the available capacity of $\sim 200\text{m}^3$ and $\sim 600\text{m}^3$ for D4 and D48 respectively.

2.5.6.2.7 Zone 7

Zone 7 is a mix of predominantly formalised urban areas with some fringe industrial and informal urban areas. 13 storage areas are present, nine of which are formal storage areas (ponds) and four of which are informal storage areas. Additional ponds are present, however, their storage capacity was beneath the $1,000\text{m}^3$ threshold (per Lidar analysis) and so were consequently not included in the model. Pond 9 and Pond 10 have been combined into a single storage area (P9_10) given their interaction. Towards the north-east, informal storage areas are landlocked despite some associated stormwater networks. This network, however, only drains the storage areas towards D39 (which also has $\sim 4,000\text{m}^3$ of its storage lost to groundwater). The formal ponds are otherwise drained by associated stormwater networks, aside from P13 and D14 (falling outside of the study area). The result is the typical response expected when considering the ponds of relevance, with the rainbow effect evident and some ponds (particularly P7) spilling into the neighbourhood. Aside from P13 and D11 which can only spill via overland flow paths, only a single instance of inadequate stormwater conduit sizing is noted west of P17.

2.5.6.3 Recommended Improvements to the PCSWMM Model

The simulation of the rainfall-runoff response of the study area has been undertaken at a high level with less detail than in a typical stormwater master plan. This high-level approach, while intended, has also been influenced by the available data. As such, this study is a 'first pass' to identify the potential stormwater management concerns likely to be experienced within the study area.

Various limitations that influence model accuracy have already been noted, with additional limitations outlined in this section (as part of the recommended improvements).

The following is proposed as a means by which to improve model accuracy and from which more realistic interventions can be proposed while moving towards a master plan level of assessment:

- Survey information has informed the development of the stormwater model. However, the opposite could now be considered, with a targeted survey that is informed by the model build, the challenges encountered due to absent survey in places and the model results. In considering the availability of Lidar (providing detailed terrain data), the survey should be simplified by a focus on subsurface elements which would allow for cost/time savings.
- There were numerous instances of assumed inverts and pipe dimensions because many manholes could not be opened. Furthermore, the survey focussed on the ponds and not upstream and downstream conduits, which would also need to be confirmed.
- A survey was undertaken of 20 keys ponds within the area. However, further survey information of the additional 42 storage areas would be helpful to confirm the stormwater conduits, size of existing conduits or any narrow channels not featured in the Lidar. Confirmation of the adopted 1000m^3 threshold volume would also be required to establish the relevant storage areas.
- The most detailed Lidar dataset available (ideally flown during the dry season where standing water is less likely given the inability of Lidar to penetrate water), should be provided. This Lidar is likely suited (based upon other studies utilising CoCT Lidar) to the development of a 0.25m DTM which will substantially improve the level of accuracy of the model by enabling $400\times$ the detail compared to the 5m DTM. Higher detail than 0.25m may also be possible if data permits. Where storage areas

nevertheless still have standing water, 'dead storage' can be assumed as this will not substantially influence model results (i.e. a bathymetric survey is not needed).

- A request (e.g. to Umvoto) to provide typical wet season groundwater levels (perhaps 90th percentile – upper limits) rather than the maximum groundwater levels utilised (which is the most conservative approach) could improve model representativeness.
- A revision to the impervious estimates presently rounded to the nearest 10% and a geotechnical survey of typical soils (to confirm the hydrological soil group classification) would improve model accuracy.

2.5.7 Water Quality Assessment

2.5.7.1 Existing Water Quality

Water quality considers the effects of physical, chemical and biological properties of water on a particular user – in the case of Philippi, most notably residents but, also local fauna and flora. The quality is usually determined by comparing a sample's properties to accepted standards or guidelines. For this study, no water sampling was undertaken. However, a visual inspection was conducted and previous water quality studies were consulted.

2.5.7.1.1 Visual inspection

In December 2021, HHO undertook a condition assessment of several stormwater facilities within the Philippi Opportunity Area. The following issues were identified:

- Illegal dumping in and around the stormwater ponds and swales
- Nearby toilets overflowing into the ponds
- Poor circulation, specifically in landlocked ponds
- Plant growth on the water surface
- Evidence of grey and black water within the ponds

Figures 2.13 to 2.16 illustrate some of these problems on site.



Figure 2.13: Illegal dumping in a stormwater swale



Figure 2.14: Poor water circulation



Figure 2.15: Plant growth on water surface



Figure 2.16: Evidence of grey and black water

The cause of these problems is multi-faceted. The Philippi East area, while having some industrial and commercial land use, is overwhelmed by informal settlements, and low-cost housing. Many residents have limited access to running water, flush toilets and suitable solid waste disposal areas. This leads to residents dumping their waste in open areas, which often include stormwater channels and ponds. The use of chemical or long drop toilets requires frequent maintenance, which is not always available and therefore, sewage spills are common. This is a health risk to residents and animals in the area.

Several landlocked ponds were visited, which typically are divided into two types:

- Ponds with no stormwater outlet or drainage path present
- Ponds with blocked outlets or pipes which prevent any outflow

These ponds are prone to stagnant water and plant growth, as shown in Figure 5.3. This results in poor quality water which is a health risk. It is also a breeding ground for mosquitoes.

2.5.7.1.2 City of Cape Town water quality report

In 2020 the City of Cape Town appointed Liz Day Consulting to prepare a report on the status and historical trends of water quality of rivers and open water bodies in the City. This report forms part of the City's goal to become a Water Sensitive City by 2040. This entails being a city where rivers, canals and streams are accessible, inclusive and safe to use.

The City outlines the variables which are tested to provide information about water quality. There are also recommended thresholds which are used to interpret the data. The water quality variables include:

- pH
- Electrical Conductivity
- Major nutrients (orthophosphate PO₄-P, total phosphorous TotP and total inorganic nitrogen TIN)
- Un-ionised ammonia nitrogen NH₃-N
- Dissolved oxygen DO
- E. coli bacteria
- Microcystin toxins
- Chlorophyll

It was noted that almost all aquatic systems in the City of Cape Town have been impacted by the receipt of additional nutrients, particularly phosphorus. These nutrients trigger excessive plant growth which substantially changes the function of aquatic ecosystems. The Philippi Opportunity Area, which has large areas of informal settlements, with poor levels of sewage, solid waste and stormwater servicing will very likely have high levels of nutrients within all its stormwater facilities.

The Zeekoe subcatchment, in which the POA is located, was one of the worst-performing in the City of Cape Town with regards to phosphorus enrichment and showed a deterioration in water quality over the 2019 period. In addition to phosphorus, a significant concern was raised over nitrogen enrichment which also showed a trend of gradual deterioration.

Detention ponds which are largely standing water bodies are typically characterised by low N:P ratios, which promotes blue-green algal dominance. The TIN concentration measured within the Zeekoe subcatchment was also categorised as unacceptable.

In the aquatic environment, the presence of ammonia NH₃-N results in ammonia toxicity in sensitive fauna, particularly fish, and impacts the general health and resilience of organisms. The Zeekoe subcatchment NH₃-N concentrations were always in the unacceptable range, which means that only the most pollutant tolerant organisms would be able to survive.

Levels of E.coli contamination were also measured within the Zeekoe catchment. The samples ranged from poor to unacceptable, indicating that the area has poor sanitation and poor servicing. While the stormwater facilities are not used for recreational purposes, it is assumed that some residents make use of them for washing. Therefore, physical contact with the water is unavoidable and could lead to serious food poisoning in humans.

The report noted that the likely sources of the water quality issues were as follows:

- Presence of relatively large areas of poorly serviced informal and backyard settlements
- Runoff from highly urbanized areas with high levels of street waste and dumping
- Agricultural runoff from the Philippi Horticultural Area

2.5.7.2 Proposed Water Quality Interventions

Poor water quality impacts human health and compromises ecosystems. Without proper management of the POA's stormwater facilities and surrounding area's services, significant costs are incurred annually to deal with reactive management issues such as solid waste removal, invasive plant management and dredging and removal of organic sludges. Therefore, it is key to consider possible interventions which could be implemented within the POA to reduce these costs and improve water quality.

These proposed interventions are high-level recommendations which would require detailed planning and budget allocation from the City of Cape Town, to be implemented:

- Increase frequency of solid waste collection both for residents and within stormwater facilities.
- Identify and prosecute illegal dumping offenders.
- Introduce litter traps at all stormwater outlets which should be cleared regularly.
- Run a campaign to educate residents on pollution and risks associated with poor water quality.
- Encourage residents to have a sense of responsibility and ownership towards stormwater facilities and their neighbourhoods.
- Provide formalized sewer connections to properties, as well as central ablution and wash basin facilities.
- Construct new stormwater pipes to connect landlocked ponds to the wider stormwater network.
- Conduct periodic water quality testing specific to the POA's stormwater facilities to track improvements.
- Install low flow diversions for the redirection of proportions of contaminated stormwater into sewers.

2.5.8 Status Quo Conclusions & Recommendations

The City of Cape Town (CoCT) Spatial Planning and Environment Directorate, Urban Catalytic Investment Department (UCI), requires a review and assessment of the stormwater system serving the Philippi Opportunity Area (POA). An investigation is required into the possible use of detention ponds and other parts of the stormwater system as potential multifunctional spaces and to improve the public realm. One aspect that was identified as a serious constraint and inhibiting factor that will prevent the POA from progressing towards its full potential is the inadequate stormwater management system in the area.

2.5.8.1 Stormwater – Status Quo

This report and the associated stormwater modelling presents the ‘status quo’ of the stormwater management of the study area.

A PCSWMM model was set up to simulate the stormwater response of the study area, focusing on the storage areas (including formal ponds) and the primary stormwater network draining them. The overall level of detail intended, was below that of a stormwater master plan (i.e. a high-level model was developed). The PCSWMM model developed, enabled the simulation of the 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year RI, 24-hour storm events. The results of the simulation of these six design events have been presented in **Figure 2.5** which illustrates the approximate extent of flooding associated with storage areas or overland flow paths that are necessary to convey stormwater (due to no known stormwater network or an insufficiently sized stormwater network). Results are for the maximum, and may therefore be highly transient, lasting only a few minutes. **Figure 2.5** summarizes the status quo by providing a single snapshot for all events of relevance.

Overland flow paths activating illustrate the possible need for either a larger stormwater conduit/s or a new stormwater conduit if none is present. Larger storage areas may also be relevant. In the upper reaches of the model, the stormwater management is largely a function of the cascading storage areas, with the stormwater network gaining importance further downstream. Storage area results should typically demonstrate a ‘rainbow’ effect since larger storm events would lead to a wider area of flooding, particular where pond capacity is exceeded and flooding spreads into the greater storage area. In some instances, this rainbow effect is not evident. A combination of groundwater influences and no relevant stormwater conduit to drawdown a storage area result in this difference such that the 1:2 year RI event can produce the same result as the 1:100 year RI event (visually, for the affected storage area). Appendix B clarifies the difference in design events for all storage areas.

A key consideration in the model setup and associated results is that no blockages were considered. Any blockages would likely exacerbate the flooding simulated. Furthermore, no calibration or verification of the PCSWMM model has been undertaken given the absence of suitable observed data. The results of the simulations performed are consequently expected to approximate reality.

Figures 2-6 to 2-12 present the results for the seven zones identified (for reporting purposes). Model results were summarised at a high level (for each zone). The reader is, however, cautioned that the results (as simulated) will have inaccuracies due to various assumptions in the model build. This inaccuracy is also likely compounded by the cascading system of storage areas and associated conduits (e.g. inaccuracy at one storage area affects the downstream storage areas).

The high-level approach to modelling, while intended, has also been influenced by the available data. As such, this study is a ‘first pass’ of the potential stormwater management concerns likely to be experienced within the study area. Various limitations that influence model accuracy have already been noted, with additional limitations outlined in this section (as part of the recommended improvements). One major improvement would be the integration of the City’s latest Lidar dataset.

The 5m DTM provided enables a moderately detailed level of terrain detail. This detail can likely be increased 400x, through the provision of the original Lidar dataset (this opinion is based upon associated work on behalf of the City). Survey has also previously informed the development of the stormwater model, however, the opposite should now be considered. A targeted survey that is informed by the model build, the challenges encountered due to absent survey and the model results should be undertaken. Improving the model parameter estimates including the influence of groundwater and impervious area estimates would also enhance model accuracy.

The final recommendation for the follow-on from this status quo report, would be to undertake a feasibility study and conceptual design to reduce or prevent the identified problems or constraints. This may include increasing the storage volume of certain ponds, introduction of bulk infrastructure or the integration of ponds with their surroundings.

2.5.8.2 Water Quality

In December 2021, HHO undertook a condition assessment of several stormwater facilities within the Philippi Opportunity Area identifying issues of:

- Illegal dumping in and around the stormwater ponds and swales
- Nearby toilets overflowing into the ponds
- Poor circulation, specifically in landlocked ponds
- Plant growth on the water surface
- Evidence of grey and black water within the ponds

In 2020 the City of Cape Town appointed Liz Day Consulting to prepare a report on the status and historical trends of water quality of rivers and open water bodies in the City. The report noted that the likely sources of the water quality issues were as follows:

- Presence of relatively large areas of poorly serviced informal and backyard settlements
- Runoff from highly urbanized areas with high levels of street waste and dumping
- Agricultural runoff from the Philippi Horticultural Area

Poor water quality impacts human health and compromises ecosystems. Without proper management of the POA's stormwater facilities and surrounding area's services, significant costs are incurred annually to deal with reactive management issues such as solid waste removal, invasive plant management and dredging and removal of organic sludges. Therefore, it is key to consider possible interventions which could be implemented within the POA to reduce these costs and improve water quality. These proposed interventions are high-level recommendations which would require detailed planning and budget allocation from the City of Cape Town, to be implemented:

- Increase frequency of solid waste collection both for residents and within stormwater facilities.
- Identify and prosecute illegal dumping offenders.
- Introduce litter traps at all stormwater outlets which should be cleared regularly.
- Run a campaign to educate residents on pollution and risks associated with poor water quality.
- Encourage residents to have a sense of responsibility and ownership towards stormwater facilities and their neighborhoods.
- Provide formalized sewer connections to properties, as well as central ablution and wash basin facilities.
- Construct new stormwater pipes to connect landlocked ponds to the wider stormwater network.
- Conduct periodic water quality testing specific to the POA's stormwater facilities to track improvements.
- Install low flow diversions for the redirection of proportions of contaminated stormwater into sewers.

3 PROPOSED CONCEPT

This chapter is comprised of two sections. Section A outlines the proposed conceptual stormwater management interventions for the POA and presents the simulated results of these proposed improvements. Section B expands on the stormwater proposals outlined in Section A and provides an Integrated Open Space Concept to guide future stormwater management and open space improvements in the POA.

3.1 SECTION A: Proposed Conceptual Stormwater Management Interventions & Results

3.1.1 Stormwater Model Setup

The overall stormwater model setup was in principle the same as the Status Quo model setup. However, additional or reconfigured conduits, flow paths and storage nodes/ponds were modelled in order to demonstrate the interventions required to alleviate or mitigate the duration or intensity of flooding in the Philippi Opportunity Area.

A presumed degree of additional urbanisation (impervious area) was added to the Concept Proposal model (when compared to the Status Quo model setup) to account for the anticipated future development of the study area. All subcatchments' impervious areas were set to a minimum of 30%, with a 10% increase for Status Quo subcatchments which had an impervious area less than 70%.

Additional impervious area results in a greater proportion of rainfall converted to runoff. The implication of this is that the Concept Proposal results account for greater volumes of runoff when compared to the Status Quo.

The proposed Concept Proposal model setup is shown graphically below in **Figure 3.1**, with the proposed concepts and their results discussed in the following sections.

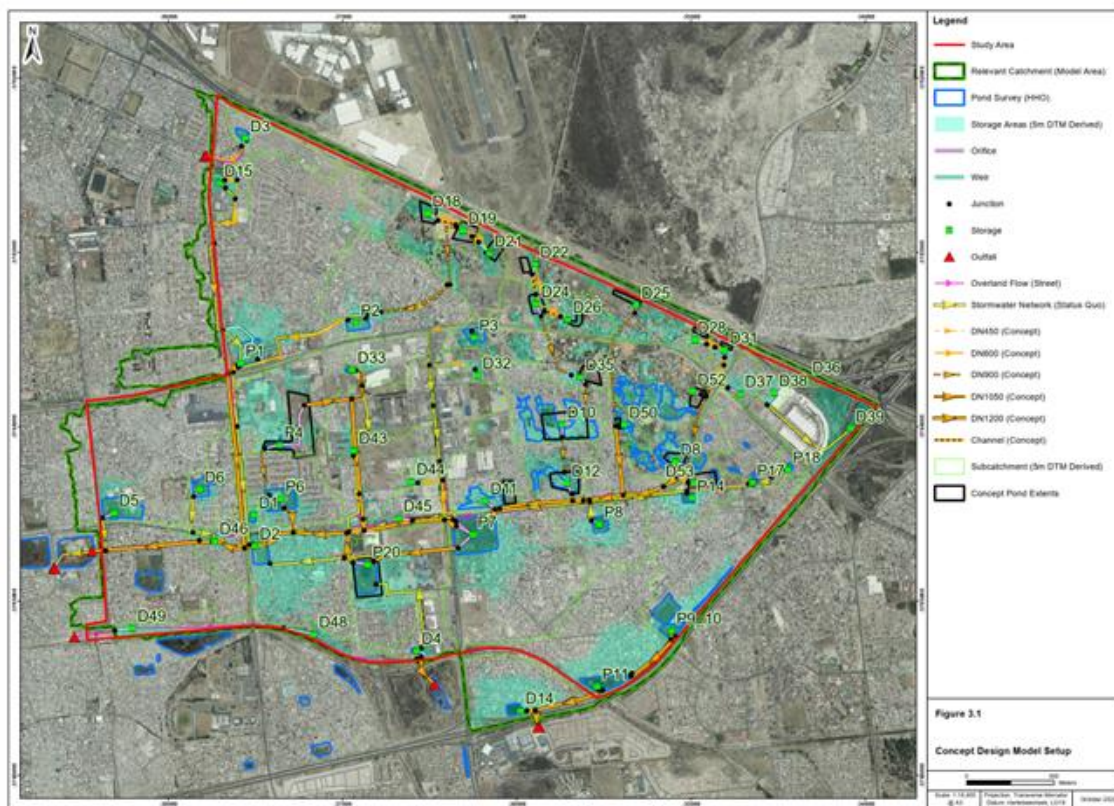


Figure 3.1: Concept Proposal Model Setup

3.1.2 Stormwater Model Concepts and Results

The reader is reminded that the Concept Proposal model includes a greater proportion of impervious area (associated with an assumed increase in urbanisation over time) with the Concept Proposal results likely including an increased rainfall-runoff response compared to the Status Quo model results.

In many cases, the Concept Proposal required the use of Concept Ponds. **Figure 3.2** below shows the overall results of the simulation in terms of flooding extents for all RI's, with each Zone discussed separately thereafter.

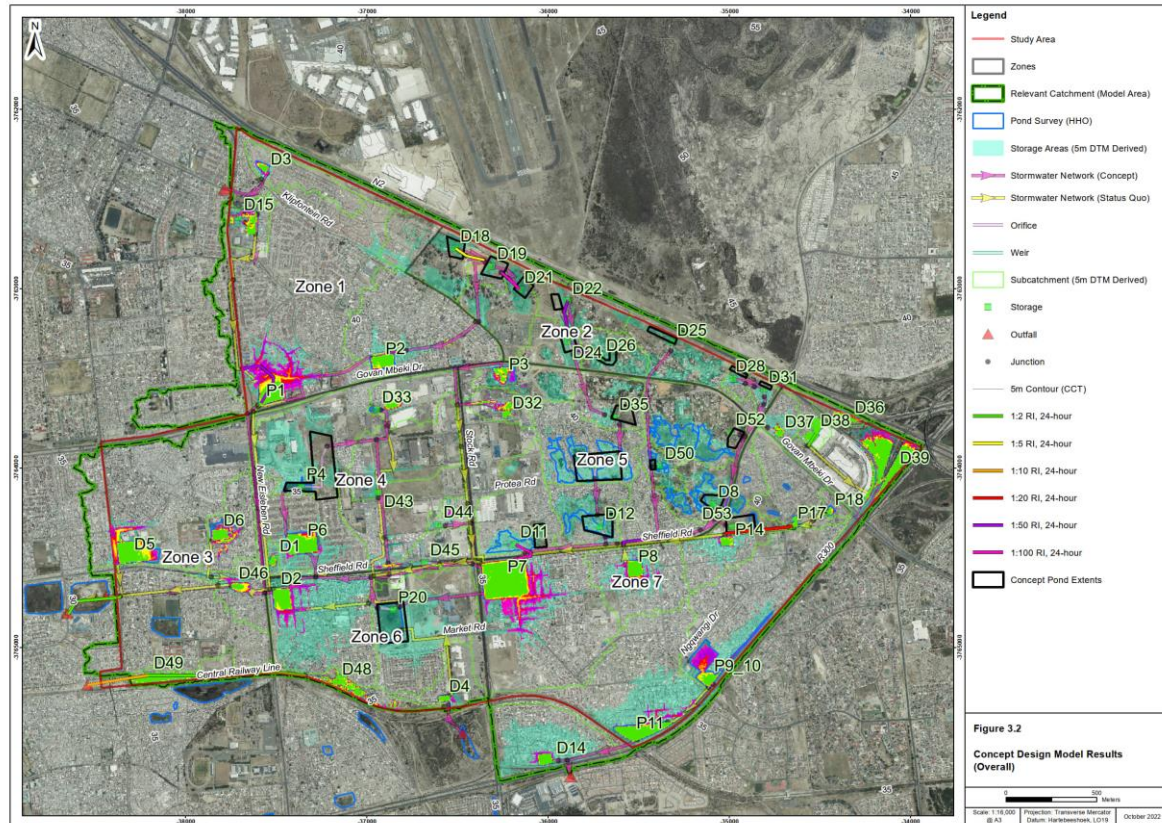


Figure 3.2: Concept Proposal Model Results (Overall)

3.1.2.1 Zone 1

Refer to **Figure 3.1**. The proposed concept for Zone 1 entails the provision of:

- a new DN600 outlet conduit from storage area D3 (where one did not previously exist) which ties into the stormwater pipeline in Miller Street (modelled as an outfall).
- an additional DN600 outlet conduit from storage area D15 which ties into the bulk stormwater pipeline in New Eisleben Road and discharges into Pond P1.
- an additional DN450 conduit which receives some flows from the ponds proposed for Zone 2 and connects into Pond P2.
- an additional DN600 conduit which connects Pond P2 to Pond P1.
- an additional DN1200 outlet conduit from Pond P1 which traverses southwards along New Eisleben Road into Zone 3, parallel to the existing bulk DN1200 stormwater conduit.

The shaping of Pond P1 is also proposed to improve its storage potential for depths below 1m. Informal storage areas D16, D17 and D20 will have their runoff contributions directed into the cascading system of ponds proposed for Zone 2



Figure 3.3: Concept Proposal Model Results (Zone 1)

Figure 3.3 shows the peak extents of flooding in Zone 1 for the various recurrence interval (RI) events.

