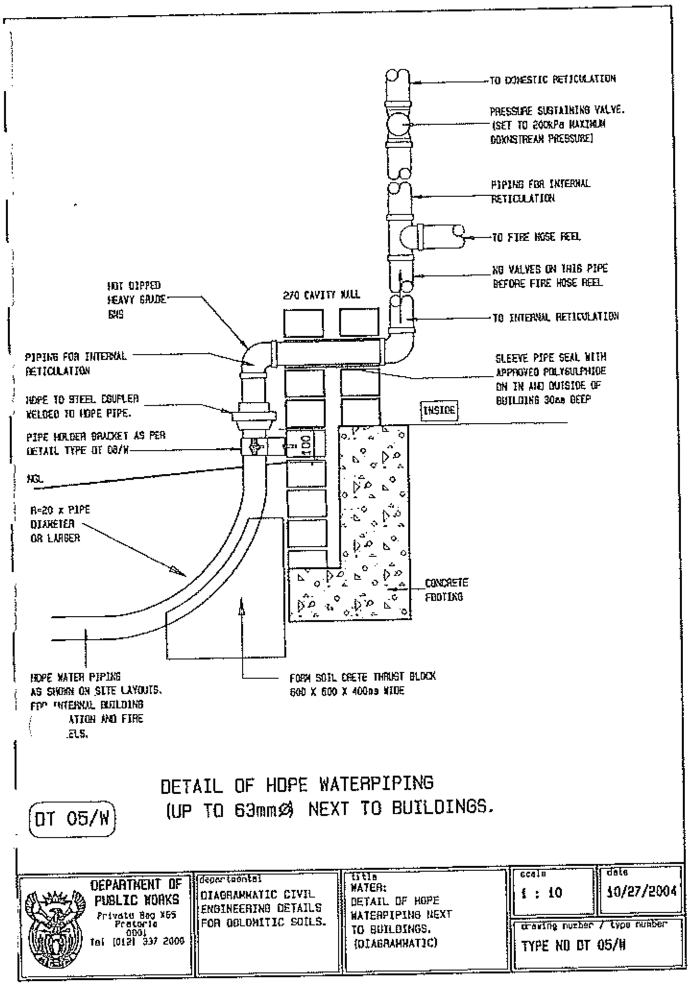
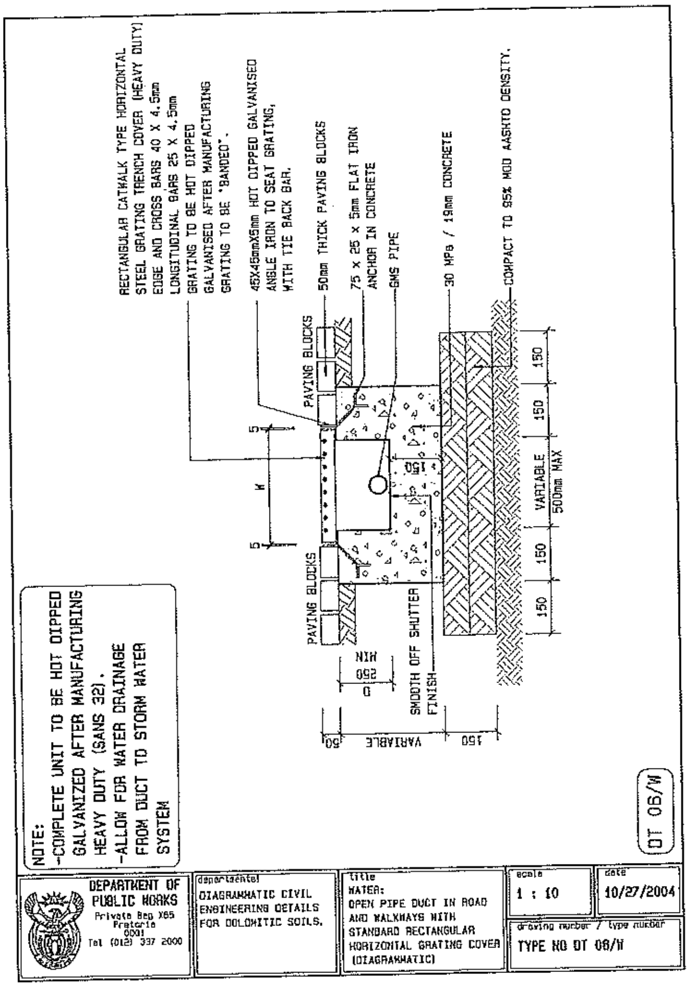
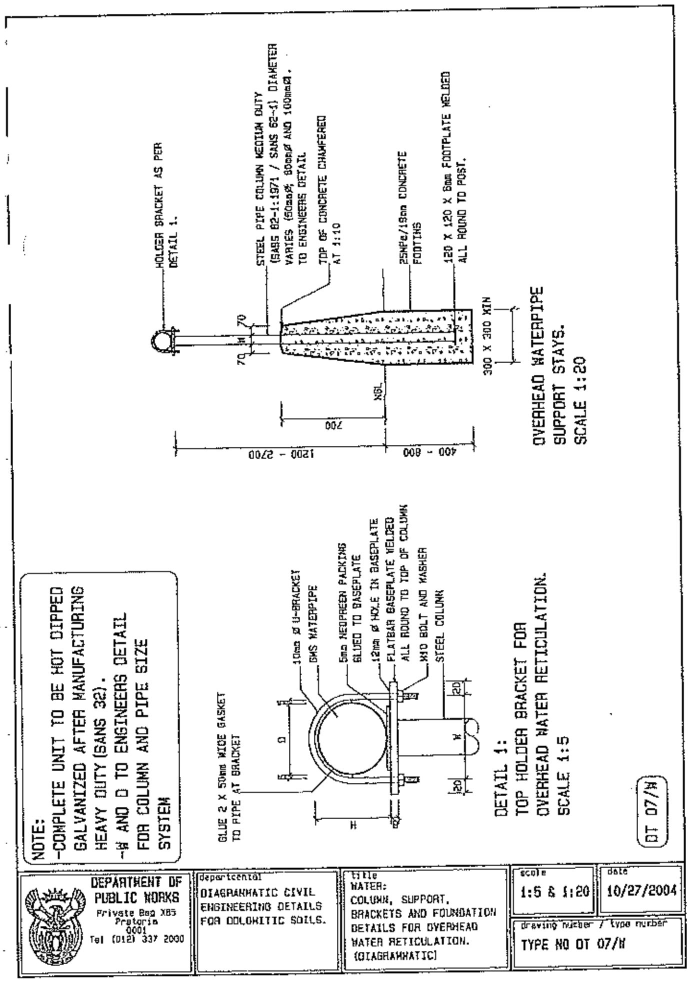
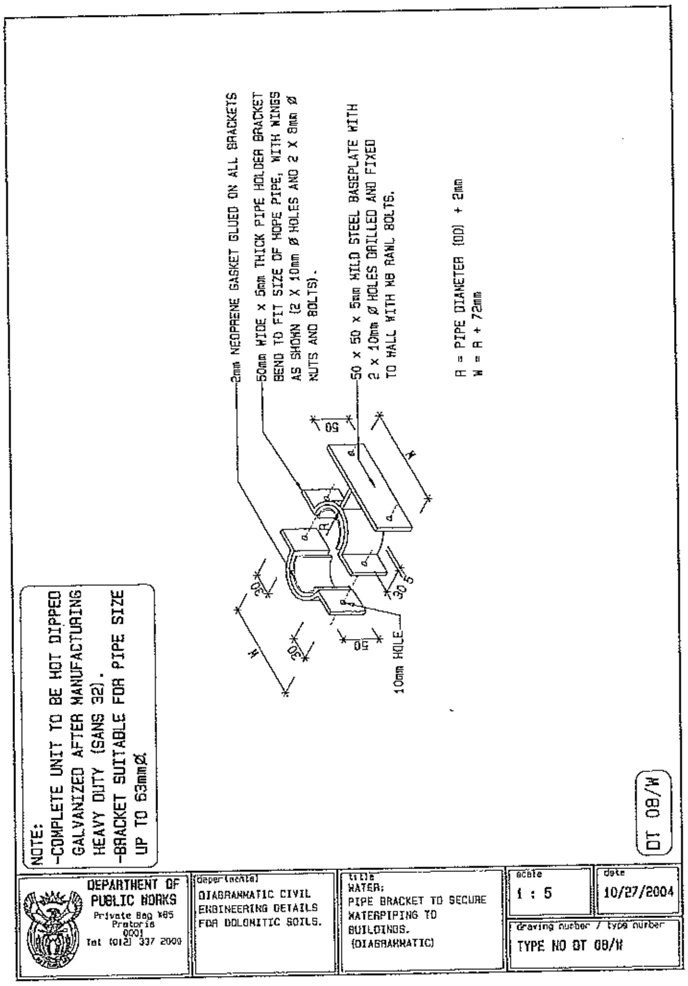

TO DOMESTIC RETICULATION
PRESSURE SUSTAINING VALVE. (SET TO 200kPa MAXIMUM DOWNSTREAM PRESSURE)
PIPING FOR INTERNAL RETICULATION
TO FIRE HOSE REEL
NO VALVES ON THIS PIPE BEFORE FIRE HOSE REEL
TO INTERNAL RETICULATION
SLEEVE PIPE SEAL WITH APPROVED POLYSULPHIDE ON IN AND OUTSIDE OF BUILDING 30mm DEEP
INSIDE
HOT DIPPED HEAVY GRADE GMS
270 CAVITY WALL
PIPING FOR INTERNAL RETICULATION
HDPE TO STEEL COUPLER WELDED TO HDPE PIPE.
PIPE HOLDER BRACKET AS PER DETAIL TYPE DT 08/W
100
NGL
R=20 x PIPE DIAMETER OR LARGER
CONCRETE FOOTING
HDPE WATER PIPING AS SHOWN ON SITE LAYOUTS. FOR INTERNAL BUILDING ATION AND FIRE ELS.
FORM SOIL CRETE THRUST BLOCK 600 X 600 X 400mm WIDE
DETAIL OF HDPE WATERPIPING (UP TO 63mmØ) NEXT TO BUILDINGS.
DT 05/W
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.
title
WATER:
DETAIL OF HDPE WATERPIPING NEXT TO BUILDINGS.
(DIAGRAMMATIC)
scale
1 : 10
date
10/27/2004
drawing number / type number
TYPE NO DT 05/W

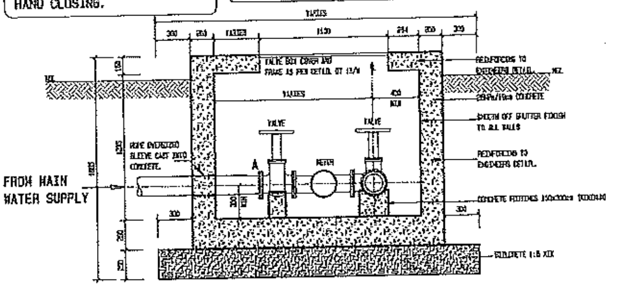

RECTANGULAR CATWALK TYPE HORIZONTAL STEEL GRATING TRENCH COVER (HEAVY DUTY) EDGE AND CROSS BARS 40 X 4.5mm LONGITUDINAL BARS 25 X 4.5mm GRATING TO BE HOT DIPPED GALVANISED AFTER MANUFACTURING GRATING TO BE 'BANDED'.
45X45mmX5mm HOT DIPPED GALVANISED ANGLE IRON TO SEAT GRATING, WITH TIE BACK BAR.
50mm THICK PAVING BLOCKS
75 x 25 x 5mm FLAT IRON ANCHOR IN CONCRETE
GMS PIPE
30 MPa / 19mm CONCRETE
COMPACT TO 95% MOD AASHTO DENSITY.
PAVING BLOCKS
PAVING BLOCKS
SMOOTH OFF SHUTTER FINISH
250 MIN
150
VARIABLE 500mm MAX
50 VARIABLE 150
NOTE:
-COMPLETE UNIT TO BE HOT DIPPED GALVANIZED AFTER MANUFACTURING HEAVY DUTY (SANS 32).
-ALLOW FOR WATER DRAINAGE FROM DUCT TO STORM WATER SYSTEM
DT 06/W
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.
title
WATER:
OPEN PIPE DUCT IN ROAD AND WALKWAYS WITH STANDARD RECTANGULAR HORIZONTAL GRATING COVER
(DIAGRAMMATIC)
scale
1 : 10
date
10/27/2004
drawing number / type number
TYPE NO DT 06/W


HOLDER BRACKET AS PER DETAIL 1.
STEEL PIPE COLUMN MEDIUM DUTY (SABS 62-1:1971 / SANS 62-1) DIAMETER VARIES (50mmØ, 80mmØ AND 100mmØ). TO ENGINEERS DETAIL
TOP OF CONCRETE CHAMFERED AT 1:10
25MPa/19mm CONCRETE FOOTING
120 X 120 X 6mm FOOTPLATE WELDED ALL ROUND TO POST.
300 X 300 MIN
NGL
700
1200 - 2700
400 - 600
OVERHEAD WATERPIPE SUPPORT STAYS. SCALE 1:20
NOTE:
-COMPLETE UNIT TO BE HOT DIPPED GALVANIZED AFTER MANUFACTURING HEAVY DUTY (SANS 32).
-W AND D TO ENGINEERS DETAIL FOR COLUMN AND PIPE SIZE SYSTEM
10mm Ø U-BRACKET
GMS WATERPIPE
5mm NEOPREEN PACKING GLUED TO BASEPLATE
12mm Ø HOLE IN BASEPLATE
FLATBAR BASEPLATE WELDED ALL ROUND TO TOP OF COLUMN
M10 BOLT AND WASHER
STEEL COLUMN
GLUE 2 X 50mm WIDE GASKET TO PIPE AT BRACKET
DETAIL 1: TOP HOLDER BRACKET FOR OVERHEAD WATER RETICULATION. SCALE 1:5
DT 07/W
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.
title
WATER:
COLUMN, SUPPORT, BRACKETS AND FOUNDATION DETAILS FOR OVERHEAD WATER RETICULATION.
(DIAGRAMMATIC)
scale
1:5 & 1:20
date
10/27/2004
drawing number / type number
TYPE NO DT 07/W

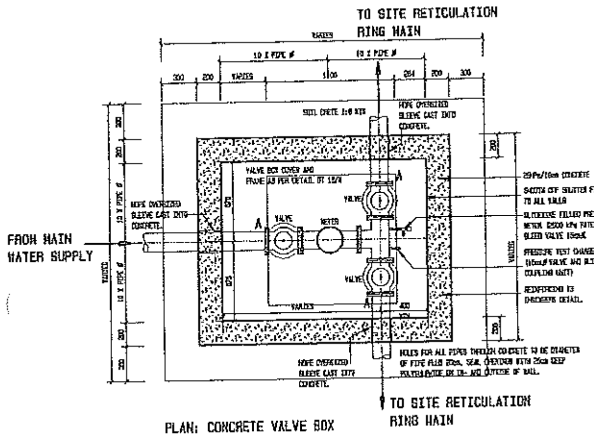

2mm NEOPRENE GASKET GLUED ON ALL BRACKETS
50mm WIDE x 5mm THICK PIPE HOLDER BRACKET BEND TO FIT SIZE OF HDPE PIPE, WITH WINGS AS SHOWN (2 X 10mm Ø HOLES AND 2 X 8mm Ø NUTS AND BOLTS).
50 x 50 x 5mm MILD STEEL BASEPLATE WITH 2 x 10mm Ø HOLES DRILLED AND FIXED TO WALL WITH M8 RAWL BOLTS.
R = PIPE DIAMETER (OD) + 2mm
W = R + 72mm
10mm HOLE
NOTE:
-COMPLETE UNIT TO BE HOT DIPPED GALVANIZED AFTER MANUFACTURING HEAVY DUTY (SANS 32).
-BRACKET SUITABLE FOR PIPE SIZE UP TO 63mmØ
DT 08/W
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.
title
WATER:
PIPE BRACKET TO SECURE WATERPIPING TO BUILDINGS.
(DIAGRAMMATIC)
scale
1 : 5
date
10/27/2004
drawing number / type number
TYPE NO DT 08/W

NOTE:
-FOR PIPE SCHEDULE FORMAT SEE DETAIL TYPE NO DT 11 (2)/W
-ALL VALVES TO BE RIGHT HAND CLOSING.

A = STUB AND FLANGE WELDED TO HDPE PIPE AND FLANGE ADAPTORS TO PIPE END AND VALVE AS WELL AS VJ (STEPPED IF NEEDED) COUPLING IN BETWEEN TO LOOSEN FITTINGS IN VALVE BOX
ALL FITTINGS TO BE NUMBERED P1, P2 ETC. AND INDICATED IN PIPE SCHEDULE.



SECTION: CONCRETE VALVE BOX



PLAN: CONCRETE VALVE BOX

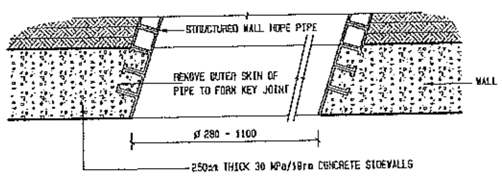
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: CONCRETE VALVE BOX DETAILS. (DIAGRAMMATIC)	scale 1 : 30	date 10/27/2004
			drawing number / type number TYPE NO DT 11-1/W	

PIPE MARK OR FITTING	NUMBER	DIAMETER	DESCRIPTION	MATERIAL	SABS (SPEC)	CLASS	DRILLING TABLE	THREAD SIZE (mm)
P1								
P2								
P3								
P4								
P5								
P6								
P7								
P8								
P9								
P10								
P11								
P12								
P13								
P14								
P15								
P16								
P17								
P18								
P19								
P20								
P21								
P22								

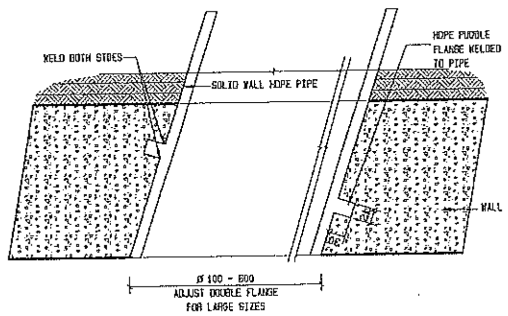
TYPICAL PIPE SCHEDULE SHEET.

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: TYPICAL PIPE SCHEDULE SHEET. (DIAGRAMMATIC)	scale N.A.	date 10/27/2004
			drawing number / type number TYPE NO DT 11-2/W	

NOTE:
DETAIL APPLICABLE TO WATER, SEWER AND STORMWATER

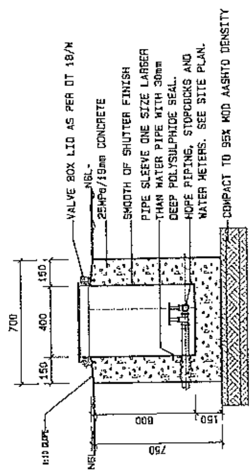


DETAIL 1:
JUNCTION OF STRUCTURED WALL HDPE PIPE IN CONCRETE SIDEWALL.

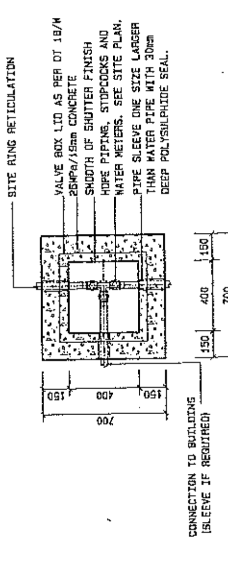


DETAIL 2:
JUNCTION OF SOLID WALL HDPE PIPE IN CONCRETE SIDEWALL

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: JUNCTION OF HDPE PIPE IN CONCRETE SIDEWALL. (DIAGRAMMATIC)	scale N.A.	date 10/27/2004
			drawing number / type number TYPE NO DT 12/W	



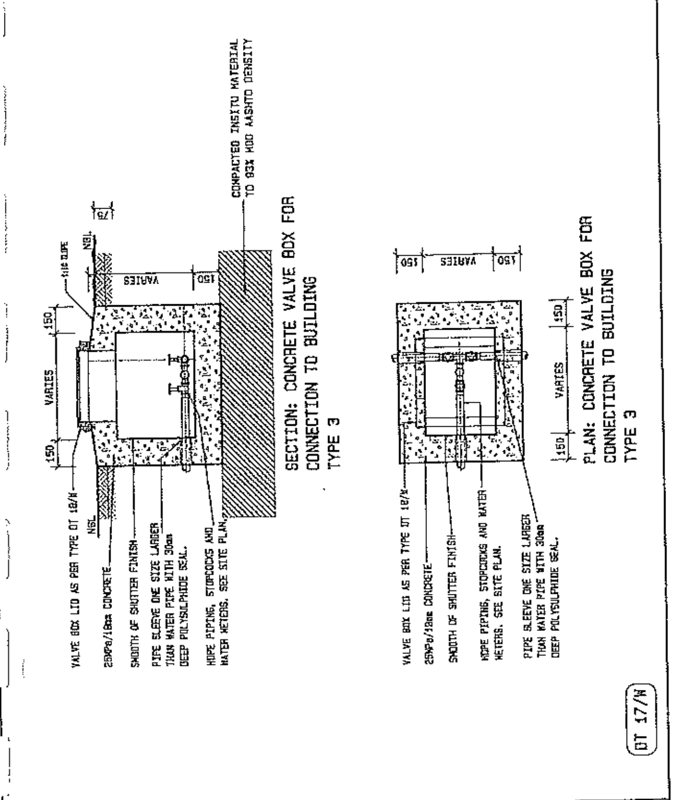
SECTION: CONCRETE VALVE BOX
TYPE 2



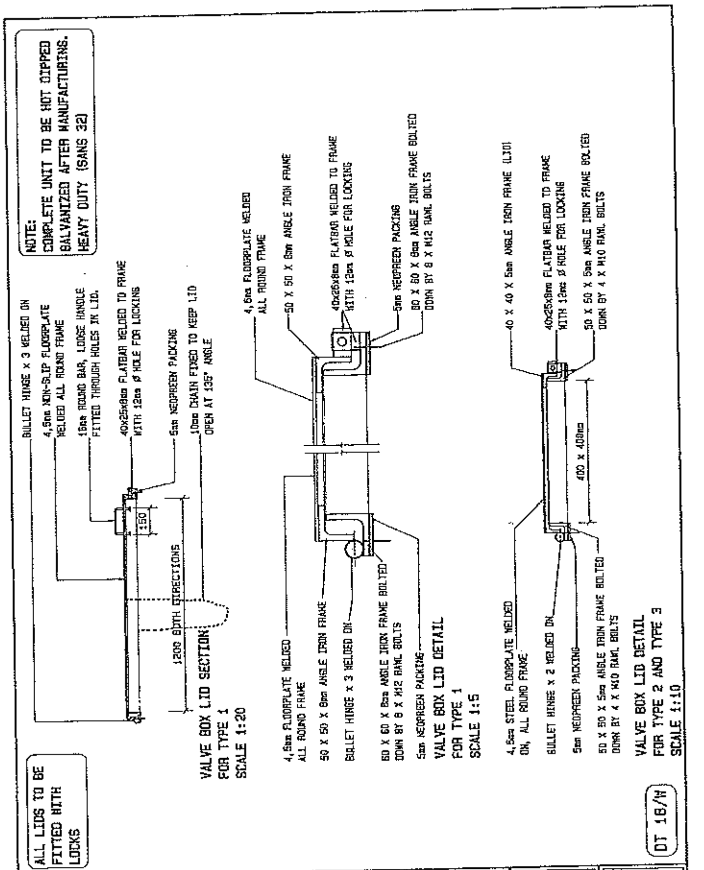
PLAN: CONCRETE VALVE BOX FOR CONNECTIONS TO BUILDINGS
TYPE 2

DT 16/W

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: CONCRETE VALVE BOX. TYPE 2. (DIAGRAMMATIC)	scale 1 : 20	date 10/27/2004
			drawing number / type number TYPE NO DT 16/W	



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: CONCRETE VALVE BOX. TYPE 3. (DIAGRAMMATIC)	scale 1 : 10	date 10/27/2004
			drawing number / type number TYPE NO DT 17/W	

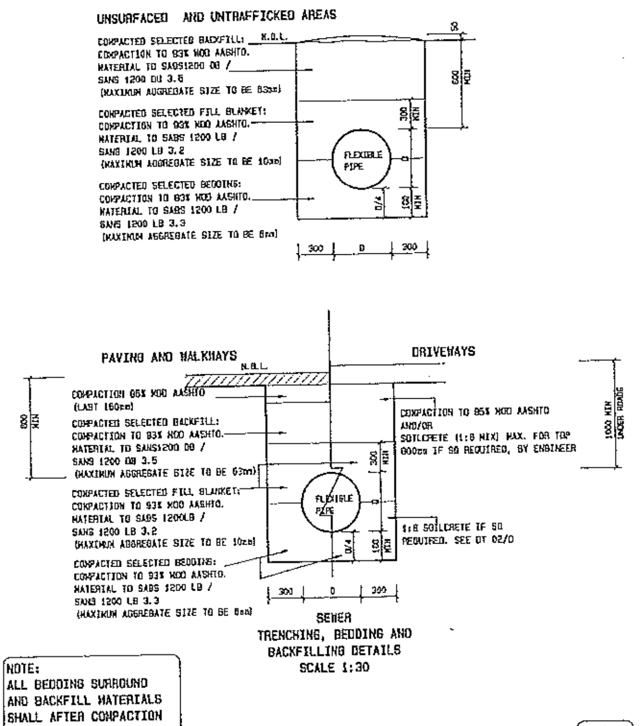


DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.	title WATER: VALVE BOX LID DETAILS FOR TYPE 1, 2 & 3. (DIAGRAMMATIC)	scale 1:5; 1:10 & 1:20	date 10/27/2004
			drawing number / type number TYPE NO DT 18/W	

SEWER DRAINAGE DETAILS.

DT 01/0	SEWER TRENCHING, BEDDING AND BACKFILLING DETAILS.
DT 02/0	SOILCRETE / CONCRETE PIPE PROTECTION
DT 03/0	HDPE JUNCTION CHAMBER TYPICAL CONNECTION TO ALL BUILDINGS.
DT 04/0	SECTION OF 800-1200mmØ MANHOLE ON MAIN SEWER LINE.
DT 05/0	SECTION OF HDPE JUNCTION CHAMBER IN OPEN AREAS
DT 06/0	CASTING OF CONCRETE SLABS OVER FLEXIBLE PIPES.
DT 07/0	PLAN AND ELEVATION FOR SURFACE MOUNTING OF SEWER PIPES TO EXISTING BUILDINGS.
D	STANDARD HEAVY DUTY PRECAST CONCRETE ROOFSLAB AND LID FOR HDPE MANHOLE.
DT 09/0	TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: PLAN
DT 10/0	TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION A
DT 11/0	TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION B
DT 12/0	TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION C

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: DRAWING LIST.	scale N.A.	date 10/27/2004
			drawing number / type number TYPE NO DT 00/0	

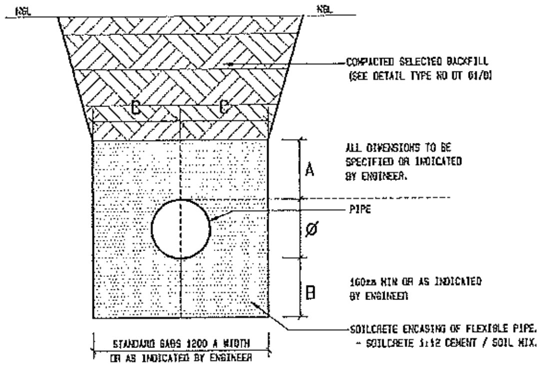


SEWER
TRENCHING, BEDDING AND
BACKFILLING DETAILS
SCALE 1:30

NOTE:
ALL BEDDING SURROUND AND BACKFILL MATERIALS SHALL AFTER COMPACTION BE LESS PREMEABLE THAN THE IN-SITU SURROUNDING SOIL.

DT 01/D

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: SEWER TRENCHING, BEDDING AND BACKFILLING DETAILS (DIAGRAMMATIC)	scale 1 : 30	date 10/27/2004
			drawing number / type number TYPE NO DT 01/D	

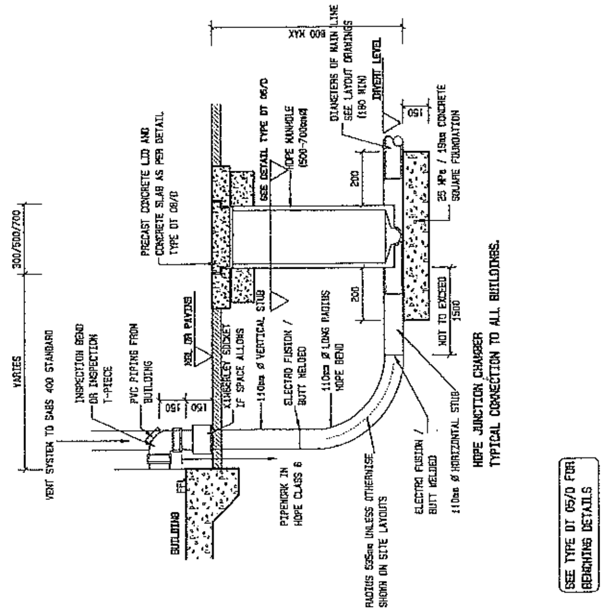


SOILCRETE PIPE PROTECTION

NOTE:
ALL BACKFILL MATERIALS SHALL AFTER COMPACTION BE LESS PERMEABLE THAN THE IN-SITU SURROUNDING SOIL.

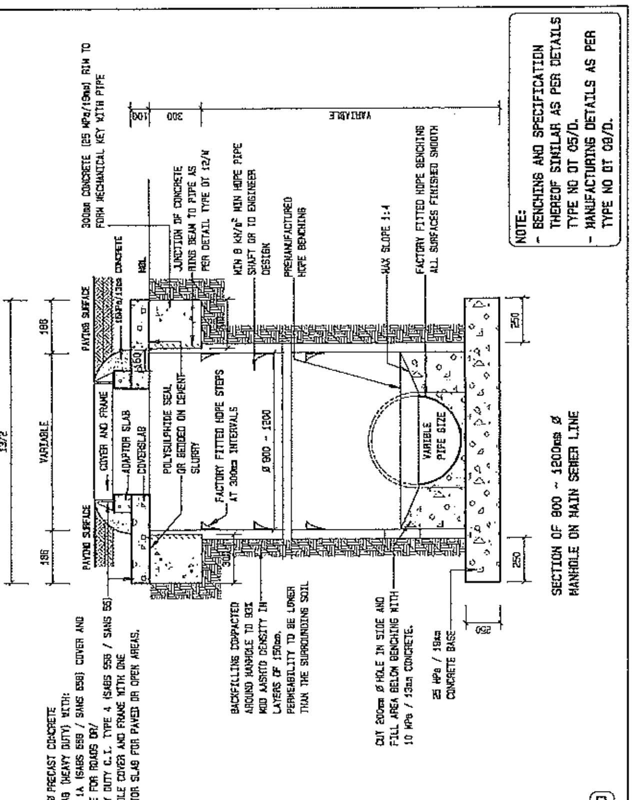
DT 02/D

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: SOILCRETE / CONCRETE PIPE PROTECTION (DIAGRAMMATIC)	scale 1 : 10 drawing number / type number TYPE NO DT 02/D	date 10/27/2004



DT 03/D

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: HDPE JUNCTION CHAMBER TYPICAL CONNECTION TO ALL BUILDINGS. (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 03/D	date 10/27/2004

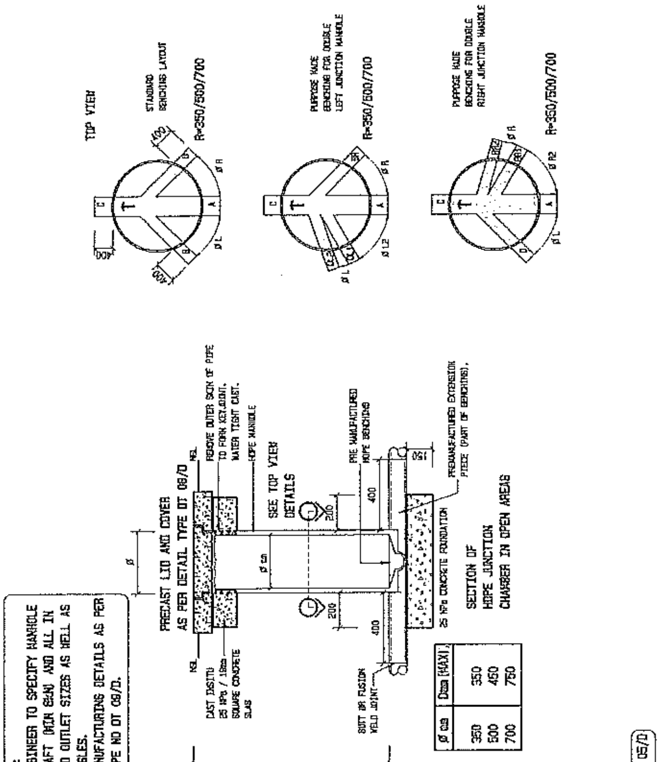


SECTION OF 900 - 1200mm Ø MANHOLE ON MAIN SEWER LINE

NOTE:
- BENCHING AND SPECIFICATION THEREOF SIMILAR AS PER DETAILS TYPE NO DT 05/D.
- MANUFACTURING DETAILS AS PER TYPE NO DT 09/D.

DT 04/D

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: SECTION OF 900-1200mm MANHOLE ON MAIN SEWER LINE (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 04/D	date 10/27/2004

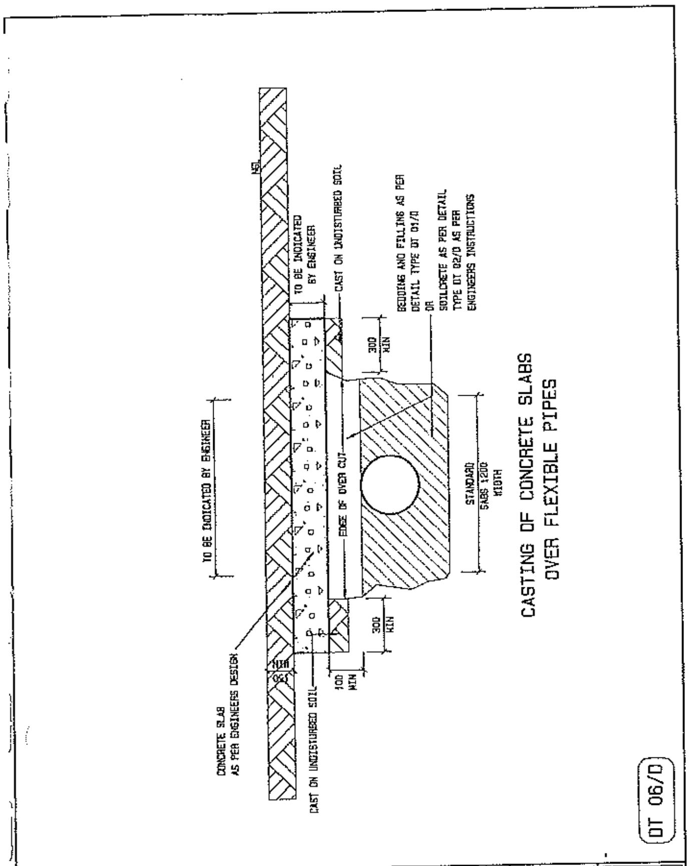


Ø Dm	Dmm (MAX)
350	350
500	450
700	750

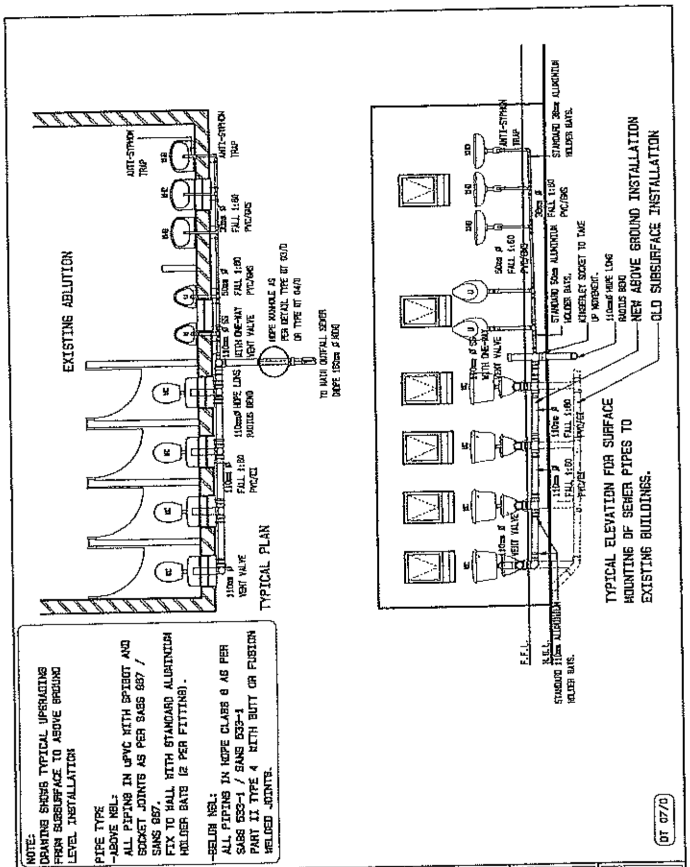
NOTE:
- ENGINEER TO SPECIFY MANHOLE SHAFT (MIN Ø...) AND ALL IN AND OUTLET SIZES AS WELL AS ANGLES.
- MANUFACTURING DETAILS AS PER TYPE NO DT 09/D.

DT 05/D

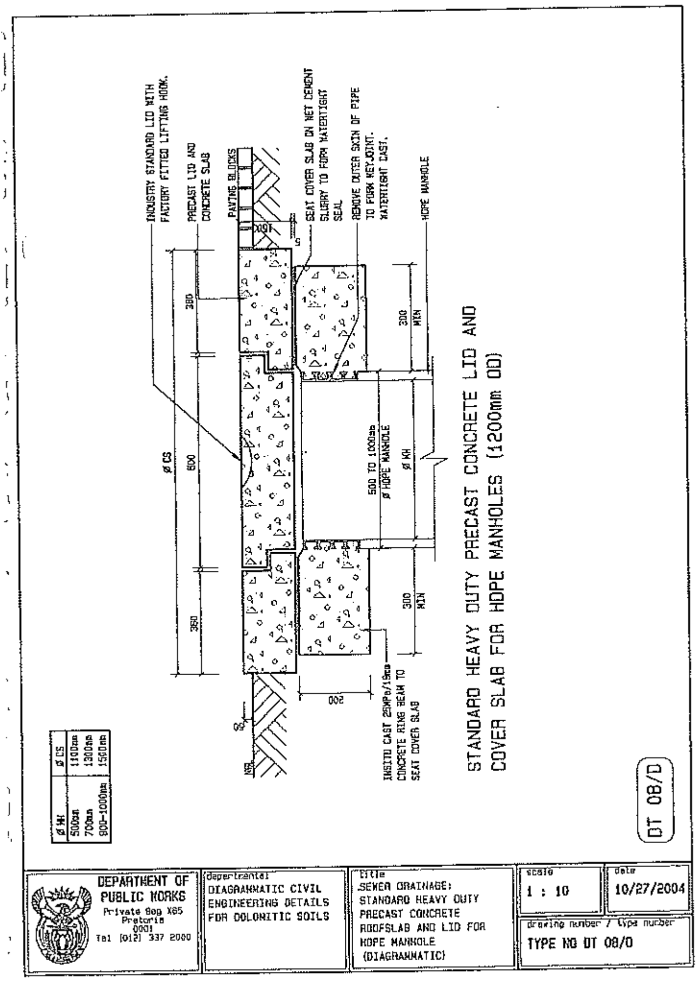
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SECTION OF HDPE JUNCTION CHAMBER IN OPEN AREAS (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 05/D	date 10/27/2004



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: CASTING OF CONCRETE SLABS OVER FLEXIBLE PIPES (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 06/D	date 10/27/2004



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: PLAN AND ELEVATION FOR SURFACE MOUNTING OF SEWER PIPES TO EXISTING BUILINGS. (DIAGRAMMATIC)	scale 1 : 60 drawing number / type number TYPE NO DT 07/D	date 10/27/2004



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title SEWER DRAINAGE: STANDARD HEAVY DUTY PRECAST CONCRETE ROOFSLAB AND LID FOR HDPE MANHOLE (DIAGRAMMATIC)	scale 1 : 10 drawing number / type number TYPE NO DT 08/D	date 10/27/2004

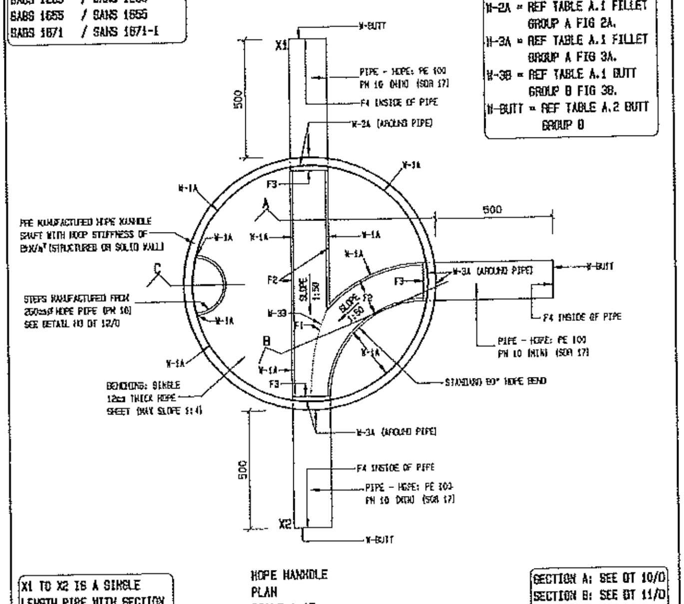
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427
HOOP STIFFNESS OF MANHOLE SHAFT TO BE 8kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999, SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999, SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999, SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS SEE SABS 0270 / SANS 10270 PAR 6 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



X1 TO X2 IS A SINGLE LENGTH PIPE WITH SECTION REMOVED TO FORM CHANNEL

HDPE MANHOLE
PLAN
SCALE 1:15

SECTION A: SEE DT 10/D
SECTION B: SEE DT 11/D
SECTION C: SEE DT 12/D

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: PLAN	scale 1 : 15 drawing number / type number TYPE NO DT 09/D	date 10/27/2004

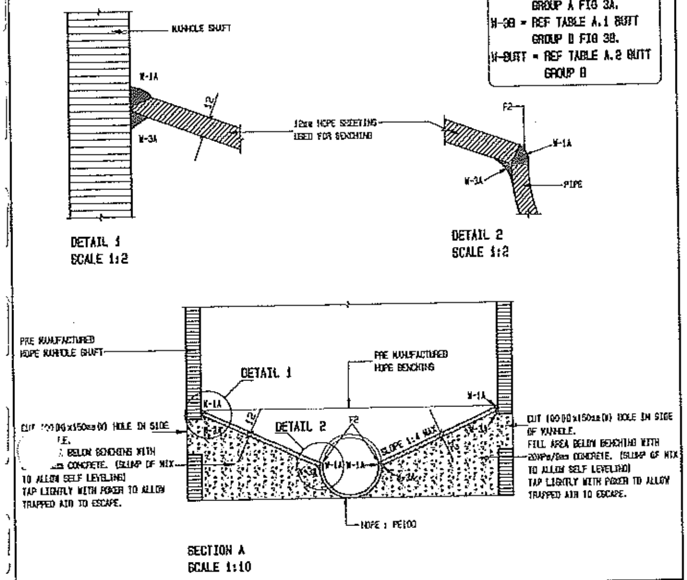
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427
HOOP STIFFNESS OF MANHOLE SHAFT TO BE 8kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999, SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999, SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999, SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS
SEE SABS 0270 / SANS 10270
PAR 5 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

title: TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION A

scale: AS SHOWN

date: 10/27/2004

drawing number / type number: TYPE NO DT 10/D

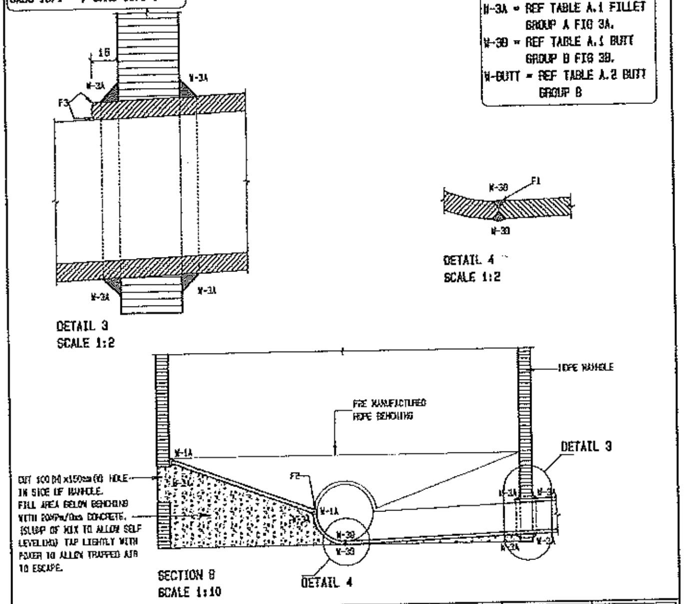
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427
HOOP STIFFNESS OF MANHOLE SHAFT TO BE 8kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999, SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999, SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999, SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS
SEE SABS 0270 / SANS 10270
PAR 5 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

title: TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION B

scale: AS SHOWN

date: 10/27/2004

drawing number / type number: TYPE NO DT 11/D

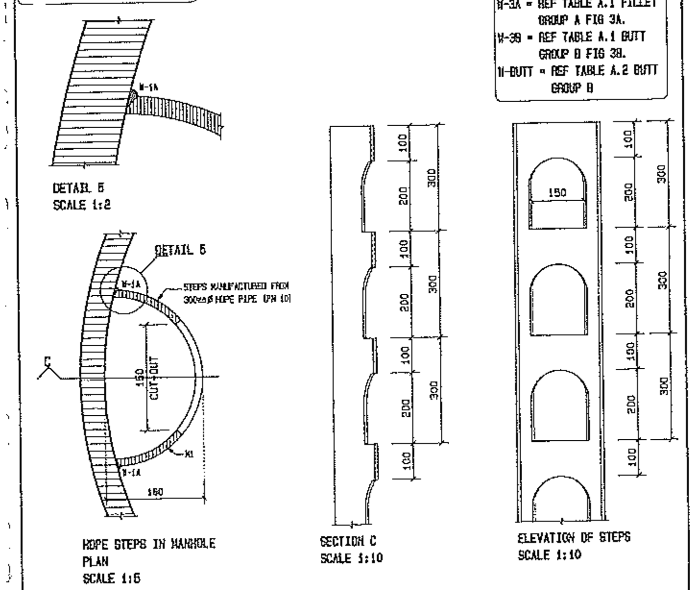
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS4427
HOOP STIFFNESS OF MANHOLE SHAFT TO BE 8kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
55 / SANS 1655
71 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999, SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999, SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999, SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS
SEE SABS 0270 / SANS 10270
PAR 5 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

title: TYPICAL WELDING DETAILS FOR HDPE SEWER MANHOLE: SECTION C

scale: AS SHOWN

date: 10/27/2004

drawing number / type number: TYPE NO DT 12/D

STORMWATER DETAILS

STORM WATER DETAILS: LIST OF DRAWINGS

DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

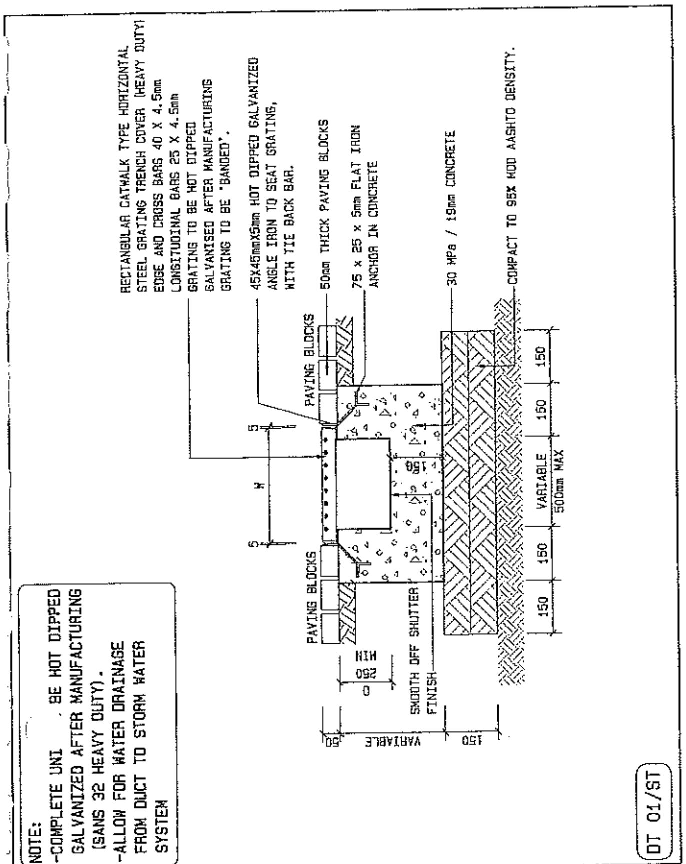
department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

project: STORMWATER: DRAWING LIST.

scale: -

date: 10/27/2004

drawing number / type number: TYPE NO DT 00/ST



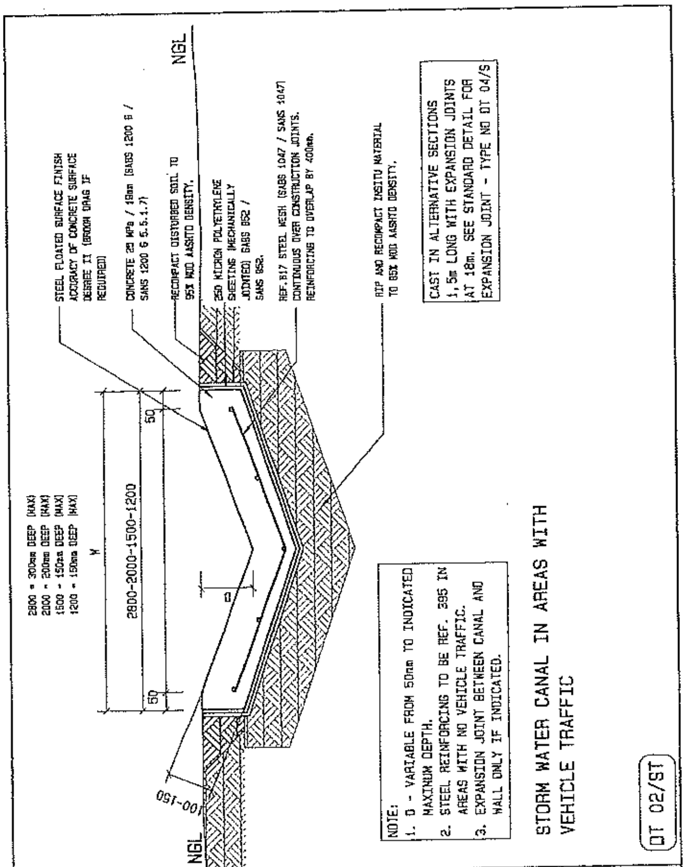
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000

departmental: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS.

title: STORM WATER: DUCT FOR ROADWAYS AND WALKWAYS

scale: 1 : 10 | date: 10/27/2004

drawing number / type number: TYPE NO DT 01/ST



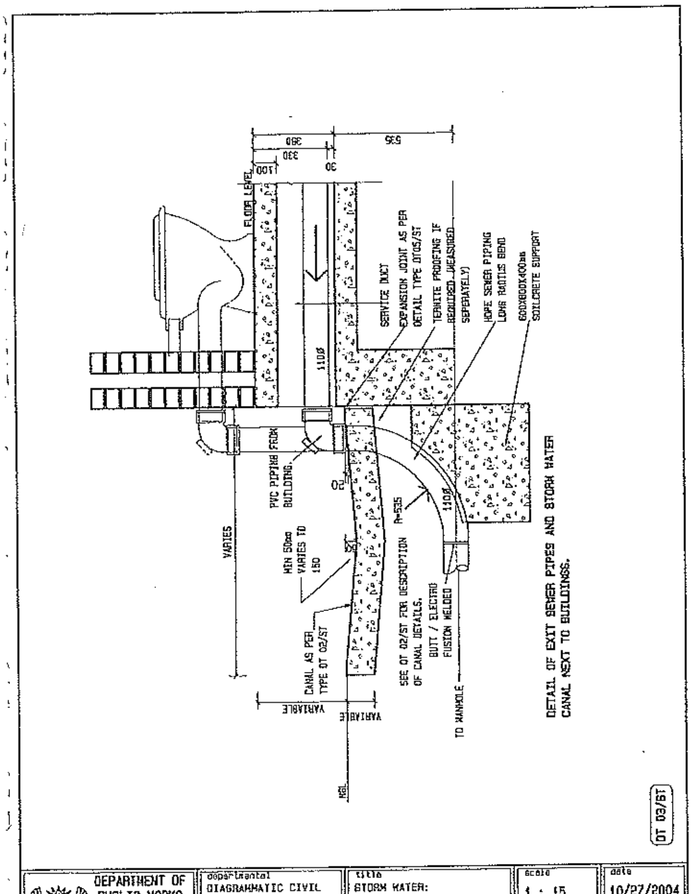
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000

departmental: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

title: STORM WATER: CANAL IN AREAS WITH VEHICLE TRAFFIC (DIAGRAMMATIC)

scale: 1 : 10 | date: 10/27/2004

drawing number / type number: TYPE NO DT 02/ST



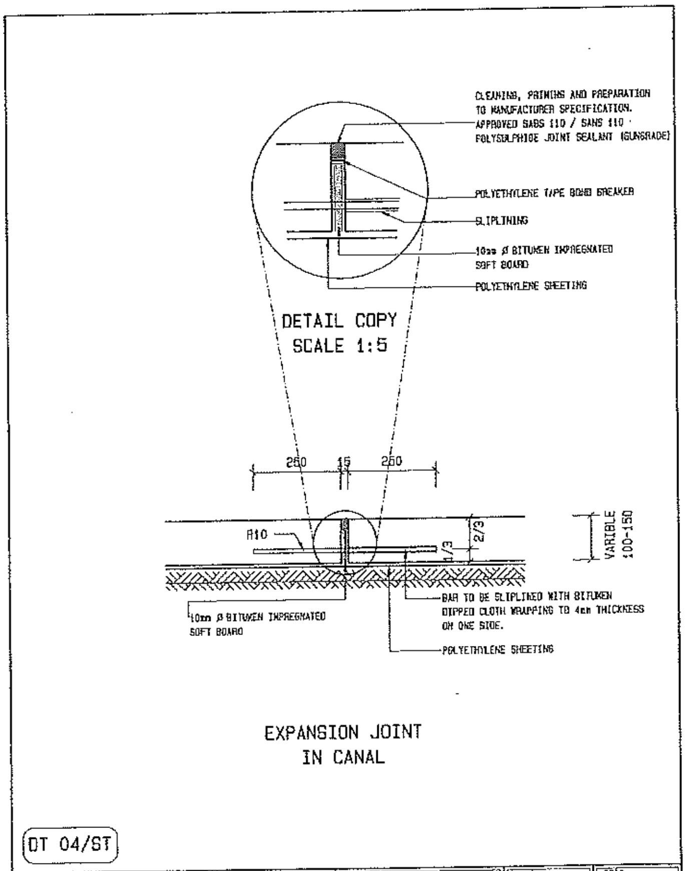
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000

departmental: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

title: STORM WATER: DETAIL OF EXIT OF SEWER PIPES AT STORM WATER CANAL NEXT TO BUILDINGS. (DIAGRAMMATIC)

scale: 1 : 15 | date: 10/27/2004

drawing number / type number: TYPE NO DT 03/ST



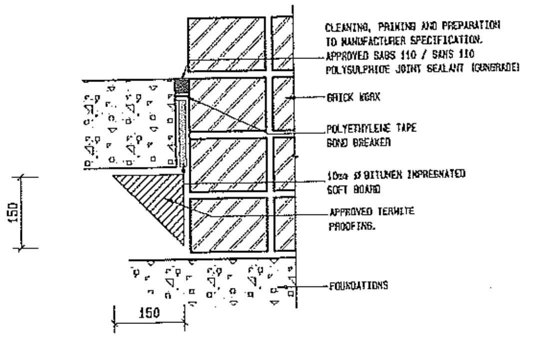
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000

departmental: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS

project: STORM WATER: EXPANSION JOINT IN CANAL (DIAGRAMMATIC)

scale: 1 : 10 | date: 10/27/2004

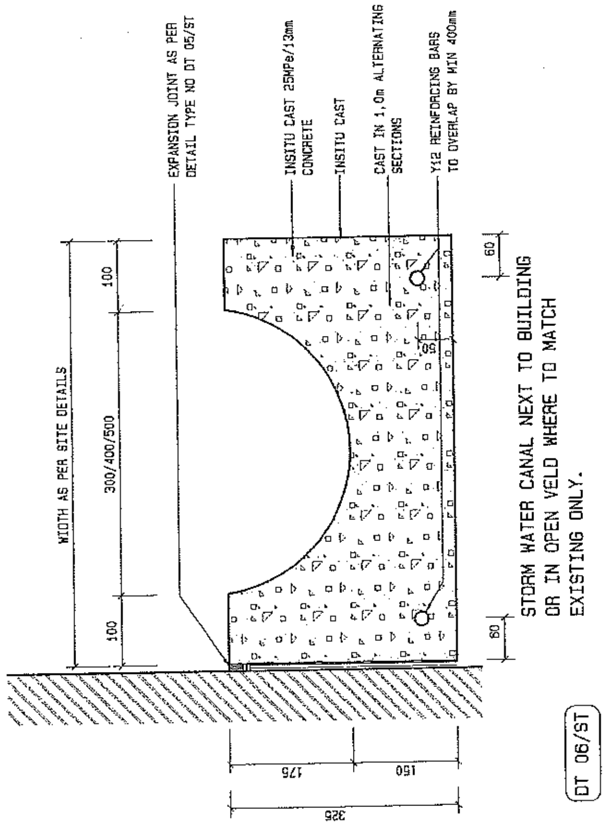
drawing number / type number: TYPE NO DT 04/ST



EXPANSION JOINT AGAINST BUILDING

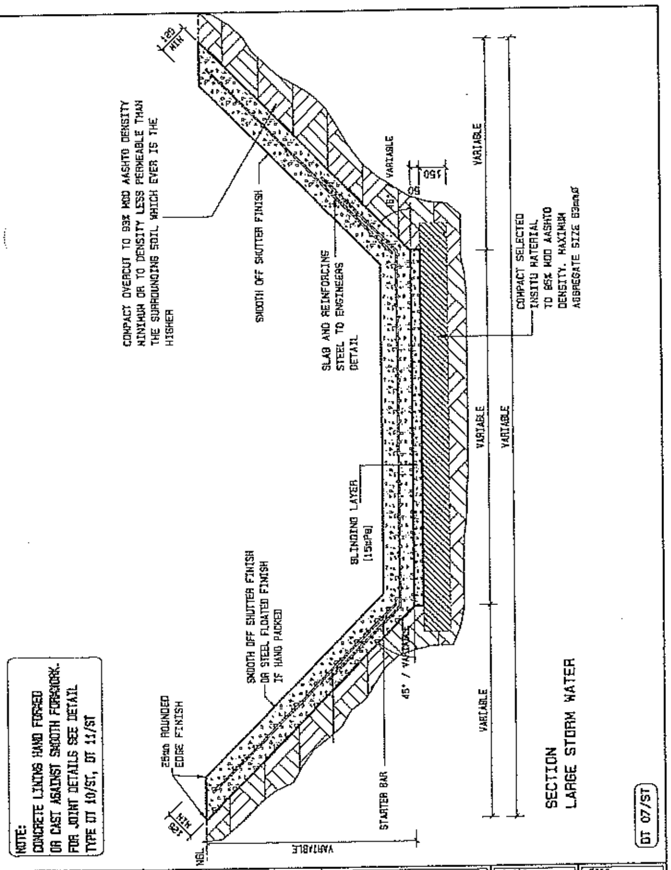
DT 05/ST

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: STORM WATER: EXPANSION JOINT AGAINST BUILDING (DIAGRAMMATIC)	scale: 1 : 5	date: 10/27/2004
			drawing number / type number: TYPE NO DT 05/ST	



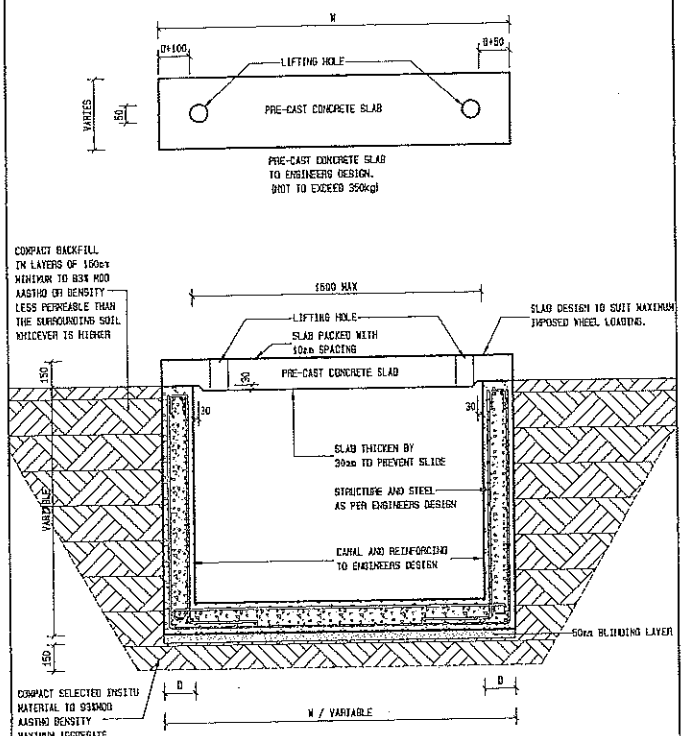
DT 06/ST

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: STORM WATER: STORM WATER CANAL NEXT TO BUILDING OR IN OPEN VELD WHERE TO MATCH EXISTING ONLY. (DIAGRAMMATIC)	scale: 1 : 5	date: 10/27/2004
			drawing number / type number: TYPE NO DT 06/ST	



DT 07/ST

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: STORM WATER: (SECTION) LARGE STORM WATER CANAL. (DIAGRAMMATIC)	scale: 1 : 20	date: 10/27/2004
			drawing number / type number: TYPE NO DT 07/ST	



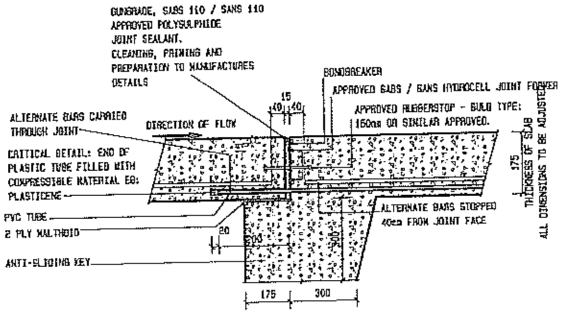
TYPICAL COVERED STORM WATER CANAL

DT 09/ST

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: STORM WATER: (SECTION) TYPICAL COVERED STORM WATER CANAL. (DIAGRAMMATIC)	scale: 1 : 20	date: 10/27/2004
			drawing number / type number: TYPE NO DT 09/ST	

NOTE:
DIMENSIONS TO BE ADJUSTED
IN ACCORDANCE WITH
CANAL FLOORSLAB THICKNESS.

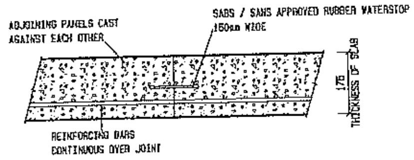
SLIDING KEY REINFORCING AND
DEPTH TO ENGINEERS DESIGN



STORM WATER CANAL
FLOOR EXPANSION JOINT.

DT 10/ST

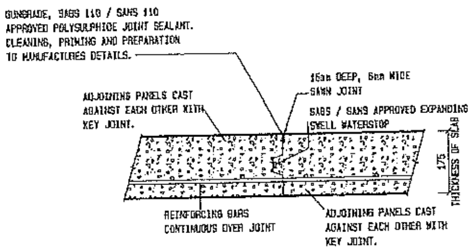
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STORM WATER: FLOOR EXPANSION JOINT DETAIL (DIAGRAMMATIC)	scale 1 : 10.	date 10/27/2004
			drawing number / type number TYPE NO DT 10/ST	



STORM WATER CANAL
CONSTRUCTION JOINT - TYPE 1

DT 11/ST

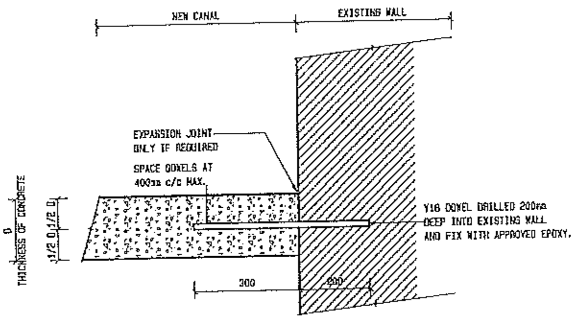
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STORM WATER: CONSTRUCTION JOINT - TYPE 1 (DIAGRAMMATIC)	scale 1 : 10	date 10/27/2004
			drawing number / type number TYPE NO DT 11/ST	



STORM WATER CANAL
CONSTRUCTION JOINT - TYPE 2

DT 12/ST

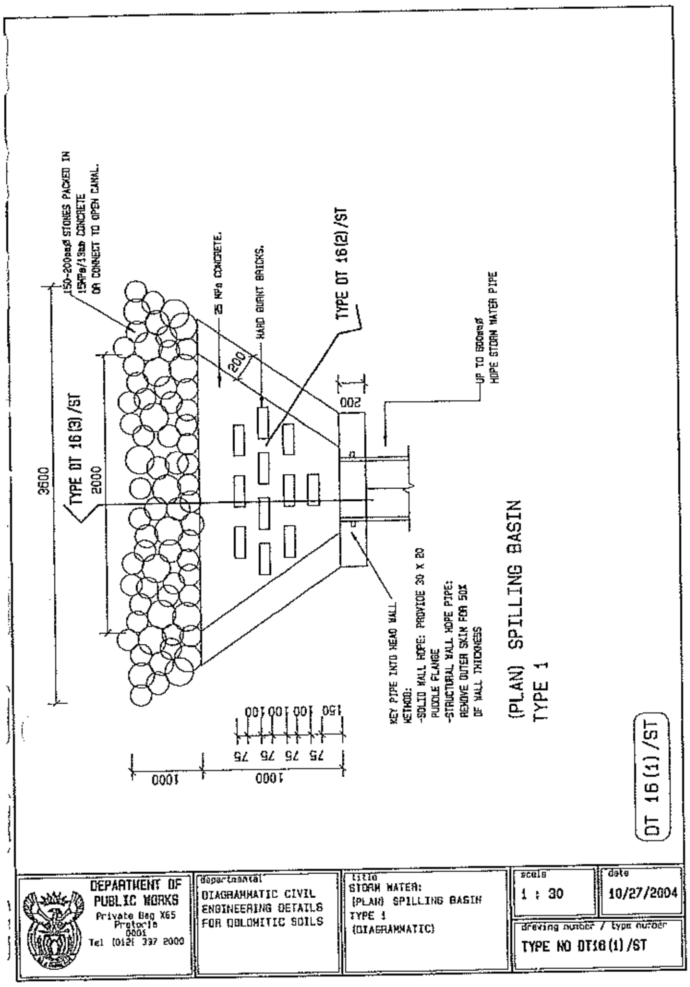
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STORM WATER: CANAL CONSTRUCTION JOINT - TYPE 2 (DIAGRAMMATIC)	scale 1 : 10	date 10/27/2004
			drawing number / type number TYPE NO DT 12/ST	



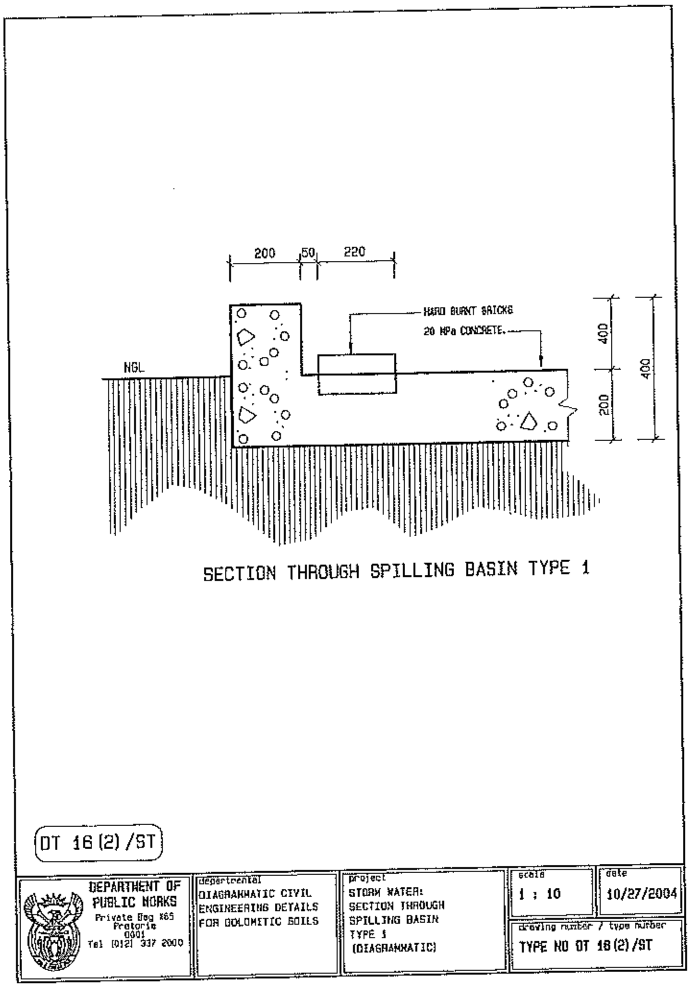
STORM WATER CANAL
CONSTRUCTION JOINT - TYPE 3

DT 13/ST

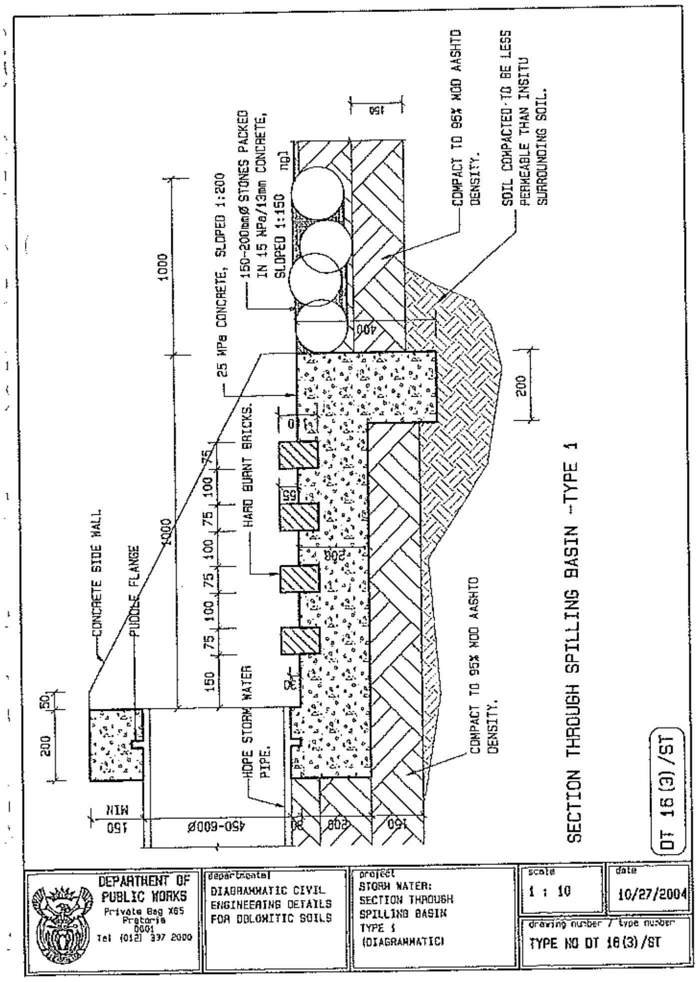
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STORM WATER: STORM WATER CANAL CONSTRUCTION JOINT - TYPE 3 (DIAGRAMMATIC)	scale 1 : 10	date 10/27/2004
			drawing number / type number TYPE NO DT 13/ST	



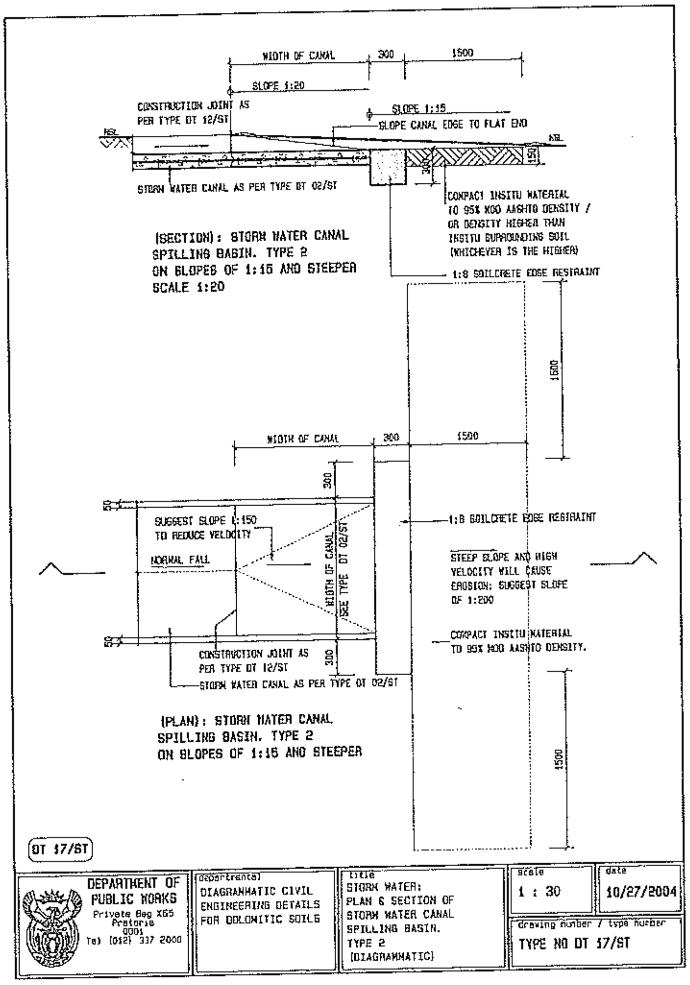
150-200mmø STONES PACKED IN 15MPa/13mm CONCRETE OR CONNECT TO OPEN CANAL.
25 MPa CONCRETE.
HARD BURNT BRICKS.
TYPE DT 16(2)/ST
TYPE DT 16(3)/ST
3600
2000
UP TO 600mmø HDPE STORM WATER PIPE
KEY PIPE INTO HEAD WALL
(PLAN) SPILLING BASIN
TYPE 1
DT 16(1)/ST
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
STORM WATER: (PLAN) SPILLING BASIN TYPE 1 (DIAGRAMMATIC)
1 : 30
10/27/2004
TYPE NO DT16(1)/ST



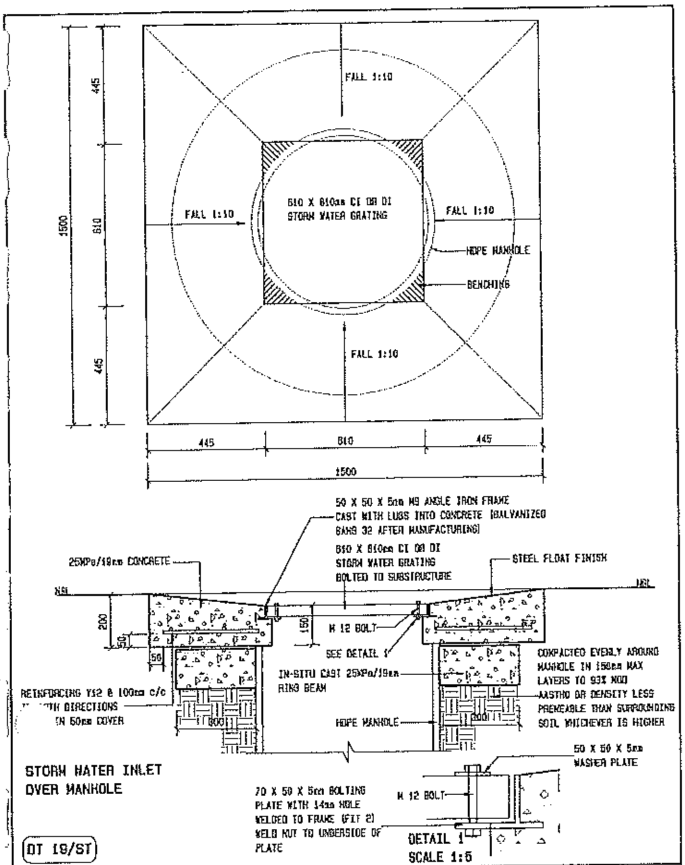
200
50
220
HARD BURNT BRICKS
20 MPa CONCRETE.
NGL
400
200
SECTION THROUGH SPILLING BASIN TYPE 1
DT 16(2)/ST
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
STORM WATER: SECTION THROUGH SPILLING BASIN TYPE 1 (DIAGRAMMATIC)
1 : 10
10/27/2004
TYPE NO DT 16(2)/ST



COMPACT TO 95% MOD AASHTO DENSITY.
SOIL COMPACTED TO BE LESS PERMEABLE THAN INSITU SURROUNDING SOIL.
150-200mmø STONES PACKED IN 15 MPa/13mm CONCRETE, SLOPED 1:150
25 MPa CONCRETE, SLOPED 1:200
HARD BURNT BRICKS.
CONCRETE SIDE WALL
PUDDLE FLANGE
HDPE STORM WATER PIPE.
450-600ø
SECTION THROUGH SPILLING BASIN -TYPE 1
DT 16(3)/ST
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
STORM WATER: SECTION THROUGH SPILLING BASIN TYPE 1 (DIAGRAMMATIC)
1 : 10
10/27/2004
TYPE NO DT 16(3)/ST



WIDTH OF CANAL
300
1500
SLOPE 1:20
CONSTRUCTION JOINT AS PER TYPE DT 12/ST
SLOPE 1:15
SLOPE CANAL EDGE TO FLAT END
NGL
STORM WATER CANAL AS PER TYPE DT 02/ST
COMPACT INSITU MATERIAL TO 95% MOD AASHTO DENSITY / OR DENSITY HIGHER THAN INSITU SURROUNDING SOIL (WHICHEVER IS THE HIGHER)
(SECTION): STORM WATER CANAL SPILLING BASIN. TYPE 2 ON SLOPES OF 1:15 AND STEEPER SCALE 1:20
1:8 SOILCRETE EDGE RESTRAINT
SUGGEST SLOPE 1:150 TO REDUCE VELOCITY
NORMAL FALL
STEEP SLOPE AND HIGH VELOCITY WILL CAUSE EROSION; SUGGEST SLOPE OF 1:200
COMPACT INSITU MATERIAL TO 95% MOD AASHTO DENSITY.
CONSTRUCTION JOINT AS PER TYPE DT 12/ST
STORM WATER CANAL AS PER TYPE DT 02/ST
(PLAN): STORM WATER CANAL SPILLING BASIN. TYPE 2 ON SLOPES OF 1:15 AND STEEPER
DT 17/ST
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
STORM WATER: PLAN & SECTION OF STORM WATER CANAL SPILLING BASIN. TYPE 2 (DIAGRAMMATIC)
1 : 30
10/27/2004
TYPE NO DT 17/ST



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: STORM WATER: INLET OVER MANHOLE (DIAGRAMMATIC)	scale: 1:10 / 1:5	date: 10/27/2004
			drawing number / type number: TYPE NO DT 19/ST	

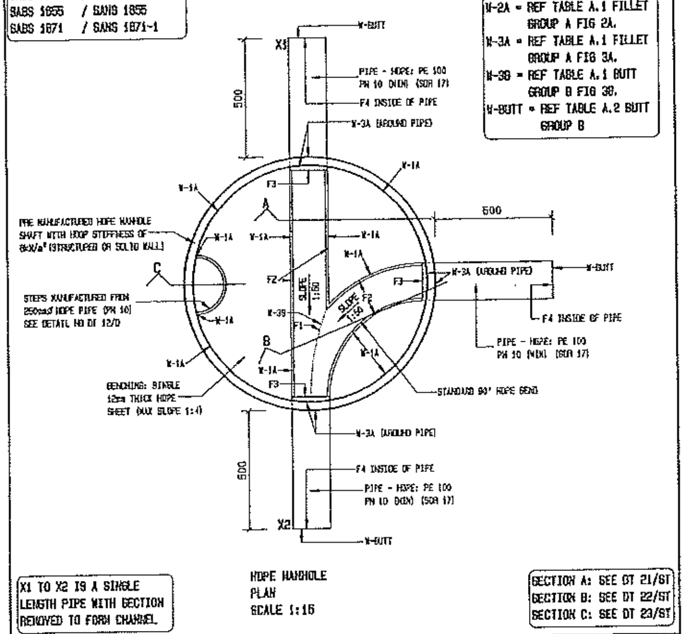
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427.
  HOOP STIFFNESS OF MANHOLE SHAFT TO BE 6kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999. SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999. SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999. SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS SEE SABS 0270 / SANS 10270 PAR 6 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



X1 TO X2 IS A SINGLE LENGTH PIPE WITH SECTION REMOVED TO FORM CHANNEL

SECTION A: SEE DT 21/ST
SECTION B: SEE DT 22/ST
SECTION C: SEE DT 23/ST

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: TYPICAL WELDING DETAILS FOR HDPE STORM WATER MANHOLE: PLAN	scale: 1 : 15	date: 10/27/2004
			drawing number / type number: TYPE NO DT 20/ST	

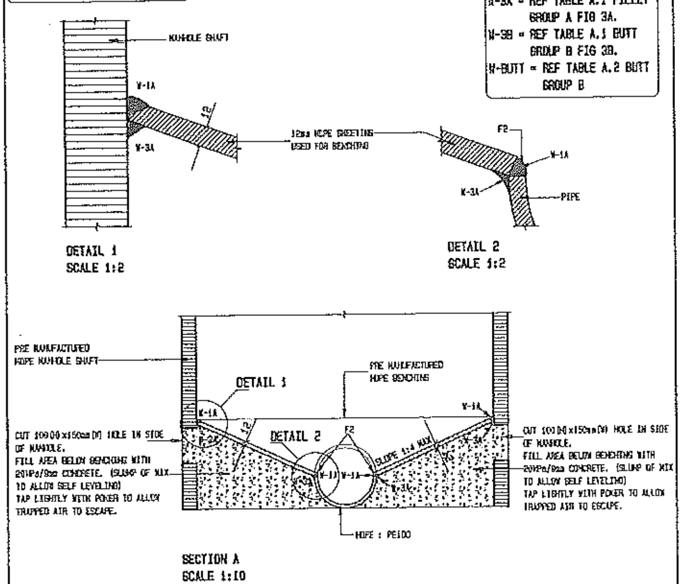
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427.
  HOOP STIFFNESS OF MANHOLE SHAFT TO BE 6kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999. SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999. SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999. SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS SEE SABS 0270 / SANS 10270 PAR 6 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: TYPICAL WELDING DETAILS FOR HDPE STORM WATER MANHOLE: SECTION A	scale: AS SHOWN	date: 10/27/2004
			drawing number / type number: TYPE NO DT 21/ST	

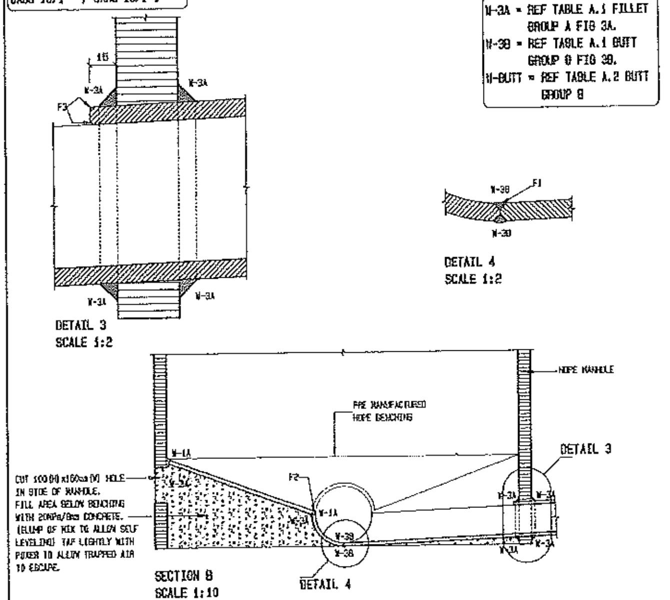
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427
  HOOP STIFFNESS OF MANHOLE SHAFT TO BE 6kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0269 / SANS 10269
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999. SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999. SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999. SANS 10268-4

GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS SEE SABS 0270 / SANS 10270 PAR 6 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department: DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title: TYPICAL WELDING DETAILS FOR HDPE STORM WATER MANHOLE: SECTION B	scale: AS SHOWN	date: 10/27/2004
			drawing number / type number: TYPE NO DT 22/ST	

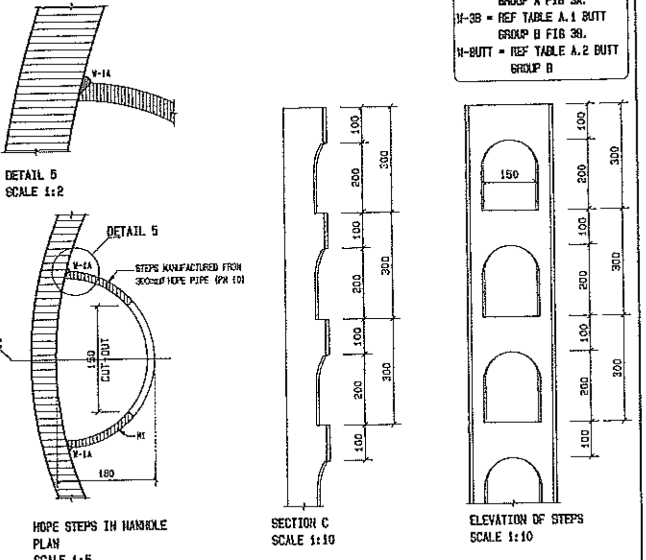
GENERAL NOTE:
- ALL MATERIALS TO BE HDPE PE-100 AS PER SABS ISO 4427 / SANS 4427
  HOOP STIFFNESS OF MANHOLE SHAFT TO BE 6kN/m²

OTHER RELEVANT MANUFACTURING STANDARDS:
SABS 0268-1 / SANS 10268-1
SABS 0268 / SANS 10268
SABS 0270 / SANS 10270
SABS 1269 / SANS 1269
SABS 1655 / SANS 1655
SABS 1671 / SANS 1671-1

GENERAL WELDING SPECIFICATION:
- BUTT WELDING OF PIPES TO COMPLY TO SABS 0268-1:1999. SANS 10268-1
- HOT GAS WELDING TO COMPLY TO SABS 0268-3:1999. SANS 10268-3
- HOT GAS EXTRUSION WELDING TO COMPLY TO SABS 0268-4:1999. SANS 10268-4

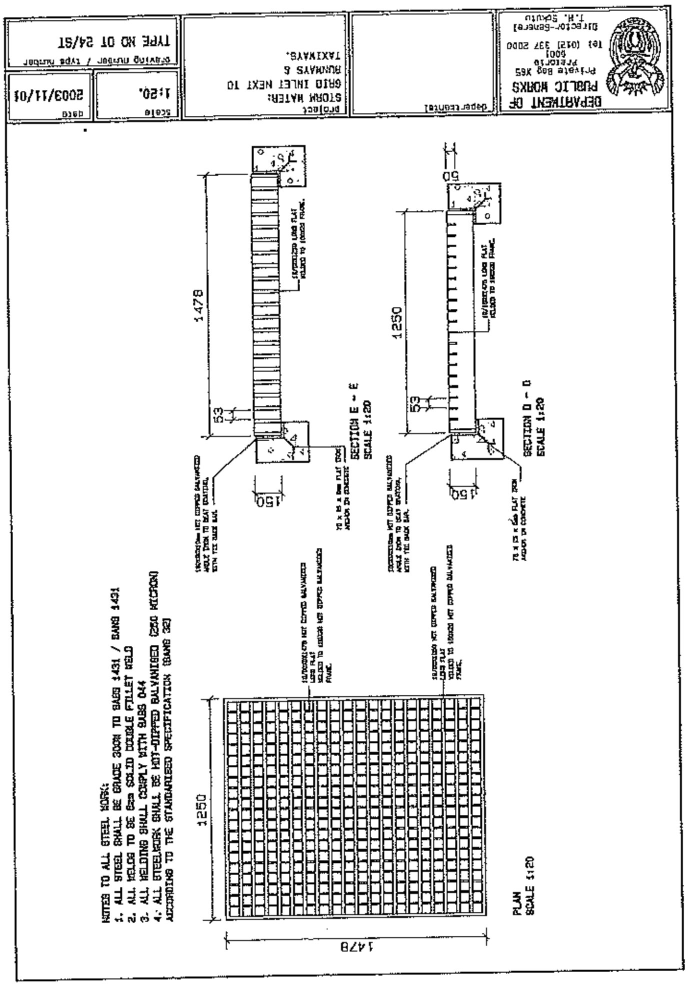
GENERAL FINISHING NOTE:
F1- REMOVE FILLER EXPULSION AND FINISH WELD SMOOTH WITH PIPE SURFACE.
F2- REMOVE FILLER EXPULSION AND FINISH WELD WITH SMOOTH ROUNDED EDGE.
F3- FINISH PIPE WITH SMOOTH ROUNDED EDGE.
F4- REMOVE INTERNAL WELDING BEAD.