A comparative hydrograph H1 shown in **Figure 3.4** below illustrates the flow from the single outfall located in Zone 1, for the smallest (2-year) and largest (100-year) design RI events. The addition of a DN600 conduit draining D3 results in a greater volume of runoff reaching the outfall.

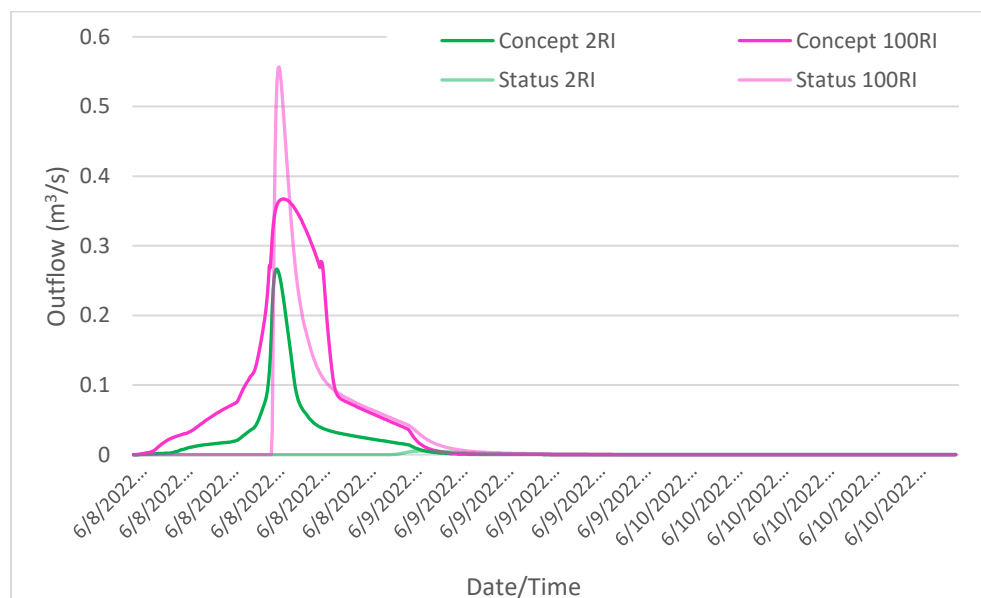


Figure 3.4: Outflow Hydrograph H1

Figure 3.5 below illustrates the head and volume comparison for Pond P1. The drawdown for the pond is significantly quicker than the Status Quo, while the maximum flood height is less.

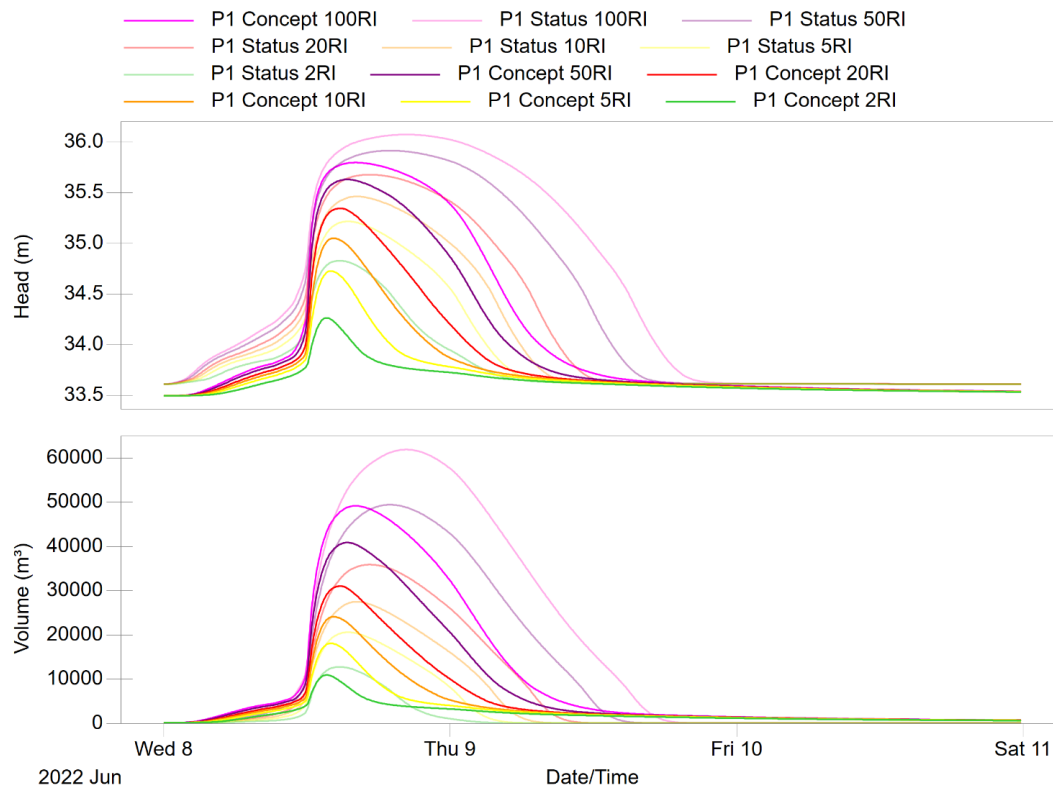


Figure 3.5: Head and volume comparison for Pond – P1

Table 3.1 summarises the pond characteristics within Zone 1 (as informed by both model results and CCT satellite imagery – March 2022), with no wet ponds noted and near the maximum volume available for storage as a result. All ponds in Zone 1 are thus dry ponds which may be suitable for dual usage (i.e. stormwater management and recreation/facility use).

Table 3.1: Zone 1 Pond Characteristics

Pond	Max. Volume (m³)	Available Storage (m³)	Dry Pond
P1	49,191	49,074	Yes
P2	8,323	8,300	Yes
D3	2,337	2,337	Yes
D15	1,463	1,463	Yes

3.1.2.2 Zone 2

Refer to **Figure 3.1**. The proposal for Zone 2 centers around the concept of a “green belt” running parallel to the N2 which borders the site. The green belt is envisioned as a cascading system of ten (10No.) new ponds integrated into landscaped surroundings which will replace the existing informal system of storage areas in this zone. The ponds will be drained one into the other in a “daisy-chain” configuration toward localized collector points, where flow from the ponds will enter new, proposed stormwater conduits.

The proposed stormwater conduits draining the above system of ponds include:

- a new DN450 conduit draining the three (3No.) ponds proposed for the northwest portion of Zone 2 (ponds D18, D19 and D21), which ties into the existing Pond P2 in Zone 1.
- a new DN450 conduit draining the three (3No.) ponds proposed for the central portion of Zone 2 (ponds D22, D24 and D26), traversing southwards towards the ponds proposed for Zone 5 (Marikana). This path will function as a major drainage corridor through the overall site.

- a new DN450 conduit draining the pond proposed for the central-eastern portion of the Zone 2 (pond D25), traversing southwards towards Sheffield Road.
- a new DN450 conduit draining the two (2No.) ponds proposed for the eastern portion of Zone 2 (ponds D28 and D31), traversing southwards towards Sheffield Road.

Figure 3.6 below shows the peak extents of flooding in Zone 2 for the various RI events. It should be noted that the City has demarcated a portion of land abutting Klipfontein and Govan Mbeki Roads in Zone 2 for housing. The layout of the ponds proposed in this zone must therefore incorporate these plans.



Figure 3.6: Concept Proposal Model Results (Zone 2)

Table 3.2 summarises the pond characteristics within Zone 2 (as informed by both model results and CCT satellite imagery – March 2022), with no dry ponds noted. Two (2No.) ponds have the possibility of being dry and amenable to multiple uses (require further assessment), and thus any proposed interventions should take this into consideration. Available storage in these two ponds is consequently reduced given the standing water anticipated in them.

Table 3.2: Zone 2 Pond Characteristics

Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
D18	12,502	8,502	No
D19	12,090	10,914	No
D21	6,192	3,192	No
D22	3,558	2,058	No
D24	8,399	7,663	No
D25	4,421	4,009	Possibly
D26	4,499	2,499	No
D28	1,805	805	No
D31	790	590	Possibly

3.1.2.3 Zone 3

Refer to **Figure 3.1**. The proposed concept for Zone 3 entails the provision of:

- an additional DN1200 bulk conduit, aligned roughly parallel to Sheffield Road. This conduit will receive flows from all the other zones, serving as the area's main bulk stormwater conduit and discharging into the existing pond / public open space beyond Ing lube Street (major system outfall point). It should be noted that the flood response of the pond at the system's outfall point was deemed to be outside the scope of this conceptual design report.
- an additional DN1200 bulk conduit in New Eisleben Road, conveying the flow from Pond P1 in Zone 1 towards the DN1200 bulk conduit proposed for Sheffield Road.

No new or additional conduits are proposed for informal storage areas D46 or D49. These are therefore not discussed in the results below.

Figure 3.7 below shows the peak extents of flooding in Zone 3 for the various RI events.



Figure 3.7: Concept Proposal Model Results (Zone 3)

Comparative hydrographs H2 (major system outflow) and H3 (outflow from storage area D49, south of Sheffield Road) shown in Figures 3.8 and 3.9 below illustrate the flow from the two outfalls located in Zone 3, for the smallest (2-year) and largest (100-year) design RI events.

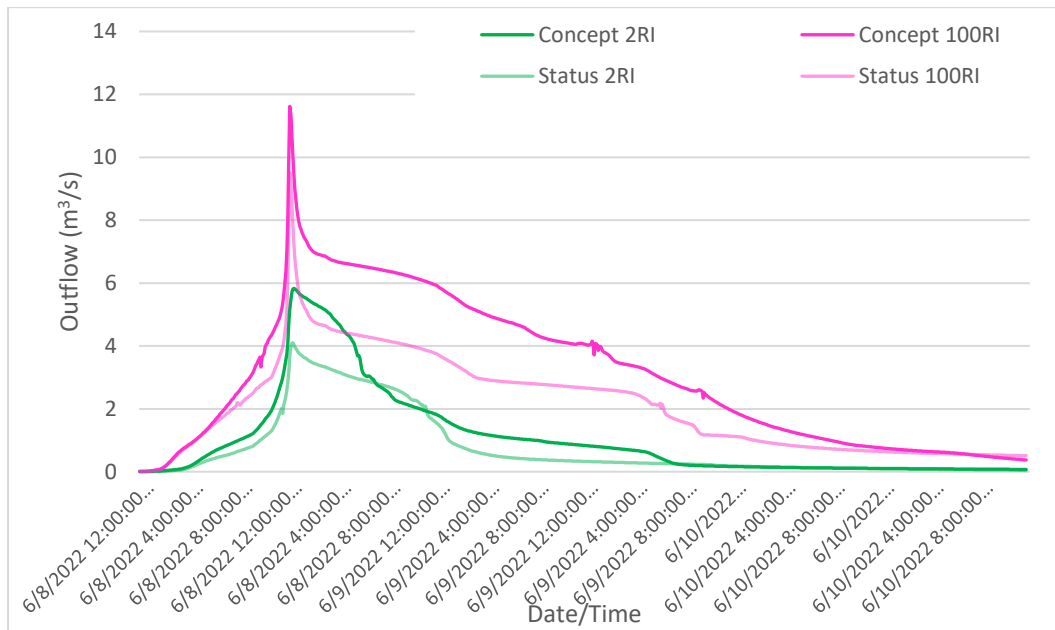


Figure 3.8: Outflow Hydrographs for 'H2'

For the Concept Proposal, expansion to the stormwater network upstream of H2 result in the faster accumulation of flow, with a greater volume discharging at H2 (compared to the Status Quo).

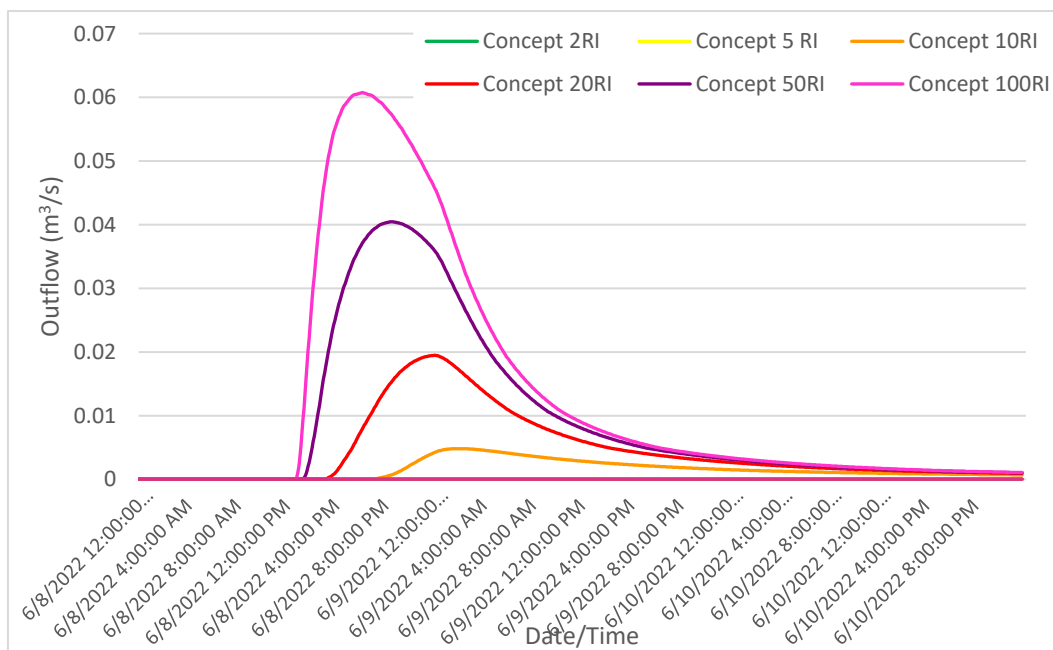


Figure 3.9: Outflow Hydrographs for 'H3'

H3 illustrates an outflow, having not exhibited one before. This is likely due to the additional urbanization (i.e. increased impervious area) accounted for in the Concept Proposal.

Table 3.3 summarises the pond characteristics within Zone 3 (as informed by both model results and CCT satellite imagery – March 2022), with three dry ponds noted, being amenable to multiple uses. One pond has the possibility of being dry (requires further assessment). Any proposed interventions should thus take the status of these ponds into consideration. Available storage is consequently reduced given the standing water anticipated in this pond.

Table 3.3: Zone 3 Pond Characteristics

Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
D5	24,803	24,801	Yes
D6	4,933	4,933	Yes
D46	4,452	4,452	Yes
D49	4,012	2,321	Possibly

3.1.2.4 Zone 4

Refer to Figure 3.1. The proposed concept for Zone 4 entails the provision of:

- an additional DN1200 bulk conduit, aligned parallel to Sheffield Road. This conduit will receive flows from Zones 4, 5, 6 and 7, serving as the area's main bulk stormwater conduit, and will traverse through Zone 3 to discharge into the existing pond / public open space beyond Ingulube Street (major system outfall point).
- an additional DN1050 outlet conduit from pond D33, becoming a DN1200 conduit as it traverses southwards, collecting flows from pond D43. This DN1200 conduit would then tie into the additional DN1200 bulk conduit proposed for Sheffield Road.
- a new DN1200 outlet conduit from Pond P4, traversing eastward and connecting to the proposed additional DN1200 conduit approaching pond D43. Pond P4 and informal storage areas D33 & D43 will be consolidated into a system of interlinked stormwater detention facilities.
- a second new outlet conduit of DN450 from Pond P4, conveying flow southwards to discharge at Pond P6.
- a new DN1050 outlet conduit from Pond P6, to tie into the DN1200 bulk conduit proposed for Sheffield Road.
- a new DN600 outlet conduit from informal storage area D44, to tie into the DN1200 bulk conduit proposed for Stock Road.

All other informal storage areas in this zone will be filled in / omitted from the system and are not discussed in the results below.

Figure 3.10 below shows the peak extents of flooding in Zone 4 for the various RI events.

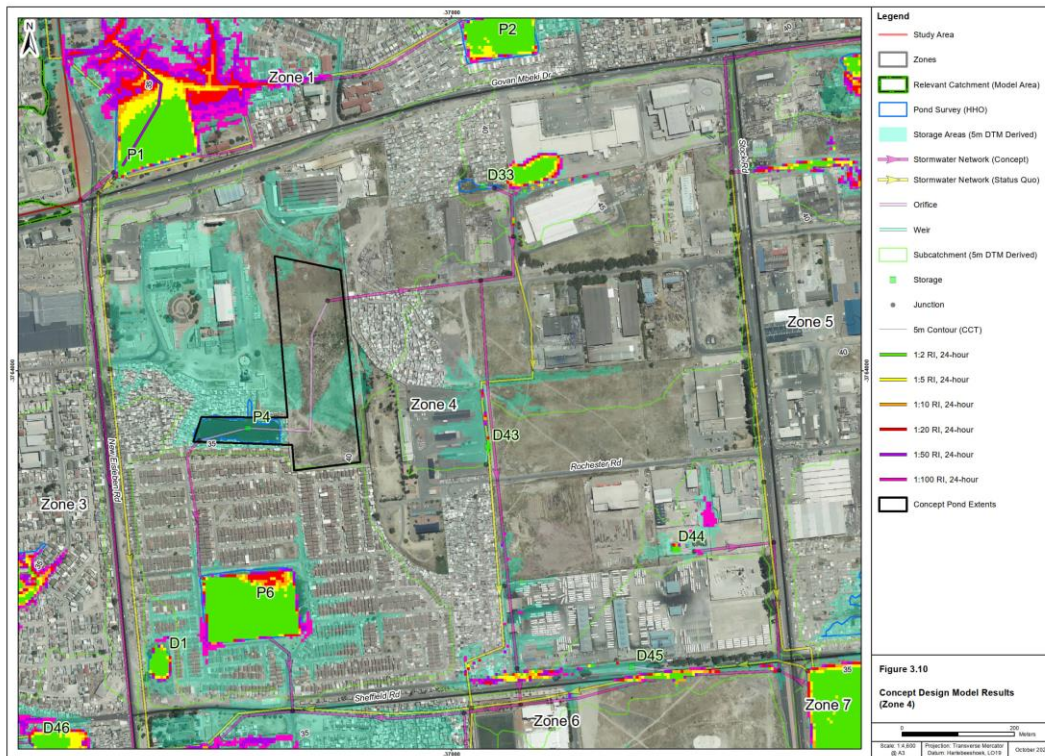


Figure 3.10: Concept Proposal Model Results (Zone 4)

Comparative inflow hydrographs (**Figure 3.11**) for Pond D2 show a similar total inflow (near identical) between the Status Quo and Concept Proposal models, for the smallest (2-year) and largest (100-year) design RI events.

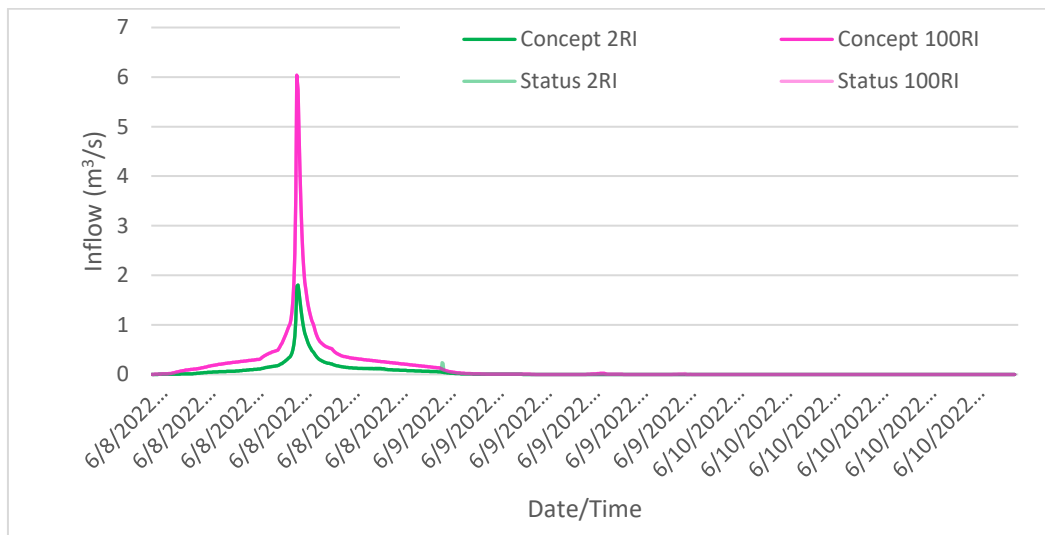


Figure 3.11: Inflow Hydrograph at Pond D2

Table 3.4 summarises the pond characteristics within Zone 4 (as informed by both model results and CCT satellite imagery – March 2022), with two (2No.) large wet ponds and five (5No.) dry ponds noted, with the latter being amenable to multiple uses and thus any proposed interventions for the five (5No.) dry ponds should take this into consideration. Available storage is consequently reduced given the standing water anticipated in the ponds.

Table 3.4: Zone 4 Pond Characteristics

Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
P4	89,622	61,671	No
P6	20,893	20,893	No
D1	1,034	993	Yes
D33	1,587	1,587	Yes
D43	90	90	Yes
D44	279	279	Yes
D45	523	523	Yes

3.1.2.5 Zone 5

Since Zone 5 currently contains almost no formal underground stormwater infrastructure and is largely an informal area, the proposed stormwater concept for this zone is closely linked to the proposed road network layout for this zone. The proposed road network will establish a rationalized grid pattern of roadways across the zone along which new stormwater conduits can be aligned.

The existing storage areas, comprised of both formal ponds and informal depressions, will be rationalized, consolidated or omitted from the system, as applicable.

Refer to **Figure 3.1**. The proposed concept for Zone 5 entails the following:

- The Status Quo depressions D7, D10, D12, D35 and D41 will be rationalized and consolidated into a cascading system of ponds, namely D35, D10 and D12 (traversing from north to south in Zone 5). These ponds will receive stormwater runoff from a proposed DN450 conduit emanating from the ponds in Zone 2. This proposed DN450 conduit will effectively link the three (3No.) ponds to the additional DN1200 stormwater conduit proposed for Sheffield Road, which will in turn discharge into Pond P7 in Zone 7.
- At Pond P3 and depression D32, new DN450 conduits are proposed to link these storage areas to the existing DN1050 conduit in Stock Road.
- Depression D11 will receive a new DN600 conduit which will drain into Pond P7 in Zone 7.
- The Status Quo depressions D8, D9 and D13 will be consolidated into Concept Ponds D8 and D52 to accommodate a shopping centre which is planned for the eastern portion of Zone 5.
- A new DN450 conduit is proposed to link pond D52 to pond D8.
- A new DN1200 outlet conduit is proposed for Concept Pond D8, which would then traverse towards Sheffield Road.
- Concept Ponds D50 and D53, connecting to the DN1200 conduits proposed for Stock Road and Sheffield Road respectively, will take up the function of several small ponds / depressions from the Status Quo scenario.
- Depressions D29, D30 and D42 will be filled in / omitted from the system and are not discussed in the results below.