WELDING NOTATION FOR JOINTS SEE SABS 0270 / SANS 10270 PAR 5 AS WELL AS ANNEX A.
W-1A = REF TABLE A.1 FILLET GROUP A FIG 1A.
W-2A = REF TABLE A.1 FILLET GROUP A FIG 2A.
W-3A = REF TABLE A.1 FILLET GROUP A FIG 3A.
W-3B = REF TABLE A.1 BUTT GROUP B FIG 3B.
W-BUTT = REF TABLE A.2 BUTT GROUP B



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	TYPICAL WELDING DETAILS FOR HDPE STORM WATER MANHOLE: SECTION C	AS SHOWN	10/27/2004
		drawing number / type number	
		TYPE NO DT 23/ST	



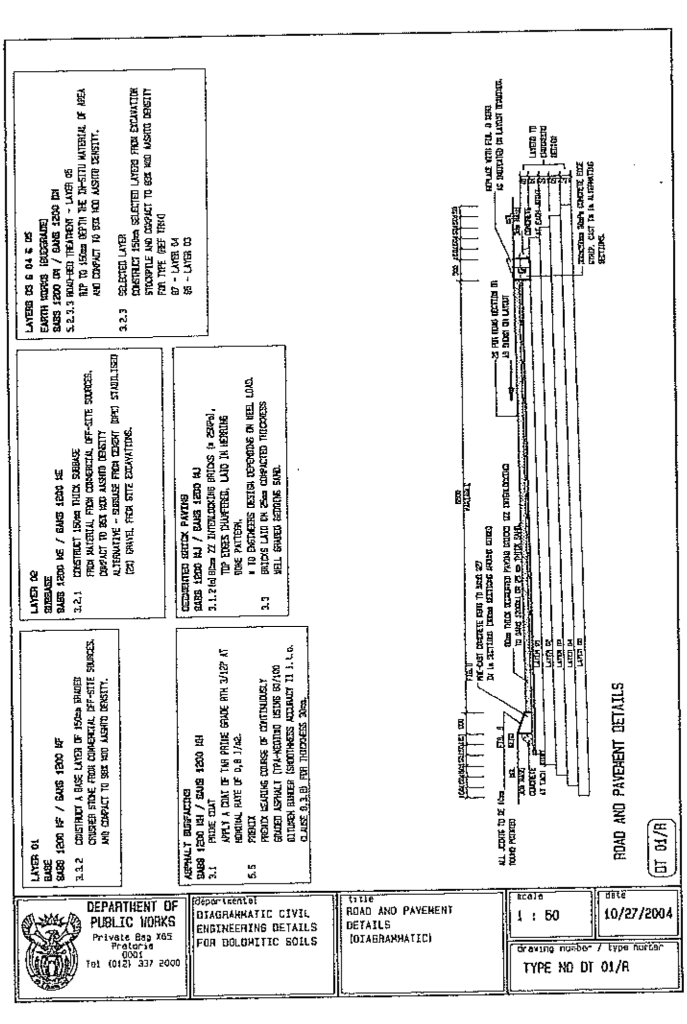
ROADS DETAILS

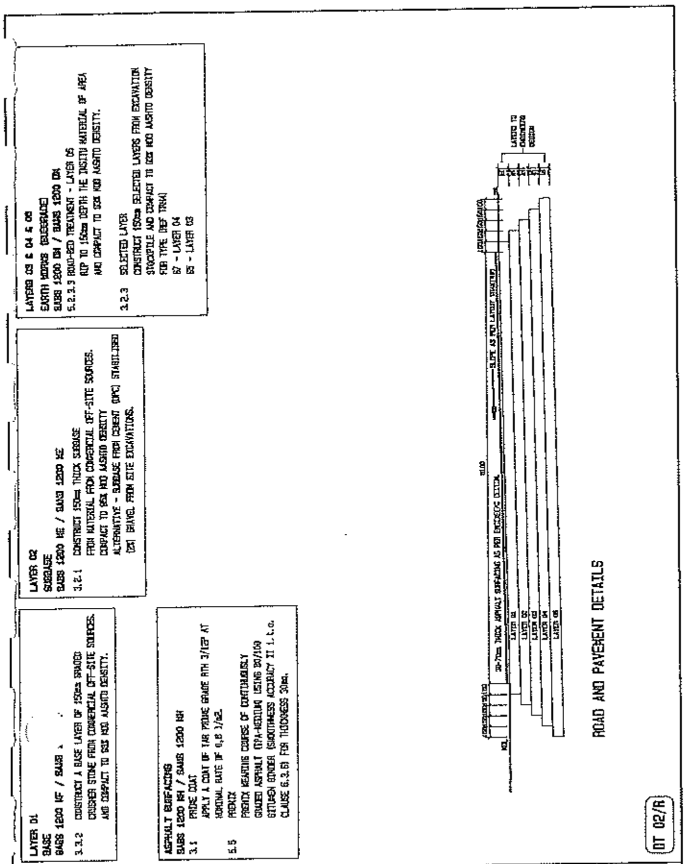
ROAD DETAILS: LIST OF DRAWINGS

DT 01/R ROAD AND PAVEMENT DETAILS
DT 02/R ROAD AND PAVEMENT DETAILS
DT 03/R ROAD AND PAVEMENT DETAILS
DT 04/R EARTHWORKS ON PAVEMENT

DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000
Director-General
T.W. Sotutu

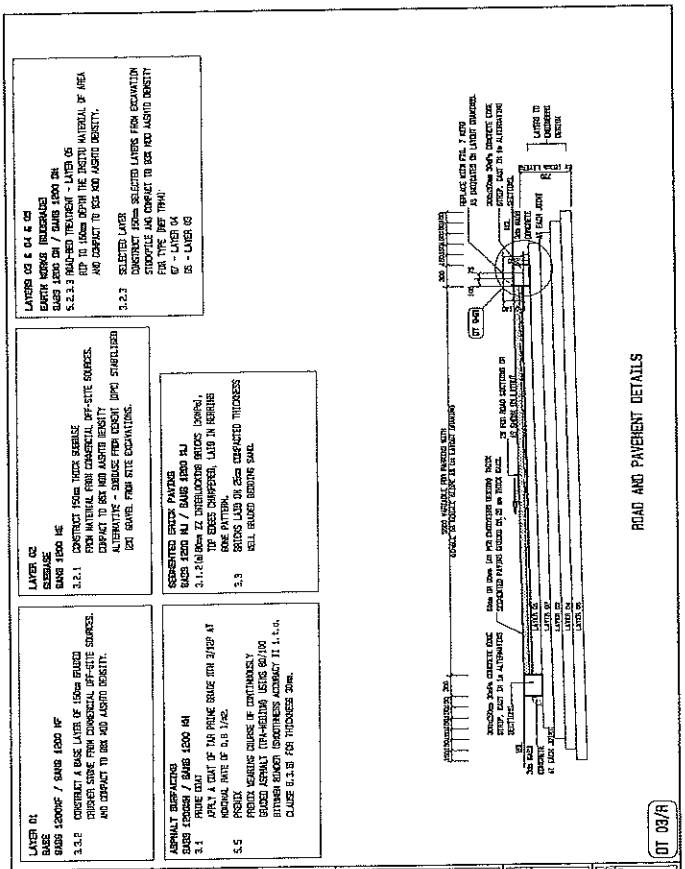
department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	DRAWING LIST.	-	10/27/2004
		drawing number / type number	
		TYPE NO DT 00/R	





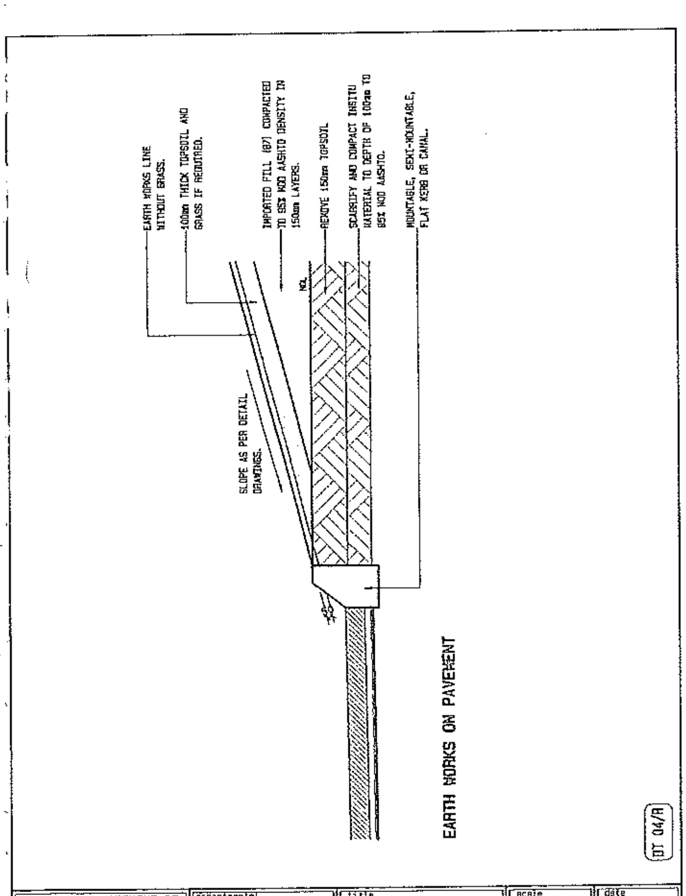
DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	ROAD AND PAVEMENT DETAILS (DIAGRAMMATIC)	1 : 50	10/27/2004
		drawing number / type number	TYPE NO DT 02/R



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	ROAD AND PAVEMENT DETAILS (DIAGRAMMATIC)	1 : 50	10/27/2004
		drawing number / type number	TYPE NO DT 03/R



DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	EARTH WORKS ON PAVEMENT (DIAGRAMMATIC)	1 : 30	10/27/2004
		drawing number / type number	TYPE NO DT 04/R

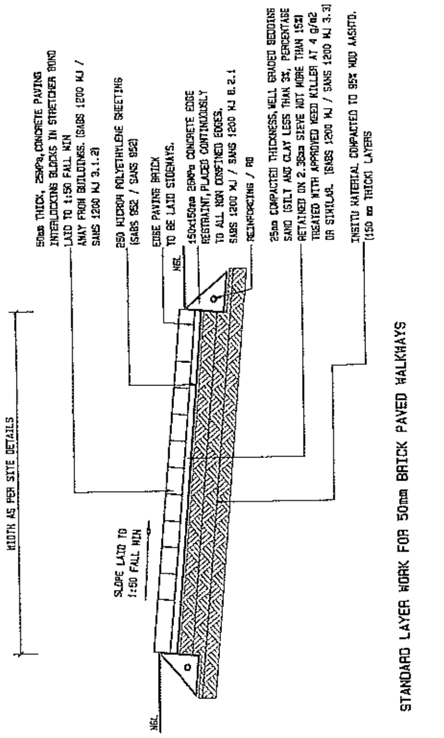
PAVING DETAILS

PAVING DETAILS: LIST OF DRAWINGS

DT 01/P	STANDARD LAYER WORK FOR 60mm BRICK PAVED WALKWAYS.
DT 02/P	STANDARD PAVING AROUND BUILDINGS
DT 03/P	STANDARD EDGE STRIPS FOR BRICK PAVED WALKWAYS.
DT 04/P	UNREINFORCED CONCRETE PAVEMENT SLAB NEXT TO BUILDINGS.
DT 05/P	UNREINFORCED CONCRETE PAVEMENT SLAB NEXT TO BUILDING AND ROADS.
DT 06/P	CONCRETE PAVEMENT SLAB WITH EDGE THICKENING.

DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000

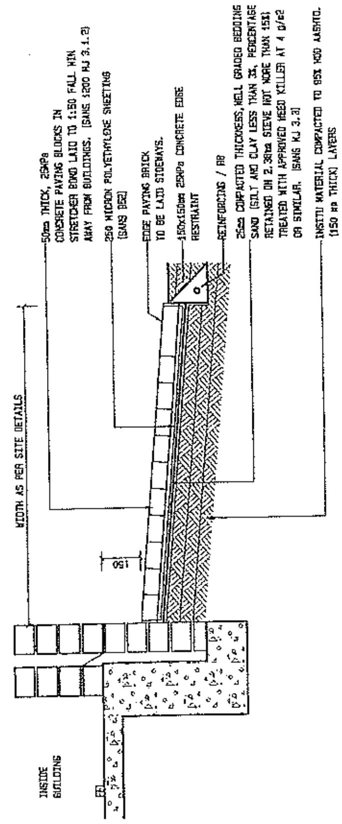
department	title	scale	date
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	DRAWING LIST.		10/27/2004
		drawing number / type number	TYPE NO DT 00/P



STANDARD LAYER WORK FOR 50mm BRICK PAVED WALKWAYS

DT 01/P

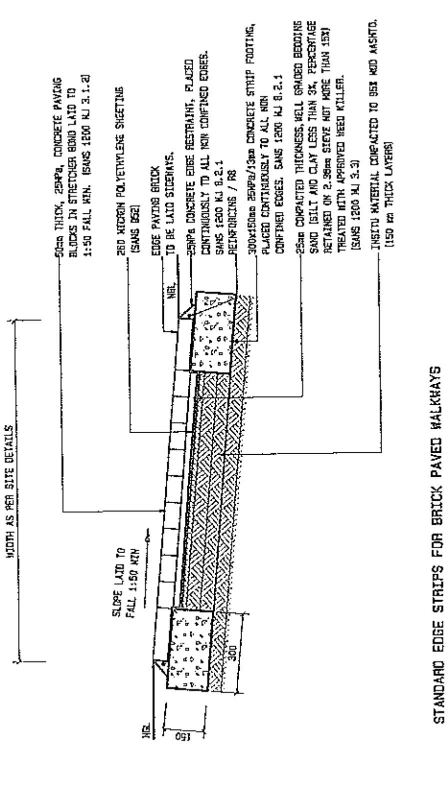
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STANDARD LAYER WORK FOR 50mm BRICK PAVED WALKWAYS (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 01/P	date 10/27/2004



STANDARD PAVING AROUND BUILDINGS

DT 02/P

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STANDARD PAVING AROUND BUILDINGS (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 02/P	date 10/27/2004

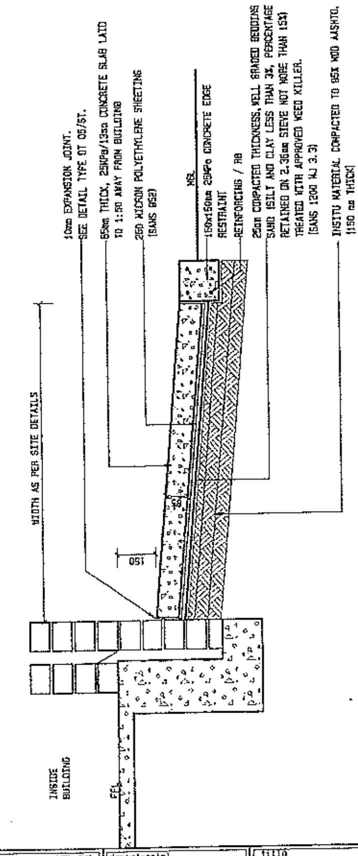


STANDARD EDGE STRIPS FOR BRICK PAVED WALKWAYS

DT 03/P

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title STANDARD EDGE STRIPS FOR BRICK PAVED WALKWAYS (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 03/P	date 10/27/2004

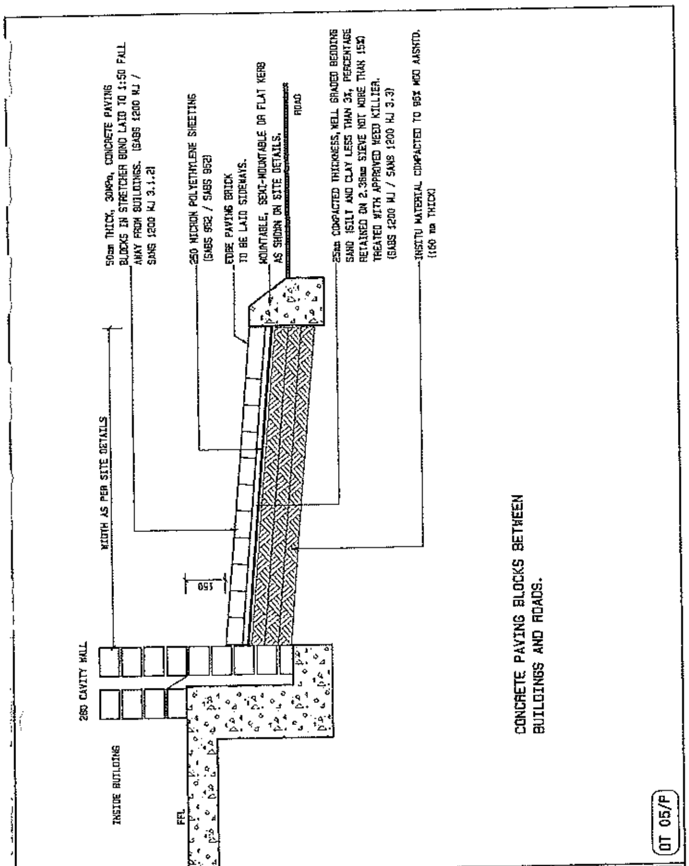
USE DETAIL FOR: 1. NEXT TO BUILDINGS
2. UNCONFINED WALKWAYS
(PLACE EDGE STRIP BOTH SIDES)



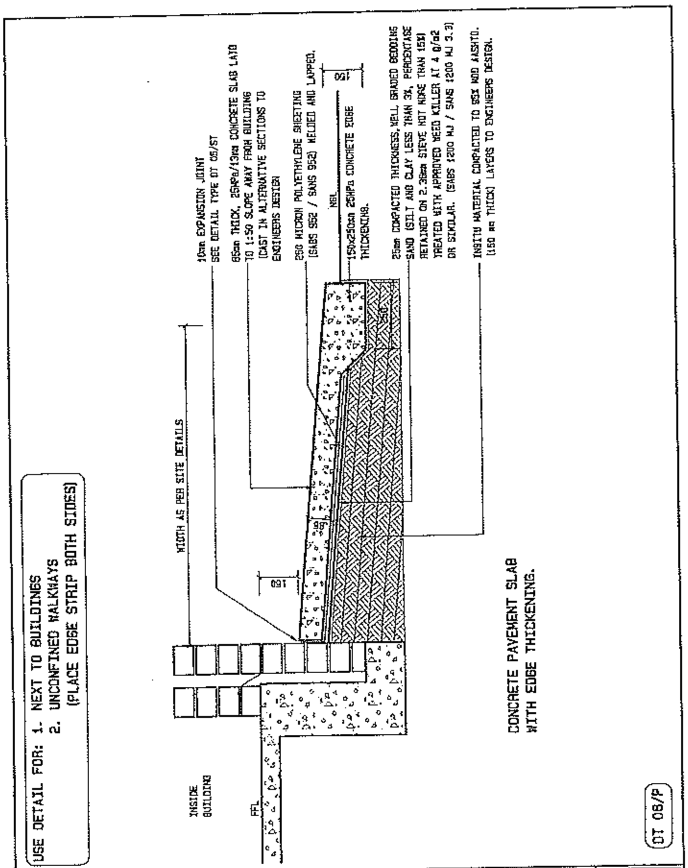
UNREINFORCED CONCRETE PAVEMENT SLAB NEXT TO BUILDINGS.

DT 04/P

DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	departmental DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title UNREINFORCED CONCRETE PAVEMENT SLAB NEXT TO BUILDINGS. (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 04/P	date 10/27/2004



DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title UNREINFORCED CONCRETE PAVEMENT BETWEEN BUILDINGS AND ROADS. (DIAGRAMMATIC)	scale 1 : 10 drawing number / type number TYPE NO DT 05/P	date 10/27/2004



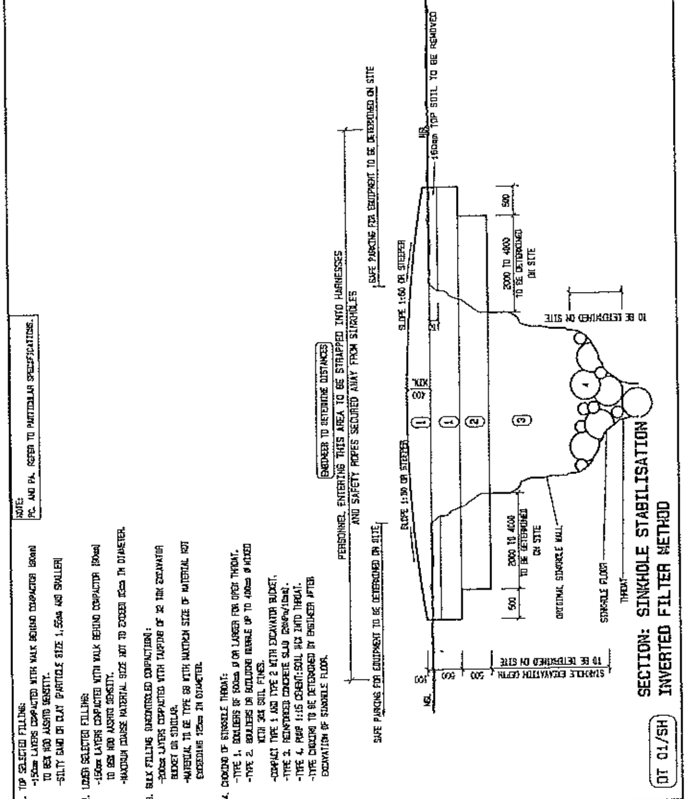
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title CONCRETE PAVEMENT SLAB WITH EDGE THICKENING. (DIAGRAMMATIC)	scale 1 : 20 drawing number / type number TYPE NO DT 08/P	date 10/27/2004

SINKHOLE DETAILS

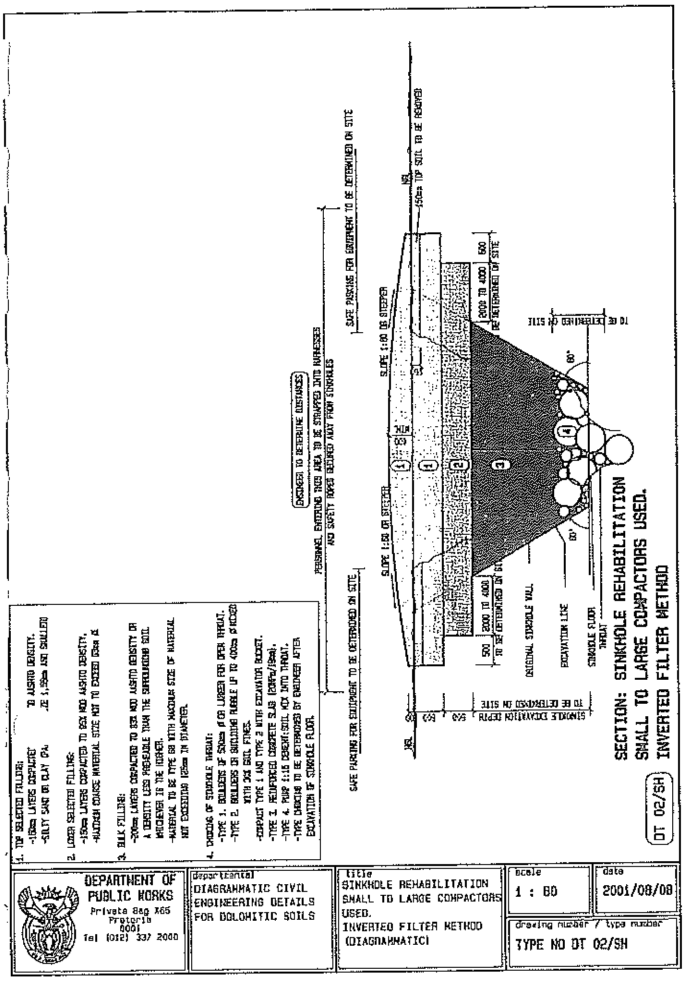
SINKHOLE DETAILS: LIST OF DRAWINGS

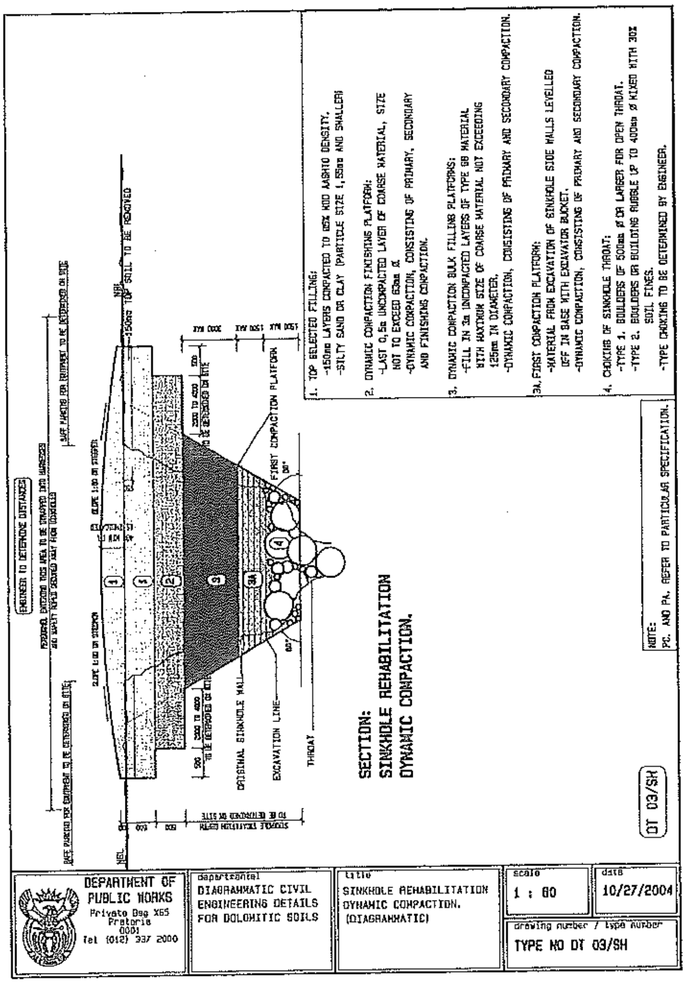
DT 01/SH	SINKHOLE STABILISATION INVERTED FILTER METHOD.
DT 02/SH	SINKHOLE REHABILITATION SMALL TO LARGE COMPACTORS USED. INVERTED FILTER METHOD.
DT 03/SH	SINKHOLE REHABILITATION DYNAMIC COMPACTION
DT 04/SH	DOLINE REHABILITATION DYNAMIC COMPACTION
SH	DOLINE REHABILITATION CONVENTIONAL COMPACTION.
DT 06/SH	FILLING OF LOW LAYING AREAS. (OPEN AREAS)
DT 07/SH	SETTING OUT GRID FOR DYNAMIC COMPACTION (PLAN)
DT 08/SH	EARTH WORKS TO IMPROVE STORMWATER DRAINAGE IN TRAFFICKED AREAS.

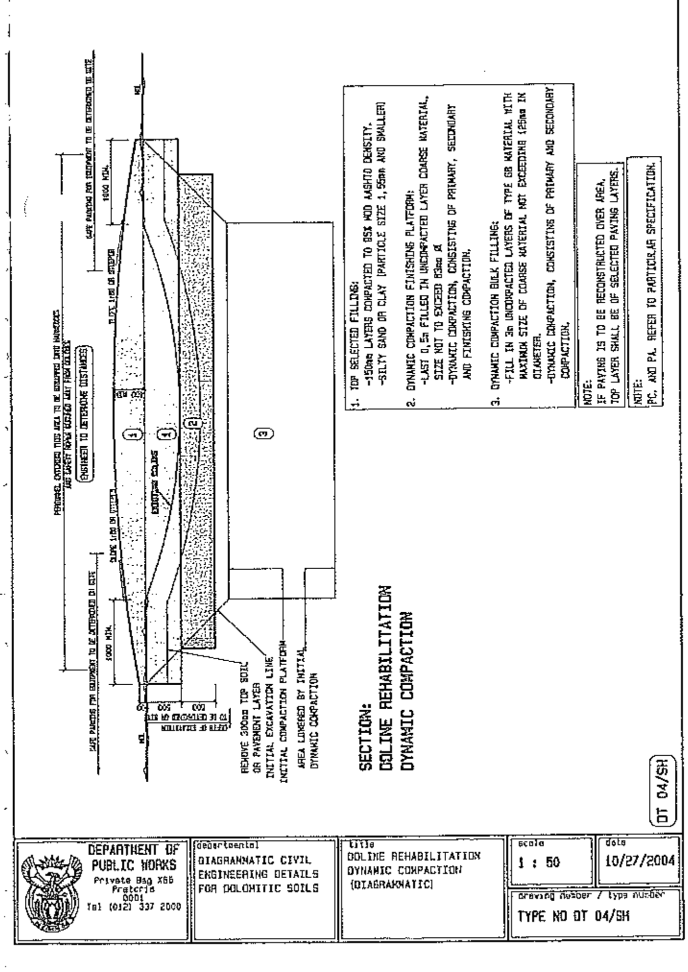
DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	title DRAWING LIST.	scale - drawing number / type number TYPE NO DT 00/SH	date 2001/08/08

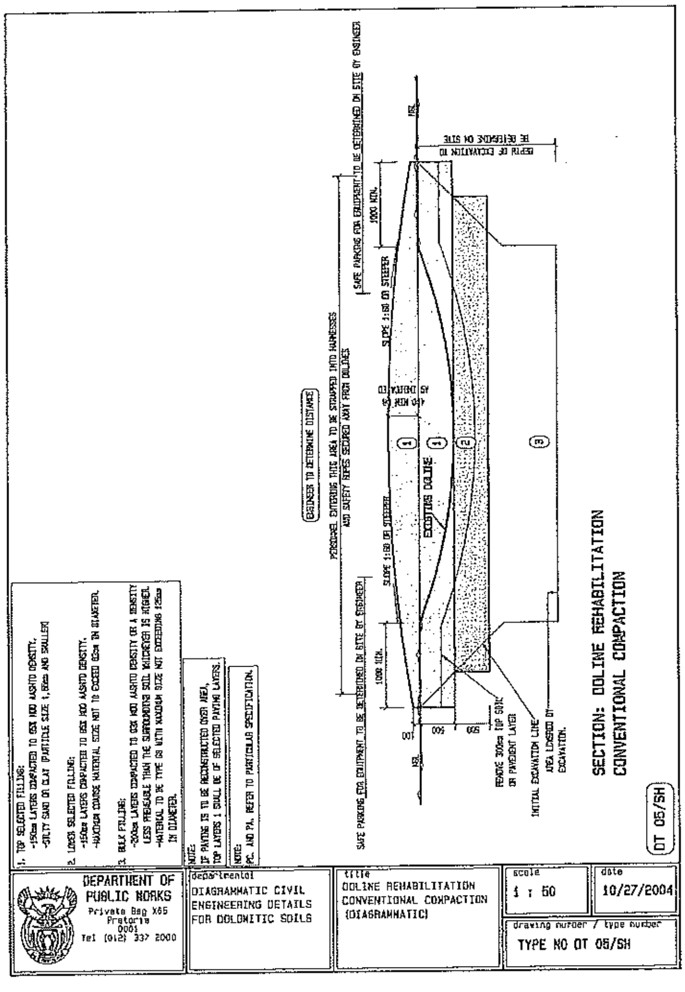


DEPARTMENT OF PUBLIC WORKS Private Bag X65 Pretoria 0001 Tel (012) 337 2000	department DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS	project SINKHOLE STABILISATION INVERTED FILTER METHOD (DIAGRAMMATIC)	scale 1 : 60 drawing number / type number TYPE NO DT 01/SH	date 10/27/2004

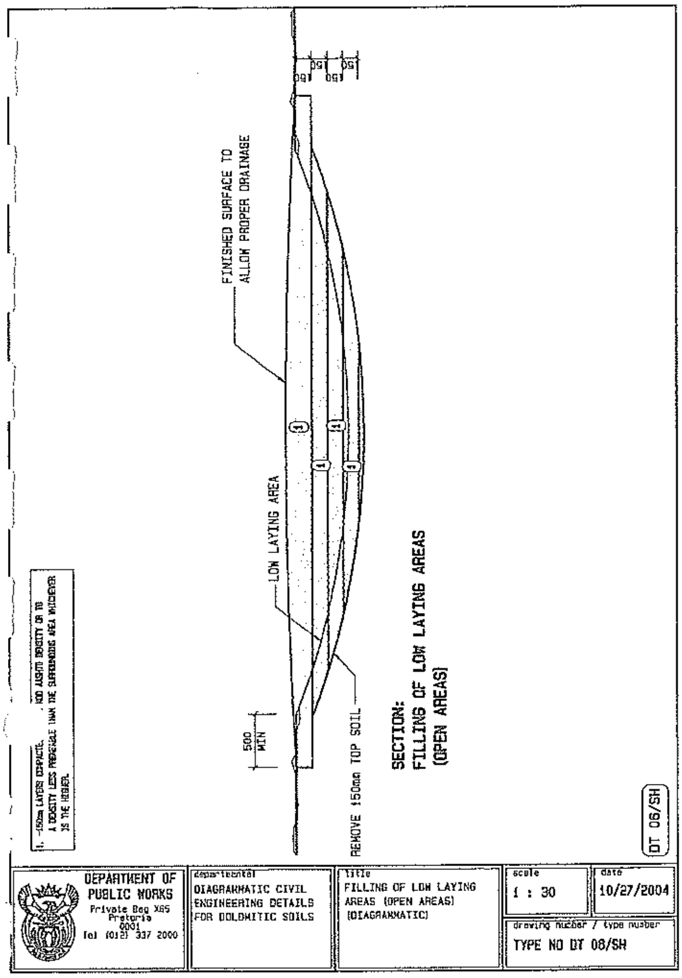

SECTION: SINKHOLE REHABILITATION
SMALL TO LARGE COMPACTORS USED.
INVERTED FILTER METHOD
DT 02/SH
DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
title
SINKHOLE REHABILITATION SMALL TO LARGE COMPACTORS USED. INVERTED FILTER METHOD (DIAGRAMMATIC)
scale
1 : 60
date
2001/08/08
drawing number / type number
TYPE NO DT 02/SH

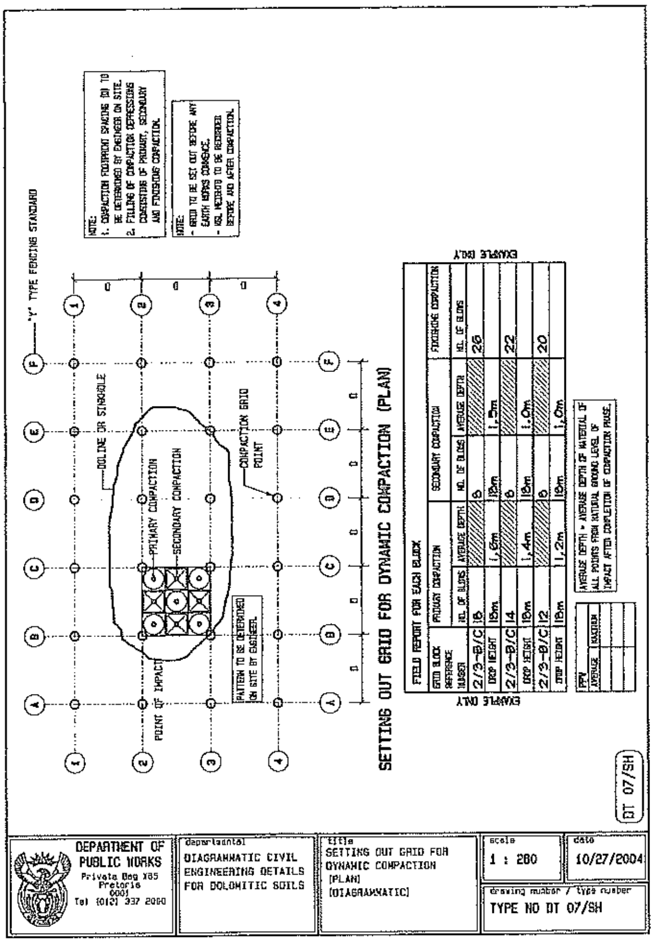

SECTION:
SINKHOLE REHABILITATION
DYNAMIC COMPACTION.
DT 03/SH
NOTE:
PC. AND PA. REFER TO PARTICULAR SPECIFICATION.
DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
title
SINKHOLE REHABILITATION DYNAMIC COMPACTION. (DIAGRAMMATIC)
scale
1 : 60
date
10/27/2004
drawing number / type number
TYPE NO DT 03/SH

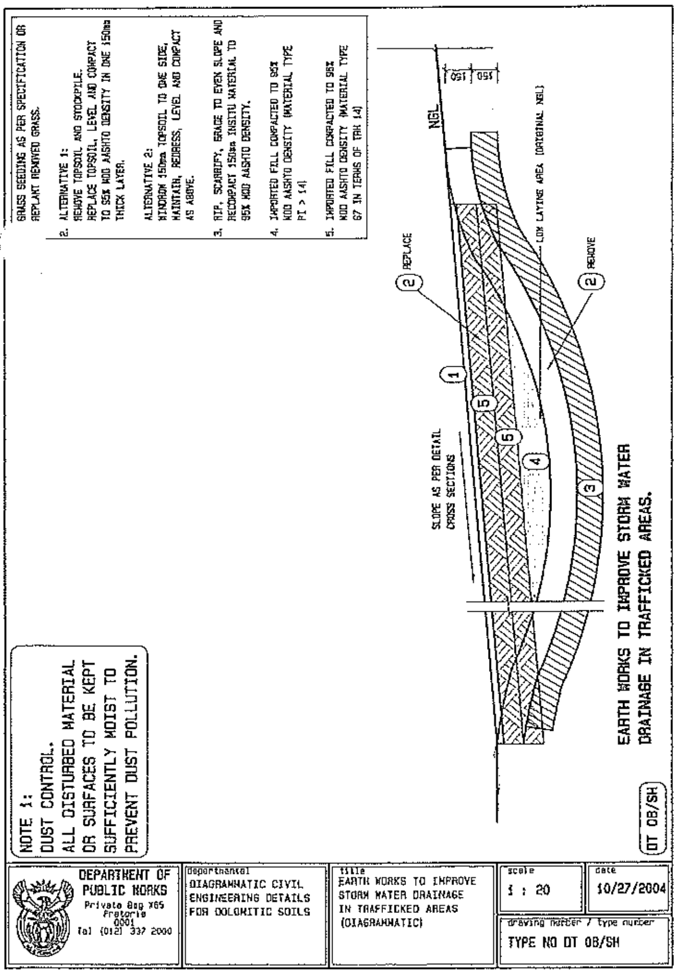

SECTION:
DOLINE REHABILITATION
DYNAMIC COMPACTION
DT 04/SH
NOTE:
PC. AND PA. REFER TO PARTICULAR SPECIFICATION.
DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
title
DOLINE REHABILITATION DYNAMIC COMPACTION (DIAGRAMMATIC)
scale
1 : 50
date
10/27/2004
drawing number / type number
TYPE NO DT 04/SH


SECTION: DOLINE REHABILITATION
CONVENTIONAL COMPACTION
DT 05/SH
DEPARTMENT OF PUBLIC WORKS
Private Bag X65
Pretoria
0001
Tel (012) 337 2000
departmental
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
title
DOLINE REHABILITATION CONVENTIONAL COMPACTION (DIAGRAMMATIC)
scale
1 : 50
date
10/27/2004
drawing number / type number
TYPE NO DT 05/SH

APPENDIX 6


FINISHED SURFACE TO ALLOW PROPER DRAINAGE
LOW LAYING AREA
500 MIN
REMOVE 150mm TOP SOIL
SECTION:
FILLING OF LOW LAYING AREAS
(OPEN AREAS)
DT 08/SH
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
FILLING OF LOW LAYING AREAS (OPEN AREAS) (DIAGRAMMATIC)
1 : 30
10/27/2004
TYPE NO DT 08/SH


"Y" TYPE FENCING STANDARD
DOLINE OR SINKHOLE
PRIMARY COMPACTION
SECONDARY COMPACTION
COMPACTION GRID POINT
POINT OF IMPACT
PATTERN TO BE DETERMINED ON SITE BY ENGINEER
SETTING OUT GRID FOR DYNAMIC COMPACTION (PLAN)
FIELD REPORT FOR EACH BLOCK
EXAMPLE ONLY
DT 07/SH
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
SETTING OUT GRID FOR DYNAMIC COMPACTION (PLAN) (DIAGRAMMATIC)
1 : 200
10/27/2004
TYPE NO DT 07/SH


NOTE 1:
DUST CONTROL.
ALL DISTURBED MATERIAL OR SURFACES TO BE KEPT SUFFICIENTLY MOIST TO PREVENT DUST POLLUTION.
NGL
REPLACE
REMOVE
LOW LAYING AREA (ORIGINAL NGL)
SLOPE AS PER DETAIL CROSS SECTIONS
EARTH WORKS TO IMPROVE STORM WATER DRAINAGE IN TRAFFICKED AREAS.
DT 08/SH
DEPARTMENT OF PUBLIC WORKS
Private Bag X65 Pretoria 0001
Tel (012) 337 2000
DIAGRAMMATIC CIVIL ENGINEERING DETAILS FOR DOLOMITIC SOILS
EARTH WORKS TO IMPROVE STORM WATER DRAINAGE IN TRAFFICKED AREAS (DIAGRAMMATIC)
1 : 20
10/27/2004
TYPE NO DT 08/SH

ANNEXURE D3a
WETLAND ASSESSMENT

REPORT

HYDROPEDOLOGY BASED WETLAND ASSESSMENT AND MANAGEMENT REPORT:

PROPOSED LEEUWPOORT SOUTH DEVELOPMENT, GAUTENG PROVINCE

3 May, 2016

Compiled by:
J.H. van der Waals
(PhD Soil Science, Pr.Sci.Nat.)
Member of:
Soil Science Society of South Africa (SSSSA)

Accredited member of:
South African Soil Surveyors Organisation (SASSO)

Registered with:
The South African Council for Natural Scientific Professions
Registration number: 400106/08

Declaration

I, Johan Hilgard van der Waals, declare that:

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing
  - any decision to be taken with respect to the application by the competent authority; and
  - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

J.H. VAN DER WAALS
TERRA SOIL SCIENCE

TABLE OF CONTENTS

HYDROPEDOLOGY BASED WETLAND ASSESSMENT AND MANAGEMENT REPORT: PROPOSED LEEUWPOORT SOUTH DEVELOPMENT, GAUTENG PROVINCE

1. INTRODUCTION

1.1 TERMS OF REFERENCE

Terra Soil Science was appointed by Bokamoso to conduct a hydropedology based wetland assessment and management investigation of the wetlands / watercourses on the proposed Leeuwpoort South development in the Gauteng Province. The focus of the investigation is to identify, delineate and asses the wetlands / watercourses on the site and to address specifically the functioning of the wetland/s, historical impacts and drivers of change in the wetland system, hydropedology parameters for the wetland and site as well as broad management interventions for water management and quality on the site.

1.2 AIM OF THIS REPORT

The aim of this report is to delineate and asses the wetlands / watercourses on the investigation site as well as to provide a hydropedology perspective on the functioning of the wetlands, historical impacts and drivers of change in the wetland system and elucidate the hydropedology parameters for the wetland/s and site. Ultimately the aim is to provide guidance on the understanding and management of the wetland systems on the site, should these be present, and the management of the site and water impacts should the development proceed.

1.3 DISCLAIMER

This report was generated under the regulations of NEMA (National Environmental Management Act) that guides the appointment of specialists. The essence of the regulations are 1) independence, 2) specialisation and 3) duty to the regulator. The independent specialist has, in accordance with the regulations, a duty to the competent authority to disclose all matters related to the specific investigation should he be requested to do such (refer to declaration above).

It is accepted that this report can be submitted for peer review (as the regulations also allow for such). However, the intention of this report is not to function as one of several attempts by applicants or competent authorities to obtain favourable delineation outcomes. Rather, the report is aimed at addressing specific site conditions in the context of current legislation, guidelines and best practice with the ultimate aim of ensuring the conservation and adequate management of the water resource on the specific site.

Due to the specific legal liabilities wetland specialists face when conducting wetland delineations and assessments this author reserves the right to, in the event that this report becomes part of a delineation comparison exercise between specialists, submit the report to the competent authorities, without entering into protracted correspondence with the client, as an independent report.

1.4 METHODOLOGY

The report was generated through:

1. The collection and presentation of baseline land type and topographic data for the site;
2. The thorough consideration of the statutory context of wetlands assessment and the process of wetland delineation;
3. The identification of water related landscape parameters (conceptual and real) for the site;
4. Aerial photograph interpretation of the site;
5. Assessment of historical impacts and changes on the site through the accessing of various historical aerial photographs and topographic maps;
6. Focused soil and site survey data interpretation in terms of soil properties as well as drainage feature properties;
7. Assessment of the functioning, status and hydropedology of the wetlands on the site; and
8. Presentation of the findings of the various components of the investigation.

2. SITE LOCALITY AND DESCRIPTION

2.1 SURVEY AREA BOUNDARY

The site lies between 26° 15’ 17’’ and 26° 17’ 14’’ south and 28° 14’ 22’’ and 28° 17’ 37’’ east in Boksburg in the Gauteng Province (**Figure 1**).

2.2 LAND TYPE DATA

Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System (MacVicar et al., 1977). The soil data was interpreted and re-classified according to the Taxonomic System (Soil Classification Working Group, 1991).

The site falls into the **Ab7** and **Bb3** land types (Land Type Survey Staff, 1972 - 2006) with **Figure 2** providing the land type distribution for the site. The **Ab7** land type is dominated by freely drained soils and the **Bb3** land type a distinct yellow plinthic catena soil sequence with structured soils in valley bottom positions.

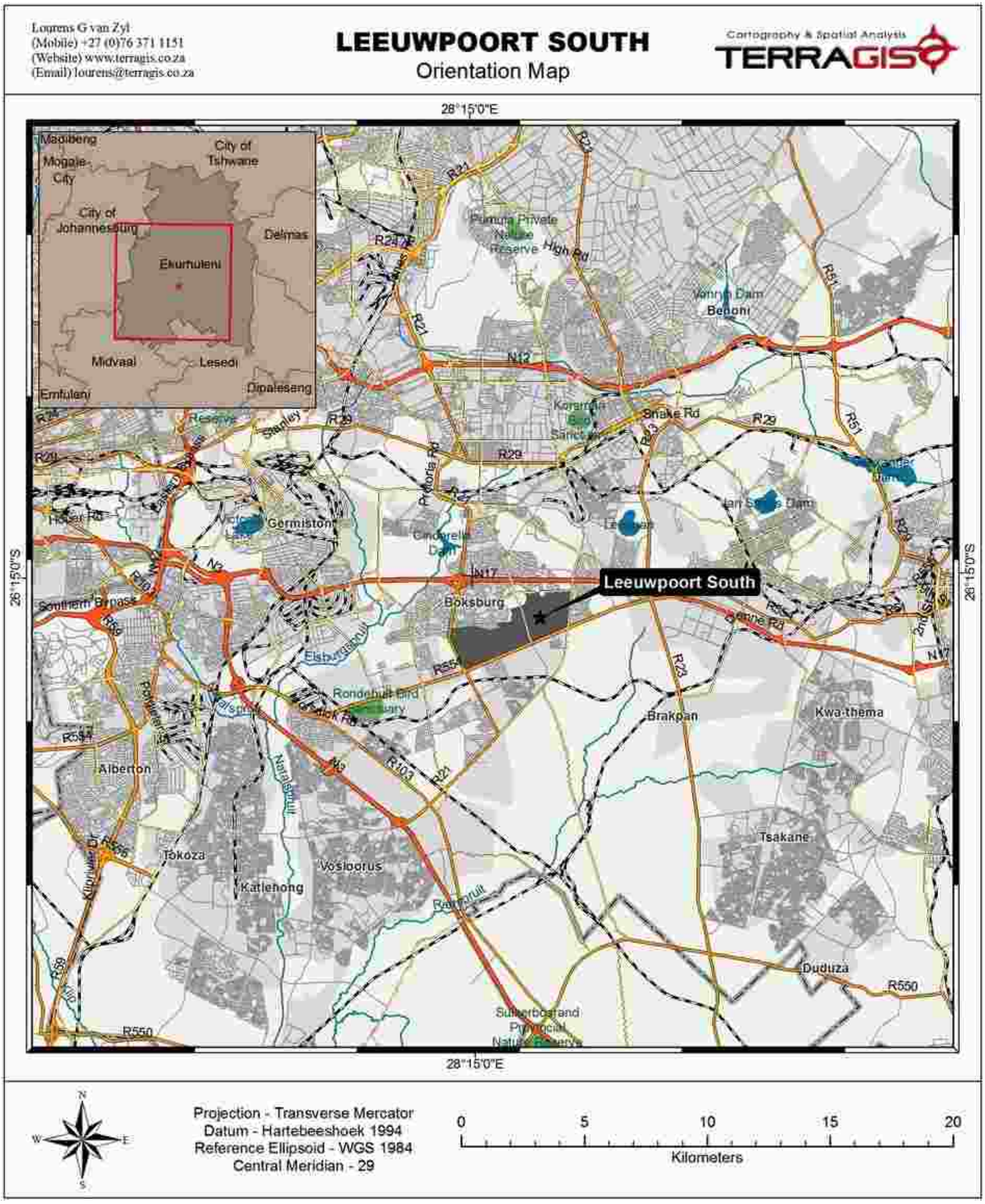


Figure 1 Locality of the survey site

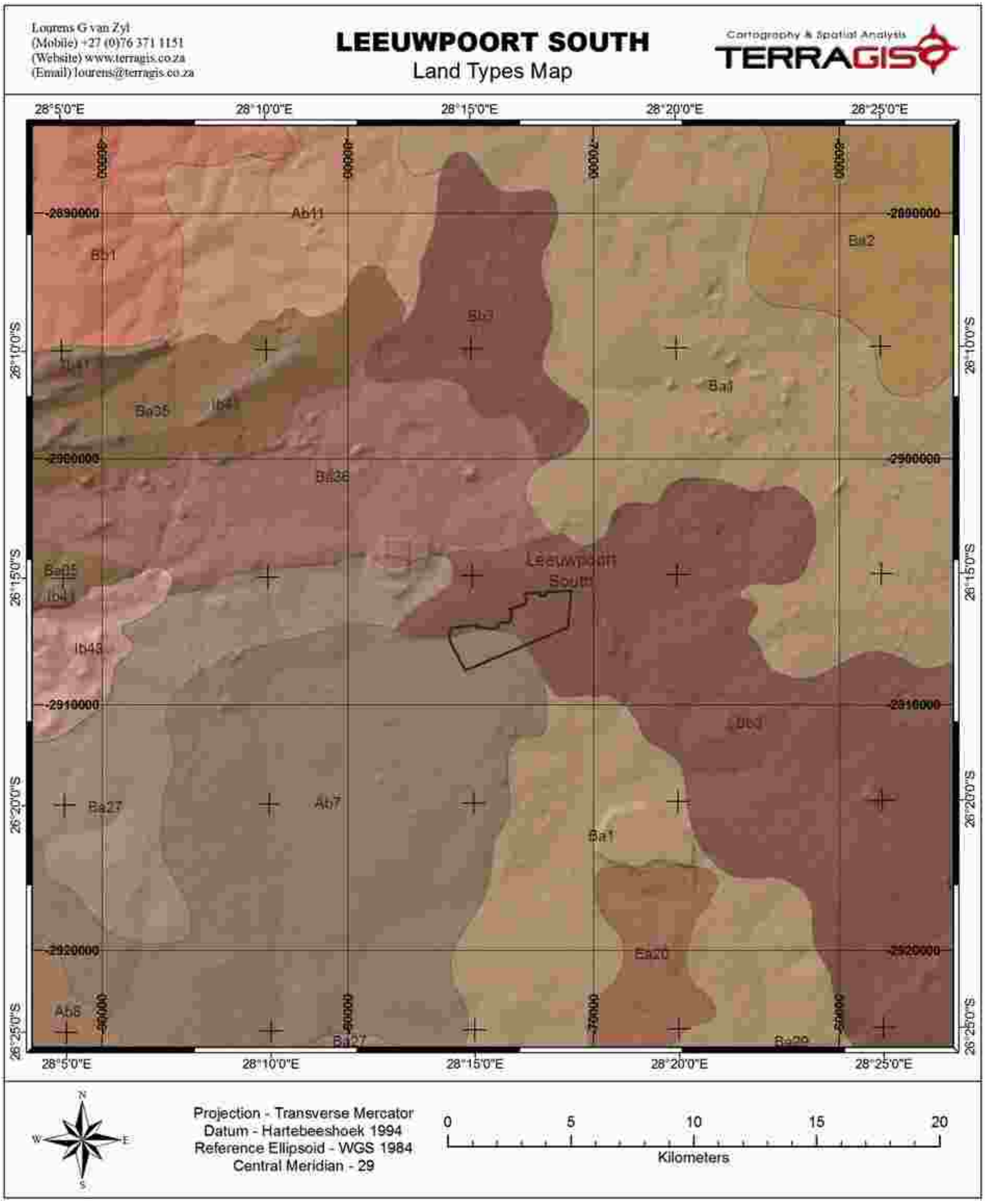


Figure 2 Land type map of the survey site and surrounding area

2.3 TOPOGRAPHY

The topography of the general area is predominantly flat to moderately undulating. The site slopes gently downwards to the west and is characterised by a distinct drainage depression draining out to the west. The eastern side is characterised by two pan depressions. The satellite image map for the site is provided in **Figure 3**. From contour data for the site a digital elevation model (DEM) was generated (**Figure 4**). The topographic data was further interpreted and the approaches and results are discussed later in the report.

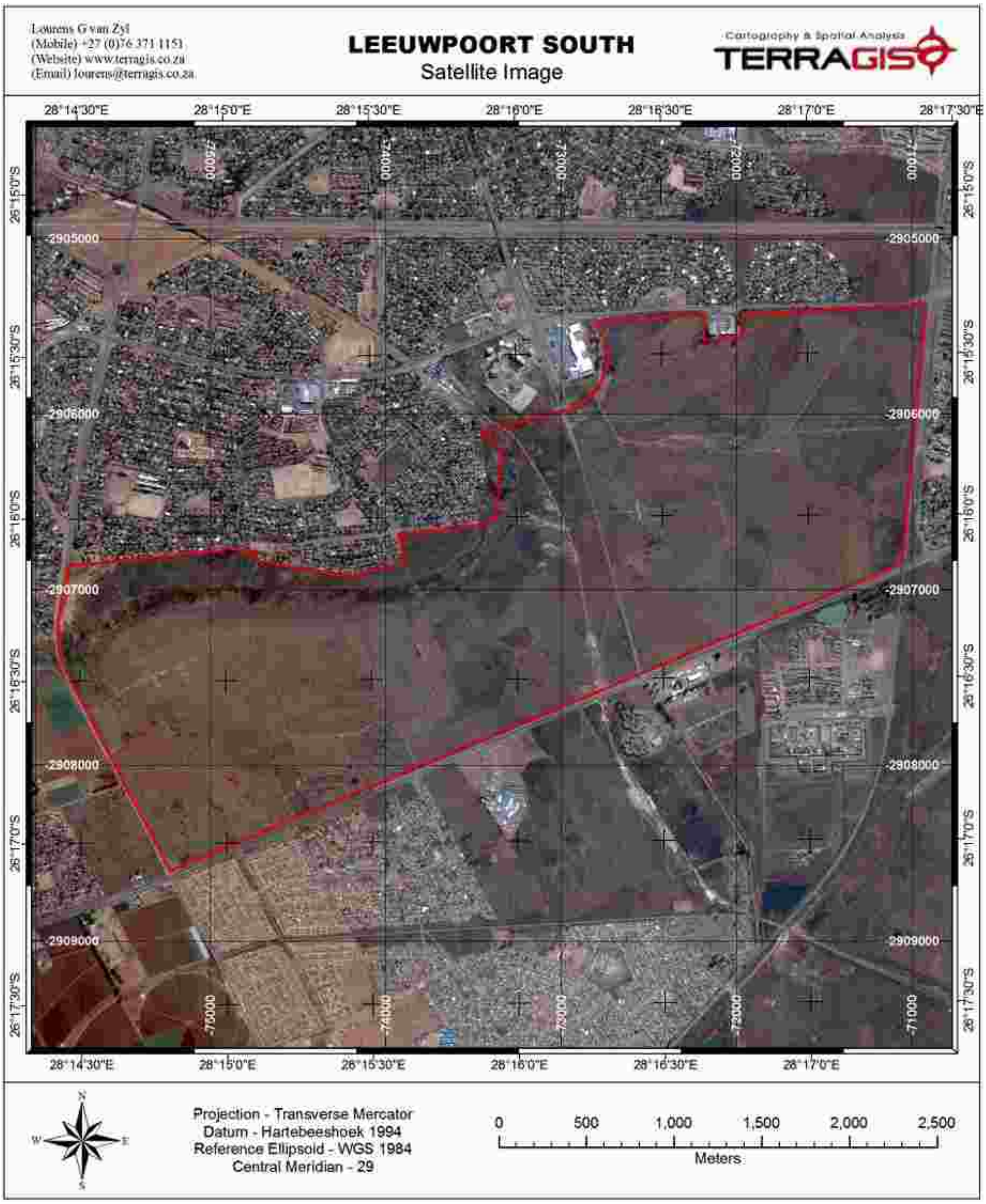


Figure 3 Satellite image map of the investigation area

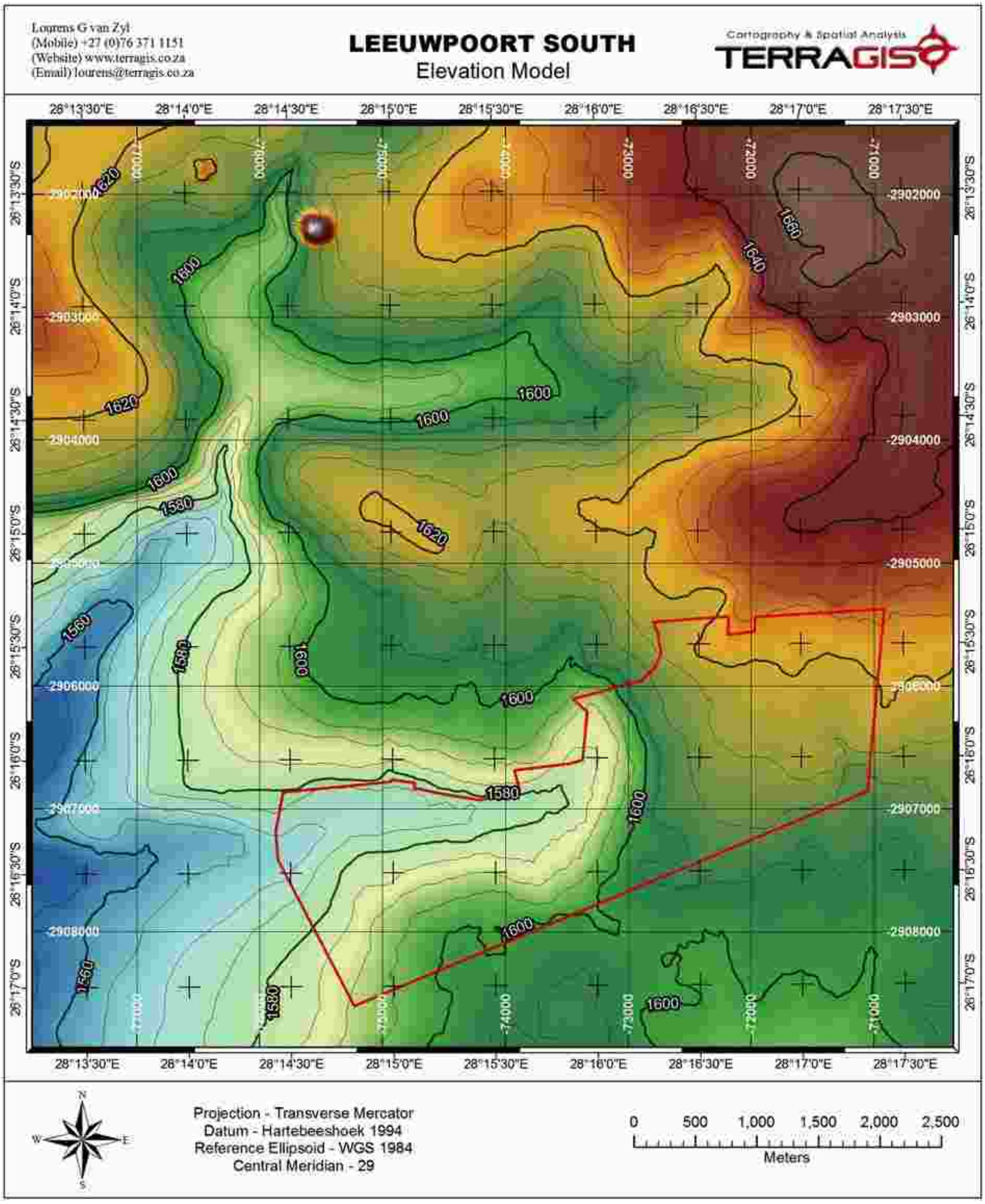


Figure 4 DEM of the survey site

3. PROBLEM STATEMENT

The Ab7 and Bb3 land types prove challenging to conduct wetland delineation assessments in as they have varying expression of redox morphology. The Ab7 land type is dominated by Mn rich soils derived from the dolomite parent material therefore leading to a very limited expression of redox morphology as a result of redox poise reactions by Mn. The Bb3 land type on the other hand is dominated by yellow and bleached soils plinthic soils (with very low Mn levels) as well as structured soils in depressions. The result is that the expression of wetness differs between the land types as the soils are differentially buffered in terms of redox morphology expression. The investigation site has also been impacted through historical mining and urban development activities that have impacts on the hydrological functioning and expression of wetness in terms of mottles and vegetation indicators. The hydrological characteristics of the plinthic soils on the site lead to very specific pollution risk pathways and chemical determinants that yield specific risk zones within the terrestrial and wetland areas. This investigation will therefore focus on the identification of the wetland features based on soil hydromorphy, landscape hydrology as well as various historical modifiers through a dedicated assessment and elucidation of hydropedological processes experienced in the catchment and on the site. A summary will be provided of the chemical risk factors associated with the dominant hydrological processes and historical activities on the site.

4. STATUTORY CONTEXT

The following is a brief summary of the statutory context of wetland delineation and assessment. Where necessary, additional comment is provided on problematic aspects or aspects that, according to this author, require specific emphasis.

4.1 WETLAND DEFINITION

Wetlands are defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

4.2 WATERCOURSE DEFINITION

"Catchment" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"…, in relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points;"

"Watercourse" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"*(a)* a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the *Gazette*, declare to be a water course,
and a reference to a watercourse includes, where relevant, its bed and banks;"

4.3 THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled "A practical field procedure for identification and delineation of wetland and riparian areas" (DWAF, 2005). The "…manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries." The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- "**Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation"
- "The presence, at least occasionally, of **water loving plants (hydrophytes)**"
- "A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil."

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.
- Soil Form Indicator. A number of soil forms (as defined by MacVicar et al., 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of "bleaching" and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use soils (soil form and wetness) as the criteria for the delineation of wetlands. The applicability of these guidelines in the context of the survey site will be discussed in further detail later in the report.

Due to numerous problems with the delineation of wetlands there are a plethora of courses being presented to teach wetland practitioners and laymen the required techniques. Most of the courses and practitioners focus on ecological or vegetation characteristics of landscapes and soil characteristics are often interpreted incorrectly due to a lacking soil science background of these practitioners. As such this author regularly presents, in conjunction with a colleague (Prof. Cornie van Huysteen) from the University of the Free Sate, a course on the aspects related to soil classification and wetland delineation.

4.4 THE RESOURCE DIRECTED MEASURES FOR PROTECTION OF WATER RESOURCES

The following are specific quotes from the different sections of the "Resource Directed Measures for Protection of Water Resources." as published by DWAF (1999).

4.4.1 The Resource Directed Measures for Protection of Water Resources: Volume 4: Wetland Ecosystems.

<u>From the Introduction:</u>

"This set of documents on Resource Directed Measures (RDM) for protection of water resources, issued in September 1999 in Version 1.0, presents the procedures to be followed in undertaking **preliminary determinations of the class, Reserve and resource quality objectives for water resources**, as specified in sections 14 and 17 of the South African National Water Act (Act 36 of 1998).

The development of procedures to determine RDM was initiated by the Department of Water Affairs and Forestry in July 1997. Phase 3 of this project will end in March 2000. Additional refinement and development of the procedures, and development of the full water resource classification system, will continue in Phase 4, until such time as the detailed procedures and full classification system are ready for publication in the Government Gazette.

It should be noted that until the final RDM procedures are published in the Gazette, and prescribed according to section 12 of the National Water Act, all determinations of RDM, whether at the rapid, the intermediate or the comprehensive level, will be considered to be preliminary determinations."

4.4.2 The Resource Directed Measures for Protection of Water Resources: Generic Section "A" for Specialist Manuals – Water Resource Protection Policy Implementation Process

"Step 3: Determine the reference conditions of each resource unit"

"What are reference conditions?"

"The determination of reference conditions is a very important aspect of the overall Reserve determination methodology. Reference conditions describe the natural unimpacted characteristics of a water resource. Reference conditions quantitatively describe the ecoregional type, specific to a particular water resource."

4.4.3 The Resource Directed Measures for Protection of Water Resources: Appendix W1 (Ecoregional Typing for Wetland Ecosystems)

Artificial modifiers are explained namely:

"Many wetlands are man-made, while others have been modified from a natural state to some degree by the activities of humans. Since the nature of these alterations often greatly influences the character of such habitats, the inclusion of modifying terms to accommodate human influence is important. In addition, many human modifications, such as dam walls and drainage ditches, are visible in aerial photographs and can be easily mapped. The following Artificial Modifiers are defined and can be used singly or in combination wherever they apply to wetlands:

Farmed: the soil surface has been physically altered for crop production, but hydrophytes will become re-established if farming is discontinued

Artificial: substrates placed by humans, using either natural materials such as dredge spoils or synthetic materials such as concrete. Jetties and breakwaters are examples of Non-vegetated Artificial habitats

Excavated: habitat lies within an excavated basin or channel

Diked/Impounded: created or modified by an artificial barrier which obstructs the inflow or outflow of water

Partially Drained: the water level has been artificially lowered, usually by means of ditches, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes."

4.4.4 The Resource Directed Measures for Protection of Water Resources: Appendix W4 IER (Floodplain Wetlands) Present Ecological Status (PES) Method

In Appendix W4 the methodology is provided for the determination of the present ecological status (PES) of a palustrine wetland.

The present ecological state (PES) of the wetland was determined according to the method described in "APPENDIX W4: IER (FLOODPLAIN WETLANDS) PRESENT ECOLOGICAL STATUS (PES) METHOD" of the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999). However, the PES methodology already forms an adaptation from the methodology to assess palustrine wetlands. Hillslope seepage wetlands have a range of different drivers and as such some modification of the criteria has been made by this author to accommodate the specific hydropedology drivers of hillslope seepage wetlands.

The criteria as described in Appendix 4 is provided below with the relevant modification or comment provided as well.

The summarised tasks in the PES methodology are (for detailed descriptions refer to the relevant documentation):

1. Conduct a literature review (review of available literature and maps) on the following:
   a. Determine types of development and land use (in the catchment in question).
   b. Gather hydrological data to determine the degree to which the flow regime has been modified (with the "virgin flow regime" as baseline). The emphasis is predominantly on surface hydrology and hydrology of surface water features as well as the land uses, such as agriculture and forestry, that lead to flow modifications. Important Note: The hydropedology of landscapes is not explicitly mentioned in the RDM documentation and this author will make a case for its consideration as probably the most important component of investigating headwater systems and seepage wetlands and areas.
   c. Assessment of the water quality as is documented in catchment study reports and water quality databases.
   d. Investigate erosion and sedimentation parameters that address aspects such as bank erosion and bed modification. Important Note: The emphasis in the RDM documentation is again on river and stream systems with little mention of erosion of headwater and seepage zone systems. Again a case will be made for the emphasis of such information generation.
   e. Description of exotic species (flora and fauna) in the specific catchment in question.
2. Conduct and aerial photographic assessment in terms of the parameters listed above.
3. Conduct a site visit and make use of local knowledge.
4. Assess the criteria and generate preliminary PES scores.
5. Generation of report.

Table 1 presents the scoresheet with criteria for the assessment of habitat integrity of palustrine wetlands (as provided in the RDM documentation).

Table 1 "Table W4-1: Scoresheet with criteria for assessing Habitat Integrity of Palustrine Wetlands (adapted from Kleynhans 1996)"

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.		
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for		

	wetland biota.		
Water Quality			
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.		
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.		
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.		
Biota			
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.		
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.		
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).		
Alien fauna	Presence of alien fauna affecting faunal community structure.		
Overutilisation of biota	Overgrazing, Over-fishing, etc		
TOTAL MEAN			

Scoring guidelines per attribute:

natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.

Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Important Note: The present ecological state (PES) determination is, as discussed earlier in the report, based on criteria originally generated for palustrine and floodplain wetlands. Seepage wetlands very rarely have the same degree of saturation or free water and consequently often do not have permanent wetland zones. These wetlands are therefore often characterised by seasonal or temporary properties and as such a standard PES approach is flawed. The existing criteria is provided below as is a comment on the applicability as well as proposed improvements.

Criteria

Hydrological Criteria

- "Flow modification: Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland." Comment: Although the description is wide it is very evident that seepage or hillslope wetlands do not become inundated but rather are fed by hillslope return flow processes. The main criterion should therefore be the surface and subsurface hydrological linkages expressed as a degree of alteration in terms of the surface, hydropedology and groundwater hydrology.
- "Permanent inundation: Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota." Comment: Mostly not applicable to hillslope seepage wetlands.

Water Quality Criteria

- "Water quality modification: From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland." Comment: Water quality in this context applies generally but cognisance should be taken of seepage water quality that can be natural but significantly different to exposed water bodies. The main reason for this being the highly complex nature of many redox processes within the hillslope.
- "Sediment load modification: Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats." Comment: This is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences.

Hydraulic / Geomorphic Criteria

- "Canalisation: Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.

- "Topographic Alteration: Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.

Biological Criteria

- "Terrestrial encroachment: Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.
- "Indigenous vegetation removal: Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion."
- "Invasive plant encroachment: Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading)."
- "Alien fauna: Presence of alien fauna affecting faunal community structure."
- "Overutilisation of biota: Overgrazing, Over-fishing, etc."

Scoring Guidelines

Scoring guidelines per attribute:
Natural, unmodified = 5
Largely natural = 4
Moderately modified = 3
Largely modified = 2
Seriously modified = 1
Critically modified = 0

Relative confidence of score:
Very high confidence = 4
High confidence = 3
Moderate confidence = 2
Marginal/low confidence = 1

4.4.5 The Resource Directed Measures for Protection of Water Resources: Appendix W5 IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC)

In Appendix W5 the methodology is provided for the determination of the ecological importance and sensitivity (EIS) and ecological management class (EMC) of floodplain wetlands.

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC)." Please refer to the specific document for more detailed information.

The following primary determinants are listed as determining the EIS:

1. Rare and endangered species
2. Populations of unique species
3. Species / taxon richness
4. Diversity of habitat types or features
5. Migration route / breeding and feeding site for wetland species
6. Sensitivity to changes in the natural hydrological regime
7. Sensitivity to water quality changes
8. Flood storage, energy dissipation and particulate / element removal

The following modifying determinants are listed as determining the EIS:

1. Protected status
2. Ecological integrity

4.5 NATIONAL NORMS AND STANDARDS FOR THE REMEDIATION OF CONTAMINATED LAND (NSCLA) (GN R.331 OF 2014)

4.5.1 Limitations of the NSCLA

The assessment of contaminated land is conducted in accordance with the National Norms and Standards for the Remediation of Contaminated Land (NSCLA) (GN R.331 of 2014). The NSCLA is an outflow of Part 8 (Sections 35 to 41) of the National Environmental Management Waste Act (Act 59 of 2008) and it was implemented on the 2nd of May, 2014 (Papenfus, et al, 2015).

Papenfus et al, (2015) discusses some of the challenges regarding the use of the NSCLA in various soils. These challenges pertain to the main assumptions that were made in the generation of the soil screening values (SSV) in that soil pH values were assumed to be 7 and set distribution coefficients (K_d values – indicative of the soil and water mobile fraction of a particular element/compound) were adopted. The thrust of the challenge is the fact that soils are much more variable and investigations conducted by Papenfus et al, (2015) confirm these concerns. The implication is that the NSCLA cannot be used with certainty as the variables in natural and polluted environments render the SSV values moot.

The NSCLA also omits elements that are of concern in mining environments such as uranium and does not indicate how to deal with highly acidified and salt impacted soils and materials present in current and old mining impact areas.

4.5.2 Uranium

Uranium has been shown in recent years to exhibit a chemical toxicity risk signature far in excess of its radiological risk signature at low concentrations and in this regard the international norm for a maximum concentration in drinking water is 2-3 µg/l. From several confidential investigations conducted by the author and colleagues, as well as published reports (Coetzee, 2006), it is evident that U levels in soils, soil water and surface waters in areas of the Witwatersrand far exceed the recommended international norms.

The chemistry of U is complex and in soil it follows certain patterns. A detailed discussion will not be provided here except for indicating that U is mobilised (solubilised) in soils in its oxidised state (U(VI)) and in the presence of carbonates and it is immobilised in organic sediments and in its reduced state (U(IV)). Land remediation processed that involve liming of acid mine impact soils and spoil material will mobilise U where as the U will accumulate in wetland areas where organic matter contents are higher and where reducing conditions prevail. It therefore follows that the presence and condition of wetlands on a polluted site play a very large role in the determination of pollution risk and contamination characteristics.

4.6 SUMMARY AND PROPOSED APPROACH

When working in environments where the landscape and land use changes are significant (such as urban and mining environments) it is important to answer the following critical questions regarding the assessment and management planning for wetlands:

1. What is the reference condition?
2. What is the difference between the reference condition and the current condition and how big is this difference from a hydrological driver perspective?
3. What are the hydrological drivers (as a function of geology, topography, rainfall and soils) and what are the relative contributions of these drivers to the functioning of the wetland system?
4. What is the intended or planned land use in the wetland as well as terrestrial area and how will these developments impact on the hydrology of the landscape and wetlands?
5. How can the intended land use be plied to secure the best possible hydrological functioning of the landscape in terms of storm water attenuation, erosion mitigation and water quality?

6. What are the site and wetland remedial actions to be taken to assess and prevent pollutant mobilisation on the site and reduce the risk of future site development to workers and inhabitants / land users.

The key to the generation of adequate information lies in the approach that is to be followed. In the next section an explanation about and motivation in favour of will be provided for a hydropedology assessment approach. Due to the detailed nature of the information that can be generated through such an approach it is motivated that all wetland assessments be conducted with the requirements of criminal law in mind. The main reason for this is the fact that many well-meaning administrative exercises often yield not tangible results due to the gap in terms of information that is required should there be a compliance process followed.

To Summarise:

During wetland assessments and delineations it is important to provide a perspective on assessment tools, the original or reference state of the wetland, the assessment process and outcome as well as the intended or possible state of the wetland and site post development. Urban and mining developments are good examples of cases where surrounding developments and land use changes have significant effects on wetland integrity and water quality emanating from the site.

5. CHALLENGES REGARDING WETLAND DELINEATION AND HYDROPEDOLOGY ASSESSMENTS IN DOLOMITIC AND PLINTHIC ENVIRONMENTS

[redacted]

In order to discuss the procedures followed and the results of the wetland identification exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

5.1 PEDOGENESIS

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely (Jenny, 1941):

- Parent material;
- Climate;
- Topography;
- Living Organisms; and
- Time.

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

5.2 WATER MOVEMENT IN THE SOIL PROFILE

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards under the influence of gravity.

The following needs to be highlighted in order to discuss water movement in soil:

- Capillary rise refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

  $$\text{Height} = 0.15/\text{radius}$$

  Usually the eventual height of rise is greater in fine textured soil, but the rate of flow may be slower (Brady and Weil, 1999; Hillel, 1983).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

The maximum amount of water that a soil profile can hold before leaching occurs is called the field capacity of the soil. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady and Weil, 1999; Hillel, 1983).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

  Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

  Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$), in the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$). This amount of water differs according to soil type, structure and texture (Brady and Weil, 1999; Hillel, 1983).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

  The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

  $$Q = Ksat.A.\Delta P/L$$

  Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

  Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady and Weil, 1999; Hillel, 1983).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. The driving force behind unsaturated water flow is matric potential. Water movement will be from a moist to a drier zone (Brady and Weil, 1999; Hillel, 1983).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

  $$I = Q/A.t$$

  Where I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water (m^3), A is the area of the soil surface exposed to infiltration (m^2), and t is time (s).

  If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit a high 2:1 clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady and Weil, 1999; Hillel, 1983).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially the down pouring of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water is moving into the underlying soil in response to both matric and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady and Weil, 1999; Hillel, 1983).

  The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady and Weil, 1999; Hillel, 1983). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. The macropores of the coarse textured sand offer less attraction to the water molecules than the macropores of the fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matric potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady and Weil, 1999; Hillel, 1983).

A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady and Weil, 1999; Hillel, 1983).

Field observations and laboratory-based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991.) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – an horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);
- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown apedal B-horizon).

5.3 WATER MOVEMENT IN THE LANDSCAPE

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials. The movement of water in these materials is dominantly subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. **Figure 5** provides a simplified schematic representation of an idealised landscape (in "profile curvature". The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape.

The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

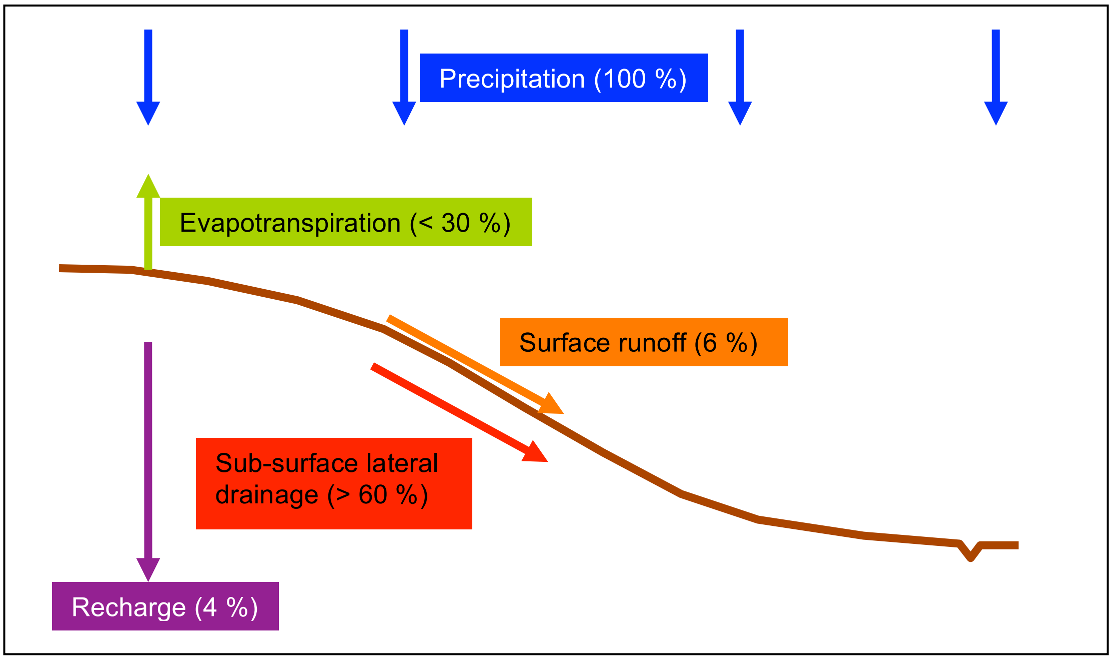


Figure 5 Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %).

Flow paths through soil and geological strata, referred to as “interflow” or “hillslope water”, are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as “redox morphology”. In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories. **Figure 6** provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as 1) recharge (vertically downwards) of groundwater; 2) lateral flow of water through the landscape along the hillslope (interflow or hillslope water); 3) return flow water that intercepts the soil/landscape surface; and 4) surface runoff. Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are: a) valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water); b) hillslope seepage wetlands (fed by interflow water and/or return flow water); and wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

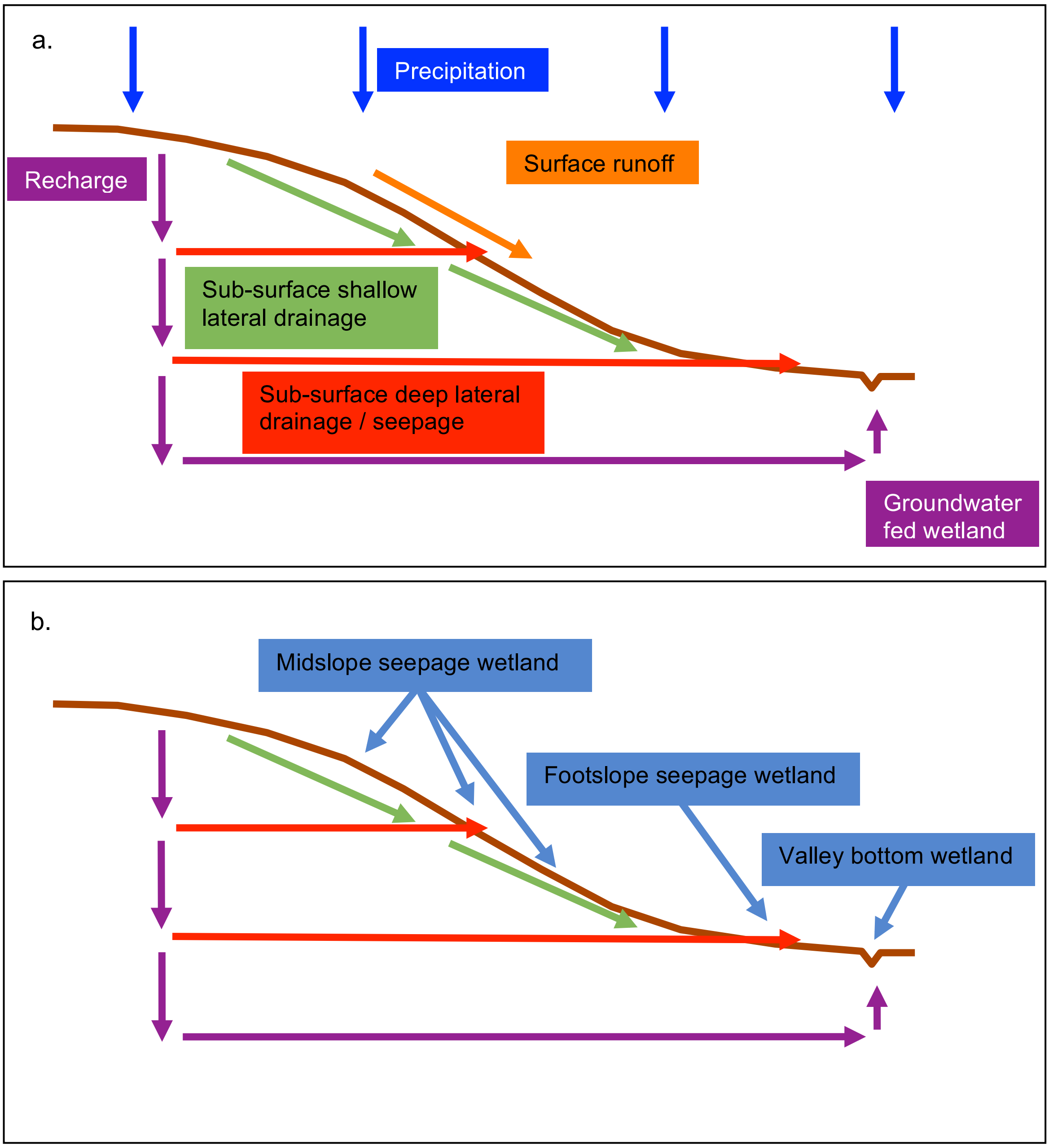


Figure 6 Different flow paths of water through a landscape (a) and typical wetland types associated with the water regime (b)

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. **Figure 7** illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

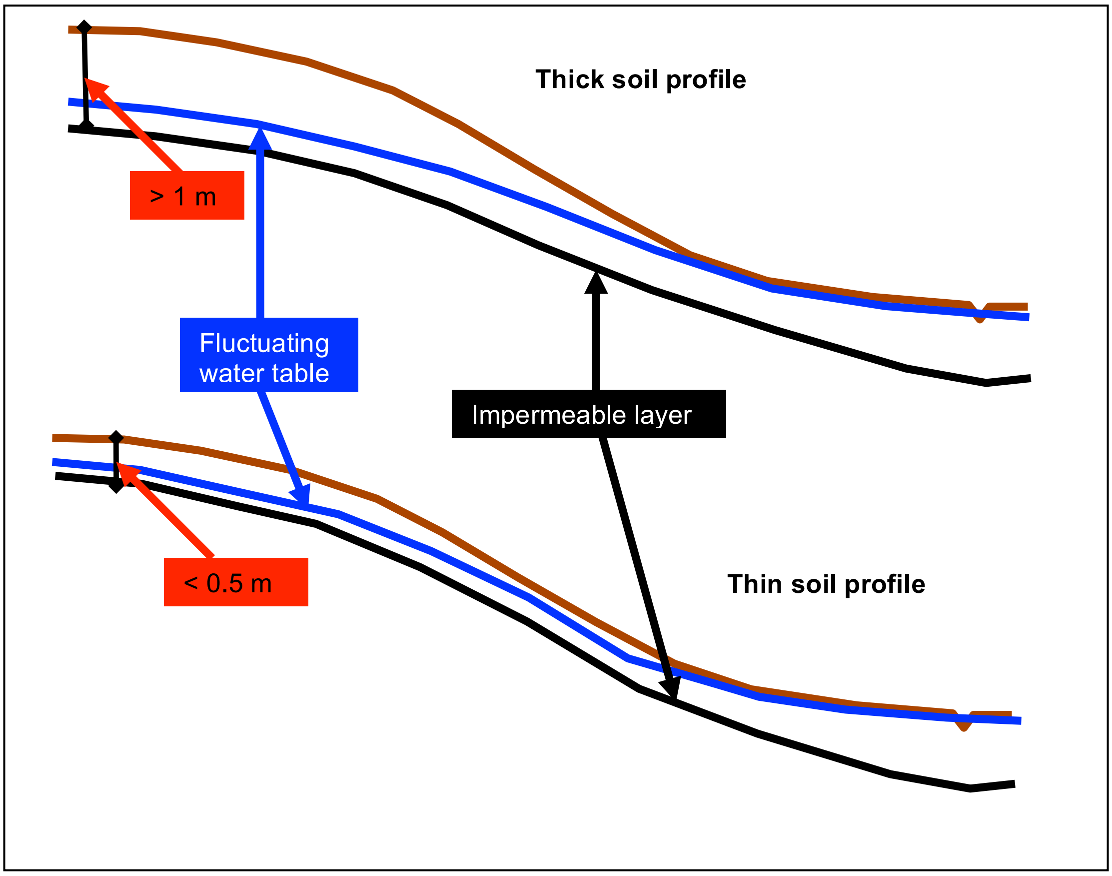


Figure 7 The difference in water flow between a dominantly thick and dominantly thin soil profile.

5.4 THE CATENA CONCEPT

Here it is important to take note of the “catena” concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. **Figure 8** illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peat land). Variations on this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

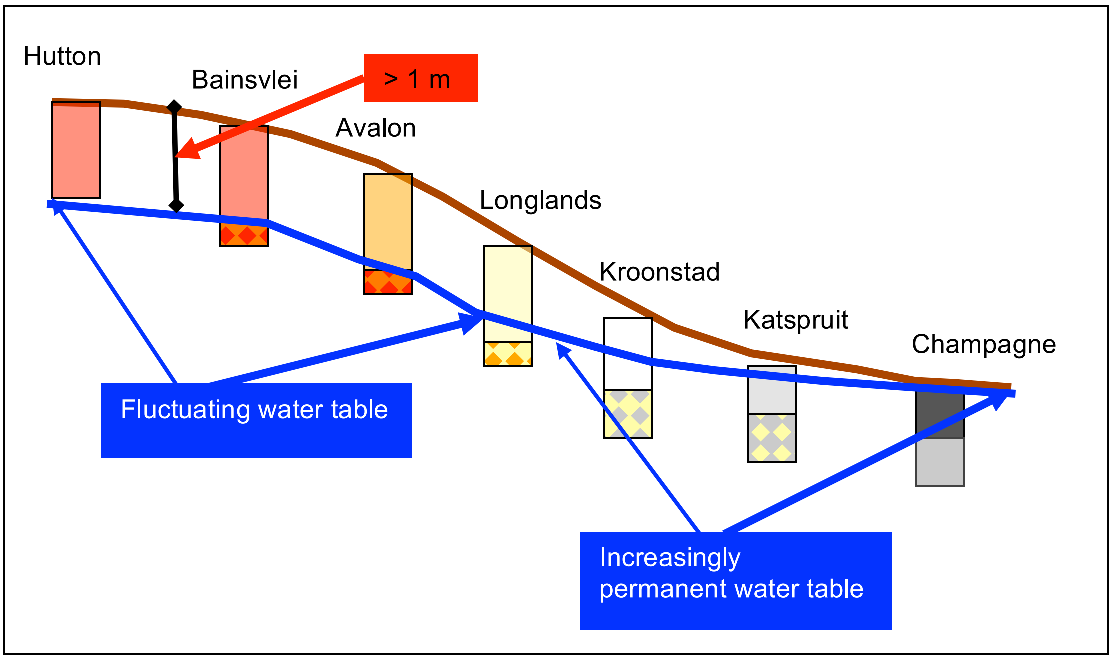


Figure 8 Idealised catena on a quartz rich parent material.

5.6 CONVEX VERSUS CONCAVE LANDSCAPES IN AN IDEALISED CATENA

An additional factor of variation in all landscapes is the shape of the landscape along contours (referred to a "plan curvature"). Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of "dryer" soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of "signs of wetness" such as grey colours, organic matter and subsurface clay accumulation. **Figure 9** presents the difference between these landscapes in terms of typical soil forms encountered in an idealised catena. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the midslope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E-horizons).

In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions. Similar patterns are observed for other geological areas with the variation being consistent with the soil variation in the catena.

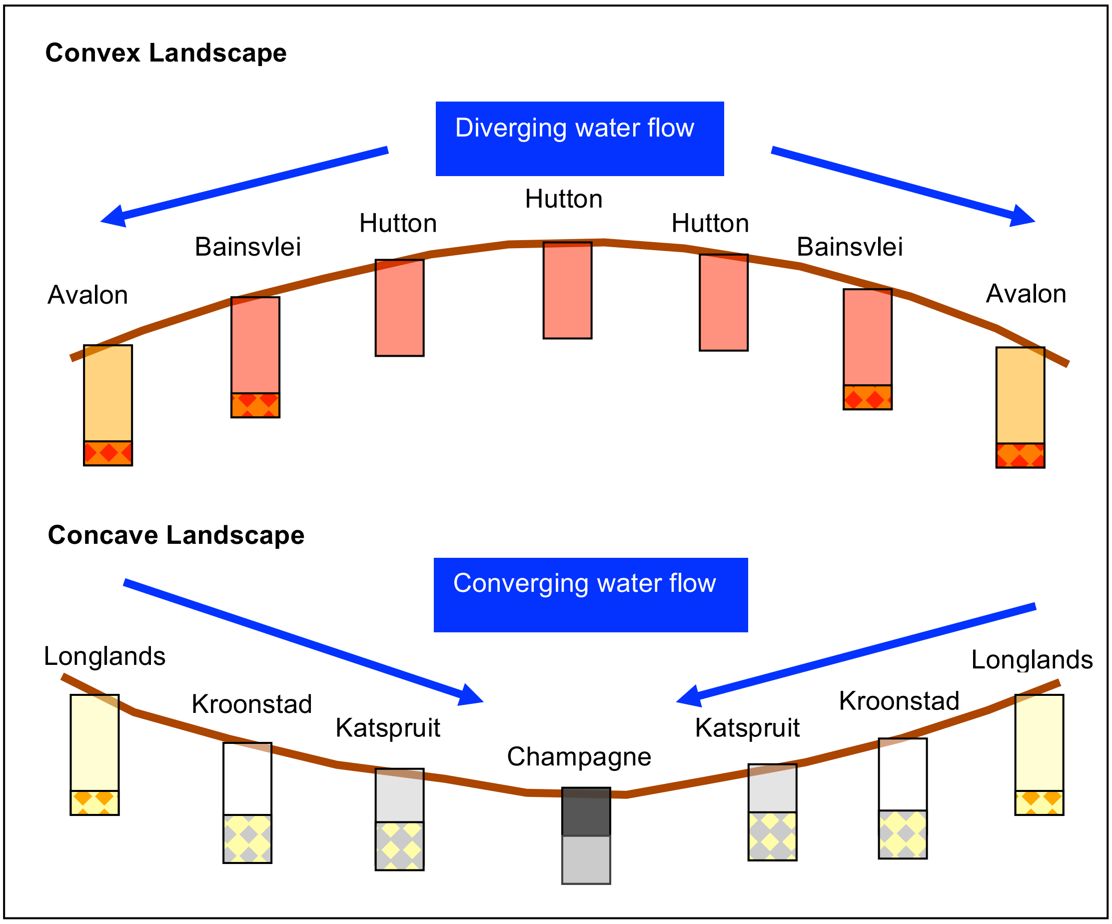


Figure 9 Schematic representation of the soils in convex and concave landscapes in an idealised catena

Often these concave and convex topographical environments occur in close proximity or in one topographical sequence of soils. This is often found where a convex upslope area changes into a concave environment as a drainage depression is reached (**Figure 10**). The processes in this landscape are the same as those described for the convex and concave landscapes above.

5.7 THE AB7 LAND TYPE CATENA CHALLENGE

The main difference between the Ab7 catena and the idealised catena discussed above is the fact that the Ab7 land type is dominated by soils that are freely draining and often have elevated levels of Mn due to the dolomite parent material influence (**Figures 11** and **12**). The presence of relatively large amounts of Mn in a soil leads to a distinct redox buffering (redox poise) effect that prevents redox morphology in the form of Fe mottles forming under conditions of seasonal or temporary fluctuating water levels.

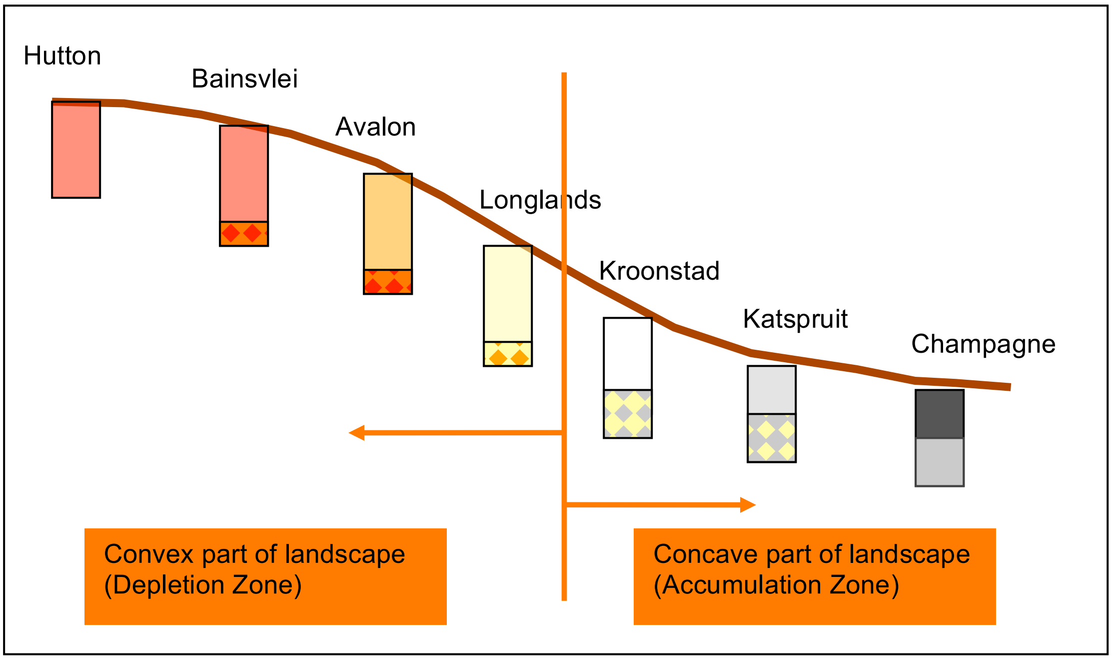


Figure 10 Schematic representation of the soils in a combined convex and concave landscape in an idealised catena.

The soils are predominantly coarse textured and red in colour with a small proportion of the landscape (> 2%) having soils with yellow colours and mottles or distinct signs of reduction. These are limited to drainage depressions and watercourses with the consequence that the landscape often exhibits wetland presence (as based on delineation approaches emphasising mottles and bleached colours) in less than 2 % of the landscape. In these cases wetland vegetation often indicated more permanent wetland conditions within the wetland zones and soil indicators of temporary and seasonal wetland zones are largely absent and restricted to localised depressions.

5.8 Implications for Wetland Delineation and Application of the Guidelines In The Ab7 Land Type Catena

As discussed above the expression of morphological signs of wetness is highly limited in the Ab7 land type due to the redox poise effect of large amounts of Mn inherited from the parent materials (dolomite). The implication is that these land types exhibit very limited distribution of redox morphology associated with wetland zones. It often happens that wetland vegetation is found on red soils, and aspect that confuses wetland delineators. The result is that the vegetation indicates a certain degree of wetness that is not expressed in the soil due to the differing redox poise and redox morphology expression conditions. In cases such as these the wetland vegetation (if present) should be used as the main wetland indicator.

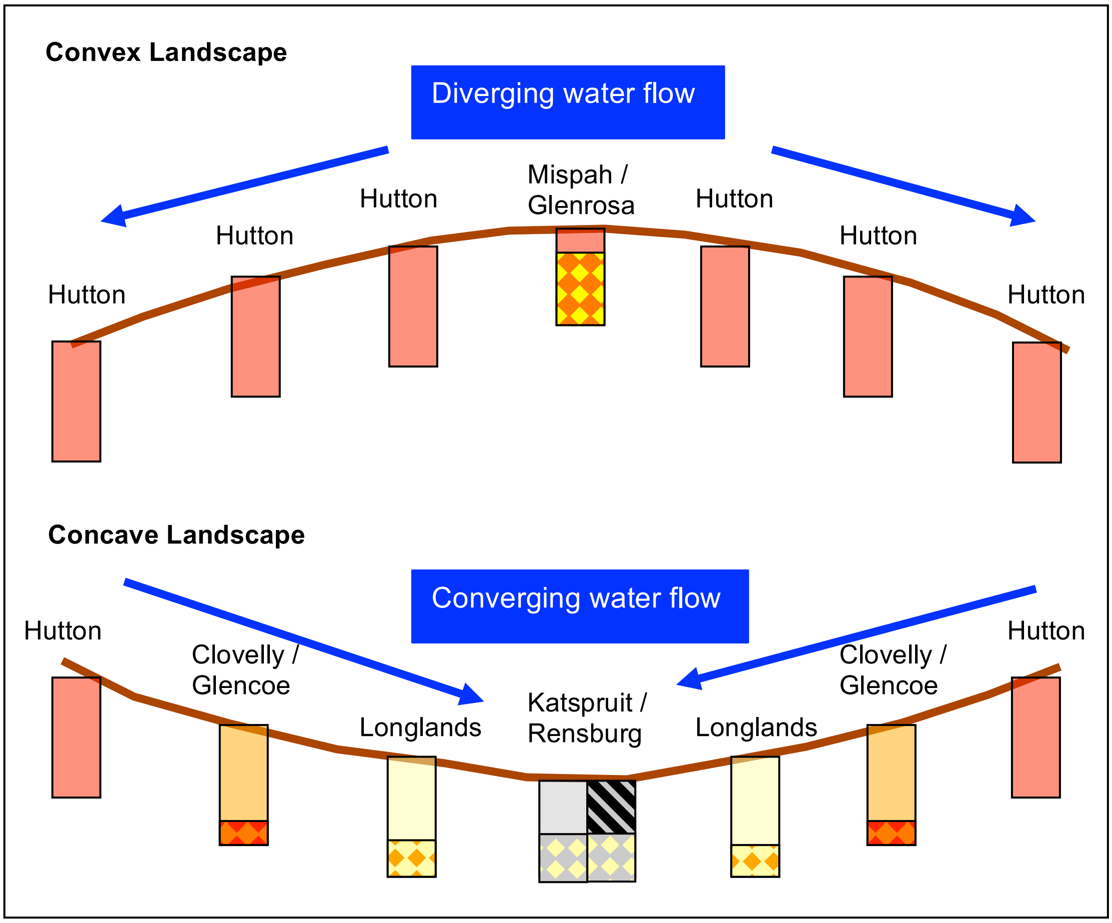


Figure 11 Schematic representation of the soils in convex and concave landscapes in the Ab7 land type catena

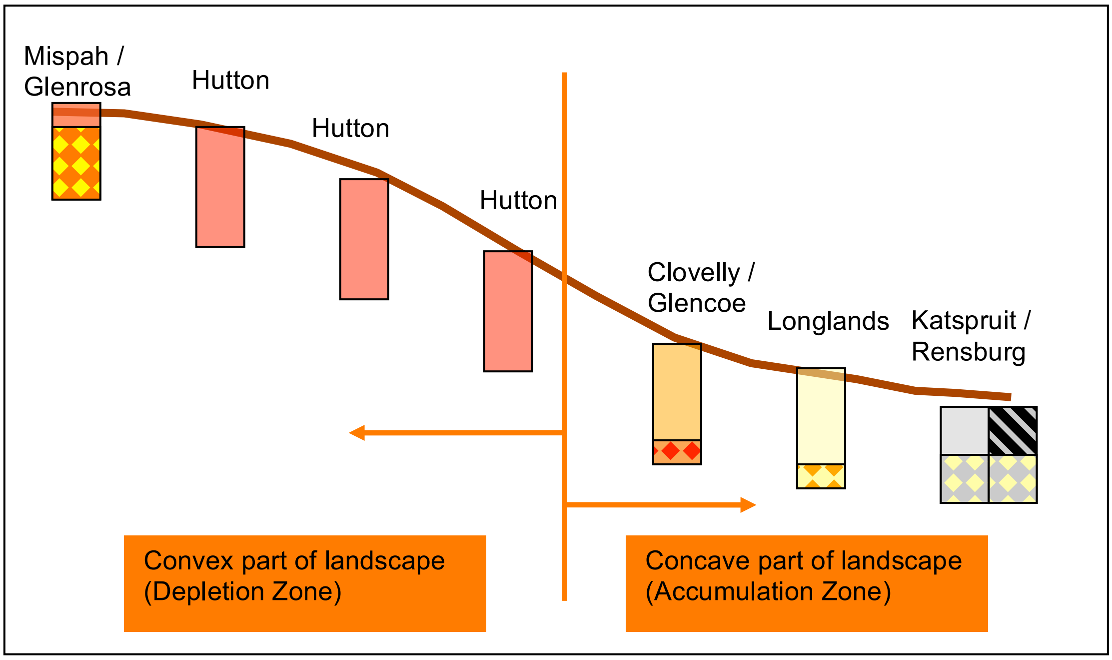


Figure 12 Schematic representation of the soils in a combined convex and concave landscape in the Ab7 land type catena.

5.9 THE BB3 LAND TYPE CATENA CHALLENGE

The typical catena that forms in the **Bb3** land type differs from the idealised one discussed above in two main respects namely that 1) the soils throughout the higher lying parts of the landscape are predominantly yellow or bleached (**Figures 13** and **14**) and 2) the soils in the lower lying landscape positions often exhibit high clay content, structure and swelling properties (**Figure 15**). The description provided in **Figure 15** is a conceptual one to illustrate that apedal soils grade into structured soils from higher lying positions to lower positions respectively in this landscape. The transition from the higher lying part of the landscape is often characterised by an increased degree of bleaching in the sandy material following into a transition of soil with increasing clay content and degree of structure expression. Due to the distinct increase in clay content in the soils further down the slope these landscapes exhibit numerous ephemeral seepage areas in the sandy soils where water is forced to the surface through accumulation form upslope areas and decreased saturated hydraulic conductivity of the high clay content soil layers. Lateral water movement can still take place within the structured soils as well as within the weathered zone below the soil but here the rates are much slower than those on the surface and within the sandy profiles. In the high clay content soils saturated flow of water decreases significantly and unsaturated water movement (capillary movement) starts to dominate.

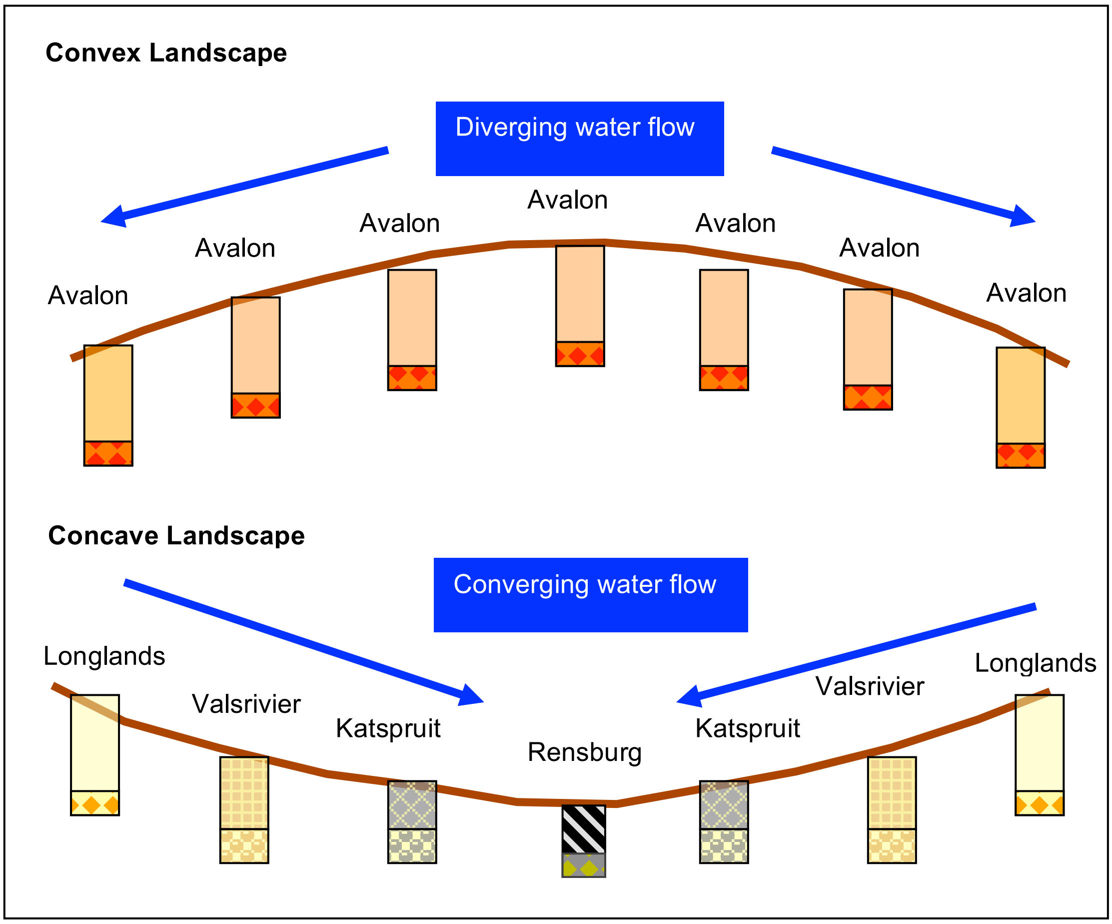


Figure 13 Schematic representation of the soils in convex and concave landscapes in the Bb3 land type catena

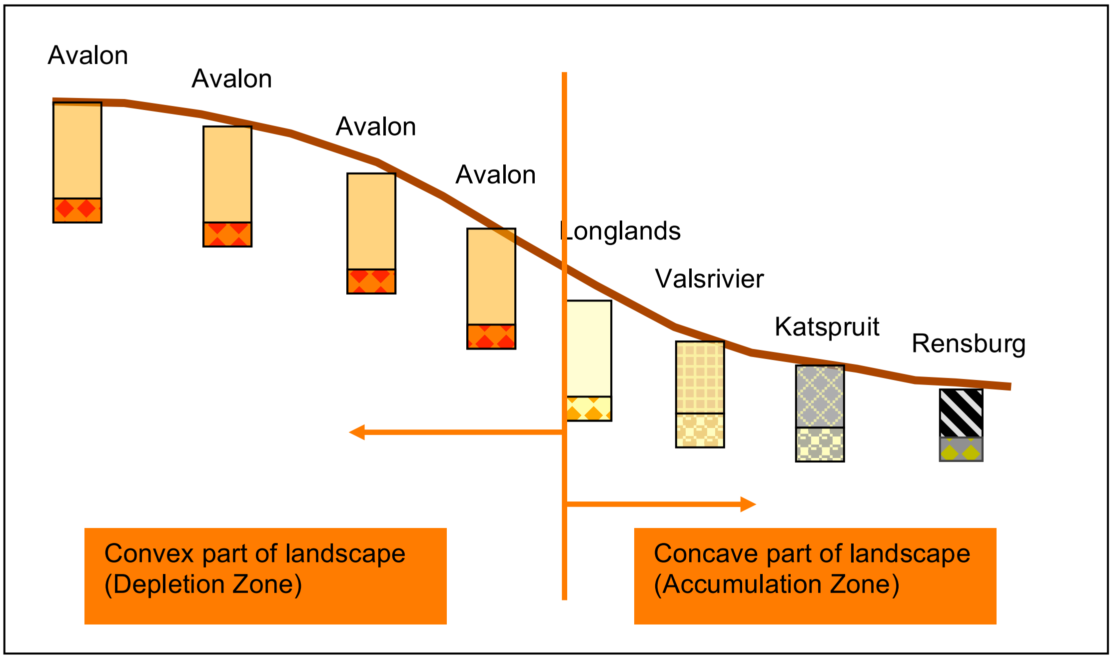


Figure 14 Schematic representation of the soils in a combined convex and concave landscape in the Bb3 land type catena

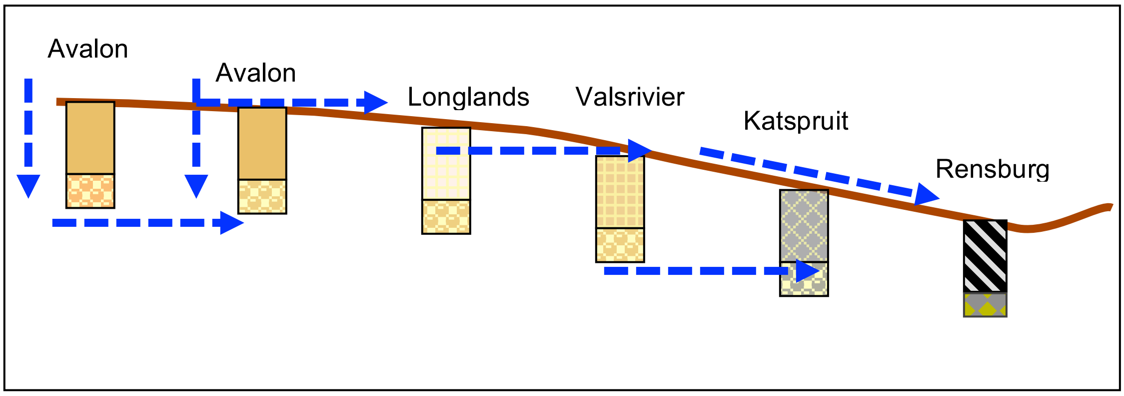


Figure 15 Idealised lower portion of the catena in the Bb3 land type

The essence of this landscape is the fact that the higher lying areas act as the recharge zones that feed water into the weathered zone and sandy soil profiles. The water dynamics change down the slope in that the lateral feeding of water decreases dramatically in quantity due to the higher clay content of the soils with a subsequent forcing of the water to the surface. This means that the valley bottom wetland areas are characterised predominantly by surface flows of water into these zones with a secondary feeding through lateral unsaturated flow processes that can occur from the side and below, albeit at a fraction of the magnitude of the surface flows. The unsaturated or capillary flow of water continues for long periods after rainfall events, mainly due to the slow rate of water movement, and contribute to the persistence of moist conditions in these valley bottom wetlands.

A problematic aspect of this land type is that the high clay content and often structured soils have a high base status with above neutral pH values. The specific clay minerals (2:1 swelling and non-swelling clays) that occur in these landscapes form under above neutral pH conditions. This aspect has very specific implications for the identification of morphological signs of wetness. Wetlands are invariably associated with the lowest points in the landscape and as such this aspect is critical (and therefore addressed in more detail later). Due to the high clay content (and often swelling nature) the soils are characterised predominantly by surface flow of water with very slow percolation rates through the profiles. Lateral flow of water on impervious layers is therefore not encountered with the exception being planes of weakness in the underlying weathered and hard rock. The drainage depressions in these landscapes often exhibit signs of high energy flow events in the form of eroded soils as well as young recently transported soil material.

The expression of hydromorphism is very different between the soil zones with the sandy material adhering to the principles discussed under sections 5.4 and 5.5 Below follows a discussion on the expression of redox morphology in alkaline (swelling clay soils) environments.

5.10 REDOX MORPHOLOGY IN ALKALINE SOILS

Wetland delineation is a very challenging exercise in areas dominated by alkaline soils such as lime containing and/or vertic/melanic soils. This is mainly due to the almost complete absence of Fe-mottles in the soils that grade from the terrestrial to the wetland areas. There are a number of reasons that will be explained in more detail below.

In order to illustrate the stability and distribution of Fe minerals in soils the figure provided below (**Figure 12**) was copied from page 124 of a book entitled “Soil Chemistry” by Bohn, et al., (1990). The essence is that when reduction and oxidation reactions of Fe (in this case) are considered in soils both the electron activity (driver of reducing conditions) and pH have to be considered as they are intimately linked and dependent on each other. Suffice to say that for redox and mineral stability purposes they are indicated on the same graph. From Figure 4.6 (**Figure 16**) it is clear that as the Eh decreases (increasing reducing conditions) the dominant Fe species in solution changes from Fe^{3+} (insoluble and forming brightly coloured minerals) to Fe^{2+} (soluble and essentially colourless). Once pH is included in the observation it is clear that distinct Fe minerals come into play. Applying the decreasing Eh values to Fe minerals at high pH it is clear that the dominant Fe mineral under oxidizing conditions is FeOOH (Goethite – predominantly yellow). As the conditions become more reducing the equilibrium shifts to $FeCO_3$ (Siderite – white) and thereafter to FeS_2 (Pyrite). Whereas goethite has a distinct colour in soil, siderite and pyrite are less conspicuous in small quantities. It follows therefore that Fe minerals are much less visible in high pH reduced soils than in oxidised soils. In addition, vertic and melanic soils are dark coloured and it is therefore also clear that this dark colour will mask the presence of the above mentioned Fe minerals.

Another factor related to pH is the degree of reduction that is required to reduce Fe from its oxidised to its reduced state. From the graph it is clear that there is a steep decreasing gradient as the pH of the soil increases. This implies that much more intensive reducing conditions are required for the same degree of Fe reduction when high pH conditions (as those experienced in vertic and melanic soils) are compared to low pH conditions.

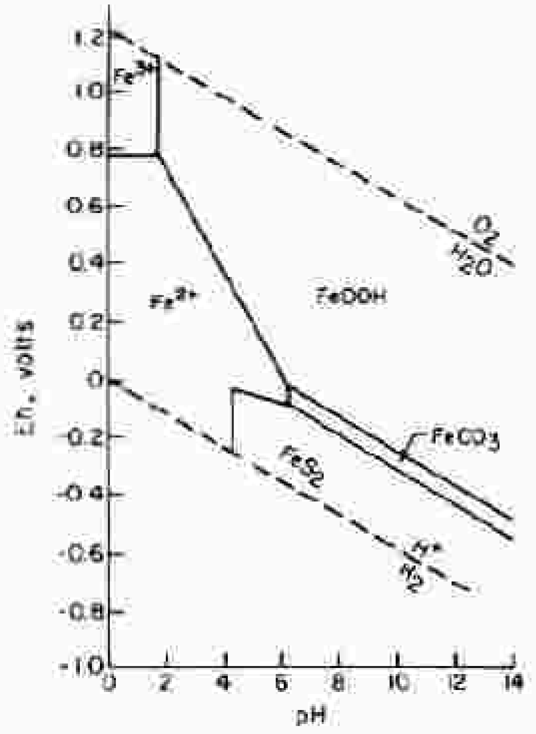


FIGURE 4.6. The *Eh*–pH diagram of various iron ions and compounds.

Figure 16 Eh pH diagram as sourced from Bohn, et al., (1990) p124

The situation becomes even more complex as other intermediate Fe minerals (blue green rusts) come into play. The essence of the presence of blue-green rusts is that they are tints that occur extensively in poorly drained and poorly aerated soils such as G-horizons under vertic and/or melanic A-horizons. These minerals are not stable and often disappear within a few minutes of exposure to the atmosphere. They in all probability form some of the most important Fe phases in vertic soils but disappear rapidly. Before they disappear it is also evident that these minerals are visible against a grey matrix but poorly visible against a black or dark background.

In essence therefore, a number of factors, including degree of reduction, soil pH and dominant Fe minerals, conspire against the use of Fe indicators in vertic, melanic and lime containing soils for the delineation of wetlands. There is no quick solution to this problem and delineators should use as many other indicators of wetland conditions in such soils as they can.

<u>**One word of caution**</u>: The wetland delineation guidelines (DWAF, 2005) indicate the Rensburg and Willowbrook soil forms as occurring in the permanent wetland zone. This is somewhat erroneous. Although these can occur in permanent wetland zones their formation is dependent on distinct cycling between wet and dry seasons. The development of 2:1 clays (found in these soils) depends on the accumulation of weathering products and clays in lower lying landscape positions.

These clays are, depending on a range of factors, either swelling or non-swelling and their formation requires a distinct time (seasonally) where evaporation exceeds precipitation, with consequent drying of the soil, to lead to a concentration of bases (Ca and Mg). These clay minerals (such as smectite) often express themselves in the form of distinct cracks in Vertic soils. From this discussion it follows that the Rensburg and Willowbrook soils could only have formed in conditions that resemble a **seasonal wetland**. Drainage lines on the site can, if dominated by Rensburg or Willowbrook soils, therefore not be classified as permanent wetlands unless there are other characteristics indicating conditions of permanent saturation.

5.11 Implications for Wetland Delineation and Application of the Guidelines in Alkaline Soils

The main implication for the delineation of wetlands and the application of the guidelines is the fact that highly variable conditions occur in the specific land type. One set of indicators of hydromorphism cannot be used as many of the clayey soils do not exhibit mottling or grey colours. The opposite is true for the sandy soils where a very large proportion of them will indicate signs of Fe removal. But this, as explained earlier is a function of slightly acid pH and a low Fe reserve. A delineation exercise is therefore a complex process with a very distinct possibility of not elucidating the hydrological parameters needed for the making of informed decision regarding the impact of the development on the wetland.

5.12 Implications for Wetland Conservation in Urban Environments

Whether an area is designated a wetland or not loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50 cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. **Figures 17** and **18** provide schematic representations (as contrasted with **Figure 6**) of water dynamics in urban environments with distinct excavations and surface sealing activities respectively.

Through the excavation of pits (**Figure 17**) for the construction of foundations for infrastructure or basements for buildings the shallow lateral flow paths in the landscape are severed. As discussed above these flow paths can account for up to 60 % of the volume of water entering the landscape in the form of precipitation. These severed flow paths often lead to the ponding of water upslope from the structure with a subsequent damp problem developing in buildings. Euphemistically we have coined the term “wet basement syndrome” (WBS) to describe the type of problem experienced extensively on the HHGD. A different impact is experienced once the surface of the land is sealed through paving (roads and parking areas) and the construction of buildings (in this case the roof provides the seal) (**Figure 18**). In this case the recharge of water into the soil and weathered rock experienced naturally is altered to an accumulation and concentration of water on the surface with a subsequent rapid flowing downslope. The current approach is to channel this water into storm water structures and to release it in the nearest low-lying position in the landscape. These positions invariable correlate with drainage features and the result is accelerated erosion of such features due to a drastically altered peak flow regime.

The result of the above changes in landscape hydrology is the drastic alteration of flow dynamics and water volume spikes through wetlands. This leads to wetlands that become wetter and that experience vastly increased erosion pressures.

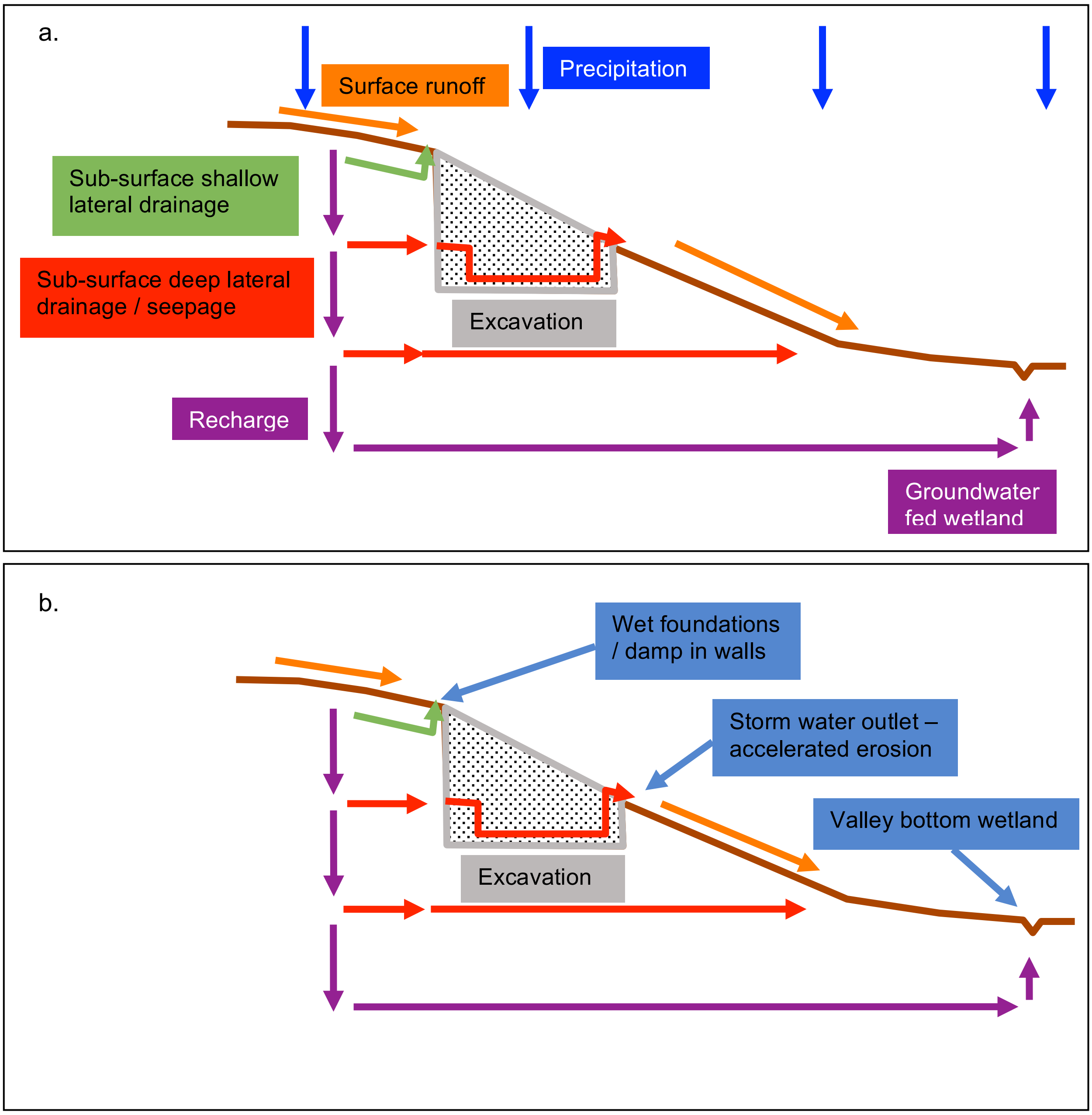


Figure 17 Different flow paths of water through a landscape with an excavated foundation (a) and typical wetland types associated with the altered water regime (b)

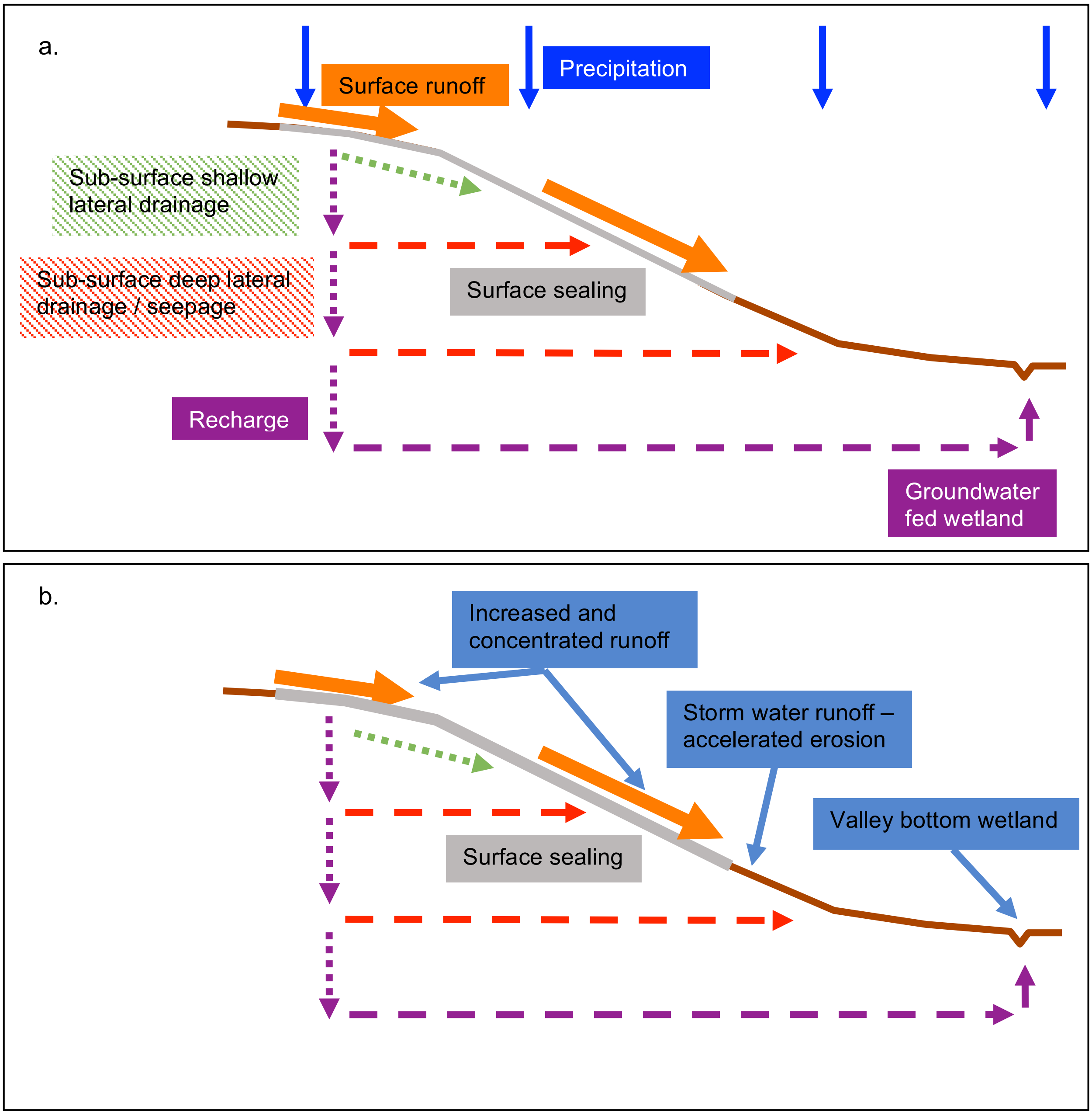


Figure 18 Different flow paths of water through a landscape with surface sealing (buildings and paving) (a) and typical wetland types associated with the altered water regime (b)

5.13 Wetland Pollution Sources and Sinks in Gold Mining Environments

Gold mining activities lead to 1) the acidification of surface soils from treatment plant effluent or tailings disposal activities due to pyrite oxidation (associated with most South African gold ores) and 2) the accumulation of pollutant elements and compounds from the treatment processes or ores. The most common pollutants are sulphate (from pyrite oxidation), cyanide (from gold extraction processes), Zn, Co, Cu, As, Se, and U. The elements Zn, Co and Cu occur in the soils as cations and are generally immobilised (rendered less soluble) through liming processes that also ameliorate soil acidity. The elements As, Se and U occur in soils as oxyanions and these are mobilised (rendered more soluble) through liming processes. Arsenic and U are also redox sensitive and their solubilities increase in the reduced state.

The above aspects have significant implications for land management in a plinthic catena in that the mobilised elements will follow the water flow pathways. Invariably these elements will accumulate in wetland sediments and organic material. Uranium especially forms insoluble organic complexes in wetland environments and this process is on form of capturing mobile U fractions. However, should the wetland area dry out or experience a drastic change in hydrological functioning (artificially drained, erosion and transportation of sediments, trampling by cattle with a subsequent drying out of the surface soils, etc.) it is highly likely U will oxidise an become mobile and soluble. This aspect can have far reaching impacts on pollution risks and human health.

It is therefore imperative that the wetland assessment and delineation outcome be used by town planners / developers to identify risk areas in order to generate sustainable and safe management plans for the wetland areas.

5.14 RECOMMENDED ASSESSMENT APPROACH – HYDROPEDOLOGY INVESTIGATION

5.14.1 Hydropedology Background

The identification and delineation of wetlands rest on several parameters that include topographic, vegetation and soil indicators. Apart from the inherent flaws in the wetland delineation process, as discussed earlier in this report, the concept of wetland delineation implies an emphasis on the wetlands themselves and very little consideration of the processes driving the functioning and presence of the wetlands. One discipline that encompasses a number of tools to elucidate landscape hydrological processes is “hydropedology” (Lin, 2012). The crux of the understanding of hydropedology lies in the fact that pedology is the description and classification of soil on the basis of morphology that is the result of soil and landscape hydrological, physical and chemical processes. But, the soils of which the morphology are described, also take part in and intimately influence the hydrology of the landscape. Soil is therefore both an indicator as well as a participator in the processes that require elucidation.

Wetlands are merely those areas in a landscape where the morphological indicators point to prolonged or intensive saturation near the surface to influence the distribution of wetland vegetation. Wetlands therefore form part of a larger hydrological entity that they cannot be separated from.

5.14.2 Hydropedology – Proposed Approach

In order to provide detailed pedohydrological information both detailed soil surveys and hydrological investigations are needed. In practice these intensive surveys are expensive and very seldom conducted. However, with the understanding of soil morphology, pedology and basic soil physics parameters as well as the collection and interpretation of existing soil survey information, assessments at different levels of detail and confidence can be conducted. In this sense four levels of investigation are proposed namely:

1. Level 1 Assessment: This level includes the collection and generation of all applicable remote sensing, topographic and land type parameters to provide a "desktop" product. This level of investigation rests on adequate experience in conducting such information collection and interpretation exercises and will provide a broad overview of dominant hydropedological parameters of a site. Within this context the presence, distribution and functioning of wetlands will be better understood than without such information.
2. Level 2 Assessment: This level of assessment will make use of the data generated during the Level 1 assessment and will include a reconnaissance soil and site survey to verify the information as well as elucidate many of the unknowns identified during the Level 1 assessment.
3. Level 3 Assessment: This level of assessment will build on the Level 1 and 2 assessments and will consist of a detailed soil survey with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters that elucidate and confirm the morphological parameters identified during the field survey.
4. Level 4 Assessment: This level of assessment will make use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters for an adequate time period. The data generated can be used for the building of detailed hydrological models (in conjunction with groundwater and surface hydrologists) for the detailed water management on specific sites.

For most wetland delineation exercises a Level 2 or Level 3 assessment should be adequate. For this investigation a Level 2 assessment was conducted with a reconnaissance soils survey and field work. Analysis of soils was not conducted but data from other sites with highly similar soils was also used to illustrate the challenges faced on the site and in the broader area.

The process of the hydropedology assessment entails the aspects listed in the methodology description below. These items also correspond with the proposed PES assessment methodology discussed in section 4.4.4. The results of the assessment will therefore be structured under the headings as provided below.

6. METHOD OF SITE INVESTIGATION

6.1 WETLAND CONTEXT DETERMINATION

For the purposes of the wetland assessment the context of the specific wetland was determined. This was done through the thorough consideration of the geological, topographical, climatic, hydropedological, catchment and artificial modifier context of the site.

6.2. AERIAL PHOTOGRAPH INTERPRETATION

An aerial photograph interpretation exercise was conducted through the use of historical aerial photographs as well as Google Earth images of the site. This data was used to obtain an indication of the extent of the wetlands on the site as well as to provide an indication of the artificial modifiers evident on the site and in the catchment.

6.3 TERRAIN UNIT INDICATOR

Contours of the site (5 m intervals) were used to provide an indication of drainage depressions and drainage lines in the form of concave landscape areas. From this data the terrain unit indicator was deduced.

6.4 SOIL FORM AND SOIL WETNESS INDICATORS

The description of the Ab7 and Bb3 catenas as provided in sections 5.7 and 5.10 apply to the soils on the site. The site had experienced various forms (and intensities) of human impacts at the date of the site investigation (March and April 2016) and it was therefore difficult to ascertain the pre-impact conditions in many of the wetland areas.

6.5 VEGETATION INDICATOR

Due to the timing of the survey as well as the extent of the historical impacts in certain areas a dedicated vegetation survey for the purpose of wetland delineation was not conducted. Relevant vegetation parameters were noted and these are addressed in the report where applicable.

6.6 ARTIFICIAL MODIFIERS

Artificial modifiers of the landscape and wetland area were identified during the different components of the investigation and are addressed in the context of the wetland management plan.

7. SITE SURVEY RESULTS AND DISCUSSION

7.1 WETLAND CONTEXT

The land type, topography and geological setting of the site have been elucidated in section 2 of this document. The entire site has been impacted by human activities in the form of gold mining related activities, urban developments with storm water and sewage effluent outflows, and historical tillage and agricultural land use activities (**Figure 19**). Some of the wetlands associated with watercourses show distinct human influences and alteration in expression and functioning. These aspects will be elucidated in more detail in the subsequent sections. The positions of the aerial photographs discussed in the following section are indicated on the image in **Figure 19**.

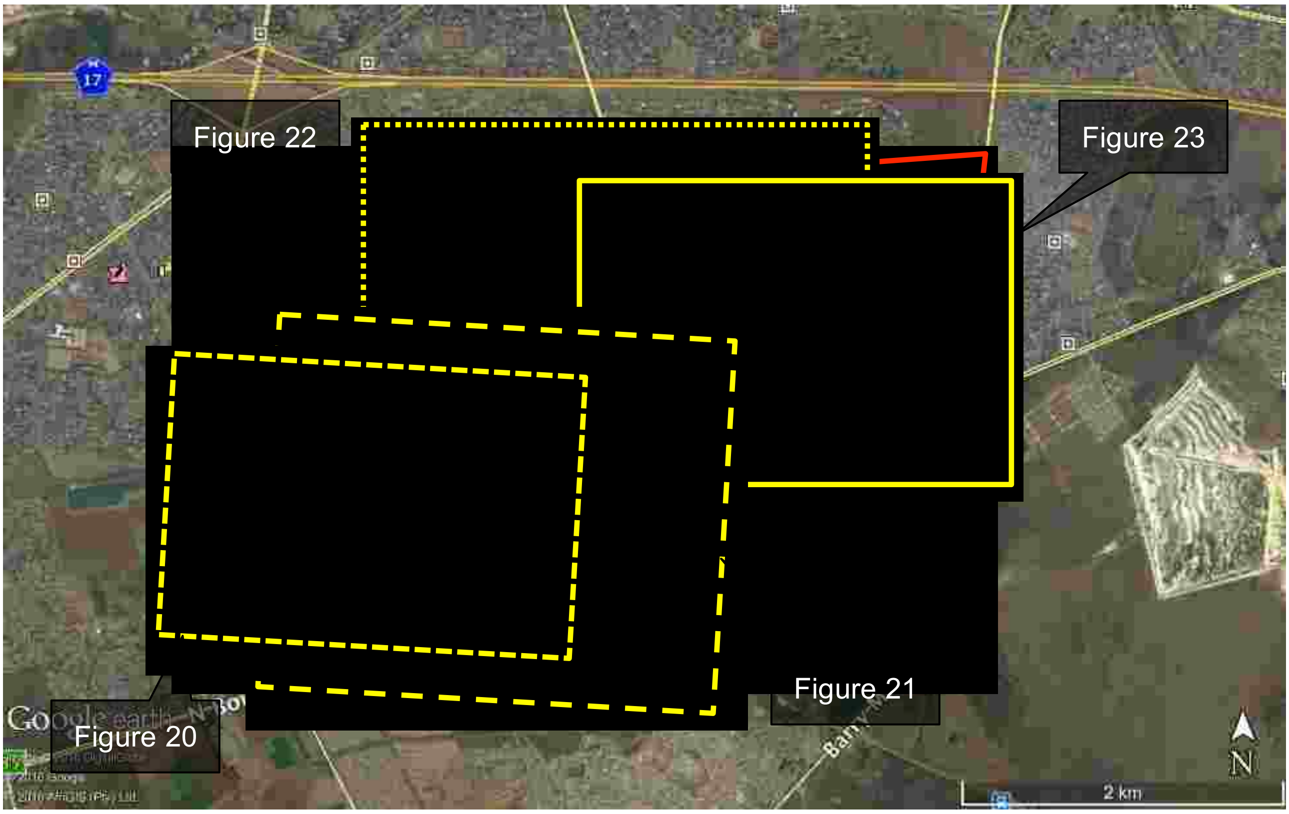


Figure 19 Proposed development site (red border) with clear signs of historical alteration surrounding the site and drainage features with the position of the historical photographs indicted by yellow rectangles

7.2 AERIAL PHOTOGRAPH INTERPRETATION

The aerial photograph interpretation was conducted in two phases namely 1) the use of a 1938 historical aerial photograph and 2) the use of more recent Google Earth images.

7.2.1 Historical Aerial Photographs

The survey site is covered by four images from 1938 namely **Figures 20** to **23**. The approximate positions of these images are indicated on the image in **Figure 19**. From the images it is clear that extensive gold mining related activities had not yet started and that the drainage feature on the western side exhibited typical land cover characteristics of such features in the Ab7 land type (western side of the site – **Figures 20** and **21**). These characteristic are: 1) a drainage depression with a vegetation signature very similar to the terrestrial areas and 2) a complete lack of permanent wetland vegetation as is evident on the site today. A small north flowing drainage feature is evident and this feature has similar land cover characteristics as the larger feature discussed earlier. The pans that are evident in **Figures 22** and **23** appear to have similar vegetation characteristics as the rest of the landscape as well with the exception with the southern section of the small pan that appears to have some water in it. The large pan however seems to be relatively dry.

Figure 20 Aerial photograph of the site (1938) with drainage features indicated by yellow arrows

Figure 21 Aerial photograph of the site (1938) with drainage features indicated by yellow arrows

Figure 22 Aerial photograph of the site (1938) with the pan and drainage feature indicated by yellow arrows

Figure 23 Aerial photograph of the site (1938) with the pans (small and large) indicated by yellow arrows

7.2.2 Google Earth Images

The most recent Google Earth images of the site are provided in **Figures 24**.

Figure 24 Google Earth images of the western (top) and eastern (bottom) sections of the site with the watercourse and pans indicated with yellow arrows.

The vegetation signature of the westerly draining watercourse is one of reeds and permanent wetland vegetation (**Figure 25**). This image also clearly indicates gold tailing spillage from pipes into the drainage feature. This watercourse appears to be fed water being pumped into it from mining related infrastructure as well as from storm water from the urban areas (refer to all the storm water signatures).

Figure 25 Permanent wetland vegetation (green arrows) in the watercourse on the western side of the site, distinct gold mine tailings spills from pipes (yellow arrows) and storm water signatures (blue arrows)

The eastern section of the site is indicated in **Figure 26** with storm water, sewage effluent and a sewer pipe(?) signatures very evident. The pipeline traverses the large pan and cuts it effectively in half.

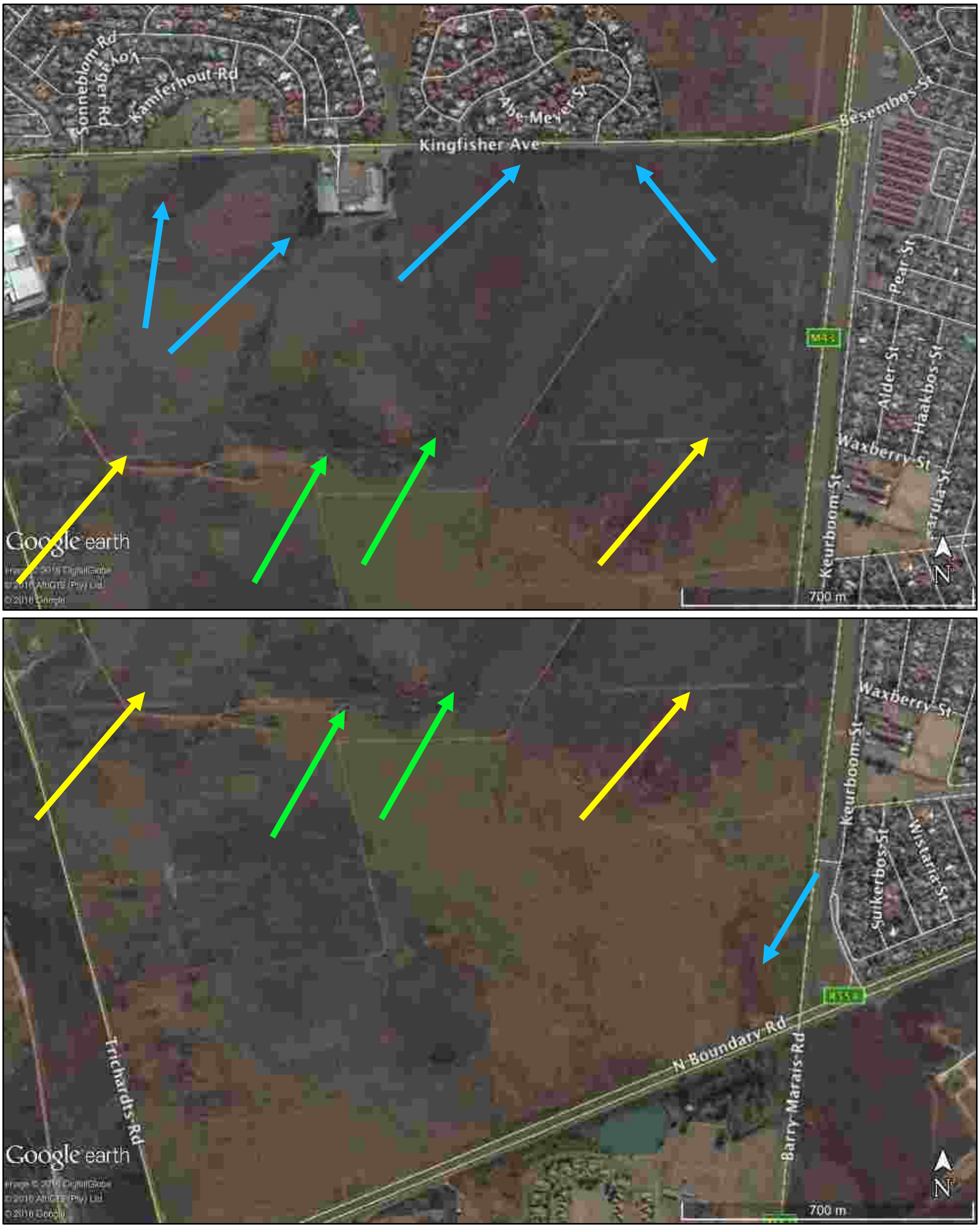


Figure 26 Wetland vegetation, in the eastern side of the site (north: top; south: bottom), associated with storm water signatures (blue arrows) and sewage effluent (green arrows) as well as a distinct pipeline effect (yellow arrows)

7.3 Terrain Unit Indicator

From the contour data a topographic wetness index (TWI) (**Figure 27**) was generated for the area surrounding the site.

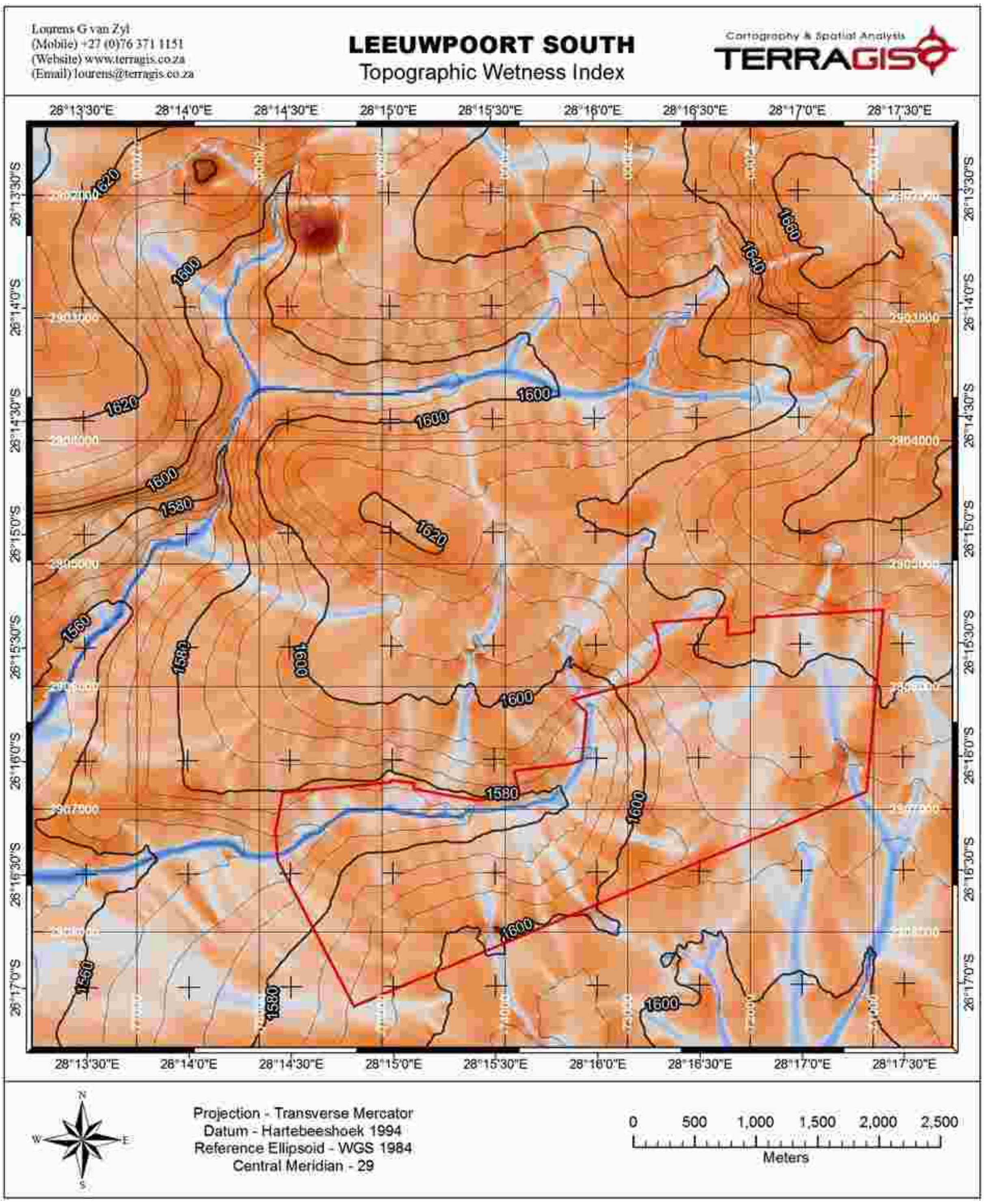


Figure 27 Topographic wetness index (TWI) of the site and surrounding area

From extensive experience on the field of hydropedology it is evident that the TWI provides a very accurate indication of water flow paths and areas of water accumulation that are often correlated with wetlands. This is a function of the topography of the site and ties in with the dominant water flow regime in the soils and the landscape (refer to previous section where the concept of these flows was elucidated). Areas in blue indicate concentration of water in flow paths with lighter shades of blue indicating areas of regular water flows in the soils and on the surface of the wetland / terrestrial zone interface.

The image indicates a watercourse that drains towards the west it most of the inflow appearing to emanate from the built-up area to the north as well as from the open land area on the site lying to the south. The eastern section has a general flow of water to the south with the pans forming depressions within these features. Many of the storm water outflows from built-up areas coincide with depressions on the site – as this is expected due to the principles of storm water planning by town planners and engineers. The storm water signatures observed on the Google Earth images are more intensely developed that what would be expected for natural (and non-impacted) vegetation conditions on the site as observed in the TWI features.

7.4 SOIL FORM AND SOIL WETNESS INDICATORS (AND VEGETATION)

The soil form and wetness indicators follow the principles discussed in sections 5.5 to 5.10 with the difference that the storm water outflows, sewage effluent flows and mining related water and tailing spill and discharge areas exhibit much more intensive wetland vegetation establishment that what would be expected from natural pre-disturbance conditions on the site.

Within the mine water outflow and tailings material spill areas the alteration of the site's biophysical characteristics entail the following:

1. Drastic alteration of the soils' physical and hydrological properties through compaction, surface sealing and spillage and dumping of fine textured gold tailings material. These impacts lead to the preferential ponding and retention of surface water in depressions with a consequent alteration in expression of soil and vegetation signs of wetness.
2. Impacting of soils through alteration of hydrological regimes as well as tailings material related pollution in the form of elevated sulphate levels, acidity and metals. These alterations lead to a change in the redox conditions (as pH is a main driver of electron activity as measured in redox measurements) with an increased expression of Fe accumulation in the form of yellow and bright orange minerals. These lead to a distinct change in the perceptible expression of morphological signs of wetness required for the identification of wetland conditions.
3. Alteration of plant community composition from original species to those species adapted for high salt and acid conditions in all the impact areas. The vegetation found within the impacted drainage feature on site is signature vegetation associated with extensive historical gold mining related activities.

The sewage effluent area exhibits clear vegetation characteristics associated with eutrophication in the form of elevated levels of N and P. The soil and vegetation parameters on the sewage effluent, mine water outflow and tailings material spillage areas are therefore compromised and reflect the human induced alteration of the site. The areas that have not been impacted exhibit soil characteristics in accordance with the descriptions provided earlier in the report and the vegetation indicators in these areas point to terrestrial conditions with the pans and associated depression exhibiting temporary and seasonal wetland vegetation composition. It is therefore very evident that the human activities have lead to an intensification of the wetland expression characteristics.

7.5 ARTIFICIAL MODIFIERS

Most of the physical historical artificial modifiers on the site were addressed in the sections above. The emphasis here is on the distinct alteration of the main drainage features on the site (apart from the pans) to reflect more intense permanent wetland features although the soils indicate the direr history of the site.

8. WETLAND ASSESSMENT

8.1 PROPOSED DELINEATION AND BUFFER CHALLENGE

A proposed wetland delineation based on the topographic and associated vegetation signatures is provided in **Figure 28**. It must be emphasised here that the wetland area has been altered completely from its original pre-human impact state (reference state) to one with a distinctly different chemical, biological and hydrological signature and functioning. Most of the wetland features on the site are larger and wetter than the pre-human impact environment. The exception here are the pans that appear to be relatively unaltered except for species composition changes related to tillage and grazing.

The proposing of a buffer is also challenging in that a buffer on the site will have very little benefit for ecological purposes when considering the highly altered chemical and hydrological environment. Rather, a buffer on the wetland area should be instituted once the areas outside of the wetland have been cleaned or the pollution risks mitigated. In this regard the wetland and watercourse contains a build-up of pollutants and contaminants (sediment, sulphates, various metals, and possible reduction of sulphate to a range of sulphide metal minerals and phases with different stabilities and sensitivities to oxidation) that is best left undisturbed to prevent aeration and oxidation. A buffer should therefore function as an exclusion zone for ANY uncontrolled human activity in the wetland area and its associated sediments. It is critical that the wetland be protected against erosion that could generate sediments and liberate pollutants that could migrate to downstream water sources.

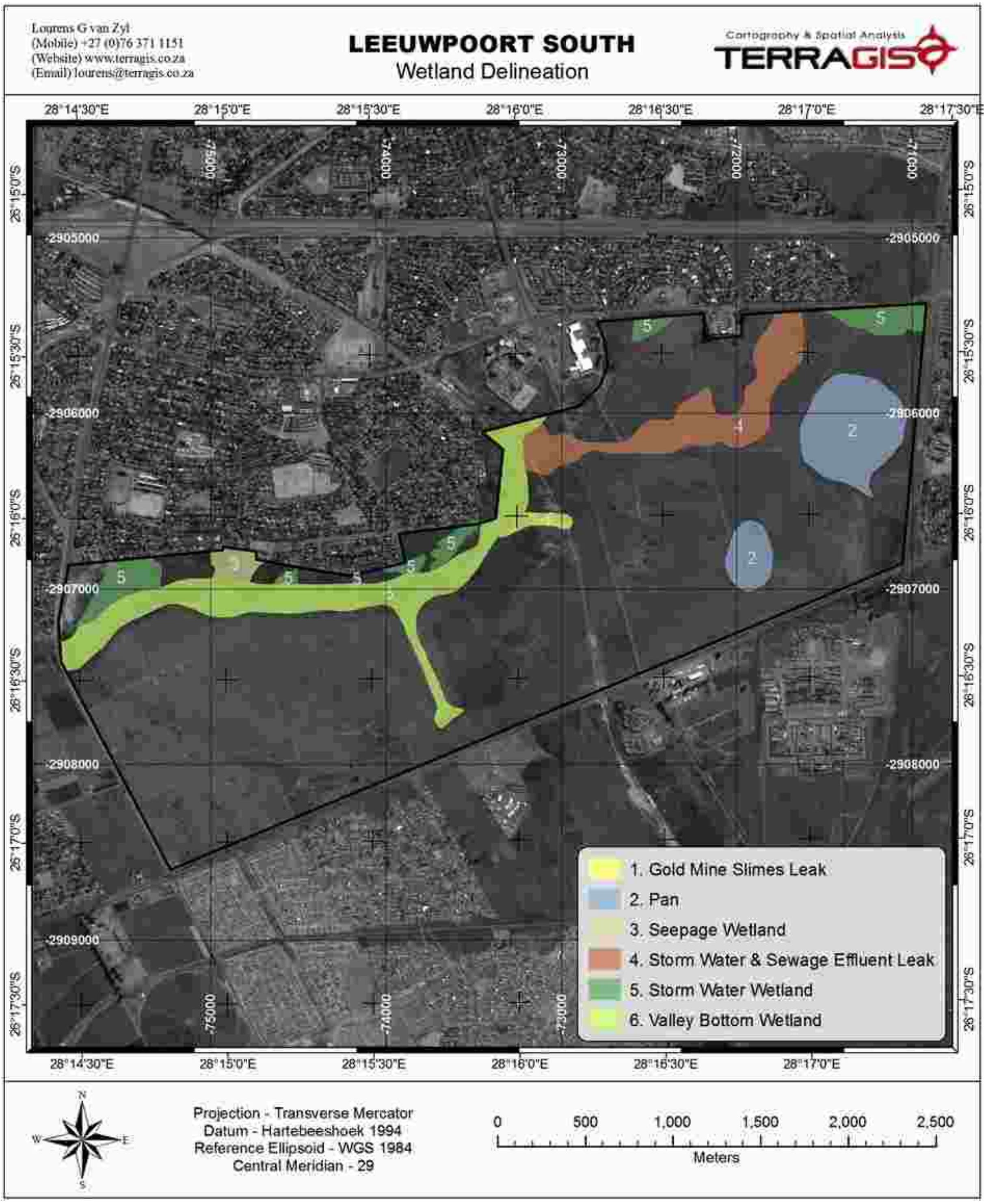


Figure 22 Investigation site with positions of different wetlands / water bodies

8.2 WETLAND CLASSIFICATION / TYPES AND FUNCTIONALITY

Based on the soil and aerial photograph information presented in this report the wetland signatures on the site are classified as being 1) associated with a channelled valley bottom system that has been altered significantly hydrologically physically and chemically through mining and urban related developments and activities and 2) pan systems that appear to be relatively intact apart from vegetation impacts and the linear impact of a sewer pipe on the vegetation and soils. The effect of the pipe construction activities on the pan is not known and it is possible that the activities compromised the natural pan lining with the effect that the pan leaks more readily and is drier after the construction.

8.3 PRESENT ECOLOGICAL STATUS (PES) DETERMINATION

The PES determination requires a comparison between the reference state and the current state of the watercourse/wetland.

Westerly Draining Watercourse: As there is a drastic hydrological, chemical, and biological alteration due to the historical mining associated and urban activities for this watercourse and associated wetlands the PES is classified as an F.
Pans: The PES for the small pan is classified as a C due to the fact that it is hydrologically intact and only impacted by grazing and historical tillage activities. The PES for the large pan is classified as a D due to the same historical activities but with the addition of the pipeline that was constructed through it.

9. MANAGEMENT REQUIREMENTS AND MITIGATION OF STORM WATER

Due to the critical pollution and contamination risk associated with the soils, tailings materials and sediments on the site it is imperative that any open soil areas be protected against increased erosion pressures through the implementation of the following:

1. Adequate storm water mitigation throughout the construction site (from start to completion) to prevent large pulses in storm water.
2. Sediment containment structures throughout the site to prevent sediment runoff and accumulation in the wetland area.

It is not the purpose of this document to provide detailed designs for mitigation measures as these should be generated by a suitably qualified engineer in conjunction with a suitably qualified wetland soil specialist. There are a few general pointers though that should be adhered to namely:

1. Subsurface lateral flow of water leads to the interception of such water once foundations are sunk into the soils and weathered rock / hard plinthite. Adequate drainage structures should be constructed to prevent damp problems in structures arising within the soil profiles and landscape start filling with water once rainfall increased during summer months.
2. Surface sealing of the landscape through roads, parking areas, roof covered areas and general soil compaction leads to accelerated and increased surface water runoff. In order to mitigate the potential large volumes over a large area numerous small containment structures with choked outflows should be constructed throughout a site. The fewer these structures are the larger other structures have to be to contain the said water. As a minimum requirement these structures should be adequate and enough to contain the

standard storm water runoff from a site before it reaches the wetland /drainage feature area.

3. Several soft engineering approaches exist for the successful mitigation of storm water. If these are incorporated into the design and layout of development sites impacts on the wetlands and drainage features can be successfully mitigated.
4. In terms of both the NWA (National Water Act) and NEMA (National Environmental Management Act) landowners have a duty to protect water resources, watercourses and wetlands. In addition, CARA (Conservation of Agricultural Resources Act) and the municipal bylaws address storm water aspects that are of importance to land owners and managers. Insufficient attention to storm water related impacts during the design phase of a development can lead to administrative and criminal liabilities for the developer / land owner post development.
5. Important: In the absence of adequate management of storm water, wetland impacts in terms of erosion will be inevitable therefore exposing the relevant entities involved with the development to unacceptable punitive administrative action or even criminal prosecution.

10. CONCLUSIONS AND RECOMMENDATIONS

A wetland investigation on the proposed Leeuwpoort South development site yielded that:

1. The site is divided into two main hydrological sections namely 1) a westerly draining watercourse and 2) two pans in the eastern section of the site.
2. In addition to the two main hydrological zones several anthropogenic water impacts have been identified in the form of 1) increased storm water runoff from development sites into the wetland features, 2) sewage effluent from what appears to be a leaking pipeline, 3) mine water decant / outflow from a pumping facility in the north central part of the site, 4) gold tailings material spillages from compromised pipes running through the site, and 5) the historical construction of a pipe through the centre of a pan depression on the eastern section of the site.
3. The pan wetlands / depressions appear to be in hydrological equilibrium with historical pre-human impact conditions save for the possible compromising of the natural liner (aquaclude) in the large pan due to pipe construction activities.
4. The watercourse draining to the west has been impacted significantly in a hydrological sense in that it is significantly wetter (as well as for longer periods) due to the constant inflow of water from pumping activities as well as rainy season storm water outflows from the urban areas. The wetland signature is therefore larger and wetter that the reference state for this wetland area. The prognosis is not clear especially if the cessation of pumping activities is considered to be a distinct possibility in the not to distant future.
5. Although dedicated sampling and analysis was not conducted it is stated with a high degree of confidence that the mining water and tailing material impacted wetland areas is highly polluted with sulphates, acidity and metals. The sediments captured within the depressions of the wetland system are in all probability highly enriched with a range of

pollutants and under anaerobic conditions. The anaerobic conditions would lead to the immobilisation of elements such as U.

6. The pollutants in the impacted wetland on the site are postulated to include a range of heavy metals of which U is considered one of the larger risks to future development. Uranium is currently not addressed in the guidelines for contaminated land but a significant international body of recent literature indicate a much larger chemical than radiological risk at levels that even approach background radiological signatures. This aspect will require dedicated elucidation, in conjunction with a thorough pollution status assessment for the site.
7. It is imperative that the site be decontaminated or the risk and hazards of the pollutants on human health be addressed before any development is authorised within or near the mine water and tailings material impact sites. In this regards it is critical that human activities within the wetland areas be limited to an absolute minimum and that erosion prevention and mitigation be implemented. The risk associated with erosion of wetland sediments relates to the alteration of the oxidation state (through aeration) of pollutants and associated minerals in the sediments that could lead to an increase in mobility, human health and environmental impacts.

Important Note:
A wetland assessment and radiological risk assessment of the impacted areas on the site is considered inadequate to determine and guide impact and development zones and management. It is imperative that a dedicated pollution assessment risk be conducted that will focus on both radiological and chemical toxicity risk of the pollutants associated with the historic activities. This is especially relevant if activities are contemplated within the wetland / watercourse features on the site.

REFERENCES

Brady, N.C. and Weil, R.P. 1999. *The Nature and Properties of Soils*. Twelfth edition. Upper Saddle River, New Jersey: Prentice Hall.

Coetzee, H. (compiler) 2004. An assessment of sources, pathways, mechanisms and risks of current and potential future pollution of water and sediments in gold-mining areas of the Wonderfonteinspruit catchment. WRC Report No 1214/1/06, Pretoria, 266 pp.

Department of Water Affairs and Forestry (DWAF). 2005. A practical field procedure for identification and delineation of wetland and riparian areas. DWAF, Pretoria.

Hillel, D. 1982. Introduction to soil physics. Acedemic Press, INC. Harcourt Brace Javonovich, Publishers.

Jenny, H. 1941. Factors of soil formation. New York, NY, USA: McGraw-Hill Book Company, p 281

Land Type Survey Staff. (1972 – 2006). *Land Types of South Africa: Digital map (1:250 000 scale) and soil inventory databases*. ARC-Institute for Soil, Climate and Water, Pretoria.

MacVicar, C.N. et al. 1977. *Soil Classification. A binomial system for South Africa.* Sci. Bull. 390. Dep. Agric. Tech. Serv., Repub. S. Afr., Pretoria.

Papenfus, M., Tesfamariam, E.H., de Jager, P.C., Steyn, C.S., and Herselman, J.E. 2015. Using soil-specific partition coefficients to improve accuracy of the new South Africa guideline for contaminated land. *Water SA Vol. 41, No.1*, pp. 9-14.

Soil Classification Working Group. 1991. Soil Classification. A taxonomic system for South Africa. *Mem. Agric. Nat. Resour. S.Afr.* No.15. Pretoria.