Figure 3.12 below shows the peak extents of flooding in Zone 5 for the various RI events.

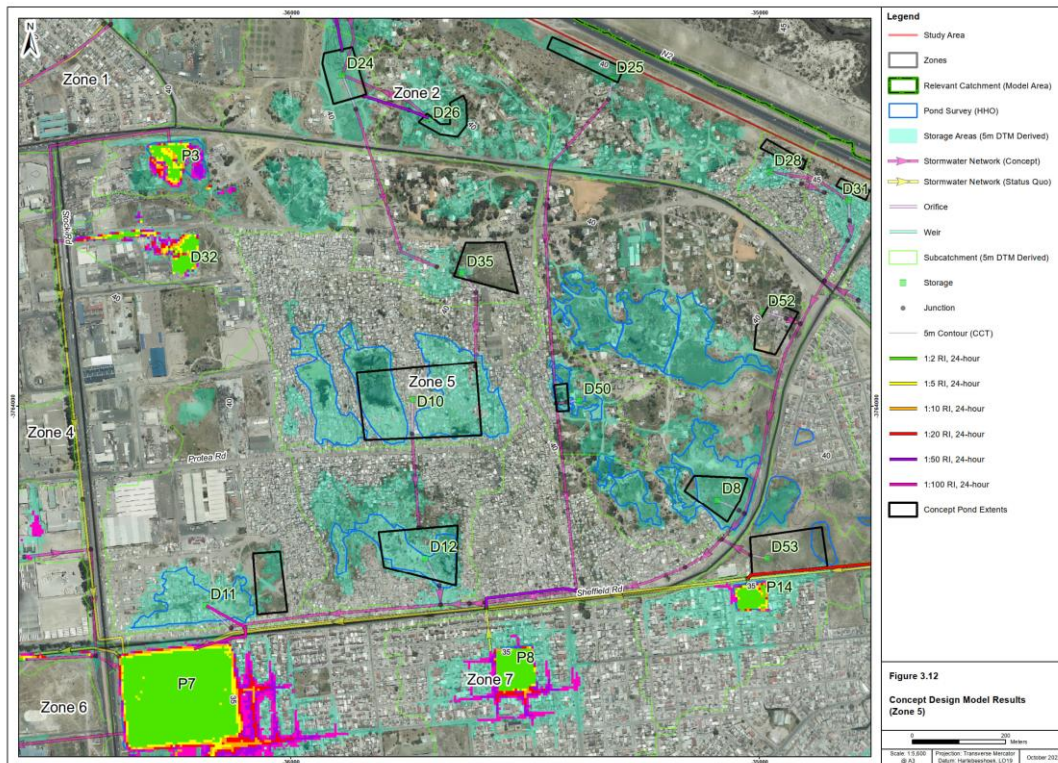


Figure 3.12: Concept Proposal Model Results (Zone 5)

The conceptual ponds have approximate extents as illustrated in Figure 3.12 above such that the reader can understand the expected flood extent for all design events. In all RI cases, the floods are contained within the Concept Pond boundaries.

Comparative inflow hydrographs (**Figure 3.13**) for Pond D2 for the smallest (2-year) and largest (100-year) design RI events illustrate an increase in inflows into the pond, indicating that the Concept Pond is managing a significantly larger inflow volume than in the Status Quo.

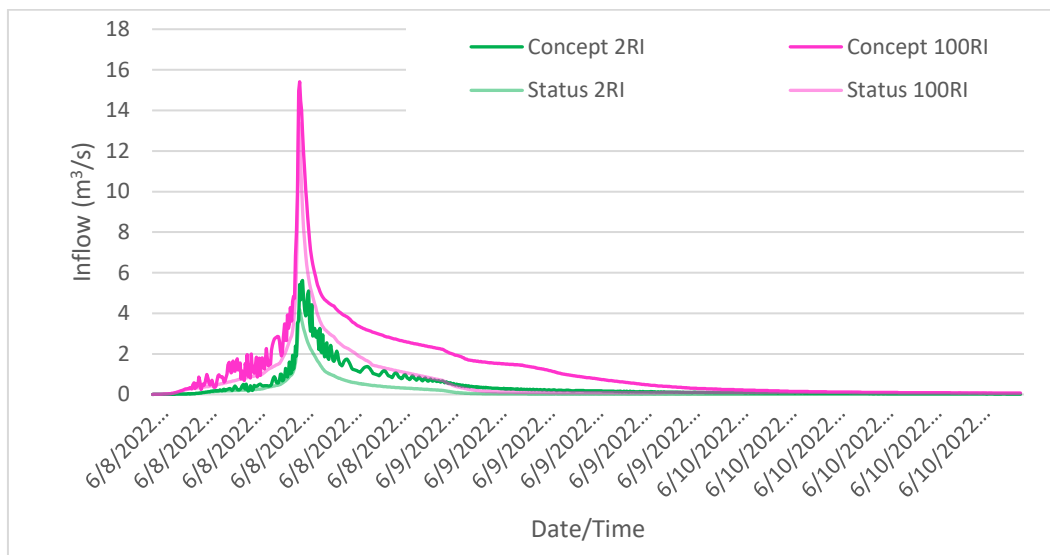


Figure 3.13: Inflow Hydrograph at Pond P7

Table 3.5 summarises the pond characteristics within Zone 5 (as informed by both model results and CCT satellite imagery – March 2022), with two dry ponds noted, being amenable to multiple uses. Six ponds have the possibility of being dry (requires further assessment) and thus any proposed interventions should take this into consideration. Available storage is reduced in some instances given the standing water anticipated in the ponds.

Table 3.5: Zone 5 Pond Characteristics

Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
P3	3,568	3,568	Yes
D8	9,492	8,675	Possibly
D10	28,735	26,276	Possibly
D11	7,626	7,622	Possibly
D12	28,500	21,858	Possibly
D32	1,386	1,386	Yes
D50	650	650	Possibly
D52	8,727	8,711	Possibly

3.1.2.6 Zone 6

Refer to **Figure 3.1**. The proposed concept for the largely formalized Zone 6 involves the provision of new outlet conduits to the existing ponds / depressions:

- Pond D2 will be linked to the new DN1200 conduit proposed for Sheffield Road.
- A new DN1200 conduit will link Pond P7 (in Zone 7) to Pond P20. A second new DN1200 conduit will then convey flow from Pond P20 into the new DN1200 conduit proposed for Sheffield Road.
- A new DN1200 outlet conduit is proposed for pond D4, discharging into the existing open space south of Zone 6.
- No interventions have been proposed for pond D48. Excess runoff from this depression will travel overland towards D49 and then to an outfall. As such it is not discussed in the results below.

Figure 3.14 below shows the peak extents of flooding in Zone 6 for the various RI events.



Figure 3.14: Concept Proposal Model Results (Zone 6)

Hydrograph H4 in **Figure 3.15** below illustrates the flow anticipated for the smallest (2-year) and largest (100-year) design RI events as a result of the new connection from D4 into the existing open space south of Zone 6.

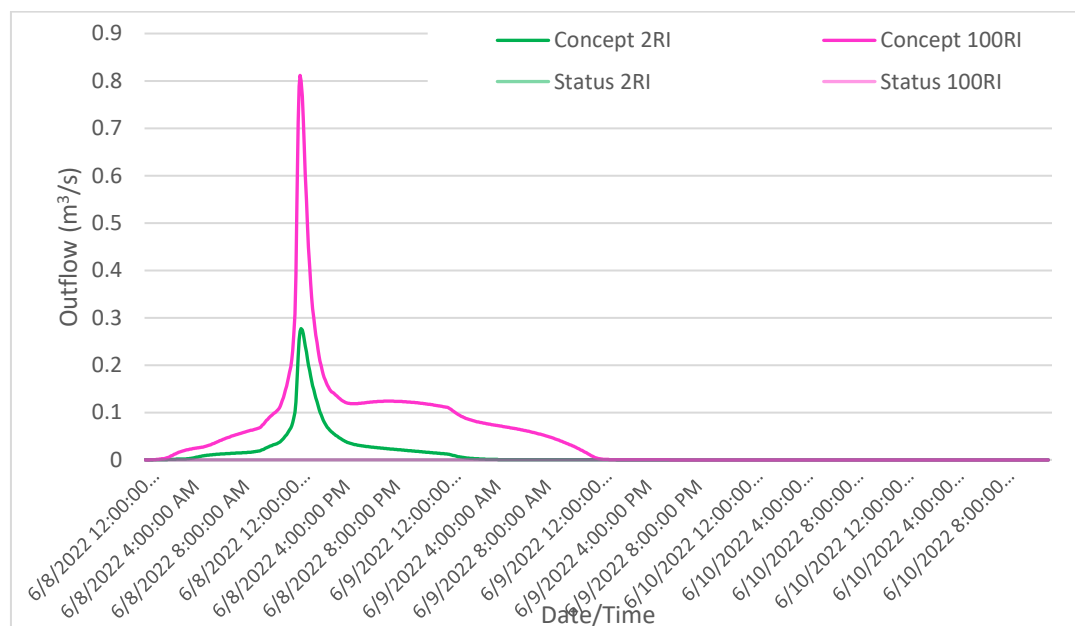


Figure 3.15: Outflow Hydrographs for 'H4'

Figure 3.16 below illustrates the head and volume comparison for Pond D2. The drawdown for the pond is significantly quicker than previously, while the maximum flood height is less.

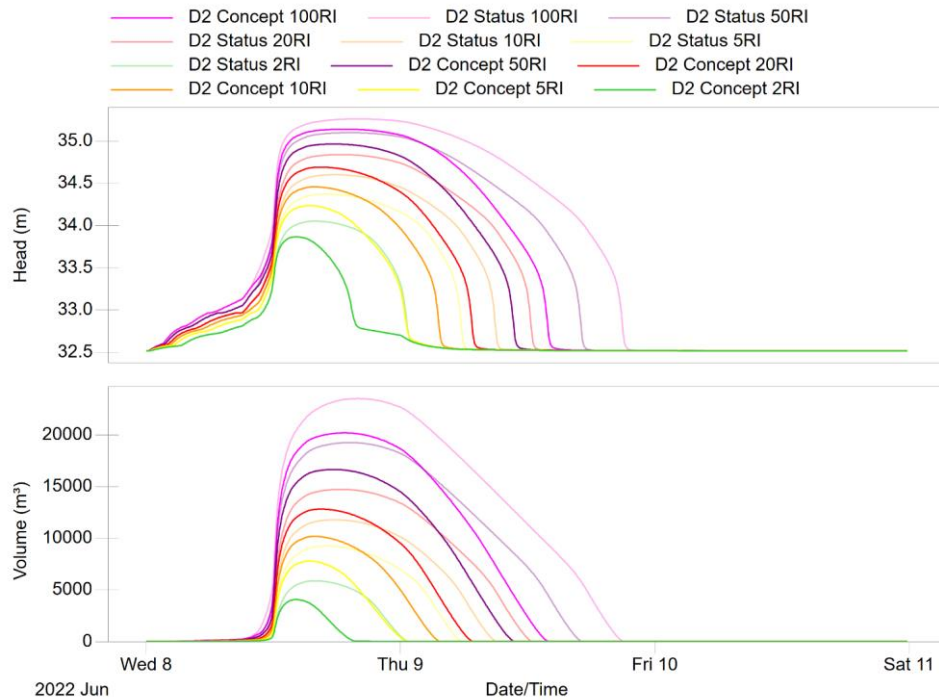


Figure 3.16: Head and volume comparison for Pond – D2

Table 3.6 summarises the pond characteristics within Zone 6 (as informed by both model results and CCT satellite imagery – March 2022), with one dry pond and three potentially dry ponds (requires additional investigation), thus being amenable to multiple uses. This should be taken into consideration in terms of any proposed interventions. Available storage is influenced by anticipated standing water in places.

Table 3.6: Zone 6 Pond Characteristics

Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
P20	39,662	39,373	Possibly
D2	20,206	20,202	Yes
D4	1,065	1,062	Yes
D48	4,512	3,942	Yes

3.1.2.7 Zone 7

Refer to **Figure 3.1**. The proposed concept for Zone 7 entails the provision of

- an additional DN1200 outlet conduit from Pond P7 to Sheffield Road.
- a second additional DN1200 outlet conduit from Pond P7 to Pond P20 in Zone 6 along Park Road (one street block southwards from Sheffield Road).
- an additional DN1200 outlet conduit from Pond P9_10 to Pond P11.
- an additional DN1200 outlet conduit from Pond P11 towards pond D14.
- an additional DN600 outlet conduit from pond D14 towards Pond P11. A DN1200 outfall conduit is proposed at the point where the additional conduits from ponds P11 and D14 intersect.
- a new DN600 outlet conduit from the pond D53 which will tie into the DN1200 conduit proposed for Sheffield Road.

It should be noted that Pond P7 will play a critical role in the management and attenuation of stormwater runoff on the site. It will serve as the major discharge point for the DN1200 conduit proposed for Sheffield Road, receiving flows from much of Zones 2, 5 and 7. The two (2No.) additional outlet conduits proposed for Pond P7 (one to Sheffield Road and one to Pond P2) will then serve to convey the outflow from Pond P7 back into the system.

The remaining smaller ponds and depressions (D3, D36, D39, P8, P13, P14, P17 and P18) will not receive any conceptual interventions.

Figure 3.17 below shows the peak extents of flooding in Zone 7 for the various RI events.

Hydrograph H5 (see **Figure 3.18**) illustrates the flow anticipated as a result of the new D1200 proposed parallel to the R300 (i.e. ponds P9_10 to D14). This new connection will increase stormwater conveyance thereby resulting in increased flows for all design events.

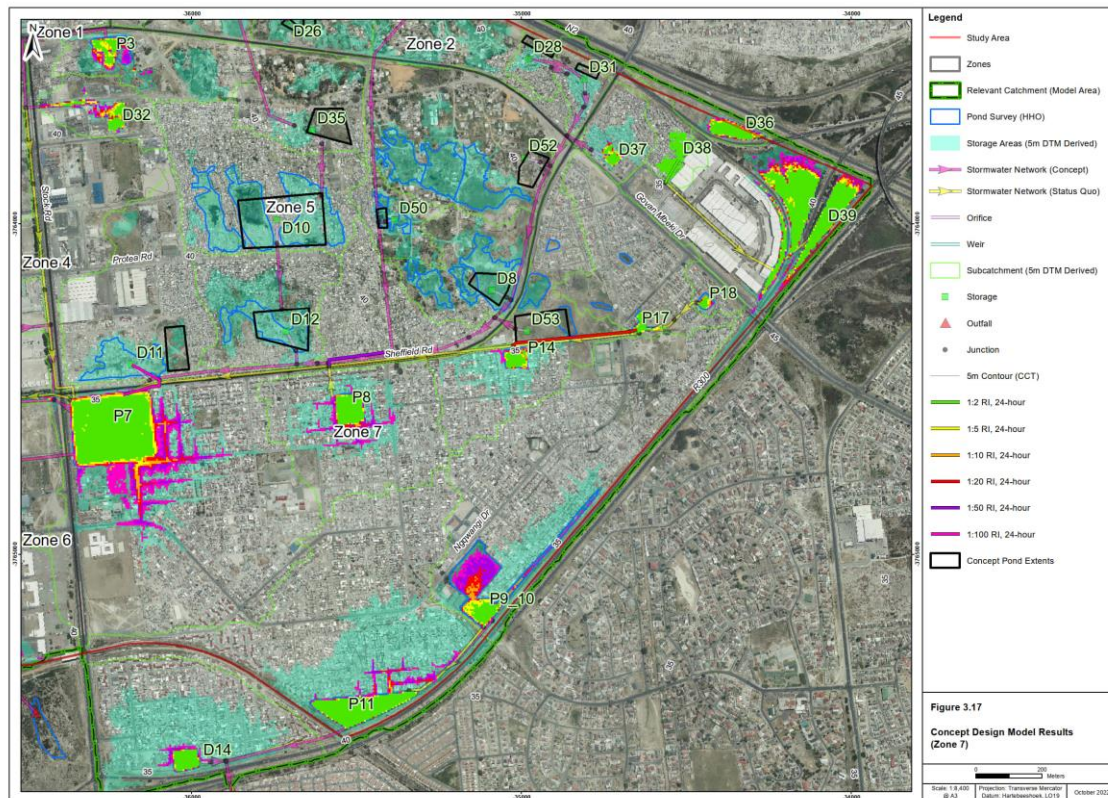


Figure 3.17: Concept Proposal Model Results (Zone 7)

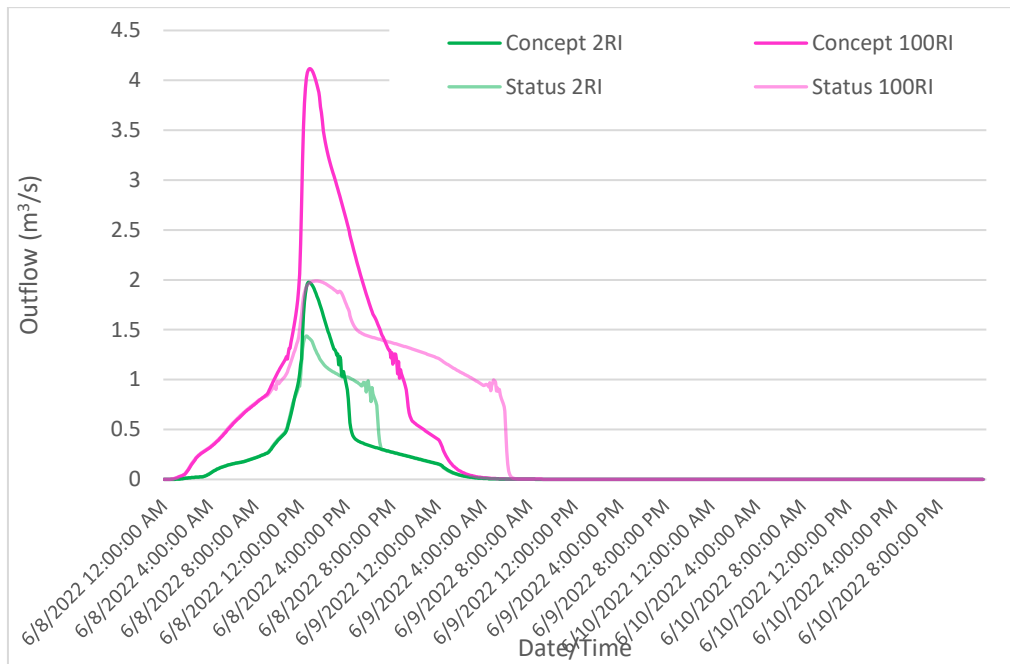


Figure 3.18: Outflow Hydrographs for 'H5'

Figure 3.19 below illustrates the head and volume comparison for Pond P7. The drawdown for the pond is significantly quicker than previous, while the maximum flood height is less.

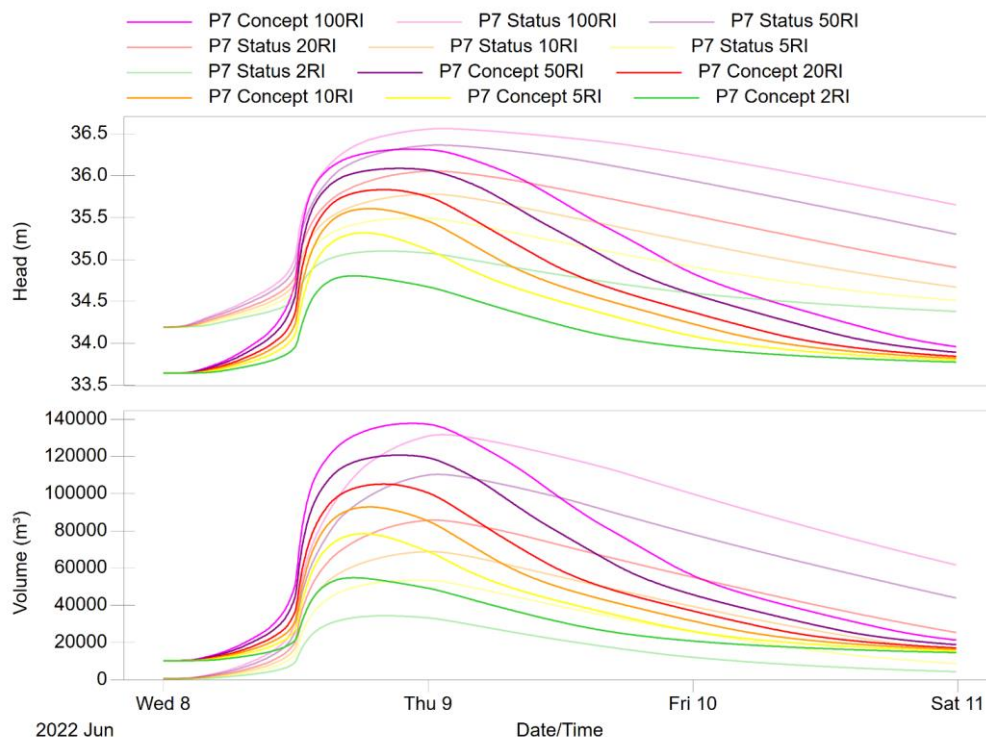


Figure 3.19: Head and volume comparison for Pond – P7

Table 3.7 summarises the pond characteristics within Zone 7 (as informed by both model results and CCT satellite imagery – March 2022), with half the ponds dry (and thus amenable to multiple uses) and the other half wet. This must thus be taken into consideration in terms of any proposed interventions. Available storage in these wet ponds is consequently influenced by anticipated standing water.