ANNEXURE D3b
STORMWATER MANAGEMENT PLAN

BIGEN AFRICA

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENT

LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

SEPTEMBER 2016

Issued by:
Leeuwpoort Development Company (Pty) Ltd
P O Box 49, Bedfordview, 2008
37 Empire Road
PARKTOWN NORTH
Tel: 011 – 482 3666
Fax: 011 – 482 9734
Attention: Mr Hannes Botes

Compiled by:

BIGEN AFRICA Services (Pty) Ltd
Allan Cormack Street, The Innovation Hub, Pretoria
PO Box 29, Innovation Hub, 0087
Tel: +27(0)12 842 8700
Fax: +27(0)12 843 9000/9001
e-mail: pretoria@bigenafrica.com

Enquiries: Mr D Smit Pr Eng; Ms M McGarry Pr Eng

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

CONTENTS LIST

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

Stormwater Management Report

Part A Introduction

Section A1 Background

The Ekurhuleni Metropolitan Municipality ("EMM") appointed Leeuwpoort Development Company (Pty) to proceed with the Leeuwpoort development. The Leeuwpoort development consists of land owned by EMM. The project area, is the Remaining Extent of the Farm Leeuwpoort 113IR, measuring approximately 1 300 Ha. The development is located south of Boksburg as indicated in the Figure below.

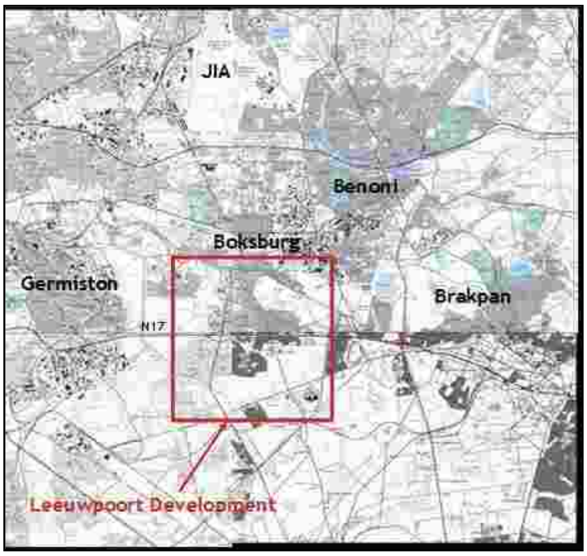


Figure A.1. Locality plan.

The development consists of 10 phases on 3 land parcels with a scope of approximately 17,343 building opportunities with a composition of subsidised, institutional and bonded housing. The Leeuwpoort Development is intended for mixed income and will provide a mix of housing products and forms of tenure. All 3 parcels are suitable for development and the report will focus on development of **Leeuwpoort South.**

Bigen Africa Consulting Engineers were appointed to do the investigations on the existing and proposed internal and external infrastructure for the Leeuwpoort Development.

Section A2 Existing/Future Roads around development

Several existing and future planned infrastructure affects the proposed development of Leeuwpoort. Water, sewer and electricity servitudes on the development area can be seen on Drawings included in Annexure A.

Roads affecting the layout plan and specifically Leeuwpoort South are the following:

Table A2.1 Leeuwpoort South

No	Road Name	Description
1	K132 (North Boundary Rd)	A Class 2 Major Arterial serves as a southern boundary to the development. Provides east – west movement to Brakpan, Springs, and Aldore
2	K155 (Barry Marais Rd)	A Class 2 Major Arterial serves as an eastern boundary to the development. Provides north – south movement to and from Boksburg, Benoni, and other northern areas.
3	K131(R21) – Rondebult Rd	A Class 2 Major Arterial linking the N12 to the north and the N17 to the south
4	Kingfisher Ave	A Class 3 road that provides east – west movement linking the K131, Trichardts Rd and the K155
5	Proposed extension of K165 (Class1)	A portion of the proposed K165 is planned to connect with the existing Class 2 Trichardts Rd linking with North boundary Rd which will provide north – south movement through the development.

Another major infrastructure affecting the development is a railway line running in a north-south direction through South phase 3.

Section A3 Phasing

Three separate development parcels are to be developed. These are shown on the locality plan drawing number 0741.00.AAA.02.S001. Leeuwpoort South will be subdivided in six different phases as seen on the Leeuwpoort Phasing Plan, drawing 0741.00.GZC.02.S001 in Annexure A.

Project phasing has been selected by taking cognisance of infrastructure needed for each parcel and to defer the investment in external services as far as is possible. The driving factor was the reservoirs' supply zones and the electricity feeding areas. The sewage drainage areas and the roads and stormwater infrastructure had minimum effect on the phasing process.
The three parcels are as follows (See drawings from Urban Dynamics attached in Annexure B):

- Reiger Park Extension 19 – Phase 1
- Parkdene Extension 7 – Phase 1
- Leeuwpoort South – Phase 1 -6

Section A4 Purpose of this report

The purpose of this report is to provide a stormwater management plan that will satisfy the requirements of the Department of Water Affairs and Environment (DWAE), the Gauteng Department of Agriculture and Rural Development and the Ekhurhuleni Metropolitan Municipality.

The report therefore addresses the following:

- The conditions prevailing on and around the site;
- The environmental impact of the stormwater of the proposed development during and after construction;
- Proposed mitigation measures;
- The impact of the development after mitigation measures have been applied.

The report may also be used to supplement any reports submitted to the environmental authorities as support for change of land use, and to provide guidance for the detailed design of the elements of the stormwater management system on the development.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

Part B Stormwater Management

Section B1 Objectives

The objectives of the stormwater management for this development are summarised as follows:

- To provide a stormwater drainage system for the convenience of the community and the protection of property from damage by the run-off from frequent storms.
- To prevent loss of life and reduce damage to property by the run-off from severe storms.
- To prevent land and watercourse erosion.
- To protect water resources from pollution.
- To prevent increased flood peaks in the existing major drainage system and further downstream from the development.
- To preserve natural watercourses and their ecosystems
- To achieve the foregoing objectives at minimal total cost.

Section B2 Natural River System and Flood Lines

The Leeuwpoort South Development has two drainage zones. Regional drainage zones are indicated on drawing 0741.00.GZC.04.A002 in Annexure B. Areas A – F, indicated in the aforementioned drawing, drain to the stream indicated by the flood lines on drawing 0741.00.GZC.04.A001 in Annexure B. Provision has been made for the water to cross Rondebult Road. The water table in this area is very high and problems occur with water seeping during the wet season. The stormwater system will need to address this problem.

The remainder south eastern section of the Site, Areas H and G drains towards the south eastern corner to an existing system of culverts underneath North Boundary Road. This system will need to be upgraded during the completion of the development.

There are three flood lines affecting the project site: two wetland areas in the south-eastern corner and a stream south of Sunward Park. These areas have been designated as wetlands and will be retained for drainage, detention and ecological purposes. These flood lines are indicated on drawing 0741.00.GZC.04.A001.

Section B3 Geotechnical Precautions

Reference is made to the GFSH-2, Phase 1 Dolomite Stability Investigation Report compiled by Messrs Intraconstult. Based on the gathered geological, geophysical, geohyrological and soils data, the stability of the site is described in terms of four Dolomite Stability Zones. The dolomite stability zones identified on site can be classified according to the NHBRC Dolomite Area Designations as follows:

Table D2.1 Dolomite Designations

Dolomite Stability Zone	NHBRC Dolomite Designation	Description
1	D2	The risk of sinkhole and doline formation is adjudged to be such that only *general precautionary measures*, which are intended to prevent the concentrated ingress of water into the ground are required to permit the construction of housing units
2	D2/D3	See description for D2 and D3
3	D3	The risk of sinkhole and doline formation is adjudged to be such that *precautionary measures*, in addition to those pertaining to the prevention of concentrated ingress of water into the ground, are required to permit the construction of housing units
4	D4	The risk of sinkhole and doline formation is such that precautionary measures cannot adequately reduce the risk to acceptable limits so as to permit the construction of housing units, or the precautionary measures which are required are impracticable to implement

The Geotechnical Investigations carried out by Messrs Intaconsult indicated that a portion in the south-western region of the Leeuwpoort South Development can be designated as Dolomite Zone D4. This area is indicated in the Drawing IR 801/S included Annexure A and should be read in conjunction with the Leeuwpoort South Layout Plan D11/2016.04.15.

The dolomitic nature of the underlying geology leads to various precautionary and monitoring requirements in order to ensure a safe township. These requirements are included in the dolomitic stability report prepared by Messrs Intraconsult. The precautionary measures affecting the stormwater management system proposed for the Leeuwpoort Development are as follows:

- Open areas shall be shaped to permit drainage of surface water and to prevent ponding. Boundary walls should incorporate drainage ports to permit the passage of surface runoff.
- Natural ponds and watercourses shall be rendered impervious.
- Backwash and other water from swimming pools shall be discharged into either the storm water or drainage systems as required by the local authority.
- The dolomitic stability over the route of any bulk water bearing service should be evaluated.
- Underground services shall be designed and constructed so as to minimise maintenance requirements and any potential leakage points in wet services and shall, as far as possible, be designed to avoid possible disturbance of the underground environment.
- The relevant provision of SABS 1200 DB, L, LB, LC, LD and LE shall be observed in the installation of all underground services. No rocks in top layer.
- The backfilling to service trenches and other excavations shall, except in rock, not be more permeable than the surrounding material.
- The storm water drainage system shall incorporate measures to ensure watertightness of the conduits and other compartments. Whenever possible storm water should be channelled in lined surface channels. Concrete non-pressure pipes should be of the spigot and socket type with rubber ring seals.
- Joints in the box culverts, channels, etc. should be sealed
- Storm water drainage conduits shall be constructed at gradients which will not permit the deposition of silt, or sand. All water bearing pipes and channels will be watertight. All laid drainage pipes should be tested for leakage using the air test (see NBRI INFO. Sheet X/BOU 2-34) on

installation. The responsible local authority should have a system whereby follow up tests for leakage are carried out and the results monitored.
- Provision shall be made in all water bearing pipelines to accommodate any potential differential movements without causing the pipeline or joints to leak.
- Flexible couplings should be provided on either side of manholes.
- Road surfaces shall be located sufficiently low so as to permit the drainage of erven onto them.
- Roadways, which have a gradient of less than 1:80, shall be surfaced.
- Roadways which act as major storm water collectors, shall be surfaced.
- The velocity of the 1 in 20 year stormwater, flowing along un-surfaced roadways shall not exceed 1.5 m/s.
- During construction, excavations should be opened and closed as rapidly as possible.
- During construction, berms should be constructed on either side of trenches to prevent the inflow of water during storms. If blasting is necessary, it is essential that appropriately experienced blasters be approached to determine the particular method specification for blasting.

It should be noted that the land-use within the areas designated as Dolomite Area D4 have been set aside for Urban Agriculture, Public Open Space and Sports fields. In so doing these land-use types will prevent the development of housing units on areas with a high risk of sinkhole formation.

Section B4 Design Norms, Standards and Drainage Philosophy

Permissible stormwater flow on roadways within the development will be based on guidelines included in the Ekurhuleni Metropolitan Municipality Standards for Roads and Stormwater and the "The Red Book".

The "Water Sensitive Urban Design for South Africa: Framework and guidelines" prepared by the Water Research Commission in 2014, highlights the importance of stormwater management through Sustainable Drainage Systems (SuDS). "The management of stormwater holistically is achieved by mimicking the hydrological cycle where the key objectives include:

- The effective management of stormwater runoff quantity and quality

- Promoting the amenity value

- Preserving / encouraging biodiversity value.

Simply put, there is no point focussing on biodiversity if life and property have not already been protected." (WSUD, Water Research Commision, 2014)

The typical SuDS treatment train is portrayed in the image below:

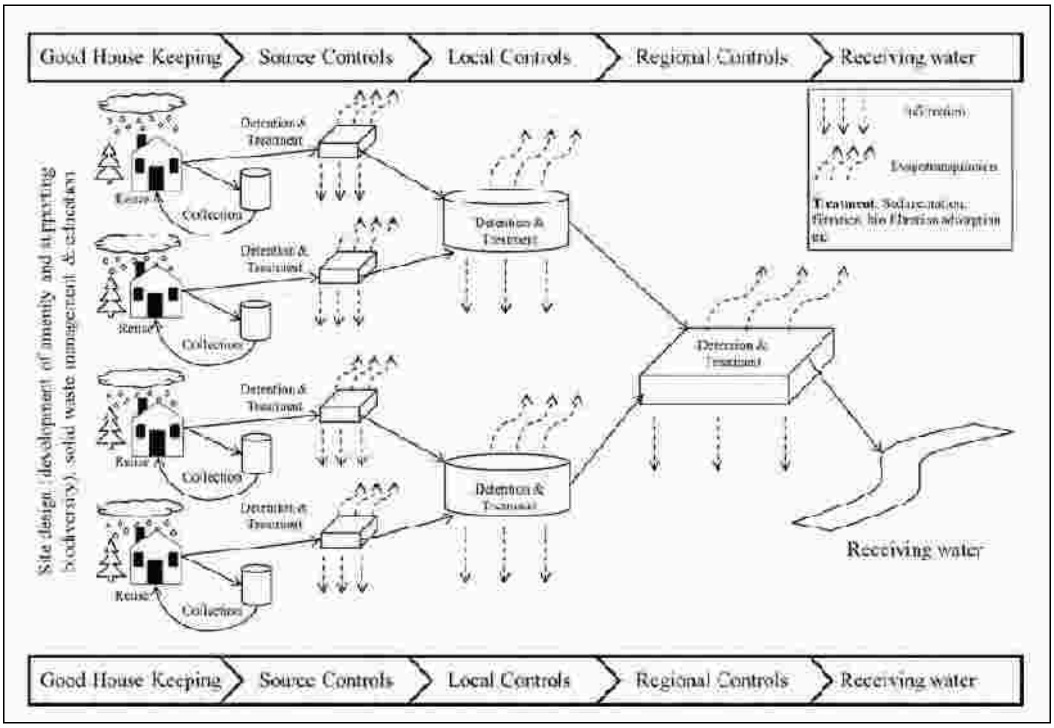


Figure B.1: Typical stormwater treatment train

The stormwater management tools that will likely be used within this development include:

- *Attenuation (or detention ponds)*
- *Storage (or retention ponds)*
- *Grass and lined swales (to reduce run-off velocity and provide for the possibility for storage)*
- *The effective use of roads (as stormwater cut-offs and channels) and piped systems to convey stormwater to the correct location.*
- *The use of rip-rap or gabions to protect against erosion, by slowing the flow*

rate over these structures down (as a result of the rocks and vegetation growing through it and around it).

- *Silt traps (where discharge will not be via attenuation ponds into the downstream stormwater system)*

The development site will be delineated into distinct drainage zones wherein the stormwater is mostly removed from the site in the roads.

The overall drainage of the site will make use of both surface and piped stormwater drainage systems. The surface drainage systems will consist of the surfaced roads in the development, lined channels and natural watercourses on the site. The minor flood will typically be accommodated by the piped stormwater systems. Stormwater will be directed off the surface as quickly as possible into the piped systems. The intention of this is to keep the volume of water flowing on roads to a minimum for traffic safety reasons.

Major flood peak flows will require the combined capacity of both the piped and surface drainage systems. In the case of drainage of the major flood the piped systems will operate full pipe capacity. The remainder of the peak flow will be contained within the limits of the formal surface drainage systems. No uncontrolled stormwater drainage will be permitted in order to safeguard human life and protect property from the risk of damage.

All streets in the township will be bitumen surfaced and will be designed to act as stormwater collectors and conveyors. The streets will be placed below natural ground level so that stormwater from adjacent erven can drain onto the streets. The layout and vertical alignment of the streets will be designed so that stormwater can be conveyed to the natural drainage channel that traverses the site.

An underground stormwater drainage system will be supplied to handle the minor floods (1:5 year) so that the traffic is not disrupted by the minor floods. Major floods that cannot be accommodated in the minor stormwater drainage system will be conveyed on the road surface and will not overspill into adjacent erven.

Table B.1: Design Criteria and Standards

PARAMETER	SPECIFICATION
Recurrence Interval	No kerb overtopping 1:5 years
Maximum flow velocity	3 m/s

PARAMETER	SPECIFICATION
on road edge	
Kerb inlet position	At kerb overtopping, and road intersection
Kerb inlet size	1,5m minimum 10,0m maximum
Pipe Size	450 dia minimum
Rational model	C Value = $0,53_{AVERAGE}$ MAP = 740mm Summer rainfall region

In view of the prevailing dolomitic geology, certain areas in the Leeuwpoort South Development will be subject to the requirements described in SANS 1936 (Development of dolomite land).

The stormwater management will need to be further developed during the preliminary and detail design stages and will require input from the environmental consultant, authorities and the client.

Section B5 Drainage Zones

The primary drainage zones for the Leeuwpoort Development were determined by considering the natural topography, spatial framework, and proposed positions of the attenuation ponds within the development. Within each of these primary drainage zones are a number of smaller secondary and tertiary drainage zones. The primary drainage zones for Leeuwpoort South are shown on drawing 0741.00.GZC.04.A002 included in Annexure B

Section B6 Design Flood

Section B6.1 Minor System

The minor system comprises catch pits, junction boxes, manholes, inlet structures and pipes necessary to drain stormwater of regular storms.

A design storm with a 1:5 year recurrence interval is used as the design standard.

Section B6.2 Major System

The major system will utilise the elements of the minor system as well as the road surface itself, pipes, box culverts, canals, natural low points, rivers and flood-attenuation structures necessary to drain stormwater of larger storms without damage to property and/or loss of life.

A design storm with a 1:50 year recurrence interval is used as the design standard, in such a way that -

- the section of the major system comprising roads and enlarged stormwater drainage systems in combination with the minor system, up to a natural waterway or low point be designed for a post development run-off with a 1:25 year recurrence interval;

- the major system, where it consists of a natural or canalised waterway or low point, be designed for a 1:50 year recurrence interval to convey a post-development run-off without flooding any building.

Section B7 Stormwater Attenuation

It is a requirement of the EMM that provision for stormwater attenuation is made. This development will result in changes to the nature of the run-off generated. The stated objectives of the stormwater management plan include prevention of increased flood peaks in existing downstream drainage systems. The ultimate objectives are to avoid exceeding the capacity of the downstream stormwater infrastructure and to prevent changes in the floodlines that would endanger life and property downstream of the development.

In the interest of minimising the adverse effects of increased stormwater runoff due to urbanisation, attenuation ponds are proposed and planned for in the township layouts. The ponds will provide temporary storage of stormwater runoff during times when the runoff exceeds that of the pre-development scenario and in so doing ensure that the capacity of downstream facilities is not exceeded. An added advantage of this system would be the gravity settling of pollutants etc. prior to the stormwater being discharge into the region catchment.

The following measures will be included in the design of the stormwater infrastructure for the attenuation of peak run-off on the development:

- Flood storage facilities are required.

- Outlet structures from these storage facilities must control the discharge flow rate so that the aggregate effect is that post-development peak flow does not exceed the pre-development peak flow.

- The concentration of the runoff at the attenuation facilities requires that erosion protection measures be provided to mitigate the potential environmental degradation.

- Attenuation facilities, including outlets structures must be designed to minimize the need for maintenance.

It is proposed that stormwater be attenuated and detained in ponds located within areas to be determined in conjunction with the finalisation of the layout.

Within the southern development area (Leeuwpoort South), the intention is to make use of existing and future infrastructure to assist with the attenuation and protection of the environment. The stormwater attenuation concept that will be adopted within this development consists of the use of 2 attenuation controls:

- The use of Aquarius road (through the engineering design of the culverts under this road – refer to discussion further below);

- The use of the existing Pan located on the western side of the development – refer to discussion further below.

<u>Aquarius Road</u>

Part of the development includes the construction of major roads across the existing drainage courses. One of these roads is the extension of Aquarius road. As discussed previously in this report, the floodlines (1:50 and 1:100 storm events) have been calculated and are indicated on the attached layout drawings.

The construction of this road will include culverts which have been designed to allow the normal stormwater flow through during minor storm events. The intention is however, to size these culverts so that during major storm events (1:50 and 1:100 year events) the culverts will also function as an attenuation control. This will ensure that during major storm events, the river downstream is protected from the increased stormwater run-off (as a result of the development) and is protected somewhat against erosion that would occur during the large storm events. The impact on the floodline has been calculated and is indicated on the attached drawings. No development will occur within this 1:100 floodline.

The sizing of the culverts will form part of the detail design stage of the development. Refer to drawing numbers 0741.00.GZC.04.D003 and 0741.00.GZC.03.L001 in Annexure B for an indication of the proposed road crossing.

Existing Pan

The existing Pan located on the western side already fulfils an attenuation control function. The intention is to protect the Pan's outlet (through the construction of a gabion mattress outlet) which will control the stormwater flow from the Pan, thereby preventing erosion at the Pan's outlet as velocity will be controlled and the outlet designed for that velocity.

The Pan's ability to provide attenuation will then be used in a controlled and designed manner. The 1:100 floodline at this Pan will not be changed and is indicated on the drawings. The downstream stormwater system will not be affected as stormwater will be discharged to pre-development levels at a controlled manner that will protect the downstream environment and also prevent erosion at the current outlet. The current outlet (without gabion protection) will have erosion occurring and will result in pollution of the downstream environment. The proposal is therefore twofold, in that it protects the environment, and also enables the control of stormwater discharge into the downstream system. Refer to drawings included in Annexure B for further details of the proposed erosion protection mechanism.

Section B8 Prevention of pollution and erosion protection

At the discharge points of stormwater drainage lines and pipe into attenuation points, the flow velocities will be reduced below the settlement velocity of grit and silt. These will (where possible) then be deposited in the attenuation dams from where it can easily be removed during dry periods. Where the discharge points cannot be discharged into attenuation ponds, they will controlled by means of silt-traps where required. Pollution of the main water course will therefore be prevented. Refer to Annexure B for further details of the proposed silt trap.

Erosion along drainage lines will be prevented by establishing indigenous vegetation and grass in those areas. Steep slopes will be flattened by using gabion weirs at intervals. If flow velocities cannot be reduced to levels that will not be erosive, permeable linings such as grass blocks will be used to stabilize the soils and vegetation. The controlled release of stormwater (at acceptable velocities and by means of dispersion over a wide area or through numerous outlets) from Pans, culverts and overflows/outlets will also prevent and minimise erosion.

Section B9 Run-off Discharge calculation method

The Rational Method as described in the SANRAL Road Drainage Manual will be used to determine the probable flood discharge for the specified recurrence intervals. The runoff coefficients will be based on the design norms and standards as specified by the SANRAL Road Drainage Manual.

Section B10 Summary of key calculations

Presented here is a summary of the key calculated values (concept stage) regarding the stormwater infrastructure for the development. Detailed calculations will be concluded as part of the preliminary and detail design stage. Some of the key calculations are included in **Annexure C**.

Section B10.3 Leeuwpoort South

Table 1: Pre- and Post-development Runoff Peak Calculation (Rational Method)

Area Description	Run-off coeff	Area (ha)	Intensity		Q (m^3/s)	
			1:5	1:25	1:5	1:25
Pre-Development Catchment: Leeuwpoort South	0.3	769.8	24	38	12.31	22.67
Post-Development Catchment: Leeuwpoort South	0.49	769.8	36	52	30.17	50.67

Developed Area	567.62 ha
Undeveloped Area	202.23 ha
Attenuation Storage Required*	198 670 m^3

* Attenuation storage required based on a volume of 350 m^3/ha of developed land.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

Part C Conclusion

The discussion above and the calculations/drawings included in the Annexures illustrate how stormwater management for the Leeuwpoort Development (within Parkdene, Reiger Park and Leeuwpoort South) have been planned according to the requirements of the Department of Water Affairs and the local authorities.

The detailed design process will include specific calculations and drawings to verify those presented in this report.

The following key objectives of the stormwater management for this development have been addressed:

- Guarantee the convenience of the community and protect property during the occurrence of frequent storms;
- Prevent loss of life and the reduction of damage to property during the occurrence of storms;
- Ensure that the discharge of stormwater do not cause the erosion of flood plains and pollution of natural resources;
- Mitigate the impact of the development on the environment.

The stormwater management may need to be further developed during the detail design stages and will require input from the environmental consultant, authorities and the client.

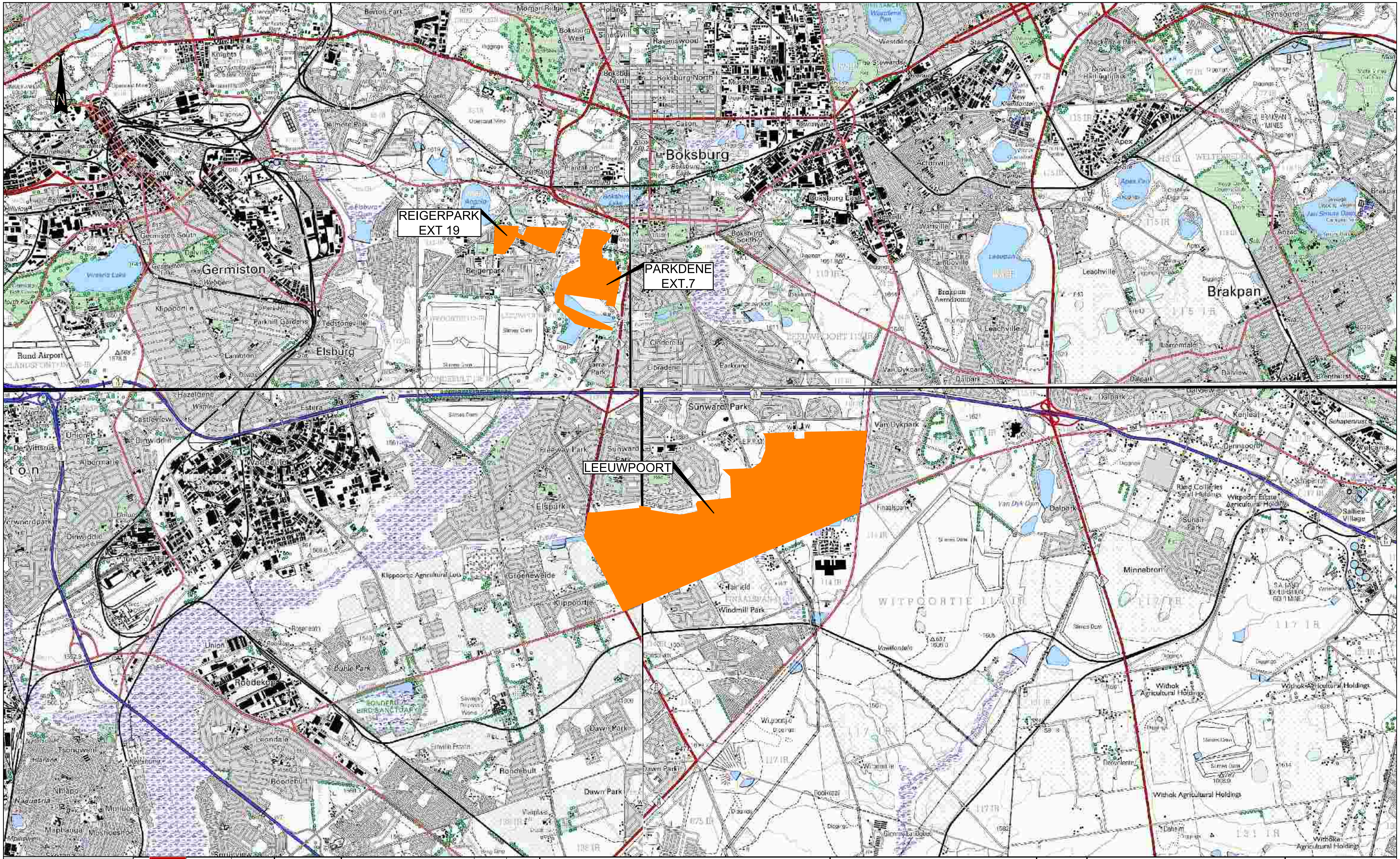
LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

ANNEXURE A

Locality Plan



F:\Drawings\0741\drawings\02\s\0741.00.AAA.02.S001.dwg, File path, File path

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

SURVEYED	–
DESIGNED	
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No.	REVISION	APPROVED: D SMIT Pr.Eng. No: 20080336
0741.00.AAA.02.S001	1.0	

APPROVED ON BEHALF OF BIGEN AFRICA:

NAME: ....

SIGNATURE: ....

DATE: ....

	AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENTS (PTY) LTD

LOCALITY PLAN

Ekurhuleni
METROPOLITAN MUNICIPALITY

SCALE

1:30 000 ON ORIGINAL – DRAWING

AS–BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS–BUILT FOR CONTRACT :

ENGINEER DATE

DRAWING No.

FILE No.

PROJECT

PROPOSED TOWNSHIP

LEEUWPOORT SOUTHERN PART

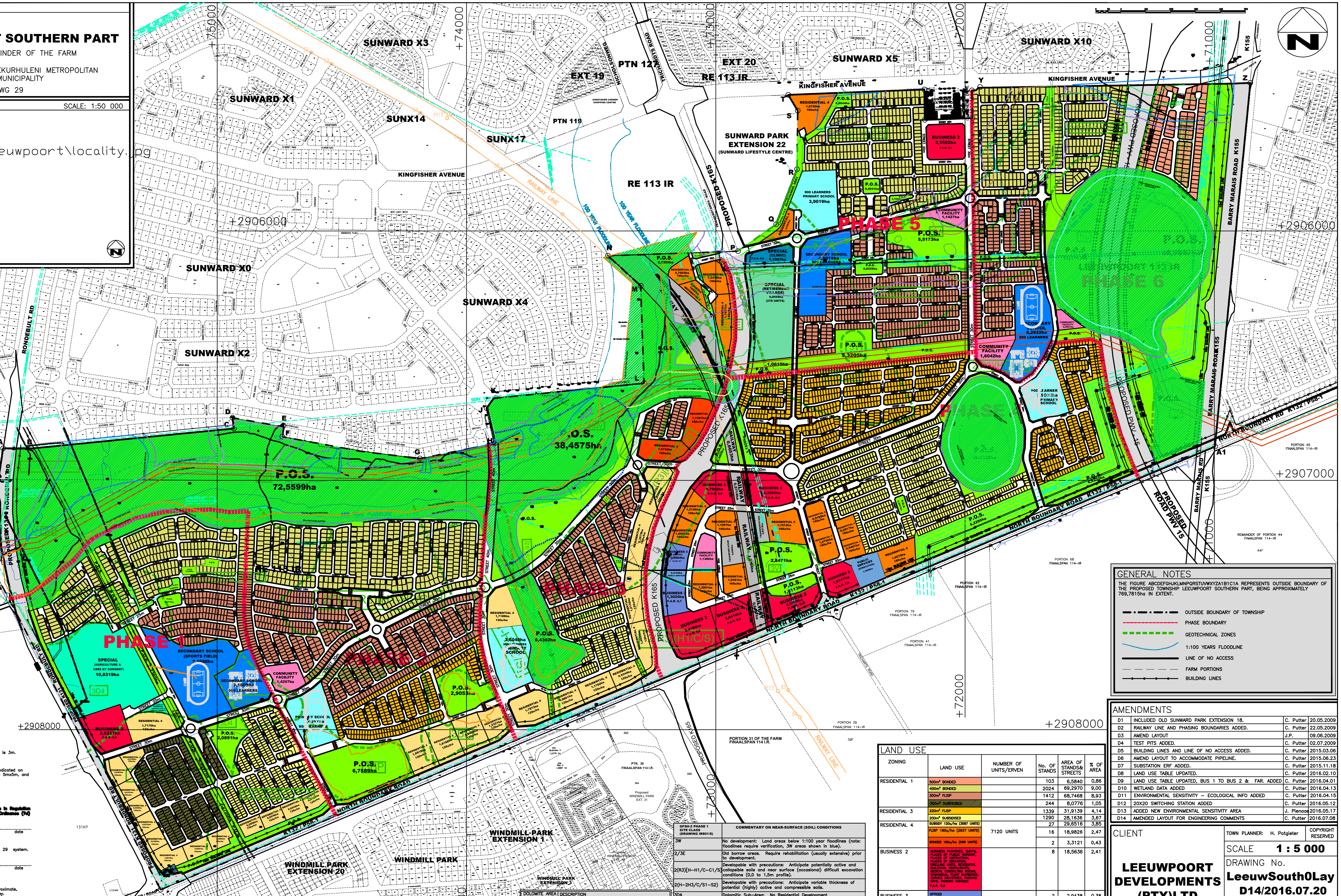
SITUATED ON THE REMAINDER OF THE FARM LEEUWPOORT 113 IR

LOCAL AUTHORITY : EKURHULENI METROPOLITAN MUNICIPALITY

GEODETICAL SYSTEM : WG 29

LOCALITY SCALE: 1:50 000

\Boksburg\Leeuwpoort\locality.jpg



GENERAL NOTES

RESIDENTIAL SITES

The minimum width of panhandle accesses is 3m. Splays on panhandle erven are 3mx3m.

ROADS

Reserve widths of all internal streets are indicated on the plan. Splays on all Class 5 streets are 5mx5m, and a class 4 streets are 10 x 10m.

Maximum slope on roads is 1:____
Minimum slope on roads is 1:____

CONTOURS

Contours are based on standards laid down in Regulation 21(2) of the Town Planing and Townships Ordinance (Tvl) 25 of 1965 as amended.

....
XAN SWART date

CO-ORDINATES

The Co-ordinate reference is based on WG 29 system. Baseplan mapping was done by

....
XAN SWART date

DIMENSION AND SIZES

All dimensions shown on the plan are approximate, scaled in meters and subject to final survey.

FLOODWATER

It is hereby certified that in accordance with section 144 of the national water act (Act 36 of 1998) that the floodline shown indicates the maximum level likely to be reached by floodwater on average once every 100 years.

....
CONSULTING ENGINEER date

GEOLOGICAL

It is hereby certified that the layout of the township complies with the recommendations and requirements set out in the geotechnical report no. ________ dated ____________________.

Engineering Geologist..

Firm..

DOLOMITE STABILITY ZONE	APPROPRIATE DEVELOPMENT
D1	Residential (no density constraints), commercial or light (dry) industrial development.
D2	Residential (max. 40–60 units/ha), commercial or light (dry) industrial development.
D3	Residential, commercial or light (dry) industrial development. Minimum stand size 300m².
D4	Selected commercial or light (dry) industrial. No residential development. SANS10400 only allows for very selected commercial development in this risk class.

DOLOMITE AREA DESIGNATION D	DESCRIPTION
D1	No precautionary measures are required to permit the construction of housing units due to the geological setting.
D2	The risk of sinkhole and doline formation is adjudged to be such that only general precautionary measures, which are intended to prevent the concentrated ingress of water into the ground, are required to permit the construction of housing units.
D3	The risk of sinkhole and doline formation is adjudged to be such that precautionary measures, in addition to those pertaining to the prevention of concentrated ingress of water into the ground, are required to permit the construction of housing units
D4	The risk of sinkhole and doline formation is such that precautionary measures cannot adequately reduce the risk to acceptable limits so as to permit the construction of housing units, or the precautionary measures which are required impracticable to implement.

GFSH-2 PHASE 1 SITE CLASS (DRAWING IR801/S)	COMMENTARY ON NEAR-SURFACE (SOIL) CONDITIONS
3W	No development: Land areas below 1:100 year floodlines (note: floodlines require verification, 3W areas shown in blue).
2/3E	Old borrow areas. Require rehabilitation (usually extensive) prior to development.
2(R3)[H–H1/C–C1/S]	Developable with precautions: Anticipate potentially active and collapsible soils and near surface (occasional) difficult excavation conditions (0,0 to 1,5m profile).
2(H–2H3/C/S1–S2)	Developable with precautions: Anticipate variable thickness of potential (highly) active and compressible soils.
3D4	Dolomitic Sub–Area: No Residential Development
2PD3(R3) [H1–H2/C/S]	Developable with precaution: Dolomitic Sub–Area (see IR801/R). Anticipate variable thickness of potentially heave/shrink soils and near–surface (occasional) difficult excavation conditions (0,0 – 1,5m profile).
2PD2/D3(R3) {H1–H2/C/S)	Developable with precaution: Dolomitic Sub–Area (see IR801/R). Anticipate variable thickness of potentially heave/shrink soils and near–surface (occasional) difficult excavation conditions (0,0 – 1,5m profile).
2(R3)[H1–H2/C/S]	Developable with precautions. Anticipate variable thickness of potentially heave/shrink soils and near surface (occasional) difficult excavation conditions (0,0 – 1, 5m) profile.
2(R3)[H1/C/S]	Developable with precautions. Near surface difficult excavation conditions in 0.0 to 1.5m profile.
2(R3)[H1/C/S]	Developable with precautions. Anticipate potentially heave/shrink soils and near–surface (occasional) difficult excavation conditions in 0.0 to 1.5m profile.
3BP	Extensive and deep borrow pits with limited development potential. Possible use as materials sites for new townships.
3V	Pan features with vlei areas (with the pans). Limited development potential. Possible incorporation as stormwater attenuation ponds in new townships.

LAND USE

ZONING	LAND USE	NUMBER OF UNITS/ERVEN	No. OF STANDS	AREA OF STANDS& STREETS	% OF AREA
RESIDENTIAL 1	500m² BONDED		103	6,5840	0,86
	400m² BONDED		2024	69,2970	9,00
	300m² FLISP		1412	68,7468	8,93
	300m² SUBSIDISED		244	8,0776	1,05
RESIDENTIAL 3	220m² FLISP		1339	31,9139	4,14
	200m² SUBSIDISED		1290	28,1636	3,67
RESIDENTIAL 4	SUBSIDY 120u/ha (3587 UNITS)	7120 UNITS	27	29,6516	3,85
	FLISP 160u/ha (2937 UNITS)		16	18,9826	2,47
	BONDED 180u/ha (598 UNITS)		2	3,3121	0,43
BUSINESS 2	BUSINESS PURPOSES, SHOPS, PLACES OF PUBLIC WORSHIP, PLACES OF INSTRUCTION, PLACES OF EDUCATION, DWELLING UNITS, RESIDENTIAL BUILDINGS, RESTAURANTS, MEDICAL CONSULTING ROOMS, GYMNASIUM, PLANT NURSERIES, SERVICE INDUSTRIES, PARKING BAYS, PARKING GARAGES F.A.R. 0,6		8	18,5636	2,41
BUSINESS 3	OFFICES F.A.R. 0,7		2	2,9438	0,38
SPECIAL	CLINIC F.A.R. 0,8		1	1,1067	0,14
	RETIREMENT VILLAGE, FRAIL CARE AND ASSOCIATED USES (278 UNITS)		1	6,8558	0,89
	GATE HOUSES		20	0,2100	0,03
	AGRICULTURE & USES BY CONSENT (NOT DEVELOPABLE)		2	11,1240	1,44
PUBLIC SERVICES	ELECTRICAL SUBSTATION		4	1,9248	0,25
COMMUNITY FACILITY	COMMUNITY FACILITY F.A.R. 0,6		5	5,8167	0,76
	PRIMARY SCHOOL 4500 LEARNERS		4	13,8127	1,79
	SECONDARY SCHOOL 2700 LEARNERS		4	20,8448	2,71
PUBLIC OPEN SPACE	PARK		66	238,8953	31,03
TRANSPORTATION	RAILWAY, STATION, TAXI, PARKING		7	12,7182	1,65
ROADS	PROVINCIAL ROADS			55,4800	7,21
	STREETS			114,8275	14,92
TOTAL			6583	769,8531	100%

GENERAL NOTES

THE FIGURE ABCDEFGHJKLMNPQRSTUVWXYZA1B1C1A REPRESENTS OUTSIDE BOUNDARY OF THE PROPOSED TOWNSHIP LEEUWPOORT SOUTHERN PART, BEING APPROXIMATELY 769,7815ha IN EXTENT.

- OUTSIDE BOUNDARY OF TOWNSHIP
- PHASE BOUNDARY
- GEOTECHNICAL ZONES
- 1:100 YEARS FLOODLINE
- LINE OF NO ACCESS
- FARM PORTIONS
- BUILDING LINES

AMENDMENTS

D1	INCLUDED OLD SUNWARD PARK EXTENSION 18.	C. Putter	20.05.2009
D2	RAILWAY LINE AND PHASING BOUNDARIES ADDED.	C. Putter	22.05.2009
D3	AMEND LAYOUT	J.P.	09.06.2009
D4	TEST PITS ADDED.	C. Putter	02.07.2009
D5	BUILDING LINES AND LINE OF NO ACCESS ADDED.	C. Putter	2015.03.06
D6	AMEND LAYOUT TO ACCOMMODATE PIPELINE.	C. Putter	2015.06.23
D7	SUBSTATION ERF ADDED.	C. Putter	2015.11.18
D8	LAND USE TABLE UPDATED.	C. Putter	2016.02.10
D9	LAND USE TABLE UPDATED, BUS 1 TO BUS 2 & FAR. ADDED	C. Putter	2016.04.01
D10	WETLAND DATA ADDED	C. Putter	2016.04.13
D11	ENVIRONMENTAL SENSITIVITY – ECOLOGICAL INFO ADDED	C. Putter	2016.04.15
D12	20X20 SWITCHING STATION ADDED	C. Putter	2016.05.12
D13	ADDED NEW ENVIRONMENTAL SENSITIVITY AREA	J. Pienaar	2016.05.17
D14	AMENDED LAYOUT FOR ENGINEERING COMMENTS	C. Putter	2016.07.08

CLIENT

LEEUWPOORT DEVELOPMENTS (PTY)LTD

TOWN PLANNER: H. Potgieter

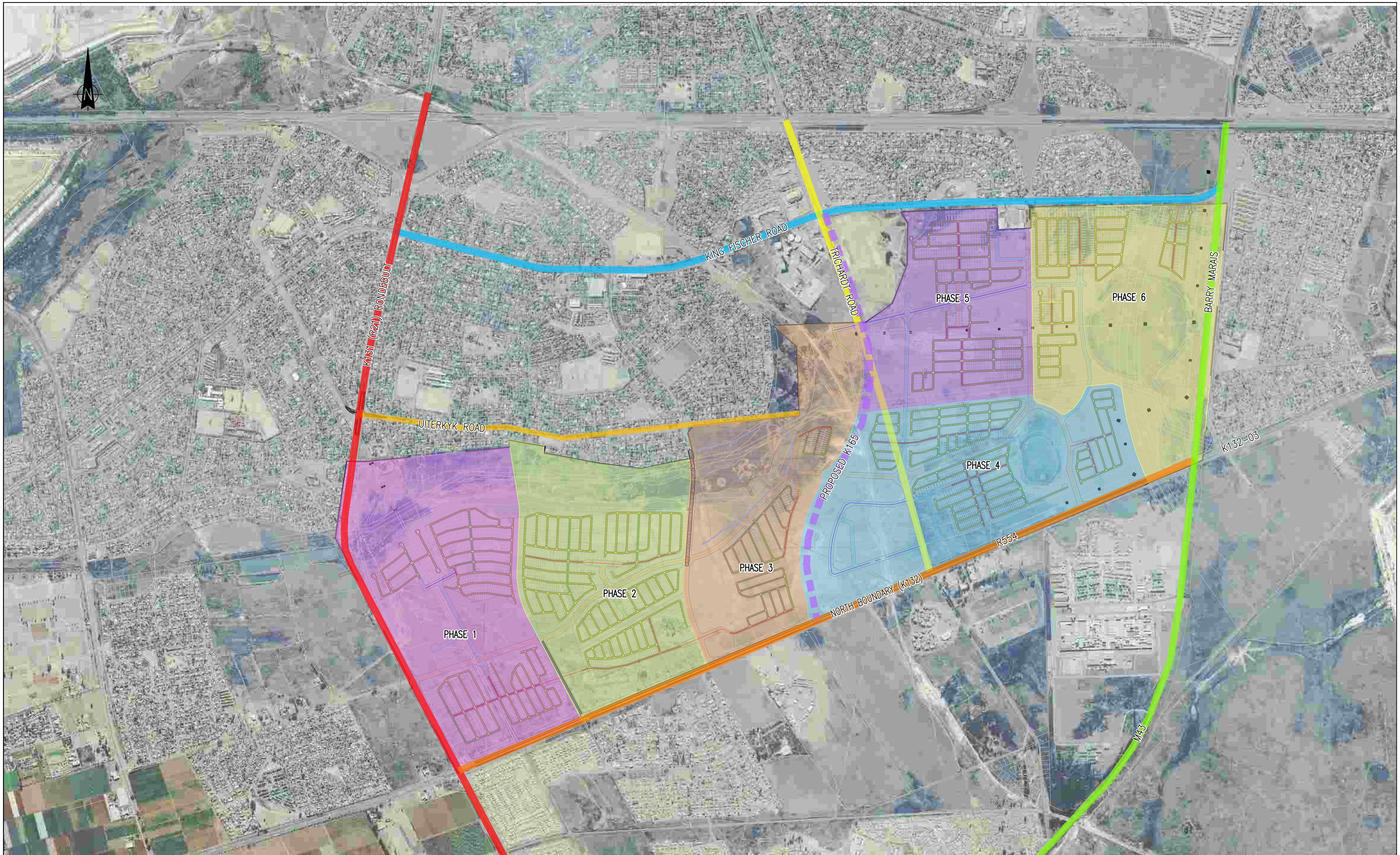
SCALE **1 : 5 000**

DRAWING No. **LeeuwSouth0Lay D14/2016.07.20**

LAYOUT PLAN STATUS **DRAFT**

37 EMPIRE ROAD
PARKTOWN
P.O. BOX 291803
MELVILLE
2109
TEL: (+27 11) 482-4131
TEL: (+27 11) 482-9959
E-MAIL: danie@urbandynamics.co.za

R:\GENERAL\Template2009\maplogo.tif



BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

SURVEYED	–
DESIGNED	–
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No.	REVISION	APPROVED: D SMIT Pr.Eng. No: 20080336
0741.00.GZC.02.S001	1.0	

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE:
DATE:

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

PHASING LAYOUT

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE
1:10 000 ON ORIGINAL – DRAWING

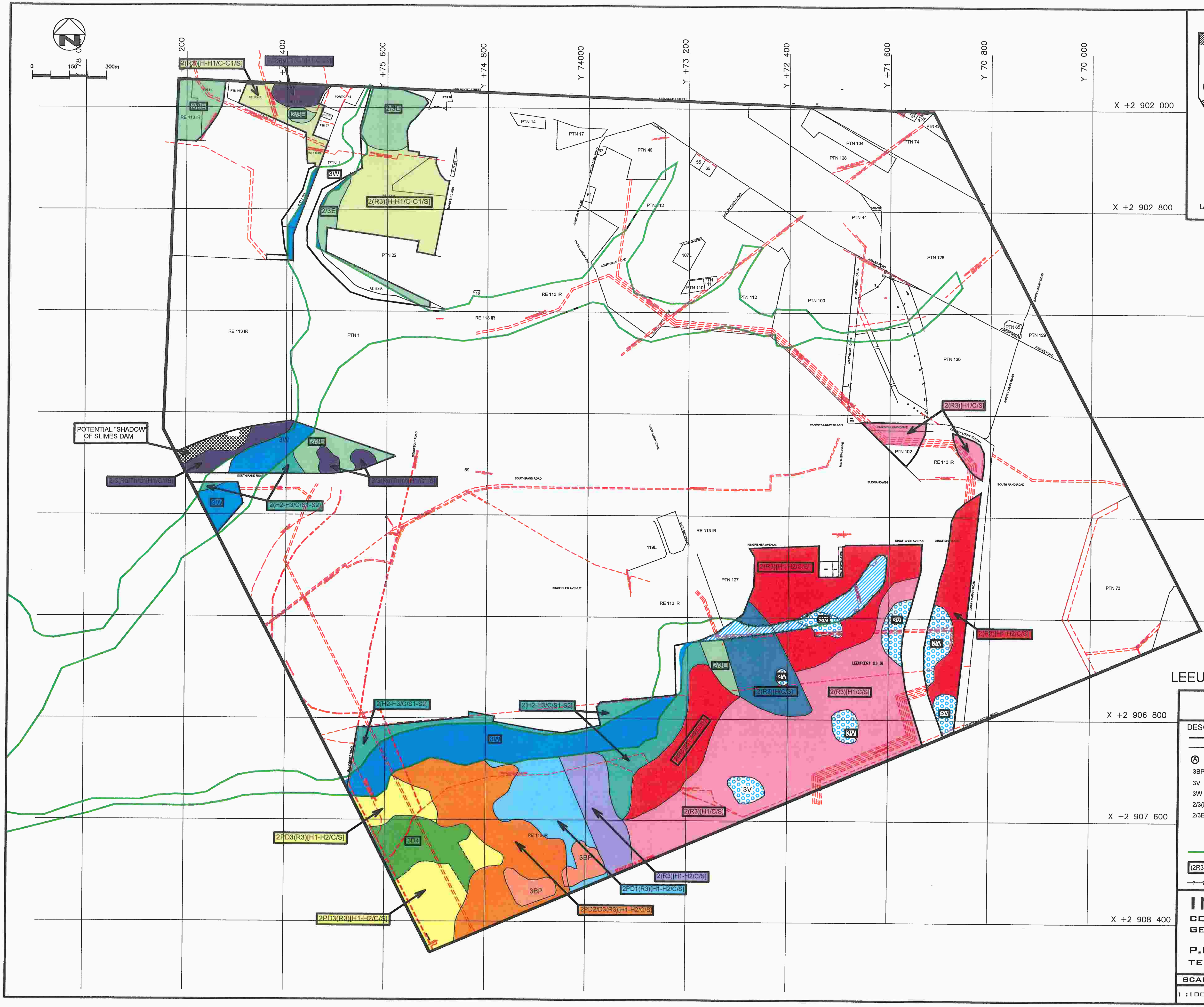
AS-BUILT RECORD

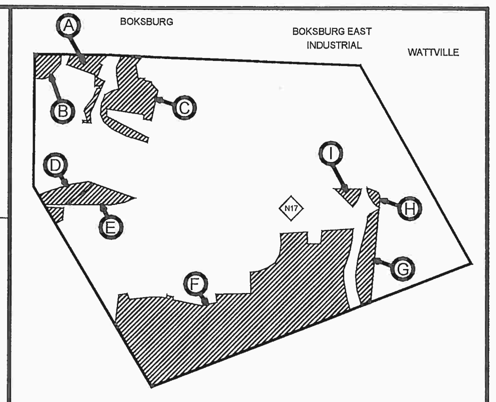
CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS-BUILT FOR CONTRACT :
ENGINEER DATE

DRAWING No.

FILE No.





LAND PARCEL LOCALITY PLAN (AS DISCUSSED IN REPORT IR801/S)

LEEUWPOORT DEVELOPMENT AREA

SOIL MAP [NHBRC]

(AT NATURAL GROUND GRADIENTS)

DESCRIPTION:

	LAND PARCEL BOUNDARIES
	PRESUMED BOUNDARY OF SITE CLASS AT SUB-AREA
Ⓐ	LAND PARCEL LABLE(DISCUSSED IN REPORT IR801/S)
3BP	DEEP BORROW PIT AREAS
3V	VLEI AREA (WITHIN PAN)
3W	WET AREA (WITHIN ALLUVIAL FLOOD PLAIN)
2/3(Ra/Th/U)	REMNANTS OF SLIMES DAMS
2/3E	OLD BORROW PIT AREAS (REHABILITATION REQUIRED)
	TRIAL PIT POSITION AND NUMBER
	1:100 YEAR FLOODLINES (REQUIRE CERTIFICATION)
(2R3)[H1-H2/C/S]	PRELIMINARY SITE CLASS OF SUB AREA
	FLOODLINES UNCLEAR (REQUIRE VERIFICATION)

INTRACONSULT
CONSULTING ENGINEERING GEOLOGISTS
P.O.Box 604, Fourways 2055
TEL. (011) 469-0854

SCALE	DATE	DRAWN	REV.NO	REF.NO
1 :10000	NOV.2006	MAPTECH	0	IR 801/S

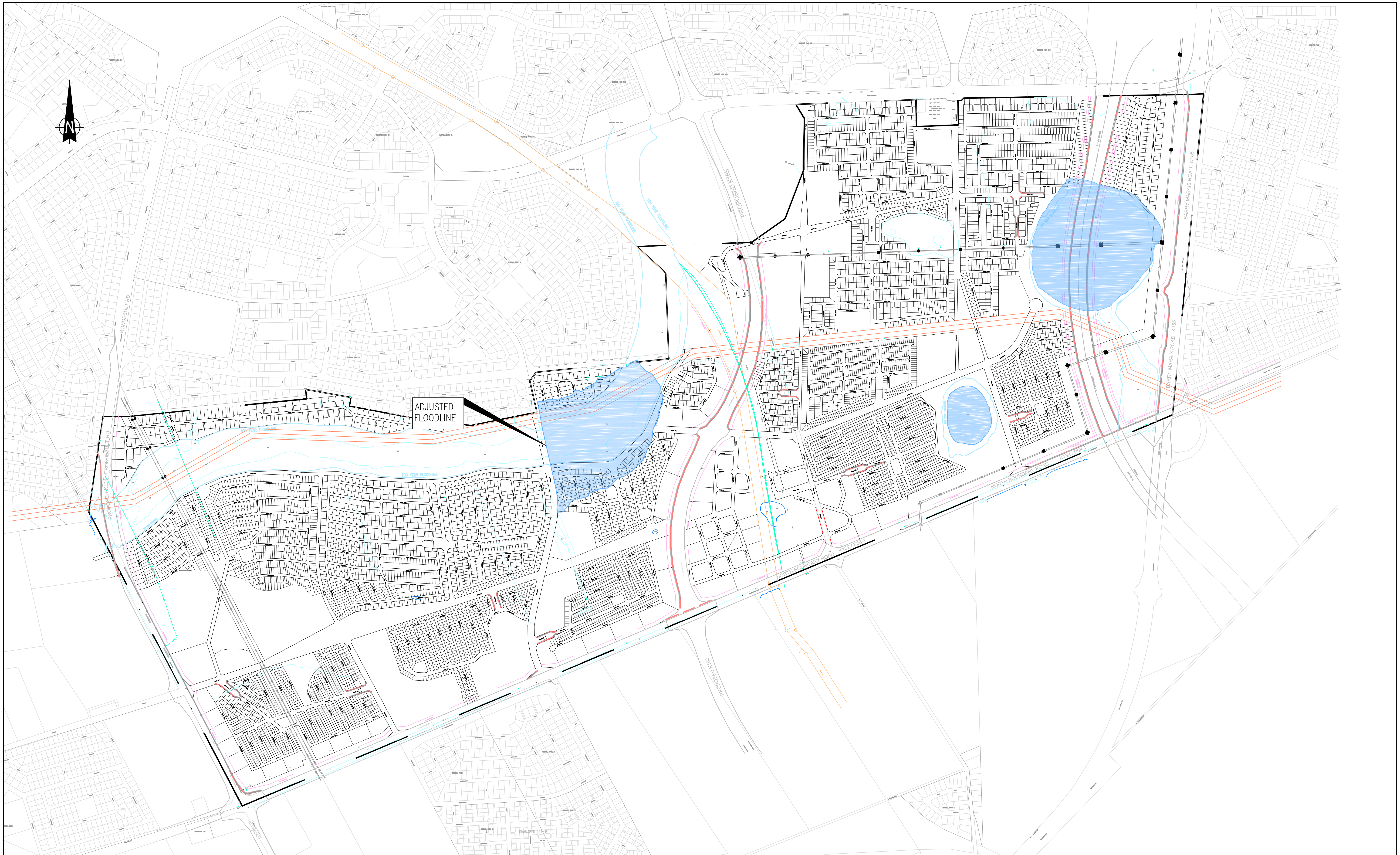
LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT – LEEUWPOORT SOUTH

STORMWATER MANAGEMENT REPORT

ANNEXURE B

Drawings



BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

SURVEYED	–
DESIGNED	M McGARRY
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No.	REVISION	APPROVED: D SMIT Pr.Eng. No: 20080336
0741.00.GZC.04A001	1.0	

APPROVED ON BEHALF OF BIGEN AFRICA:

NAME: D SMIT ....

SIGNATURE: ....

DATE: ....

	AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

PROPOSED FLOODLINE WITH ATTENUATION PONDS

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE

1:8000 ON ORIGINAL – DRAWING

AS–BUILT RECORD

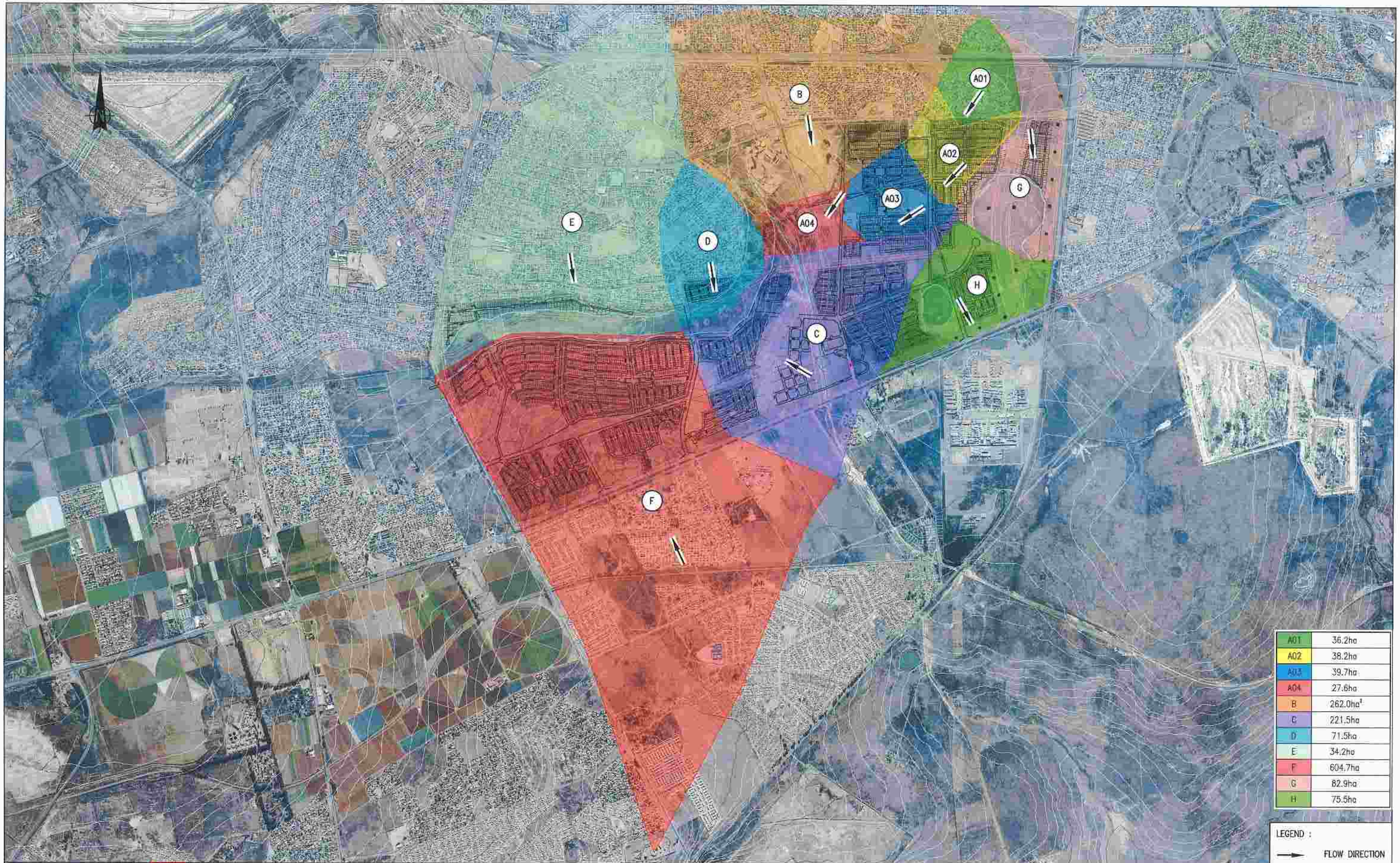
CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS–BUILT FOR CONTRACT :

ENGINEER DATE

DRAWING No.

FILE No.



A01	36.2ha
A02	38.2ha
A03	39.7ha
A04	27.6ha
B	262.0ha²
C	221.5ha
D	71.5ha
E	34.2ha
F	604.7ha
G	82.9ha
H	75.5ha

LEGEND :

→ FLOW DIRECTION

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

SURVEYED	–
DESIGNED	M McGARRY
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No. 0741.00.GZC.04.A002

REVISION 1.0

APPROVED: D SMIT
Pr.Eng. No: 20080336

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE:
DATE:

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

REGIONAL DRAINAGE ZONES

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE 1:12 500 ON ORIGINAL – DRAWING

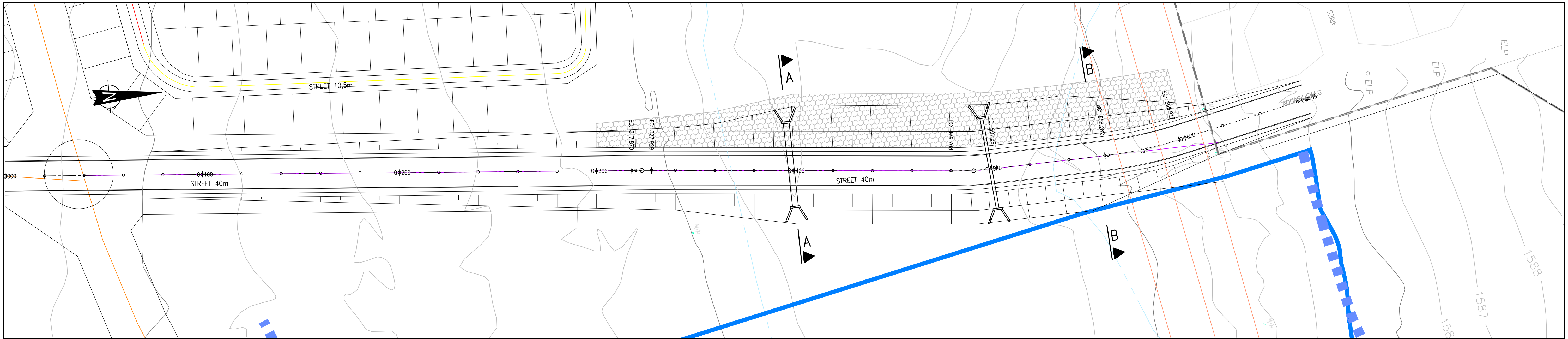
AS–BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS–BUILT FOR CONTRACT :
ENGINEER DATE

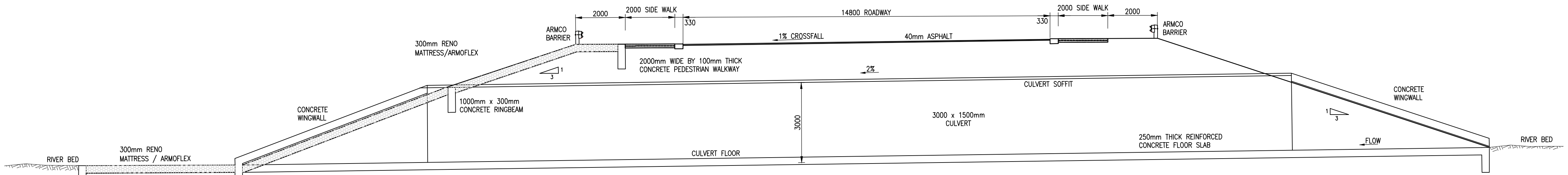
DRAWING No.

FILE No.



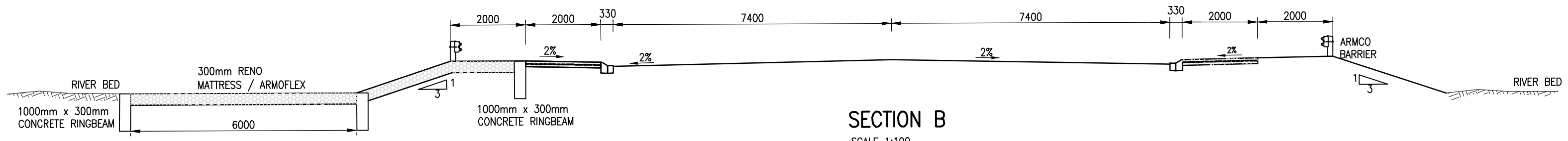
PLAN

SCALE 1:1000



SECTION A

SCALE 1:100



SECTION B

SCALE 1:100

NOTES:
1. 30 MPa CONCRETE TO BE USED.
2. 100mm THICK CONCRETE PEDESTRIAN WALKWAY TO BE CAST IN ALTERNATIVE SECTIONS OF 2500mm.
3. REF. 395 MESH TO BE CONTINEOUS ACROSS CONSTRUCTION JOINTS.
4. 12mm POLYSTYRENE EXPANSION JOINTS TO BE PROVIDED AT 30m CENTRES
5. CONCRETE SURFACE OF WALKWAY TO BE WOOD TROWELLED FINISHED.
6. SLOPE FO EMBANKMENT TO BE GRASS SEEDED.

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

BIGEN AFRICA

SURVEYED	–
DESIGNED	M McGARRY
DRAWN	M STEENBERG
CHECKED	J D SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	J D SMIT

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: J D SMIT
SIGNATURE: ....
DATE: ....

PRIVATE DRAWING No.	REVISION	APPROVED: D SMIT Pr.Eng. No: 20080336
0741.00.GZC.04.D003	1.0	

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

BRIDGE ROAD EMBANKMENT

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE

AS SHOWN ON ORIGINAL – DRAWING

AS-BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

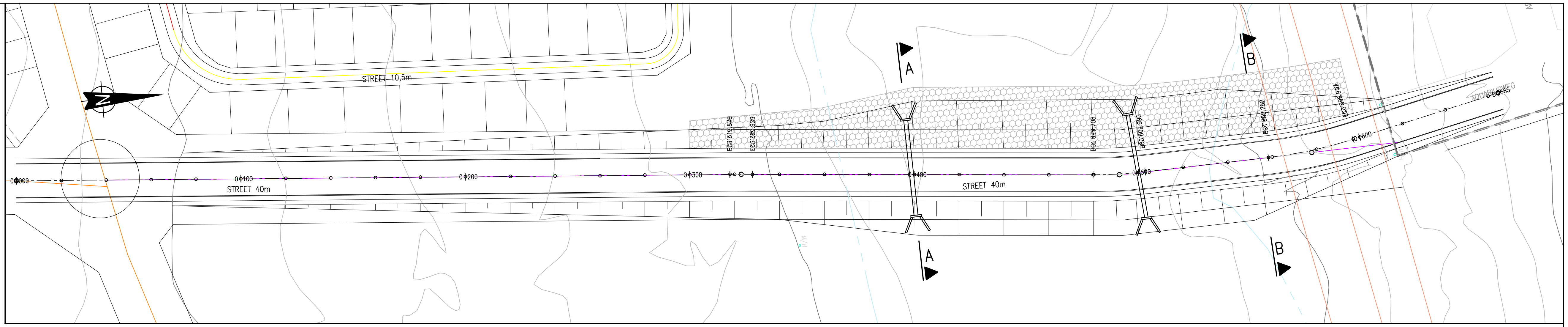
CERTIFIED AS-BUILT FOR CONTRACT :
ENGINEER DATE

DRAWING No.

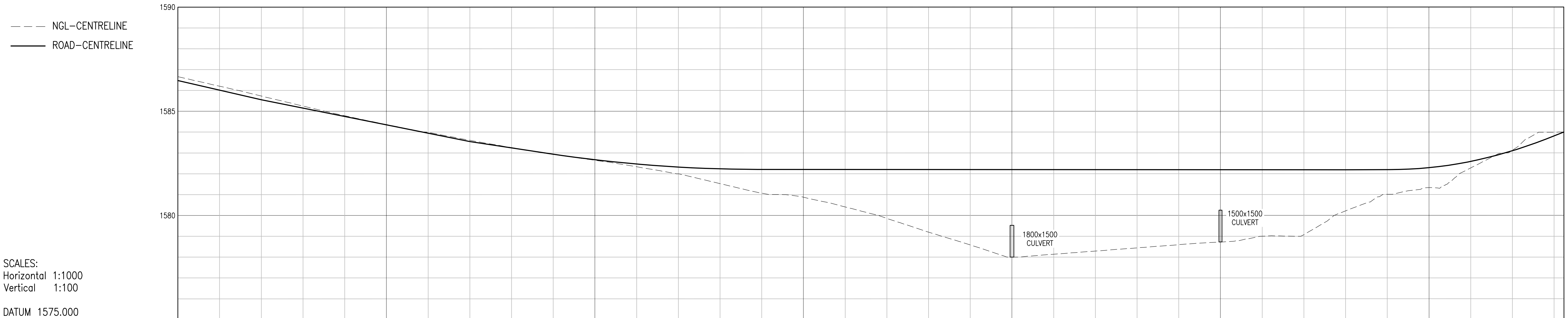
FILE No.

NOTES :

1. CULVERTS HAVE BEEN DESIGNED TO ACCOMMODATE THE 1:25 YEAR FLOOD RECURENCE WITH-OUT OVER TOPPING OF THE ROADWAY.
2. DURING HIGHER FLOOD RECURENCES THE ROADWAY MAY BE OVERTOPPED



LAYOUT PLAN
SCALE 1:1000



SCALES:
Horizontal 1:1000
Vertical 1:100

DATUM 1575.000

CUT / FILL	-0.186	-0.192	-0.181	-0.102	-0.040	-0.016	-0.037	-0.059	-0.012	0.015	0.027	0.132
ROAD LEFT	1586.476	1586.013	1585.550	1585.150	1584.750	1584.350	1583.950	1583.550	1583.246	1582.942	1582.675	1582.468
ROAD CENTRELINE	1586.476	1586.013	1585.550	1585.150	1584.750	1584.350	1583.950	1583.550	1583.246	1582.942	1582.675	1582.468
ROAD RIGHT	1586.476	1586.013	1585.550	1585.150	1584.750	1584.350	1583.950	1583.550	1583.246	1582.942	1582.675	1582.468
C/L GROUND LEVEL	1586.661	1586.205	1585.731	1585.252	1584.790	1584.366	1583.987	1583.609	1583.258	1582.927	1582.647	1582.335
DISTANCE (m)	0.000	20.000	40.000	60.000	80.000	100.000	120.000	140.000	160.000	180.000	200.000	220.000

CUT / FILL	0.323	0.707	1.141	1.332	1.799	2.350	3.004	3.617	4.204	4.065	3.911	3.757
ROAD LEFT	1582.321	1582.235	1582.210	1582.209	1582.207	1582.206	1582.205	1582.204	1582.203	1582.201	1582.200	1582.199
ROAD CENTRELINE	1582.321	1582.235	1582.210	1582.209	1582.207	1582.206	1582.205	1582.204	1582.203	1582.201	1582.200	1582.199
ROAD RIGHT	1582.321	1582.235	1582.210	1582.209	1582.207	1582.206	1582.205	1582.204	1582.203	1582.201	1582.200	1582.199
C/L GROUND LEVEL	1581.998	1581.528	1581.068	1580.877	1580.408	1579.856	1579.201	1578.587	1577.998	1578.137	1578.289	1578.442
DISTANCE (m)	240.000	260.000	280.000	300.000	320.000	340.000	360.000	380.000	400.000	420.000	440.000	460.000

CUT / FILL	3.603	3.471	3.191	3.117	1.976	1.184	0.955	0.318	-0.022	-0.176	0.000
ROAD LEFT	1582.198	1582.196	1582.195	1582.194	1582.193	1582.195	1582.291	1582.593	1583.103	1583.816	1583.999
ROAD CENTRELINE	1582.198	1582.196	1582.195	1582.194	1582.193	1582.195	1582.291	1582.593	1583.103	1583.816	1583.999
ROAD RIGHT	1582.198	1582.196	1582.195	1582.194	1582.193	1582.195	1582.291	1582.593	1583.103	1583.816	1583.999
C/L GROUND LEVEL	1578.595	1578.726	1579.004	1579.077	1580.217	1581.011	1581.336	1582.275	1583.126	1583.993	1583.999
DISTANCE (m)	480.000	500.000	520.000	540.000	560.000	580.000	600.000	620.000	640.000	660.000	664.693

VERTICAL PROFILE
-1:43.215 -2.314% | -1:50.000 -2.000% | -1:65.780 -1.520% | VCL=100.000m K=66.0 | -1:16445.742 -0.006% | 1:7815.504 0.013% | VCL=75.000m K=19.3 | 1:25.641 3.900%

HORIZONTAL ALIGNMENT
STRAIGHT 184° 13' 20" | BC 317.9 R=1000m EC 327.9 | STRAIGHT 184° 48' 00" | BC 479.7 R=200m EC 503.0 | STRAIGHT 178° 07' 40" | BC 558.3 R=200m EC 596.9 | STRAIGHT 167° 03' 40"

SUPERELEVATION LEFT .... RIGHT — —

PAVEMENT DESIGN

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

SURVEYED	–
DESIGNED	M McGARRY
DRAWN	M STEENBERG
CHECKED	J D SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No. 0741.00.GZC.03.L001 | REVISION 1.0 | APPROVED: D SMIT Pr.Eng. No: 20080336

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT ....
SIGNATURE: ....
DATE: ....

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

BRIDGE ROAD : LONGITUDINAL SECTON :

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE
AS SHOWN ON ORIGINAL – DRAWING

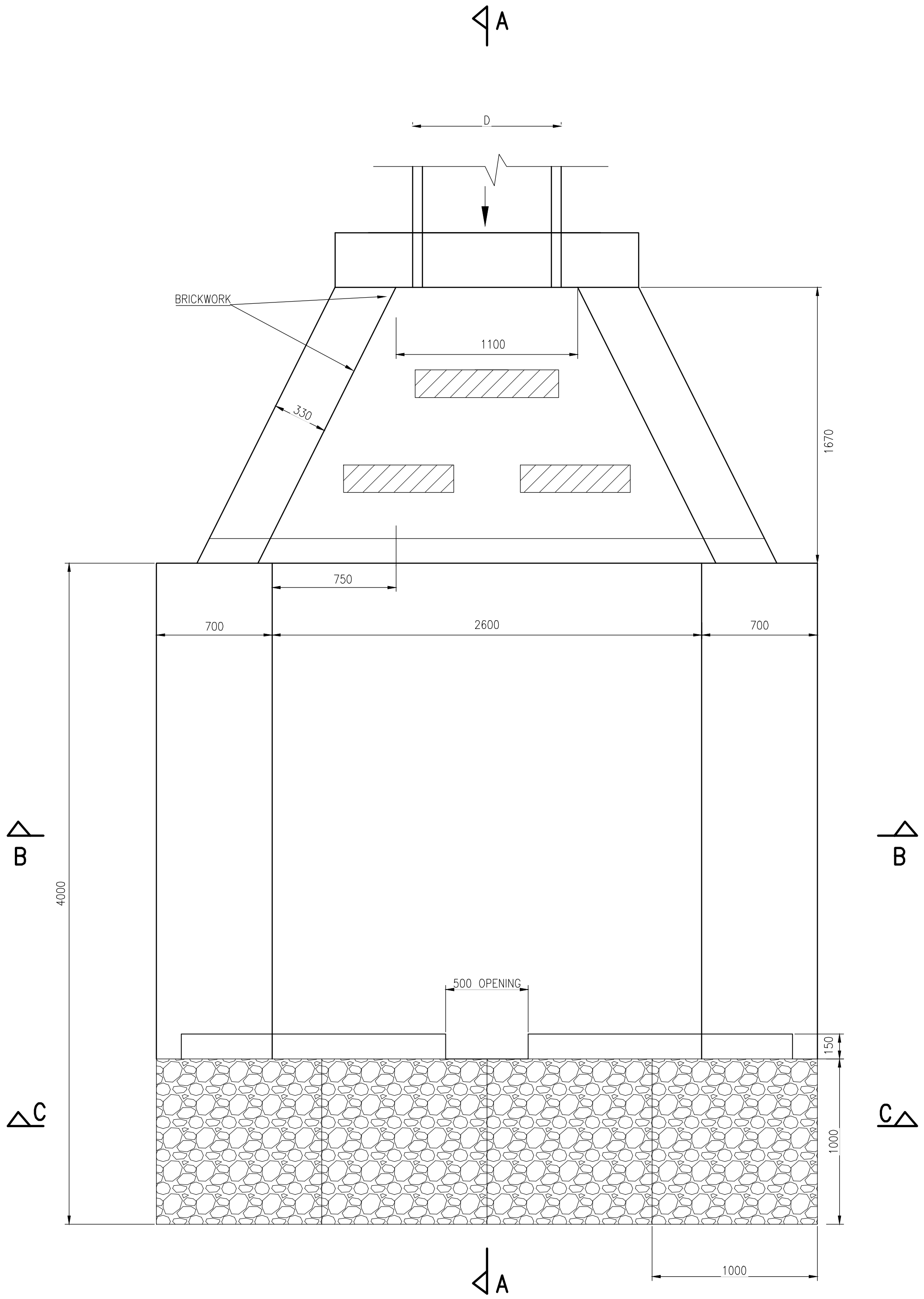
AS–BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

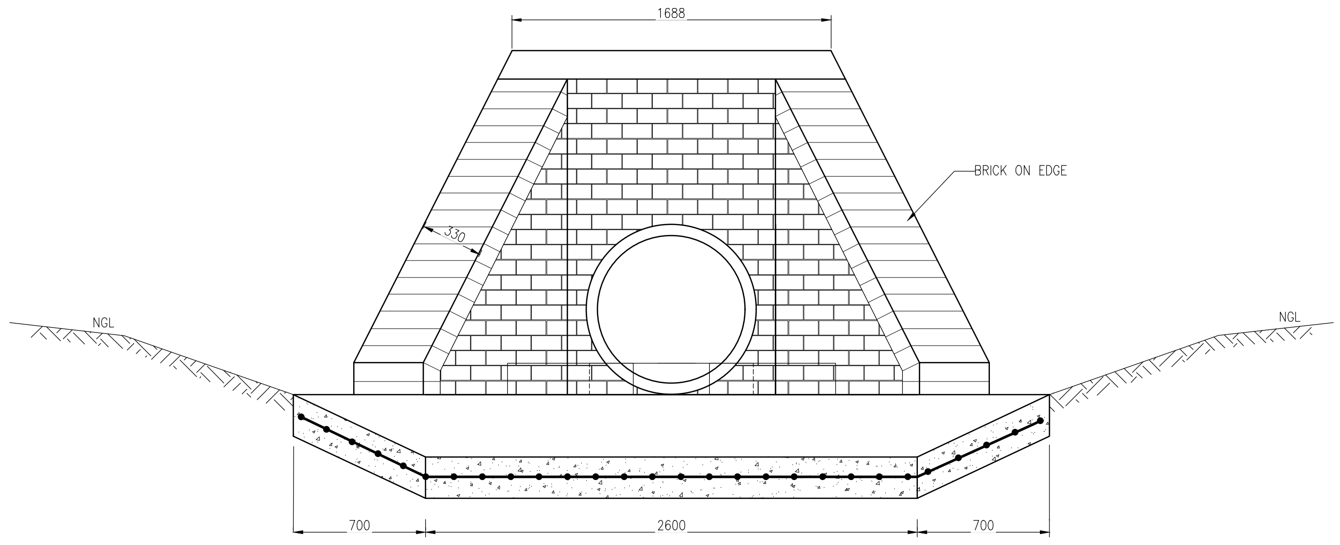
CERTIFIED AS–BUILT FOR CONTRACT :
ENGINEER DATE

DRAWING No.

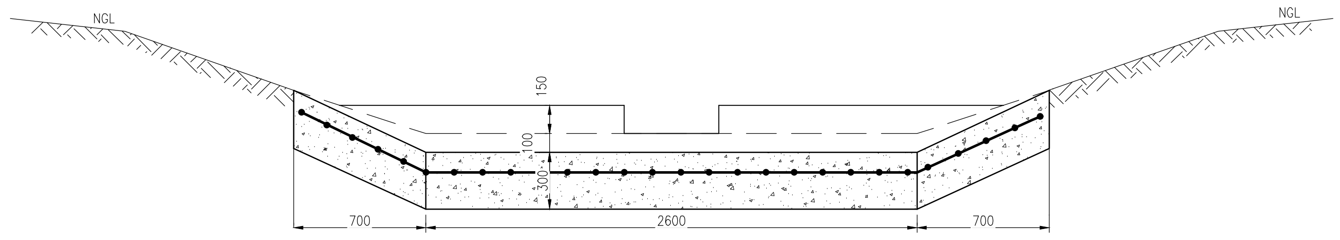
FILE No.



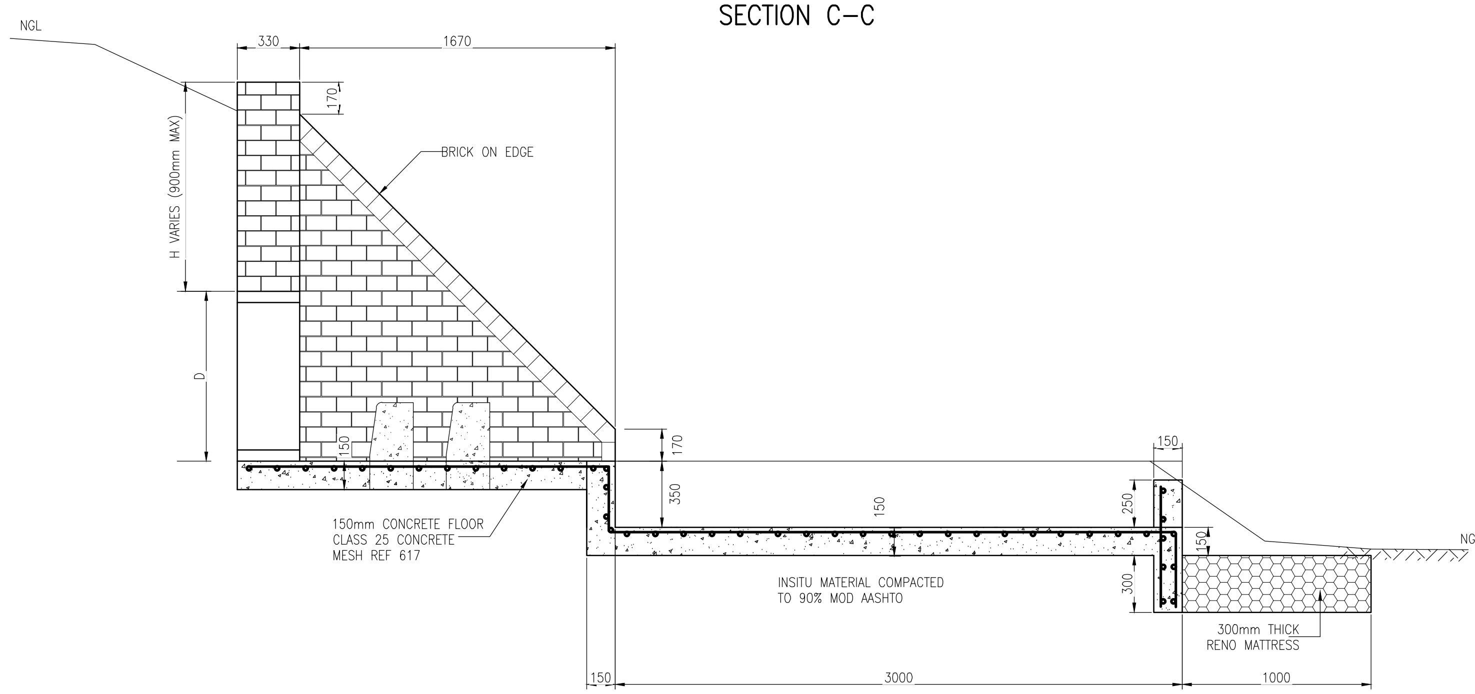
PLAN OF STORMWATER OUTLET WITH SILT TRAP



SECTION B–B



SECTION C–C



SECTION A–A

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

PRIVATE DRAWING No.	REVISION	APPROVED: D SMIT Pr.Eng. No: 20080336
0741.00.GZC.04.D001	1.0	

SURVEYED	–
DESIGNED	J SMIT
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE: ....
DATE: ....

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

STORMWATER OUTLET STRUCTURE
WITH SILT TRAP

Ekurhuleni
METROPOLITAN MUNICIPALITY

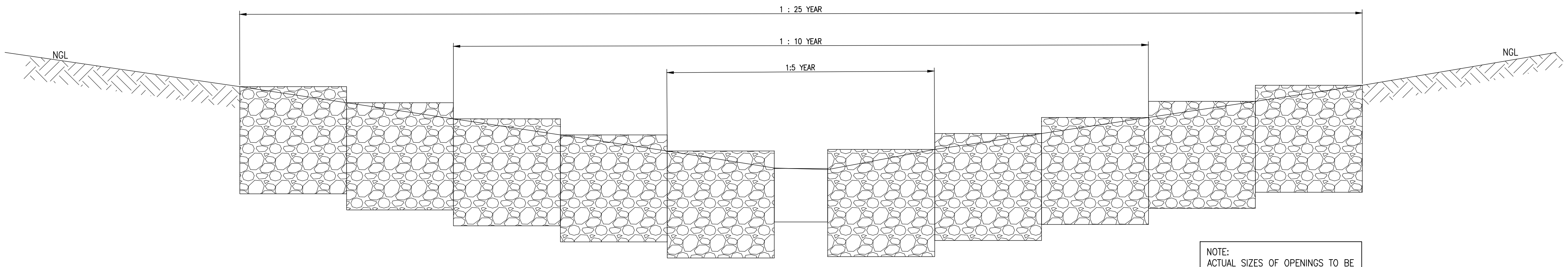
SCALE
1:20 ON ORIGINAL – DRAWING

AS–BUILT RECORD			
CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS–BUILT FOR CONTRACT :
ENGINEER DATE

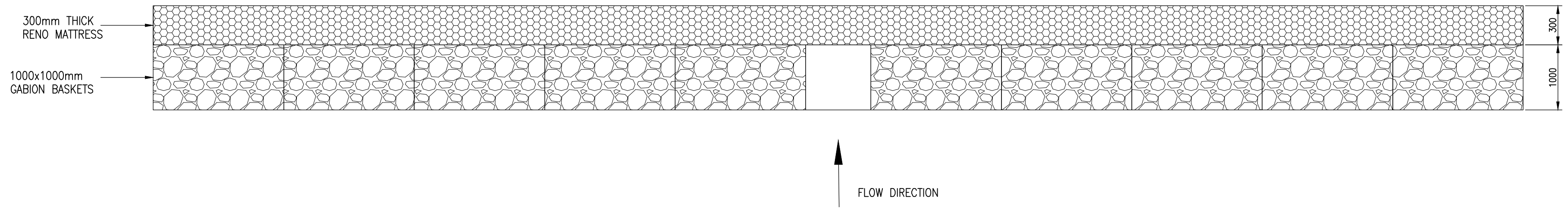
DRAWING No.

FILE No.



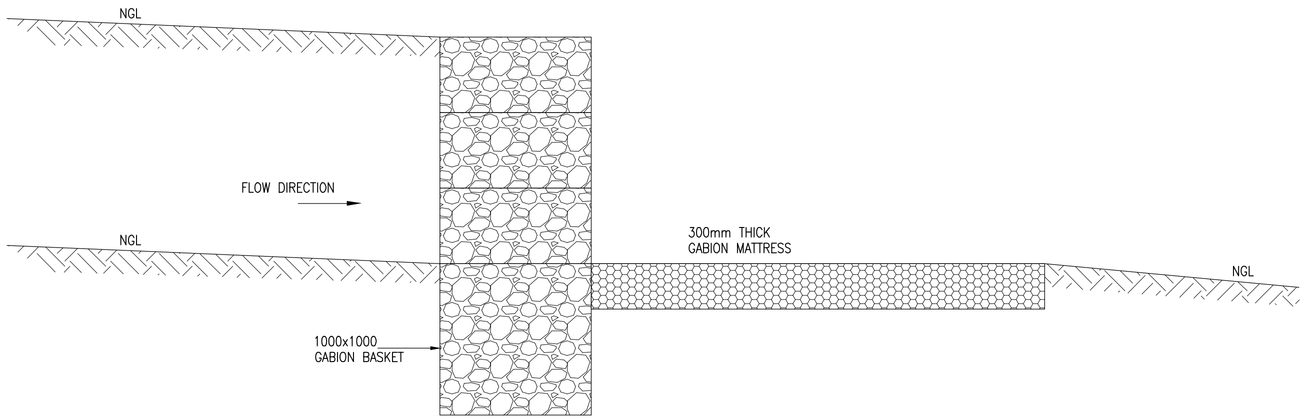
NOTE:
ACTUAL SIZES OF OPENINGS TO BE DETERMINED. TYPICAL ATTENUATION OPENINGS INDICATED BELOW

ELEVATION

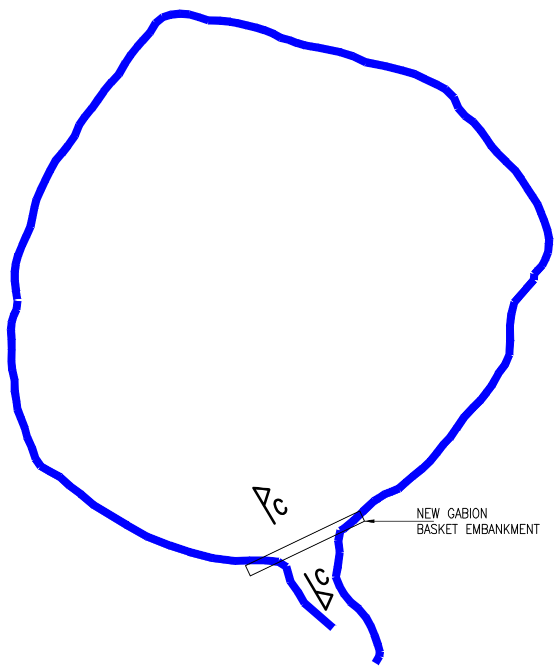


PLAN

TYPICAL DETAIL OF CONTROLLED OUTLET AT POND



SECTION C–C



SCHEMATIC POND

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel:+ 27 (0) 12 842 8700
Fax:+ 27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

BIGEN AFRICA

SURVEYED	–
DESIGNED	J SMIT
DRAWN	M STEENBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

PRIVATE DRAWING No.: 0741.00.GZC.04.D002
REVISION: 1.0
APPROVED: D SMIT
Pr.Eng. No: 20080336

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE: ....
DATE: ....

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT SOUTH

STORMWATER OUTLET STRUCTURE WITH GABIONS

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE: 1:20 ON ORIGINAL – DRAWING

AS–BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS–BUILT FOR CONTRACT :
ENGINEER DATE

DRAWING No.

FILE No.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

STORMWATER MANAGEMENT REPORT

ANNEXURE C

Key Calculations

LEEUWPOORT DEVELOPMENT

LEEUWPOORT SOUTH

Determination of Post-Development Runoff Coefficient

Land Use	Undeveloped Area (ha)	Developed Area (ha)	Runoff Coefficient	Area-Coeff Product
Residential 1		174.2	0.40	69.67
Residential 3		56.6	0.50	28.32
Residential 4 (120-180 du/ha)		61.8	0.80	49.45
Business 2 (FAR 0.6)		13.5	0.70	9.47
Business 3 (FAR 0.7)		3.4	0.70	2.40
Special: Community facilities and any other approved uses (clinic, reteriment village, gate houses)		8.8	0.60	5.27
Public Services: Electrical Sub-station & Servitude		1.2	0.80	0.98
Community and Educational Facilities		49.0	0.60	29.39
Transportation: taxi rank, railway station, parking		13.7	0.80	10.96
Streets		185.3	0.60	111.20
POS	190.4		0.30	57.13
Municipal (Agriculture)	11.8		0.30	3.54
TOTAL	**202.2**	**567.6**	**-**	**377.78**

Aggregate Post Development Runoff Coefficient **0.49**

BIGEN AFRICA

Leeuwpoort Development
Leeuwpoort South

STORMWATER RUNOFF CALCULATION
FOR: 1:2 , 1:5 , 1:20 , 1:25 , 1:50 , 1:100

1:5	1:25	1:50	1:100
3	5	6	7

0741-00 **4.2**

Note: -No Reduction Factors Applied

AREA DESCRIPTION	AREA	Over Land		Water Course		Channel		C	A	Tc	Time of Concentration			Intensity				Q	(Q=C x I x A)		
		L	H	L	H	L	H	Infiltr.	Area	Over L	Water C	Chanl	TOTAL	1:5	1:25	1:50	1:100	1:5	1:25	1:50	1:100
	(m²)	(m)	(m)	(m)	(m)	(m)	(m)		(ha)	(min)	(min)	(min)	(min)	(mm/h)	(mm/h)	(mm/h)	(mm/h)	(m³/s)	(m³/s)	(m³/s)	(m³/s)
LEEUWPOORT SOUTH																					
Leeuwpoort South: Pre-Dev	7 698 500	890	15	6000	50			0.30	769.850	50.75	99.89		150.64	24	38	48	55	12.318	22.672	29.254	35.285
Leeuwpoort South: Post-Dev	7 698 500	275	1.32	3190	37.5			0.49	769.850	39.32	53.80		93.11	36	52	65	75	30.178	50.674	64.705	78.589

Character of Catchment Area	C
Parks, Sportsfields and areas not suitable for development	0.25
Mountainous areas not suitable for development	0.35
Residential areas	0.4
Medium density development and industrial areas	0.5
High density development and C.B.D	0.8

Notes / Comments:

1. Calculations done by Mcgams
2. Calculations for developed scenario
3. Pipe system designed to accommodate 1:5 year flood
4 Attenuation designed for 1:25 year flood.
5. For C-Value determination refer to: SW C-value Calculation

ANNEXURE D4a

FAUNA HABITAT ASSESSMENT

Fauna Habitat Assessment for a part of the remaining extent of the Farm Leeuwpoort 113 IR, Gauteng Province

March 2016

Landscape Architects & Environmental Consultants: Specialist Division

T: (+27)12 346 3810 l F: (+27) 86 570 5659 l E: corne@bokamoso.net l www.bokamoso.biz.
36 Lebombo Street, Ashlea Gardens, Pretoria l P.O. Box 11375 Maroelana 0161

Report Authors: **Corné Niemandt (Mammals, Amphibia and Reptilia)**

Mark I. Cooper (Invertebrates)

Reviewed by: **Reinier F. Terblanche (Pr.Sci.Nat Reg. No. 400244/05)**

Review of

Fauna Habitat Assessment for a part of the remaining extent of the Farm Leeuwpoort 113 IR, Gauteng Province

Review: July 2016

Reviewer: Reinier F. Terblanche

(M.Sc, *Cum Laude*; Pr.Sci.Nat, Reg. No. 400244/05)

APPROACH OF REVIEWER TO ECOLOGICAL REVIEWS

Ecological studies and applied ecology comprise the consideration of a diversity of factors, even more so in South Africa with its exceptional high floral and faunal diversities, various soil types, geological formations and diversity of habitats in all its biomes. Therefore it would be easy to add onto or show gaps in any ecological impact assessment, rehabilitation actions or management plans stemming from ecological assessments. The approach followed here is to review the ecological study in a reasonable context and focus on the successful fulfillment of the aims of the study within the limits of cost and time.

ECOLOGICAL REVIEW: FAUNA HABITAT ASSESSMENT FOR A PART OF THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113 IR, GAUTENG PROVINCE

Findings of the review

- The report contains details of the expertise of the persons who prepared the report and a declaration that the person who prepared the report is acting independently.
- The aims of the report are clear.
- The report provides references and descriptions of the principles and guidelines to be taken into account for fauna habitat assessment.
- Acceptable methods and limitations have been given in detail to reach the goal of the assessment.
- Relevant laws and guidelines have been mentioned and integrated.
- The report gives a clear assessment of the status fauna at the site and also added an extensive literature survey and existing knowledge survey.
- The recommendations and the conclusion are consistent with the aims of the report.
- It is to be commended that the report is economical and practical so that it adds value to the team effort of addressing the management and future of the habitats at the site.

Overall the report appears to be relevant, detailed enough for the purposes of this study and complete and finally addressing the key issues at stake.

Reinier F. Terblanche

M.Sc. Ecology; Pr.Sci.Nat, Reg. No. 400244/05

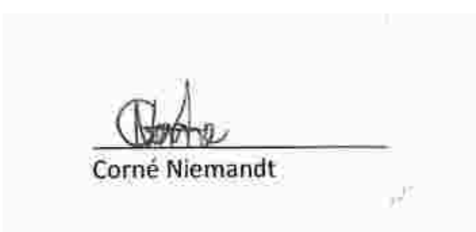
Specialist

Specialist investigator: Mr. C. Niemandt (M.Sc. *Cum Laude*)

<u>Declaration of independence</u>:

I, the above mentioned specialist investigator responsible for conducting this particular specialist flora study, declare that:

- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part;
- I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse the proposed development, but aim to present facts, findings and recommendations based on relevant professional experience, guidance from professional experts and scientific data;
- I do not have any influence over decisions made by the governing authorities;
- I have the necessary qualifications and guidance from professional experts (registered Pr. Nat. Sci.) in conducting specialist reports relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- This document and all information contained herein are and will remain the intellectual property of Bokamoso Environmental: Specialist Division. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigator.



Specialist

Specialist investigator: Mark Ian Cooper (*M.Sc., Pr. Sci. Nat.* (Biological Sciences))

<u>Declaration of independence</u>:

The specialist investigator responsible for conducting this particular specialist fauna study declares that:

• I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse the proposed development, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I have the necessary qualifications and is registered as a professional scientist (Pr. Nat. Sci.) in conducting specialist reports relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;

• This document and all information contained herein are and will remain the intellectual property of Bokamoso Environmental: Specialist Division. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.

• I will comply with the Act, regulations and all other applicable legislation.

Mark Ian Cooper

Table of Contents

FIGURES:

1. INTRODUCTION

Bokamoso Environmental Consultants CC: Specialist Division was appointed to conduct a Fauna Assessment for the proposed mixed use development on a part of the remaining extent of the Farm Leeuwpoort 113 IR, Gauteng Province, also known as Leeuwpoort South (hereafter referred to as the study area).

This report is based on the faunal species present on the study area as well as species that could potentially occur. The report acts as an overview of the probable and/or known occurrence for following faunal groups; Mammals, Reptiles, Amphibians and Invertebrates. Avifauna is not included in this report, as a separate avifaunal assessment was conducted for the study area. The primary focus of this report falls on threatened species and other species with conservation importance occurring on or near the study area to ensure that, should any such species exists, the appropriate actions are taken to guarantee the well-being of these species.

2. SCOPE AND OBJECTIVE OF ASSESSMENT

- To qualitatively and quantitatively assess the significance of the mammal habitat components and current general conservation status of the property
- Comment on ecological sensitive areas within the study area
- Comment on connectivity with natural vegetation and habitats on adjacent site
- To provide a list of mammals which occur or might occur, and to identify species of conservation importance
- To highlight potential impacts of the proposed development on the mammals of the study site, and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. STUDY AREA

The study area is situated on a part of the remaining extent of the Farm Leeuwpoort 113 IR, Gauteng Province (also known as Leeuwpoort South Mixed use Development). The size of the property is approximately 733 ha and is located in the quarter degree squares (QDSs) 2628AD and 2628AC, GPS coordinates 26°16'19.47"S, 28°15'51.27"E. The study area is located south of the N17 highway, east of Rondebult Road (R21), west of Barry Marais Road (M43) and towards the north of N Boundary Road (R554) (**Figures 1 and 2**). The study area is situated in two vegetation units as defined by Mucina and Rutherford (2006): the Carletonville Dolomite Grassland to the west (considered Vulnerable: Mucina and Rutherford, 2006) and the Tsakane Clay Grassland to the east (considered Endangered: Government gazette no. 34809, 2011) (**Figure 3**). The Kliprivier Highveld Grassland threatened ecosystem is located towards the eastern part of the study site (**Figure 3**) and is considered Critically Endangered (Government gazette no. 34809, 2011).

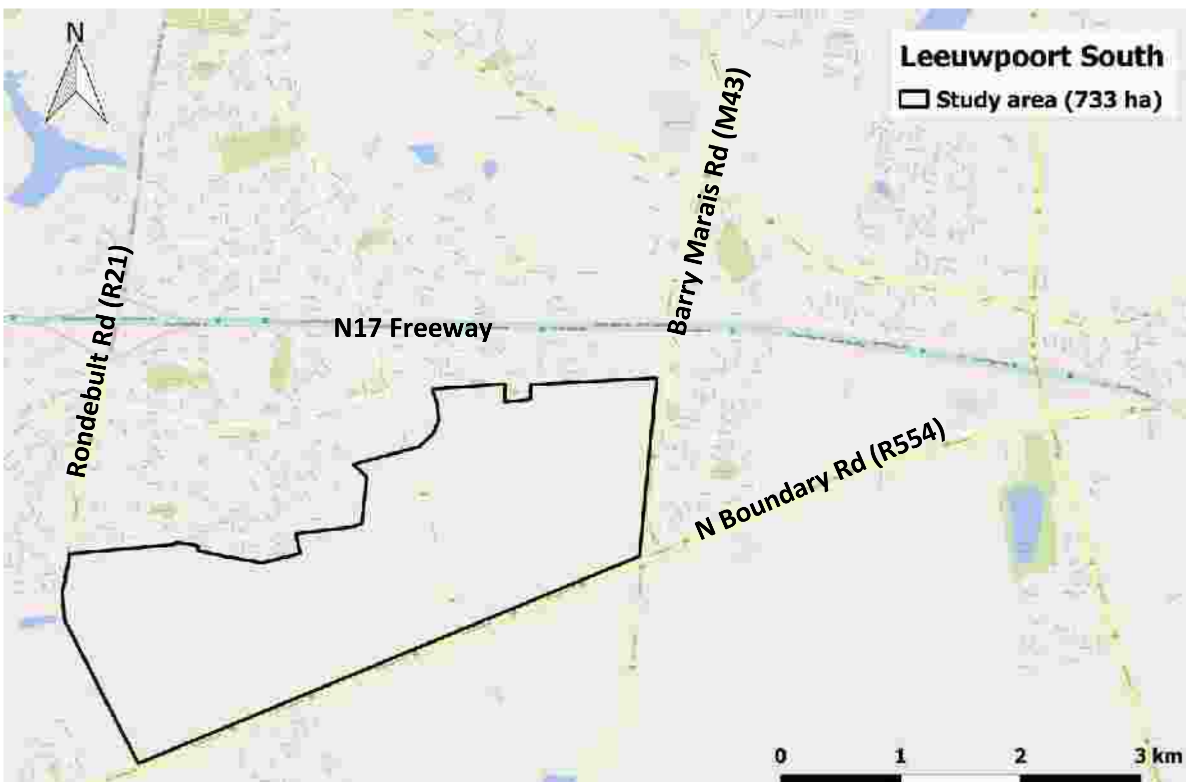


Figure 1: Locality Map

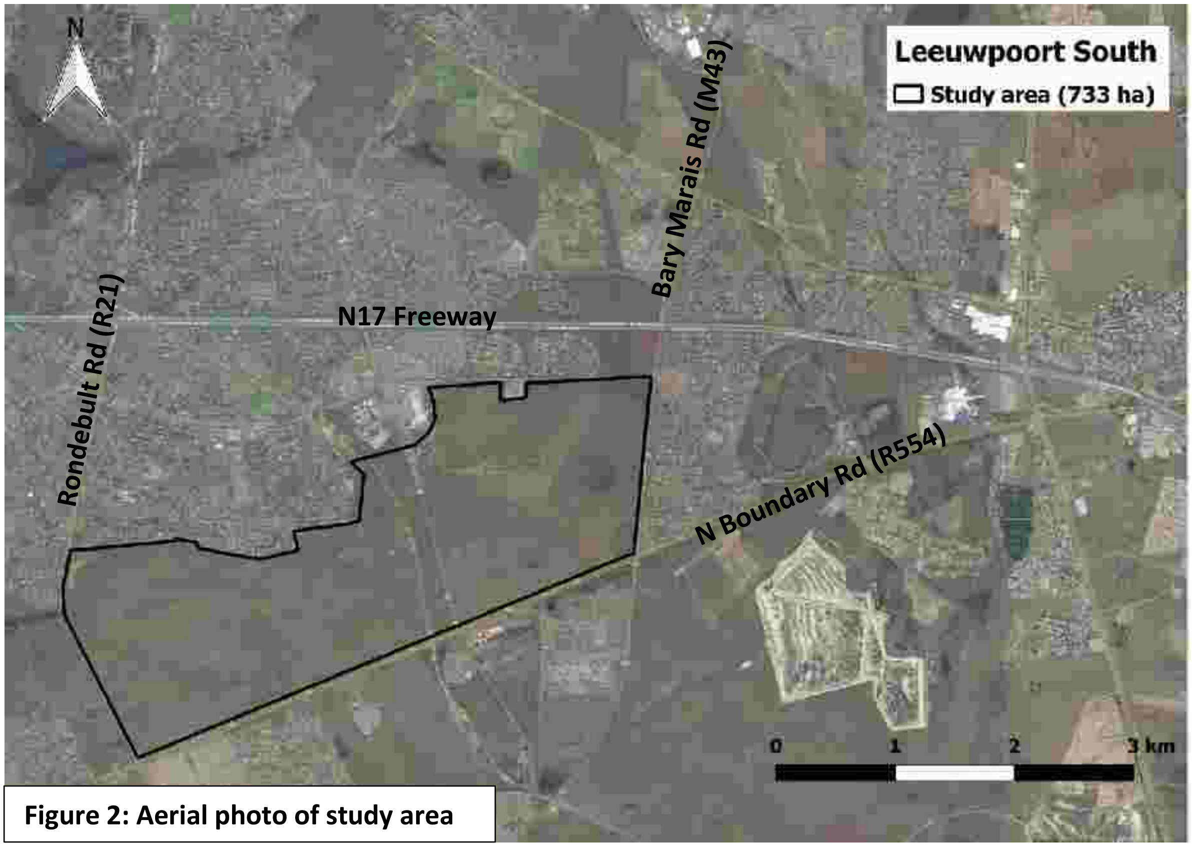


Figure 2: Aerial photo of study area

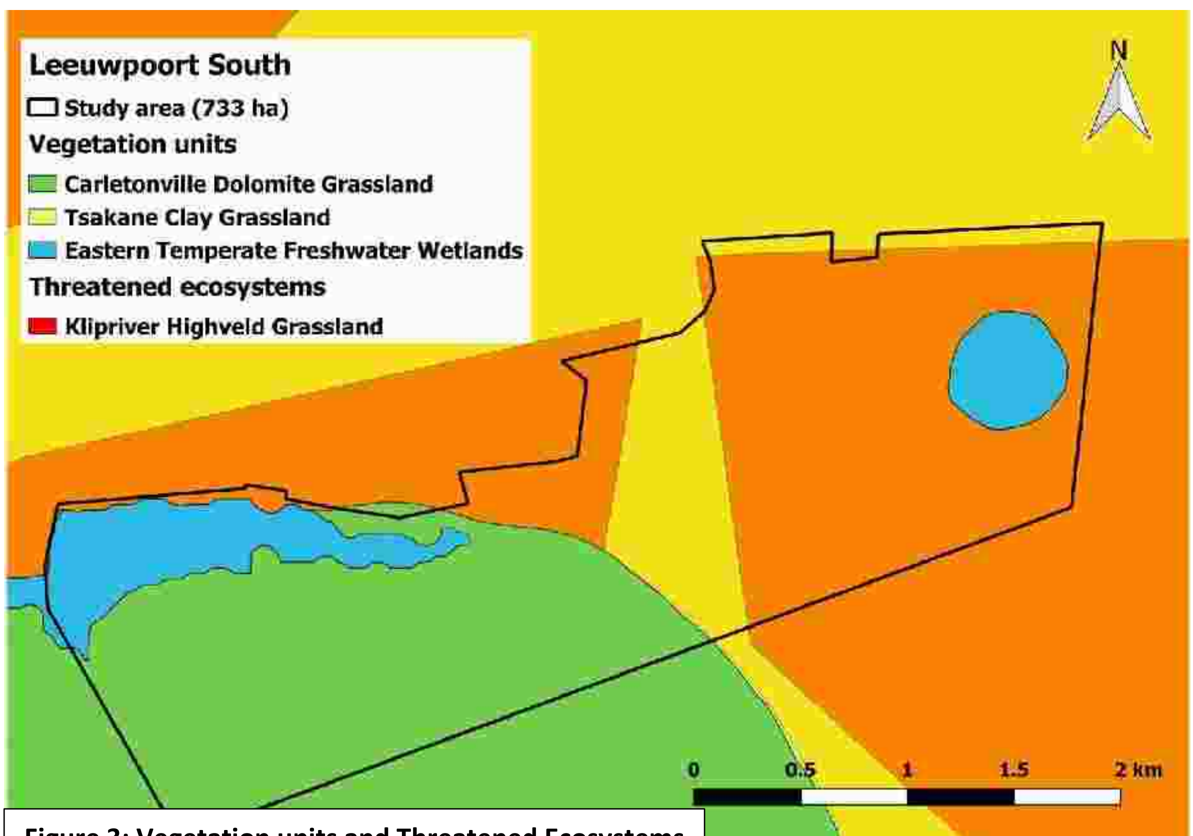


Figure 3: Vegetation units and Threatened Ecosystems

4. METHODS

Before conducting a field survey on the study area a desktop assessment was conducted to note the prevalent faunal species occurring on or near the site. A list of expected species was compiled and used as a reference during the field survey to ensure that species that should theoretically occur were not overlooked. All distinct faunal habitats were identified on site, after which each habitat was assessed to record the associated faunal species for each of the respective faunal group (Mammals, Herpetofauna, and Invertebrates) present in that specific habitat. Moreover the 500 meters surrounding the study area were scanned for any additional faunal habitats.

5. RESULTS

During the habitat assessment five distinct habitats were identified within the study area. These habitats include: Disturbed *Verbena - Eragrostis* Pan, *Setaria - Typha* Drainage Line, Moist *Themeda - Eragrostis* Grassland, Transformed *Eucalyptus - Hyparrhenia* Grassland and Disturbed *Eragrostis - Hyparrhenia* Grassland (**Figure 4**).

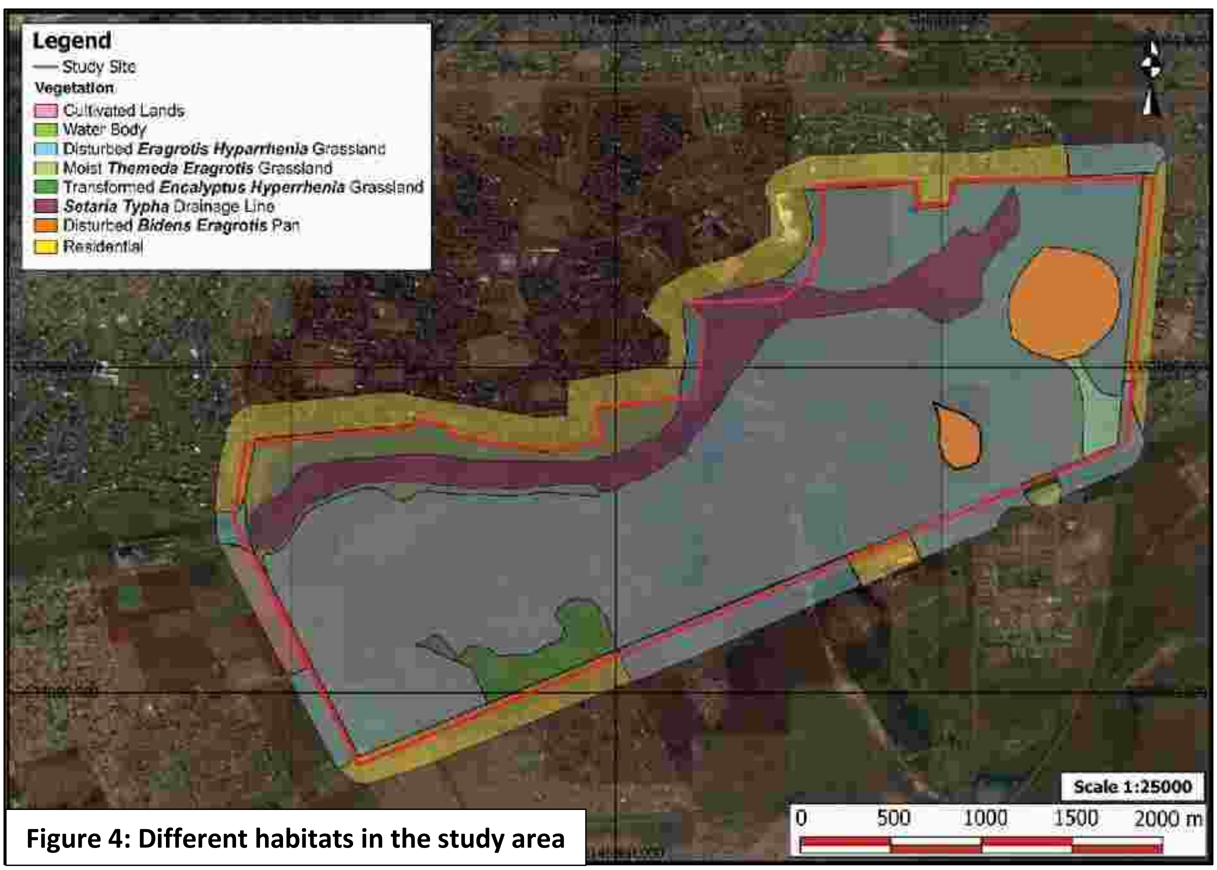


Figure 4: Different habitats in the study area

5.1 Disturbed *Verbena - Eragrostis* Pan

In general, the pan is in a degraded state as it is dominated by several alien species such as *Cosmos bipinnatus, Verbena bonariensis* and *Verbena brasiliensis* (Figure 5). In addition, several grass species occur such as *Panicum coloratum, Cynodon dactylon, Setaria sphacelata* var. *torta* and several species belonging to the genus *Eragrostis.* One Orange List species, *Hypoxis hemerocallidea* was recorded in abundance in the pans.

Figure 5: Disturbed *Verbena - Eragrostis* Pan

5.2 *Setaria - Typha* Drainage Line

Species dominating the drainage line include *Typha capensis, Phragmites australis, Setaria incrassata, Cyperus* spp., *Paspalum* spp., *Persicaria* spp. and *Verbena bonariensis* (Figure 6). The Drainage line remains in a semi-natural state, however several alien plant species occur in the drainage line. There is suitable habitat for Orange list plant species of which one, *Hypoxis hemerocallidea,* was recorded. This site is considered ecologically sensitive. The drainage line towards the north east of the study area is not considered natural due to storm water runoff from the adjacent development. The nature of this area should be confirmed by a wetland specialist.

Figure 6: *Setaria - Typha* Drainage Line

5.3 Moist *Themeda - Eragrostis* Grassland

This study unit remains in a natural condition as no disturbances were observed (Figure 7). It is dominated by climax grass species such as *Digitaria eriantha, Panicum coloratum, Themeda triandra* and several *Eragrostis* species. The forb layer is represented by the dominant species *Scabiosa columbaria, Berkheya radula* and *Wahlenbergia undulata.* The site is considered ecologically sensitive as the habitat is suitable for Red List plant species and as the area could support several aquatic fauna species.

Figure 7: Moist *Themeda - Eragrostis* Grassland

5.4 Transformed *Eucalyptus - Hyparrhenia* Grassland

This Grassland is regarded as transformed due to the high occurrence of alien plant species within this habitat (Figure 8). Dominant species include those of the *Eucalyptus* genus, *Melia azedarach*, *Solanum mauritianun, Tipuana tipu* and *Robinia pseudoacacia*. Dominant forbs include *Bidens* species, *Tagetes minuta, Tribulus Terrestris* and *Verbena* species. Several dominant graminoid species include *Arundo donax*, *Chloris virgata, Cynodon dactylon, Melinis repens* and *Hyparrhenia hirta.* Furthermore, illegal dumping causes the degradation of indigenous vegetation.

Figure 8: Moist *Themeda - Eragrostis* Grassland

5.5 Disturbed *Eragrostis - Hyparrhenia* Grassland

The greater part of the study area falls within this habitat. At several locations the habitat is more disturbed compared to other sites which are dominated by alien vegetation such as *Paspalum dilatatum, Bidens formosa, Bidens pilosa, Bidens bipinnata, Tagetes minuta, Verbena* species and *Campuloclinium macrocephalum.* The grass layer is overall dominated by *Aristida species, Cynodon dactylon, Eragrostis* spp.*, Heteropogon contortus, Hyparrhenia hirta, Setaria* spp.*, Themeda triandra* and *Urochloa panicoides.* Several dominant forb species include *Cucumis zeyheri, Datura stramonium, Hermannia depressa, Hilliardiella oligocephala, Ledebouria* spp*.* and *Verbena* spp*.* The grassland was previously cultivated as seen from remnant activities on site and from Google Earth images.

Figure 9: Disturbed *Eragrostis - Hyparrhenia* Grassland

6. MAMMAL HABITAT ASSESSMENT

Special attention was paid to the evaluation of the quantitative and qualitative habitat conditions of Red Data species judged to have a probable occurrence on the site. Mitigation measures to lesser the impacts and effects of the proposed development were suggested where applicable. Furthermore, it was aimed to investigate which mammals might still reside in the study area and to compile a complete list of mammal species.

6.1 Methods

The study site was visited on the 23rd and 25th of March 2016 during which all observed mammal species as well as all the potential mammal habitats on the study site were identified. Following the field survey a desktop assessment was conducted to add additional mammal species expected to occur on the study site on account of their individual habitat preferences in accordance with the habitats identified on the study area. Mammal occurrence probability can be attributed to the well recorded and known distributions of South African mammals as well as the quantitative and qualitative nature of the habitats present on site.

Field Survey

Before the commencement of the field survey a list of expected mammal species was compiled to use as a reference in the field. All the threatened and sensitive mammals with distribution ranges overlapping the study area were included in the aforementioned reference list. These species were prioritized and special attention was paid in terms of identifying their associated habitat preferences and noting signs of their occurrence. The field survey was conducted by means of random transect walks within each habitat. During the field survey mammal species were identified in accordance with individual habitat preferences as well as actual observations and signs such as spoor, scats, burrows and roosting sites indicating their presence (Stuart & Stuart, 2011).

Desktop Survey

Due to the fact that the majority of mammals are either nocturnal, hibernators, secretive and/or seasonal it is increasingly difficult to confirm their presence or absence by means of actual observations alone. Therefor a number of authoritative tomes such as field guides, databases and scientific literature were utilized to deduce the probable occurrence of mammal species. The Animal Demography Unit:

Virtual Museum (http://vmus.adu.org.za/) was consulted to verify the records and occurrence of recorded mammal species within the QDSs 2628AD and 2628AC. The Gauteng Conservation Plan (C-plan v3.3) was consulted to evaluate ecologically sensitive areas associated with mammals. A comprehensive list of probable mammalian occurrence with reference to the study area was compiled on account of the well-known and documented distributions of mammals in South Africa, especially in the Gauteng province.

The occurrence probability of mammal species was deduced in accordance with a species' distribution and habitat preferences. Where a species' distribution range was found to overlap with the study area and its preferred habitat was present, the applicable species was deemed to have a high occurrence probability on or near the study area.

In the case were the preferred habitat of a species' were found to be suboptimal on the study area however its distribution range still overlapped the study area, the applicable species' occurrence probability was deemed to be medium.

When the habitat preferences of a species were absent from the site, the applicable species was deemed to have a low occurrence probability regardless of its distribution range.

6.2 Specific Requirements

During the field survey attention was paid to note any signs of potential occurrence of threatened and sensitive species as well as species associated with wetlands (GDARD, 2014).

These species include:

Vlei rat (*Otomys irroratus*), Angoni vlei rat (*Otomys angoniensis*), African march rat (*Dasymys incomtus*), Water mongoose (*Atilax paludinosus*), Spotted-necked otter (*Hydrictis maculicollis*), Juliana's golden mole (*Neamblysomus julianae*), Rough-haired golden mole (*Chrysospalax villosus*), southern African hedgehog (*Atelerix frontalis*), White-tailed rat (*Mystromys albicaudatus*), and several bat species including Blasius's/Peak-Saddle Horseshoe Bat (*Rhinolophus blasii*), Darling's Horseshoe Bat (*Rhinolophus darlingi*), Geoffroy's Horseshoe Bat (*Rhinolophus clivosus*), Hildebrandt's Horseshoe Bat (*Rhinolophus hildebrandtii*), Schreibers's Long-Fingered Bat (*Miniopterus natalensis*) and Temminck's Hairy Bat (*Myotis tricolo*).

Mammal species listed according to IUCN as Near Threatened: Highveld Golden Mole (*Amblysomus septentrionalis*) and Cape Clawless Otter (*Aonyx capensis*).

6.3 Results

6.3.1 Mammal habitats identified

Mammals' local occurrences are closely dependent on broadly defined habitat types, such as terrestrial, rock-dwelling, arboreal and wetland associated vegetation cover. Therefore, the presence of mammal species can be inferred by assessing the habitat types on site considering their known distribution ranges. During the habitat assessment five distinct mammalian habitats were identified within the study area (**Figure 4**).

6.3.2 Expected and observed Mammal species

Three mammal species were recorded during the field survey either from observation or from visual signs of their occurrence. Seventeen of the 41 mammal species known to occur in the QDSs 2628AD and 2628AC have a high occurrence probability in the study area (Table 1). Another eighteen species have a medium probability to occur or are expected to be occasional visitors on the study area (Table 1). The drainage line and pan habitats are the most suitable for most of the species for sleeping, breeding and foraging purposes, especially for amphibian species.

Table 1: Mammals observed or expected to occur, or to be occasional visitors on the study site. Red List Category species (indicated in Red) were considered based on Global status[1] (IUCN, 2016) and Regional status[2] (Friedmann and Daly, 2004).

Family	Scientific Name	Common Name	Red List Catagory	Occurrence Probability
Bathyergidae	*Cryptomys hottentotus*	Common African Mole-rat	Least Concern	4
Chrysochloridae	*Amblysomus septentrionalis*	Highveld Golden Mole	Near Threatened[1]	1
Emballonuridae	*Taphozous mauritianus*	Mauritian Tomb Bat	Least Concern	3
Erinaceidae	*Atelerix frontalis*	Southern African Hedgehog	Near Threatened[2]	3
Felidae	*Leptailurus serval*	Serval	Near Threatened[2]	3
Galagidae	*Galago moholi*	Southern Lesser Bushbaby	Least Concern	2
Herpestidae	*Atilax paludinosus*	Marsh Mongoose	Least Concern	5
Herpestidae	*Galerella sanguineus*	Slender Mongoose	Least Concern	5

Herpestidae	*Cynictis penicillata*	Yellow Mongoose	Least Concern	4
Hystricidae	*Hystrix africaeaustralis*	Cape Porcupine	Least Concern	3
Leporidae	*Lepus saxatilis*	Scrub Hare	Least Concern	5
Macroscelididae	*Elephantulus brachyrhynchus*	Short-snouted Sengi	Data deficient[2]	3
Muridae	*Aethomys ineptus*	Tete Veld Rat	Least Concern	2
Muridae	*Aethomys namaquensis*	Namaqua Rock Mouse	Least Concern	2
Muridae	*Dasymys incomtus*	African Marsh Rat	Near Threatened[2]	4
Muridae	*Dendromus melanotis*	Grey Climbing Mouse	Least Concern	4
Muridae	*Dendromus mystacalis*	Chestnut Climbing Mouse	Least Concern	4
Muridae	*Gerbilliscus brantsii*	Highveld Gerbil	Least Concern	3
Muridae	*Gerbilliscus leucogaster*	Bushveld Gerbil	Data deficient[2]	3
Muridae	*Lemniscomys rosalia*	Single-striped Grass Mouse	Data deficient[2]	3
Muridae	*Mastomys coucha*	Southern Multimammate Mouse	Least Concern	4
Muridae	*Mastomys natalensis*	Natal Multimammate Mouse	Least Concern	4
Muridae	*Mus minutoides*	Pygmy Mouse	Least Concern	3
Muridae	*Rhabdomys pumilio*	Four-striped grass mouse	Least Concern	3
Muridae	*Steatomys pratensis*	Common African Fat Mouse	Least Concern	3
Muridae	*Otomys angoniensis*	Angoni Vlei Rat	Least Concern	4
Muridae	*Otomys irroratus*	Southern African Vlei Rat	Least Concern	4
Mustelidae	*Poecilogale albinucha*	African Striped Weasel	Data deficient[2]	3
Mustelidae	*Mellivora capensis*	Honey Badger	Near Threatened[2]	3
Soricidae	*Crocidura cyanea*	Reddish-grey Musk Shrew	Data Deficient[2]	4
Soricidae	*Crocidura fuscomurina*	Tiny Musk Shrew	Data Deficient[2]	4
Soricidae	*Crocidura hirta*	Lesser Red Musk Shrew	Data Deficient[2]	4
Soricidae	*Crocidura mariquensis*	Swamp Musk Shrew	Data deficient[2]	4
Soricidae	*Myosorex varius*	Forest Shrew	Data deficient[2]	3
Soricidae	*Suncus varilla*	Lesser Dwarf Shrew	Data Deficient[2]	3

Thryonomyidae	*Thryonomys swinderianus*	Greater Cane Rat	Least Concern	3
Vespertilionidae	*Neoromicia capensis*	Cape Serotine Bat	Least Concern	4
Vespertilionidae	*Scotophilus dinganii*	African Yellow Bat	Least Concern	3
Vespertilionidae	*Scotophilus viridis*	Green House Bat	Least Concern	2
Viverridae	*Genetta genetta*	Small-spotted Genet	Least Concern	3
Viverridae	*Genetta maculata*	Common Large-spotted Genet	Least Concern	2

*The occurrence probability of the mammal species listed above is indicated as follows:
1 - Not likely to occur; 2 - Low occurrence probability; 3 - Medium occurrence probability; 4 - High occurrence probability; 5 - Confirmed occurrence.

6.3.3 Threatened and Red Listed Mammal species

The drainage line and pan habitats are suitable for threatened aquatic species such as *D. incomtus* (Near Threatened) and *Otomys* spp. Vlei Rats are considered to be sensitive due to their intolerance to drought and their association with wetlands. Their reliance on wetlands serves as the main reason for their sensitive status.

The terrestrial habitat is fragmented and not well connected with similar habitats in the surrounding area. *A. frontalis, L. serval* and *M. capensis* is considered 'Near Threatened' (Friedmann & Daly, 2004) as a result of conflict with humans, predation by human feral pets and expanding development resulting in fragmentation of their habitats. *A. frontalis* is capable of withstanding predation with their passive defence mechanisms, while *M. capensis* is considered the most fearless animal in the world.

No suitable bat roosts were observed on the study site, thus it is not expected that any of the threatened bat species are resident, although the drainage line and pan habitats might still be utilized by bats for foraging purposes.

The listed shrews (**Table 1**) are not necessarily threatened but are listed as a precautionary measure as a result of their unknown regional status.

No other threatened or sensitive mammal species are thought to be present within the study area due to various factors such as man-made disturbances, transformed habitats, suboptimal habitat and restricted distribution ranges.

6.4 Findings

Parts of the terrestrial habitats present on the study area have been transformed and degraded to such an extent that it can no longer be regarded as typical of either the Carletonville Dolomite Grassland to the west or the Tsakane Clay Grassland to the east (Mucina and Rutherford, 2006). There is limited connectivity with similar habitats as the study site is surrounded by roads, residential and rural developments. There is suitable terrestrial habitat for numerous small mammal species, but no threatened species are expected to occur on site permanently. No evidence exists to consider the terrestrial habitat as sensitive for mammal species.

The drainage line and pan habitats are suitable for several aquatic mammal species which might either stay there permanently or be occasional visitors on the study area. Both these habitats are considered sensitive and no construction may take place within these areas. The drainage area has the potential to support sensitive species with conservation concerns such as *D. incomtus* (Near Threatened) and *Otomys* spp. The drainage area does provide important ecological habitat for certain small mammal species as well as foraging habitat for bat species which might be roosting in the surrounding areas.

7. HERPETOFAUNA HABITAT ASESSMENT

7.1 Methods

The study site was visited on the 23rd and 25th of March 2016. Adequate amount of random transect walks in the study site was attempted to identify herpetofauna species. Habitat types identified within the study site was recorded, and a combined species list was compiled of the possible presence of herpetofauna species, considering the knowledge of their preferred habitats. Species were identified using the following field guides: for amphibians (Du Preez & Carruthers, 2009) and for reptilia (Marais, 2004; Alexander & Marais, 2007).

A desktop study was done to identify suitable habitats for the Red List fauna species known to occur in the QDSs 2628AD and 2628AC. The Animal Demography Unit: Virtual Museum (http://vmus.adu.org.za/) was consulted to verify the record of occurrence of herpetofauna species recorded within the QDS 2628AA. The Gauteng Conservation Plan (C-plan v3.3) was consulted to evaluate ecologically sensitive areas.

The majority of herpetofauna species are nocturnal, poikilothermic secretive and seasonal, which makes it difficult to observe them during field surveys. In this case the presence of herpetofauna species was examined on habitat preferred by selected species and respective documented ranges. Accordingly, distributional ranges and the presence of suitable habitats were used to infer the presence or absence of amphibian and reptiles species based on field guides, scientific literature, atlases, databases and respected books (see *References* section 13 for a full list of resources used). Obtaining this information can be done irrespective of season.

7.2 Specific Requirements

During the survey the site was surveyed and assessed for the potential occurrence of Red List and/or ridge and wetland associated fauna species. No amphibians are listed according to GDARD (2014). Reptilia species listed: Striped Harlequin Snake (*Homoroselaps dorsalis*) as 'Near Threatened' (Bates *et al*., 2014; GDARD, 2014) and Coppery Grass Lizard (*Chaemaesaura aenea*) as 'Near Threatened' (Bates *et al*., 2014).

7.3 Results

7.3.1 Herpetofauna habitats identified

Both the terrestrial and aquatic habitats on the study area have suitable habitat for herpetofauna species. The terrestrial habitat was previously cultivated and only started to recover in the last five years. Thus, many mammal species were displaced and suitable terrestrial habitat only recently started to emerge on site. The drainage line and pan habitats form suitable micro-habitats for various amphibian species (**Table 2**).

7.3.2 Expected and observed Herpetofauna species

Based on the impressions gathered during the site visit and records from the "*Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland"* (Minter *et al*., 2004), "*Ensuring a future for South Africa's frogs: a strategy for conservation research*" (Measey 2011), "*Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland*" (Bates *et al*., 2014) and the databases *FrogMAP* (continuation of the Southern African Frog Atlas Project) and *ReptileMAP* (the continuation of the Southern African Reptile Conservation Assessment), the following lists of species which may occur in the study area was compiled (**Tables 2 and 3**). No amphibians or reptiles were observed during the survey. Twelve amphibian species and 40 reptile species are expected to occur in the QDSs 2628AD and 2628AC (**Tables 2 and 3 respectively**). Of these species, six amphibian and eight reptile species have a high probability to occur on the study area or to be occasional visitors due to the large terrestrial habitat and the aquatic habitats in the study area.

Table 2: Amphibian species observed or expected to occur in QDSs 2628AD and 2628AC. The conservation status of each species follows Minter *et al*. (2004) and Du Preez & Carruthers (2009).

Family name	Species name	Common name	Conservation status	Occurrence Probability
BUFONIDAE	*Schismaderma carens*	Red Toad	Least Concern	3
BUFONIDAE	*Amietophrynus rangeri*	Raucous Toad	Least Concern	4
BUFONIDAE	*Amietophrynus gutturalis*	Guttural Toad	Least Concern	4
HYPEROLIIDAE	*Kassina senegalensis*	Bubbling Kassina	Least Concern	4
PIPIDAE	*Xenopus laevis*	Common Platanna	Least Concern	4
PYXICEPHALIDAE	*Amietia fuscigula*	Cape River Frog	Least Concern	3
PYXICEPHALIDAE	*Amietia poyntoni*	Poynton's River Frog	Data deficient	3
PYXICEPHALIDAE	*Amietia quecketti*	Queckett's River Frog	Least Concern	4
PYXICEPHALIDAE	*Cacosternum boettgeri*	Common Caco	Least Concern	4
PYXICEPHALIDAE	*Pyxicephalus adspersus*	Giant Bull Frog	Near Threatened	4
PYXICEPHALIDAE	*Tomopterna cryptotis*	Tremelo Sand Frog	Least Concern	2
PYXICEPHALIDAE	*Tomopterna natalensis*	Natal Sand Frog	Least Concern	2

*The occurrence probability of the mammal species listed above is indicated as follows:
1 - Not likely to occur; 2 - Low occurrence probability; 3 - Medium occurrence probability; 4 - High occurrence probability; 5 - Confirmed occurrence.

Table 3: Reptile species observed and/or deducted to occur in QDSs 2628AD and 2628AC. Bates et al. (2014) was used for the conservation status of each species.

Family name	Species name	Common name	Conservation status	Occurrence
AGAMIDAE	*Agama aculeata distanti*	Eastern Ground Agama	Least Concern	3
AGAMIDAE	*Agama atra*	Southern Rock Agama	Least Concern	2
CHAMAELEONIDAE	*Chamaeleo dilepis dilepis*	Common Flap-neck Chameleon	Least Concern	2
COLUBRIDAE	*Crotaphopeltis hotamboeia*	Red-lipped Snake	Least Concern	4
COLUBRIDAE	*Dasypeltis scabra*	Rhombic Egg-eater	Least Concern	2
CORDYLIDAE	*Chaemaesaura aenea*	Coppery Grass Lizard	Near Threatened	3
CORDYLIDAE	*Cordylus vittifer*	Common Girdled Lizard	Least Concern	3

CORDYLIDAE	*Pseudocordylus melanotus melanotus*	Common Crag Lizard	Least Concern	2
ELAPIDAE	*Elapsoidea sundevallii media*	Highveld Garter Snake	Least Concern	3
ELAPIDAE	*Hemachatus haemachatus*	Rinkhals	Least Concern	3
GEKKONIDAE	*Lygodactylus capensis*	Common Dwarf Gecko	Least Concern	4
GEKKONIDAE	*Pachydactylus affinis*	Transvaal Gecko	Least Concern	3
GEKKONIDAE	*Pachydactylus capensis*	Cape Gecko	Least Concern	3
GERRHOSAURIDAE	*Gerrhosaurus flavigularis*	Yellow-throated Plated Lizard	Least Concern	3
LACERTIDAE	*Nucras lalandii*	Delalande's Sandveld Lizard	Least Concern	3
LAMPROPHIIDAE	*Aparallactus capensis*	Black-headed Centipede-eater	Least Concern	3
LAMPROPHIIDAE	*Atractaspis bibronii*	Bibron's Stiletto Snake	Least Concern	3
LAMPROPHIIDAE	*Boaedon capensis*	Brown House Snake	Least Concern	4
LAMPROPHIIDAE	*Duberria lutrix lutrix*	South African Slug-eater	Least Concern	
LAMPROPHIIDAE	*Homoroselaps dorsalis*	Striped Harlequin Snake	Near Threatened	3
LAMPROPHIIDAE	*Homoroselaps lacteus*	Spotted Harlequin Snake	Least Concern	2
LAMPROPHIIDAE	*Lamprophis aurora*	Aurora House Snake	Least Concern	3
LAMPROPHIIDAE	*Leptotyphlops scutifrons conjunctus*	Eastern Thread Snake	Least Concern	3
LAMPROPHIIDAE	*Leptotyphlops scutifrons scutifrons*	Peters' Thread Snake	Least Concern	3
LAMPROPHIIDAE	*Lycodonomorphus inornatus*	Olive House Snake	Least Concern	3
LAMPROPHIIDAE	*Lycodonomorphus rufulus*	Brown Water Snake	Least Concern	3
LAMPROPHIIDAE	*Lycophidion capense*	Cape Wolf Snake	Least Concern	3
LAMPROPHIIDAE	*Prosymna sundevallii*	Sundevall's Shovel-snout	Least Concern	2
LAMPROPHIIDAE	*Psammophis crucifer*	Cross-marked Grass Snake	Least Concern	3
LAMPROPHIIDAE	*Psammophylax rhombeatus rhombeatus*	Spotted Grass Snake	Least Concern	4
PELOMEDUSIDAE	*Pelomedusa subrufa*	Central Marsh Terrapin	Least Concern	3
SCINCIDAE	*Panaspis wahlbergii*	Wahlberg's Snake-eyed Skink	Least Concern	4
SCINCIDAE	*Trachylepis capensis*	Cape Skink	Least Concern	4
SCINCIDAE	*Trachylepis punctatissima*	Speckled Rock Skink	Least Concern	4
SCINCIDAE	*Trachylepis varia*	Variable Skink	Least Concern	3

TESTUDINIDAE	*Stigmochelys pardalis*	Leopard Tortoise	Least Concern	2
TYPHLOPIDAE	*Afrotyphlops bibronii*	Bibron's Blind Snake	Least Concern	2
TYPHLOPIDAE	*Rhinotyphlops lalandei*	Delalande's Beaked Blind Snake	Least Concern	3
VIPERIDAE	*Bitis arietans arietans*	Puff Adder	Least Concern	3
VIPERIDAE	*Causus rhombeatus*	Rhombic Night Adder	Least Concern	4

*The occurrence probability of the mammal species listed above is indicated as follows:
1 - Not likely to occur; 2 - Low occurrence probability; 3 - Medium occurrence probability; 4 - High occurrence probability; 5 - Confirmed occurrence.

7.3.3 Threatened and Red Listed Herpetofauna species

The threatened amphibian species, *P. adspersus* is expected to occur in the pan habitats during the rainy season. This species has a specialised habitat which is at risk from increasing urbanisation and agricultural activities. This species can remain up to 1m underground throughout most of the year when conditions are unfavourable.

No threatened reptile species were observed on the study area, although *H. dorsalis* and *C. aenea* have both a medium occurrence probability to occur on site. *H. dorsalis is* partially fossorial and known to inhabit old termitaria (limited in study area) in grassland habitat while *C. aenea* shelters in the base of grass tussocks. Both species are threatened by habitat loss and fragmentation due to urban, industrial and mining developments in the Gauteng Highveld (Bates et al. 2014).

7.4 Findings

The pan habitat is probably the most crucial to protect as it is the most sensitive and critical for the survival for *P. adspersus.* The drainage line furthermore supports many aquatic herpetofauna species and should also be protected. There are limited tree species found on site, thus no arboreal species are expected to occur on site. Logs and leaf litter is minimal and minimal burrows or termite mounds suitable for shelter were observed on site. This site could potentially support threatened herpetological species, but considering the limited habitat connectivity and the high human presence in the surrounding area it is highly unlikely that they occur on site.

8. INVERTEBRATE HABITAT ASSESSMENT

8.1 Methods

A species survey was conducted on the 23rd and 25th of March 2016, which consisted of several random walked transects. The dominant invertebrate species and possible suitable habitats for Red List invertebrate species were noted and sampled if necessary. Habitat characteristics for species present were derived from a survey and descriptions given in the field guide by Picker *et al.* (2004). All insects were identified *sensu*. Picker *et al*. (2004). Red Listed Butterflies were identified *sensu*. Henning *et al.* (2009) and Mecenero *et al*. (2013). Other Red Listed Species were identified using the IUCN conservation status (IUCN, 2015).

A desktop study was done to identify suitable habitats for invertebrate species, especially Red List species known to occur in the QDSs 2628AD and 2628AC. The Animal Demography Unit: Virtual Museum (http://vmus.adu.org.za/) was consulted to verify the record of occurrence of invertebrate species recorded within the QDS.

Invertebrate species are usually small, poikilothermic, and seasonal, which makes them difficult to observe during field surveys. In this case the presence of invertebrate species was examined on habitat preferred by selected species and respective documented ranges.

8.2 Specific Requirements

The survey took place during the end of the wet season, thus the probability of detecting identifiable life history stages was highest based on their biology.

During the survey the site was surveyed and assessed for the potential occurrence of Red List and/or ridge and wetland associated fauna species. Four invertebrate species, three butterflies and one beetle, are considered Vulnerable in Gauteng (GDARD, 2014): Highveld Blue Butterfly (*Lepidochrysops praeterita*), Heidelberg Copper Butterfly (*Chrysoritis aureus*), Roodepoort Copper Butterfly (*Aloeides dentatis dentatis*) and Stobbia's Fruit Chafer Beetle (*Ichnestoma stobbiai*).

8.3 Results

8.3.1 Invertebrate habitats identified

The major habitats of concern for the study area are the drainage line, pan and the terrestrial habitats. Wetland areas provide suitable habitat for many hemi-metabolous invertebrates to complete their life-cycles as they rely on water for breeding and nymphs/juveniles are aquatic.

8.3.2 Expected Invertebrate species

Table 4: Invertebrate species deducted to occur within QDSs 2628AD and 2628AC. Red Listed Butterflies were identified sensu. Henning et al. (2009) and Mecenero et al. (2013). Other Red Listed Species were identified using the IUCN conservation status (IUCN, 2015).

	Scientific name	Common name	Red List Status	Occurrence Probability
1.	*Anax imperator*	Blue Emperor	Not listed	4
3.	*Acraea horta*	Garden acraea	Least Concern	4
4.	*Acraea neobule*	Wandering donkey acraea	Least Concern	3
5.	*Actizera lucida*	Rayed blue	Least Concern	3
7.	*Africallagma glaucum*	Swamp Bluet	Not listed	4
8.	*Aloeides aranda*	Aranda copper	Least Concern	3
9.	*Aloeides dentatis*	Roodepoort copper	Least Concern	3
10.	*Aloeides henningi*	Henning's copper	Least Concern	3
11.	*Aloeides molomo*	Molomo copper	Least Concern	3
12.	*Aloeides taikosama*	Dusky copper	Least Concern	3
13.	*Aloeides trimeni*	Trimen's copper	Least Concern	3
14.	*Anax imperator*	Blue Emperor	Not listed	4
15.	*Anthene amarah*	Black striped hairtail	Least Concern	3
16.	*Anthene definita*	Common hairtail	Least Concern	3
17.	*Anthene livida*	Pale hairtail	Least Concern	3
18.	*Axiocerses tjoane*	Eastern scarlet	Least Concern	3
19.	*Azanus jesous*	Topaz babul blue	Least Concern	3
20.	*Azanus jesous*	Topaz babul blue	Least Concern	3
21.	*Azanus moriqua*	Black-bordered babul blue	Least Concern	3
22.	*Azanus ubaldus*	Velvet-spotted babul blue	Least Concern	3
23.	*Belenois aurota*	Brown-veined white	Least Concern	4
24.	*Belenois creona severina*	African common white	Least Concern	3
26.	*Bocchoris inspersalis*		Not Evaluated	3
27.	*Byblia ilithyia*	Spotted joker	Least Concern	4
28.	*Cacyreus marshalli*	Common geranium bronze	Least Concern	3
29.	*Cacyreus virilis*	Mocker bronze	Least Concern	3
31.	*Catacroptera cloanthe*	Pirate	Least Concern	3

32.	*Catopsilia florella*	African migrant	Least Concern	3
33.	*Chilades trochylus*	Grass jewel	Least Concern	3
34.	*Chrysoritis aureus*	Heidelberg opal	Endangered	3
38.	*Coeliades forestan*	Striped policeman	Least Concern	3
39.	*Coeliades pisistratus*	Two-pip policeman	Least Concern	3
40.	*Colias electo*	African clouded yellow	Least Concern	3
42.	*Colotis euippe omphale*	Smoky orange tip	Least Concern	3
43.	*Colotis evagore antigone*	Small orange tip	Least Concern	3
44.	*Colotis evenina evenina*	Orange tip	Least Concern	3
45.	*Cupidopsis cissus*	Common meadow blue	Least Concern	3
46.	*Cupidopsis jobates*	Tailed meadow blue	Least Concern	3
47.	*Danaus chrysippus orientis*	African monarch, Plain tiger	Least Concern	3
48.	*Eicochrysops messapus mahallakoaena*	Cupreous blue	Least Concern	3
50.	*Eretis umbra umbra*	Small marbled elf	Least Concern	3
51.	*Euchrysops dolorosa*	Sabie smoky blue	Least Concern	3
54.	*Eurema brigitta*	Broad-bordered grass yellow	Least Concern	4
55.	*Eurema hecabe solifera*	Lowveld yellow	Least Concern	3
56.	*Gegenes niso*	Common hottentot	Least Concern	3
57.	*Gegenes pumilio gambica*	Dark hottentot	Least Concern	3
58.	*Hypolimnas misippus*	Common diadem	Least Concern	3
59.	*Junonia hierta cebrene*	Yellow pansy	Least Concern	4
60.	*Junonia oenone*	Blue pansy	Least Concern	3
61.	*Junonia orithya madagascariensis*	Eyed pansy	Least Concern	3
62.	*Kedestes barberae*	Barber's ranger	Least Concern	3
63.	*Kedestes lepenula*	Chequered ranger	Least Concern	3
64.	*Kedestes nerva*	Scarce ranger	Least Concern	3
65.	*Lampides boeticus*	Pea blue	Least Concern	3
66.	*Lepidochrysops ketsi ketsi*	Ketsi blue	Least Concern	3
68.	*Lepidochrysops patricia*	Patricia blue	Least Concern	3
69.	*Lepidochrysops plebeia*	Twin-spot blue	Least Concern	3
71.	*Leptomyrina henningi*	Henning's black-eye	Least Concern	3
72.	*Leptotes* species	Zebra blue	Least Concern	3
74.	*Metisella meninx*	Marsh sylph	Least Concern	3
75.	*Mylothris agathina*	Common dotted border	Least Concern	3
78.	*Orthetrum caffrum*	Two-striped Skimmer	Not listed	3
79.	*Orthetrum caffrum*	Two-striped Skimmer	Not listed	3
80.	*Papilio demodocus*	Citrus swallowtail	Least Concern	4
81.	*Paternympha narycia*	Spotted-eye brown	Least Concern	3
82.	*Pinacopteryx eriphia*	Zebra white	Least Concern	3
83.	*Platylesches neba*	Flower-girl hopper	Least Concern	3
84.	*Pontia helice helice*	Common meadow white	Least Concern	3
85.	*Precis archesia archesia*	Garden commodore	Least Concern	3

86.	*Precis octavia sesamus*	Gaudy Commodore	Least Concern	3
87.	Pseudagrion citricola	Yellow-faced Sprite	Not listed	2
88.	*Pseudagrion salisburyense*	Slate Sprite	Not listed	2
89.	*Spialia asterodia*	Star sandman	Least Concern	3
91.	*Spialia diomus ferax*	Common sandman	Least Concern	4
92.	*Spialia mafa*	Mafa sandman	Least Concern	3
93.	*Spialia spio*	Mountain sandman	Least Concern	3
95.	*Sympetrum fonscolombii*	Red-veined Darter or Nomad	Not listed	2
96.	*Tarucus sybaris*	Dotted blue	Least Concern	3
97.	*Telchinia rahira*	Marsh acraea	Least Concern	3
98.	*Teracolus agoye bowkeri*	Speckled sulphur tip	Least Concern	3
99.	*Teracolus eris*	Banded gold tip	Least Concern	3
100.	*Teracolus subfasciatus*	Lemon traveller	Least Concern	3
101.	*Trithemis kirbyi*	Orange-winged Dropwing	Not listed	2
102.	*Tsitana tsita*	Dismal sylph	Least Concern	3
105.	*Vanessa cardui*	Painted lady	Least Concern	3
106.	*Zintha hintza hintza*	Hintza pierrot	Least Concern	3
107.	*Zizeeria knysna*	African grass blue	Least Concern	3
109.	*Zizula hylax*	Tiny grass blue	Least Concern	3

*The occurrence probability of the mammal species listed above is indicated as follows:
1 - Not likely to occur; 2 - Low occurrence probability; 3 - Medium occurrence probability; 4 - High occurrence probability; 5 - Confirmed occurrence.

8.3.3 Threatened and Red Listed Invertebrate species

No Red List invertebrate species were recorded or are expected to occur on the study area.

8.4 Findings

No Red Data invertebrate species were recorded or are expected to occur on or near the study site. The terrestrial habitat is not considered ecologically sensitive with respect to invertebrates; however the drainage line and pan habitats are considered important for the survival of several invertebrate species. Aquatic habitats are important for hemi-metabolic insects for breeding and for the survival of their nymphs, and are therefore necessary to preserve.

9. OVERALL FINDINGS AND IMPLICATIONS

The terrestrial habitat present on the study area has been previously cultivated which could have displaced many fauna species, especially mammals and terrestrial reptile species. Thus, as the habitat had to adjust it is expected that only primary successional species are present on site or are likely to occur. However, since there is limited terrestrial habitat connectivity with similar habitats in the surrounding area, it is unlikely for specialist species to recolonize the study area. The terrestrial habitat is considered to be of medium sensitivity due to its semi-natural state and the suitable habitat it provides for several fauna species.

There is limited evidence to suggest that the drainage line and pan habitats were transformed or disturbed in the past, thus aquatic species were less impacted and is therefore expected that more specialist species could occur on site. There is aquatic habitat connectivity towards the west of the study area, thus species could move freely to similar habitats. These habitats have the potential to support sensitive species and/or species with conservation concerns such as the African Marsh Rat and Vlei Rats. None of these species were recorded in this survey, but have a high probability of occurring in the study area. Ten mammal species and six amphibian species are expected to have a high probability of occurring in the drainage line and pan habitats (**Tables 1 and 2**). *P. adspersus* have a high probability to occur on site. However, GDARD does not regard this species as truly 'Near Threatened' in South Africa and "*no specialist studies for any species of amphibian are requested for consideration in the review of a development application*" (GDARD, 2014). Thus, it is not a requirement from GDARD to determine whether *P. adspersus* occurs on site. Both the drainage line and pan habitats provide important ecological functions in terms of connectivity and as such both are considered to be highly sensitive from a faunal perspective **(Figure 10)**.

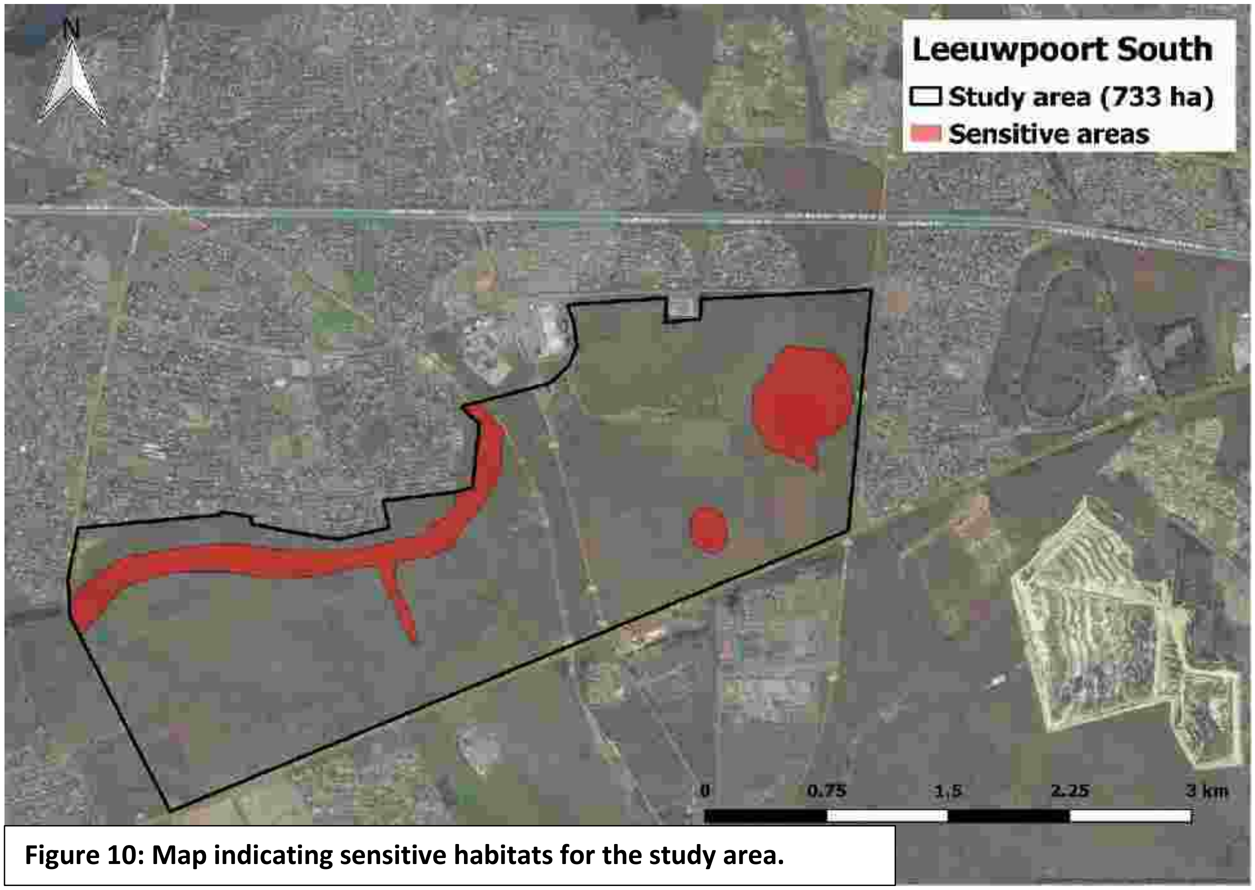


Figure 10: Map indicating sensitive habitats for the study area.

10. LIMITATIONS

Even though considerable care is taken to ensure accuracy and professionalism of this fauna report, environmental assessment studies are limited in scope, time and budget. Several years are needed to derive a 100% accurate report based on intensive field collecting and observations where all seasons are considered to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage.

The desktop study made up the largest part of the data used to conclude the distribution of Red Data species which were sourced by making use of the Animal Demography Unit: Virtual Museum data basis. Any limitations in the above mentioned data basis will in effect have implications on the findings and conclusion of this assessment.

Therefore, Bokamoso Environmental: Specialist Division cannot accept responsibilities for conclusions and mitigation measures made in good faith with the limited available information at the time of the directive. This report should be viewed and acted upon considering these limitations.

11. RECOMMENDATIONS

- An appropriate management authority that must be contractually bound to implement the EMP and RoD during the constructional and operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.
- Prior to any activities commencing on site, all construction staff should be briefed in an environmental induction regarding the environmental status and requirements of the site. This should include providing general guidelines for minimizing environmental damage during construction, as well as education with regards to basic environmental ethics, such as the prevention of littering, lighting of fires, etc.
- Induction should be done for all civil contractors and for each building contractor prior to them commencing on site.
- Construction should be restricted to areas deemed to have a low ecological sensitivity (Please refer to **Figure 10**).
- Areas where construction is to take place should be clearly demarcated and fenced off, all areas outside that of the defined works should be deemed no-go areas such as the drainage line and pan habitats.
- All construction activities must be restricted to the demarcated areas to ensure that no further disturbance into the surrounding vegetation or habitat takes place.
- It is recommended that prior to the commencement of construction activities' initial clearing of all alien vegetation should take place.
- No vehicles should be allowed to move in or through the drainage line or the pan habitats. This will cause destruction of faunal habitat and will leave notable scares on site.
- The contractor must ensure that no faunal species are trapped, killed or in any way disturbed during the constructional phase.
- It is recommended that all concrete and cement works be restricted to areas of low ecological sensitivity and defined on site and clearly demarcated. Cement powder has a high alkalinity pH

rating, which can contaminate and affect both soil and water pH dramatically. A shift in the pH can have serious consequences on the functioning of soil, vegetation and fauna.

- To ensure minimal disturbance of faunal habitat it is recommended that construction should take place during winter, outside the reproductive season of the species present on site.
- Construction, vegetation clearing and top soil clearing should commence from a predetermined location and gradually commence to ensure that fauna present on the site have enough time to relocate.
- When construction is completed, disturbed areas should be rehabilitated using vegetation cleared prior to construction to ensure that the habitat stays intact and that faunal species present on the site before construction took place, return to the area.

12. CONCLUSION

Due to the sensitive nature of the drainage line and pan habitats, induction with all the partaking contractors, workers, road engineers and landowners is necessary, in order to make them aware of the areas deemed to be sensitive according to this report and act accordingly. Development should be excluded from these sensitive areas (**Figure 10**).

Storm water management must ensure that neither the drainage line or pan habitat is damaged or become degraded. The terrestrial habitat in general is considered suitable to support medium population densities of fauna species, especially small mammal and reptile species. The drainage line and pan habitat is highly suitable for several aquatic fauna species and should be conserved accordingly. The abovementioned mitigation measures should be followed during the construction and operational phases. If abovementioned mitigation measures are implemented correctly, the proposed development will not result in the destruction and/or loss of important or ecologically sensitive habitat units from a faunal perspective.

13. LITERATURE SOURCES

ALEXANDER, G. J., MARAIS, J. A. 2007. Guide to the Reptiles of Southern Africa. Random House Struik, Cape Town. ISBN-13: 9781770073869.

Animal Demography Unit. 2016. Virtual Museum. Accessed at http://vmus.adu.org.za/?vm.

BATES, M.F., BRANCH, W.R., BAUER, A.M., BURGER, M., MARAIS, J., ALEXANDER, G.J. & DE VILLIERS, M.S. (eds.). 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1. South African National Biodiversity Institute, Pretoria.

DU PREEZ, L., CARRUTHERS, V. A. 2009. Complete Guide to the Frogs of Southern Africa. Struik Nature, Cape Town.

FRIEDMAN, Y. & DALY, B. 2004. Red data book of the mammals of South Africa: A conservation assessment. Johannesburg, CBSG-EWT

GDARD. 2014. Technical Report for the Gauteng Conservation Plan (Gauten C-Plan v3.3). Gauteng Department of Agriculture and Rural Development: Nature Conservation Directorate. 60 pages.

HENNING, G.A., TERBLANCHE, R.F. & BALL, J.B. 2009. South African Red Data Book: butterflies. South African National Biodiversity Institute Biodiversity Series 13: 63-64.

IUCN. 2015. The IUCN Red List of Threatened Species. Version 2015-4. <http://www.iucnredlist.org>. Downloaded on 19 November 2015.

IUCN. 2016. World Conservation Monitoring Centre. 1996. *Homoroselaps dorsalis*. The IUCN Red List of Threatened Species 1996: e.T10242A3184734.
http://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T10242A3184734.en. Downloaded on **14 June 2016**.

MammalMAP.2016. Virtual Museum of African Mammals. Accessed at http://mammalmap.adu.org.za/

MARAIS, J. 2004. ‘n Volledige Gids tot die Slange van Suider-Afrika. Struik Uitgewers, Kaapstad.

MECENERO, S., BALL, J. B., EDGE, D. A., HAMER, M. L. HENNING, G.A., KRÜGER, M., PRINGLE, E. L., TERBLANCHE, R. F., WILLIAMS, M. C. 2013. Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas.

MEASEY, G.J. (ed.) 2011. Ensuring a future for South Africa's frogs: a strategy for conservation research. SANBI Biodiversity Series 19. South African National Biodiversity Institute, Pretoria.

MINTER L.R., BURGER M., HARRISON J.A., BRAACK H.H., BISHOP P.J. and KLOEPFER D. (Eds.). 2004. *Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland*. SI/MAB Series no. 9. Smithsonian Institution, Washington, D.C.

MUCINA, L., AND RUTHERFORD, M.C. 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

PICKER, M. D., GRIFFITHS, C., WEAVING, A. 2004. Field Guide to Insects of South Africa. Struik Publishers, South Africa.

SKINNER, J.D. AND CHIMIMBA, T.C. 2005. The Mammals of the Southern African Subregion. 3rd edition. Cambridge University Press.

STUART, C., AND STUART, M. 2015. Stuart's Field Guide to Mammals of Southern Africa. Struik Nature, South Africa

STUART, C., STUART, T. 2000. A Field Guide to the Tracks & Signs of Southern and East African Wildlife. 3rd edition. Struik Publishers, Cape Town.

TAYLOR, P.J. 2000. Bats of Southern Africa. University of Natal Press: Pietermaritzburg.

ANNEXURE D4b
FLORA ASSESSMENT

Flora Assessment for the Remainder of The Farm Leeuwpoort 113-IR

March 2016

Landscape Architects &

Environmental Consultants: Specialist Division

T: (+27)12 346 3810 l F: (+27) 86 570 5659 l E: corne@bokamoso.net; sampie@bokamoso.net l www.bokamoso.biz.

36 Lebombo Street, Ashlea Gardens, Pretoria l P.O. Box 11375 Maroelana 0161

Report Authors: SE van Rooyen

Reviewed by: J.V. van Greuning

Specialists

Specialist investigators: Mr. S.E. van Rooyen (M.Sc. Restoration Ecology and Botany candidate)

<u>Declaration of independence</u>:

The specialist investigators responsible for conducting this particular specialist vegetation study declare that:

• I consider ourselves bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report we did not have any interest, hidden or otherwise, in the proposed development, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, we will not be affected in any manner by the outcome of any environmental process of which this report may form a part;

• I declare that there are no circumstances that may compromise our objectivity in performing this specialist investigation. We do not necessarily object to or endorse the proposed development, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I have the necessary qualifications and guidance from professional experts (registered Pr. Nat. Sci.) in conducting specialist reports relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;

• This document and all information contained herein is and will remain the intellectual property of Bokamoso Environmental: Specialist Division. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.

• I will comply with the Act, regulations and all other applicable legislation;

S.E. van Rooyen

VERIFICATION STATEMENT

This communication serves to verify that the flora report compiled by S. E. van Rooyen has been prepared under my supervision, and I have verified the contents thereof.

Declaration of independence: I, Dr. J.V. van Greuning (Pr. Sci. Nat. reg. no. 400168/08) declare that I:

- am committed to biodiversity conservation but concomitantly recognise the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them.
- abide by the Code of Ethics of the S.A. Council of Natural Scientific Professions
- act as an independent specialist consultant in the field of Botany
- am subcontracted as specialist consultant by Bokamoso Environmental Consultants for the proposed Mixed Use development on the remainder of the Farm Leeuwpoort 113-IR described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- have or will not have any vested or conflicting interests in the proposed development
- undertake to disclose to Bokamoso Environmental Consultants and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2014.

Dr. J. V. van Greuning

Table of Contents

1. Introduction

Bokamoso Environmental: Specialist Division was commissioned to conduct a flora assessment for the proposed Mixed Use development on the remainder of the Farm Leeuwpoort 113-IR. The objective was to conduct a floristic species survey to determine which species occur within the site of the proposed development. Special attention was given to possible habitats for the recording of Red and Orange List plant species that may occur in the area. Furthermore, the ecological integrity and sensitive habitats of the site were investigated.

2. Objectives of the study

- To assess the habitat component and current ecological status of the area;
- To identify and list the current plant species occurring on the site and indicate whether they are indicated as Red and Orange List species;
- Make recommendations if any Red and Orange List species are found;
- To indicate the sensitive habitats of the area;
- To highlight the current impacts on the flora of the site; and
- Provide recommendations to mitigate negative impacts and enhance positive impacts on the current flora should the proposed development be approved.

3. Scope of study

This report:

- Lists all flora species, including alien species, recorded during the flora survey;
- Indicate and provide recommendations on Red and Orange List plant species;
- Indicate medicinal plants recorded;
- Comments on ecological sensitive areas;
- Comments on current impacts affecting the flora of the site;
- Evaluate the conservation importance and significance of the area within and adjacent the proposed development, with special emphasis on the current status of threatened species; and
- Provide recommendations to mitigate or reduce negative impacts, should the proposed development be approved.

4. Study area

4.1. Regional vegetation

The study site lies within the Quarter Degree Squares (QDS) 2628AC and 2628AD. The site falls partly within the Tsakane Clay Grassland vegetation unit (Mucina and Rutherford, 2006) and the Klipriver Highveld Grassland (SANBI, 2011). The Tsakane Clay Grassland vegetation unit is considered Endangered, while the Klipriver Highveld Grassland (SANBI, 2011) is listed as Critically Endangered according to the National list of threatened terrestrial ecosystems for South Africa, 2011 (Government Gazette no. 34809, 2011).

Only a small portion of 1.5% of the Tsakane Clay Grassland patches are protected with the conservation target at 24 %, whilst 60 % is already transformed due to urbanisation and cultivated lands (Mucina and Rutherford, 2006). The authors described the landscape of the Highveld plateau as flat to slightly undulating plains and low hills. The vegetation is described as short and densely tufted grassland, dominated almost entirely by *Themeda triandra, Elionurus muticus*, *Heteropogon contortus* and a varietry of species belonging to the *Eragrostis* genus (Mucina and Rutherford, 2006). Dominant forb species include species belonging to the families of *Asteraceae, Rubiaceae, Fabaceae, Malvaceae* and *Lamiaceae*.
Only 1% of the original area of the Klipriver Highveld Grassland is protected, mainly in the Klipriviersberg Nature Reserve and Rondebult Bird Sanctuary (SANBI, 2011). There are 25 threatened and/or endemic plant and animal species known to occur within this vegetation unit (SANBI, 2011).

Almost half of the study area falls within the Carletonville Dolomite Grassland vegetation unit, which according to the authors, is dominated by a wide variety of species (Mucina and Rutherford, 2006). This species-rich Grassland falls on slightly undulating plains dissected by prominent rocky chert ridges. From the targeted 24% only a small extent is conserved in statutory and private conservation areas (Mucina and Rutherford, 2006). The Vulnerable status of this vegetation unit is earned due to a quarter of the unit already being transformed into cultivated lands, residential areas and mining areas.

4.2. The study site

The proposed mixed use development is situated on the Remainder of the Farm Leeuwpoort 113-IR. This site is approximately 733 Ha and is situated just south of the N17 highway and towards the north of the R554 road (Figure 1).

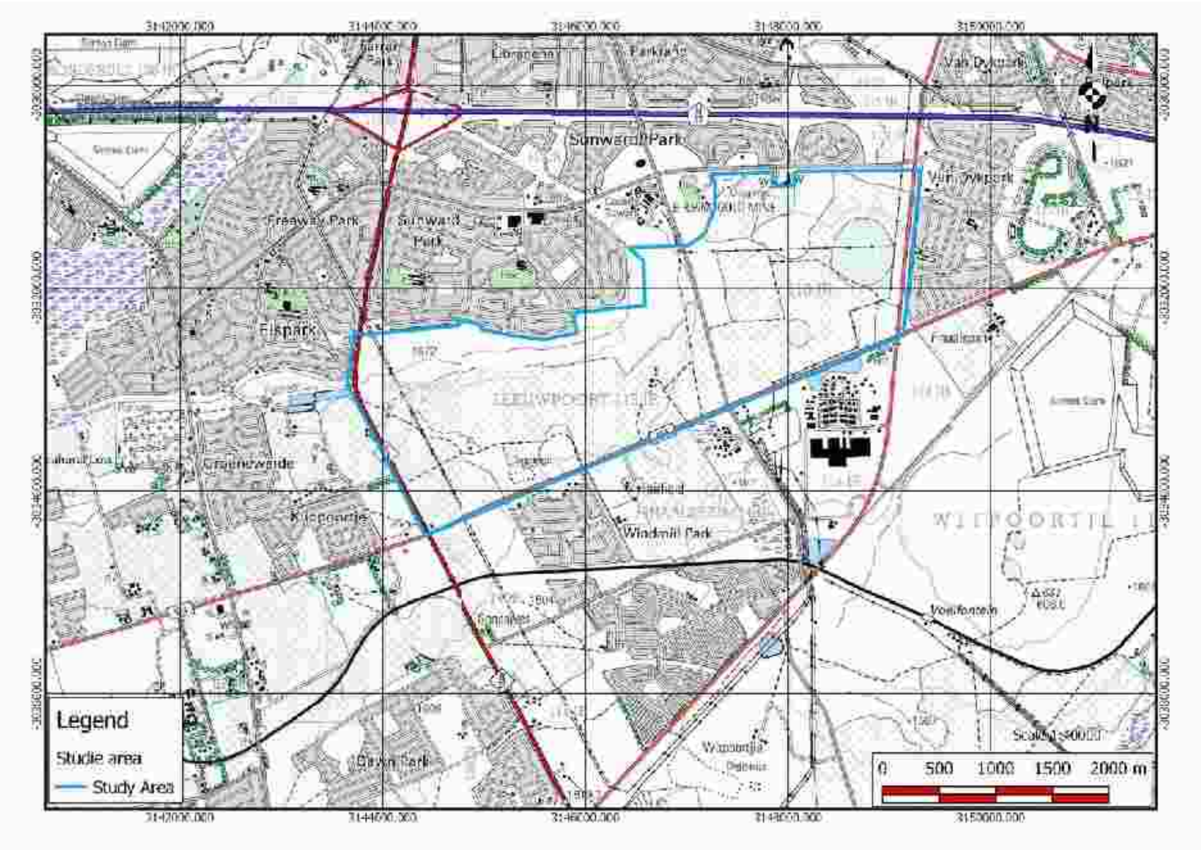


Figure 1 Locality map of the study site indicated in blue polygon.

5. Methods

The study site was visited on the 23rd and 25th of March 2016. For each study unit identified, a species list was compiled for all plants recorded within a 100 m by 25 m sampling plot. Field guides such as those by Germishuizen and Meyer (2003), Koekemoer *et al*. (2014), Pooley (1998), van Ginkel *et al.* (2011), van Oudtshoorn *et al.* (2014), van Wyk and Malan (1998) and van Wyk (2013) were used to identify the species.