Table 3.7: Zone 7 Pond Characteristics

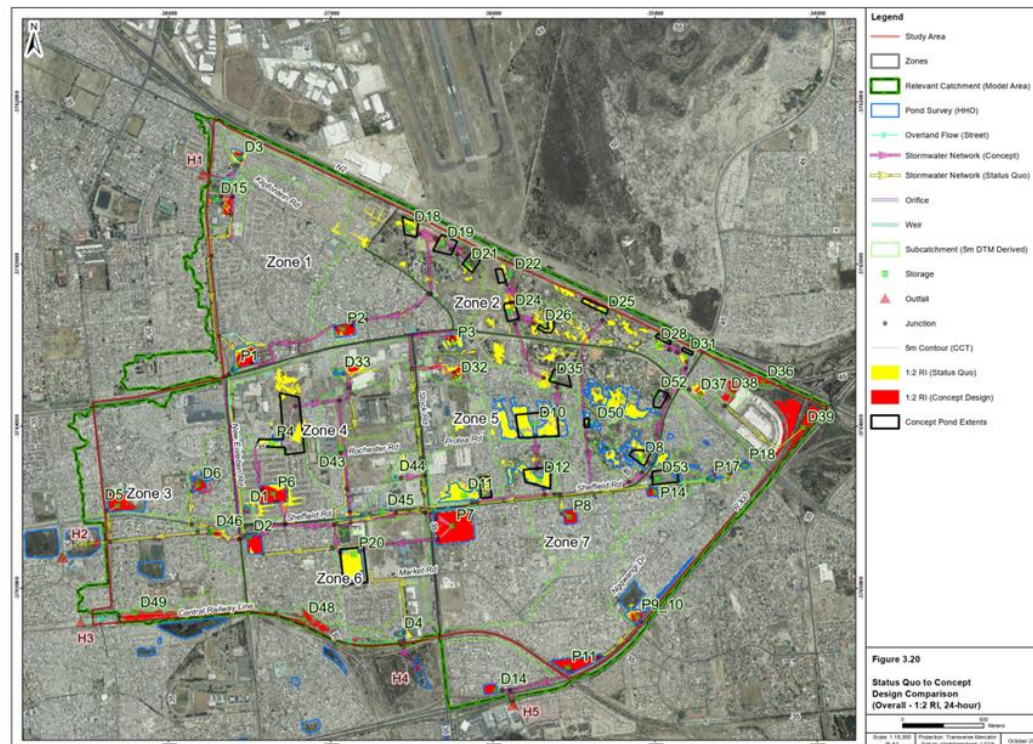
Pond	Max. Volume (m ³)	Available Storage (m ³)	Dry Pond
P7	137,771	127,593	No
P8	9,595	9,595	Possibly
P9_10	8,114	8,114	No
P11	18,581	18,581	No
P14	3,666	3,666	Possibly
P17	2,112	2,112	No
P18	634	634	No
D36	3,096	2,307	No
D37	886	881	Yes
D38	2,658	2,352	Possibly
D39	31,846	28,072	No
D53	13,712	7,712	Possibly

3.1.3 Graphical Summary of Results

The reduction in flooding extents for the various simulated storm RI's is presented graphically in **Figure 3.20** to **Figure 3.25** below.

Areas indicated in red shading represent the flooding extents after the implementation of the Concept Proposal, compared to the Status Quo scenario, shown in yellow shading.

Conceptual pond extents are indicated and were modelled using storage curves in the absence of modelled terrain data. For all RI's, flooding was contained within the boundaries of the concept pond extents.

**Figure 3.20: 1:2 Year Storm Event Comparison**

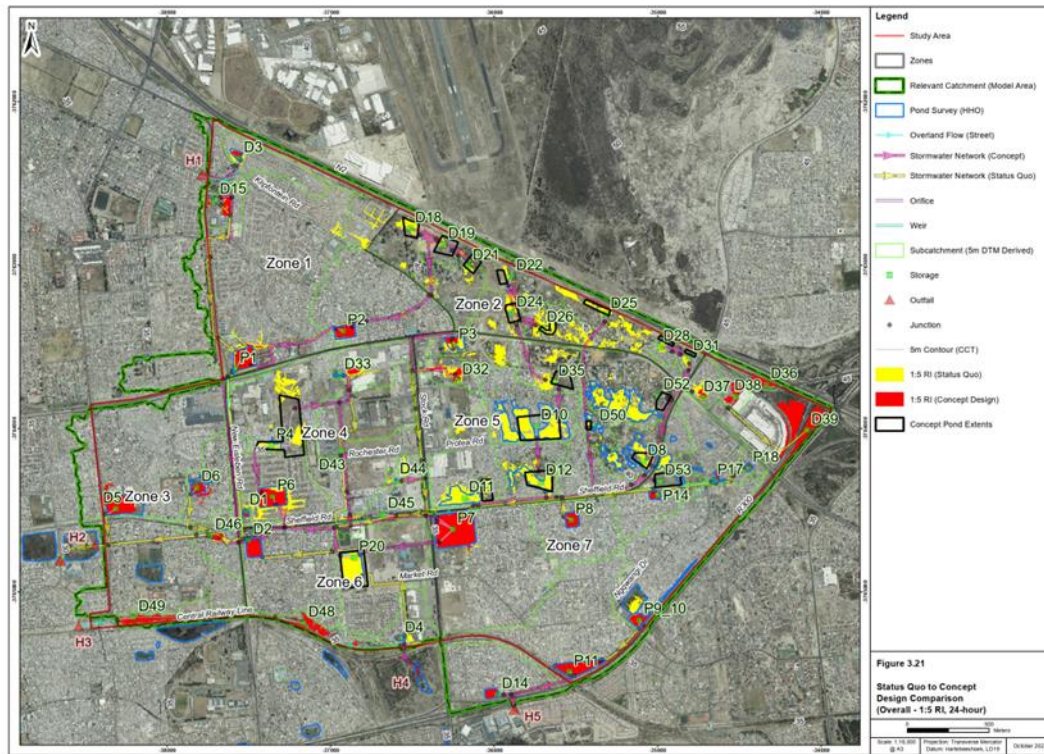


Figure 3.21: 1:5 Year Storm Event Comparison

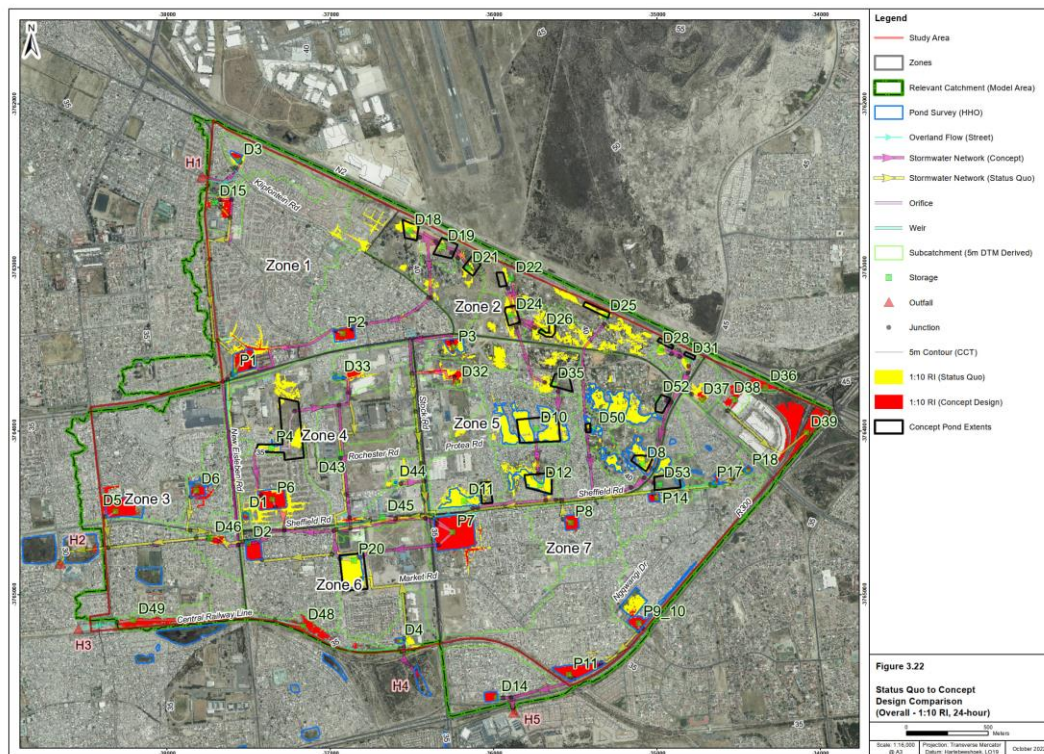


Figure 3.22: 1:10 Year Storm Event Comparison

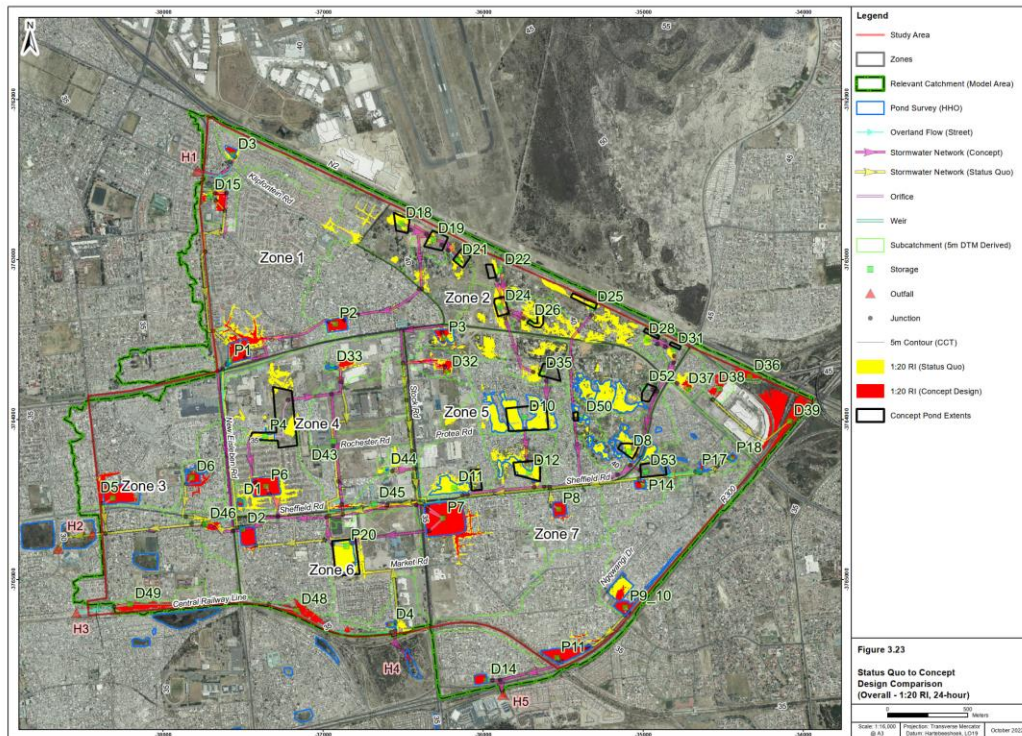


Figure 3.23: 1:20 Year Storm Event Comparison

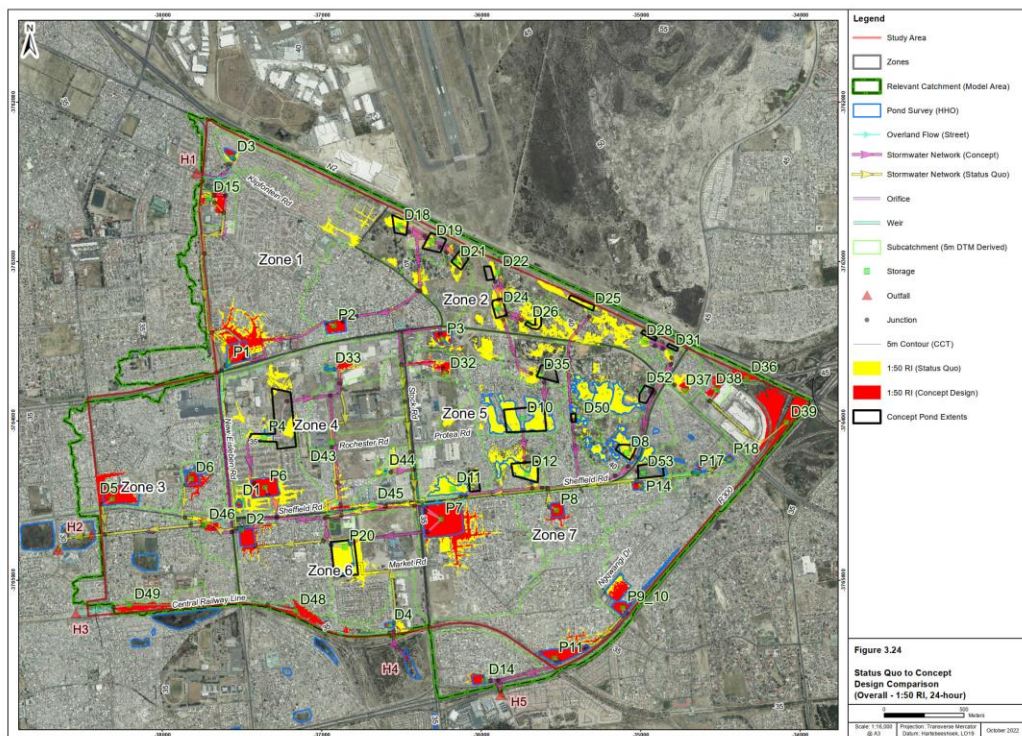


Figure 3.24: 1:50 Year Storm Event Comparison

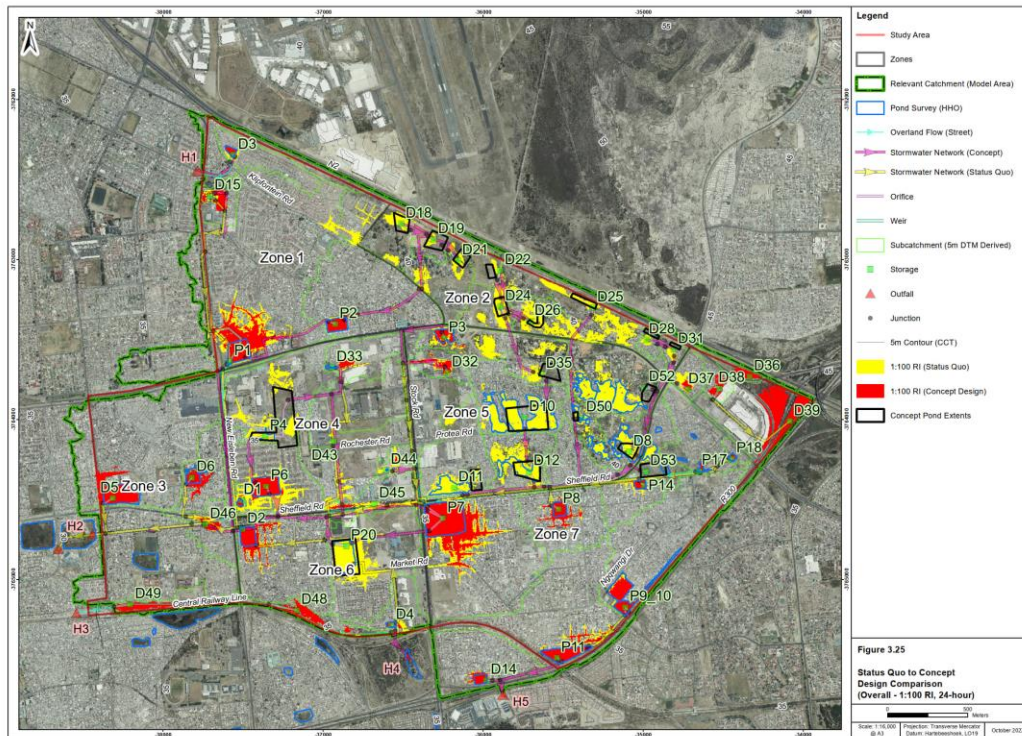


Figure 3.25: 1:100 Year Storm Event Comparison

Figure 3.26 and Figure 3.27 below present a summary of the reductions in chart format.

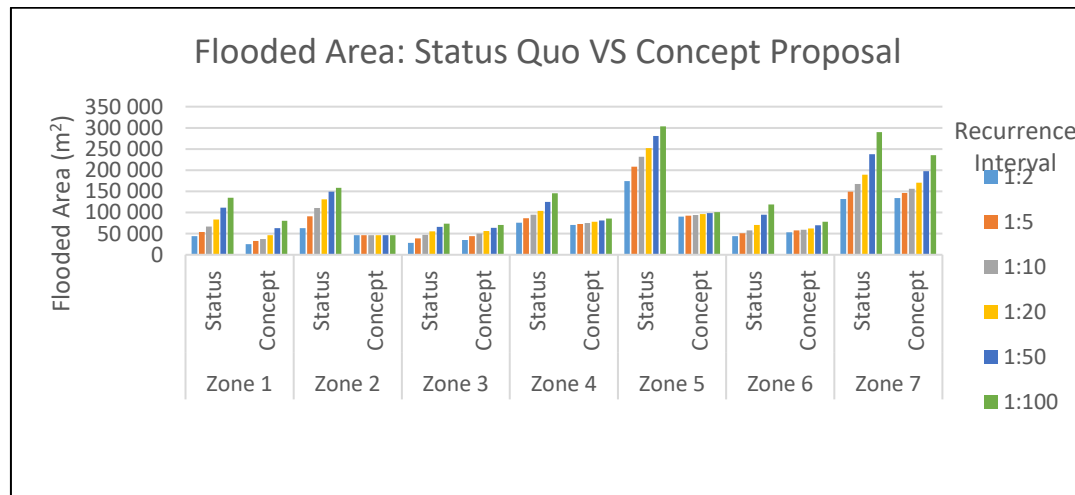


Figure 3.26: Comparison of Flooded Area

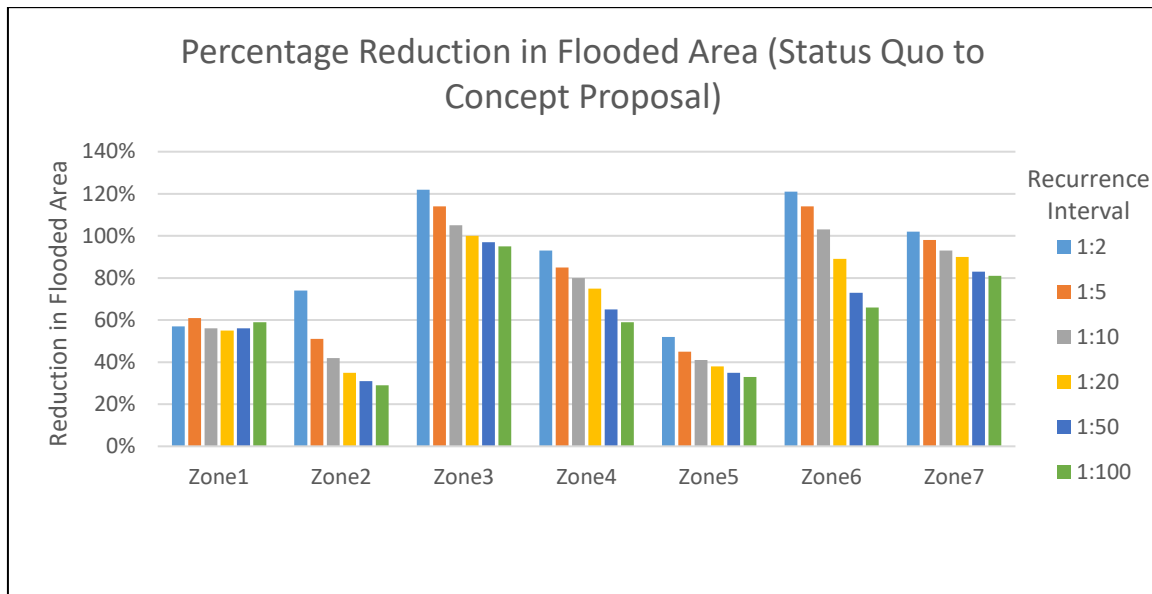


Figure 3.27: Percentage Reduction in Flooded Area

3.2 Summary of Concept Proposal Results

In considering the comparison of results between the Status Quo and the Concept Proposal model output (Refer to **Figures 3.20 to 3.25** above), the following changes from the Status Quo in terms of flooding extents are noted:

3.2.1 Zone 1

- Pond P2 remains similar, contained within the pond boundary.
- Pond D15 shows some improvement.
- Pond D3 now drained by a DN600 shows a significant reduction in flooded area.
- Pond P1 demonstrates an improvement, however, there is still a spread of flooding into the urban surrounds despite increased pond capacity and the addition of a DN1200 outlet conduit.

3.2.2 Zone 2

In Zone 2, no comparison with the Concept Proposal results is possible as all Status Quo ponds were informal and have now been replaced with conceptual ponds. These conceptual ponds have approximate extents as illustrated in Figure 3.6 above such that the reader can understand the expected flood extent for all design events. In all RI cases, the floods are contained within the Concept Pond boundaries.

3.2.3 Zone 3

- Pond D5 and D6 remain similar, with a slight reduction likely due to some alleviation in the existing network.

3.2.4 Zone 4

- Pond D33, now drained by a DN1050 conduit, shows a significant reduction in flooded extents.
- Pond D43, connected to a DN1200 conduit, previously had little flooding and continues with that trend.
- Pond P4, having been replaced by a Concept Pond, is contained within the extent illustrated for all events.
- Pond P6, now being drained by a DN1050 conduit, sees a substantial reduction in its flooding extents.

3.2.5 Zone 5

Comparison with the Concept Proposal results is limited as most of the Status Quo ponds in this zone were informal and have now been replaced with conceptual ponds, with the exception of ponds P3 and D32.

These ponds show reduced flooding for all design events given the addition of the DN450 pipe.

3.2.6 Zone 6

- Pond P20 being a Concept Pond is now illustrated as being fully contained with the extent indicated.
- D2 demonstrates an improvement, however, there is still a spread of flooding into the urban surrounds (a mix of increased urbanization and increased stormwater conveyance being at play).

3.2.7 Zone 7

- Pond D14, P9_10 and Pond P11 see some reduction in flooding (mostly noted within P9_10).
- P8 and P14 likewise see some reduction in flooding mostly noticeable in the 1:100 RI event.
- D37 shows a significant improvement due to the addition of a DN600.
- D53 is a new concept pond and flooding is simulated as being contained within the defined extent.
- P7 demonstrates an improvement, however, there is still a spread of flooding into the urban surrounds (a mix of increased urbanization and increased stormwater conveyance being at play).

For all zones, there are instances of increased flooding for smaller design events (when the Concept Proposal scenario is considered). This may be due to either the assumed increased urbanisation (and therefore runoff) or the change in routing of flood waters, or the addition of new ponds. When larger design events are considered, reductions in flooding are noted, with some substantial improvements in places.

3.3 SECTION B: Integrated POA Open Space and Stormwater Concept

A summary of the key informants of the stormwater model that informed the POA Open Space and Stormwater Concept are as follows:

- Underground stormwater infrastructure improvements should be prioritized in the POA with minimal or very selective application of above ground stormwater management options such as swales, due to the increased maintenance requirements associated with these options;
- The location and extent of new required stormwater ponds within the POA have been confirmed. The location of these new ponds has also informed the logic for a new open space network in areas of the POA that will be formalized in the future.
- The location of ponds that are suitable for multifunctional use
- The location of new underground stormwater infrastructure, thereby creating opportunities to align these facilities with new public space improvements including street planting and local SUDS treatment.

3.3.1 Conceptual Approach

Building on the POA regeneration theme to develop an integrated and multifunctional green network, the following guiding concepts have been applied in the conceptual approach for the completion of the POA Open Space and Stormwater Concept are as follows:

1. **PROMOTING CLUSTERED & MULTIFUNCTIONAL GREEN SPACES-** Supporting the **clustering** of recreation, sports, public facilities & stormwater spaces within the POA (new & old) to ensure **efficient** and **multifunctional** use of available green space. To avoid retention ponds becoming isolated and disjointed areas, (thereby increasing the potential for antisocial behaviour) they should wherever possible be linked with other green/open space and community uses to promote increased surveillance and usage.
2. **CONNECTING THE CLUSTERED SPACES-** Developing a network of **linear parks** and **green streets** to connect the open spaces (of which stormwater ponds are a component). The use of linear parks and green streets will link and connect the open spaces and support the making of a legible and integrated open space network. Green streets should be designed to function as NMT friendly and safe spaces that include sidewalks with pedestrian lighting, tree planting and where appropriate other local SUDS treatments. Priority should be given to supporting the making of positive building frontage along these routes to ensure safe pedestrian and cycling conditions. Wide street medians and electrical servitudes in the POA are to be included in the definition of linear parks. With limited open space available with the POA, it is critical that these spaces are not treated as left over areas. They should be designed to function as active green spaces within the POA.
3. **ACTIVATING THE STORMWATER PONDS-** Identifying additional functions/ uses to activate stormwater ponds and broaden their use and value within the community. Differing design solutions should be applied to wet and dry ponds to ensure that they function as positive spaces within the local community. It critical that active frontage, to support increased surveillance, is achieved on as many sides as possible around the retention ponds.



As indicated in the diagrams below, the application of these concepts differ between areas in the POA that are already developed and areas that will be formalized in the future. Retention ponds and wetlands in new development areas and or areas that will be formalized in the future can be proactively planned to function as positive spaces while existing retention ponds and existing development around wetlands require remedial interventions to address their current challenges.

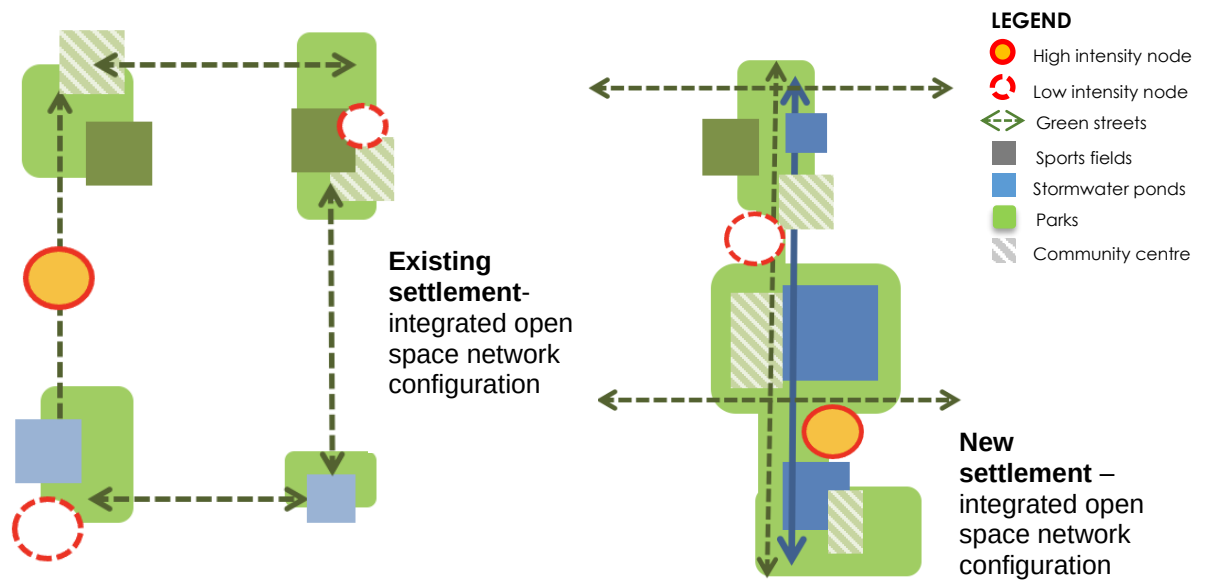


Figure 3.28: Application of the guiding concepts in existing and new development areas

- CELEBRATING WATER-** A dominant landscape characteristic of Philippi is its low-lying terrain and prevalence of water due to the high water table in the area. Currently wetlands and retention ponds are not experienced as positive spaces in the POA.

Moving forward, design solutions to better manage stormwater and improve flooding should focus on ways to celebrate the inherent features of the landscape of which water is a key component. Retention ponds, if better planned by being positively integrated within the urban environment, better designed and actively maintained, can provide access to high quality natural spaces and become features of the area.

Adopting a holistic and transversal approach to improving and upgrading existing stormwater infrastructure in the POA, presents a real opportunity to not only reduce flooding but also improve its environmental character and sense of place.

3.3.2 Integrated POA Open Space and Stormwater Concept and its components

The proposed integrated open space and stormwater concept for the POA is provided below. Key components of the concept which are discussed in more detail below include:

- Green Streets and Linear Parks
- Clustering of Mixed Use Open Spaces
- Active Stormwater Ponds. This component of the plan confirms both the role and character of the various stormwater ponds as well as confirming where new proposed development in the POA can support the making of positive frontage onto stormwater ponds.

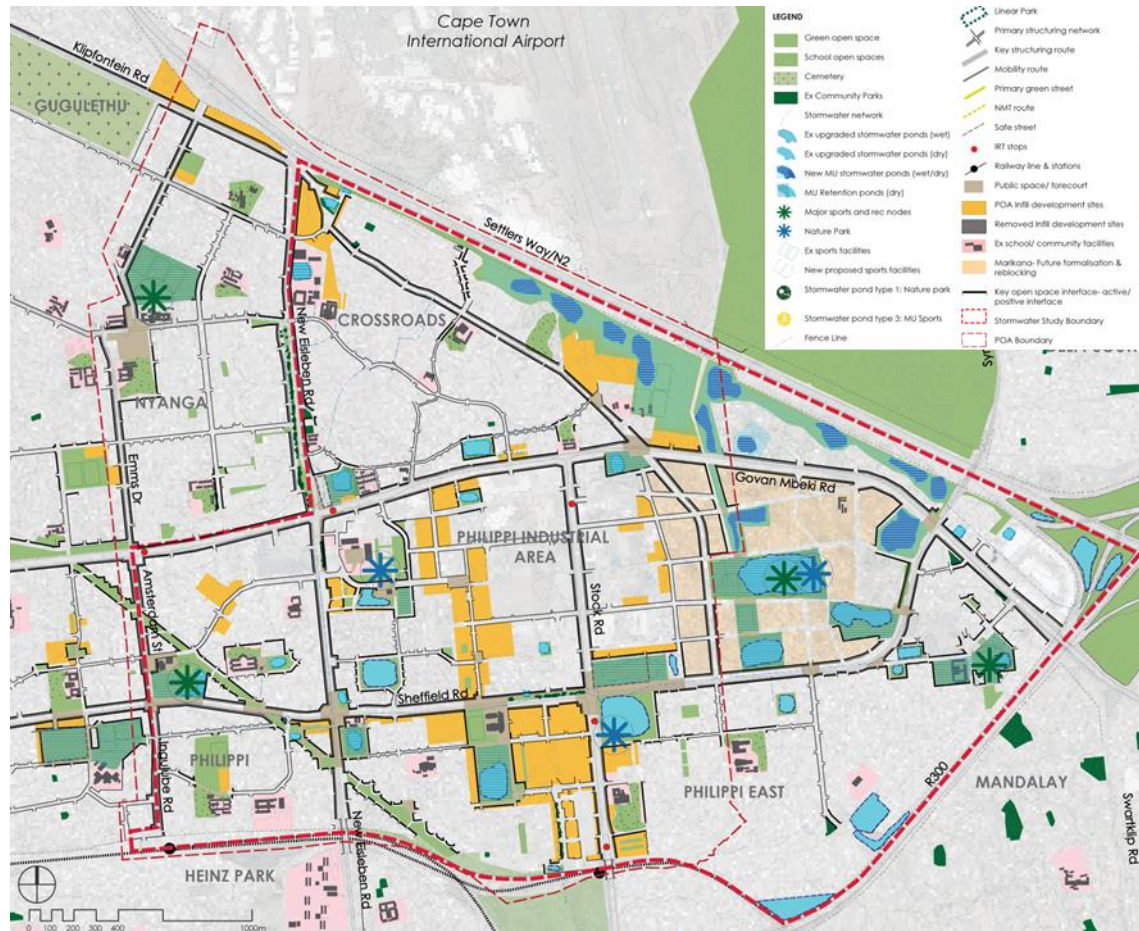


Figure 3.29: Integrated Open Space and stormwater Concept

A. Green Streets and Linear Parks

The plan below identifies the location of proposed Green streets and Linear Parks. The Green streets and Linear Parks play a critical function in connecting the various stormwater, open spaces which include parks, sports and community facilities together.

The plan below identifies the location of proposed Green streets and Linear Parks. The Green streets and Linear Parks play a critical function in connecting the various stormwater, open spaces which include parks, sports and community facilities together.

Three new linear parks are proposed, which include the conversion of the existing electrical servitude in Browns Farm into an active and positive space:

1. Redevelopment of portions of the road median on Sheffield Road adjacent to the Golden Arrow bus depot. This is being explored in more detail as part of the parallel Sheffield Road Scheme Review project.

2. Development of a new continuous open space corridor across portions of Marikana. The Marikana Linear Park is envisioned to function as a new metropolitan park and destination that would have a similar level of investment as Wynberg Park and Green Point Park.

A hierarchy of green streets are proposed which relates to the overall street network for the POA. The network is structured to promote convenient and safe accessibility within the POA as well as to connect the various stormwater ponds and open spaces. Where possible, the green network aligns with new required underground stormwater infrastructure. This will allow implementation associated with NMT, landscaping and infrastructure to be integrated, thereby reducing costs and minimising disruptions in the area. As indicated in Figure 3.30 below, all of the green streets include elements to promote safe, active and attractive street conditions but which vary in scale according its significance within the overall street network.



Figure 3.30: Green Streets and Linear Parks

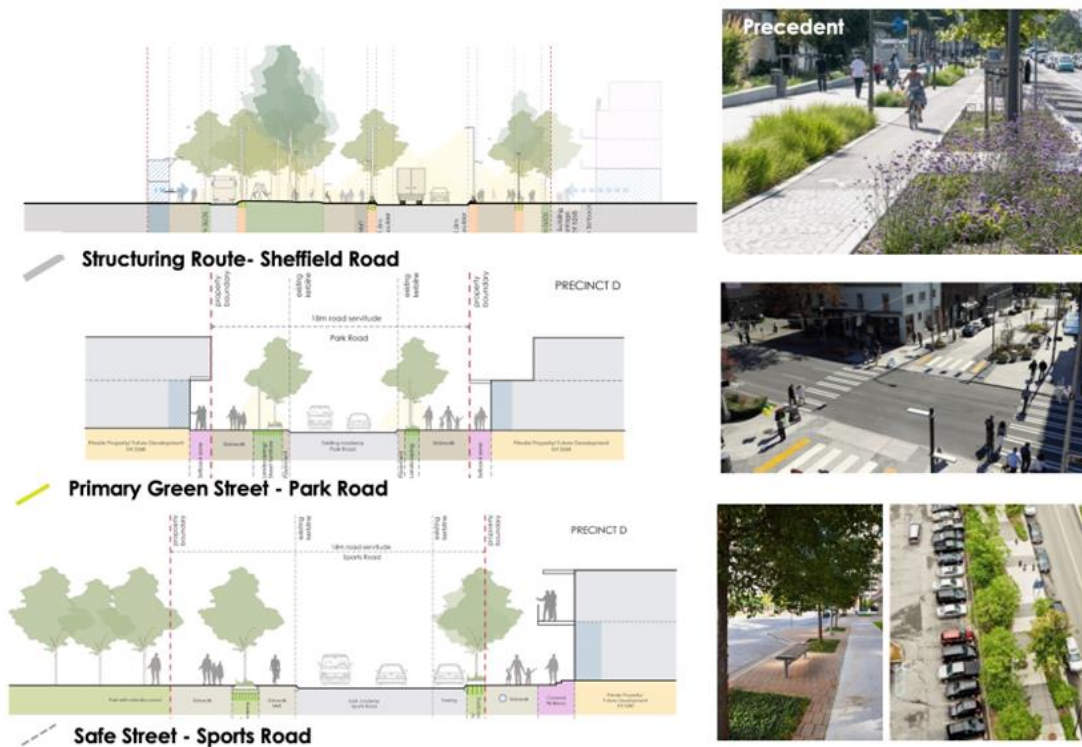


Figure 3.31: Hierarchy of green streets- living street

B. Clustered Mixed-Use Spaces

In order to encourage greater optimisation of the limited available open space in the POA as well as to support easier maintenance and increased surveillance, stormwater ponds should be located within a cluster of open space and community facilities. This includes the clustering of stormwater ponds with complementary uses such as parks, sports, schools, and community facilities (clinic, library, community hall, water points, recycling etc). In some cases these clusters exist and should be reinforced while new clusters have been identified where the need for new ponds have been confirmed in the Stormwater Model. Wherever possible, retention ponds should not occur in isolation.



Figure 3.32: Active Stormwater Ponds

C. Confirming the role and character of retention ponds

The role and character of the various stormwater ponds across the POA are confirmed in **Figure 3.33** below. It is critical that all retention ponds, wet and dry, are designed to have expanded use beyond their primary stormwater function to ensure that they perform as positive spaces within the POA.

The role of wet ponds are expanded to include recreation uses that allow them to function as nature parks, while dry ponds should be designed to function as multifunctional urban parks such as the existing iThemba Labantu facility on the corner of Sheffield and New Eisleben Road. All proposed additional uses in existing stormwater pond sites are envisioned as complementary to its core stormwater function and will not reduce their water retention requirements.

D. Supporting Active frontage onto Open spaces

To ensure that stormwater ponds start to function as positive spaces in the POA, changes are also required around the edges of these sites. Moving forward, particular focus should be given to the design of walls and buildings to support increased surveillance onto open spaces. Wherever possible blank boundary/ buildings walls are to be avoided. As indicated in Figure 3.33 below, there are several locations where new planned infill development in the POA occurs adjacent to existing/ new stormwater ponds and open space. The development of these sites will provide an opportunity to demonstrate how to create positive frontage around open space.



Figure 3.33: Active Stormwater ponds

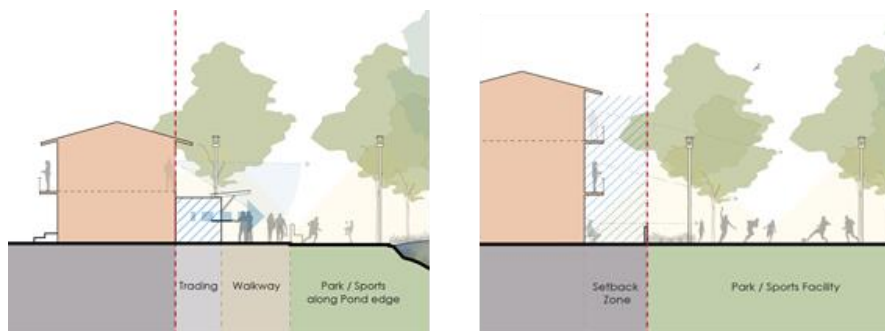


Figure 3.34: Supporting positive frontage onto open space

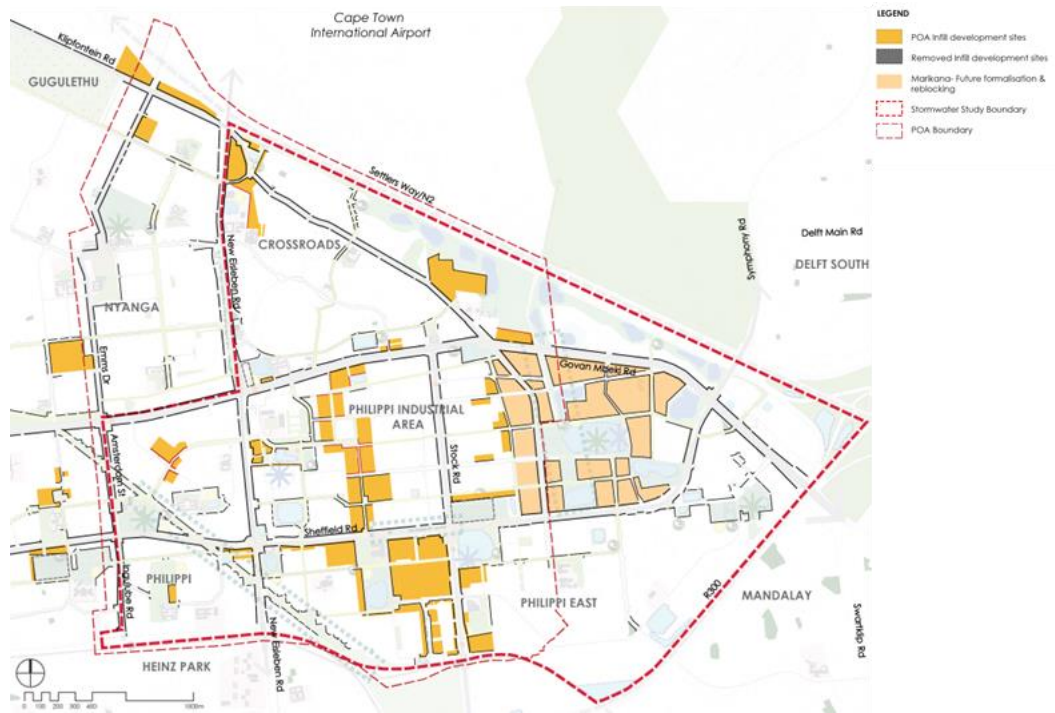


Figure 3.35: Proposed development in the POA

3.3.3 Stormwater Pond Design Guidelines

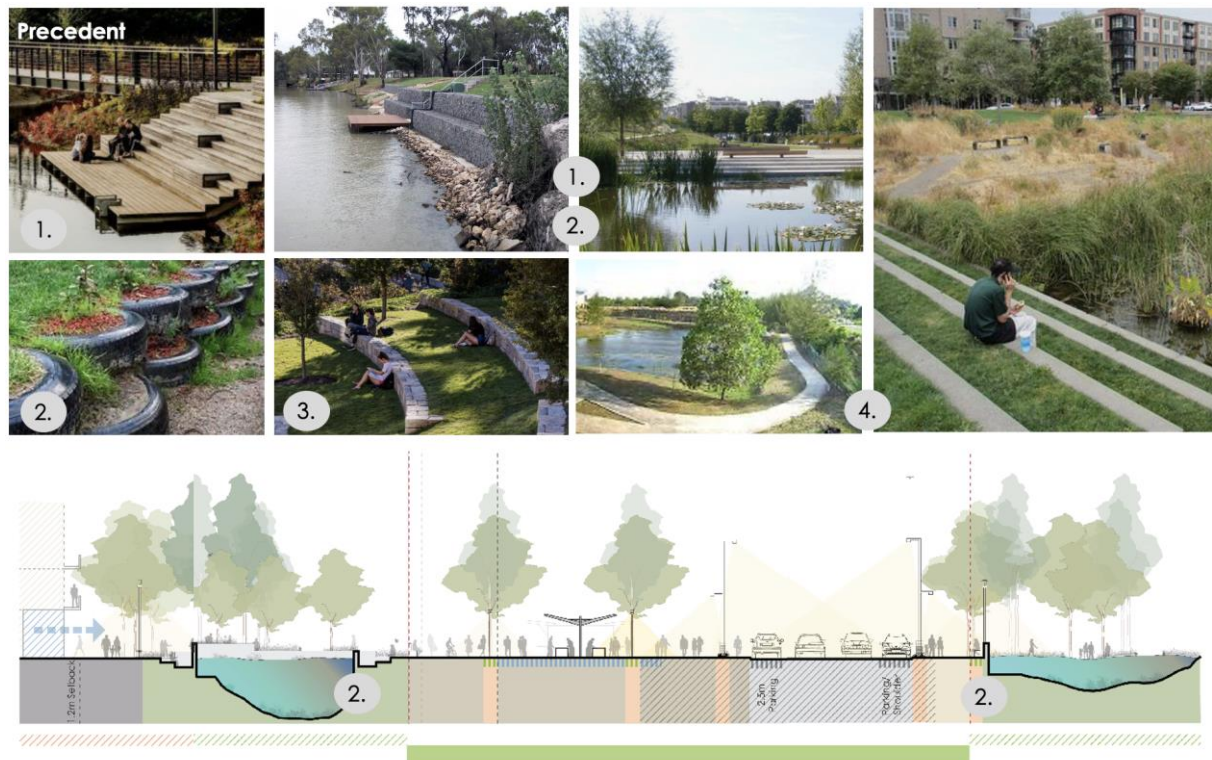
A set of urban design guidelines have been developed to guide future detailed planning and design processes for the rehabilitation of existing ponds and/ or the development of new stormwater ponds. They respond to the differing characteristics and functions of the ponds and are structured as follows:

- Wet ponds- Nature Parks
- Dry Ponds- Multifunctional Urban Parks
- Hybrid Ponds/ Linear Urban Parks

The guidelines recognise the core stormwater function of the ponds and seek to optimise and diversify the potential use of these spaces in the POA.

3.3.3.1 Wet Ponds/ Nature Parks

Celebrate the water- redesign existing wet ponds as amenity attractions and multi-functional nature parks.



1. Design the pond to have a clearly visible body of open water throughout the year and consider grading or creating levels of the pond to create improved 'access to the water' with an 'open' water's edge along some parts of the pond. Vegetation grows in shallow water and this can be achieved with an elevated floating platform or boardwalk or a stepped edge.
2. Provide 'hard edges' with retaining walls on structuring street edges of the site – to define the street and sidewalk edge.
3. Reshape the overall site to include a series of terraces to promote increased 'usable' space in drier months. Design terracing structures as multipurpose elements i.e.: terraced seating.
4. Protect and encourage NMT desire lines across the site with the inclusion of pathways and boardwalks around and where appropriate across the pond.
5. Provide vehicular access for ongoing maintenance to the pond.
6. Provide elements within the space to promote increased usage and safety including lighting, tree planting, seating and play or picnic equipment.
7. Limit blank boundary walls around green spaces in order to promote active surveillance onto green spaces.
8. Provide incentives to encourage supportive building typologies around the site i.e.: high density buildings with upper stories being able to survey the space.
9. Incentivise visually permeable fencing treatment around ponds
10. Provide a 'development encroachment' zone on existing blank edges of site to create active and positive frontage. Temporary structures like containers or properties abutting pond sites may

encroach onto the site if active frontage is created. The width of the encroachment zone will be specific to the pond site and how much land can be safely released.

The application of these principles is demonstrated below for pond P7. The required stormwater activities on the sites have not been reduced. All proposed additional uses will be designed to tolerate temporary flooding during peak rainfall events.