The survey also included information about the occurrence of Red and Orange List plant species obtained from GDARD (Pfab, 2002; Pfab and Victor, 2002; Annexure A). The Red List Plant Species Guidelines and Requirements for Biodiversity Assessments v3. issued by GDARD (2014) was consulted. A desktop study was done to identify suitable habitats for the Red and Orange List plant species known to occur in the (QDS) 2628AC and 2628AD. The plant species list for this (QDS) obtained from SANBI (Plants of Southern Africa: an online checklist) was consulted to verify the record of occurrence of the plant species recorded at the site Leeuwpoort 113-IR. The Gauteng Conservation Plan (C-plan v3.3) was also consulted to evaluate ecologically sensitive areas.

Each vegetation unit was further assessed for the occurrence of alien plant species (Bromilow, 2010) and any form of disturbance. Alien species are included in the species lists (indicated in bold in the relevant Tables) as they suggest the particular state of each study unit. For each alien species the Category is indicated according to the *Alien and Invasive species lists* (2014) amended in NEMBA (National Environmental Management: Biodiversity Act (ACT NO, 10 OF 2004).

For each plant species, the medicinal properties were assessed (van Wyk et al., 2013). Medicinal plants indicated in the tables below. Harvesting of medicinal plants causes a decline of the particular species and, therefore, threatens the conservation of these species. Medicinal plants are marked with an asterisk (*) in the respective Tables (Tables 1 – 6).

6. Results

6.1. Study Units

Five study units were identified for this study:

1. Disturbed *Verbena - Eragrostis* Pan
2. Transformed *Eucalyptus - Hyparrhenia* Grassland
3. Moist *Themeda - Eragrostis* Grassland
4. Disturbed *Eragrostis - Hyparrhenia* Grassland
5. *Setaria - Typha* Drainage Line

Table 1 The number of species recorded per study unit, including the total number of medicinal and exotic plants.

Study Unit	Total number of species per unit	No. of medicinal species per unit	No. of alien species per unit
Disturbed *Verbena-Eragrostis* Pan	20	1	6
Transformed *Eucalyptus - Hyparrhenia* Grassland	36	1	19
Moist *Themeda - Eragrostis* Grassland	38	1	10
Disturbed *Eragrostis - Hyparrhenia* Grassland	64	8	15
Setaria - Typha Drainage Line	29	4	12

6.1.1. Medicinal Plants

The number of medicinal plants for each study unit is indicated in Table 1, and in representative species lists (Table 2 to 6) the species are indicated with a (*). The Disturbed *Eragrostis - Hyparrhenia* Grassland study unit has the highest amount of medicinal species followed by the *Setaria - Typha* Drainage Line (Table 1).

6.1.2. Alien Plants

The number of alien plants for each study unit is indicated in Table 1, and in representative species lists (Table 2 to 6) the species are indicated in **bold.** The Transformed *Eucalyptus - Hyparrhenia* Grassland has the highest species richness of alien plants followed by the Disturbed *Eragrostis - Hyparrhenia* Grassland (Table 1).

Removal of Category 1 alien invaders is **compulsory** in terms of the regulations formulated under "The Conservation of Agricultural Resources Act" (Act No. 43 of 1983), as amended. All Category 2 exotics should likewise be removed, unless a permit is obtained to control it in a demarcated area or a biological control reserve. Category 3 Declared Invader plants may not occur on any land, or inland water surface other than in a biological control reserve. If Category 3 Declared Invader plants exist on the study site, a land user must take all responsible steps to stop the spreading of propagating material belonging to these plants.

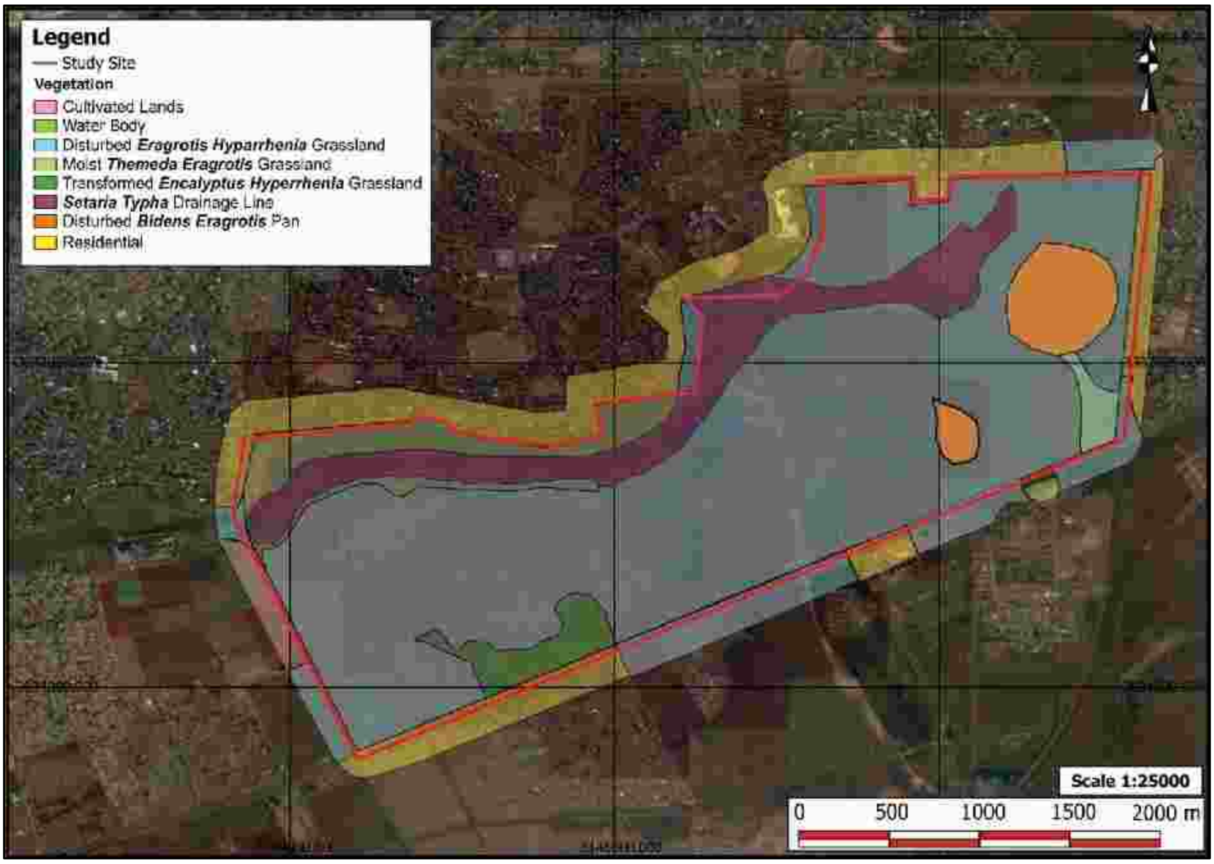


Figure 2 Study site map with study units indicated

6.1.3. Disturbed *Verbena - Eragrostis* Pan

This study unit (Figure 2) is in a degraded state (Figure 3 a, b) as it is dominated by alien species such as *Cosmos bipinnatus, Verbena bonariensis* and *Verbena brasiliensis* in combination with a grass layer dominated by *Panicum coloratum, Cynodon dactylon, Setaria sphacelata* var. *torta* and several species belonging to the genus *Eragrostis.*

According to the Gauteng Conservation Plan (GDARD, 2014) the two pans identified within the study area are considered as important areas which are suitable habitats for Orange list plant species. One Orange List species, *Hypoxis hemerocallidea* were recorded in abundance with the conservation status of Declining is Gauteng.

A certified wetland specialist needs to determine the extent of the wetland surrounding the Disturbed *Verbena - Eragrostis* Pan. As wetlands form biological filters and drainage lines from corridors for the movement of a variety of species, which include several plant species and their pollinators, it is considered a sensitive area and no development should take place on this study unit. The necessary buffers need to be maintained around this Disturbed *Verbena - Eragrostis* Pan, if so determined by the appointed wetland specialist.

Table 2 Species list for Disturbed *Verbena - Eragrostis* Pan.

GROWTH FORM	Invasive category
TREES/SHRUBS	
Ulmus parviflora	
GRASSES/SEDGES	
Aristida congesta subsp. *barbicollis*	
Cortaderia selloana	1b
Cymbopogon pospischilii	
Cynodon dactylon	
Eragrostis curvula	
Panicum coloratum	
Setaria sphacelata var. *torta*	
Sporobolus fimbriatus	
FORBS	
Amaranthus sp.	
Chlorophytum transvaalense	
Commelina africana	
Cosmos bipinnatus	
Gnaphalium luteo-album	
Habenaria humilior	
Hibiscus trionum	
*Hypoxis hemerocallidea**	
Senecio inornatus	
Verbena bonariensis	1b
Verbena brasiliensis	1b

Alien species indicated in bold; Medicinal species indicated with (*)

Figure 3 (a, b) Disturbed *Verbena - Eragrostis* Pan. View to the West (a) and view to the South (b).

6.1.4. Transformed *Eucalyptus - Hyparrhenia* Grassland

This Grassland (Figure 2) is regarded as transformed (Figure 4 a, b) due to the occurrence of 26 exotic species out of the 36 species recorded within this study unit. Dominant species include those of the *Eucalyptus* genus, *Melia azedarach*, *Solanum mauritianun, Tipuana tipu* and *Robinia pseudoacacia* with invasive categories of 1b and 3 respectively (Table 3). The forb layer is dominated by *Bidens* species, *Tagetes minuta, Tribulus Terrestris* and *Verbena* species, which are all alien plant species. Several dominant grass species include *Chloris virgata, Cynodon dactylon, Melinis repens* and *Hyparrhenia hirta.* Illegal dumping causes the degradation of indigenous vegetation.

Table 3 Species list for the Transformed *Eucalyptus* - *Hyparrhenia* Grassland.

GROWTH FORM	**Invasive category**
TREES/SHRUBS	
Celtis africana	
***Eucalyptus* sp.**	1b
Melia azedarach	1b & 3
Opuntia ficus-indica	1b
Robinia pseudoacacia	1b
Salix babylonica	
Solanum mauritianum	1b
Tipuana tipu	3
*Vachellia karroo**	
GRASSES/SEDGES	
Aristida congesta subsp. congesta	
Arundo donax	1b

Chloris virgata *Cymbopogon caesius* *Cynodon dactylon* ***Cyperus esculentus*** *Hyparrhenia hirta* *Hyparrhenia* cf. *viriabilis* *Melinis repens* *Panicum coloratum* ***Paspalum dilatatum*** *Pogonarthria squarrosa* *Setaria sphacelata* var. *torta* *Sporobolus fimbriatus* *Urochloa panicoides*	
FORBS	
Amaranthus sp.	
Bidens pilosa	
Bidens bipinnata	
Chamaecrista mimosoides	
Cosmos bipinnatus	
Gnaphalium luteo-album	
Mirabilis jalapa	1b
Senecio inornatus	
Tagetes minuta	
Tribulus Terrestris	
Verbena brasiliensis	1b

Alien species indicated in bold; Medicinal species indicated with (*)

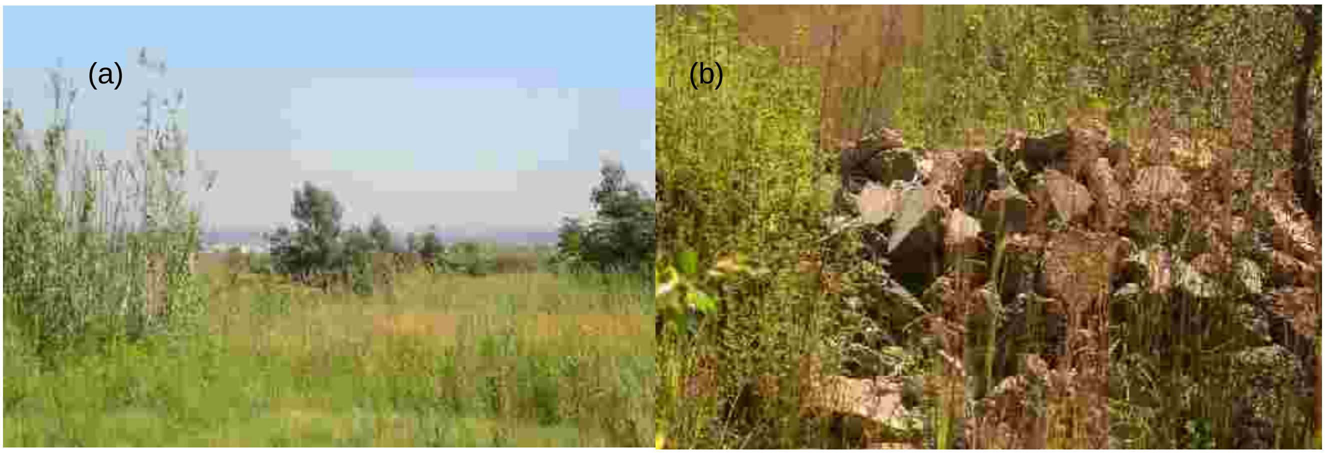


Figure 4 (a, b) Transformed *Eucalyptus - Hyparrhenia* Grassland (a), with illegal dumping on site (b).

6.1.5. Moist *Themeda - Eragrostis* Grassland

This study unit (Figure 2) remains in a natural condition as no disturbances were observed. It is dominated by climax grass species i.e. *Digitaria eriantha, Panicum coloratum, Themeda triandra* and several *Eragrostis* species. The forb layer is represented by the dominant species *Scabiosa columbaria, Berkheya radula* and *Wahlenbergia undulata.*
According to the Gauteng Conservation Plan (GDARD, 2014) several parts of this study unit is considered as important areas that provides a suitable habitat for Orange List plant species, although no Orange List species have been recorded during the site visit.

This study site potentially falls within a wetland. A certified wetland specialist needs to determine the extent of the wetland surrounding the Moist *Themeda - Eragrostis* Grassland. As wetlands form biological filters and drainage lines from corridors for the movement of a variety of species, which include several plant species and their pollinators, it is considered a sensitive area and no development should take place on this study unit. The necessary buffers need to be maintained around this Moist *Themeda - Eragrostis* Grassland, if so determined by the appointed wetland specialist.

Table 4 Species occurring within the Moist *Themeda - Eragrostis* Grassland.

GROWTH FORM	Invasive category
TREES/SHRUBS	
Morus alba	3
GRASSES/SEDGES	
Andropogon appendiculatus	
Aristida congesta subsp. *congesta*	
Aristida stipitata	
Cynodon dactylon	
Cyperus esculentus	
Digitaria eriantha	
Eragrostis chloromelas	
Eragrostis curvula	
Eragrostis gummiflua	
Heteropogon contortus	
Hyparrhenia hirta	
Kyllinga erecta	
Panicum coloratum	
Paspalum* cf. *notatum	
Paspalum dilatatum	
Pogonarthria squarrosa	
Schoenoplectus sp.	

Setaria sphacelata var. *torta*	
Themeda triandra	
Trachypogon spicatus	
Triraphis andropogonoides	
FORBS	
Berkheya radula	
Campuloclinium macrocephalum	1b
Cosmos bipinnatus	
Gnaphalium luteo-album	
Habenaria humilior	
Indigofera sp.	
Nidorella hottentotica	
Persicaria lapathifolia	
*Scabiosa columbaria**	
Selago densiflora	
Senecio sp.	
Seriphium plumosum	
Tagetes minuta	
Verbena brasiliensis	1b
Wahlenbergia undulata	

Alien species indicated in bold; Medicinal species indicated with (*)

Figure 5 Moist *Themeda - Eragrostis* Grassland.

6.1.6. Disturbed *Eragrostis - Hyparrhenia* Grassland

The greater part of the study site falls within this study unit (Figure 2) with a low ecological importance as signs of old cultivation activities appear within the grassland (Figure 6b). At Several locations(Figure 6a) the vegetation are more disturbed than the rest and is dominated by alien vegetation i.e. *Paspalum dilatatum, Bidens formosa, Bidens pilosa, Bidens bipinnata, Tagetes minuta, Verbena* species and *Campuloclinium macrocephalum* (Invasive category 1b). The grass layer is overall dominated by *Aristida* species, *Cynodon dactylon, Eragrostis* species, *Heteropogon contortus, Hyparrhenia hirta, Setaria* species, *Themeda triandra* and *Urochloa panicoides.* Several dominant forb species include *Cucumis zeyheri*, *Datura stramonium, Hermannia depressa, Hilliardiella oligocephala, Ledebouria* species and *Verbena* species.

According to the Gauteng Conservation Plan several parts of this study unit is considered as important areas that provides a suitable habitat for Orange List plant species. One Orange Listed species have been identified i.e. *Hypoxis hemerocallidea,* with the conservation status of Declining.

Table 5: Species occurring within the Disturbed *Eragrostis - Hyparrhenia* Grassland.

GROWTH FORM	Invasive category
TREES/SHRUBS	
Vachellia cf. *karroo**	
GRASSES/SEDGES	
Aristida congesta subsp. *barbicollis*	
Aristida congesta subsp. *congesta*	
Bewsia biflora	
Brachiaria nigropedata	
Chloris virgata	
Cynodon dactylon	
Cyperus esculentus	
Diheteropogon amplectens	
Eleusine coracana	
Eragrostis chloromelas	
Eragrostis curvula	
Eragrostis nindensis	
Heteropogon contortus	
Hyparrhenia hirta	
Melinis repens	
Paspalum dilatatum	
Setaria sphacelata var. *torta*	
Sporobolus fimbriatus	
Themeda triandra	

Trichoneura grandiglumis *Urochloa panicoides*	
FORBS	
Barleria sp.	
Bidens pilosa	
Bidens bipinnata	
Campuloclinium macrocephalum	1b
Chamaecrista comosa	
Cleome maculata	
Convolvulus sagittatus var. *hirtellus*	
Cosmos bipinnatus	
Cucumis zeyheri	
Cyanotis speciosa	
Datura stramonium*	
Gazania krebsiana	
Gladiolus cf. *crassifolius*	
Gnaphalium luteo-album	
*Gomphocarpus fruticosus**	
Gomphrena celosioides	
Habenaria humilior	
Haplocarpha lyrata	
Helichrysum nudifolium var. *nudifolium* *	
Helichrysum rotundatum	
Hermannia depressa	
Hibiscus trionum	
*Hilliardiella oligocephala**	
*Hypoxis hemerocallidea**	
Indigofera cf. comosa	
Indigofera melanadenia	
Ledebouria sp.	
Macledium zeyheri	
Pentanisia angustifolia	
Phytolacca octandra	
Pollichia campestris	
*Scabiosa columbaria**	
Selago densiflora	
Senecio inornatus	
Senecio sp.	
Seriphium plumosum	
Solanum panduriforme	
Tagetes minuta	
Tephrosia capensis	
Verbena bonariensis	1b
Verbena brasiliensis	1b
Wahlenbergia undulata	

Alien species indicated in bold; Medicinal species indicated with (*)

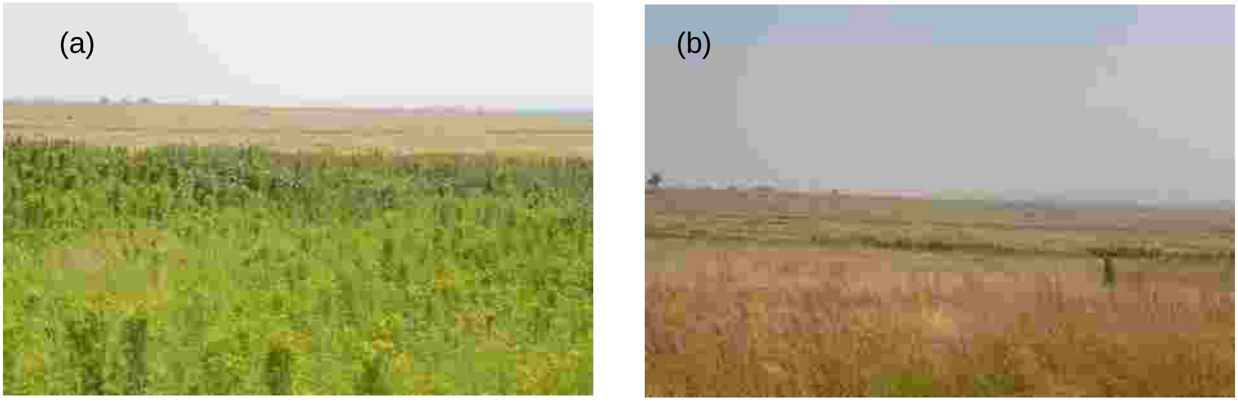


Figure 6 (a, b) Disturbed *Eragrostis - Hyparrhenia* Grassland (b), with alien species dominating several areas (a).

6.1.7. *Setaria - Typha* Drainage Line

This Drainage line (Figure 2) remains in a semi-natural state (Figure 7b) with some exotic species (i.e. *Cyperus esculentus, Paspalum* species, *Arundo donax, Bidens* speices and *Verbena* species) invading the area (Figure 7a). Species dominating the drainage line include *Typha capensis, Phragmites australis, Setaria incrassata, Cyperus* species, *Paspalum* species, *Persicaria* species and *Verbena bonariensis.*

According to the Gauteng Conservation Plan (GDARD, 2014) this vegetation unit is considered as important areas that provides a suitable habitat for Orange List plant species. One Orange List species has been identified i.e. *Hypoxis hemerocallidea,* with the conservation status of Declining.

A certified wetland specialist needs to determine the extent of the wetland surrounding the *Setaria - Typha* Drainage Line. As wetlands form biological filters and drainage lines from corridors for the movement of a variety of species, which include several plant species and their pollinators, it is considered a sensitive area and no development should take place on this study unit. The necessary buffers needs to be maintained around this *Setaria - Typha* Drainage Line, if so determined by the appointed wetland specialist.

Table 6 Species occurring within the *Setaria - Typha* Drainage Line.

GROWTH FORM	Invasive category
GRASSES/SEDGES	
Andropogon eucomus	
Arundo donax	1b
Cynodon dactylon	
Cyperus esculentus	

Eragrostis curvula	
Hyparrhenia hirta	
Panicum coloratum	
Paspalum dilatatum	
Paspalum notatum	
Phragmites australis	
Setaria incrassata	
FORBS	
Amaranthus sp.	
Bidens bipinnata	
Conyza bonariensis	
Cosmos bipinnatus	
Datura stramonium*	
Dipcadi sp.	
Gomphrena celosioides	
*Helichrysum nudifolium**	
Hermannia depressa	
*Hypoxis hemerocallidea**	
Nidorella hottentotica	
Persicaria decipiens	
Persicaria lapathifolia	
Senecio inornatus	
Tagetes minuta	
*Typha capensis**	
Verbena bonariensis	1b
Wahlenbergia undulata	

Alien species indicated in bold; Medicinal species indicated with (*)

Figure 7 (a, b) *Setaria - Typha* Drainage Line with several alien species invading the area (a). A power line also occurs on the study unit (b).

6.2. Red and Orange List species

22 Red and Orange List species occur within the QDS 2628AC and 2628AD. One Orange List species i.e. *Hypoxis hemerocallidea* is situated within the study site. No Orange- or Red List plant taxa occur on the study site or within 5km from the study site (Pfab, 2002; Pfab and Victor, 2002). Red Listed plants known to occur within the Klipriver Highveld Grassland vegetation unit includes *Cineraria longipes, Delosperma purpureum,* and *Delosperma leendertziae*. However, this site has no suitable habitats for any of these species. See Annexure A for a list of the Red and Orange List species known to occur in the respective QDS, conservation status and their flowering periods.

7. Findings and potential implications

The study units i.e. Moist *Themeda - Eragrostis* Grassland, Disturbed *Verbena - Eragrostis* Pan and *Setaria - Typha* Drainage Line are considered sensitive and should be excluded from development (Figure 8).

The Transformed *Eucalyptus - Hyparrhenia* Grassland is highly disturbed and degraded with numerous exotic plant species dominating the area and is therefore not considered ecologically sensitive. The Disturbed *Eragrostis - Hyparrhenia* Grassland has a moderate ecological importance due to its moderately high species richness (Table 1) and the occurrence of the Orange List species *Hypoxis hemerocallidea*. The Orange list species *Hypoxis hemerocallidea* was found in abundance and a rescue plan should be implemented to ensure the survival of this species.

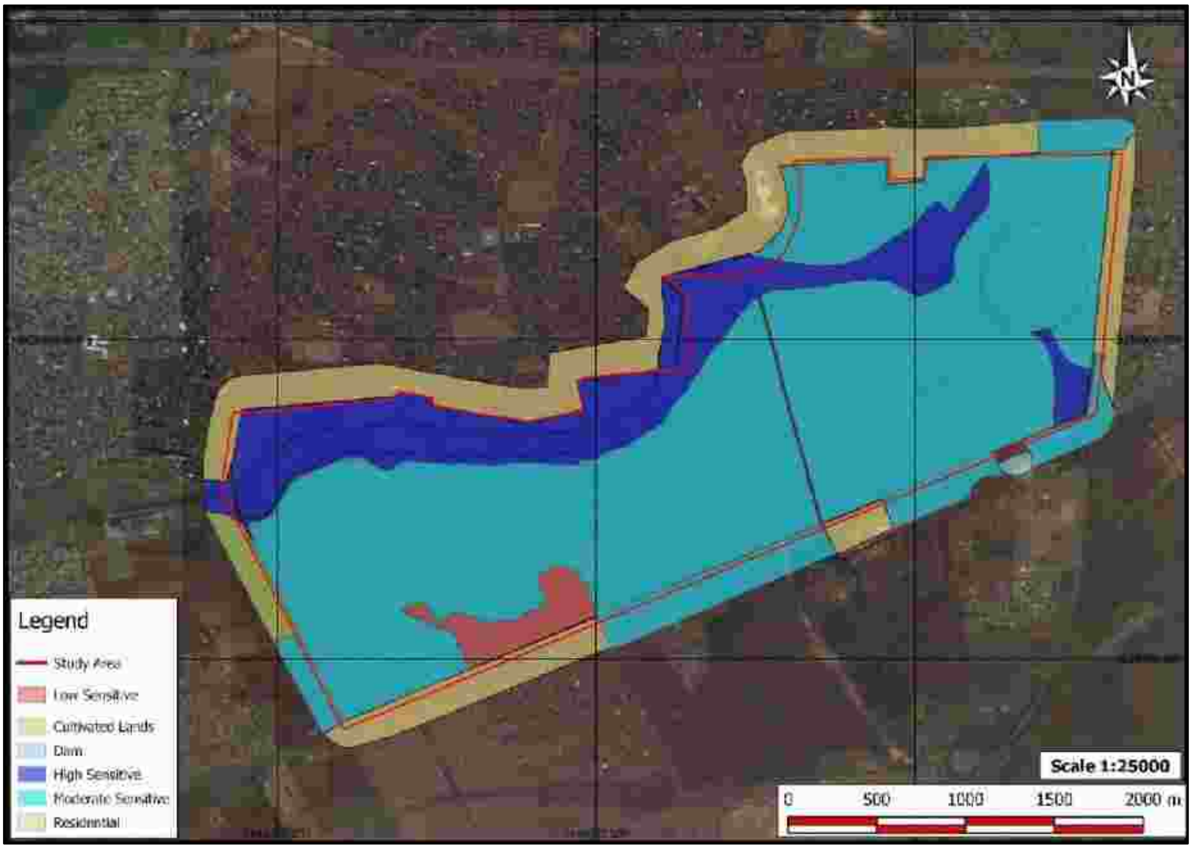


Figure 8 Sensitivity Map of the study site.

8. Discussion, recommendations and mitigation implications

Competent and appropriate management authority should be appointed to implement the Ecological Management Plan (EMP) and Environmental Impact Assessment (EIA) conditions throughout all phases of development, including the operational phase. The EMP should comply with the *Minimum Requirements for Ecological Management Plans* according to GDARD. The EMP and EIA should take into account all recommendations and mitigation measures as outlined by all Flora assessments conducted for the EIA process. The following recommendations and mitigation measures are proposed:

- The attached sensitivity map should be used as a decision tool to guide the layout design.
- All areas designated as sensitive in the attached sensitivity map should be incorporated into an open space system. Development should be located on the areas of lowest sensitivity.

- Development structures should be clustered as close as possible to existing development.
- The open space system should be managed in accordance with the EMP that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- Before construction is initiated, the open space system should be fenced-off from ecologically sensitive areas, and all construction-related impacts must be contained within the fenced-off development areas. These areas should be demarcated on site layout plans. All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. An overspill of construction activities into areas outside of the study area is permitted within designated non-sensitive areas. No personnel or vehicles may be permitted in ecologically sensitive areas except for those authorised to do so. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
- A pre- and post-construction exotic and invasive control, monitoring and eradication programme must be implemented along with an on-going programme to ensure persistence of indigenous species. A qualified botanist/ecologist should compile and supervise the implementation of this programme.
- Construction activities at or close to wetlands, drainage lines and water bodies should be limited. The drainage line area should maintain a 100 m buffer from the edge of the riparian vegetation.
- Engineering measures are recommended to lower the risk of spillages into any wetlands located within 200m of the proposed development.
- A plan for the immediate rehabilitation of damage caused to wetlands should be compiled by a specialist registered in accordance with the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science. This rehabilitation plan should form part of the EMP and a record book should be maintained on site to monitor and report on the implementation of the plan.
- Rehabilitation of natural vegetation should proceed in accordance with a rehabilitation plan compiled by a specialist registered in terms of the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science.
- Where active rehabilitation or restoration is mandatory, it should make use of indigenous plant species native to the study area. The species selected should strive to represent habitat types typical of the ecological landscape prior to construction. As

far as possible, indigenous plants naturally growing within the vicinity of the study area, but would otherwise be destroyed during construction, should be used for re-vegetation/landscaping purposes.

- To ensure the persistence of populations and reduce mortality of individuals of all Red and Orange List species should be included in a monitoring programme. A qualified botanist/ecologist should compile and supervise the implementation of this programme.
- Information boards should be erected within the development to inform residents of the presence of Red and/or Orange List species, their identification, conservation status and importance, biology, habitat requirements and management requirements.
- It is strongly prohibited for Red List species to be relocated, but should be protected *in situ*. This means that if any Red List species is recorded at a site, the relevant buffers should be applied and no construction may take place within this area.
- Only plant species that are indigenous to the natural vegetation of the study area should be used for landscaping in communal areas, such as *Hypoxis hemerocallidea*. As far as possible, plants naturally growing on the development site, but would otherwise be destroyed during clearing for development purposes, should be incorporated into landscaped areas. Forage and host plants required by pollinators should also be planted in landscaped areas.
- In order to minimize artificially generated surface storm-water runoff, total sealing of paved areas such as parking lots, driveways, pavements and walkways should be avoided. Permeable material should rather be utilized for these purposes.
- Competent hydrologist needs to delineate the two wetland pan areas and construct the necessary buffer zones around the water bodies.

9. Conclusions

It is recommended that sensitive areas identified be excluded from construction for the proposed development, especially the Moist *Themeda - Eragrostis* Grassland and *Setaria - Typha* Drainage Line. The relevant buffer zones should be applied to the water bodies by the specialist that should be considered part of the sensitivity map. Dumping of builders' rubble and other waste must be prevented in ecologically sensitive areas, such as the Moist *Themeda - Eragrostis* Grassland and *Setaria - Typha* Drainage Line. These areas should be properly managed throughout the lifespan of the project to ensure continuous biodiversity. The disturbed, exotic vegetation areas within the Disturbed *Eragrostis - Hyparrhenia* Grassland and Transformed *Eucalyptus - Hyparrhenia* Grassland can be used for storage of building materials during the development phase. All exotic species, especially in Category 1 and 2 must be eradicated as a matter of urgency to preclude their spreading during the construction phase.

10. Literature sources

Bromilow, C. 2010. *Problem plants of South Africa*. Briza Publications, Pretoria.

Department of environmental affairs. 2014. National environmental management: Biodiversity Act 2004 (ACT NO, 10 OF 2004) Alien and invasive species lists. www.gpwonline.co.za.

GDARD. 2012. Red List Plant Species Guidelines. Compiled 26 June 2006 with minor edits in January 2012. Obtained from Lorraine Mills (Lorraine.Mills@gauteng.gov.za).

GDARD. 2014. Requirements for Biodiversity Assessments version 3. Gauteng Department of Agriculture and Rural Development: Biodiversity Management Directorate. 24 pages.

GDARD. 2014. Technical report for the Gauteng Conservation Plan (Gauteng C-Plan v3.3). Gauteng Department of Agriculture and Rural Development: Nature Conservation Directorate. 60 pages.

Germishuizen, G. and Meyer, N.L. 2003. Plants of southern Africa: an annotated checklist. Strelitzia 14, National Botanical Institute, Pretoria.

Government Gazette no. 34809. 9 December 2011. 1002 National Environmental Management: Biodiversity Act (1 0/2004): National list of ecosystems that are threatened and in need of protection. http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/10/20111209-National-Gazette-No-34809-of-09-December-2011-Volume-558.pdf.

Government Gazette no. 37885. 1 August 2014. R. 598 National Environmental Management: Biodiversity Act (10/2004): Alien and Invasive Species Regulations. www.gpwonline.co.za.

Henderson, L. 2001. *Alien weeds and invasive plants*. Plant Protection Research Institute, Agricultural Research Council, Pretoria.

Henderson, L. 2007. Invasive, naturalized and casual alien plants in southern Africa: a summary based on the Southern African Plant Invaders Atlas (SAPIA). *Bothalia*, **37**(2): 215–248.

IUCN. 2015. IUCN Red List Categories. Prepared by the IUCN Species Survival Commission. Gland, Switzerland.

Koekemoer, M., Steyn, H.M. and Bester, S.P. 2014. Guide to Plant Families of southern Africa. Strelitzia 31. South African National Biodiversity Institute, Pretoria.

Mucina, L. and Rutherford, M.C. 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Pfab, M.F. 2002. Priority ranking scheme for Red Data plants in Gauteng, South Africa. *South African Journal of Botany* **68**: 299-303.

Pfab, M.F. and Victor, J.E. 2002. Threatened plants of Gauteng, South Africa*. South African Journal of Botany* **68**: 370-375.

Pfab, M.F. 2014. *GDARD Requirements for Biodiversity Assessments*. Version 3. Gauteng Department of Agriculture and Rural Development: Nature Conservation Directorate.

Pooley, E. 1998. *A field to the wild flowers of Kwazulu-Natal and the eastern region*. Natal Flora Publications Trust, Durban.

Raimondo, D., Van Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. and Manyama, P.A. 2009. *Red Data List of South African Plants*. Strelitzia 25, South African National Biodiversity Institute, Pretoria.

South African National Biodiversity Institute (SANBI). Threatened terrestrial ecosystems for South Africa (2011): Available from Biodiversity GIS website (http://bgis.sanbi.org/ecosystems/showecosystem.asp?CODE=Gm%2010), accessed on 16 March 2016.

van Ginkel, C.E., Glen, R.P., Gordon-Gray, K.D., Cilliers, C.J., Muasya, M., and van Deventer, P.P. 2011. Easy identification of some South African Wetland Plants (Grasses, Restios, Sedges, Rushes, Bulrushes, Eriocaulons and Yellow-eyed grasses). WRC Report No TT 479/10. ISBN: 978-1-4312-0066-5.

van Oudtshoorn, F. 2014. *Guide to grasses of southern Africa*. Briza Publications, Pretoria.

van Wyk, B. and Malan, S. 1998. *Field guide to the wildflowers of the Highveld*. Struik Publishers, Cape Town.

van Wyk, B. and van Wyk, P. 2013. *Field guide to trees of southern Africa*. Struik Publishers, Cape Town.

van Wyk, B-E., Van Oudtshoorn, B., and Gericke, N. 2013. *Medicinal plants of South Africa*. Briza Publications, Pretoria.

The following information is to remain confidential and is not meant for the general public. Please do not distribute under any circumstances without the permission from GDARD.

Annexure A: Red Data Flora (confidential)

The following Red Data floral species are listed for the QDS 2628AC and 2628AD. An indication is also provided if the species was recorded on site.

SPECIES	FLOWERING SEASON	SUITABLE HABITAT	CRITERIA	CATAGORY ([1]global status; [2]national status)	OBSERVED
Adromischus umbraticola subsp. *umbraticola*	September-January	Rock crevices on rocky ridges, usually south-facing, or in shallow gravel on top of rocks, but often in shade of other vegetation.	A2	Near Threatened[1]	NO
Argyrolobium campicola	November-February	Highveld grassland.	A3	Near Threatened[1]	NO
Bowiea volubilis subsp. *volubilis*	September-April	Shady places, steep rocky slopes and in open woodland, under large boulders in bush or low forest.	B	Vulnerable[2]	NO
Cineraria longipes	March-May	Grassland, on koppies, amongst rocks and along seepage lines, exclusively on basalt on south-facing slopes.	A1	Vulnerable[1]	NO
Delosperma leendertziae	October-April	Rocky ridges; on rather steep south facing slopes of quartzite in mountain grassveld.	A2	Near Threatened[1]	NO
Delosperma purpureum	November-April	South facing slopes, grows in shallow soils among quartzitic rocks of crystalline or conglomerate type, in open or in broken shade, rarely in shade, in grassland with some trees.	A1	Endangered[1]	NO

Dioscorea sylvatica	October-January	Wooded places with fair to reasonably good rainfall, such as the moister bushveld areas, coastal bush and wooded mountain kloofs.	B	Vulnerable[2]	NO
Eucomis autumnalis	November-April	Damp, open grassland and sheltered places.	N/A	Declining[2]	NO
Eulophia coddii	Early December	Steep hillsides on soil derived from sandstone, grassland or mixed bush.	A2	Vulnerable[1]	NO
Gnaphalium nelsonii	October-December	Seasonally wet grasslands.	A2	Rare[1]	NO
Gunnera perpensa	October-March	In cold or cool, continually moist localities, mainly along upland streambanks.	N/A	Declining[2]	NO
Habenaria barbertoni	February-March	In grassland on rocky hillsides.	A2	Near Threatened[1]	NO
Habenaria bicolor	January-April	Well-drained grasslands at around 1600m.	B	Near Threatened[2]	NO
Habenaria kraenzliniana	February-April	Terrestrial in stony, grassy hillsides, recorded from 1000 to 1400m.	A3	Near Threatened[1]	NO
Habenaria mossii	March-April	Open grassland on dolomite or in black sandy soil.	A1	Endangered[1]	NO
Holothrix micrantha	October	Terrestrial on grassy cliffs, recorded from 1500 to 1800m.	A1	Endangered[1]	NO
Holothrix randii	September-October	Grassy slopes and rock ledges, usually southern aspects.	B	Near Threatened[2]	NO
Hypoxis hemerocallidea	September-March	Occurs in a wide range of habitats, from sandy hills on the margins of dune forests to open rocky grassland; also grows	N/A	Declining[2]	NO

		on dry, stony, grassy slopes, mountain slopes and plateaux; appears to be drought and fire tolerant.			
Ilex mitis var. *mitis*	October-December	Riverbanks, streambeds, evergreen forests.	N/A	Declining[2]	NO
Khadia beswickii	July-April	Open areas on shallow surfaces over rocks in grassland.	A1	Vulnerable1	NO
Kniphofia typhoides	February-March	Low-lying wetlands and seasonally wet areas in climax Themeda triandra grasslands on heavy black clay soils, tends to disappear from degraded grasslands.	A3	Near Threatened[1]	NO
Lithops lesliei subsp. *lesliei*	March-June	Primary habitat appears to be the arid grasslands in the interior of South Africa where it usually occurs in rocky places, growing under the protection of surrounding forbs and grasses.	B	Near Threatened[2]	NO
Melolobium subspicatum	September-May	Grassland.	A1	Vulnerable[1]	NO
Stenostelma umbelluliferum	September-March	Deep black turf in open woodland mainly in the vicinity of drainage lines.	A3	Near Threatened[1]	NO

ANNEXURE D4c
AVI-FAUNA ASSESSMENT

AVIFAUNAL ASSESSMENT OF THE SOUTHERN PART OF THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113 IR

Landscape Architects &

Environmental Consultants: Specialist Division

T: (+27)12 346 3810 l F: (+27) 86 570 5659 l E: cw@bokamoso.net; l www.bokamoso.net.

36 Lebombo Street, Ashlea Gardens, Pretoria l P.O. Box 11375 Maroelana 0161

Report author: Mr C.W. Vermeulen (BSc Zoology)
Report Reviewed by: Lukas Niemand (MSc Zoology: Pr. Sci.)

PACHNODA
CONSULTING

88 Rubida Street
Murrayfield X1
Pretoria

P.O. Box 72847
Lynwood Ridge
Pretoria
0040

Tel: 012 365 2546
Cell: 083 978 0817
Fax: 012 365 3217
E-mail: lukas@pachnoda.co.za

CK 2007/043724/23
VAT No. 4690249976

18 July 2016

To whom it may concern,

REVIEW OF SPECIALIST AVIFAUNAL ASSESSMENT:

AVIFAUNA ASSESSMENT OF AVIFAUNAL ASSESSMENT OF THE SOUTHERN PART OF THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113 IR

I, Lukas Jurie Niemand, member and principal consultant of Pachnoda Consulting and registered professional scientist in the fields of Zoological and Ecological sciences, evaluated the avifaunal (bird) component of the abovementioned specialist assessment compiled by Mr CW Vermeulen of Bokamoso. The report was evaluated in accordance with the Gauteng Directorate of Nature Conservation (GDARD) Requirements for Biodiversity Assessments Version 3 and in terms of general content and avifaunal conservation.

In general, criticism lodged against avifaunal/ecological studies include: poor use of relevant scientific literature, lack of, or poor field surveys and associated data collection, poor use of regional information datasets, general poor knowledge of subject, failure to describe limitations or constraints on survey methodology, insufficient or inadequate data, vague generalisations with no indication of the relative importance of a particular component. With regards to the above criticism, none of it is relevant to the avifaunal assessment of the aforementioned report.

88 Rubida Street
Murrayfield X1
Pretoria

P.O. Box 72847
Lynwood Ridge
Pretoria
0040

Tel: 012 365 2546
Cell: 083 978 0817
Fax: 012 365 3217
E-mail: lukas@pachnoda.co.za

CK 2007/043724/23
VAT No. 4690249976

It is concluded that the report comply with the general provincial requirements, and the content as discussed in the report is relevant and concise.

Lukas Niemand
MSc Zoology - UP; Pr. Sci. Nat. Reg. no. 400095/06)
Pachnoda Consulting

Table of Contents

Figures

Tables

Specialist

Specialist investigator: Mr. C.W. Vermeulen (B.Sc. Biological and Environmental Science)

<u>Declaration of independence</u>:

I, the above mentioned specialist investigator responsible for conducting this particular specialist Avifauna study, declare that:

- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favorable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part;
- I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse the proposed development, but aim to present facts, findings and recommendations based on relevant professional experience, and scientific data;
- I do not have any influence over decisions made by the governing authorities;
- I have the necessary qualifications and guidance from professional experts (registered Pr. Nat. Sci.) in conducting specialist reports relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- This document and all information contained herein are and will remain the intellectual property of Bokamoso Environmental: Specialist Division. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the respective specialist investigator.

CW Vermeulen

1. Introduction

Bokamoso Environmental Consultants CC; Specialist Division was appointed to conduct an Avifaunal Assessment for the proposed Mixed Use development on the southern part of the remainder of the Farm Leeuwpoort 113-IR.

This report is based on the avifaunal species present on the study area as well as species that could potentially occur. The report primarily focuses on species with conservation concerns (**NT** = Near Threatened, **VU** = Vulnerable, **EN** = Endangered, **CR** = Critically Endangered) and other species with conservation importance occurring on or near the study area to ensure that, should any such species exists, the appropriate actions are taken to guarantee the well-being of these species. Furthermore, the ecological integrity and possible presents of sensitive habitats were investigated.

2. Scope of the study

- To identify the dominant bird species present on the study area.
- To identify all the distinct avifaunal habitats on the study area.
- To compare the species occurring in and around the study area with all the species that has been recorded in that area in recent history.
- To identify ecologically sensitive areas in terms of species occurrence and/ or habitat.
- To provide lists of all the bird species occurring on the study area as well as species possibly occurring in the area as a result of habitat preferences and previous records.
- To provide a list of species with conservation importance.
- To provide recommendations in the form of mitigation of negative impacts, should the development be approved.

3. Study Area

The study area is situated on the southern section of the remaining extent of the Farm Leeuwpoort 113 IR just south of the N17 highway towards the north of the R554 road (26˚16'15.71"S; 28˚16'08.22"E) (**Figure 1**). The size of the property is approximately 733 ha and is located within the 2628AC and 2628AD quarter degree squares (QDS) and within the 2615_2810 and 2615_2815 pentads (a pentad is a 5 minute x 5 minute coordinate grid super-imposed over the continent for spatial reference, one QDS comprises of 9 pentads) (SABAP2). The study area consists of three main habitats units namely; Grassland, Wetland vegetation and Degraded Pans. The property largely consists of grassland with a large wetland vegetation habitat unit situated on the north-western side of the study area. The entire grassland habitat unit was previously utilized as agricultural lands. The property is located approximately 1590 meters above sea level and slopes gradually to the west. The study area falls within the

Carletonville Dolomite Grassland and Tsakane Clay Grassland vegetation units (Mucina and Rutherford, 2006) as well as within the Klipriver Highveld Grassland (GP5; SANBI, 2011).

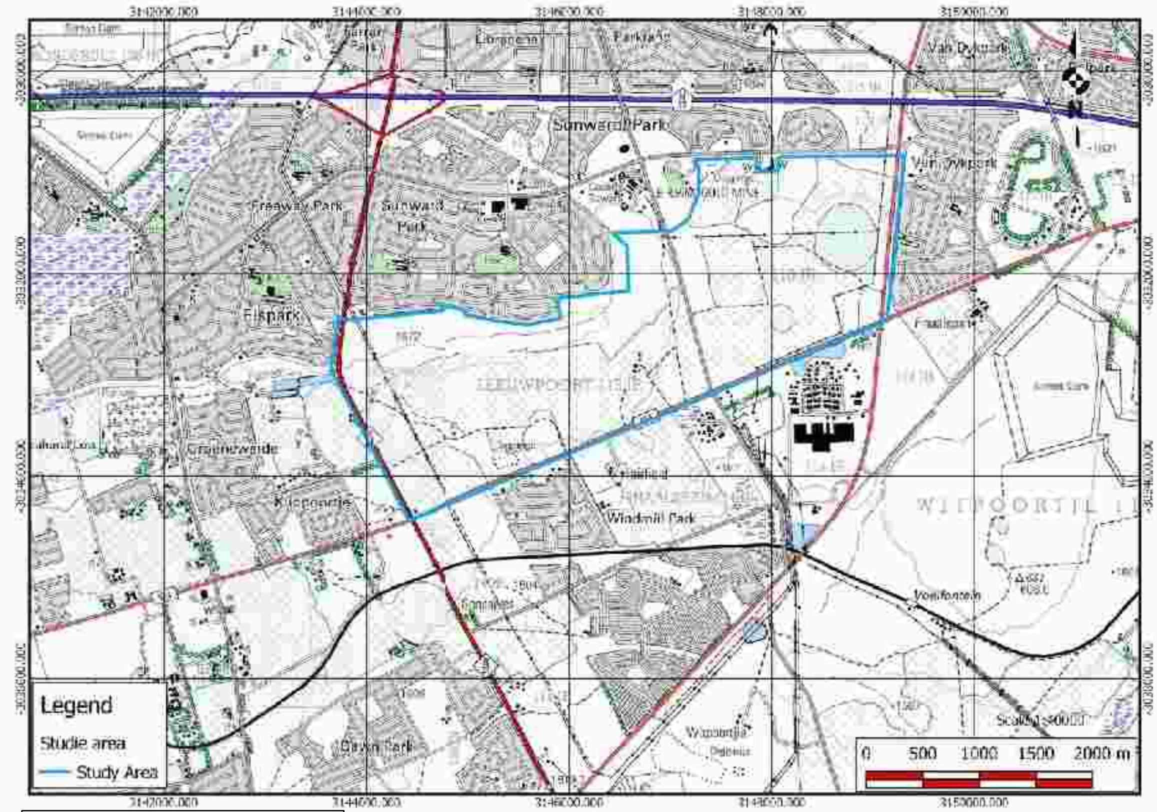


Figure 1: Locality Map

A locality map showing all the surrounding roads and open space within the surrounding area.

4. Methods

4.1 Field Survey

Two field surveys were conducted on the 23rd and 24th of March 2016. A total of 6 hours were spent on the study area whilst conducting the field survey. Before conducting the field survey, a desktop assessment was conducted to document the prevalent avifaunal species occurring on or near the study area. A list of expected species were compiled and used as a reference guide during the field survey to ensure that bird species that should theoretically occur within the study area were not overlooked. All discrete avifaunal habitats were identified on site, after which each habitat was assessed to document the associated avifaunal species by means of random transect walks. Species were identified by actual sightings, calls as well as signs of presence in the form of eggshells, nests, droppings and feathers (Chris & Tilde Stuart., 2000). Where necessary, species were verified using Sasol Birds of Southern Africa (Sinclair *et al*., 2011).

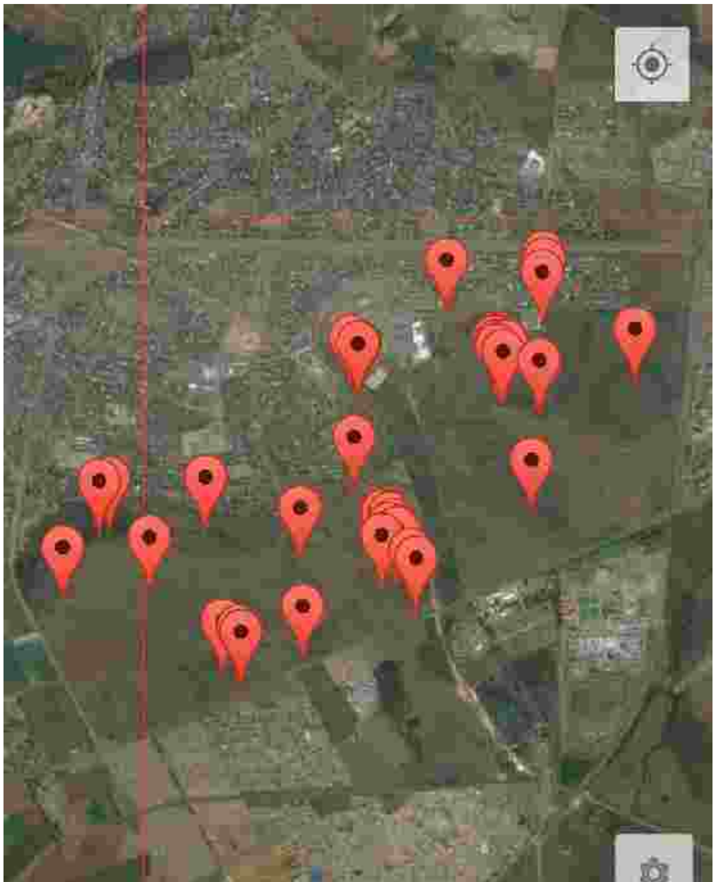


Figure 2: GPS waypoints for each bird species recorded

The geographical position of each bird species recorded within the study area, thereby illustrating the relative density of birds in the area. These observed species are colour coded and listed in **Table 1** (Recorded on site – 5)

4.2 Species occurrence

By consulting Southern Africa Bird Atlas Project 1 and 2 (SABAP2), a comprehensive species list could be compiled for the 2628AC and 2628AD QDS's and the 2615_2810 and 2615_2815 pentads. SABAP2 is the follow-up project to the Southern African Bird Atlas Project (referred to as SABAP1). This first bird atlas project took place from 1987-1991. The second bird atlas project started on 1 July 2007 and plans to run indefinitely. The project aims to map the distribution and relative abundance of birds in Southern Africa. The field work for this project is done by more than one thousand nine hundred volunteers, known as citizen scientists. The unit of data collection is the pentad, five minutes of latitude by five minutes of longitude, squares with sides of roughly 9 km.

The species list for the QDS's can however not be used as an accurate list in terms of the species actually occurring within the study area since it covers a larger area, as well as a larger variety of habitats. In order to compile an accurate species list for the study area, all the species previously recorded in the 2628AC and 2628AD QDS's were considered, and added or eliminated based on the habitats present on the study area as well as the habitat preferences of individual species.

4.3 Threatened and near threatened bird species

By consulting the SABAP2 database, all the threatened and near threatened bird species previously recorded within the 2628AD QDS were added to the expected list of species that could potentially occur on or near the study area. All the threatened species previously recorded on or near the study area were reviewed (Roberts VII, Hockey et al. 2005; Taylor et al., 2015) before conducting the field survey. During the field survey special attention was paid to identify any signs such as; actual sightings, suitable habitat, nest sites, suitable hunting/foraging habitat or roosting spots indicating the presence of these species.
A list was compiled to indicate the presence and/or occurrence probability of bird species with conservation concerns based on the above mentioned indicators (**Table 2**).

4.4 Specific Requirements in terms of Red Data Avifaunal species

According to the Gauteng Department of Agriculture and Rural Development's (GDARD) requirements for Biodiversity Assessments, Version 3.3 (March 2014), as well as for any other Red Data species: Eleven threatened and near threatened bird species were prioritized for inclusion into the Gauteng C-Plan based on:

1. Threat status (2 Endangered **(EN),** 5 Vulnerable (**VU**) and 4 Near Threatened (**NT**)).
2. Whether the species was actually present, on a frequent basis, in the province. Vagrants, erratic visitors or erratic migrants to the province (Tarboton et al., 1987) have been excluded from the conservation plan.
3. Whether the threat was due to issues related to land use planning. Species which are impacted on mostly by threats such as poisoning were excluded.

Important Threatened and Near Threatened Bird species regional conservation status (Taylor et al., 2015):

- Half-Collared Kingfisher (*Alcedo semitorquata*) **NT**
- Blue Crane (*Anthropoides paradiseus*) **NT**

- African Marsh-Harrier (*Circus ranivorus*) **EN**
- White-bellied Korhaan (*Eupodotis senegalensis)* **VU**
- White-backed Night-Heron (*Gorsachius leuconotus*) **VU**
- Cape Vulture (*Gyps coprotheres*) **EN**
- African Finfoot (*Podica senegalensis*) **VU**
- Secretarybird (*Sagittarius serpentarius*) **VU**
- African Grass-Owl (*Tyto capensis*) **VU**
- Abdims Stork (*Ciconia abdimii)* **NT**
- Black-winged Pratincole (*Glareola nordmanni)* **NT**

5. Results

5.1 Avifaunal Habitat Assessment:

Three discrete avifaunal habitat types were identified within the study area. These habitat units include: Wetland vegetation, Grassland and Degraded Pans. (**Figure 3**). All the habitats identified on the study area are individually discussed hereafter.

Figure 3: Habitats Identified

5.1.1 Degraded Pans:

Two natural pans are situated on the south-eastern section of the study area. Both pans are severely degraded due to alien vegetation encroachment, mainly by *Bidens bipinnata, Cosmos bipinnatus and Verbena sp.* During high rainfall events both pans hold water and create seasonal wetlands. During this time large numbers of widespread bird species such as Swallows, Swifts, Yellow-billed Ducks (*Anas undulata*), White-face Ducks *(Dendrocygna viduata)*, Ralids, Herons, Bishops and Widowbirds can be expected to be present within the habitat unit. The degraded status of this area can mainly be attributed to alien vegetation encroachment and grass and other vegetation harvesting (**Figure 4**). Both pans contain minimal grass cover as most of the habitat has been entirely over grown by alien weeds. Although both pans show high alien vegetation encroachment they do however still provide suitable breeding habitat for the regionally Vulnerable African Grass-owl. It is however important to note that the pans do not provide the optimal breeding habitat for African Grass-owls although previous records show that they do occasionally breed in grassland patches were dense alien vegetation forming suitable coverage is present. On account of the aforementioned disturbances and the overall degraded nature of this study unit the probability of threatened or near threatened bird species occurrence was judged to be low. However, during high rainfall events both pans are expected to support wetland associated avifauna, and in addition possibly providing suitable breeding habitat for the regionally threatened African Grass-owl. As such this habitat unit can potentially be identified with a medium avifaunal sensitivity, however should any signs of African Grass-owl presence be noted in future within this habitat unit it must be regarded as highly sensitive.

Figure 4: Disturbed Pan

5.1.2 Wetland Vegetation:

The wetland vegetation habitat unit is situated along the north-western section of the study area with one small artificial wetland (due to a sewerage leak) to the east. The total surface area of the wetland vegetation study unit is approximately 100 ha. This habitat unit is dominated by palustrine vegetation such as *Phragmites australis, Imperata cylindrical*, *Cypress spp., Schoenoplectus spp*. *Setaria incrassata, Paspalum* species, *Persicaria* species, *Verbena bonariensis* and *Typha capensis* as well as other wetland associated vegetation (**Figure 5**). The wetland vegetation habitat provides the preferred habitat for large number of bird species including Ralids, Herons, Bishops, Cormorants, Warblers and Weavers. The wetland vegetation habitat unit does not contain any open water stands, as such the occurrence probability of ducks and other open water species is low. This habitat unit remains largely undisturbed with the only disturbance being alien vegetation encroachment. The habitat unit is highly isolated from surrounding homogeneous habitat as a result of urban development, infrastructure such as roads and other anthropogenic disturbances in the surrounding urban area. Although the wetland vegetation study unit provides the preferred habitat for two threatened bird species previously recorded within the 2628AD QDS namely, African Marsh-harrier (*Circus ranivorus*) and African Grass-owl (*Tyto capensis*), their occurrence probability is low on account of the highly isolated nature of the study area.

During the field survey a single nesting Marsh Owl was recorded. Two threatened bird species (African Grass-owl (*Tyto capensis*) and African Marsh Harrier (*Circus ranivorus*)) prefer similar breeding and foraging habitats to the Marsh Owl (*Asio capensis*). The fact that an actively breeding Marsh Owl was observed during the field survey increases the possible occurrence of the aforementioned threatened species. A thorough desktop survey was conducted during which all previous records (since 2007) of African Grass-owl and African Marsh-harrier within a 10km radius of the study area was assessed. Only one African Grass-owl (in 2007) has been recorded within a 10km radius of the study area with one African Marsh-harrier (in 2014) record in the surrounding 10 km in the past 10 years. The fact that neither of the aforementioned threatened species have been recorded in the surrounding area within the past 10 years is most likely due to the highly isolated nature of the study area.

On account of previous records and the isolated nature of the wetland vegetation habitat unit the occurrence probability of both the African Grass-owl and African Marsh-harrier was judged to be unlikely even though the habitat within the study are can be considered as the optimal habitat for both of these species.

Due to the undisturbed nature, high species diversity and the optimal habitat this study unit provides for wetland associated and threatened avifauna, this study unit was judged to be highly sensitive as an avifaunal habitat.

Figure 5: Wetland Vegetation with Marsh Owl in the foreground.

5.1.3 Grassland:

The entire grassland habitat was previously utilized as agricultural lands. The Grassland habitat contains mostly grass and forb vegetation (**Figure 6)** and is dominated by *Aristida* species*, Cynodon dactylon, Eragrostis species, Heteropogon contortus, Hyparrhenia hirta, Setaria species, Themeda triandra* and *Urochloa panicoides* grass species. Several dominant forb species include *Cucumis zeyheri, Datura stramonium, Hermannia depressa, Hilliardiella oligocephala, Ledebouria* species and *Verbena species.* A number of alien vegetation species are also present within the grassland habitat unit including *Paspalum dilatatum, Bidens formosa, Bidens pilosa, Bidens bipinnata, Tagetes minuta, Verbena* species and *Campuloclinium macrocephalum.* Vast sections of the grassland habitat have been completely transformed due to alien vegetation encroachment (**Figure 7**). Grassland habitats generally have low to medium avifaunal species richness as a result of the highly specialised environment. A number of widespread bird species such as Bishops, Sparrows, Doves, Lapwings, Swallows, Cisticolas and Widowbirds were present within the grassland habitat. Connectivity with surrounding homogenous habitats is low as a result of various developments, both residential and industrial in the surrounding area. A number of disturbances such as, grass harvesting, dirt-roads, trampling, illegal rubbish dumping and alien vegetation encroachment were also noted within this habitat unit. Although the grassland habitat unit includes disturbed areas, the largest part of this study unit is dominated by natural indigenous grassland. The grassland habitat forms part of Marsh-owl foraging habitat and will could thus be utelised similarly should African Grass-owls and/or African Marsh-harriers be present.

If the absence of African Grass-owls and/or African Marsh-harrier can be confirmed, the grassland habitat unit can be identified with a low avifaunal sensitivity on account of the aforementioned low connectivity and ongoing disturbances within the habitat unit.

If either African Grass-owls or African Marsh-harriers are found to be present within the larger study area, 300ha of optimal foraging habitat within the grassland habitat unit should be identified and regarded as highly sensitive.

Figure 6: Grassland habitat unit

Figure 7: Alien vegetation encroachment within the Grassland

Table 1: Bird species observed within the study area during the field survey, as well as bird species potentially occurring on the study area as a result of habitat preferences and previous records.

The biodiversity index below indicates the probability of a species breeding (BR) within the study area as well as the occurrence probability of a species within the study area according to its specific habitat preferences (HP). Very Low – 1, Low – 2, Medium – 3, High – 4, Recorded on site – 5, Not likely to occur/breed – 0, Threatened Species

	Species name	***Taxonomic name***	Rep Rate (%)	HP	BR
1.	Avocet, Pied	*Recurvirostra avosetta*	19.57	2	2
2.	Barbet, Black-collared	*Lybius torquatus*	25.88	3	3
3.	Barbet, Crested	*Trachyphonus vaillantii*	50.75	5	4
4.	Bishop, Southern Red	*Euplectes orix*	73.40	5	5

5.	Bishop, Yellow-crowned	*Euplectes afer*	31.14	5	4
6.	Bittern, Little	*Ixobrychus minutus*	1.95	3	3
7.	Bokmakierie	*Telophorus zeylonus*	29.28	2	2
8.	Bulbul, Dark-capped	*Pycnonotus tricolor*	49.75	5	4
9.	Canary, Black-throated	*Crithagra atrogularis*	23.77	5	4
10.	Canary, Yellow	*Crithagra flaviventris*	3.75	2	2
11.	Chat, Anteating	*Myrmecocichla formicivora*	6.04	3	3
12.	Chat, Familiar	*Cercomela familiaris*	4.78	3	3
13.	Cisticola, Cloud	*Cisticola textrix*	9.40	3	3
14.	Cisticola, Desert	*Cisticola aridulus*	9.40	5	4
15.	Cisticola, Levaillant's	*Cisticola tinniens*	54.61	5	4
16.	Cisticola, Zitting	*Cisticola juncidis*	31.49	5	4
17.	Cliff-swallow, South African	*Hirundo spilodera*	6.46	3	2
18.	Coot, Red-knobbed	*Fulica cristata*	80.89	3	3
19.	Cormorant, Reed	*Phalacrocorax africanus*	55.90	5	1
20.	Coucal, Burchell's	*Centropus burchellii*	2.18	3	3
21.	Crake, Black	*Amaurornis flavirostris*	18.69	4	4
22.	Crow, Pied	*Corvus albus*	14.75	5	3
23.	Cuckoo, Diderick	*Chrysococcyx caprius*	14.07	4	4
24.	Darter, African	*Anhinga rufa*	26.63	4	1
25.	Dove, Laughing	*Streptopelia senegalensis*	93.74	5	5
26.	Dove, Red-eyed	*Streptopelia semitorquata*	60.18	5	5
27.	Dove, Rock	*Columba livia*	49.67	5	2
28.	Duck, White-faced	*Dendrocygna viduata*	21.10	5	4
29.	Duck, Yellow-billed	*Anas undulata*	35.16	5	5
30.	Egret, Cattle	*Bubulcus ibis*	62.25	5	1
31.	Egret, Little	*Egretta garzetta*	10.13	3	1
32.	Falcon, Amur	*Falco amurensis*	10.01	5	0
33.	Falcon, Red-footed	*Falco vespertinus*	0.12	1	0
34.	Finch, Red-headed	*Amadina erythrocephala*	29.65	4	3
35.	Fiscal, Common (Southern)	*Lanius collaris*	93.39	5	4
36.	Flufftail, Red-chested	*Sarothrura rufa*	0.58	5	4
37.	Flycatcher, Fiscal	*Sigelus silens*	17.08	4	3
38.	Go-away-bird, Grey	*Corythaixoides concolor*	13.72	2	2
39.	Goose, Egyptian	*Alopochen aegyptiacus*	67.21	4	4
40.	Goose, Spur-winged	*Plectropterus gambensis*	18.50	2	2
41.	Grass-owl, African	*Tyto capensis*	0.46	2	2
42.	Grebe, Little	*Tachybaptus ruficollis*	45.67	3	3
43.	Greenshank, Common	*Tringa nebularia*	6.15	2	0
44.	Guineafowl, Helmeted	*Numida meleagris*	52.24	5	5
45.	Gull, Grey-headed	*Larus cirrocephalus*	52.66	5	0

46.	Hamerkop, Hamerkop	*Scopus umbretta*	4.25	3	0
47.	Heron, Black-headed	*Ardea melanocephala*	49.22	5	1
48.	Heron, Grey	*Ardea cinerea*	24.65	4	1
49.	Heron, Purple	*Ardea purpurea*	16.09	3	1
50.	Heron, Squacco	*Ardeola ralloides*	12.99	3	2
51.	Hoopoe, African	*Upupa africana*	35.16	4	3
52.	Ibis, African Sacred	*Threskiornis aethiopicus*	63.47	5	1
53.	Ibis, Glossy	*Plegadis falcinellus*	48.79	5	3
54.	Ibis, Hadeda	*Bostrychia hagedash*	81.05	5	4
55.	Kestrel, Lesser	*Falco naumanni*	0.58	1	0
56.	Kingfisher, Malachite	*Alcedo cristata*	3.21	2	2
57.	Kite, Black-shouldered	*Elanus caeruleus*	84.79	5	3
58.	Lapwing, African Wattled	*Vanellus senegallus*	31.45	4	4
59.	Lapwing, Blacksmith	*Vanellus armatus*	87.09	5	4
60.	Lapwing, Crowned	*Vanellus coronatus*	87.66	5	4
61.	Lark, Red-capped	*Calandrella cinerea*	13.95	3	3
62.	Lark, Rufous-naped	*Mirafra africana*	9.41	4	4
63.	Lark, Spike-heeled	*Chersomanes albofasciata*	7.60	2	2
64.	Longclaw, Cape	*Macronyx capensis*	42.57	5	4
65.	Marsh-harrier, African	*Circus ranivorus*	4.66	1	1
66.	Martin, Banded	*Riparia cincta*	7.14	5	4
67.	Martin, Brown-throated	*Riparia paludicola*	37.29	5	3
68.	Martin, Rock	*Hirundo fuligula*	8.86	4	2
69.	Masked-weaver, Southern	*Ploceus velatus*	89.72	5	5
70.	Moorhen, Common	*Gallinula chloropus*	52.92	3	3
71.	Mousebird, Red-faced	*Urocolius indicus*	43.72	5	3
72.	Mousebird, Speckled	*Colius striatus*	27.21	4	3
73.	Myna, Common	*Acridotheres tristis*	76.08	5	4
74.	Neddicky, Neddicky	*Cisticola fulvicapilla*	7.64	3	3
75.	Night-Heron, Black-crowned	*Nycticorax nycticorax*	7.87	4	1
76.	Owl, Barn	*Tyto alba*	0.35	2	1
77.	Owl, Marsh	*Asio capensis*	20.87	5	5
78.	Palm-swift, African	*Cypsiurus parvus*	27.73	5	0
79.	Pigeon, Speckled	*Columba guinea*	69.93	5	2
80.	Pipit, African	*Anthus cinnamomeus*	30.11	4	4
81.	Plover, Three-banded	*Charadrius tricollaris*	31.45	4	4
82.	Prinia, Black-chested	*Prinia flavicans*	26.40	5	4
83.	Prinia, Tawny-flanked	*Prinia subflava*	16.08	3	3
84.	Quail, Common	*Coturnix coturnix*	1.03	3	3
85.	Quailfinch, African	*Ortygospiza atricollis*	7.49	2	2
86.	Quelea, Red-billed	*Quelea quelea*	13.22	3	2

87.	Rail, African	*Rallus caerulescens*	14.14	4	4
88.	Reed-warbler, African	*Acrocephalus baeticatus*	3.33	4	4
89.	Reed-warbler, Great	*Acrocephalus arundinaceus*	4.09	5	0
90.	Robin-chat, Cape	*Cossypha caffra*	27.55	5	4
91.	Ruff, Ruff	*Philomachus pugnax*	18.27	3	0
92.	Rush-warbler, Little	*Bradypterus baboecala*	6.31	4	4
93.	Sandpiper, Common	*Actitis hypoleucos*	4.82	2	0
94.	Sandpiper, Marsh	*Tringa stagnatilis*	8.91	4	0
95.	Sandpiper, Wood	*Tringa glareola*	14.25	4	0
96.	Shoveler, Cape	*Anas smithii*	21.79	4	3
97.	Snipe, African	*Gallinago nigripennis*	14.83	5	4
98.	Sparrow, Cape	*Passer melanurus*	87.82	5	5
99.	Sparrow, House	*Passer domesticus*	54.84	5	4
100.	Sparrow, Southern Grey-headed	*Passer diffusus*	5.62	4	2
101.	Spoonbill, African	*Platalea alba*	22.02	3	0
102.	Spurfowl, Swainson's	*Pternistis swainsonii*	34.70	3	3
103.	Starling, Cape Glossy	*Lamprotornis nitens*	33.29	5	3
104.	Starling, Pied	*Spreo bicolor*	28.17	2	2
105.	Starling, Wattled	*Creatophora cinerea*	7.95	2	1
106.	Stilt, Black-winged	*Himantopus himantopus*	27.13	4	2
107.	Stint, Little	*Calidris minuta*	10.28	2	0
108.	Stonechat, African	*Saxicola torquatus*	64.34	5	4
109.	Sunbird, Amethyst	*Chalcomitra amethystina*	0.92	3	3
110.	Sunbird, White-bellied	*Cinnyris talatala*	1.49	3	3
111.	Swallow, Barn	*Hirundo rustica*	35.35	5	0
112.	Swallow, Greater Striped	*Hirundo cucullata*	46.39	5	2
113.	Swallow, White-throated	*Hirundo albigularis*	29.57	5	3
114.	Swamp-warbler, Lesser	*Acrocephalus gracilirostris*	34.20	5	4
115.	Swamphen, African Purple	*Porphyrio madagascariensis*	28.85	3	3
116.	Swift, Little	*Apus affinis*	29.43	5	1
117.	Swift, White-rumped	*Apus caffer*	30.26	5	1
118.	Teal, Hottentot	*Anas hottentota*	22.63	3	3
119.	Teal, Red-billed	*Anas erythrorhyncha*	28.40	3	3
120.	Thick-knee, Spotted	*Burhinus capensis*	21.79	4	4
121.	Thrush, Karoo	*Turdus smithi*	49.79	2	2
122.	Turtle-dove, Cape	*Streptopelia capicola*	93.35	5	4
123.	Wagtail, Cape	*Motacilla capensis*	82.58	5	4
124.	Waxbill, Common	*Estrilda astrild*	33.67	5	4
125.	Waxbill, Orange-breasted	*Amandava subflava*	15.36	5	4
126.	Weaver, Cape	*Ploceus capensis*	7.57	3	3
127.	Weaver, Thick-billed	*Amblyospiza albifrons*	2.94	3	3

128.	Wheatear, Capped	*Oenanthe pileata*	29.80	**3**	**2**
129.	White-eye, Cape	*Zosterops virens*	20.10	**3**	**1**
130.	Whydah, Pin-tailed	*Vidua macroura*	30.27	**5**	**4**
131.	Widowbird, Fan-tailed	*Euplectes axillaris*	6.00	**5**	**4**
132.	Widowbird, Long-tailed	*Euplectes progne*	68.71	**5**	**4**
133.	Widowbird, Red-collared	*Euplectes ardens*	2.07	**4**	**4**
134.	Widowbird, White-winged	*Euplectes albonotatus*	7.03	**4**	**4**
Totals			0	**0**	15 (11.19%)
			1	3 (2.24%)	15 (11.19%)
			2	16 (11.94%)	21 (15.67%)
			3	31 (23.13%)	33 (24.63%)
			4	26 (19.4%)	42 (31.34%)
			5	58 (43.28%)	8 (5.97%)
Total Red Data Species			**3**		

The reporting rate is calculated as follows: Total number of cards on which a species was reported (SABAP1) x 100 ÷ total number of cards submitted for the particular grid cell + the total number of cards on which a species was reported (SABAP2) x 100 ÷ total number of cards submitted for the particular pentad ÷ 2.

Of the 134 bird species listed in **Table 1**, 84 species (62.68%) were either confirmed or are highly likely to occur in or around the study area of which Fifty (50) species are likely to breed on or near the study area. Thirty-one (31) of the 134 listed bird species have a medium occurrence probability and eight-teen (18) a low to very low occurrence probability. Two threatened and/or near threatened species, namely Red-footed Falcon (*Falco vespertinus*), African Grass-owl (*Tyto capensis*) and African Marsh-harrier (*Circus ranivorus*) prefer the Wetland Vegetation and Grassland habitat units present within the study area. Although the habitats present within the study area are the preferred habitat for the aforementioned threatened and near threatened bird species their occurrence probability was judge to be low due to a number of factors of which limited connectivity with homogeneous habitats forms the main reason for the unlikeliness of their occurrence.

Seventeen (17) threatened and/or near threatened bird species have previously been recorded within the 2628AC and 2628AD QDS and are listed in **Table 2**.

Table 2: Threatened and near threatened bird species previously recorded within the 2628AD QDS.

Threatened and near threatened bird species previously recorded within the 2628AD QDS according to Taylor *et al.* (2015), Harrison *et al*. (1997), Tarboton *et al*. (1987), SABAP2 (**Table2**).

	Species name	Latest Date Record (Year)	Red Data: (Regional; Global)	Taxonomic name	Rep Rate (%)	HP	Br
1.	Crane, Blue	**Prior to 2007**	**NT, VU**	*Anthropoides paradiseus*	0.92	0	0
2.	Duck, Maccoa	**Prior to 2007**	**NT, NT**	*Oxyura maccoa*	2.41	0	0
3.	Eagle, Verreauxs'	**Prior to 2007**	**VU, LC**	*Aquila verreauxii*	1.15	0	0
4.	Falcon, Red-footed	**Prior to 2007**	**NT,NT**	*Falco vespertinus*	0.12	1	0
5.	Flamingo, Greater	**2013**	**NT, LC**	*Phoenicopterus ruber*	16.32	0	0
6.	Flamingo, Lesser	**Prior to 2007**	**NT, NT**	*Phoenicopterus minor*	6.65	0	0
7.	Godwit, Black-tailed	**Prior to 2007**	**NT, NT**	*Limosa limosa*	1.26	0	0
8.	Grass-owl, African	**2007**	**VU, LC**	*Tyto capensis*	0.46	2	2
9.	Korhaan, White-bellied	**Prior to 2007**	**VU, LC**	*Eupodotis senegalensis*	0.12	0	0
10.	Marsh-harrier, African	**2014**	**EN, LC**	*Circus ranivorus*	4.66	1	1
11.	Pelican, Pink-backed	**Prior to 2007**	**LC,VU**	*Pelecanus rufescens*	0.12	0	0
12.	Pratincole, Black-winged	**Prior to 2007**	**NT, NT**	*Glareola nordmanni*	0.46	0	0
13.	Roller, European	**Prior to 2007**	**NT, LC**	*Coracias garrulus*	0.12	0	0
14.	Secretarybird,	**Prior to 2007**	**VU, VU**	*Sagittarius serpentarius*	0.35	0	0
15.	Stork, Abdim's	**Prior to 2007**	**VU, VU**	*Ciconia abdimii*	0.12	0	0
16.	Stork, Black	**Prior to 2007**	**VU, LC**	*Ciconia nigra*	0.12	0	0
17.	Stork, Yellow-billed	**Prior to 2007**	**EN, LC**	*Mycteria ibis*	0.69	0	0

Red data species Categories for the Birds of Southern Africa (Birdlife South Africa 2015)

LC = Least Concern, **NT** = Near Threatened, **VU** = Vulnerable, **EN** = Endangered, **CR** = Critically Endangered.

A total of 17 threatened and near threatened bird species have previously been recorded within the 2628AD QDS (**Table 2**). Fourteen (14) of which have not yet been recorded within the pentad since the commencement of the second South African Bird Atlas Project (SABAP2) in 2007. Therefore these species are highly unlikely to recur as they have not been recorded in the pentad within the past 9 years. Two of the 17 species have been recorded within the 2615_2815 pentad during the past three years (Greater Flamingo (*Phoenicopterus ruber*) and African Marsh-harrier (*Circus ranivorus*). No suitable habitat for Greater Flamingo is present within the study area.

The wetland habitat unit within the study area contains all the required morphological characteristics to act as a sustainable breeding habitat for African Marsh-harrier. However the entire study area is highly isolated from other homogeneous habitat which dramatically reduces the possibility of African Marsh-harrier utilizing the area for breeding purposes. Although the possibility of African Marsh-harrier utilizing the study area for breeding purposed is unlikely the possibility cannot eliminated entirely, the area might still be utilized for foraging purposes by this species on rare occasions.

During the field survey a single nesting Marsh Owl was observed within the wetland habitat unit. Due to the fact that Marsh Owls and African Grass-owls tend to inhabit similar habitats as well as having similar breeding habitat requirements, the possible occurrence of African Grass-owl cannot be denied. However the probable occurrence of Grass-owls within the study area is unlikely due the isolated nature of the study area. Apart from one incidental record in 2007 (pentad 2615_2815), no additional records have been submitted to SABAP2 for the 2615_2810 and 2615_2815 pentads nor have a single African Grass-owl record from the 8 pentads surrounding the 2615_2815 pentad. As such the occurrence probability of African Grass-owl within the study area was deemed to be low, however further studies must be conducted to confirm the absence of African Grass-owls.

Based on the above mentioned reasons, with the exception of African Grass-owl and African Marsh-harrier, none of the remaining 15 threatened and/or near threatened bird species listed in Table 2 are thought to be resident within the study area or rely on the study area for survival.

6. African Grass-owl (*Tyto capensis*) and African Marsh-harrier (*Circus ranivorus)* Occurrence Probability.

Please note: As stipulated in GDARD's requirements for biodiversity assessments Version 3 (March 2014): All sensitive habitats (e.g. wetlands) must be clearly demarcated using the appropriate techniques, even where the probability of priority Red List species utilizing them is considered small.

As per the Gauteng Conservation Plan Version 3.3 (GDARD 2014) the following habitat requirements were set out for the African Grass-owl:

The species is listed as Least Concern internationally, but is seen as locally Vulnerable (Ekstrom & Butchart, 2004; Barnes, 2000). Following the recommendation of Pfab et al. (2011) that all Vulnerable populations must be conserved in situ, and targets should be calculated to ensure that any area contributes in proportion to its share of the species population range, a targeted population of 150 breeding pairs was set. Data on the foraging range requirements of this species is not available, but an interim estimate by GDARD specialists suggest that 130ha may be sufficient for a pair, but that an equivalent area of unoccupied habitat is likely to be required as a refuge for when habitat patches are rendered temporarily unsuitable e.g. as a result of grazing pressure and/or fire which are essential tools in the management of their habitat. Therefore the requirement was doubled to 260ha per pair.

African Grass-owl (*Tyto capensis)* Habitat Survey:

The wetland vegetation habitat unit was found to hold suitable breeding habitat for the regionally Vulnerable African Grass-owl (*Tyto capensis*). As a result of this observation a thorough habitat assessment was conducted with the aim of mapping out suitable breeding and foraging habitat for this species in and around the study area to determine if the study area could sufficiently support a pair of African Grass-owls in the long term.

Firstly the optimal breeding habitat for African Grass-owls was identified and mapped, the optimal breeding habitat was then given a 170m buffer area as stipulated in the GDARD minimum requirements for this species. Thereafter all suitable foraging habitat on and around the study area was identified and mapped. The surface areas for each of the abovementioned areas were calculated with the purpose of determining the total surface area accounting for suitable and sustainable breeding and foraging habitat as required by African Grass-owls within and around the study area (**Figure 8**).

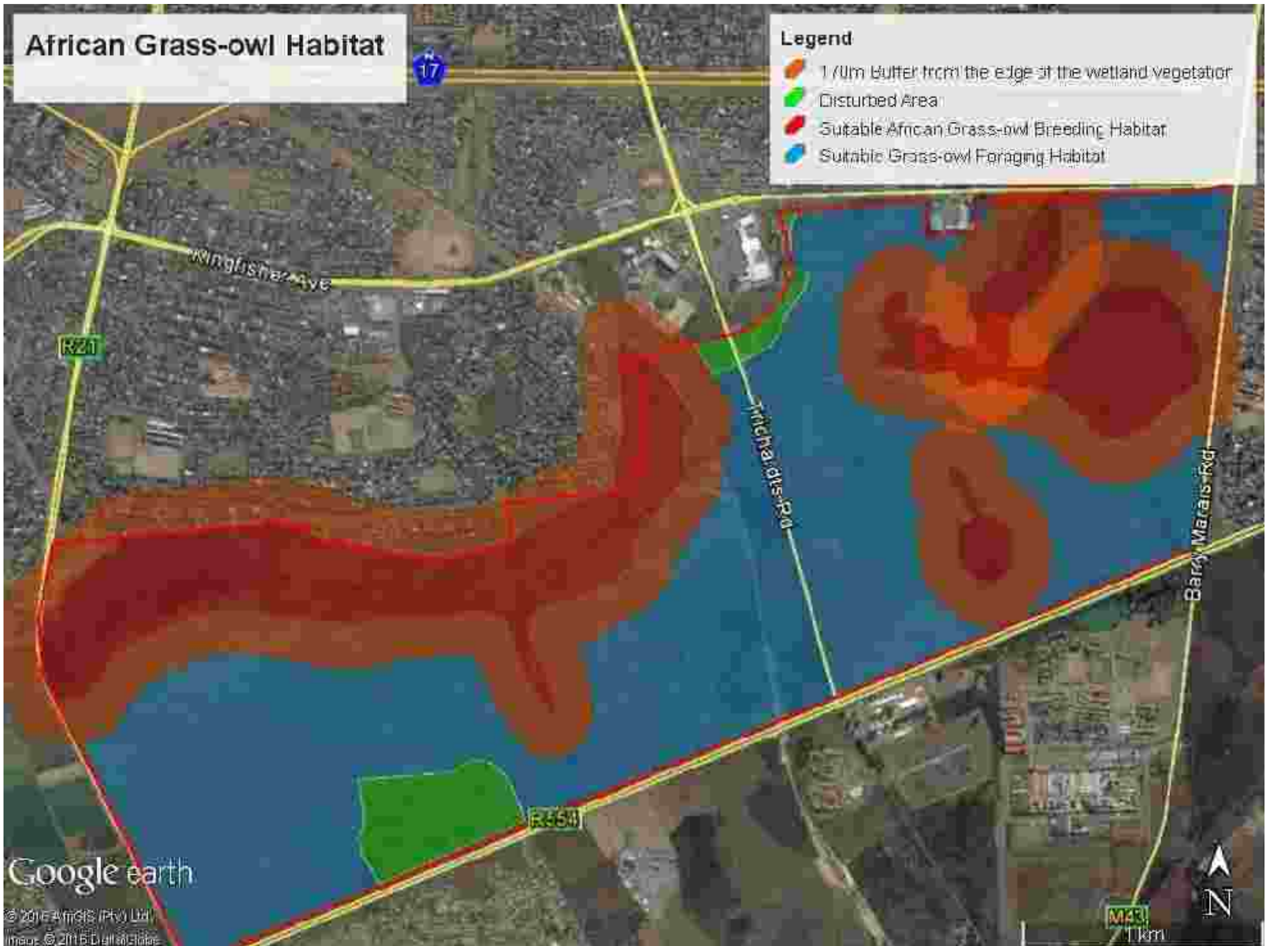


Figure 8: Suitable African Grass-owl Habitat

Table 3. The surface areas of suitable African Grass-owl habitat are as follows:

African Grass-owl (*Tyto capensis*) habitat survey	
Identified Area	**Surface Area (hectares)**
Suitable breeding habitat	154 ha
Breeding habitat 170m buffer	135 ha
Suitable foraging habitat	396.5 ha
Total suitable Grass-owl habitat	685.5 ha
Suitable habitat required as per Gauteng C-Plan V 3.3	130 – 260 ha

The result of the African Grass-owl habitat survey indicates that the surface area of available Grass-owl habitat within and directly surrounding the study area meets the requirements as set out in the Gauteng Conservation plan V3.3. As such it is feasible to conserve this area since it is viable as a sustainable Grass-owl habitat in the long-term. Consequentially a thorough African

Grass-owl Assessment must be conducted to confirm or deny the presence of this species before the final avifaunal sensitivity of the study area can be determined.

As per the Gauteng Conservation Plan Version 3.3 (GDARD 2014) the following habitat requirements were set out for the African Marsh-harrier (*Circus ranivorus*):

> The African Marsh Harrier is listed as Least Concern internationally, but is seen as locally Vulnerable (Ekstrom & Butchart, 2004). It occurs widely, but patchily within the province and is typically associated with large wetlands on which it is dependent for breeding. Wetlands (including those too small for breeding), watercourses and to a lesser extent adjacent grassland areas may be used for foraging. Aquatic habitat for which the species has been confirmed was buffered by 350m of terrestrial habitat both to protect the wetland resource and to provide for the persistence of prey species. Unsuitable habitat (e.g. ridges and permanently modified areas) were excluded from the buffered area. Remnant habitat patches < 100ha were excluded, unless linked directly to a wetland/stream.
>
> Targets were set to contain habitat for 10 breeding pairs, which is the estimated maximum population of African Marsh-Harrier now remain in the province (Tarboton et al., 1987). An area requirement of 1 000ha was set based on observations of area required for a breeding pair in the province, though it should be recognized that Tarboton & Allan (1984) found that most Highveld wetlands larger than 100ha supported a breeding pair of African Marsh Harriers, while Simmons (1997) reports breeding densities of 8 pairs per 1 000ha, which suggests that the area targets are high.
>
> Wetlands larger than 100ha that are identified as suitable habitat for this species must be buffered by 200m of terrestrial habitat.

African Marsh-harrier (*Circus ranivorus)* Habitat Survey:

The wetland vegetation habitat unit was found to hold suitable breeding habitat for the regionally threatened African Marsh-harrier (*Circus ranivorus*). As a result of this observation a thorough habitat assessment was conducted with the aim of mapping out suitable breeding and foraging habitat for this species in and around the study area to determine if the study area could sufficiently support a pair of African Marsh-harriers in the long term.

Firstly the optimal breeding habitat for African Marsh-harrier was identified and mapped, the optimal breeding habitat was then given a 200m buffer area as stipulated in the GDARD minimum requirements for this species. Thereafter all suitable foraging habitat on and around the study area was identified and mapped. The surface areas for each of the abovementioned areas were calculated with the purpose of determining the total surface area accounting for suitable and sustainable breeding and foraging habitat as required by African Marsh-harrier within and around the study area (**Figure 9**).

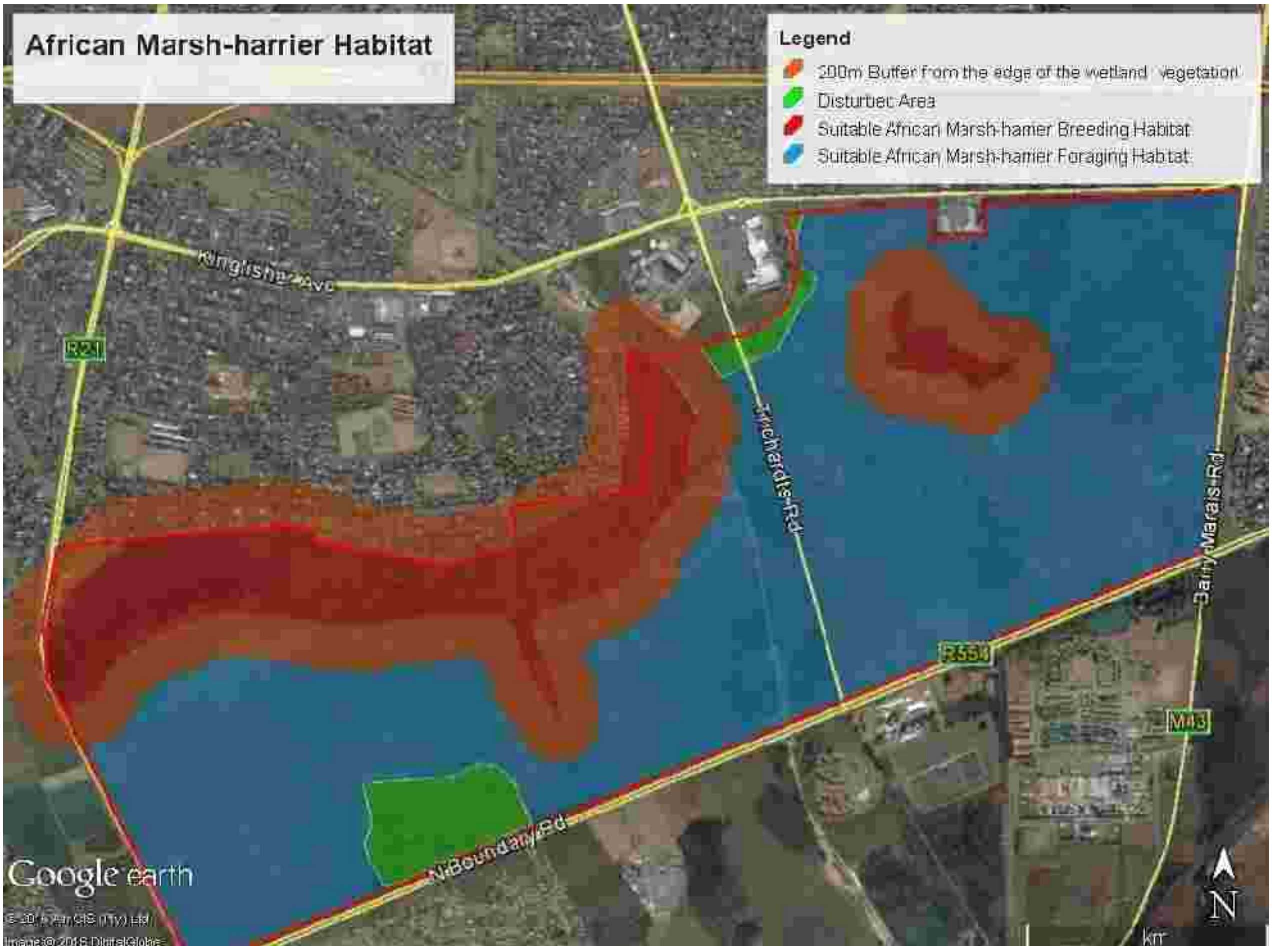


Figure 9: Suitable African Marsh-harrier habitat

Table 4. The surface areas of suitable African Marsh-harrier habitat are as follows:

African Marsh-harrier (*Circus ranivorus*) habitat survey	
Identified Area	**Surface Area (hectares)**
Suitable breeding habitat	108 ha
Breeding habitat 200m buffer	126 ha
Suitable foraging habitat	489 ha
Total suitable Grass-owl habitat	723 ha
Suitable habitat required as per Gauteng C-Plan V 3.3	100 ha wetland vegetation

The result of the African Marsh-harrier habitat survey indicates that the surface area of available Marsh-harrier habitat within and directly surrounding the study area meets the requirements as set out in the Gauteng Conservation plan V3.3. As such it is feasible to conserve this area since it is viable as a sustainable Marsh-harrier habitat in the long-term. Consequentially a thorough African Marsh-harrier assessment must be conducted to confirm or deny the presence of this species before the final avifaunal sensitivity of the study area can be determined.

7. Findings

The discrete habitats identified on the study area contain a large variety of bird species, ranging from grassland and wetland associated species to species adapted to a transformed and/ or urban environment. The wetland vegetation habitat unit can be deemed as the preferred habitat for two threatened bird species (African Grass-owl and African Marsh-harrier), thus an in-depth African Grass-owl and African Marsh-harrier assessment must be conducted to confirm or deny the occurrence of these species before the final avifaunal sensitivity for the study area can be determined. The surrounding land use and disturbance in the form of roads, urbanization, illegal dumping, alien vegetation encroachment, trampling, habitat transformation and limited connectivity significantly reduces the probable occurrence of threatened and/or near threatened bird species within the grassland and transformed area, however suitable wetland habitat is present within the study area which might hold threatened avifaunal species.

8. Limitations

The majority of the data used to conclude the distribution of Red Data species were sourced by making use of the SABAP 1 and 2 data basis. Any limitations in the above mentioned studies will in effect have implications on the findings and conclusion of this assessment. Furthermore this avifaunal assessment was conducted during March; hence the survey was done outside the main breeding period of the majority of the local bird species. Moreover, most of the Palearctic and intra-Africa migratory bird species have commenced their migration to the North by this time. With respect to this assessment, the implications of not being able to record migratory bird species will be minimal, seeing as most are threatened in their Northern hemisphere distributions.

Limited time to conduct the survey could potentially result in not recording all species within the study area. Two field surveys were conducted on the 23rd and 24th March during which a total of six hours were spent on site while conducting this avifaunal assessment. As a result of the surface area of the study area, six hours was deemed sufficient time to conduct a comprehensive avifaunal assessment.

9. Recommendations

- Prior to the commencement of any construction activities an in-depth assessment must be conducted to confirm or deny the presence of African Grass-owl and African Marsh-harrier to establish the final avifaunal sensitivity of the study area.
- Should environmental authorization for the proposed development be authorized by the competent authority the recommendation above must be included as a condition before any construction activities can commence.
- Prior to any activities commencing on site, all construction staff should be briefed in an environmental induction regarding the environmental status and requirements of the site. This should include providing general guidelines for minimizing environmental damage during construction, as well as education with regards to basic environmental ethics, such as the prevention of littering, lighting of fires, etc.
- Induction should be done for all civil contractors and for each building contractor prior to them commencing on site.
- Areas where construction is to take place should be clearly demarcated and fenced off, all areas outside that of the defined works should be deemed no-go areas.
- All construction activities must be restricted to the demarcated areas to ensure that no further disturbance into the surrounding vegetation or habitat takes place.
- It is recommended that prior to the commencement of construction activities' initial clearing of all alien vegetation should take place.
- The contractor must ensure that no avifaunal species are trapped, killed or in any way disturbed during construction. Collecting of eggs such as Guineafowl and Ducks present on site should not be tolerated.
- No vehicles should be allowed to move in or through the wetland. This will cause destruction of avifaunal habitat and will leave notable scares on site.
- It is recommended that all concrete and cement works be restricted to areas of low ecological sensitivity and defined on site and clearly demarcated. Cement powder has a high alkalinity pH rating, which can contaminate and affect both soil and water pH dramatically. A shift in the pH can have serious consequences on the functioning of soil, vegetation and fauna.
- To ensure minimal disturbance of avifaunal species it is recommended that construction should take place during winter, outside the breeding season of the species present on site.
- Construction, vegetation clearing and top soil clearing should commence from a predetermined location and gradually commence to ensure that birds and other fauna present on the site have enough time to relocate.
- When construction is completed, disturbed areas should be rehabilitated using vegetation cleared prior to construction to ensure that the habitat stays intact and that avifaunal

species present on the site before construction took place, return to the area after construction is completed.

- The attached sensitivity map should be used as a decision tool to guide the layout design of the proposed development (**Figure 10**).
- All areas labelled as sensitive in the sensitivity map (**Figure 10**) should be incorporated into an open space system if the presence of Grass-owls and/or Marsh-harriers are confirmed within the study area. Development should be located on areas of low sensitivity.
- An additional avifaunal sensitivity map (**Figure 11**) shows the potential avifaunal sensitivity of the study area should the absence of African Grass-owl and African Marsh-harrier within the study area be confirmed. This sensitivity map acts as a potential avifaunal sensitivity map and may only be used as the final avifaunal sensitivity indicator once an additional avifaunal assessment have been conducted by a qualified avifauna specialist confirming the absence of the abovementioned threatened avifaunal species.
- The open space system should be managed in accordance with the EMP that complies with the Minimum Requirements for Ecological Management Plans and forms part of the EMP.

10. Conclusion

The largest part of the study area supports a number of widespread grassland bird species such as Widowbirds, Bishops, Doves, Lapwings, Cisticolas and Weavers with other species like Rufous-napped Lark, African Stonechat, Pipits and Cape Longclaw also occurring throughout the study area at lower densities. Other species occurring on the study area are mostly confined to the wetland vegetation habitat unit.

Although 17 threatened and/or near threatened bird species have previously been recorded within the larger 2628AD QDS. The probable occurrence of any of these threatened and/or near threatened bird species are unlikely. However the wetland vegetation habitat unit provides optimal breeding and foraging habitat for both African Grass-owl and African Marsh-harrier. Thus the majority of the study area was identified with a high avifaunal sensitivity even though the probability of both these species actually occurring within the study area was judged to be low. An additional avifaunal assessment must be conducted to confirm the absence of both African Grass-owl and African Marsh-harrier before the final avifaunal sensitivity for the proposed development site can be determined.

Consequently the current avifaunal sensitivity for the majority of the study area was judged to be highly sensitive (**Figure 10**). The potential avifaunal sensitivity map (**Figure 11**) can be used as the final avifaunal sensitivity indicator once an thorough Grass-owl and Marsh-harrier assessment have been conducted by a qualified avifauna specialist in which the absence of both of these species are confirmed.

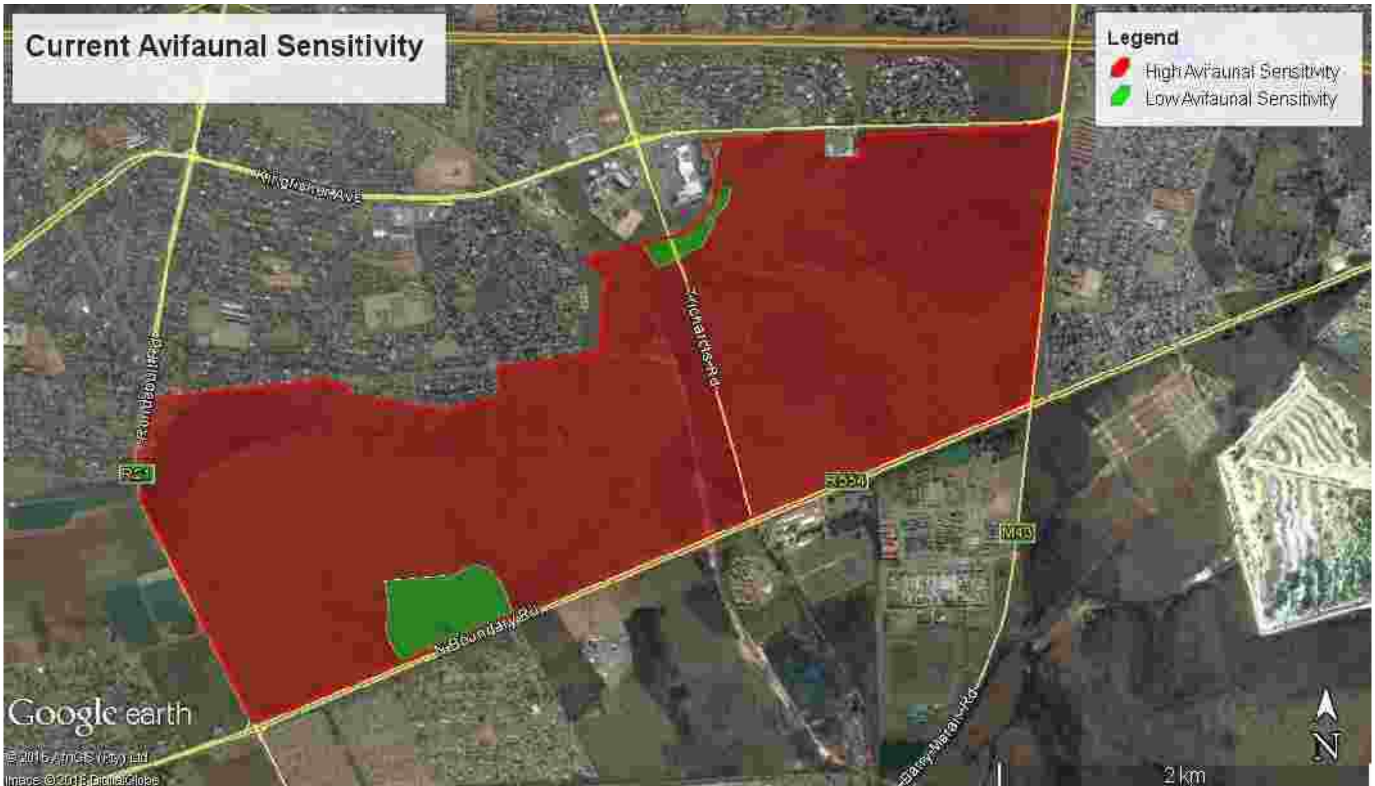


Figure 10: Current Avifaunal Sensitivity

Figure 11: Potential Avifaunal Sensitivity

11. CONDITIONS OF THIS REPORT

- **Prior to the commencement of any construction activities an additional in-depth avifauna assessment must be conducted by a qualified avifauna specialist to CONFIRM OR DENY the presence of African Grass-owl and African Marsh-harrier to establish the FINAL avifaunal sensitivity of the proposed development site.**
- **Should environmental authorization for the proposed development be authorized by the competent authority, the comment above must be included as a condition before any construction activities may commence.**
- **All areas labelled as sensitive in the CURRENT AVIFAUNAL SENSITIVITY MAP (Figure 10) should be incorporated into an open space system SHOULD Grass-owl and/or Marsh-harrier PRESENCE within the study area be CONFIRMED. Development should be located on areas of low sensitivity. If African Grass-owl and/or African Marsh-harrier ARE CONFIRMED ABSENT WITHIN THE STUDY AREA, Figure11 may be used as the FINAL avifaunal sensitivity indicator for the proposed development area.**
- **An additional avifaunal sensitivity map (Figure 11: POTENTIAL AVIFAUNAL SENSITIVITY) shows the potential avifaunal sensitivity of the study area should the**

ABSENCE of African Grass-owl and African Marsh-harrier within the study area be CONFIRMED. This sensitivity map acts as a potential avifaunal sensitivity map and may ONLY BE USED as the final avifaunal sensitivity indicator once an ADDITIONAL avifaunal assessment have been conducted by a qualified avifauna specialist CONFIRMING THE ABSENCE of the abovementioned threatened avifauna species.

12. Literature Sources

Barnes, K.N., (ed.) 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swasiland.* BirdLife South Africa, Johannesburg.

BirdLife South Africa. 2016. BirdLife South Africa official Checklist of Birds in South Africa 2016. http://www.birdlife.org.za/publications/checklists

EKSTROM, J., AND S. BUTCHART. (2004). "The IUCN Red List of Threatened Species." (On-line). Accessed November 5 (2004): 2006.

GDARD. 2014. Technical report for the Gauteng Conservation Plan (Gauteng C-Plan v3.3). Gauteng Department of Agriculture and Rural Development: Nature Conservation Directorate. 60 pages.

GDARD. 2014. Requirements for Biodiversity Assessments version 3. Gauteng Department of Agriculture and Rural Development: Biodiversity Management Directorate. 24 pages.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J. Parker, V. & Brown, C.J. (eds.). 1997. *The Atlas of Southern African Birds.* Vol. 1 &2. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J. & Ryan, P.G. 2005. *Roberts Birds of Southern Africa VIIth Edition,* The Trustees of the John Voelcker Bird Book Fund, Cape Town

Marais, M & Peacock, F., 2008. *The Chamberlain guide to Birding Gauteng,* Mirafra Publishing, CTP Book Printers, Cape Town.

Mucina, L. & Rutherford, M.C. (eds.) 2006. The vegetation of South Arica, Lesotho and Swasiland. Strelitzia 19. South Africa National Biodiversity Institute, Pretoria.

Pfab, M.F., VICTOR, J.E. & ARMSTRONG, A.J. (2011). Application of the IUCN Red Listing system to setting species targets for conservation planning purposes. Biodiversity and Conservation, 20(5), 1001-1012.

Simmons R.E. (1997). African Marsh Harrier In: Atlas of Southern African birds Vol 1. Non-passerines. (Eds James Harrison, David Allan, Les Underhill, Marc Herremans, Vincent Parker, Chris Brown) Avian Demography Unit University of Cape Town.

Sinclair I., & Hockey P & Tarboton, W. 2011. *Sasol Birds of Southern Africa.* Struik, Cape Town.

Southern African Bird Atlas Project 2. South Africa, Lesotho, Botswana, Namibia, Mozambique, Swaziland, Zimbabwe, Zambia. 2016. Animal Demography Unit. University of Cape Town. www.sabap2.adu.org.za. accessed on 28 March 2016.

Tarboton, W., Kemp, M.I., & Kemp, A.C. 1987. *Birds of the Transvaal.* Transvaal Museum, Pretoria.

Taylor, M.R., Peacock, F. & Wanless, R.M. 2015. The 2015 Eskom Red Data Book of BIRDS of South Africa, Lesotho and Swaziland. BirdLife South Africa. Gauteng.

ANNEXURE D5
PHASE 1 HIA

PHASE 1 HERITAGE IMPACT ASSESSMENT (HIA) FOR THE PROPOSED LEEUWPOORT SOUTH MIXED USE DEVELOPMENT ON A PART OF THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113 IR, BOKSBURG, EKURHULENI METROPOLIOTAN MUNICIPALITY, GAUTENG PROVINCE

Leonie Marais-Botes
Heritage Practitioner

868 Endeman Street
Wonderboom South
Pretoria
0084
Mobile: 082 576 6253
E-mail: leoniembotes@gmail.com

BA (Cultural History and Archaeology) (UP), BA (Hons) Cultural History (UP), Post Grad Dip Museology (UP), Cert Conservation of Traditional Buildings (Univ of Canberra) Post Grad Dip: Heritage (Wits)

Accredited member: SA Society for Cultural History (CH002)

For:

BOKAMOSO LANDSCAPE ARCHITECTS
& ENVIRONMENTAL CONSULTANTS
P.O. BOX 11375
MAROELANA
0161

March 2017

DISCLAIMER:

Although all possible care is taken to identify/find all sites of cultural importance during the initial survey of the study area, the nature of archaeological and historical sites are as such that it is always possible that hidden or sub-surface sites could be overlooked during the study. Leonie Marais-Botes Heritage Practitioner will not be held liable will not be held liable for such oversights or for the costs incurred as a result thereof.

DECLARATION OF INDEPENDENCE:

I, Leonie Marais-Botes declare that;

- I act as an independent specialist in this application.
- I will perform the work relating to the application in an objective matter, even if this results in views and findings that are not favourable to the applicant.
- There are no circumstances that may comprise my objectivity in performing such work.
- I have expertise in conducting the specialist report relevant to the application, including knowledge of the relevant Acts and Regulations.
- I have no, and will not engage in, conflicting interests in the undertaking of the activity.

ACKNOWLEDGEMENTS

Australia ICOMOS. *The Burra Charter*.

Bergh, J.S. Geskiedenis Atlas van Suid-Afrika. Die vier Noordelike Provinsies. Van Schaik Uitgewers, 1998.

Beyers C.J. (Editor-in-Chief). Dictionary of South African Biography (Vol I – V). Pretoria, 1987.

Coertze, P.J. & Coertze, R.D. Verklarende vakwoordeboek vir Antropologie en Argeologie. Pretoria, 1996.

Huffman, T.N. A Handbook to the Iron Age: The Archaeology of Pre- Colonial Farming Societies in Southern Africa. University of KwaZulu-Natal Press, 2007

Human Tissues Act (Act 65 of 1983 as amended)

Government Printers. 1: 50 000

National Heritage Resources Act (Act 25 of 1999)

National Environmental Management Act (Act 107 of 1998)

Ordinance on Exhumations (no 12 of 1980)

Potgieter, D.J. (editor-in-chief) Standard Encyclopaedia of Southern Africa. London 1971.

Rosenthal E. (Editor) Encyclopaedia of Southern Africa, 1973

The National Archives of South Africa databases.

Contents page

Contents **Page**

ABOUT THIS REPORT

The heritage report must reflect that consideration has been given to the history and heritage significance of the study area and that the proposed activities is sensitive towards the heritage resources and does not significantly alter or destroy the heritage significance of the study area.

The heritage report must refer to the heritage resources currently in the study area.

The opinion of an independent heritage consultant is required to evaluate if the proposed work generally follows a good approach that will ensure the conservation of the heritage resources.

The National Heritage Resources Act (Act 25 of 1999), the National Environmental Management Act (Act 107 of 1998), Ordinance on Exhumations (no 12 of 1980) and the Human Tissues Act (Act 65 of 1983 as amended) are the guideline documents for a report of this nature.

Leonie Marais-Botes was appointed by Bokamoso Landscape Architects and Environmental Consultants to carry out a Phase 1 Heritage Impact Assessment (HIA) for the proposed Leeuwpoort South mixed use development on a part of the remaining extent of the Farm Leeuwpoort 113 IR, Boksburg, Ekurhuleni Municipality, Gauteng Province. Site visits took place on 11 November 2016 and 30 March 2017.

DEFINITION OF TERMS:

''alter'' means any action affecting the structure, appearance or physical properties of a place or object, whether by way of structural or other works, by painting, plastering or other decoration or any other means.

"archaeological'' means—
(a) material remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures;
(b) rock art, being any form of painting, engraving or other graphic representation on a fixed rock surface or loose rock or stone, which was executed by human agency and which is older than 100 years, including any area within 10m of such representation;
(c) wrecks, being any vessel or aircraft, or any part thereof, which was wrecked in South Africa, whether on land, in the internal waters, the territorial waters or in the maritime culture zone of the Republic, as defined respectively in sections 3, 4 and 6 of the Maritime Zones Act, 1994 (Act No. 15 of 1994), and any cargo, debris or artefacts found or associated therewith, which is older than 60 years or which SAHRA considers to be worthy of conservation; and
(d) features, structures and artefacts associated with military history which are older than 75 years and the sites on which they are found.

''conservation'', in relation to heritage resources, includes protection, maintenance, preservation and sustainable use of places or objects so as to safeguard their cultural significance.

''cultural significance'' means aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance.

''development'' means any physical intervention, excavation, or action, other than those caused by natural forces, which may in the opinion of a heritage authority in any way result in a change to the nature, appearance or physical nature of a place, or influence its stability and future well-being, including—
(a) construction, alteration, demolition, removal or change of use of a place or a structure at a place;
(b) carrying out any works on or over or under a place;
(c) subdivision or consolidation of land comprising, a place, including the structures or airspace of a place;
(d) constructing or putting up for display signs or hoardings;
(e) any change to the natural or existing condition or topography of land; and
(f) any removal or destruction of trees, or removal of vegetation or topsoil; object that is specifically designated by that state as being of importance.

''grave'' means a place of interment and includes the contents, headstone or other marker of such a place, and any other structure on or associated with such place.

''heritage resource'' means any place or object of cultural significance.

''heritage resources authority'' means the South African Heritage Resources Agency, or in respect of a province, a provincial heritage resources authority.

''heritage site'' means a place declared to be a national heritage site by SAHRA or a place declared to be a provincial heritage site by a provincial heritage resources authority.

''improvement'', in relation to heritage resources, includes the repair,
restoration and rehabilitation of a place protected in terms of Act 25 of 1999.
''living heritage'' means the intangible aspects of inherited culture, and may include—
(a) cultural tradition;

(b) oral history;
(c) performance;
(d) ritual;
(e) popular memory;
(f) skills and techniques;
(g) indigenous knowledge systems; and
(h) the holistic approach to nature, society and social relationships.

''local authority'' means a municipality as defined in section 10B of the Local Government Transition Act, 1993 (Act No. 209 of 1993).

''management'', in relation to heritage resources, includes the conservation, presentation and improvement of a place protected in terms of Act 25 of 1999.

''meteorite'' means any naturally-occurring object of extraterrestrial origin.

''object'' means any movable property of cultural significance which may be protected in terms of any provisions of Act 25 of 1999, including—
(a) any archaeological artefact;
(b) palaeontological and rare geological specimens;
(c) meteorites; and
(d) other objects.

''palaeontological'' means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trance.

''place'' includes—
(a) a site, area or region;
(b) a building or other structure which may include equipment, furniture, fittings and articles associated with or connected with such building or other structure;
(c) a group of buildings or other structures which may include equipment, furniture, fittings and articles associated with or connected with such group of buildings or other structures;
(d) an open space, including a public square, street or park; and
(e) in relation to the management of a place, includes the immediate surroundings of a place.

''presentation'' includes—
(a) the exhibition or display of;
(b) the provision of access and guidance to;
(c) the provision, publication or display of information in relation to; and
(d) performances or oral presentations related to, heritage resources protected in terms of Act 25 of 1999.

''public monuments and memorials'' means all monuments and memorials—
(a) erected on land belonging to any branch of central, provincial or local government, or on land belonging to any organisation funded by or established in terms of the legislation of such a branch of government; or
(b) which were paid for by public subscription, government funds, or a public-spirited or military organisation, and are on land belonging to any private individual.

''site'' means any area of land, including land covered by water, and including any structures or objects thereon.
''structure'' means any building, works, device or other facility made by people and which is fixed to land, and includes any fixtures, fittings and equipment associated therewith.
''victims of conflict'' means—

(a) certain persons who died in any area now included in the Republic as a direct result of any war or conflict as specified in the regulations, but excluding victims of conflict covered by the Commonwealth War Graves
Act, 1992 (Act No. 8 of 1992);
(b) members of the forces of Great Britain and the former British Empire who died in active service in any area now included in the Republic prior to 4 August 1914;
(c) persons who, during the Anglo-Boer War (1899-1902) were removed as prisoners of war from any place now included in the Republic to any place outside South Africa and who died there; and
(d) certain categories of persons who died in the ''liberation struggle'' as defined in the regulations, and in areas included in the Republic as well as outside the Republic.

EXECUTIVE SUMMARY

Leonie Marais-Botes Heritage Practitioner was requested by Bokamoso Landscape Architects and Environmental Consultants to conduct a Phase 1 Heritage Impact Assessment (HIA) for the proposed Leeuwpoort South mixed use development on a part of the remaining extent of the Farm Leeuwpoort 113 IR, Boksburg, Ekurhuleni Metropolitan Municipality, Gauteng Province.

A field survey was conducted after which a survey of literature was undertaken.

No heritage sites situated on the site earmarked for development.

It should be noted that the sub-surface archaeological and/or historical deposits and graves are always a possibility. Care should be taken during any work in the entire area and if any of the above is discovered, an archaeologist/heritage practitioner should be commissioned to investigate.

1. INTRODUCTION

The proposed project is for establishment of a township to be known as Leeuwpoort South, south of Sunward Park, Boksburg, Ekurhuleni, Gauteng, to serve as mixed use development, situated on a part of the remaining extent of the Farm Leeuwpoort 113 IR, by the Developer – Leeuwpoort Developments (Pty) Ltd.

The proposed mixed use development will comprise of the following land uses;
Residential 1, Residential 3, Residential 4, Business 2, Business 3, Special (for clinic, retirement village and frail care, gate houses, and agriculture and other uses with consent, Public Services, Community Facility, Transportation, and Public Open Space.

1.1 WHY A PHASE 1 HERITAGE IMPACT ASSESSMENT IS REQUIRED?

This project may potentially impact on any types and ranges of heritage resources that are outlined in Section 3 of the National Heritage Resources Act (Act 25 of 1999). Subsequently a Phase 1 Heritage Impact Assessment (HIA) was commissioned by Bokamoso Landscape Architects and Environmental Consultants and conducted by Leonie Marais-Botes.

1.1.1 METHOD

The objective of this Phase 1 Heritage Impact Assessment (HIA) was to gain an overall understanding of the heritage sensitivities of the area and indicate how they may be impacted on through development activities. site surveys took place on 11 November 2016 and 30 March 2017.

In order to establish heritage significance the following method was followed:

- Investigation of primary resources (archival information)
- Investigation of secondary resources (literature and maps)
- Physical evidence (site investigation)
- Determining Heritage Significance.

1.2 PROPERTY DESCRIPTION

A part of the remaining extent of the Farm Leeuwpoort 113 IR, Boksburg, Ekurhuleni Metropolitan Municipality, Gauteng Province.

1.3 HISTORIY OF THE STUDY AREA

Boksburg (a town on the East Rand) was established in 1903 and named after the State Secretary of the " Zuid-Afrikaansche Republiek" (South African Republic), Dr W.E. Bok. Noted for its gold mines and for its lake, which is a popular pleasure resort[1].

[1] E. Rosenthal (Editor), Encyclopaedia of Southern Africa, p.68.

1.4 LOCATION AND PHOTOGRAPHIC RECORD OF STUDY AREA

The proposed development is 6.5km south of the Boksburg CBD just south of Sunward Park. The R554 (North Boundary Road) runs along the southern boundary of the proposed development, with the R21 (Rondebult Road) running along the western boundary and the M43 (Barry Marias Road) running along the eastern boundary.

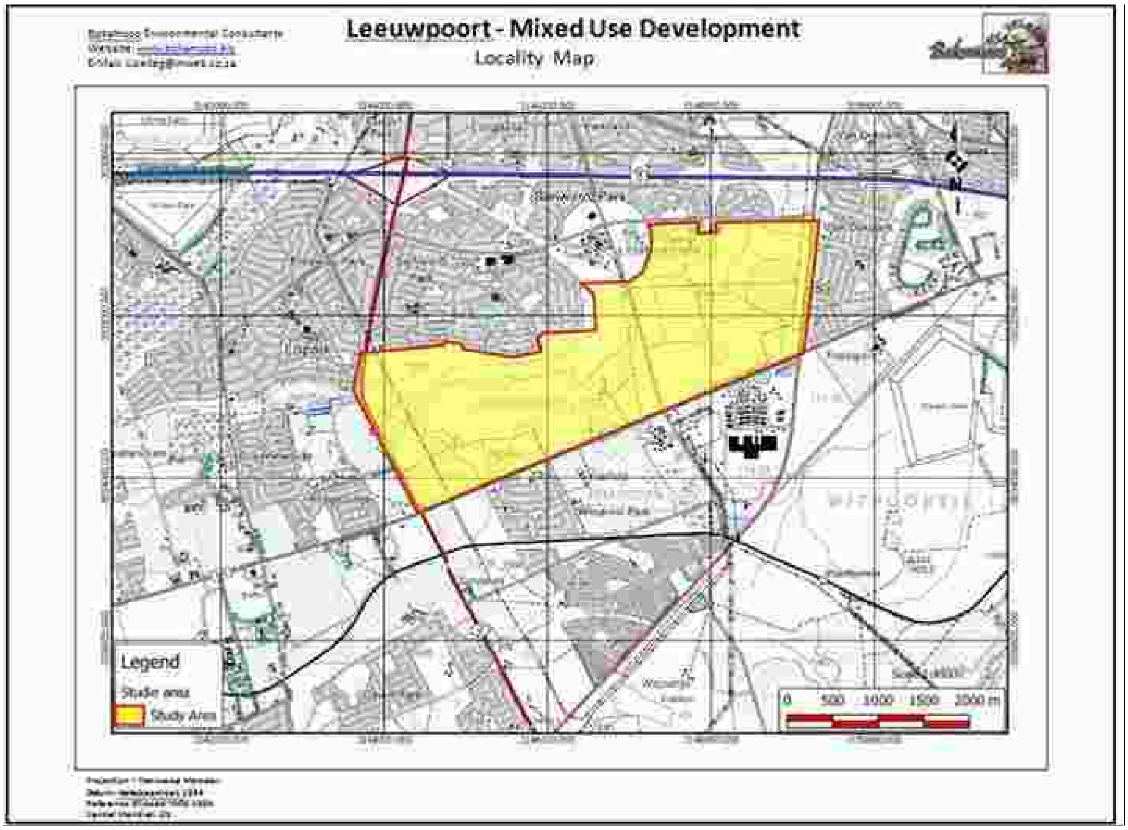


Figure 1: Locality map

Figure 2: Locaility Map

Figure 3: Site earmarked for development: East section: Photograph taken towards the east.

Figure 4: Site earmarked for development: East section: Photograph taken towards the north.

Figure 5: Site earmarked for development: East section: Photograph taken towards the west.

Figure 6: Site earmarked for development: East section: Photograph taken towards the east.

Figure 7" Site earmarked for development: West section: Photograph taken towards the west.

Figure 8: Site earmarked for development: West section: Photograph taken towards the south

Figure 9: Site earmarked for development: West section: Photograph takn towards the west.

2. FINDINGS

2.1 PRE-COLONIAL HERITAGE SITES

Possibilities: Greater study area taken into account.

Stone Age

The Stone Age is the period in human history when stone material was mainly used to produce tools[2]. In South Africa the Stone Age can be divided in three periods[3];

- Early Stone Age 2 000 000 – 150 000 years ago
- Middle Stone Age 150 000 – 30 000 years ago
- Late Stone Age 40 000 years ago - +/- 1850 AD

Iron Age

The Iron Age is the period in human history when metal was mainly used to produce artefacts[4]. In South Africa the Iron Age can be divided in three periods;

- Early Iron Age 250-900 AD
- Middle Iron Age 900-1300 AD
- Late Iron Age 1300-1840 AD[5]

There are no pre-colonial heritage sites evident in the study area. This can be attributed to previous farming and other infrastructure development in the study area.

2.2 HISTORICAL PERIOD HERITAGE SITES

Possibilities: Greater study area taken into account.

- Pioneer sites;
- Sites associated with early mining;
- Structures older than 60 years;
- Graves (Graves younger than 60 years, graves older than 60 years, but younger than 100 years, graves older than 100 years, graves of victims of conflict or of individuals of royal descent).

None of the above situated on site.

2.3 ORIGINAL LANDSCAPE

Farming and previous infrastructure development attempts have altered the original landscape in the study area.

---

[2] P. J. Coertze & R.D. Coertze, Verklarende vakwoordeboek vir Antropologie en Argeologie.
[3] S.A. Korsman & A. Meyer, *Die Steentydperk en rotskuns* in J.S. Bergh (red) Geskiedenisatlas van Suid-Afrika. Die vier noordelike provinsies.
[4] P.J. Coertze & R.D. Coertze, Verklarende vakwoordeboek vir Antropologie en Argeologie.
[5] M.M. van der Ryst & A Meyer. *Die Ystertydperk* in J.S. Bergh (red) Geskidenisatlas van Suid-Afrika. Die vier noordelike provinsies and T.N Huffman, A Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa.

2.4 INTANGIBLE HERITAGE

The intangible heritage of the greater study area can be found in the stories of past and present inhabitants.

3 CATEGORIES OF HERITAGE VALUE (ACT 25 OF 1999)

The National Heritage Resources Act (Act 25 of 1999) identifies the following categories of value under section 3(1) and (2) of the Act under the heading "National Estate":

"3 (1) For the purpose of this Act, those heritage resources of South Africa which are of cultural significance or other special value for the present community and for future generations must be considered part of the national estate and fall within the sphere of operations of heritage resources authorities.

(2) Without limiting the generality of subsection (1), the national estate may include-
- (a) places, buildings, structures and equipment of cultural significance;
- (b) places which oral traditions are attached or which are associated with living heritage;
- (c) historical settlements and townscapes;
- (d) landscapes and natural features of cultural significance;
- (e) geological sites of scientific or cultural importance;
- (f) archaeological and palaeontological sites;
- (g) graves and burial grounds, including-
  - (i) ancestral graves;
  - (ii) royal graves and graves of traditional leaders;
  - (iii) graves of victims of conflict;
  - (iv) graves of individuals designated by the Minister by notice in the Gazette
  - (v) historical graves and cemeteries; and
  - (vi) other human remains which are not covered in terms of the Human Tissue Act, 1983 (Act No. 65 of 1983);
- (h) sites of significance relating to the history in South Africa;
- (i) movable objects, including-
  - (i) objects recovered from the soil or waters of South Africa including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
  - (ii) objects to which oral traditions are attached or which are associated with living heritage;
  - (iii) ethnographic art and objects;
  - (iv) military objects
  - (v) objects of decorative or fine art;
  - (vi) objects of scientific or technological interests; and
  - (vii) books, records, documents, photographic positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section I (xiv) of the National Archives of South Africa Act, 1996 (Act No. 43 of 1996).

(3) Without limiting the generality of the subsections (1) and (2), a place or object is to be considered part of the national estate if it has cultural significance or other special value because of-
- (a) It is importance in the community, or pattern of South Africa's history;
- (b) Its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
- (c) Its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;

(d) Its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural objects;
(e) Its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) Its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) Its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
(h) Its strong or special association with the life and work of a person, group or organisation of importance in the history of South Africa; and
(i) Sites of significance relating to the history of slavery in South Africa."

3.1 HERITAGE VALUE OF WEIGHED AGAINST CULTURAL SIGNIFICANCE CATEGORIES

3.1.1 Spiritual value

During the site visit/field work, some spiritual activity was noticed on the corner of N. Boundary Road and Trichardts Road. This is however not a heritage issue, but may have social implications.

3.1.2 Scientific value

No sites of scientific value were observed on or near the site earmarked for development.

3.1.3 Historical value

The original Leeuwpoort Farm was one of the farms on which Boksburg was found.

3.1.4 Aesthetic value

No heritage item with exceptional aesthetic (architectural) value was identified in the study area.

3.1.5 Social value

Social value is attributed to sites that are used by the community for recreation and formal and informal meetings regarding matters that are important to the community. These sites include parks, community halls, sport fields etc. None of the said evident in the immediate study area.

3.2 SPECIFIC CATEGORIES INVESTIGATED AS PER SECTION 3 (1) AND (2) OF THE NATIONAL HERITAGE LEGISLATION (ACT 25 OF 1999)

3.2.1 Does the site/s provide the context for a wider number of places, buildings, structures and equipment of cultural significance?

The study area does not provide context for a wider number of places, buildings, structures and equipment of cultural significance. The reason being the low density of heritage items in the study area.

3.2.2 Does the site/s contain places to which oral traditions are attached or which are associated with living heritage?

Places to which oral traditions are attached or associated with living heritage are usually find in conjunction with traditional settlements and villages which still practises age old traditions. None of these are evident near or on the proposed site.

3.2.3 Does the site/s contain historical settlements?

No historical settlements are located on or near the proposed site.

3.2.4 Does the site/s contain landscapes and natural features of cultural significance?

Due to infra-structure development and farming activities the original character of the landscape has been altered significantly in the study area. Thus the site does not contain natural features of cultural significance.

3.2.5 Does the site/s contain geological sites of cultural importance?

Geological sites of cultural importance include meteorite sites (Tswaing Crater and Vredefort Dome), fossil sites (Karoo and Krugersdorp area), important mountain ranges or ridges (Magaliesburg, Drakensberg etc.). The proposed site is not located in an area known for sites of this importance.

3.2.6 Does the site/s contain a wide range of archaeological sites?

The proposed site does not contain any surface archaeological deposits, a possible reason is previous infra-structure development attempts and farming activities in the greater study area.

The possibility of sub-surface findings always exists and should be taken into consideration in the Environmental Management Plan.

If sub-surface archaeological material is discovered work must stop and a heritage practitioner preferably an archaeologist contacted to assess the find and make recommendations.

3.2.7 Does the site/s contain any marked graves and burial grounds?

The site does not contain any marked graves or burial grounds.

The possibility of graves not visible to the human eye always exists and this should be taken into consideration in the Environmental Management Programme.

It is important to note that all graves and cemeteries are of high significance and are protected by various laws. Legislation with regard to graves includes the National Heritage Resources Act (Act 25 of 1999) whenever graves are 60 years and older. Other legislation with regard to graves includes those when graves are exhumed and relocated, namely the Ordinance on Exhumations (no 12 of 1980) and the Human Tissues Act (Act 65 of 1983 as amended).

If sub-surface graves are discovered work should stop and a professional preferably an archaeologist contacted to assess the age of the grave/graves and to advice on the way forward.

3.2.8 Does the site/s contain aspects that relate to the history of slavery?

This is not an area associated with the history of slavery like the Western Cape Province.

3.2.9 Can the place be considered as a place that is important to the community or in the pattern of South African history?

In primary and secondary sources the proposed site is not described as important to the community or in the pattern of South African history.[6] No comment in this regard was received during the Public Participation Process.

3.2.10 Does the site/s embody the quality of a place possessing uncommon or rare endangered aspects of South Africa's natural and cultural heritage?

The proposed site does not possess uncommon, rare or endangered aspects of South Africa's natural and cultural heritage. These sites are usually regarded as Grade 1 or World Heritage Sites.

[6] Standard Encyclopaedia of Southern Africa and the TAB database at the National Archives of South Africa;
J.S. Bergh (red), Geskiedenisatlas van Suid-Afrika. Die Vier Noordelike Provinsies.

3.2.11 Does the site/s demonstrate the principal characteristics of South Africa's natural or cultural places?

The proposed site does not demonstrate the principal characteristics of South Africa's natural or cultural places. These characteristics are usually associated with aesthetic significance.

3.2.12 Does the site/s exhibit particular aesthetic characteristics valued by the community or cultural groups?

This part of the greater study area does not exhibit particular aesthetic characteristics valued by the community or cultural groups. The reason being the low density of heritage buildings and structures located in the greater study area.

3.2.13 Does the site/s contain elements, which are important in demonstrating a high degree of creative technical achievement?

The site does not contain elements which are important in demonstrating a high degree of creative technical achievement. Reason being none of the above are evident on site.

3.2.14 Does the site/s have strong and special associations with particular communities and cultural groups for social, cultural and spiritual reasons?

The proposed site does not have a strong or special association with particular communities and cultural groups for social, cultural and spiritual reasons. No comment in this regard was received during the public participation period.

3.2.15 Does the site/s have a strong and special association with the life or work of a person, group or organisation?

No indication of the above could be found in primary and secondary research sources.[7]

4. LIMITATIONS

- *Dense vegetation in certain sections.*

5. RECOMMENDATIONS

- There are no visible restrictions or negative impacts in terms of heritage associated with the site. In terms of heritage this project can proceed.
- The discovery of subsurface archaeological and/or historical material as well as graves must be taken into account in the Environmental Management Programme. See 3.2.6 and 3.2.7.

[7] Dictionary of South African Biography (vol I-V) and the TAB database at the National Archives of South Africa

6. WAY FORWARD

- Submit this report as a Section 38 Application in terms of Act 25 of 1999 (National Heritage Resources Act) to the Provincial Heritage Resources Authority of Gauteng (PHRAG).

ANNEXURE D6
AIR QUALITY IMPACT ASSESSMENT

Air Quality Impact Assessment for the Proposed Leeuwpoort Development near Boksburg, Gauteng

Project done on behalf of **Bokamoso Landscape Architects and Environmental Consultants**

Report Compiled by:
Oladapo Akinshipe

Project Manager
Terri Bird

Report No: 16BOK01_Rev.0.1 **| Date:** May 2017

Address: 480 Smuts Drive, Halfway Gardens | **Postal:** P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | **Fax:** +27 (0)11 805 7010
www.airshed.co.za

Report Details

Reference	16BOK01
Status	Rev. 0.1
Report Title	Air Quality Impact Assessment for the Proposed Leeuwpoort Development near Boksburg, Gauteng
Date Submitted	May 2017
Project Consultant	Bokamoso Landscape Architects and Environmental Consultants
Prepared by	**Oladapo Akinshipe,** M.Sc. (Env. Tech, Uni. of Pretoria) Oladapo holds a M.Sc. degree in Environmental Technology from the University of Pretoria. He is currently employed at Airshed Planning Professionals as a Senior Air Quality Specialist for over four years, focusing primarily on air quality impact assessments, air quality management plans, air quality monitoring and reporting. Oladapo has worked on various projects in South Africa, Mozambique, Zambia, Tanzania, Kenya, Namibia and Congo DR. These Projects cuts across various industries including mining and ore handling, metal recovery, power generation, exploration, chemical, petrochemical, clay brick, and waste recycling.
Reviewed by	**Terri Bird,** (Pr. Sci. Nat.), PhD (Wits) Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulfur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012 she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines) as well as coal-fired power station ash disposal facilities. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	I, Oladapo Akinshipe, as authorised representative of Airshed Planning Professionals (Pty) Ltd hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998); other than fair remuneration for worked performed, specifically in connection with the assessment summarised in this report. I also declare that I have expertise in undertaking the specialist work as required, possessing working knowledge of the acts, regulations and guidelines relating to the application. I further declare that I am able to perform the work relating to the application in an objective manner, even if this result in views and findings that is not favourable to the application; and that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Revision Number	Date	Reason for Revision
0	28th April 2017	Draft report for review
0.1	11th May 2017	Incorporation of Bokamoso Review

Specialist Report Requirements (NEMA Regulation, 2014)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	Relevant section in report
a	details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Report details (page ii) Section 8.4 (Appendix D)
b	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Report details (page ii)
c	an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
d	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 3.3
e	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Sections 1.3, 4.1 and 4.2
f	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 3.1
g	an identification of any areas to be avoided, including buffers;	Section 3.1
h	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 1.1, Figure 1,
i	a description of any assumptions made and any uncertainties or gaps in knowledge;	Sections 1.4, 1.5
j	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	Sections 4.3, 6
k	any mitigation measures for inclusion in the EMPr;	Sections 5.2, Table 11
l	any conditions for inclusion in the environmental authorisation;	Section 4.4
m	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 4.4
n	a reasoned opinion- (I) as to whether the proposed activity or portions thereof should be authorised; and (ii) if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 6 Section 6 Sections 4.1 and 5.2, 5.3 and 4.4
o	a description of any consultation process that was undertaken during the course of preparing the specialist report;	NA
p	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	NA
q	any other information requested by the competent authority.	Not applicable

Abbreviations

AERMIC	AMS/EPA Regulatory Model Improvement Committee
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Air Pollution and Prevention Act
AQSR	Air Quality Sensitive Receptor
ASG	Atmospheric Studies Group
ASTM	American Society for Testing and Materials
Bokamoso	Bokamoso Landscape Architects and Environmental Consultants
CE	Control Efficiency
DEA	Department of Environmental Affairs (South Africa)
EETM	Emissions Estimation Technique Manual
ESL	Effects Screening Levels
GLC(s)	Ground level concentration(s)
HPA	Highveld Priority Area
IFC	International Finance Corporation
IRIS	Integrated Risk Information System
Leeuwpoort	Leeuwpoort Developments (Pty) Ltd.
MH	Mixing Height
NAAQS	National Ambient Air Quality Standards (South Africa)
NAEIS	National Atmospheric Emissions Inventory System
NAERR	National Atmospheric Emission Reporting Regulations
NDCR	National Dust Control Regulations
NEM:AQA	National Environmental Management Air Quality Act (South Africa)
NPI	National Pollutant Inventory (Australia)
SA	South Africa(n)
SABS	South African Bureau of Standards
TCEQ	Texas Commission for Environmental Quality
TSP	Total Suspended Particulates
US EPA	United States Environmental Protection Agency
VKT	Vehicle kilometres travelled
VOC(s)	Volatile organic compound(s)

Glossary

Air pollution	This means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances
Ambient air	This is defined as any area not regulated by Occupational Health and Safety regulations
Atmospheric emission or emission	Any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution
Averaging period	This implies a period of time over which an average value is determined
Dispersion	The spreading of atmospheric constituents, such as air pollutants
Dust	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Frequency of Exceedance	A frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard
Mechanical mixing	Any mixing process that utilizes the kinetic energy of relative fluid motion
Oxides of nitrogen (NO_x)	The sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide (NO_2)
Particulate Matter (PM)	These comprise a mixture of organic and inorganic substances, ranging in size and shape. These can be divided into coarse and fine particulate matter. The former is called Total Suspended Particulates (TSP), whilst PM_{10} and $PM_{2.5}$ fall in the finer fraction.
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 µm. it is also referred to as thoracic particulates and is associated with health impacts due to its tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 µm. it is also referred to as respirable particulates. It is associated with health impacts due to its high tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
Vehicle Entrainment	This is the lifting and dropping of particles by the rolling wheels leaving the road surface exposed to strong air current in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed

Symbols and Units

°C	Degrees Celsius
µg	Microgram(s)
µg/m³	Micrograms per cubic meter
CO	Carbon monoxide
CO_2	Carbon dioxide
km	Kilometers
m/s	Metres per second
m^2	Metres squared
mg	Milligram(s)
mm	Millimeters
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
Pb	Lead
PM	Particulate Matter
PM_{10}	Thoracic particulate matter
$PM_{2.5}$	Respirable particulate matter
SO_2	Sulfur dioxide (1)
t/a	Tons per annum

Notes:

(1) The spelling of "sulfur" has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled "sulfur". This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

Executive Summary

Introduction

Leeuwpoort Developments (Pty) Ltd. (Leeuwpoort) in collaboration with Ekurhuleni Metropolitan Municipality (EMM), proposes to establish three developments to serve as Residential or Mixed Use Developments, as follows:

- **Reiger Park Extension 19** – Reiger Park Extension 19 (referred to as Reiger Park or Development A in this report) will be located north of Drommedaris Avenue, and west of Leon Ferreira Road, Boksburg, Gauteng, to serve as a Mixed Use Development. Reiger Park will comprise of the following land uses; Residential 3, Residential 4, community facility, public services, transportation and public open space.
- **Parkdene Extension 7** – Parkdene Extension 7 (referred to as Parkdene or Development B in this report) will be located south and west of Rondebult road, to serve as Mixed Use Development, on part of the remaining extent of the Farm Leeuwpoort 113 IR, Boksburg, Gauteng. Parkdene will comprise of the following land uses; Residential 3, Residential 4, Special for community facility, Industrial 2, Business 2, community facility, public services, transportation, and public open space.
- **Leeuwpoort South** – Leeuwpoort South (referred to as Leeuwpoort South or Development C in this report) will be located south of Sunward Park, Boksburg, Gauteng and situated on part of the remaining extent of the Farm Leeuwpoort 113 IR. Leeuwpoort South will comprise of the following land uses; Residential 1, Residential 3, Residential 4, Business 2, Business 3, Special (for clinic, retirement village and frail care), gate houses, agriculture and other uses with consent, public services, community facility, transportation, and public open space.

The construction of the three developments (the Project) may impact ambient air quality in the surrounding areas. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Bokamoso Landscape Architects and Environmental Consultants (Bokamoso) to undertake an air quality impact assessment for the Project in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA).

Scope and Approach

The following tasks, typical of an air quality impact assessment, are included in the scope of work:

- A review of proposed project activities in order to identify sources of emission and associated pollutants;
- A study of regulatory requirements and inhalation thresholds for identified key pollutants against which compliance need to be assessed and health risks screened;
- A study of the receiving environment in the vicinity of the Project; including:
  - The identification of potential air quality sensitive receptors (AQSRs);
  - A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
  - The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
- The compilation of a comprehensive emissions inventory:
  - Pollutants quantified will include particulate matter (TSP, PM_{10} and $PM_{2.5}$), and selected criteria gaseous pollutants i.e. carbon monoxide (CO), oxides of nitrogen (NOx) and sulfur dioxide (SO_2) will also be included if considered significant, especially during the construction phase. Published emissions factors from the US EPA and Australian National Pollutant Inventory (NPI) may be used to calculate emissions from the operations.

    - Non-criteria pollutants will also be quantified, including metallic compounds found in nearby gold tailings dumps and within the Project area.
- Atmospheric dispersion modelling to simulate ambient air pollutant concentrations and dustfall rates as a result of the Project.
- A screening assessment to determine:
    - Compliance of simulated criteria pollutant concentrations with ambient air quality standards;
    - The potential for health impacts as a result of exposure to non-criteria pollutants; and
    - Nuisance dustfall.
- The ranking of impact significance based on the methodology adopted by Bokamoso.
- The compilation of a comprehensive air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts.

The air quality impact assessment included a study of the receiving environment and the quantification and assessment of the impact of the Project on human health and the environment. The receiving environment was described in terms of local atmospheric dispersion potential, the location of potential AQSRs in relation to proposed activities as well as existing ambient pollutant levels and dustfall rates.

A comprehensive atmospheric emissions inventory was compiled for the construction phase of the Project. Pollutants quantified included those most commonly associated with residential and mixed use developments i.e. particulate matter (TSP, PM_{10}, and $PM_{2.5}$). PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Respirable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, total suspended particulate matter (TSP) is included to assess nuisance dust effects.

All particulate matter (PM) emissions were determined through the application of emission factors published by the US EPA and the Australian NPI. In estimating emissions due to construction phase activities, “design mitigation” as provided by Bokamoso, was utilized. Design mitigation refers to mitigation included in the Project design, which comprise the use of water sprayers and dust suppression systems on haul roads, exposed areas and all materials handling points. Non-criteria pollutants (metallic compounds from gold tailings dump) were also quantified from composition of gold tailing sample analysis.

Main Findings and Recommendation

The main findings of the assessment are summarised below:

- The receiving environment:
    - In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services, was utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South.
    - The Project area is dominated by strong winds from the north and northwest. The night-time wind rose recorded high wind speeds from the north and northwest, while the day-time wind rose recorded dominant winds from the north. An average wind speed of 4.2 m/s was measured over the 2013 to 2015 period.
    - Ambient air pollutant levels in the Project area are currently affected by the following sources of atmospheric emission; mining; industries, vehicle tailpipe emissions; agriculture; domestic fuel combustion and open areas exposed to wind erosion.

- AQSRs around the Project site include residential settlement, townships, schools, mosques and churches.

- Impact of the Project:
  - Construction phase:
    - Sources of emission quantified included area wide construction, materials handling, vehicles entrained PM on unpaved roads, windblown dust from the stockpiles.
    - Construction phase PM emissions ($PM_{2.5}$, PM_{10} and TSP) and metallic compound composition in tailings material were quantified and utilized in dispersion simulations.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of *DRD Gold's tailings recovery operation*, are generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of *removal of on-site contaminated tailings material at Reiger Park and Parkdene*, are also generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of *construction phases of the three developments* (Reiger Park, Parkdene and Leeuwpoort South) are generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Furthermore, maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of the worst case scenario – a situation when *all three construction sites and DRD Gold's tailings recovery are at peak operation* (construction of sites A, B and C + DRD Gold's operation) are also generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Finally, maximum simulated short-term and long-term impacts due to metallic compounds found in gold tailings are also low and below their respective guideline or standards. A significance rating of 'low' was assigned to potential inhalation health impacts associated with these impacts.

In conclusion, it is the specialist opinion that the project may be authorised provided that the recommended air quality management measures are implemented in order to ensure the lowest possible impact on nearby AQSRs and the environment. These air quality management measures include:

- Commissioning of a complaint register on all three construction sites at the commencement of construction activities; and
- Mitigation measures aimed at reducing emissions at sources.

Table of Contents

List of Tables

List of Figures

Air Quality Impact Assessment for the Proposed Leeuwpoort Development near Boksburg, Gauteng

1 INTRODUCTION

Leeuwpoort Developments (Pty) Ltd. (Leeuwpoort) in collaboration with Ekurhuleni Metropolitan Municipality (EMM), proposes to establish three developments to serve as Residential or Mixed Use Developments, as follows (Figure 1):

- **Reiger Park Extension 19** – Reiger Park Extension 19 (referred to as Reiger Park or Development A in this report) will be located north of Drommedaris Avenue, and west of Leon Ferreira Road, Boksburg, Gauteng, to serve as a Mixed Use Development. Reiger Park will comprise of the following land uses; Residential 3, Residential 4, community facility, public services, transportation and public open space.
- **Parkdene Extension 7** – Parkdene Extension 7 (referred to as Parkdene or Development B in this report) will be located south and west of Rondebult road, to serve as Mixed Use Development, on part of the remaining extent of the Farm Leeuwpoort 113 IR, Boksburg, Gauteng. Parkdene will comprise of the following land uses; Residential 3, Residential 4, Special for community facility, Industrial 2, Business 2, community facility, public services, transportation, and public open space.
- **Leeuwpoort South** – Leeuwpoort South (referred to as Leeuwpoort South or Development C in this report) will be located south of Sunward Park, Boksburg, Gauteng and situated on part of the remaining extent of the Farm Leeuwpoort 113 IR. Leeuwpoort South will comprise of the following land uses; Residential 1, Residential 3, Residential 4, Business 2, Business 3, Special (for clinic, retirement village and frail care), gate houses, agriculture and other uses with consent, public services, community facility, transportation, and public open space.

The construction of the three developments (the Project) may impact ambient air quality in the surrounding areas. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Bokamoso Landscape Architects and Environmental Consultants (Bokamoso) to undertake an air quality impact assessment for the Project in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA).

1.1 Scope of Work

The purpose of this investigation is to determine baseline air quality conditions, identify sensitive receptors and assess potential impacts to air quality that may arise from the Project.

The following tasks, typical of an air quality impact assessment, are included in the scope of work:

- A review of proposed project activities in order to identify sources of emission and associated pollutants;
- A study of regulatory requirements and inhalation thresholds for identified key pollutants against which compliance need to be assessed and health risks screened;
- A study of the receiving environment in the vicinity of the Project; including:
    - The identification of potential air quality sensitive receptors (AQSRs);
    - A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    - The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
- The compilation of a comprehensive emissions inventory:

- Pollutants quantified will include particulate matter (TSP, PM_{10} and $PM_{2.5}$), and selected criteria gaseous pollutants i.e. carbon monoxide (CO), oxides of nitrogen (NO_X) and sulfur dioxide (SO_2) may also be included if considered significant, during the construction phase. Published emissions factors from the US EPA and Australian National Pollutant Inventory (NPI) may be used to calculate emissions from the operations.
- Non-criteria pollutants will also be quantified, including metallic compounds found in nearby gold tailings dumps and within the Project area.

- Atmospheric dispersion modelling to simulate ambient air pollutant concentrations and dustfall rates as a result of the Project.
- A screening assessment to determine:
    - Compliance of simulated criteria pollutant concentrations with ambient air quality standards;
    - The potential for health impacts as a result of exposure to non-criteria pollutants; and
    - Nuisance dustfall.
- The ranking of impact significance based on the methodology adopted by Bokamoso.
- The compilation of a comprehensive air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts.

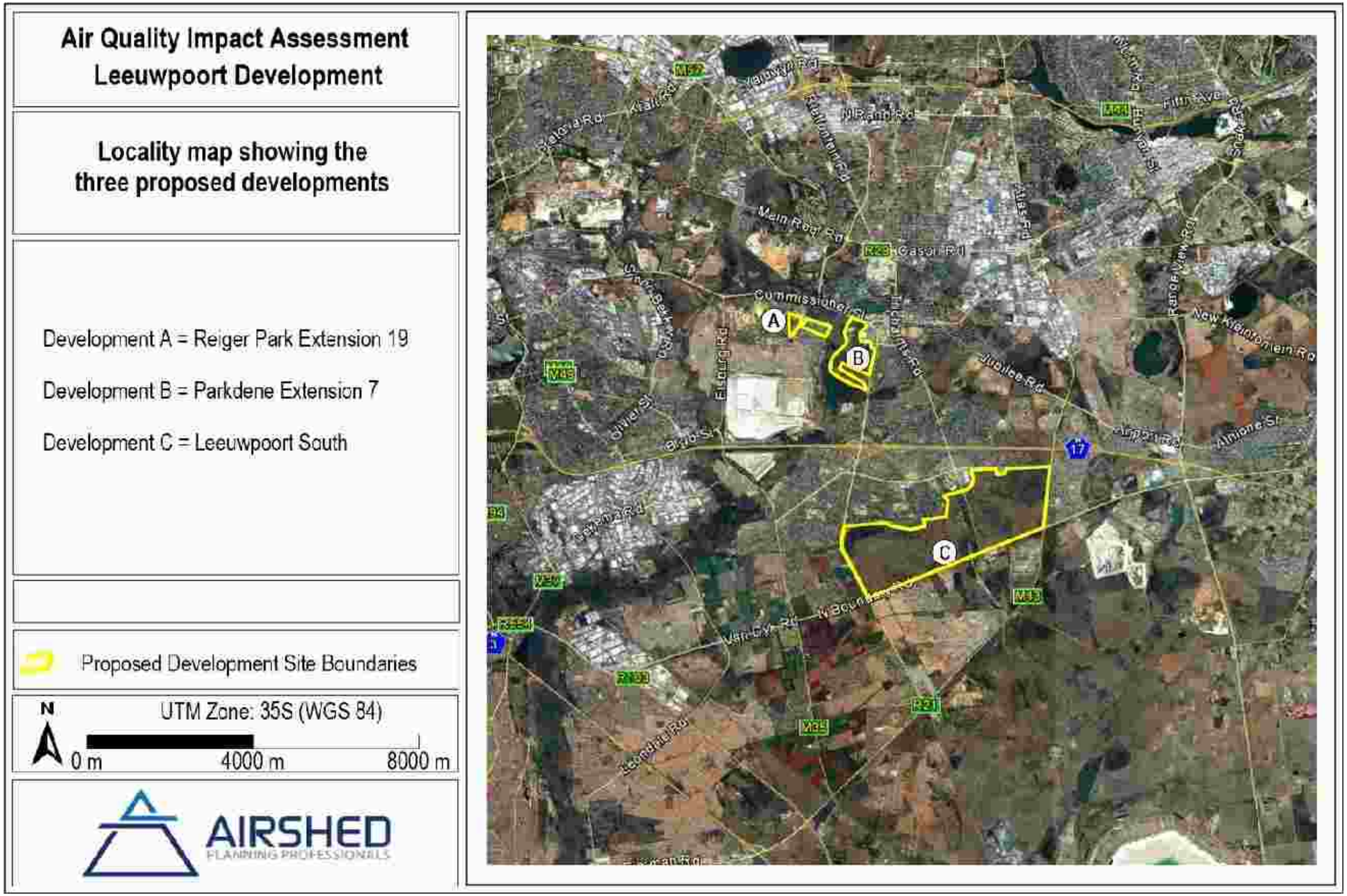


Figure 1: Locality map showing the extent of the boundaries for the three proposed developments and surrounding areas

1.2 Description of Project Activities from an Air Quality Perspective

Air quality impacts will be associated with the construction phase of the project. A description of the construction phase, from an air quality impact perspective, is summarised below.

Construction will typically include land clearing of the construction footprint, general construction activities (i.e. bulk earthworks and infrastructure development for buildings and on-site roads etc.), bulldozing, loading and grading activities. These operations will likely result in fugitive[1] particulate matter (PM) emissions as well as particulate and gaseous vehicle exhaust emissions. Gaseous emissions, associated with the combustion of diesel, mainly include carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOC). However, gaseous emission rates are generally low and immaterial for construction activities.

Particulate emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site (US EPA, 1995).

It is important to note that, in the discussion, regulation and estimation of PM emissions and impacts, a distinction is made between different particle size fractions, *viz*. TSP, PM_{10} and $PM_{2.5}$. PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Respirable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, total suspended particulate matter (TSP) is included to assess nuisance effects.

1.3 Approach and Methodology

The approach and methodology followed in the completion of tasks included in the scope of work are discussed below:

1.3.1 Project Information and Activity Review

All project related information referred to in this study was provided by Bokamoso. Project information relating to DRD Gold's operation was obtained from DRD Gold personnel.

1.3.2 The Identification of Regulatory Requirements and Screening Criteria

In the evaluation of ambient air quality impacts and dustfall rates reference was made to:

- South African National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR) as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEM:AQA); and
- Screening levels for non-criteria pollutants published by various international institutions.

1.3.3 Study of the Receiving Environment

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services (SAWS), was

[1] Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007).

utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South.

1.3.4 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the Project's emissions on the receiving environment. In the quantification of emissions, emission factors which associate the quantity of release of a pollutant to the related activities were used. Emissions were calculated using emission factors and equations published by the United States Environmental Protection Agency (US EPA) and Environment Australia (EA) in their National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETMs).

1.3.5 Compliance Assessment and Health Risk Screening

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations ($PM_{2.5}$ and PM_{10}) and dustfall rates to selected ambient air quality and dustfall criteria. Health risk screening was done through the comparison of simulated non-criteria pollutant concentrations (metallic compounds found in gold tailings) to selected inhalation screening levels.

1.3.6 Impact Significance

The significance of impacts was determined in accordance with the procedure adopted and prescribed by Bokamoso and in line with the requirements for impact assessment as outlined in the NEMA.

1.3.7 The Development of an Air Quality Management Plan

The findings of the above components informed recommendations of air quality management measures, including mitigation and reporting.

1.4 Assumptions, Exclusions and Uncertainties

The following important assumptions, exclusions and uncertainties to the specialist study should be noted:

- Project information required to calculate emissions for Project operations were provided by Bokamoso. Where necessary, assumptions were made based on common industry practice and experience.
- Only routine emissions for the construction phase were estimated and simulated. Atmospheric releases occurring as a result of non-routine conditions were not accounted for. This non-routine releases are expected to be minimal.
- Emission factors were used to estimate all fugitive and processing emissions resulting from all construction and transportation activities. These emission factors generally assume standard operating conditions.
- The exact locations of all sources within the site are bound to change throughout the construction duration. Allocation of the unknown sources into a representative volume or area source was done during the study.
- In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services (SAWS), was utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South.
- The impact assessment was limited to criteria particulates (including TSP, PM_{10} and $PM_{2.5}$) and non-criteria pollutants (metallic compounds from gold tailings dump).

- Operational phase impacts were not quantified. Air quality impacts associated with operation of mixed use developments are generally less significant than the construction phase.
- Dispersion models cannot compute real time impacts, hence designed maximum rates of activity were utilised. Though the nature of the construction operations (active working area and roads) may change over the duration of construction, the proposed sites were modelled to reflect the worst case condition (i.e. resulting in the highest impacts and/or closest to AQSRs).
- There will always be some degree of uncertainty in any geophysical model, but it is desirable to structure the model in such a way to minimize the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere. Nevertheless, dispersion modelling is generally accepted as a scientific and valuable tool in air quality management.

1.5 Gaps in Knowledge

The following was identified as gaps in knowledge during the specialist study and should be noted:

- The quantification of sources of emission was restricted to the Project. Hence, only incremental impacts due to PM_{10} and $PM_{2.5}$, as well as incremental dustfall effects were simulated. Cumulative impacts were not simulated since on-site pre-development ambient data was not available for the Project site. However, cumulative impacts were assessed qualitatively based on elevated pollutants levels in the Project region. Cumulative impacts were also considered in recommending monitoring and mitigation measures for the Project.

2 REGULATORY REQUIREMENTS AND IMPACT ASSESSMENT CRITERIA

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the environmental regulations governing the impact of such operations i.e. emission standards, ambient air quality standards and dust control regulations.

Emission standards are generally set for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods. This section summarises legislation for criteria and non-criteria pollutants relevant to the study and dustfall impacts.

2.1 Emission Standards

The NEM:AQA (Act No. 39 of 2004 as amended) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) are included as listed activities with additional activities added to the list. The updated Listed Activities and Minimum National Emission Standards were published on the 22nd November 2013 in Government Gazette No. 37054 (DEA, 2013).

According to the Project description, none of the Projects activities are expected to trigger the MES's or the need for an AEL application.

2.2 Ambient Air Quality Standards for Criteria Pollutants

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. In the context of this project, these include CO, NO_2, $PM_{2.5}$, PM_{10} and SO_2.

The South African Bureau of Standards (SABS) assisted the Department of Environmental Affairs (DEA) in the development of ambient air quality standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for PM_{10}, $PM_{2.5}$, dustfall, SO_2, NO_2, ozone (O_3), CO, lead (Pb) and benzene (C_6H_6). The final revised NAAQSs were published in the Government Gazette on 24 of December 2009 and included a margin of tolerance (i.e. frequency of exceedance) and implementation timelines linked to it. NAAQS for $PM_{2.5}$ were published on 29 July 2012. The NAAQSs referred to in this study are listed in Table 1.

Table 1: Air quality standards for criteria pollutants (SA NAAQS)

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
CO	1 hour	30 000	26 000	88	Immediate
	8 hour	10 000	8 700	11	Immediate
NO_2	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM_{10}	24 hour	75	-	4	1 Jan 2015
	1 year	40	-	0	1 Jan 2015
$PM_{2.5}$	24 hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	1 year	20	-	0	1 Jan 2016 – 31 Dec 2029
SO_2	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate
Pb	1 year	0.5	-	0	Immediate

2.3 Inhalation Health Criteria for Non-Criteria Pollutants

The potential for health impacts associated with non-criteria pollutants released from gold tailings recovery operations are assessed according to guidelines published by the Texas Commission on Environmental Quality (TCEQ) – Effects screening levels (ESLs). ESLs for metallic pollutants considered in the study are summarised in Table 2 (TCEQ, 2013).

Table 2: Chronic and acute inhalation screening criteria and cancer unit risk factors

Metal	Associated Substance in TCEQ	Short-term ESL ($\mu g/m^3$)	Long-term ESL ($\mu g/m^3$)
Silver, Ag	silver chloride (as Ag)	0.1 [a]	0.01 [a]
Aluminium, Al	sodium aluminium oxide	20 [a]	2 [a]
Arsenic, As	arsenic & inorganic compounds	3 [a]	0.067 [a]
Gold, Au	gold	25 [a]	2.5 [a]
Barium, Ba	barium & compounds (as Ba)	5 [a]	0.5 [a]
Beryllium, Be	beryllium, particulate	2.00 x10-2	0.002
Bismuth, Bi	bismuth & compounds	50 [a]	5 [a]
Calcium, Ca	calcium alkanoate solution, mixture (as Ca)	50 [a]	5 [a]
Cadmium, Cd	cadmium & compounds (as Cd)	0.1 [a]	0.01 [a]
Cobalt, Co	cobalt chloride (as Co)	0.2 [a]	0.02 [a]
Chromium, Cr	elemental chromium	3.6 [a]	0.041 [a]
Copper, Cu	copper (II) sulfate (as copper dust)	10 [a]	1 [a]
Iron, Fe	ferrous chloride (as Fe; iron salts, soluble)	10 [a]	1 [a]
Mercury, Hg	mercury metal & inorganic forms	0.25 [a]	0.025 [a]
Lithium, Li	lithium silicate (as lithium)	10 [a]	1 [a]
Magnesium, Mg	magnesium nitrate (as Mg)	50 [a]	5 [a]
Manganese, Mn	manganese carbonate (as Mn)	2 [a]	0.2 [a]
Nickel, Ni	nickel, metal & compounds	0.33 [a]	0.059 [a]
Uranium, U	uranium, insoluble compounds	2 [a]	0.2 [a]
Vanadium, V	vanadium & compounds (as vanadium pentoxide)	0.5 [a]	0.05 [a]

NOTE: [a] based on analysis of PM_{10} samples.

2.4 National Dust Control Regulations

The National Dust Control Regulations (NDCR) was published on the 1st of November 2013. The purpose of the regulation is to prescribe general measures for the control of dust in all areas including residential and non-residential areas. Acceptable dustfall rates according to the regulation are summarised in Table 3.

Table 3: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m^2-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

2.5 Screening Criteria for Vegetation

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of what the impact of dustfall on vegetation is in the South African context, a review of European studies have shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dustfall rates greater than 400 mg/m²/day (Farmer, 1993).

2.6 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding air dispersion modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, (DEA, 2014) and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

(a) in the development of an air quality management plan, as contemplated in Chapter 3 of the NEM:AQA;
(b) in the development of a priority area air quality management plan, as contemplated in section 19 of the NEM:AQA;
(c) in the development of an atmospheric impact report, as contemplated in section 30 of the NEM:AQA; and,
(d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the NEM:AQA.

The Regulation has been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications. The proposed operation falls under a Level 2 assessment which is described as follows;

- The distribution of pollutant concentrations and deposition are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed operation is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometers (less than 50 km) downwind.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulation prescribe the source data input to be used in the model. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required.

Chapter 4 of the Regulation prescribe meteorological data input from on-site observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result.

The modelling domain would normally be decided on the expected zone of influence; the extent being defined by simulated ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact adequately covered.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system requirements, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air pollutant concentration data. Chapter 6 also provides guidance on the treatment of NO_2 formation from NOx emissions, chemical transformation of SO_2 into sulfates and deposition processes. Chapter 7 of the Regulation outlines how the plan of study and modelling assessment reports are to be presented to authorities.

2.7 Highveld Priority Area – Air Quality Management Plans

With the shift of the new Air Quality Act from source control to the impacts on the receiving environment, the responsibility to achieve and manage sustainable development has reached a new dimension. The Air Quality Act has placed the responsibility of air quality management on the shoulders of provincial and local authorities that will be tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objective of the act is to ensure the protection of the environment and human health through reasonable measures of air pollution control within the sustainable (economic, social and ecological) development framework.

An Air Quality Management Plan for the Highveld Priority Area (HPA) was gazetted on the 2nd of March 2012 (Government Gazette No. 35072). The plan includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years. Included in this management plan are seven goals, each of which has a further list of objectives that has to be met. The seven goals for the Highveld Priority area are as follows:

- **Goal 1:** By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards;
- **Goal 2:** By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fall-out limit values;
- **Goal 3:** By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards;
- **Goal 4:** By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy;
- **Goal 5:** By 2020, a measurable increase in awareness and knowledge of air quality exists;
- **Goal 6:** By 2020, biomass burning and agricultural emissions will be 30% less than current and
- **Goal 7:** By 2020, emissions from waste management are 40% less than current.

The proposed Project falls within the HPA and therefore, emissions as a result of the Project will contribute to the air quality of the HPA. AQMP for the Project should therefore support the goals of the HPA.

3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

3.1 Air Quality Sensitive Receptors

Air quality sensitive receptors (AQSRs) primarily refer to places where humans reside, schools and hospitals. Ambient air quality guidelines and standards, as discussed under section 2, have been developed to protect human health. Ambient air quality, in contrast to occupational exposure, pertains to areas outside of an industrial site boundary where the public has access to and according to the Air Quality Act, excludes areas regulated under the Occupational Health and Safety Act (Act No 85 of 1993).

Towns and villages located around the Project boundary include residential settlement, townships, schools, mosques and churches. These AQSRs are listed in Table 4 and also illustrated in Figure 2.

Table 4: List of AQSRs surrounding the Project area

Receptor Number	Receptor Name	Receptor Number	Receptor Name
R1	Reiger Park	R22	Freeway Park
R2	East Rand Pty Mines	R23	Elspark
R3	Angelo	R24	Sunward Park
R4	Delmore Park	R25	Van Dykpark
R5	Plantation	R26	Van Wyk Dam
R6	Parkdene	R27	Salfin
R7	Cinderella	R28	Ethembeni Park
R8	Libradene	R29	Windmill Park
R9	Farrar Park	R30	Dawn Park
R10	Boksburg North	R31	Rondebult 136-Ir
R11	Cinderella Dam	R32	Klippoortje
R12	Boksburgmeer	R33	Groeneweide
R13	Parkrand	R34	Klippoortje 110-Ir
R14	Martin Du Preezville	R35	Rondebult 136-Ir
R15	Tedstone Ville	R36	Vredebos
R16	Elsburg	R37	Villa Liza
R17	Parkhill Gardens	R38	Waterlands
R18	Delville	R39	Roodekop
R19	Estera	R40	Spruitview
R20	Lambton Gardens	R41	Benoni South
R21	Cruywagen Park	R42	Dalpark

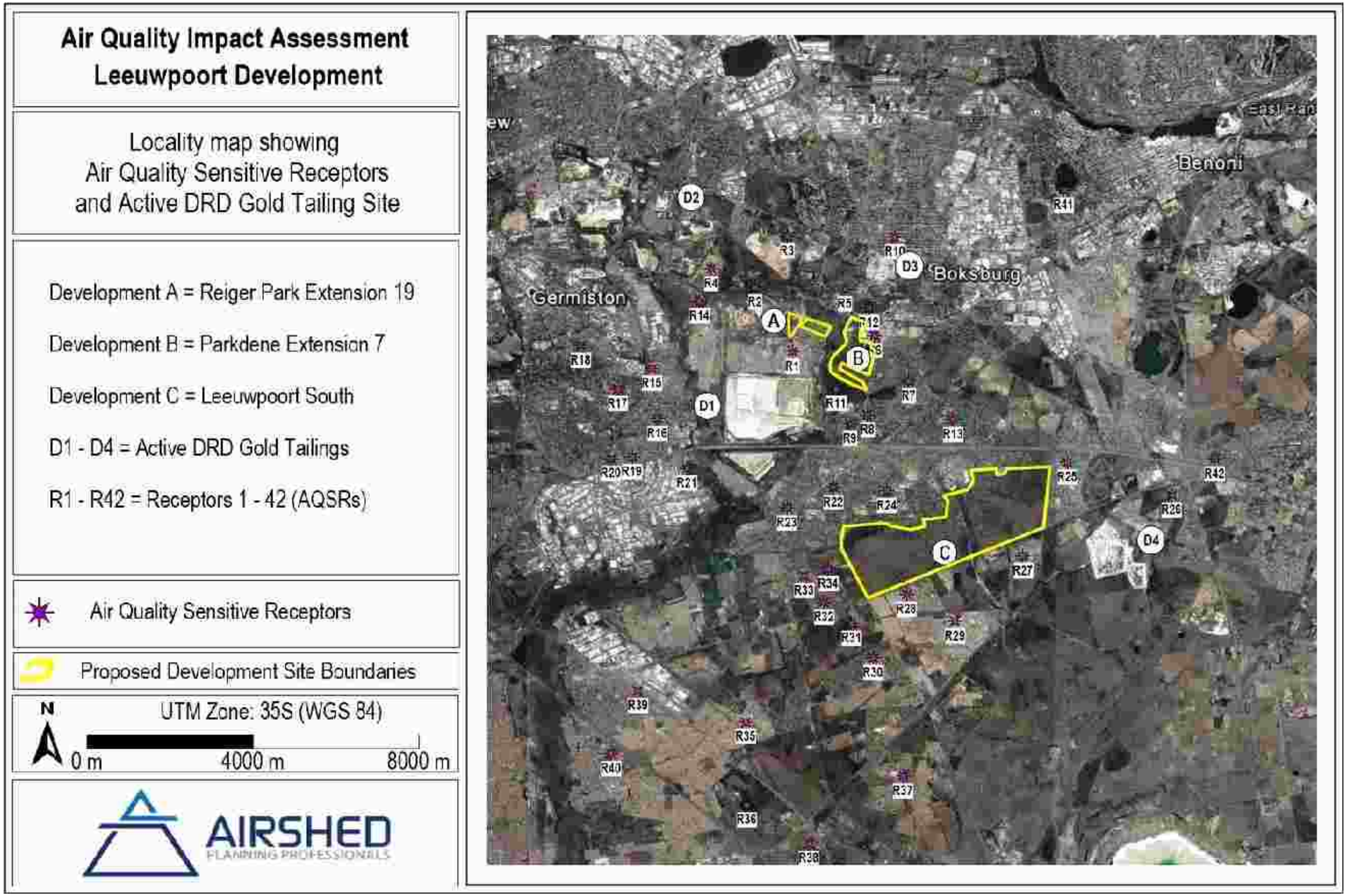


Figure 2: AQSRs surrounding the Project area

3.2 Atmospheric Dispersion Potential

Physical and meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed. In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services (SAWS), was utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South.

3.2.1 Topography

The study area is characterised by a flat surface with sparse vegetation. An analysis of topographical data indicated a slope of less than 1:10 from over most of the Project area. Dispersion modelling guidance recommends the inclusion of topographical data in dispersion simulations only in areas where the slope exceeds 1:10 (US EPA, 2004).

3.2.2 Surface Wind Field

The horizontal dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness.

Period and diurnal wind roses drawn from SAWS' OR Tambo International Airport weather station data are shown in Figure 3. Seasonal variations in the wind field are shown in Figure 4. Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing wind speeds between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

Data availability recorded for this period is ~99.8 % with an average wind speed of 4.2 m/s. The wind field for the entire period was dominated by winds from the north and northwest. The night-time wind rose recorded high wind speeds dominated by winds from the north and northwest, while the day-time wind rose recorded dominant winds from the north.

Seasonal wind roses produced slight variations from the periodic wind roses. The autumn wind rose recorded moderate wind speeds from the northwest and west northwest. The summer and winter wind roses recorded higher wind speeds from the north and northwest, with moderate components from the east and southwest respectively. The spring wind rose recorded significantly higher wind speeds from the north, with less dominant winds from the northwest and north-northwest.