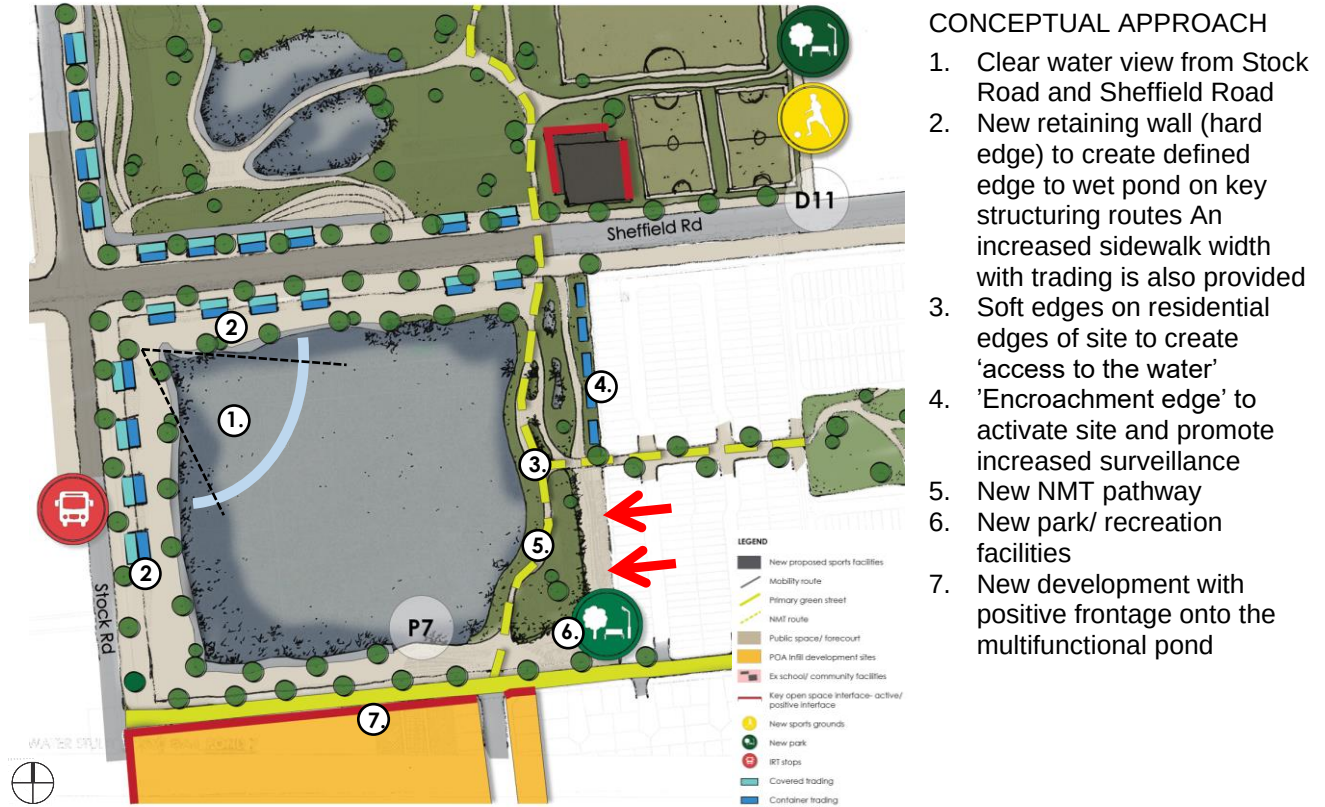
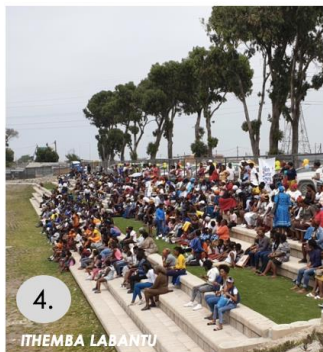


Figure 3.36: Pond P7 vision

3.3.3.2 Dry Ponds/ Multifunctional Urban Parks

These guidelines apply to existing dry ponds which should be designed to function as multi-functional urban parks.



1. Provide 'hard edges' with retaining walls on structuring street edges of the site to define the street and sidewalk edge .
2. Reshape the overall site to include a series of terraces to promote increased 'usable' space in drier months.
3. Provide and design recreation and sporting facilities on upper terraces to accommodate temporary flooding.
4. Design terracing structures as multipurpose elements i.e.: terraced seating.
5. Protect and encourage NMT desire lines across the site with the inclusion of pathways and boardwalks around and where appropriate across the pond.
6. Provide vehicular access for ongoing maintenance to the pond.
7. Provide elements within the space to promote increased usage and safety including lighting, tree planting, seating and play or picnic equipment.
8. Limit blank boundary walls around green spaces in order to promote active surveillance onto green spaces (as per Wet Pond guidelines).
9. Provide community and social facilities on the site where possible i.e.: recycling, education etc.

The application of these principles is demonstrated below for ponds P20 and P1. The required stormwater activities on the sites have not been reduced. All proposed additional uses will be designed in a way that is able to tolerate temporary flooding during peak rainfall events.

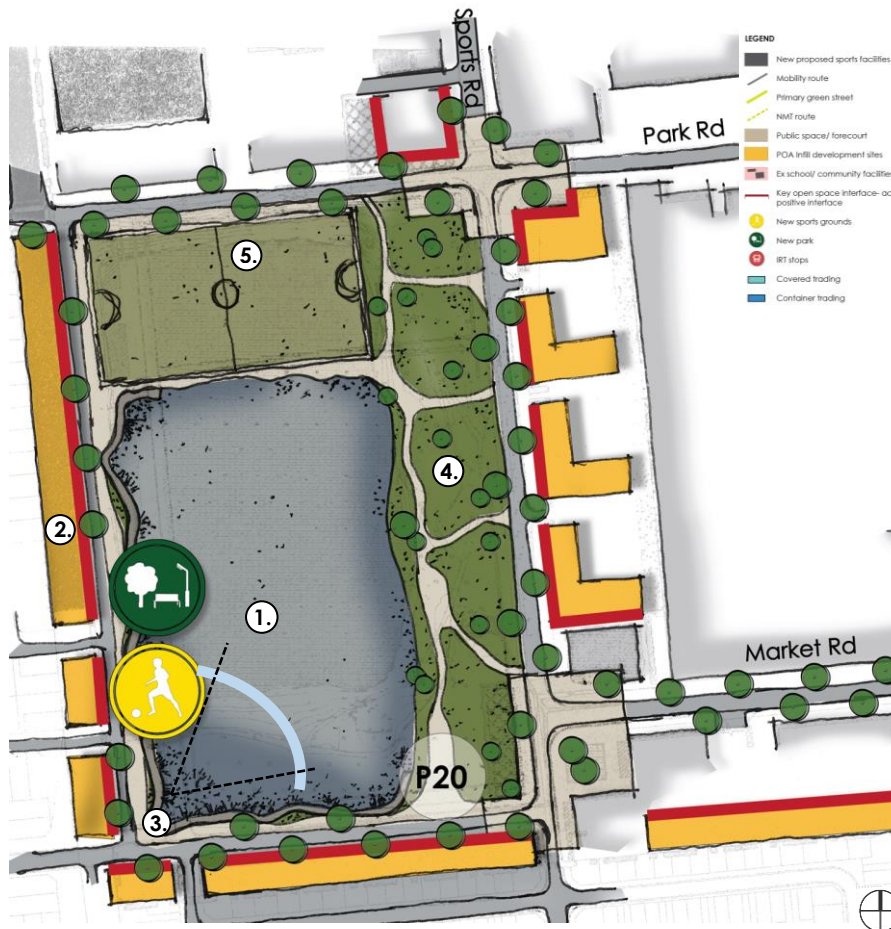


Figure 3.37: Pond 20 vision (Erf 5268)

CONCEPTUAL APPROACH:

1. Pond relocated to create sufficient space to develop new housing around the edges of the site.
2. New MU high density housing designed to be in accordance with the City's Floodplain and River Corridor Management Policy i.e.: above 100 year flood level and all basements need to be flood-proofed to the 50-year flood level.
3. New retaining walls to create hard edge along road edge of the site and views of open water.
4. New park with NMT pathways and sculpture garden- soft sloped edge to retention pond.
5. New kick-about court on Vuyiseka side of the space.



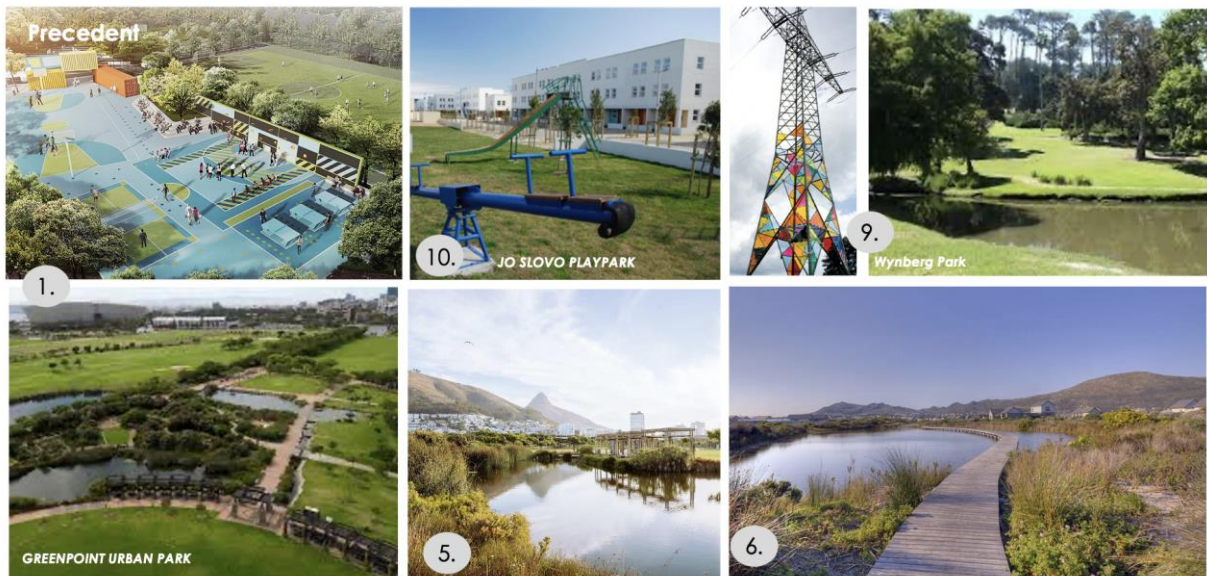
Figure 3.38: Pond P1 vision

CONCEPTUAL APPROACH:

1. New terracing and series of platforms with lowest point being on New Eiseben and Govan Mbeki corner. Terracing to be integrated with steps and to include seating to promote increased use and surveillance.
2. New retaining walls to create hard edge along road edge. New retaining walls to create hard edge along road edge. Views of open water. An increased sidewalk width with trading space is provided.
3. New community facility associated with school (final use to be confirmed).
4. New kick-about / sports facility
5. New pedestrian pathways across site.
6. 'Encroachment edge' to activate site & promote increased surveillance.

3.3.3.3 New Ponds/ Linear Urban Parks

Plan proactively and integrate new stormwater ponds to create a continuous network of dry and wet ponds to form new linear urban parks.



1. *Cluster and integrate* a range of sporting, recreation and community facilities within a system of dry and wet ponds to support active usage of green spaces.
2. Include a series of terraces to *promote increased 'usable' space* in drier months.
3. Provide or design recreation and sporting facilities on upper terraces to *accommodate temporary flooding*.
4. *Design terracing structures as multipurpose elements*: i.e.: seating.
5. Design the pond to have *clearly visible body of open water throughout year*. Consider grading or creating levels of the pond to create improved 'access to the water' with an 'open' waters edge along some parts of the pond. Vegetation grows in shallow water and this can be achieved with an elevated floating platform or boardwalk or a stepped edge.
6. *Protect and encourage NMT desire lines* across the site with the inclusion of pathways and boardwalks where appropriate across the pond.
7. *Provide vehicular access for ongoing maintenance* to the pond.
8. *Provide 'hard-edges'* with retaining walls on structuring street edges of the site to define the street and sidewalk edge
9. *Provide elements within the space to promote increased usage and safety* including lighting, tree planting, seating and play or picnic equipment.
10. *Limit blank boundary walls* around green spaces in order to promote active surveillance onto green spaces (as per Wet pond guidelines).
11. *Incorporate elements to celebrate the context* and create a sense of place i.e.: memorials, sculpture, descriptive signage etc.

Wynberg Park is a good example in the city of a Linear Park that supports both natural, stormwater and recreational functions. It is a very well used resource for communities across the City. A Landscape Masterplan for Wynberg Park was completed in 2013 by the City Parks Department. It should be referred to when completing the conceptual designs for the new components of the storm water and open space network in the POA.

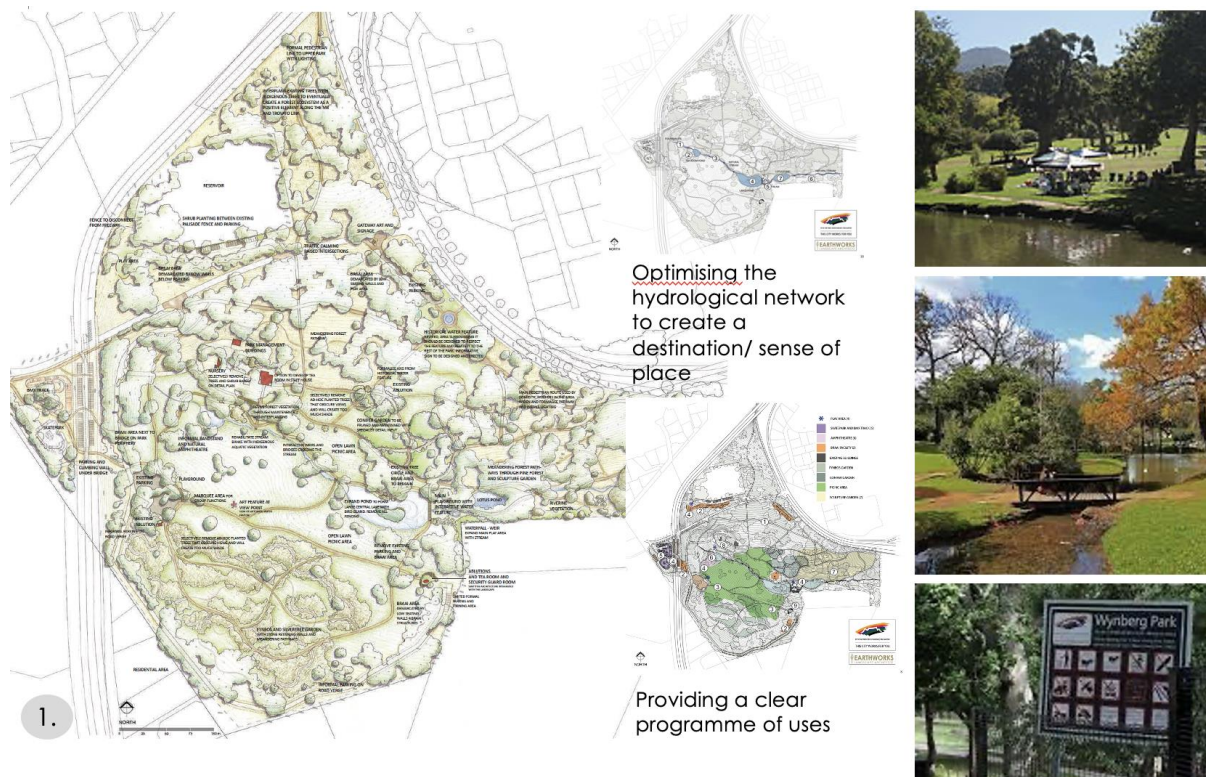


Figure 3.39: Wynberg Park landscape masterplan

4 RECOMMENDATIONS AND WAY FORWARD

4.1 Recommendations

Starting to improve stormwater challenges in the POA relates to both providing improved/ additional stormwater infrastructure in the area as well as adopting a differing approach to the design and planning of existing and new stormwater facilities.

The following recommendations are made regarding the results of the Concept Proposal:

- The Concept Proposal on which this report is based involved the creation of a high-level 1-dimensional stormwater model. A more detailed model should be set up and tested before any detailed design is undertaken. Use of the City's latest Lidar dataset would greatly improve existing model accuracy.
- A stormwater management plan should be drafted for the POA including a funding and investment plan for the ponds to function optimally in the long-term. This could include setting up a working group of public and private stakeholders to:
 - Resolve maintenance & management challenges associated with green spaces (including stormwater ponds).
 - Resolve existing co-ordination challenges associated with managing/ maintaining MU Clustered Spaces- working with different city line departments and Private/ Provincial owners.
- All outfalls modelled should be surveyed and their details verified. The landowners on whose property the outfalls are located should be engaged, and the capacity of downstream conduits and receiving water bodies should be determined.
- Ponds P1, P7 and P20 are likely to play a critical role in the management of stormwater run-off for the precinct. Pond P1 appears to be a dry pond based on the available data and as such may be suitable for the development of a mixed-use facility such as a sports field. Pond P20 appears to contain a small volume of standing water but may have potential for a multi-use facility if some dewatering interventions are implemented. Pond P7 is a wet pond and would not likely be a feasible option for a mixed-use facility.
- The CCT is currently planning several other infrastructure upgrade projects in the POA, such as the future IRT (Integrated Rapid Transit) route along Govan Mbeki Road. Co-ordination across these projects is therefore critical. At least four (4No.) DN600 stormwater culvert crossings must be provided along Govan Mbeki Road to cater for the outlets of the future ponds in Zones 1 and 2.
- Initiate discussion with key stakeholders to secure the protection of the identified green/ stormwater network and the location of new identified stormwater ponds. These include:
 - CCT: Human Settlement Directorate on the Marikana site
 - Other private property owners including Philippi Village and the proposed Shopping Development site on the Govan Mbeki side of Sheffield Road
- Create a phased implementation programme by targeting key pilot projects. It is recommended that these projects are integrated with planned infrastructure improvements along Sheffield Road. As indicated below in Figure 45, the proposed ponds include P7, D5, P1, P20. These ponds include a mix of wet and dry ponds and will allow the proposals and guidelines outlined above to be tested and improved.
- Start community engagement processes to introduce the project and its recommendations. The comments and inputs from engagement process should inform detailed stormwater design processes.
- Completion of a landscaping and planting plan comprising approved indigenous flora should be prepared for the purposes of planting the edges of the ponds.
- Engage CCT Planning and Urban Design departments to develop guidelines for new/ infill development around the retention ponds to support appropriate frontages around them to limit anti-social activities



Figure 4.1: Proposed Phase 1 Implementation

5 REFERENCES

Liz Day Consulting. 2020. Water Quality of Rivers and Open Waterbodies in the City of Cape Town: Status and historical trends, with a focus on the period April 2015 to March 2020. Technical Report prepared for City of Cape Town.

Day, E et al. 2019. 2019 Inland Water Quality Report. City of Cape Town

KC Phyto Enterprises CC. 2021. Wetlands Ecological Qualification Report for 11 Sites in the Philippi Opportunities Area (POA). Technical report prepared for Infinity Environmental.

Rossman, L., 2008. Storm Water Management Model user's manual, version 5.0, (March), 271. Retrieved from <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockkey=P10011XQ.txt>

SANRAL., 2013 "Drainage Manual - Sixth Edition", The South African National Roads Agency Limited, Pretoria.

6 CLIENT APPROVAL

6.1 Approval

The undersigned agrees that the above report is acceptable and approved. The report is iterative, and any changes will be reported in written communication via email. Any additional changes and or future changes affecting the project baselines (cost and time) will be handled through the normal change control procedure.

Wayne Alvin Davids

Name

Senior Professional Officer

Designation

24 March 2023

Date

Water & Sanitation Department

Wayne Davids

Signature

Digitally signed by Wayne Davids
Date: 2023.03.24 08:49:04
+02'00'

Gideon Brand

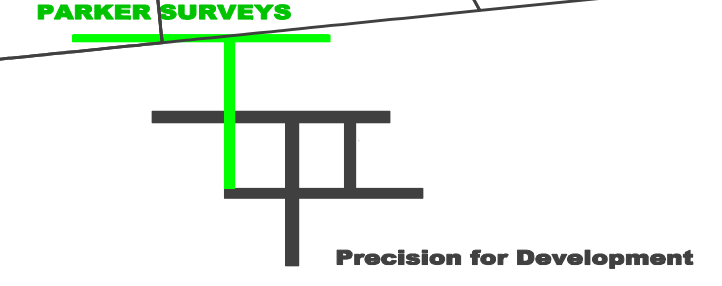
Manager: Programme Coordination & Partnerships
Urban Catalytic Investment Department

Gideon Brand

Digitally signed by Gideon Brand
Date: 2023.03.24 09:08:43
+02'00'

APPENDIX A: DETENTION POND SURVEY



AMEND.	DATE	DESCRIPTION	CO-ORDINATES		SYSTEM	WCS84 Lot19	PARKER SURVEYS		KLIENT - CLIENT		DATE	PROJECT DESCRIPTION		JOB NO.	PS2172 (375C1)	
A			POINT	Y ±	X ±	Z	 Precision for Development Parker Surveys cc 179 Belgrovia Road, Athlone, 7764 e-mail: info@ParkerSurveys.co.za Tel: 021 697 3340 / 021 696 6202		 14 Floor The Towers South 2 Her Zog Boulevard Cape Town South Africa 8001 Tel : +27 21 425 2870 Web : www.hho.co.za email : enquiries@hho.co.za		TOPOGRAPHIC SURVEY OF PONDS AND STORMWATER CHANNEL PHILIPPI EAST SW TOPOGRAPHICAL PLAN		DATE	MARCH 2022	DATE	MARCH 2022
B													PLAN NUMBER	1		
C													SHEET			
D													SCALE	1:5000		
E																
F																
G																
H																
I																
J																
K																

All spot heights and positions are single height measurement elements. Any point used as a critical design the point should be reconfirmed.

This plan was compiled using Microstation and uSmart and does not reflect all the spot heights on which the annotation is based. This plan is also available in .dgn digital format.

This survey includes only visible services and therefore should be checked against local authority as-built plans.

The position of physical boundaries must be correlated with the diagram data as provided by the SG office.

PS23 -373280.888 -3764476.288 25.987	
PS24 -37430.690 -3764484.690 25.160	
PS25 -37313.451 -3764345.812 36.825	
PS28 -37348.543 -3764888.688 25.285	
PS21 -37384.393 -3764885.584 25.694	
PS22 -37358.293 -3764878.884 26.867	
PS8B -36338.738 -3763423.274 48.956	
PS8A -36268.412 -3763436.781 34.518	
PS18 -36194.834 -3763468.182 34.844	
TSH4 -36153.418 -3764981.158 35.882	

CHECKED BY	PARKER SURVEYS	MARCH 2022
PLAN PREPARED BY	PARKER SURVEYS	MARCH 2022
SURVEYED BY	PARKER SURVEYS	MARCH 2022
CADASTRAL COMPILED BY	SG SHAPEFILES	

APPENDIX B: PCSWMM DATA OUTPUT

RI (Years)	Name	Invert Elev. (m)	Depth (m)	Max. Percent Full (%)	Total inflow (ML)	Max. HGL (m)	Max. Outflow (m³/s)
100RI	D1	34.6	1.2	47.0	1.1	35.8	0.0
100RI	D10	37.0	1.1	39.0	71.8	38.1	0.6
100RI	D11	36.5	1.1	73.0	24.5	37.6	0.9
100RI	D12	36.0	1.8	95.0	97.3	37.8	1.0
100RI	D14	33.3	1.2	7.0	30.4	34.5	1.5
100RI	D15	36.2	0.5	33.0	8.4	36.6	0.3
100RI	D18	38.0	1.6	78.0	23.2	39.6	0.6
100RI	D19	38.0	1.1	73.0	38.3	39.1	0.9
100RI	D2	32.4	2.7	17.0	40.3	35.1	0.5
100RI	D21	39.0	1.0	69.0	13.9	40.0	0.6
100RI	D22	40.0	1.2	79.0	11.0	41.2	0.6
100RI	D24	39.0	1.2	80.0	26.8	40.2	1.1
100RI	D25	39.5	1.1	91.0	14.9	40.6	0.6
100RI	D26	39.5	1.1	75.0	9.1	40.6	0.3
100RI	D28	40.0	0.9	60.0	3.0	40.9	0.1
100RI	D3	36.1	1.4	29.0	10.4	37.5	0.4
100RI	D31	40.0	0.8	53.0	5.1	40.8	0.3
100RI	D32	38.7	0.5	11.0	7.1	39.3	0.3
100RI	D33	36.9	0.7	20.0	12.5	37.6	1.0
100RI	D35	38.0	0.9	50.0	40.8	38.9	0.7
100RI	D36	38.9	1.0	42.0	3.1	39.9	0.0
100RI	D37	40.3	0.8	11.0	5.6	41.0	0.5
100RI	D38	39.7	1.0	33.0	5.5	40.7	0.4
100RI	D39	36.8	1.5	46.0	31.9	38.3	0.0
100RI	D4	35.1	0.8	15.0	14.2	35.9	0.9
100RI	D43	36.1	0.6	1.0	18.3	36.7	1.4
100RI	D44	35.6	1.2	4.0	3.3	36.8	0.4
100RI	D45	36.3	0.4	6.0	11.1	36.7	1.1
100RI	D46	32.5	1.6	35.0	33.7	34.1	0.8
100RI	D48	35.0	1.0	22.0	6.6	36.0	0.0
100RI	D49	34.6	0.7	32.0	9.3	35.3	0.2
100RI	D5	30.9	2.2	64.0	69.6	33.0	1.2
100RI	D50	38.1	0.7	65.0	4.6	38.8	0.5
100RI	D52	39.0	1.5	97.0	23.9	40.5	0.7
100RI	D53	37.0	1.1	76.0	16.0	38.1	0.2
100RI	D6	33.7	0.9	67.0	14.2	34.7	0.3
100RI	D8	37.0	1.2	79.0	15.2	38.2	0.2
100RI	P1	33.5	2.3	35.0	141.0	35.8	1.8
100RI	P11	32.2	1.9	12.0	107.0	34.1	2.7
100RI	P14	35.1	1.5	23.0	13.6	36.6	0.3
100RI	P17	37.0	1.4	79.0	18.7	38.4	1.6
100RI	P18	37.6	0.9	35.0	2.3	38.5	0.1
100RI	P2	35.4	1.4	28.0	81.1	36.8	2.0
100RI	P20	34.3	1.5	30.0	189.0	35.8	1.4
100RI	P3	37.8	1.2	21.0	13.5	39.0	0.2
100RI	P4	33.8	1.8	90.0	169.0	35.6	0.7
100RI	P6	34.1	1.3	46.0	103.0	35.4	0.9
100RI	P7	33.1	3.3	76.0	401.0	36.3	2.5
100RI	P8	35.0	1.5	37.0	32.0	36.5	0.4
100RI	P9_10	32.5	1.9	12.0	41.8	34.5	1.7

50RI	D1	34.6	1.2	43.0	0.9	35.7	0.0
50RI	D10	37.0	0.9	31.0	63.8	37.9	0.5
50RI	D11	36.5	1.0	65.0	21.7	37.5	0.7
50RI	D12	36.0	1.6	84.0	87.1	37.6	1.0
50RI	D14	33.3	1.1	6.0	27.3	34.4	1.4
50RI	D15	36.2	0.4	27.0	7.5	36.6	0.3
50RI	D18	38.0	1.4	72.0	20.4	39.4	0.5
50RI	D19	38.0	0.9	61.0	32.6	38.9	0.5
50RI	D2	32.4	2.5	14.0	35.3	35.0	0.5
50RI	D21	39.0	1.0	63.0	12.2	40.0	0.5
50RI	D22	40.0	1.1	71.0	9.5	41.1	0.5
50RI	D24	39.0	1.0	69.0	22.9	40.0	0.5
50RI	D25	39.5	0.9	77.0	12.9	40.4	0.5
50RI	D26	39.5	1.0	70.0	8.1	40.5	0.3
50RI	D28	40.0	0.9	57.0	2.7	40.9	0.1
50RI	D3	36.1	1.3	23.0	9.1	37.3	0.4
50RI	D31	40.0	0.7	47.0	4.4	40.7	0.3
50RI	D32	38.7	0.5	9.0	6.3	39.2	0.3
50RI	D33	36.9	0.6	16.0	10.9	37.5	0.9
50RI	D35	38.0	0.8	46.0	35.8	38.8	0.6
50RI	D36	38.9	0.9	37.0	2.7	39.8	0.0
50RI	D37	40.3	0.7	10.0	4.9	41.0	0.4
50RI	D38	39.7	0.9	31.0	4.8	40.6	0.3
50RI	D39	36.8	1.4	40.0	28.0	38.2	0.0
50RI	D4	35.1	0.7	13.0	10.4	35.8	0.8
50RI	D43	36.1	0.5	0.0	15.6	36.6	1.2
50RI	D44	35.6	1.0	2.0	2.9	36.6	0.4
50RI	D45	36.3	0.3	4.0	9.8	36.7	1.0
50RI	D46	32.5	1.5	29.0	29.2	34.0	0.7
50RI	D48	35.0	0.9	19.0	5.8	36.0	0.0
50RI	D49	34.6	0.7	31.0	8.3	35.3	0.1
50RI	D5	30.9	2.1	53.0	61.4	32.9	1.1
50RI	D50	38.1	0.6	57.0	4.0	38.7	0.4
50RI	D52	39.0	1.2	77.0	20.8	40.2	0.6
50RI	D53	37.0	1.0	67.0	14.3	38.0	0.2
50RI	D6	33.7	0.8	55.0	12.6	34.6	0.3
50RI	D8	37.0	1.0	69.0	13.8	38.0	0.2
50RI	P1	33.5	2.2	29.0	123.0	35.6	1.8
50RI	P11	32.2	1.8	10.0	95.6	34.0	2.6
50RI	P14	35.1	1.2	16.0	12.2	36.3	0.3
50RI	P17	37.0	1.4	72.0	16.4	38.4	1.3
50RI	P18	37.6	0.8	30.0	2.0	38.4	0.1
50RI	P2	35.4	1.2	21.0	71.2	36.6	1.9
50RI	P20	34.3	1.3	25.0	163.0	35.6	1.3
50RI	P3	37.8	1.1	16.0	12.2	38.9	0.2
50RI	P4	33.8	1.6	80.0	155.0	35.4	0.6
50RI	P6	34.1	1.1	36.0	87.3	35.2	0.8
50RI	P7	33.1	3.0	67.0	358.0	36.1	2.4
50RI	P8	35.0	1.3	28.0	29.2	36.3	0.4
50RI	P9_10	32.5	1.8	9.0	36.5	34.4	1.7
20RI	D1	34.6	1.1	35.0	0.8	35.6	0.0

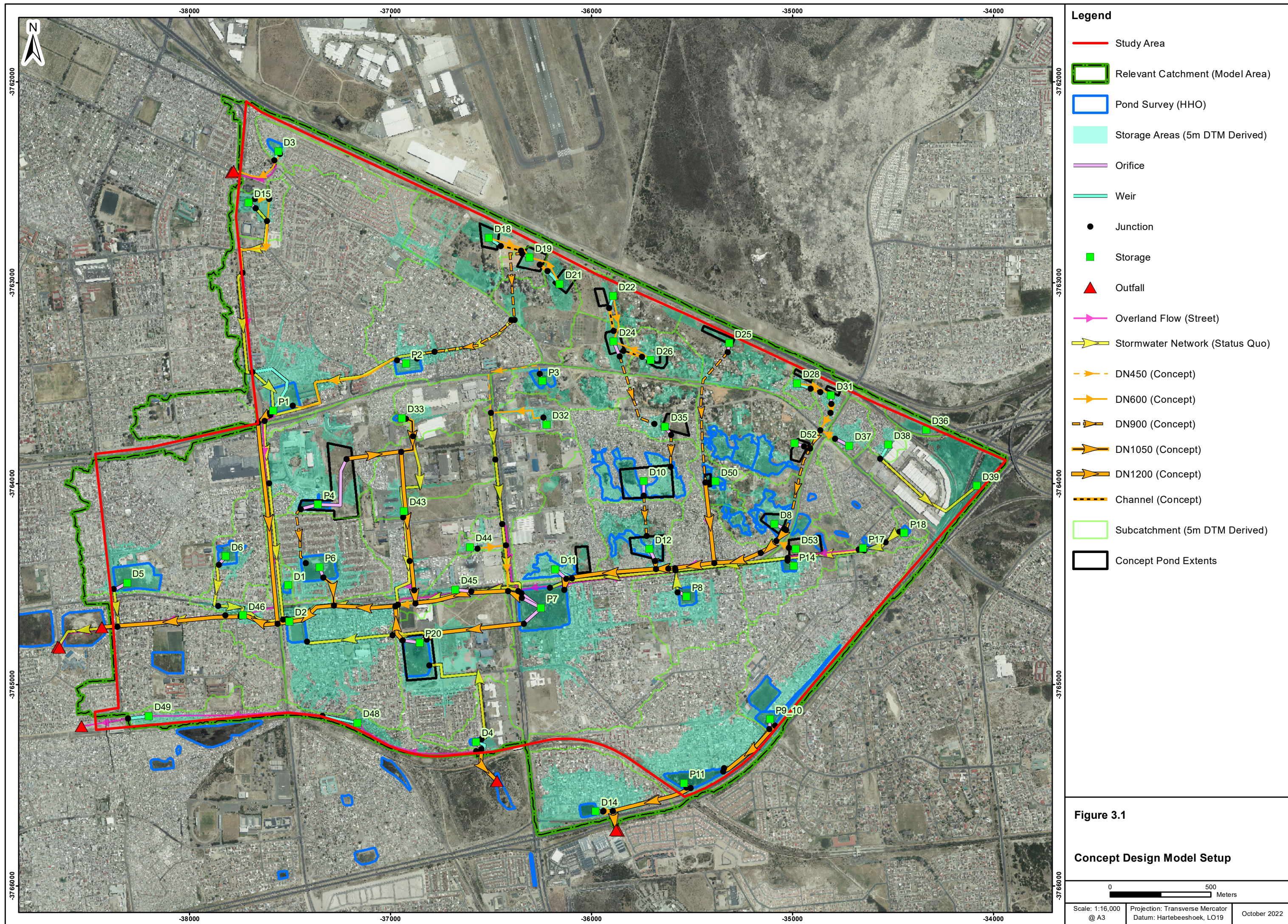
20RI	D10	37.0	0.8	25.0	54.2	37.8	0.5
20RI	D11	36.5	0.8	53.0	18.4	37.3	0.6
20RI	D12	36.0	1.2	62.0	74.2	37.2	0.7
20RI	D14	33.3	0.9	4.0	23.6	34.2	1.3
20RI	D15	36.2	0.4	21.0	6.5	36.6	0.3
20RI	D18	38.0	1.3	64.0	17.1	39.3	0.3
20RI	D19	38.0	0.7	48.0	26.9	38.7	0.4
20RI	D2	32.4	2.2	11.0	29.3	34.7	0.5
20RI	D21	39.0	0.9	58.0	10.2	39.9	0.4
20RI	D22	40.0	1.0	63.0	7.8	41.0	0.4
20RI	D24	39.0	0.8	55.0	18.7	39.8	0.4
20RI	D25	39.5	0.8	62.0	10.5	40.3	0.4
20RI	D26	39.5	0.9	63.0	6.8	40.4	0.2
20RI	D28	40.0	0.8	54.0	2.4	40.8	0.1
20RI	D3	36.1	1.1	17.0	7.5	37.1	0.3
20RI	D31	40.0	0.6	41.0	3.6	40.6	0.2
20RI	D32	38.7	0.4	7.0	5.3	39.2	0.2
20RI	D33	36.9	0.6	13.0	9.1	37.4	0.7
20RI	D35	38.0	0.7	40.0	29.9	38.7	0.5
20RI	D36	38.9	0.8	31.0	2.3	39.7	0.0
20RI	D37	40.3	0.7	8.0	4.1	40.9	0.4
20RI	D38	39.7	0.9	28.0	4.0	40.6	0.2
20RI	D39	36.8	1.3	33.0	23.2	38.1	0.0
20RI	D4	35.1	0.7	10.0	7.6	35.7	0.7
20RI	D43	36.1	0.5	0.0	12.4	36.5	0.9
20RI	D44	35.6	0.7	1.0	2.3	36.3	0.4
20RI	D45	36.3	0.3	3.0	8.3	36.6	0.8
20RI	D46	32.5	1.3	22.0	23.3	33.8	0.6
20RI	D48	35.0	0.9	15.0	4.8	35.9	0.0
20RI	D49	34.6	0.7	30.0	7.0	35.2	0.1
20RI	D5	30.9	1.9	41.0	51.4	32.7	1.0
20RI	D50	38.1	0.5	48.0	3.3	38.6	0.3
20RI	D52	39.0	0.8	54.0	17.1	39.8	0.5
20RI	D53	37.0	0.8	54.0	12.5	37.8	0.1
20RI	D6	33.7	0.7	41.0	10.5	34.5	0.3
20RI	D8	37.0	0.7	49.0	11.3	37.7	0.2
20RI	P1	33.5	1.9	22.0	103.0	35.4	1.6
20RI	P11	32.2	1.6	8.0	82.0	33.9	2.3
20RI	P14	35.1	1.0	9.0	10.5	36.1	0.3
20RI	P17	37.0	1.3	64.0	13.5	38.3	0.8
20RI	P18	37.6	0.7	22.0	1.7	38.3	0.1
20RI	P2	35.4	1.0	15.0	59.4	36.4	1.8
20RI	P20	34.3	0.9	16.0	127.0	35.2	1.1
20RI	P3	37.8	1.0	12.0	10.6	38.8	0.2
20RI	P4	33.8	1.4	70.0	136.0	35.2	0.5
20RI	P6	34.1	0.7	19.0	67.2	34.8	0.6
20RI	P7	33.1	2.8	58.0	305.0	35.8	2.3
20RI	P8	35.0	1.1	21.0	25.9	36.1	0.4
20RI	P9_10	32.5	1.7	6.0	30.0	34.2	1.7
10RI	D1	34.6	1.0	29.0	0.6	35.6	0.0
10RI	D10	37.0	0.7	21.0	47.5	37.7	0.4

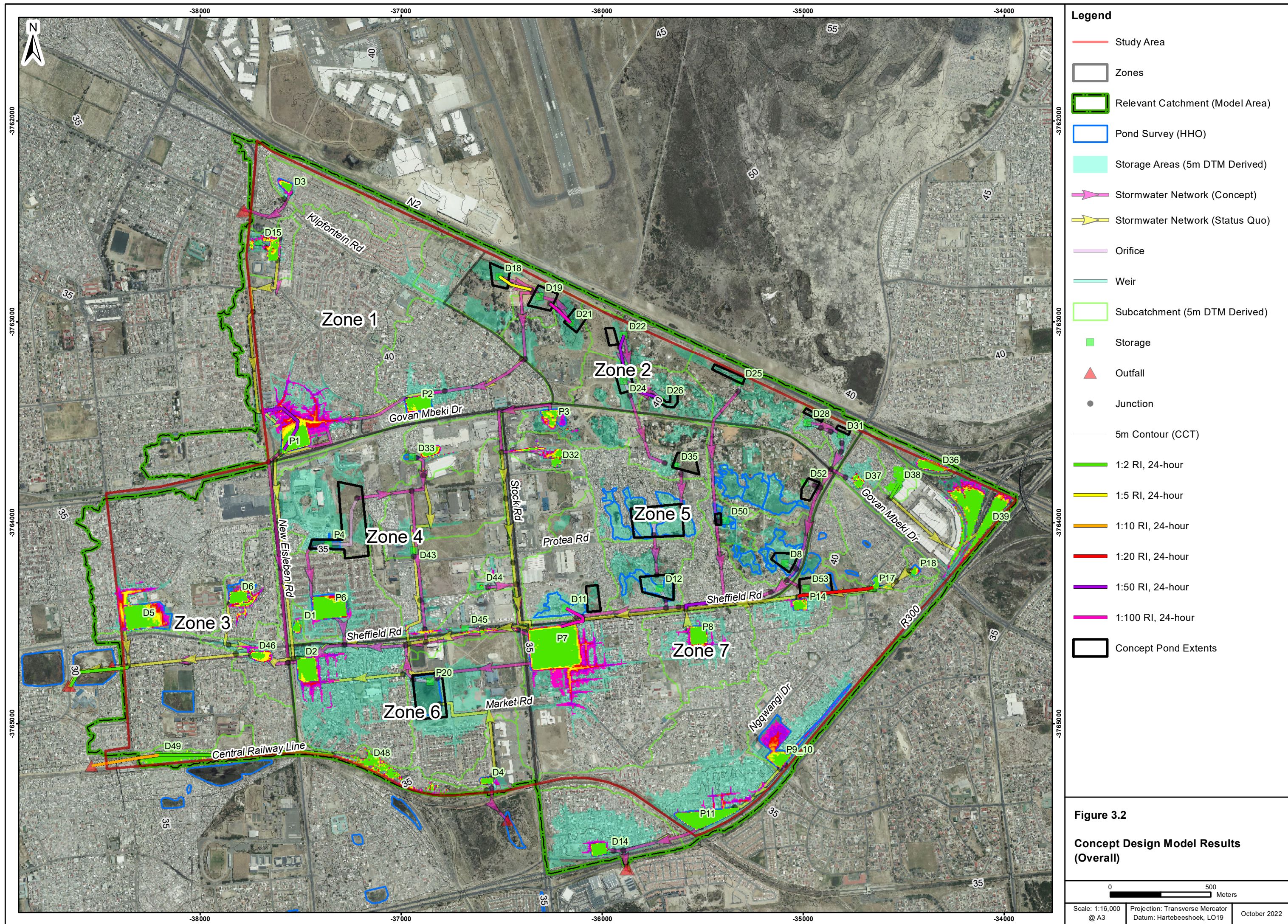
10RI	D11	36.5	0.7	45.0	16.0	37.2	0.5
10RI	D12	36.0	0.9	47.0	65.6	36.9	0.4
10RI	D14	33.3	0.8	4.0	21.0	34.0	1.2
10RI	D15	36.2	0.4	16.0	5.7	36.5	0.2
10RI	D18	38.0	1.2	58.0	14.8	39.2	0.2
10RI	D19	38.0	0.6	42.0	22.8	38.6	0.3
10RI	D2	32.4	2.0	9.0	25.1	34.5	0.5
10RI	D21	39.0	0.8	54.0	8.8	39.8	0.3
10RI	D22	40.0	0.9	58.0	6.6	40.9	0.3
10RI	D24	39.0	0.7	46.0	15.9	39.7	0.3
10RI	D25	39.5	0.7	53.0	8.9	40.2	0.3
10RI	D26	39.5	0.9	58.0	6.0	40.4	0.2
10RI	D28	40.0	0.8	51.0	2.2	40.8	0.0
10RI	D3	36.1	0.9	12.0	6.3	37.0	0.3
10RI	D31	40.0	0.6	37.0	3.1	40.6	0.2
10RI	D32	38.7	0.4	5.0	4.7	39.1	0.2
10RI	D33	36.9	0.5	10.0	7.8	37.4	0.6
10RI	D35	38.0	0.6	34.0	25.8	38.6	0.4
10RI	D36	38.9	0.8	28.0	2.0	39.7	0.0
10RI	D37	40.3	0.6	6.0	3.5	40.9	0.3
10RI	D38	39.7	0.9	25.0	3.4	40.6	0.1
10RI	D39	36.8	1.2	28.0	19.8	38.0	0.0
10RI	D4	35.1	0.6	9.0	6.6	35.7	0.5
10RI	D43	36.1	0.4	0.0	10.2	36.5	0.7
10RI	D44	35.6	0.5	1.0	2.0	36.1	0.3
10RI	D45	36.3	0.3	2.0	7.2	36.6	0.7
10RI	D46	32.5	1.1	17.0	19.7	33.6	0.6
10RI	D48	35.0	0.9	13.0	4.2	35.9	0.0
10RI	D49	34.6	0.6	28.0	6.1	35.2	0.1
10RI	D5	30.9	1.8	32.0	44.4	32.6	1.0
10RI	D50	38.1	0.4	40.0	2.8	38.5	0.2
10RI	D52	39.0	0.6	43.0	14.6	39.6	0.5
10RI	D53	37.0	0.7	49.0	11.4	37.7	0.1
10RI	D6	33.7	0.7	32.0	9.1	34.4	0.3
10RI	D8	37.0	0.5	32.0	9.1	37.5	0.2
10RI	P1	33.5	1.6	17.0	89.5	35.1	1.5
10RI	P11	32.2	1.5	7.0	72.3	33.7	2.1
10RI	P14	35.1	0.8	6.0	9.3	35.9	0.3
10RI	P17	37.0	1.1	52.0	11.4	38.1	0.7
10RI	P18	37.6	0.5	13.0	1.4	38.1	0.1
10RI	P2	35.4	0.9	11.0	51.1	36.3	1.6
10RI	P20	34.3	0.6	10.0	100.0	34.8	0.7
10RI	P3	37.8	0.9	9.0	9.4	38.7	0.2
10RI	P4	33.8	1.3	63.0	121.0	35.1	0.4
10RI	P6	34.1	0.5	11.0	53.4	34.5	0.3
10RI	P7	33.1	2.6	51.0	268.0	35.6	1.9
10RI	P8	35.0	1.0	17.0	23.5	36.0	0.4
10RI	P9_10	32.5	1.5	4.0	25.5	34.0	1.6
5RI	D1	34.6	0.9	24.0	0.5	35.5	0.0
5RI	D10	37.0	0.6	18.0	41.3	37.6	0.3
5RI	D11	36.5	0.6	38.0	13.8	37.1	0.4

5RI	D12	36.0	0.8	42.0	57.9	36.8	0.3
5RI	D14	33.3	0.6	3.0	18.5	33.9	1.0
5RI	D15	36.2	0.4	12.0	5.0	36.5	0.2
5RI	D18	38.0	1.1	53.0	12.7	39.1	0.2
5RI	D19	38.0	0.5	35.0	19.2	38.5	0.2
5RI	D2	32.4	1.8	7.0	21.1	34.2	0.5
5RI	D21	39.0	0.8	50.0	7.6	39.8	0.2
5RI	D22	40.0	0.8	53.0	5.5	40.8	0.2
5RI	D24	39.0	0.6	39.0	13.2	39.6	0.2
5RI	D25	39.5	0.6	45.0	7.5	40.1	0.2
5RI	D26	39.5	0.8	54.0	5.2	40.3	0.1
5RI	D28	40.0	0.7	48.0	1.9	40.7	0.0
5RI	D3	36.1	0.8	8.0	5.3	36.8	0.3
5RI	D31	40.0	0.5	33.0	2.6	40.5	0.1
5RI	D32	38.7	0.4	4.0	4.0	39.1	0.2
5RI	D33	36.9	0.5	8.0	6.6	37.3	0.5
5RI	D35	38.0	0.5	29.0	22.0	38.5	0.3
5RI	D36	38.9	0.7	24.0	1.8	39.6	0.0
5RI	D37	40.3	0.6	5.0	3.0	40.8	0.3
5RI	D38	39.7	0.9	24.0	2.9	40.6	0.1
5RI	D39	36.8	1.1	24.0	16.7	37.9	0.0
5RI	D4	35.1	0.5	7.0	5.6	35.6	0.4
5RI	D43	36.1	0.4	0.0	8.1	36.4	0.5
5RI	D44	35.6	0.5	1.0	1.6	36.0	0.3
5RI	D45	36.3	0.2	1.0	6.2	36.6	0.6
5RI	D46	32.5	1.0	11.0	18.2	33.4	0.7
5RI	D48	35.0	0.8	11.0	3.5	35.8	0.0
5RI	D49	34.6	0.6	26.0	5.2	35.2	0.1
5RI	D5	30.9	1.6	25.0	37.7	32.5	0.9
5RI	D50	38.1	0.3	34.0	2.3	38.4	0.2
5RI	D52	39.0	0.5	36.0	12.2	39.5	0.3
5RI	D53	37.0	0.7	47.0	10.5	37.7	0.1
5RI	D6	33.7	0.6	25.0	7.8	34.3	0.3
5RI	D8	37.0	0.3	21.0	7.7	37.3	0.1
5RI	P1	33.5	1.2	13.0	76.7	34.7	1.5
5RI	P11	32.2	1.4	5.0	63.0	33.6	1.8
5RI	P14	35.1	0.7	4.0	8.2	35.8	0.3
5RI	P17	37.0	0.9	41.0	9.5	37.9	0.6
5RI	P18	37.6	0.4	7.0	1.2	38.0	0.1
5RI	P2	35.4	0.8	9.0	43.4	36.2	1.4
5RI	P20	34.3	0.4	7.0	81.6	34.7	0.4
5RI	P3	37.8	0.8	6.0	8.4	38.6	0.2
5RI	P4	33.8	1.1	53.0	107.0	34.9	0.3
5RI	P6	34.1	0.4	8.0	44.3	34.5	0.3
5RI	P7	33.1	2.3	43.0	234.0	35.3	1.8
5RI	P8	35.0	0.8	13.0	21.3	35.9	0.4
5RI	P9_10	32.5	1.4	2.0	21.2	33.9	1.5
2RI	D1	34.6	0.8	17.0	0.4	35.4	0.0
2RI	D10	37.0	0.5	13.0	33.1	37.5	0.2
2RI	D11	36.5	0.4	28.0	10.8	36.9	0.3
2RI	D12	36.0	0.7	37.0	47.8	36.7	0.2

2RI	D14	33.3	0.5	2.0	15.2	33.8	0.6
2RI	D15	36.2	0.3	8.0	4.1	36.5	0.2
2RI	D18	38.0	0.9	46.0	10.0	38.9	0.1
2RI	D19	38.0	0.4	26.0	14.4	38.4	0.1
2RI	D2	32.4	1.4	3.0	15.6	33.9	0.5
2RI	D21	39.0	0.7	45.0	6.0	39.7	0.1
2RI	D22	40.0	0.7	47.0	4.1	40.7	0.1
2RI	D24	39.0	0.4	28.0	9.9	39.4	0.1
2RI	D25	39.5	0.4	33.0	5.6	39.9	0.1
2RI	D26	39.5	0.7	48.0	4.1	40.2	0.1
2RI	D28	40.0	0.7	45.0	1.7	40.7	0.0
2RI	D3	36.1	0.6	4.0	3.8	36.6	0.3
2RI	D31	40.0	0.4	28.0	1.9	40.4	0.1
2RI	D32	38.7	0.3	2.0	3.2	39.1	0.1
2RI	D33	36.9	0.4	5.0	4.9	37.2	0.4
2RI	D35	38.0	0.4	22.0	17.1	38.4	0.1
2RI	D36	38.9	0.7	19.0	1.4	39.6	0.0
2RI	D37	40.3	0.5	3.0	2.2	40.8	0.2
2RI	D38	39.7	0.8	21.0	2.1	40.5	0.0
2RI	D39	36.8	1.0	18.0	12.5	37.8	0.0
2RI	D4	35.1	0.4	5.0	4.3	35.5	0.3
2RI	D43	36.1	0.3	0.0	5.5	36.4	0.3
2RI	D44	35.6	0.4	1.0	1.2	35.9	0.2
2RI	D45	36.3	0.2	1.0	4.9	36.5	0.4
2RI	D46	32.5	0.6	3.0	15.5	33.1	1.0
2RI	D48	35.0	0.8	8.0	2.7	35.8	0.0
2RI	D49	34.6	0.6	22.0	4.2	35.2	0.1
2RI	D5	30.9	1.4	15.0	28.7	32.3	0.8
2RI	D50	38.1	0.2	24.0	1.7	38.3	0.1
2RI	D52	39.0	0.4	25.0	9.2	39.4	0.2
2RI	D53	37.0	0.7	43.0	9.2	37.7	0.1
2RI	D6	33.7	0.5	16.0	6.0	34.2	0.2
2RI	D8	37.0	0.3	17.0	6.4	37.3	0.0
2RI	P1	33.5	0.8	8.0	59.4	34.3	1.0
2RI	P11	32.2	1.2	4.0	50.2	33.4	1.4
2RI	P14	35.1	0.6	2.0	6.7	35.7	0.3
2RI	P17	37.0	0.7	27.0	6.9	37.7	0.5
2RI	P18	37.6	0.3	4.0	0.9	37.9	0.1
2RI	P2	35.4	0.7	6.0	33.2	36.1	1.0
2RI	P20	34.3	0.3	5.0	72.3	34.6	0.3
2RI	P3	37.8	0.6	3.0	7.0	38.4	0.2
2RI	P4	33.8	0.8	39.0	92.9	34.6	0.1
2RI	P6	34.1	0.3	5.0	39.7	34.4	0.2
2RI	P7	33.1	1.8	30.0	189.0	34.8	1.4
2RI	P8	35.0	0.7	9.0	18.2	35.7	0.3
2RI	P9_10	32.5	1.2	1.0	15.5	33.7	1.3

APPENDIX C: PCSWMM GRAPHICAL OUTPUT







Legend

Study Area

Zones

Relevant Catchment (Model Area)

Pond Survey (HHO)

Storage Areas (5m DTM Derived)

Stormwater Network (Concept)

Stormwater Network (Status Quo)

Orifice

Weir

Subcatchment (5m DTM Derived)

Storage

Outfall

Junction

5m Contour (CCT)

1:2 RI, 24-hour

1:5 RI, 24-hour

1:10 RI, 24-hour

1:20 RI, 24-hour

1:50 RI, 24-hour

1:100 RI, 24-hour

Concept Pond Extents

Figure 3.3

Concept Design Model Results (Zone 1)

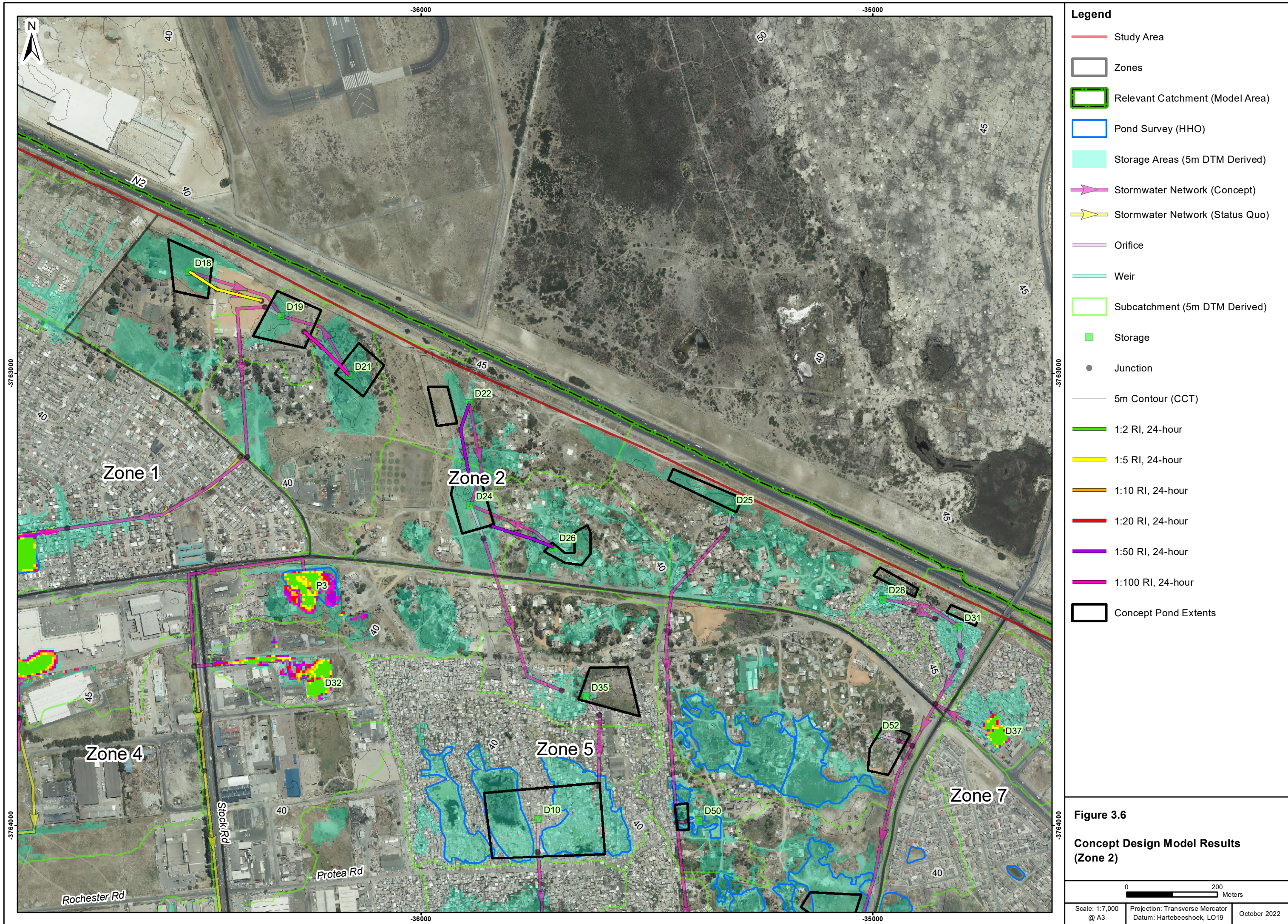
0200

Meters

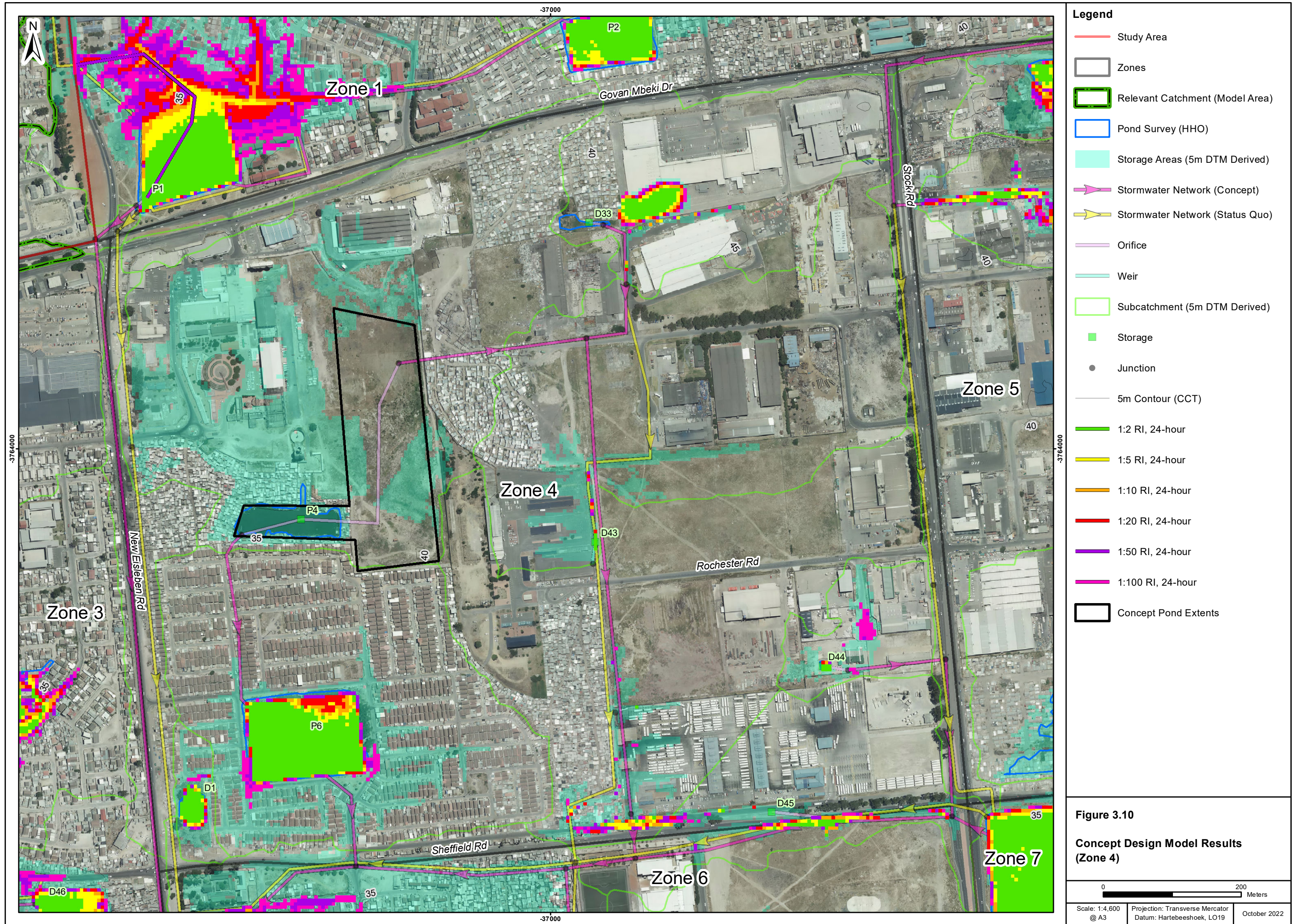
Scale: 1:6,000
@ A3

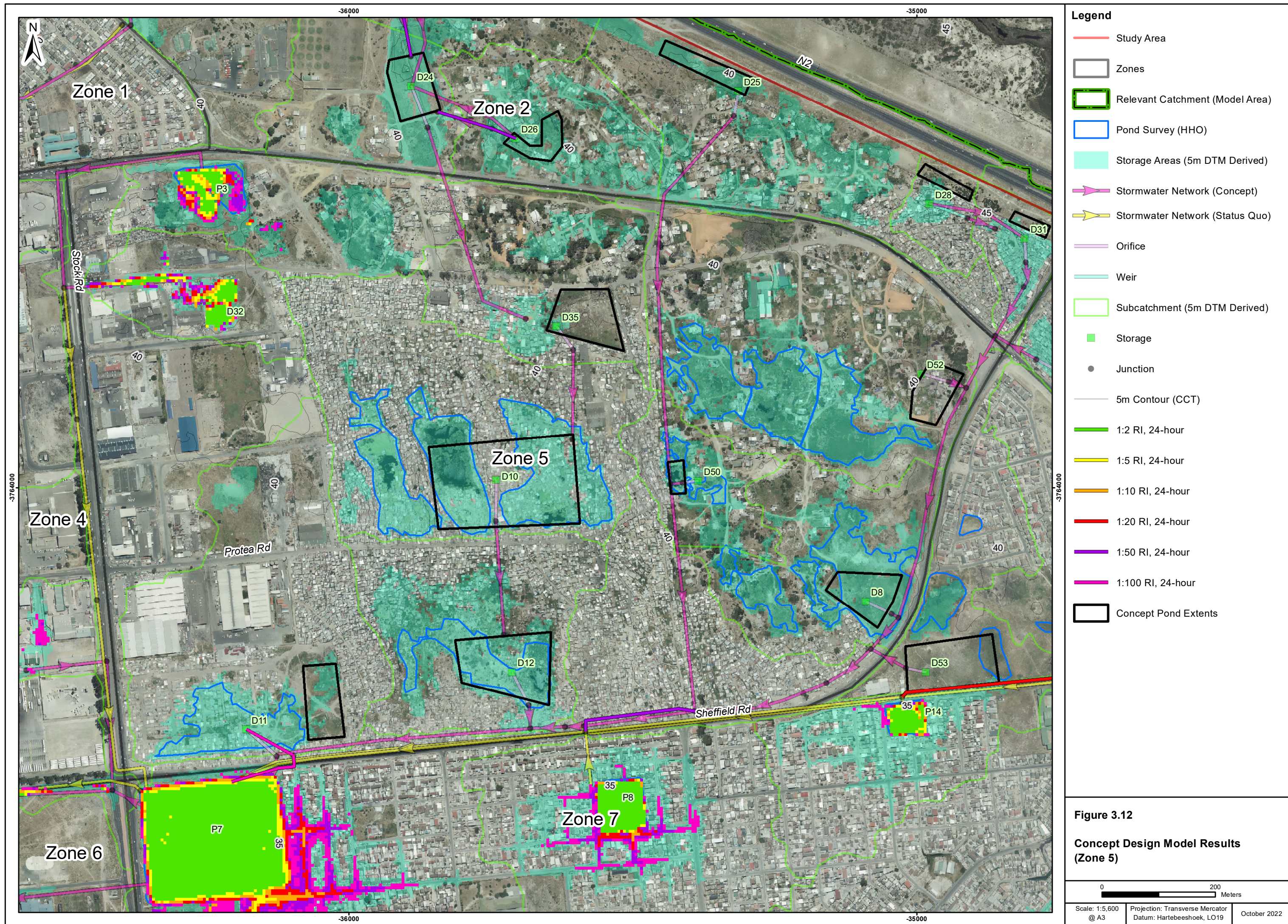
Projection: Transverse Mercator
Datum: Hartbeeshoek, LO19

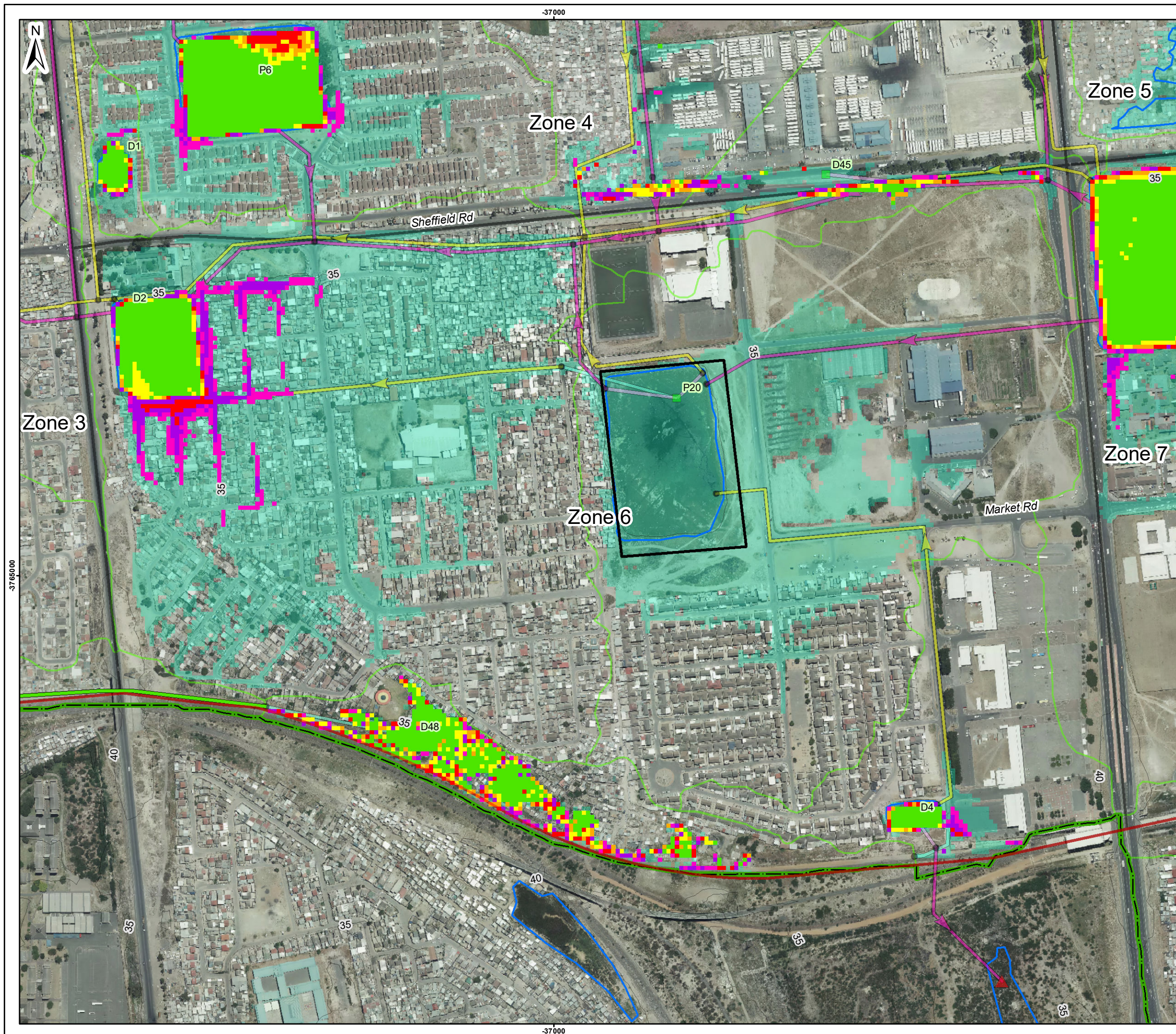
October 2022











Legend

- Study Area
- Zones
- Relevant Catchment (Model Area)
- Pond Survey (HHO)
- Storage Areas (5m DTM Derived)
- Stormwater Network (Concept)
- Stormwater Network (Status Quo)
- Orifice
- Weir
- Subcatchment (5m DTM Derived)
- Storage
- Outfall
- Junction
- 5m Contour (CCT)
- 1:2 RI, 24-hour
- 1:5 RI, 24-hour
- 1:10 RI, 24-hour
- 1:20 RI, 24-hour
- 1:50 RI, 24-hour
- 1:100 RI, 24-hour
- Concept Pond Extents

Figure 3.14

Concept Design Model Results
(Zone 6)