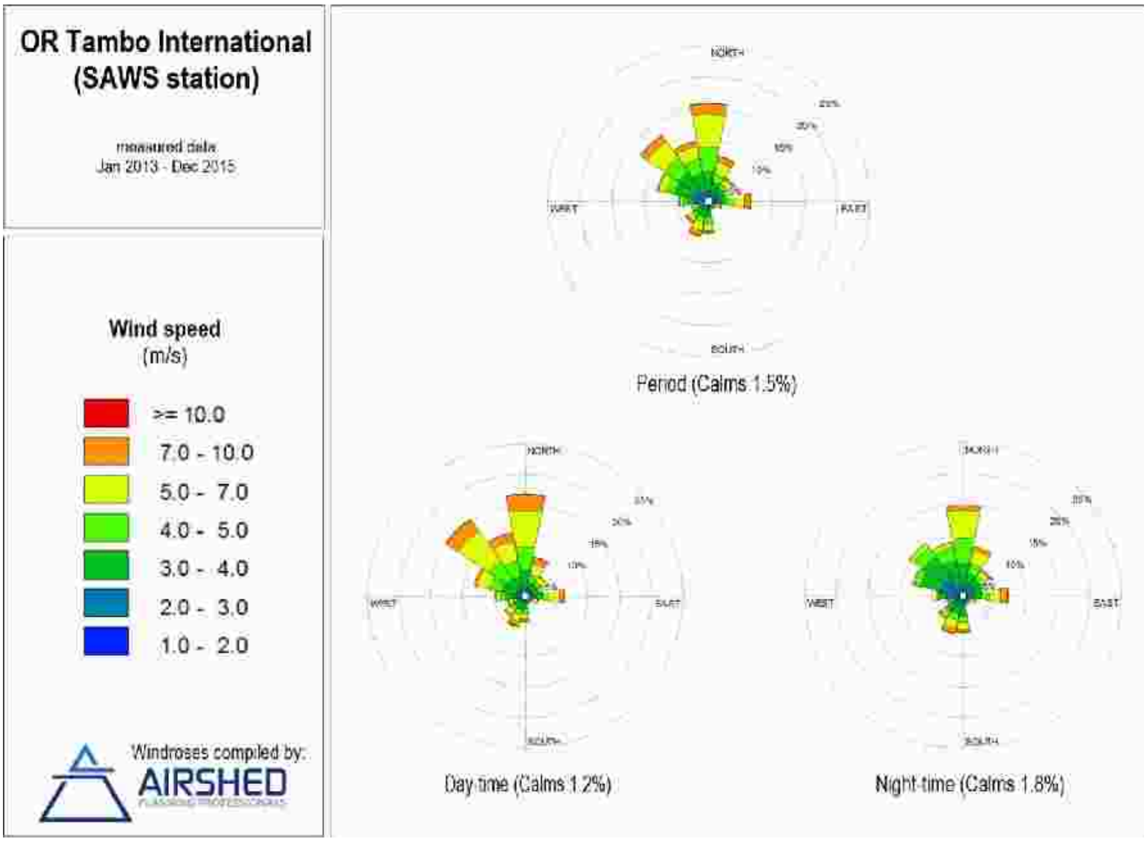


Figure 3: Period, day- and night-time wind roses – OR Tambo International Airport weather data (2013 – 2015)

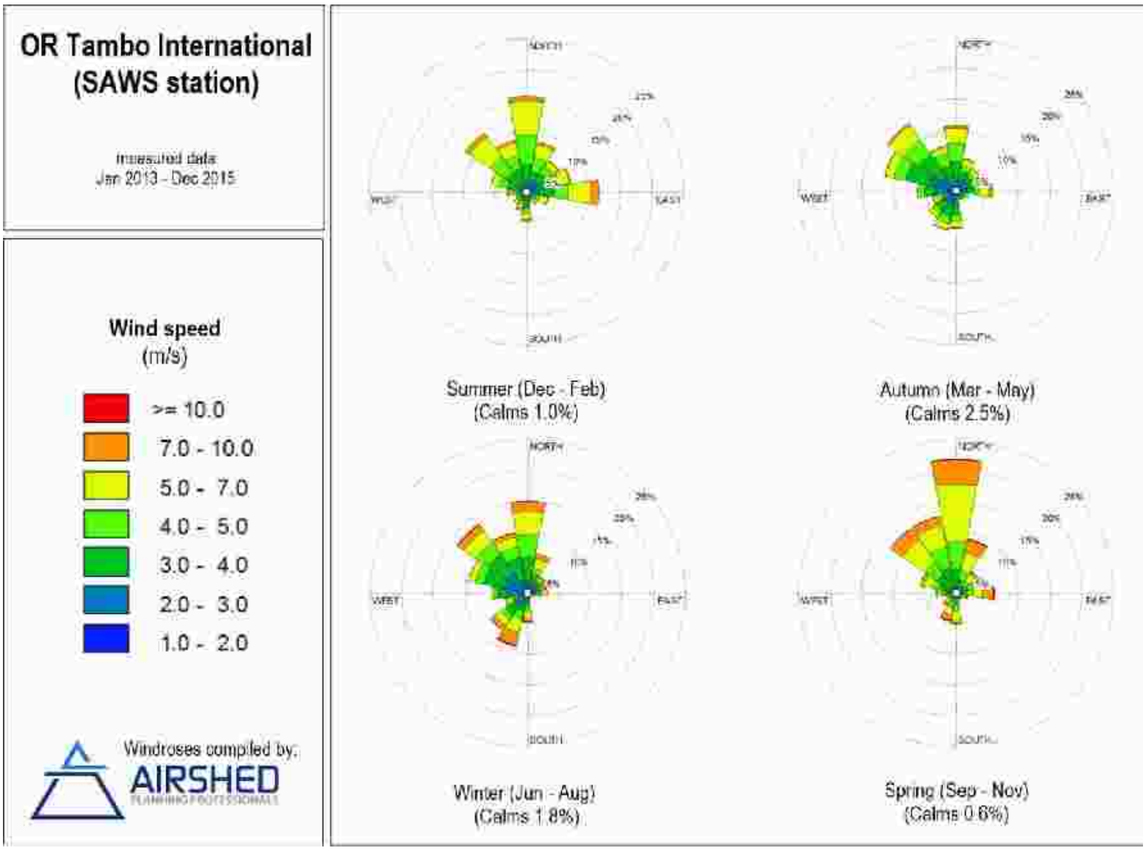


Figure 4: Seasonal wind roses – OR Tambo International Airport weather data (2013 – 2015)

3.2.3 Temperature

Air temperature provides an indication of the extent of insolation, and therefore of the rate of development and dissipation of mixing dispersion layers. Monthly mean, maximum and minimum temperatures are given in Table 5 while diurnal and average monthly temperature trends are presented in Figure 5. Monthly temperatures ranged between -3.3°C and 33.0°C. During the day, temperatures increase to reach maximum at around 14:00 – 15:00 in the afternoon during summer. Ambient air temperature decreases to reach a minimum at around 07:00 – 08:00 (before sunrise) during winter.

Table 5: Monthly temperature summary – OR Tambo International Airport weather station (2013 – 2015)

Monthly Minimum, Maximum and Average Temperatures (°C) OR Tambo International Airport weather station (January 2013 to December 2015)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	12.8	11.2	9.6	0.0	1.8	-1.3	-3.3	-1.9	-0.4	3.5	4.4	10.5
Average	20.6	20.6	18.6	16.0	15.4	11.5	11.4	13.9	17.5	19.0	19.1	20.2
Maximum	31.5	30.8	30.7	26.3	25.5	22.6	21.3	27.5	30.3	31.4	33.0	32.2

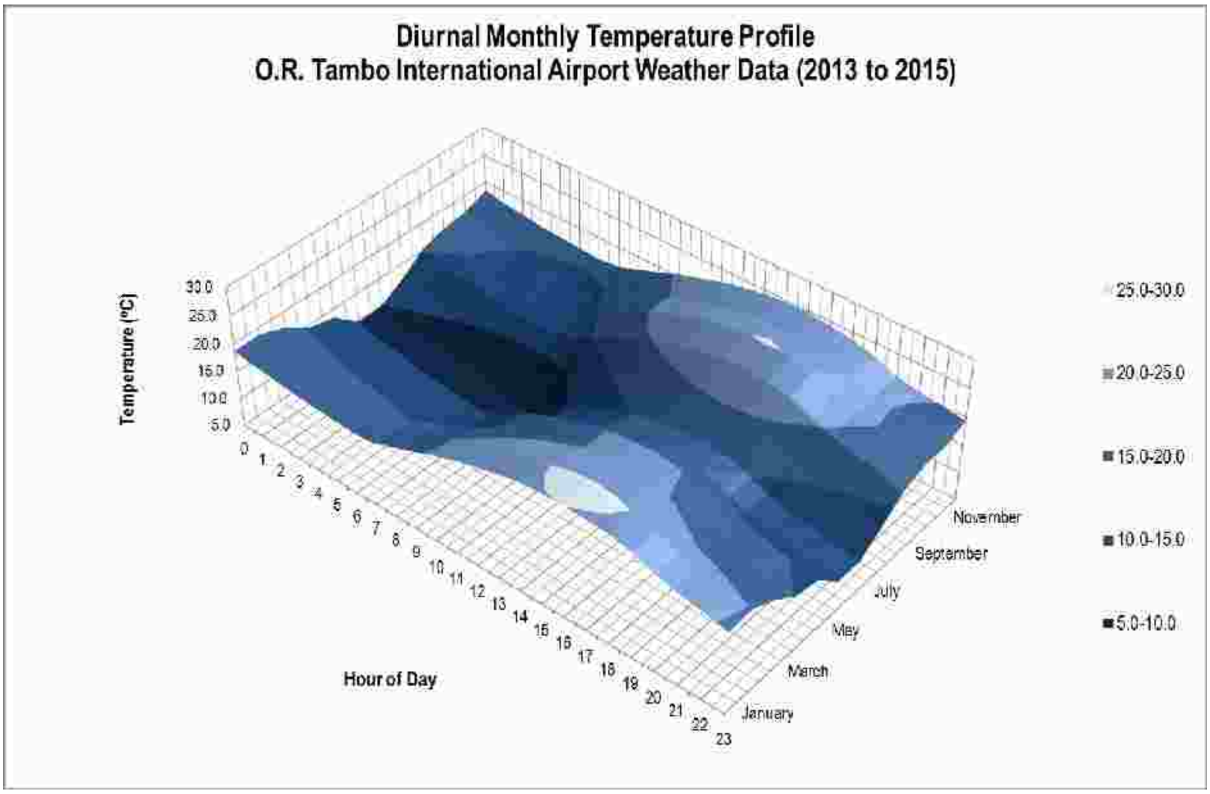
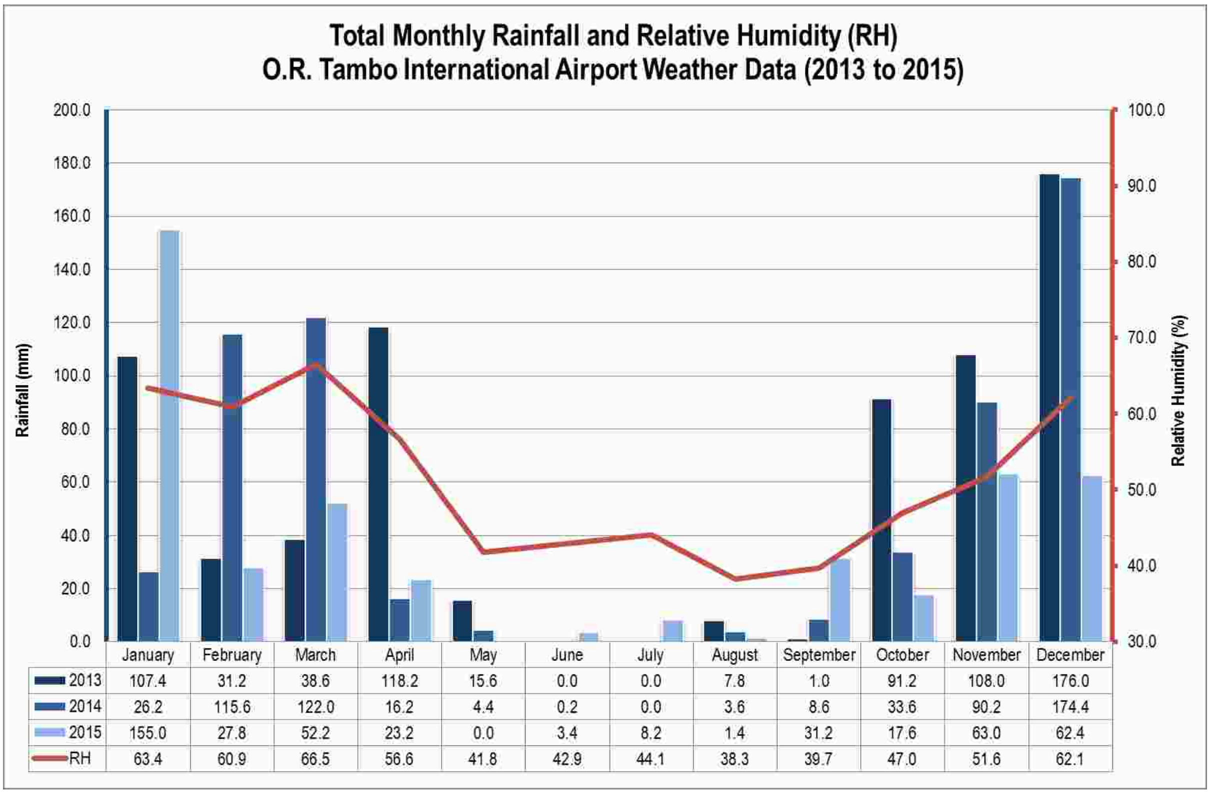


Figure 5: Diurnal temperature profile – OR Tambo International Airport weather station (2013 – 2015)

3.2.4 Rainfall and Relative Humidity

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants, and a natural dust suppression mechanism for fugitive dust sources. The weather data at OR Tambo International Airport recorded annual rainfall of 696 mm, 595 mm and 445 mm for the 2013, 2014 and 2015 period respectively. The amount of rainfall begins to increase during the spring months, reaching its peak by the summer months; and begins to dip by late autumn, hitting its lowest during the winter months. The number of days per year in which the rainfall amount exceeded the “trace of precipitation” amount of 0.254 mm is 79, 73 and 65, respectively for the years 2013, 2014 and 2015.

Relative humidity is the ratio of the actual water vapour content (moisture in the air) compared to the amount of water vapour required for saturation (maximum moisture the air can "hold") at a particular temperature and pressure. Humidity can influence the amount of precipitation recorded in a region and can also influence the impact of air pollution on visibility. For instance, a high relative humidity will significantly increase the adverse effects of pollution on visibility (Tiwary and Colls, 2010). The annual mean relative humidity recorded over the 2013, 2014 and 2015 period was ~ 52.4%, 53.9% and 47.5% respectively. Monthly rainfall and relative humidity obtained from OR Tambo International Airport weather station is presented in Figure 6.



	January	February	March	April	May	June	July	August	September	October	November	December
2013	107.4	31.2	38.6	118.2	15.6	0.0	0.0	7.8	1.0	91.2	108.0	176.0
2014	26.2	115.6	122.0	16.2	4.4	0.2	0.0	3.6	8.6	33.6	90.2	174.4
2015	155.0	27.8	52.2	23.2	0.0	3.4	8.2	1.4	31.2	17.6	63.0	62.4
RH	63.4	60.9	66.5	56.6	41.8	42.9	44.1	38.3	39.7	47.0	51.6	62.1

Figure 6: Monthly rainfall – OR Tambo International Airport weather station (2013 – 2015)

3.3 Site Visit

A site visit was not conducted for the air quality impact assessment. Adequate project information was obtained from Bokamoso, as well as from previous studies done in the area. Since ambient air quality monitoring was not included as part of the air quality assessment, a site visit will not have yielded any significant additional information from the baseline information received.

3.4 Ambient Air Quality within the region

3.4.1 Sources of Air Pollution within the Region

Mining and industrial activities, farming and residential land-uses occur in the vicinity of the Project. These land-use activities contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute significantly to background fine particulate concentrations within the South African boundary (Andreae, et al., 1996; Garstang, et al., 1996; Piketh, et al., 1996).

Sources of atmospheric emissions include:

- Gaseous and particulate emissions from mining and tailings recovery operations;
- Gaseous and particulate emissions from industrial operations;
- Miscellaneous fugitive dust sources including vehicle entrainment on roads and windblown dust from open areas;
- Gaseous and particulate emissions from vehicles and aircraft;
- Gaseous and particulate emissions from household fuel burning; and
- Gaseous and particulate emissions from biomass burning/veld fires (e.g. wild fires).

3.4.1.1 Mining Operations

Gold mining is the primary mining activity in the EMM; while coal, clay, dolomite, silver and rock are also mined (SRK Consulting, 2003). Recovery of gold tailings operations is also common in the region. Four active gold tailings recovery operations have been identified within a 5 km radius of the Project and are included in this study to determine their contribution to ambient concentration levels. Fugitive emissions sources from mining and tailings recovery operations mainly comprise of land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas and drilling and blasting. These activities mainly result in fugitive dust releases with small quantities of NO_x, CO, SO_2, CH_4 and CO_2 being released during blasting operations.

3.4.1.2 Industrial operations

According to SRK Consulting (2003), over 8000 industries are found in 20 industrial areas in the EMM. The main emissions from industrial operations are carbon dioxide (CO_2), SO_2, NOx and PM. Particulates emitted may comprise various trace elements such as arsenic, chromium, cadmium, lead, manganese, nickel, vanadium and zinc. Varying levels of volatile organic compounds (VOCs) are also released through the combustion paraffin, coal, diesel etc.

3.4.1.3 Fugitive Dust from Paved and Unpaved Roads

Emissions from unpaved roads constitute a major source of emissions to the atmosphere in the South African context. When a vehicle travels on an unpaved road the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic and the silt loading on the roads. Unpaved roads in the region are mainly haul roads.

Emissions from paved roads are significantly less than those originating from unpaved roads; however, they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface. Paved roads in the region include the R21, N17, R21, R554 etc.

3.4.1.4 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, while secondary pollutants are formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, diesel particulate matter (DPM) and lead (Pb). Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulfur acid, sulfates, nitric acid, nitric acid and nitrate aerosols. Hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

Transport in the vicinity of the Project is via trucks and private vehicles along the R21, N17, R21 and R554 roads, as well as other municipal roads, which are the main sources of vehicle tailpipe emissions; as well as unpaved haul roads. The OR Tambo International Airport, located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South, may be another source of hydrocarbon, CO, NOx and PM emissions from both vehicle and air traffic.

3.4.1.5 Household Fuel Burning

Energy use within the residential sector is given as falling within three main categories, viz.: (i) traditional - consisting of wood, dung and bagasse, (ii) transitional - consisting of coal, paraffin and liquefied petroleum gas (LPG), and (iii) modern - consisting of electricity (increasingly this includes the use of renewable energy). The typical universal trend is given as being from (i) through (ii) to (iii). Pollutants include products of combustion (CO, NO_x, SO_2 and VOC), unburned HCs and particulate matter.

3.4.1.6 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the Project vicinity wild fires may therefore represent a source of combustion-related emissions.

Biomass burning is an incomplete combustion process, with CO, CH_4 and NO_2 gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen (N_2), 10% is left is the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the Project, long-range transported emissions from this source can further be expected to impact on the air quality. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.4.1.7 Agriculture

Agriculture is also a land-use activity the Project region. These activities include crop farming such as maize, and livestock farming. Particulate matter is the main pollutant of concern from agricultural activities as particulate emissions are derived from windblown dust, burning crop residue, and dust entrainment as a result of vehicles travelling along dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load. Should chemicals be used for crop spraying, they would typically result in odiferous emissions. Crop residue burning is also an additional source of particulate emissions and other toxins. Due to the small scale of farming activities these are regarded to have an insignificant cumulative impact.

Livestock farms, especially cattle, are also significant sources of fugitive dust especially when feedlots are used and the cattle trample in confined areas. Pollutants associated with dairy production for instance include ammonia (NH_3), hydrogen sulfide (H_2S), methane (CH_4), carbon dioxide (CO_2), oxides of nitrogen (NOx) and odour related trace gasses. According to the US-EPA, cattle emit methane through a digestive process that is unique to ruminant animals called enteric fermentation. The calf-cow sector of the beef industry was found to be the largest emitter of methane emissions. Where animals are densely confined the main pollutants of concern include dust from the animal movements, their feed and their manure, ammonia (NH_3) from the animal urine and manure, and hydrogen sulfide (H_2S) from manure pits.

Organic dust includes dandruff, dried manure, urine, feed, mould, fungi, bacteria and endotoxins (produced by bacteria, and viruses). Inorganic dust is composed of numerous aerosols from building, materials and the environment. Since the dust is biological it may react with the defence system of the respiratory tract. Odours and VOCs associated with animal manure is also a concern when cattle are kept in feedlots. The main impact from methane is on the dietary energy due to the reduction of carbon from the rumen. Dust and gas levels are higher in winter or whenever animals are fed, handled or moved.

3.4.2 Measured Ambient Air Quality

The identification of existing sources of emission and the characterisation of ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts in the region. Ambient measurement data in the region from the Germiston monitoring station operated by EMM was obtained for the period January 2014 to December 2016. Germiston monitoring station is located about 6 km west of Reiger Park and Parkdene, and 9 km northwest of Leeuwpoort South.

Analysis of data for the period January 2014 to December 2016 are presented in Figure 7, Figure 8, Figure 9 and Figure 10 for CO, NO_2, PM_{10} and SO_2 respectively. From these figures, it can be deduced that ambient concentration of pollutants NO_2, CO and SO_2 do not exceed their respective standards at Germiston monitoring station. Although the NAAQ hourly NO_2, CO and SO_2 limits were exceeded occasionally, the allowed exceedance of 88 hours per annum was not exceeded. Daily PM_{10} concentrations, however, exceeded the NAAQS in 2014. Measured levels have remained below the limits since 2015. Consequently, the air quality in the region can be said to be generally below ambient standards, having an occasional spike for specific pollutants.

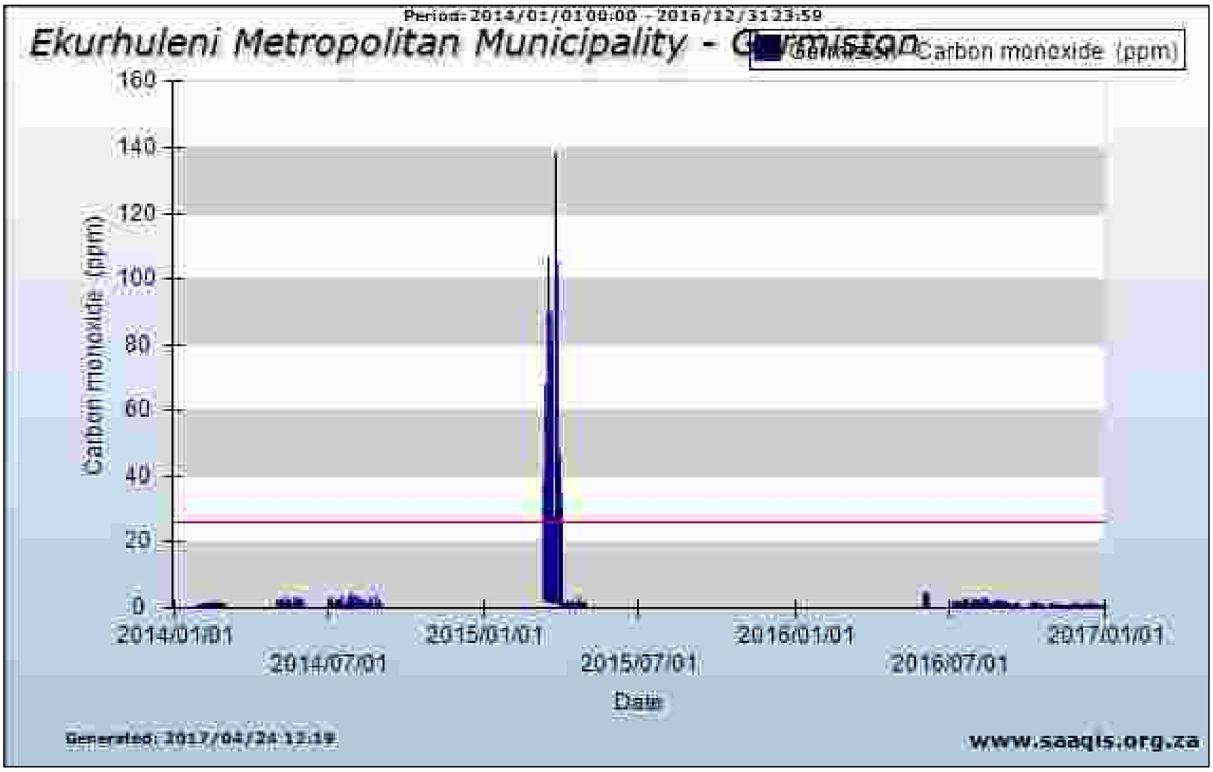


Figure 7: Hourly CO concentrations, Germiston monitoring station (Red line indicates NAAQS limit value)

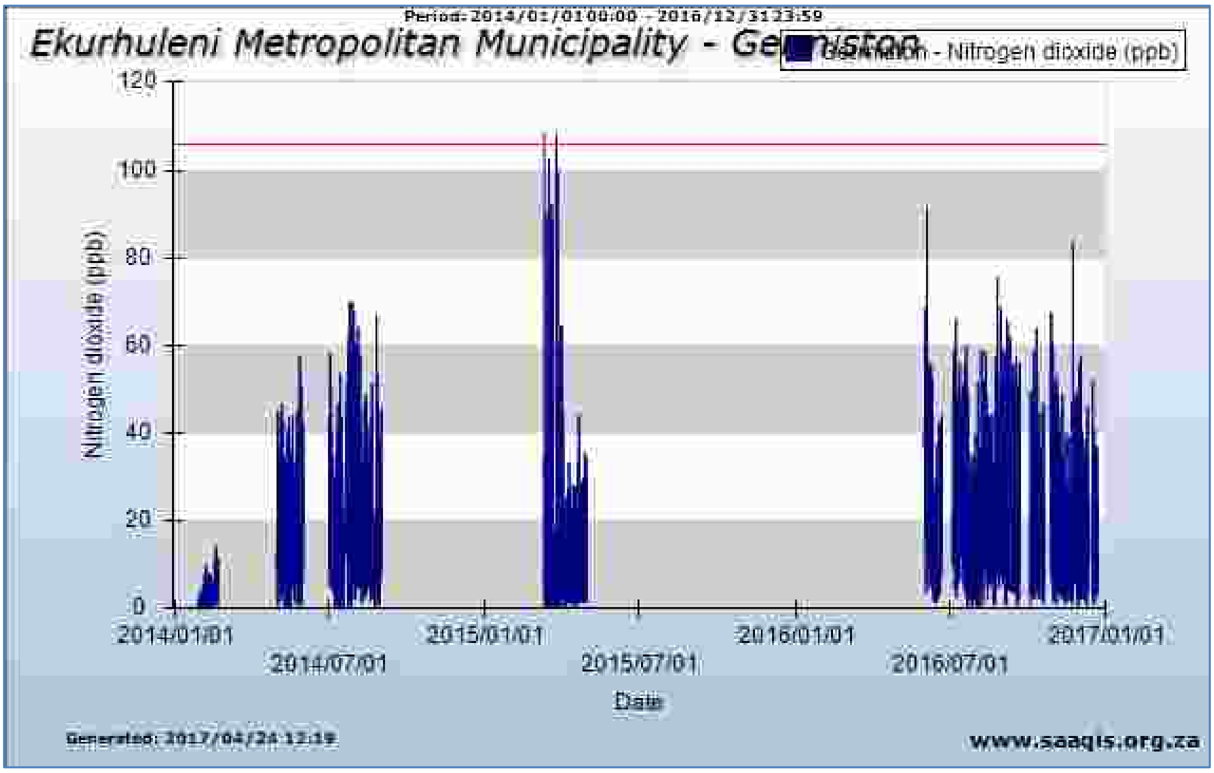


Figure 8: Hourly NO_2 concentrations, Germiston monitoring station (Red line indicates NAAQS limit value)

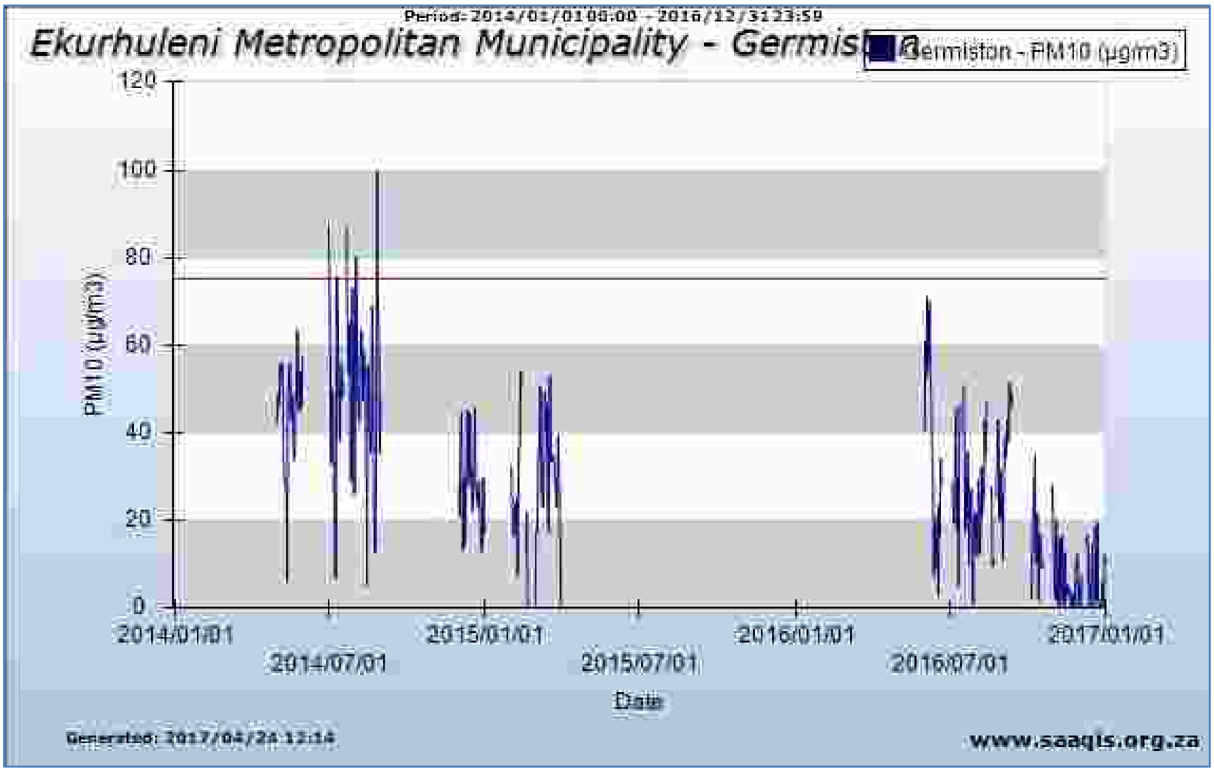


Figure 9: Daily PM_{10} concentrations, Germiston monitoring station (Red line indicates NAAQS limit value)

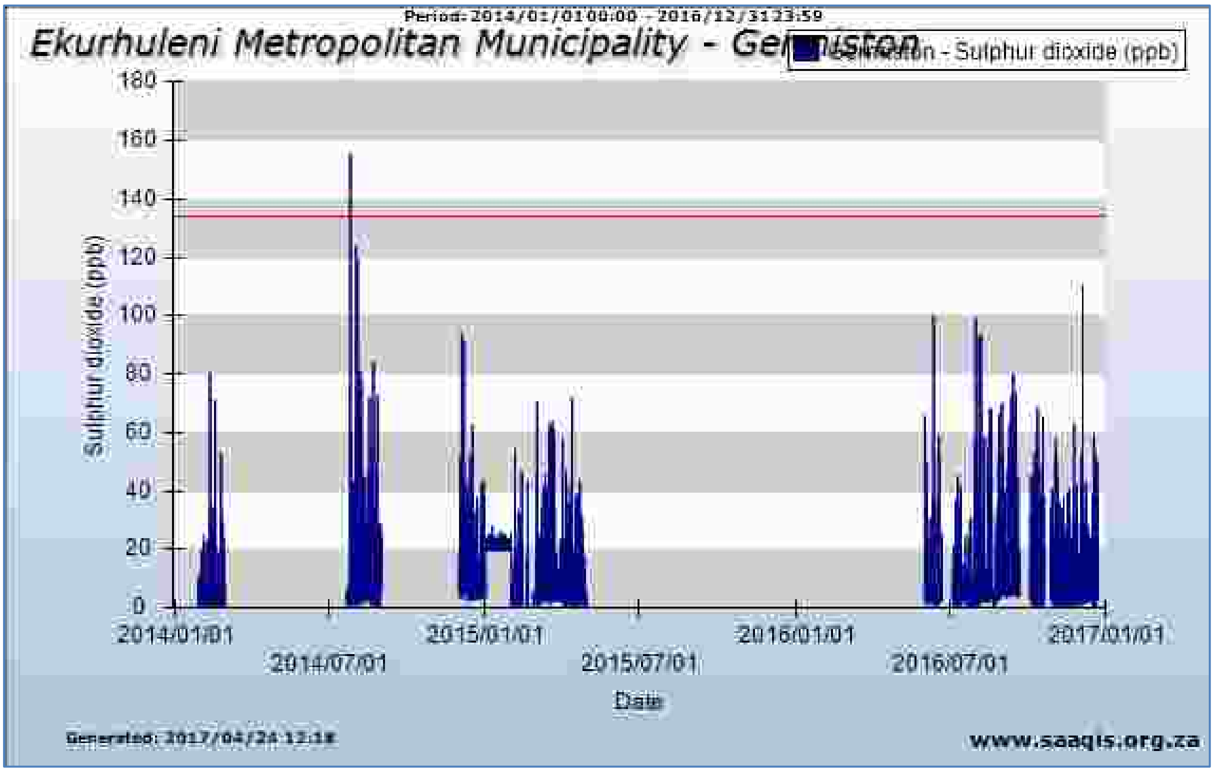


Figure 10: Hourly SO_2 concentrations, Germiston monitoring station (Red line indicates NAAQS limit value)

3.4.3 Modelled Regional Ambient Air Quality – Mpumalanga Highveld Priority Area

The Project is located in the Mpumalanga Highveld and is therefore situated within the boundaries of the Highveld Priority Area (HPA), which is an area that has been identified as characterized with poor air quality. As a result of the concerns over the poor ambient air quality over the Highveld area, the Minister of Environmental Affairs declared a portion of Mpumalanga and Gauteng provinces an air quality priority area in November 2007.

A comprehensive emissions inventory was completed for the region as part of the HPA baseline study. The results of the inventory were used to carry out a comprehensive dispersion modelling study over the area using the CALPUFF model (DEA, 2011). Results of this dispersion study are illustrated in Figure 11 and Figure 12 for SO_2 and PM_{10} respectively. These figures give the areas in which ambient air quality standards are predicted to be exceeded for more than the allowed 1% of the time. The eMalahleni area is already elevated with respect to PM_{10} and SO_2 concentrations (Figure 11 and Figure 12). Based on these dispersion modelling results, the Air Quality Management Plan (AQMP) identified Baseline Hotspots for SO_2 and for PM_{10}. The project design should therefore also ensure minimal contribution to SO_2 and PM_{10} concentrations. The CO concentrations are not included in the HPA ambient monitoring and modelling but in residential areas of high wood and coal combustion where there is high potential for increased CO concentrations.

Power Generation activity in the HPA is the major source of SO_2 emissions (82%) and NOx emissions (73%) while it is only responsible for a relatively small contribution to the total PM_{10} load (12%) (DEA, 2011). The largest contributors to all three pollutants are power generation, residential fuel burning and motor vehicles. The lowest contributors to NOx, SO_2 and PM_{10}, according to DEA (2011), are coal mines and motor vehicles.

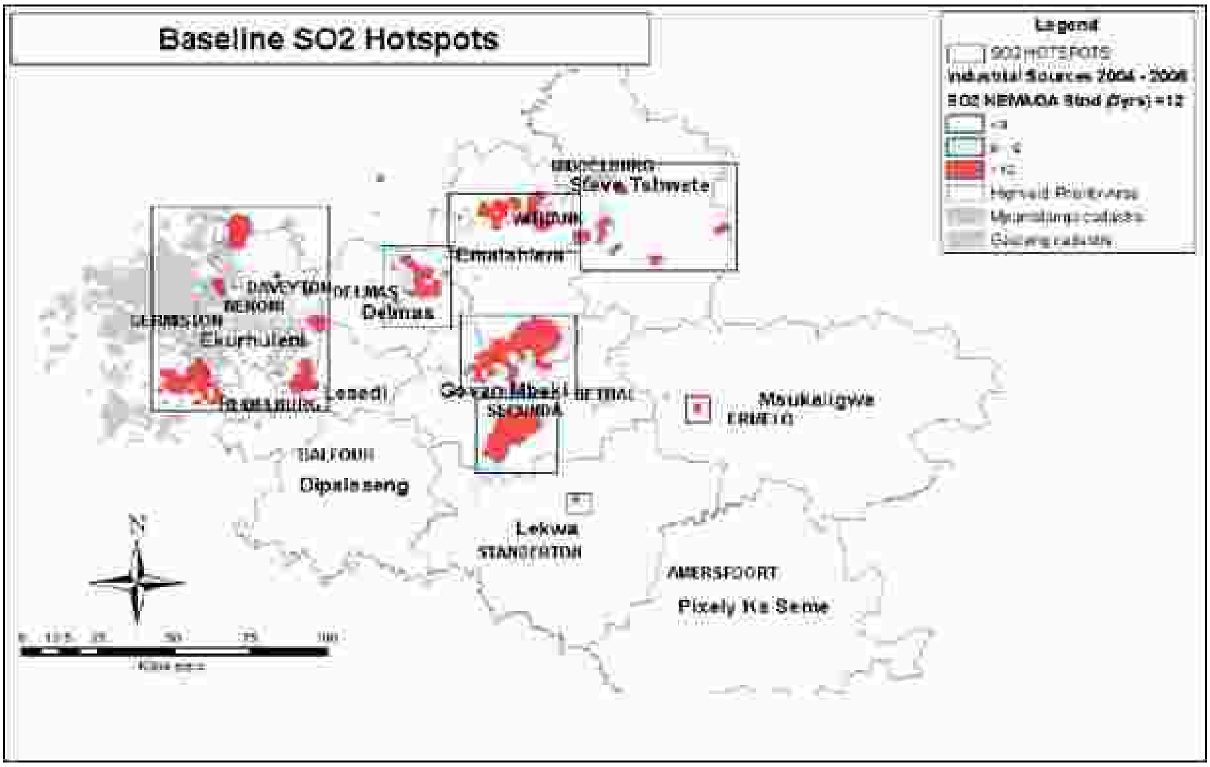


Figure 11: Simulated frequencies of exceedance of ambient SO_2 NAAQS (DEA, 2010)

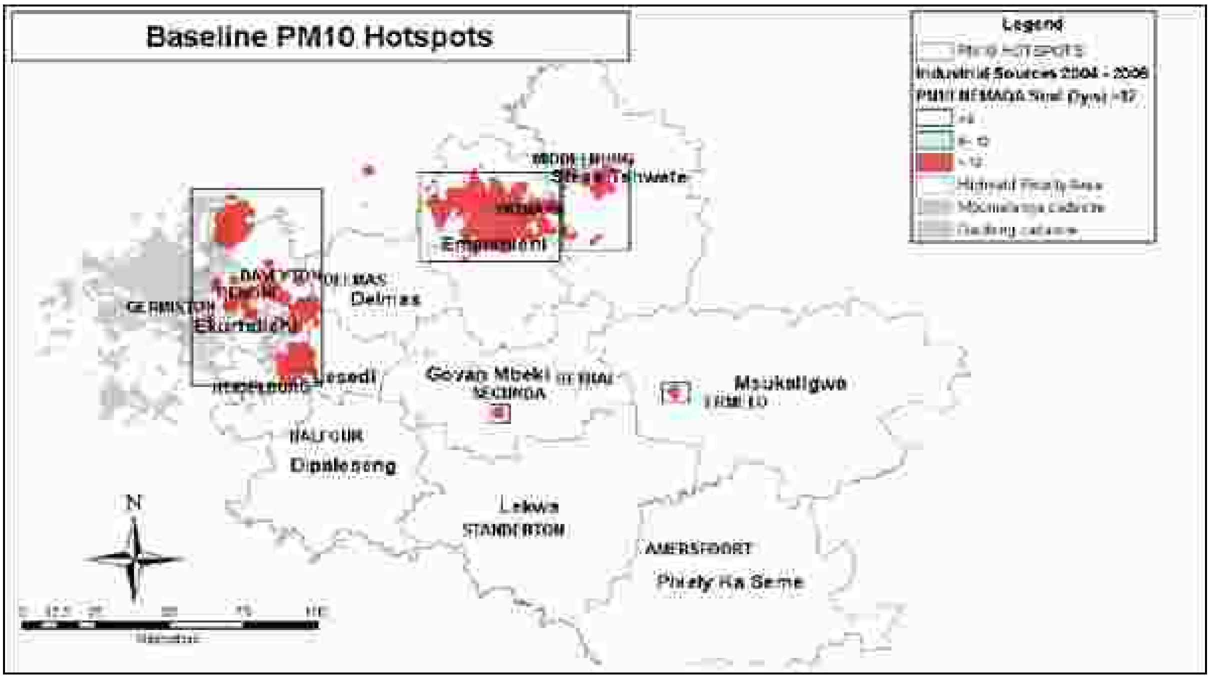


Figure 12: Simulated frequencies of exceedance of ambient PM_{10} NAAQS (DEA, 2010)

4 IMPACT ON THE RECEIVING ENVIRONMENT

4.1 Atmospheric Emissions

A discussion on the expected activities, typical of construction activities, is provided in the sections below with a summary on the typical sources and associated activities for the construction phase of the Project.

4.1.1 Construction Phase – Reiger Park, Parkdene, and Leeuwpoort South

Construction operations are potentially significant sources of dust emissions that may have a substantial temporary impact on local air quality. Construction air emissions would result from general site preparation for the developments. Construction activities that contribute to air pollution typically include: land clearing and demolition activities, excavation, material handling activities, wheel entrainment, operation of diesel or petrol engines etc. If not properly mitigated, construction sites could generate high levels of dust (typically from concrete, cement, wood, stone, silica) and this has the potential to travel for large distances.

Construction dust may be grouped into TSP with impacts generally close to the construction activities and are more responsible for soiling than health issues. Health impacts are more associated with the finer PM_{10} and $PM_{2.5}$ fractions, both of which are invisible to the naked eye. Research has shown that PM_{10} and even more significantly $PM_{2.5}$ penetrate deeply into the lungs and therefore has the potential to cause a wide range of health problems including respiratory illness, asthma, bronchitis and even cancer.

Combustion engines also emit emissions of CO, HC, NOx and CO_2. However, these gaseous emissions may often not be as significant when compared to particulate emissions, and the quantification of PM emissions (and the atmospheric dispersion thereof) is generally considered a better key-indicator pollutant than gaseous emissions. A potentially source of $PM_{2.5}$ on construction sites comes from the diesel engine exhausts of on- and off-road utility vehicles and heavy equipment as well as stationary combustion sources. These particles are known as DPM, and consist of soot (unburnt organic material), sulfates and silicates, all of which may readily combine with other compounds in the atmosphere, increasing the health risks of particle inhalation. Other noxious vapours may also originate from oils, glues, thinners, paints, treated woods, plastics, cleaners and other hazardous chemicals that may be used on construction sites.

A significant amount of the dust emissions result from construction vehicle traffic over temporary roads at construction sites. Dust emissions can also vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process.

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. Based on field measurements of total suspended particulate concentrations surrounding apartment and shopping centre construction projects, the approximate emission factors for construction activity operations are given as:

$$E_{TSP} = 2.69 \text{ Mg/hectare/month of activity } (269 \text{ g/m}^2\text{/month})$$

The PM_{10} fraction is given as approximately 35% of the US-EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate PM_{10} emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

In estimating emissions due to construction activities, **design mitigation** as provided by Bokamoso, was utilized. Design mitigation refers to mitigation included in the Project design, which comprise the use of water sprayers and dust suppression systems on haul roads and all materials handling points.

As part of the management of PM emissions, the efficiencies of some basic mitigation measures were also quantified. A summary of emission sources quantified, estimation techniques applied, and source input parameters are included in Table 6. Estimated monthly average emissions are presented in Table 7.

4.1.2 Removal of on-site contaminated tailings material – Reiger Park and Parkdene

Before commencement of the construction phase, removal of a small portion of the Reiger Park and Parkdene site that was contaminated with gold tailings material will be undertaken. This operation is projected to last for about 5 – 6 weeks, according to Bokamoso.

Sources of emissions generally associated with this operation include materials handling and vehicle entrained dust from unpaved road sections. A summary of emission sources quantified, estimation techniques applied, and source input parameters are included in Table 6. The removal of the on-site contaminated tailings material is not expected to coincide with the construction of the three site developments.

4.1.3 DRD Gold's Tailings Recovery operation – Baseline Activity

Four active gold tailings recovery operations (DRD Gold) have been identified within a 5 km radius of the three developments and are included in this study to determine their contribution to ambient concentration levels. These four operations are depicted in Figure 2 as D1, D2, D3 and D4 respectively. The tailings are recovered based on the following simplified procedure:

- **D1 and D4:** Excavators are used to dig or break the tailings material. Water cannons are then used to flush the fine material into slurry and then pumped off-site to the processing plant in Brakpan.
- **D2 and D3:** Front end loaders pick up and dump tailings material into hoppers where water is added to wash the sand into a sump. Slurry is then pumped off-site to the processing plant in Brakpan.

Sources of emissions generally associated with this operation include materials handling and windblown dust. A summary of emission sources quantified, estimation techniques applied, and source input parameters are included in Table 6. The tailings recovery operation is expected to last for: 8 years for D1; 4 years for D2; 1 year for D3; and, 8 years for D4. Therefore, tailings recovery activities are expected to coincide with the construction of the three developments.

Metallic compounds and non-criteria pollutants found in gold tailings are a potential source of inhalational health impact. The composition of metallic compound found in gold tailings was utilized in simulating the concentration of pollutants released due to DRD Gold's tailings recovery operation. The compositions of metallic compounds in gold tailings were obtained from laboratory analysis of gold tailings sample (shown in Appendix A – Section 8.1). The gold tailings sample was obtained from a gold tailing dump with similar composition to DRD Gold's tailing dump.

4.1.4 Gaseous Emissions

Exhaust emissions from construction equipment encompasses on-road vehicles (e.g. haul trucks, dump trucks), non-road vehicles (e.g. front-end loader, bulldozer) and stationary sources (e.g. generator, cranes). A large proportion of these vehicles and equipment use diesel fuels but it is noted that some equipment may also use other fuel types including gasoline, LPG and electricity. A list of machinery to be used in construction operation was provided by Bokamoso as follows: dump trucks, rollers, excavators, FELs, flatbed trucks for deliveries, cherry pickers, overhead cranes, mobile cranes, drill rigs in case of piling, graders, concrete mix delivery trucks, jack-hammer, concrete aerators, power drills and small concrete mixers.

Due to the unavailability of estimated fuel use and the non-routine nature of most construction equipment, exhaust emissions were not quantified. Operation of construction equipment are mostly non-routine in nature and their use will occur sporadically over the duration of the activity, rendering quantification and allocation of emissions for dispersion modelling difficult. Since exhaust emissions from construction equipment are typically low, general air quality measures are recommended for exhaust emissions alongside particulates emissions.

Table 6: Emission estimation techniques and parameters

Source Group	Emission Estimation Technique	Input Parameters and Activities
Removal of contaminated tailings material – Reiger Park and Parkdene	**<u>Materials Handling</u>** US EPA emission factor equation (US EPA, 2006) $$EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ Where EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in % **<u>Vehicle Entrained Dust from Unpaved Roads</u>** US EPA emission factor equation (US EPA, 2006) $$E = k \cdot \left(\frac{s}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{0.45} \cdot 281.9$$ Where EF is the emission factor in g/vehicle kilometre travelled (VKT) k is the particle size multiplier (k_{TSP} – 4.9, k_{PM10} – 1.5, $k_{PM2.5}$ – 0.15) a is an empirical constant (a_{TSP} – 0.7, a_{PM10} – 0.9, $a_{PM2.5}$ – 0.9) s is the road surface material silt content in % W is the average vehicle weight in tonnes	**<u>Materials Handling</u>** All waste handling steps (excavation and truck loading) were included. An average **wind speed of 4.2 m/s** was determined from the meteorological data set. **Moisture Assumed**: 1 % (conservative) **Hours/day and days per week:** 10 hours/day, 6 days per week **Duration:** 6 weeks **Tonnage:** Calculated rates used in the quantification of emissions are: • Reiger Park = 16,920 tons • Parkdene = 83,643 tons **Design Mitigation**: 50% control efficiency achieved through effective water sprays (NPI, 2011). **<u>Vehicle Entrained Dust from Unpaved Roads</u>** Transport activities include the transport of waste materials offsite. Rates were calculated from road lengths, truck capacities and the number of trips required for transporting waste. **Average capacity of trucks:** ~ 34 tonnes A default road surface silt content of 15% (US EPA, 2006) was applied in calculations **Hours/day and days per week:** 10 hours/day, 6 days per week **Duration:** 6 weeks **Tonnage:** Calculated rates used in the quantification of emissions are: • Reiger Park = 16,920 tons • Parkdene = 83,643 tons **Design Mitigation:** 50% control efficiency achieved through water sprays (NPI, 2011).
DRD Gold's Tailings Recovery (D1 – D4)	**<u>Windblown dust</u>** The calculation of a windblown dust emission rate for every hour of 2013 to 2015 was carried out using the ADDAS model, which is based on the dust emission model proposed by Marticorena & Bergametti (1995). A literature review on the model is provided in Appendix C.	**<u>Windblown dust</u>** Exposed stockpile and loading area was included in emission estimations based on given parameters. • Tailings D1 = 3 065 366 m² • Tailings D2 = 303 834 • Tailings D3 = 420 588 • Tailings D4 = 1 316 597 • **Hours of activity:** Continuous **Design Mitigation**: Water sprays – 50 % control efficiency achieved through effective water sprays (NPI,

Source Group	Emission Estimation Technique	Input Parameters and Activities
	<u>Materials Handling</u> US EPA emission factor equation (US EPA, 2006) $$EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ Where EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	2011). **<u>Materials Handling</u>** All waste handling steps (excavation and truck loading) were included. An average **wind speed of 4.2 m/s** was determined from the meteorological data set. **Moisture Assumed**: 1 % (conservative) **Hours/day and days per week: 10 hours/day, 6 days per week** **Duration: 6 weeks** **Tonnage:** Calculated rates used in the quantification of emissions are: • D1 = 1,200,000 tons per month • D2 = 100,000 tons per month • D3 = 10,000 tons per month • D4 = 300,000 tons per month **Design Mitigation**: 50% control efficiency achieved through effective water sprays (NPI, 2011).
Construction Activities – Reiger Park, Parkdene, and Leeuwpoort South	US EPA single valued emission factor (EF) for area-wide construction (US EPA, 1995) TSP – 2.69 Mg/ha/month PM_{10} – 2.02 Mg/ha/month $PM_{2.5}$ – 0.28 Mg/ha/month (PM_{10} and $PM_{2.5}$ calculated from PM bulldozing / scraping / grading (overburden) ratio in Table 11.9-2 (US EPA, 1998).	**<u>Reiger Park Construction</u>** Reiger Park site construction is calculated based on: • Estimated Area: 260 222 m^2 • Hours per day and days per week: 10 hours/day, 6 days per week • Duration: 24 months **<u>Parkdene Construction</u>** Parkdene site construction is calculated based on: • Estimated Area: 922 360 m^2 • Hours per day and days week: 10 hours/day, 6 days per week • Duration: 24 months **<u>Leeuwpoort South Construction</u>** Leeuwpoort South site construction is calculated based on: • Estimated Area: 7 528 462m^2 • Hours per day and days per week: 10 hours/day, 6 days per week • Duration: 72 months **Mitigation:** Water sprays – 50% control efficiency achieved through water sprays (NPI, 2011).

Table 7: Estimated annual average emission rates per source group (with design mitigation applied)

Mitigated Construction Emissions – (tons/month)				
Operation	**Emission sources**	**$PM_{2.5}$**	**PM_{10}**	**TSP**
DRD Gold's recovery of tailings (D1 – D4)	Materials handling	0.01	0.24	1.08
	Windblown dust	2.10	7.20	13.40
Removal of on-site contaminated tailings material	Materials handling	0.00	0.02	0.08
	Vehicle entrained dust from unpaved roads	0.00	0.01	0.04
Construction – Area wide construction activities	Reiger Park	0.20	1.97	2.92
	Parkdene	0.70	6.98	10.34
	Leeuwpoort South	1.91	18.99	28.13

4.2 Atmospheric Dispersion Modelling

The assessment of the impact of the Project's operations on the environment is discussed in this section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (Section 2);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the Project (Section 3.2); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 1.3).

The impact of operations on the atmospheric environment was determined through the simulation of dustfall rates and ambient pollutant concentrations. Cumulative pollutant concentrations and dustfall rates as a result of the Project in addition to pre-development air pollution levels could not be determined at this stage.

Dispersion models simulate ambient pollutant concentrations and dustfall rates as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.2.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA model – AERMOD, which is prescribed by the South African Regulations Regarding Air Dispersion Modelling for level 2 assessments.

AERMOD is a model developed with the support of AERMIC, whose objective has been to include state-of the-art science in regulatory models (Hanna, et al., 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates.

4.2.2 Meteorological Requirements

In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services (SAWS), was utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South. It is considered representative of the weather conditions at the Project site.

4.2.3 Source and Emission Data Requirements

The AERMOD model is able to model point, jet, area, line and volume sources. Sources were modelled as follows:

- Materials handling – modelled as volume sources; and
- Unpaved roads, area wide construction and windblown dust – modelled as area sources.

4.2.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 20 km (east-west) by 20 km (north-south). The area was divided into a grid matrix with a resolution of 100 m, with the Project located centrally. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor point.

4.2.5 Presentation of Results

Dispersion modelling was undertaken to determine highest hourly, highest daily and annual average ground level concentrations as well as dustfall rates for each of the pollutants considered in the study. Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Results are primarily provided in form of isopleths to present areas of exceedance of assessment criteria. Ground level concentration or dustfall isopleths presented in this section depict interpolated values from the concentrations/dustfall rates simulated by AERMOD for each of the receptor grid points specified. Isopleth plots reflect the incremental ground level concentrations (GLCs) for $PM_{2.5}$ and PM_{10}, as well as dustfall rates for TSP. Due to the unavailability of on-site ambient concentrations, cumulative pollutant concentrations could not be determined (refer to Section 3.4.2).

4.3 Dispersion Simulation Results, Health Risk and Nuisance Screening (Incremental)

Pollutants with the potential to result in human health impacts and assessed in this study include $PM_{2.5}$, PM_{10}, and metallic compounds from gold residues. Dustfall is assessed for its nuisance effects. The impact assessment methodology as discussed under Section 4.2 was followed. The level of mitigation assumed for this assessment is based on design mitigation as included in Table 6.

4.3.1 Impacts due to DRD Gold's Tailings Recovery Operation (Incremental Baseline Impacts)

The impacts due to DRD Gold's tailings recovery operation is regarded as incremental baseline impacts because it falls under baseline conditions but should not be considered as the overall baseline level for the region. The maximum simulated annual average and highest daily $PM_{2.5}$, PM_{10} and TSP impacts (over the entire modelling grid of 20 km), as a result of DRD Gold's tailings recovery operation, are presented in Table 8. Simulated maximum GLCs for each pollutant are generally low and below their respective standards.

4.3.2 Impacts due to Removal of Onsite Contaminated Tailings Material – Reiger Park and Parkdene

The removal of on-site contaminated tailings material at Reiger Park and Parkdene also form part of the incremental impact of the project. The removal of the on-site contaminated tailings material is not expected to coincide with the construction of the three developments; hence their impacts are simulated separately.

The maximum simulated annual average and highest daily $PM_{2.5}$, PM_{10} and TSP impacts (over the entire modelling grid of 20 km), as a result of removal of on-site contaminated tailings material at Reiger Park and Parkdene, are also presented in Table 8. Simulated impacts for each pollutant are generally low and below their respective standards.

4.3.3 Impacts due to Construction Phase – Reiger Park, Parkdene and Leeuwpoort South

Individual impacts due to construction of Reiger Park (Site A), Parkdene (Site B) and Leeuwpoort South (Site C) development, as well as accumulation all three impacts (i.e. sites A, B and C) were included in the dispersion simulation. The worst case scenario is a situation when all three construction sites and DRD Gold's tailings recovery are at peak operation (construction of Townships A, B and C + DRD Gold's operation). Impacts due to all these scenarios are presented in Table 8. Simulated impacts for each pollutant are generally low and below their respective standards.

The maximum simulated annual average and highest daily $PM_{2.5}$, PM_{10} and TSP impacts (over the entire modelling grid of 20 km), as a result of the aforementioned scenarios, are presented in Table 8. Simulated impacts for each pollutant are low and below their respective standards.

In addition, maximum hourly and annual average GLCs due to construction of sites A, B and C + DRD Gold's operation (worst case scenario) are presented in Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17. It should be noted that the concentrations (contours) shown in the figures below are not cumulative, but represent the impact of the Project plus the impact of the DRD Gold's tailings recovery operation. These impacts are in all cases below the ambient standard for each pollutant. They do not represent the extent of exceedance of the ambient standards or guideline.

Table 8: Maximum GLCs for criteria pollutants due to design mitigation emissions (maximums occur within the activity boundaries)

Impacts	Daily (µg/m³)		Annual (µg/m³)		Daily (mg/m²-day)
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	TSP
Impacts due to DRD Gold's Tailings Recovery Operation	36.5	48.5	3.3	6.5	303.1
Impacts due to Construction Phase – Reiger Park	2.6	29.6	0.8	7.6	158.5
Impacts due to Construction Phase – Parkdene	3.5	42.3	0.9	9.1	169.4
Impacts due to Construction Phase – Leeuwpoort South	1.6	17.4	0.3	3.5	58.0
Impacts due to Construction Phase – Reiger Park plus Parkdene plus Leeuwpoort South	3.6	43.0	0.9	9.2	170.2
Impacts due to Construction Phase – Reiger Park plus Parkdene plus Leeuwpoort South plus DRD Gold's Tailings Recovery	36.5	48.5	3.3	9.3	304.1
On-site Tailings Removal – Reiger Park plus Parkdene	1.7	21.1	0.3	3.9	219.7
NAAQS and NDCR Residential Limits	**40**	**75**	**20**	**40**	**600**

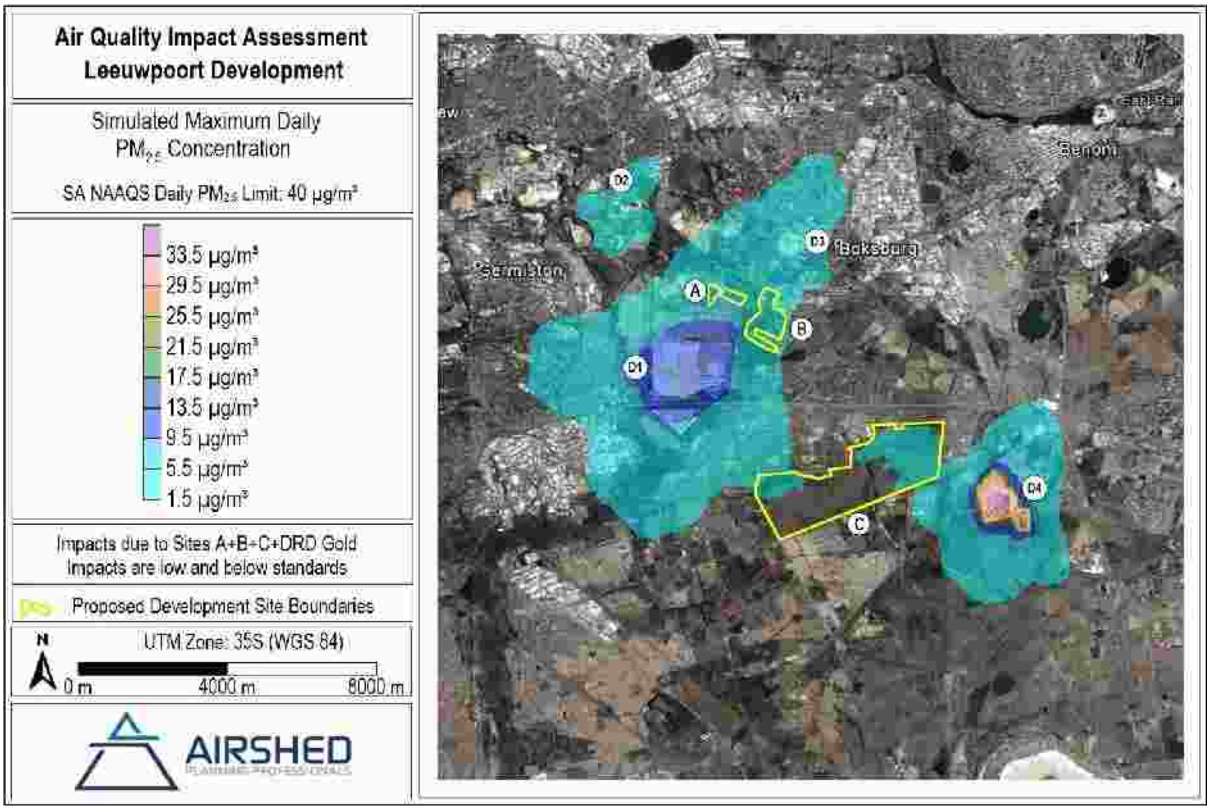


Figure 13: Simulated maximum daily $PM_{2.5}$ ground level concentration due to construction of sites A, B and C + DRD Gold's operation (design mitigation emissions) – Note: impacts are below the standard

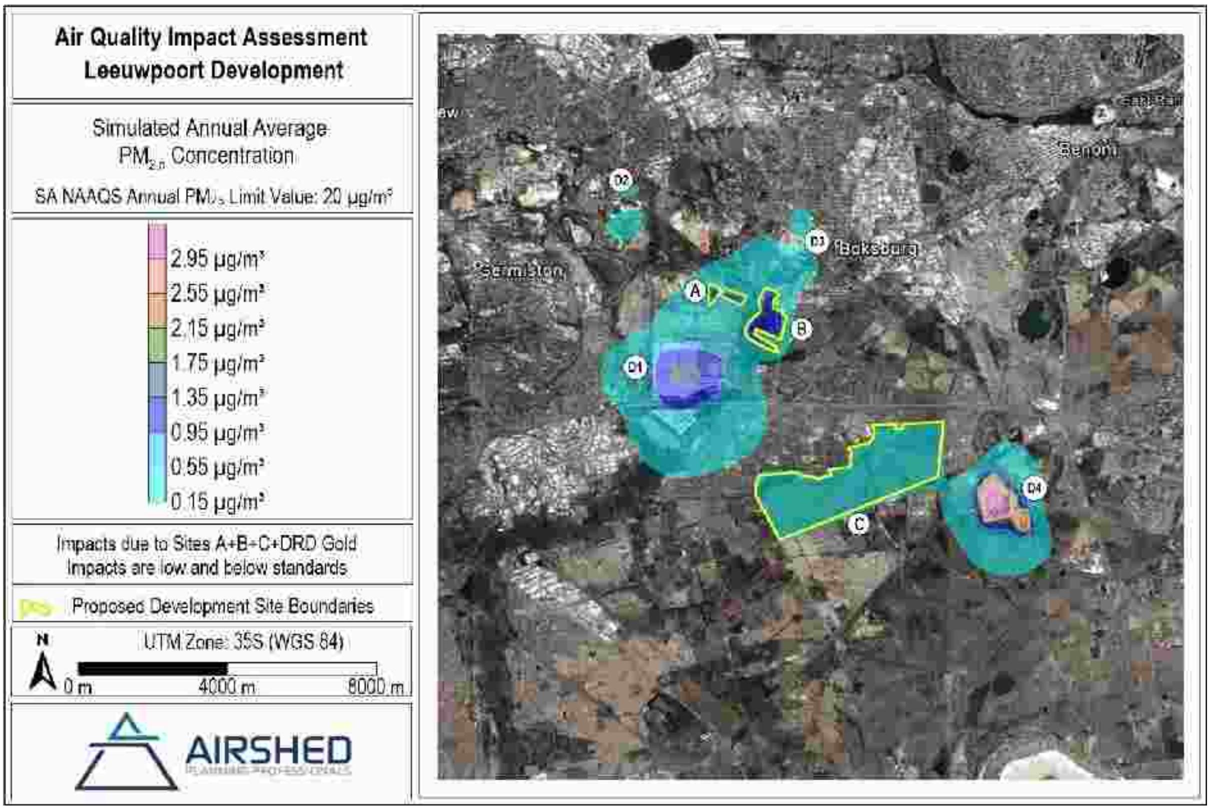


Figure 14: Simulated annual average $PM_{2.5}$ ground level concentration due to construction of sites A, B and C + DRD Gold's operation (design mitigation emissions) – Note: impacts are below the standard

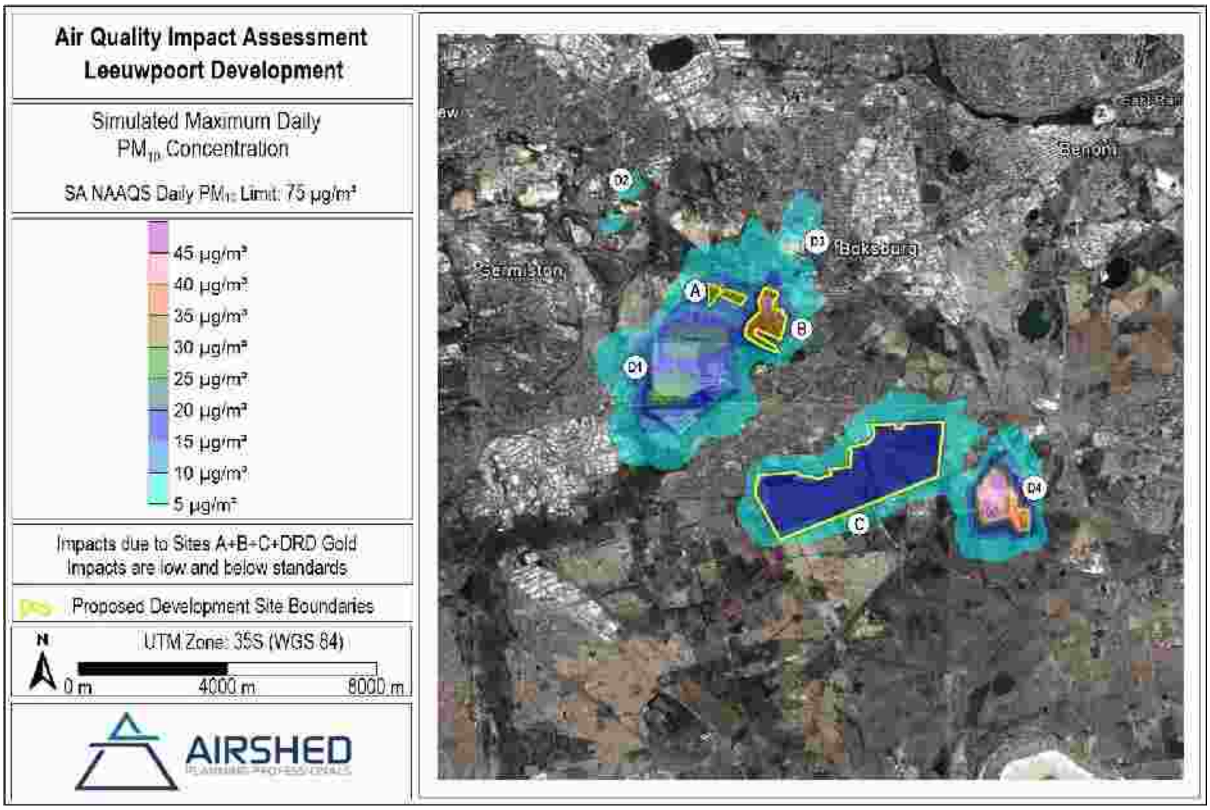


Figure 15: Simulated maximum daily PM_{10} ground level concentration due to construction of sites A, B and C + DRD Gold's operation (design mitigation emissions) – Note: impacts are below the standard

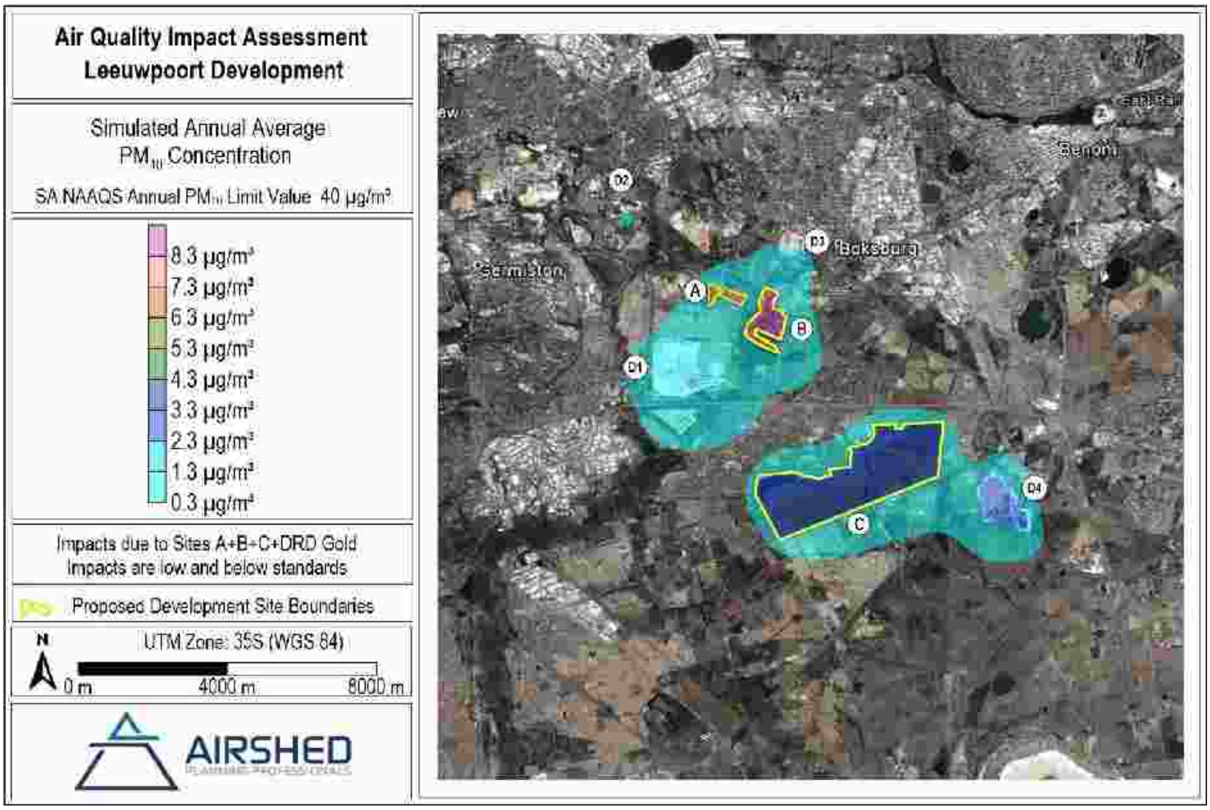


Figure 16: Simulated annual average PM_{10} ground level concentration due to construction of sites A, B and C + DRD Gold's operation (design mitigation emissions) – Note: impacts are below the standard

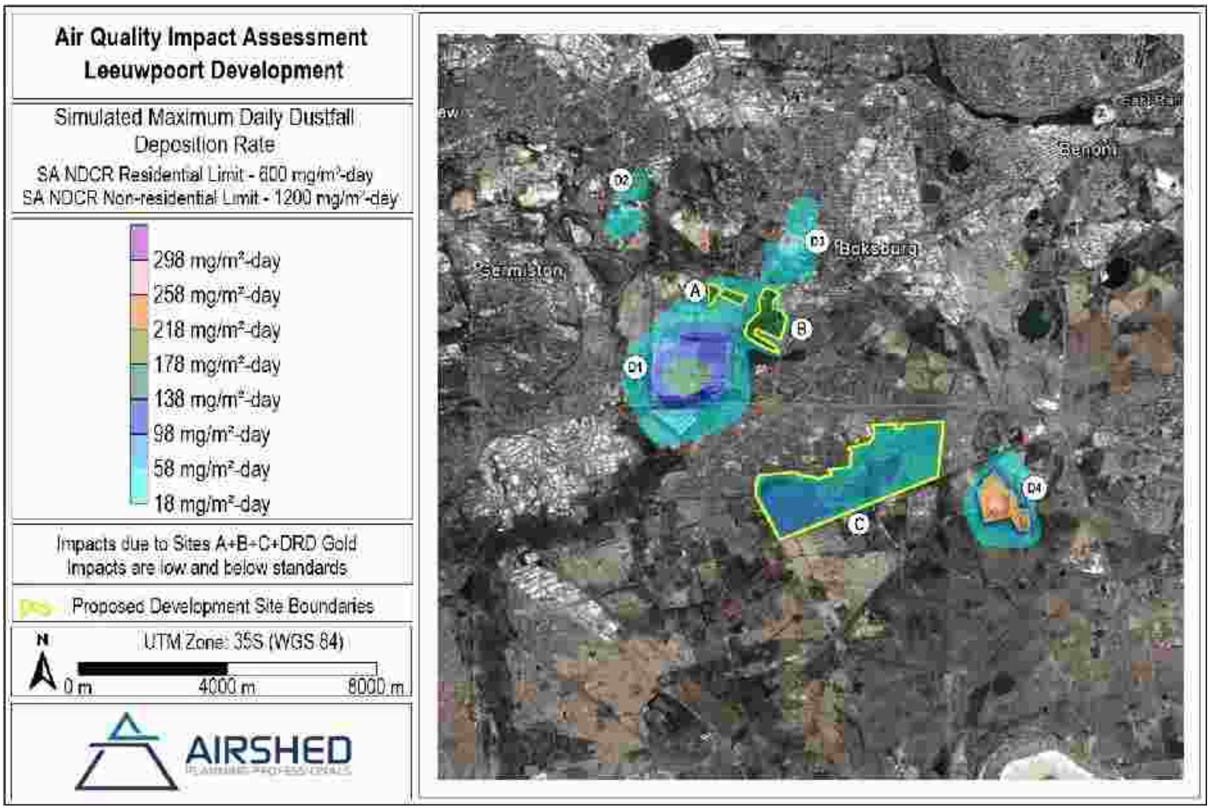


Figure 17: Simulated dustfall deposition rates due to construction of sites A, B and C + DRD Gold's operation – impacts are below the standard

4.3.4 Assessment of Metallic and Non-Criteria Pollutants

The impacts of non-criteria pollutants were assessed based on guidelines published in section 2.3. Maximum GLCs due to DRD Gold's tailings recovery operation were assessed for each pollutant as shown in Table 9. Maximum GLCs were consequently utilized in the assessment in order to ensure a conservative approach. Analysis shows that all pollutant GLCs are below their respective screening criteria. The contribution of the pollutants impacts to the baseline is expected to be minimal with little effect on the cumulative pollutant levels in the region.

Table 9: Assessment of maximum GLCs for metallic compounds found in gold tailings (maximums occur within the activity boundaries)

Metal	Short-term ESL ($\mu g/m^3$)	Short-term Screening Criteria	Short-term Hazard ratio [a]	Long-term ESL ($\mu g/m^3$)	Long-term Screening Criteria	Long-term Hazard ratio [b]
Silver, Ag	2.45×10^{-6}	0.1 [a]	0.0000	6.54×10^{-8}	0.01 [a]	0.0000
Aluminium, Al	4.24×10^{-1}	20 [a]	0.0212	1.13×10^{-2}	2 [a]	0.0057
Arsenic, As	9.27×10^{-3}	3 [a]	0.0031	2.48×10^{-4}	0.067 [a]	0.0037
Gold, Au	1.96×10^{-5}	25 [a]	0.0000	5.23×10^{-7}	2.5 [a]	0.0000
Barium, Ba	3.90×10^{-3}	5 [a]	0.0008	1.04×10^{-4}	0.5 [a]	0.0002
Beryllium, Be	2.93×10^{-5}	0.02	0.0015	7.85×10^{-7}	0.002	0.0004
Bismuth, Bi	3.42×10^{-5}	50 [a]	0.0000	9.15×10^{-7}	5 [a]	0.0000
Calcium, Ca	6.06×10^{-2}	50 [a]	0.0012	1.62×10^{-3}	5 [a]	0.0003
Cadmium, Cd	2.20×10^{-5}	0.1 [a]	0.0002	5.89×10^{-7}	0.01 [a]	0.0001
Cobalt, Co	2.59×10^{-4}	0.2 [a]	0.0013	6.93×10^{-6}	0.02 [a]	0.0003
Chromium, Cr	3.10×10^{-3}	3.6 [a]	0.0009	8.28×10^{-5}	0.041 [a]	0.0020
Copper, Cu	5.35×10^{-3}	10 [a]	0.0005	1.43×10^{-4}	1 [a]	0.0001
Iron, Fe	1.09	10 [a]	0.1086	2.90×10^{-2}	1 [a]	0.0290
Mercury, Hg	4.55×10^{-4}	0.25 [a]	0.0018	1.22×10^{-5}	0.025 [a]	0.0005
Lithium, Li	1.47×10^{-4}	10 [a]	0.0000	3.92×10^{-6}	1 [a]	0.0000
Magnesium, Mg	3.83×10^{-2}	50 [a]	0.0008	1.02×10^{-3}	5 [a]	0.0002
Manganese, Mn	6.00×10^{-3}	2 [a]	0.0030	1.60×10^{-4}	0.2 [a]	0.0008
Nickel, Ni	1.05×10^{-3}	0.33 [a]	0.0032	2.82×10^{-5}	0.059 [a]	0.0005
Uranium, U	5.09×10^{-3}	2 [a]	0.0025	1.36×10^{-4}	0.2 [a]	0.0007
Vanadium, V	1.21×10^{-3}	0.5 [a]	0.0024	3.24×10^{-5}	0.05 [a]	0.0006
Lead, Pb	_	_	_	1.65×10^{-4}	0.5	0.0003

NOTE: [a] based on analysis of PM_{10} samples.

[b] Hazard ratio values greater than 1.0 indicate that the associated screening criteria level has been exceeded. No exceedance is recorded in this case.

4.4 Impact Significance Rating

EIA Regulations require that impacts be assessed in terms of the intensity, duration, severity and probability of impacts; as well as the degree to which these impacts can be managed or mitigated. A significance ranking methodology as provided by Bokamoso is provided in Appendix B.

The impact significance rating for potential impacts due to the Project emissions are presented in Table 10. All potential impacts (health impacts due to $PM_{2.5}$, PM_{10} and metallic compounds; nuisance effects due to dustfall) during the construction of the three developments phases (Reiger Park, Parkdene and Leeuwpoort South) were assigned impact rating scores equivalent to "**low"** impact significance. All potential impacts (health impacts due to $PM_{2.5}$, PM_{10} and metallic compounds; nuisance effects due to dustfall) during the construction of sites A, B and C + DRD Gold's tailing recovery operation (worst case scenario) were also assigned impact rating scores equivalent to "**low"** impact significance.

Table 10: Impact significance rating table

Source	IMPACT DESCRIPTION		PRE - MITIGATION						POST - MITIGATION					
	Impact	Associated activities	Intensity factor	Duration	Severity factor	Severity rating	Probability rating	Significance rating	Intensity factor	Duration	Severity factor	Severity rating	Probability rating	Significance rating
Impacts due to DRD Gold's Tailings Recovery Operation	Health impacts due to $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to PM_{10} emissions		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Nuisance effects due to dustfall deposition		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
Impacts due to Construction Phase – Reiger Park	Health impacts due $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due PM_{10} emissions		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Nuisance effects due to dustfall deposition		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
Impacts due to Construction Phase – Parkdene	Health impacts due to $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to PM_{10} emissions		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Nuisance effects due to dustfall deposition		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
Impacts due to Construction Phase – Leeuwpoort South	Health impacts due $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Health impacts due PM_{10} emissions		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Nuisance effects due to dustfall deposition		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low

Source	IMPACT DESCRIPTION		PRE - MITIGATION						POST - MITIGATION					
	Impact	Associated activities	Intensity factor	Duration	Severity factor	Severity rating	Probability rating	Significance rating	Intensity factor	Duration	Severity factor	Severity rating	Probability rating	Significance rating
Impacts due to Construction Phase – Reiger Park plus Parkdene plus Leeuwpoort South plus DRD Gold's Tailings Recovery	Health impacts due to $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Health impacts due to PM_{10} emissions		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
	Nuisance effects due to dustfall deposition		1	3	3	2	3	6 = Low	1	3	3	2	3	6 = Low
On-site Tailings Removal – Reiger Park plus Parkdene	Health impacts due $PM_{2.5}$ emissions	Materials handling, hauling, windblown dust, area wide construction	1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due PM_{10} emissions		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Health impacts due to inhalation of metallic compounds		1	2	2	2	3	6 = Low	1	2	2	2	3	6 = Low
	Nuisance effects due to dustfall deposition		2	2	4	2	3	6 = Low	1	2	2	2	3	6 = Low

5 Recommended Air Quality Management Measures

The construction of Leeuwpoort developments, as well as DRD Gold's tailings recovery operation, results in low air quality impacts that are in compliance with their respective standards or guidelines. However, since cumulative impacts could not be quantitatively determined, it is recommended that Leeuwpoort commit itself to adequate air quality management planning throughout the construction phase of the Project. The air quality management plan provides options on the control of particulate matter at the main sources. Based on the findings of the impact assessment, the following mitigation and management recommendations are proposed.

5.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the Project is to ensure that operations result in cumulative ambient air concentrations and dustfall rates that are within the relevant ambient air quality standards at nearby AQSRs. In order to define site specific management objectives, the main source(s) of pollution need to be identified. The main source of pollution for the Project is the area wide construction activities on each development site (refer to section 4.1.1). It is necessary to ensure adequate mitigation of these activities in order to minimize air quality impacts at receptors.

5.2 Proposed Mitigation Measures and Target Control Efficiencies

From the above discussion, it is recommended that the Project include the following mitigation measures:

- In controlling vehicle entrained PM, it is recommended that water (at an application rate greater than 2 litre/m^2-hour) be applied (as included in the design mitigation). Literature reports an emissions reduction efficiency of more than 50 % (NPI, 2011).
- Water sprayers should be applied to all materials handling, tipping sections and exposed areas susceptible to wind erosion in order to reduce emissions. Literature reports an emissions reduction efficiency of more than 50 % (NPI, 2011).
- During transportation of materials, trucks should be covered in order to avoid spillages. This will reduce PM emissions during transportation.
- When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and haul material covered to minimise any fly-off dust. Access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.
- In order to ensure lower diesel exhaust emissions, equipment suppliers or contractors should be required to ensure compliance with appropriate emission standards for all machinery. Also, maintenance and repair of diesel engines should be carried out as prescribed by manufacturer in order to maximize combustion and reduce gaseous emissions.
- Fuel efficient driving practices on site may also help lower diesel exhaust emissions. It is recommended that a maximum speed of 40 km/h be stipulated on all unpaved site roads. In addition, other fuel efficient practices that may lower exhaust emissions are recommended. These include avoiding idling of vehicle, driving in an upper gear rather than a lower gear as much as possible, ensuring tire pressure are always adequate etc.

A summary of the air quality management objectives is presented in Table 11.

5.3 Performance Indicators and Ambient Air Quality Monitoring

Key performance indicators against which progress of implemented mitigation and management measures may be assessed form the basis for all effective environmental management practices. In the definition of key performance indicators, careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the direct source of the emission (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). For instance, ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 600 mg/m²-day represents an impact- or receptor-based performance indicator.

As a result of low air quality impacts from the Project, and due to the short/medium term duration of construction activities on site, it is recommended that an air quality complaints register be commissioned at the three development sites upon commencement of construction activities. The need for an air quality monitoring network is not deemed necessary at the start of construction activities. The complaint register will serve as an indicator of mitigation performance at nearby AQSRs; and subsequently determine whether a monitoring network is required.

Table 11: Air Quality Management Plan: construction phase of the Project

Activity	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10}, $PM_{2.5}$ concentrations and dustfall rates	**Mitigation:** A minimum mitigation measure of water sprays on unpaved roads to ensure a minimum of 50% Control Efficiency (CE).	Leeuwpoort Environmental Manager	On-going during construction phase
Wind erosion	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	**Mitigation:** Ensure exposed areas remain moist through regular water spraying during dry, windy periods (CE 50%).		
Materials handling and transfer points	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	**Mitigation:** Mining and material transfers to be controlled through the use of water sprays resulting in 50% CE. Monthly dustfall rates should not exceed 600 mg/m².day at off-site dustfall units [(a)].		
General	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	**Performance Indicator:** Air quality complaints register to be commissioned at all three development sites at the commencement of construction activities		

5.4 Periodic Inspections, Audits and Community Liaison

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with environmental audits conducted annually. Annual environmental audits should be conducted until construction is completed. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. It is recommended that interested and affected parties forums be scheduled and held on a regular basis. The consultation process should be undertaken as part of the EIA and EMP process for the Project.

5.5 Buffer Zone

The delineation of an air quality buffer zone around the Development sites is not deemed necessary, considering that "low" significance rating was assigned to pollutants impacts and the short to medium term duration of the Project's activities.

6 CONCLUSIONS AND RECOMMENDATION

A quantitative air quality impact assessment was conducted for the construction phase activities of the Project. A baseline assessment was conducted based on the meteorology, topography and land use distribution of the area, as well as the on-going DRD Gold's tailings recovery operation.

The main findings of the assessment are summarised below:

- The receiving environment:
  - In the absence of on-site surface meteorological data, hourly meteorological data for the period January 2013 to December 2015 from OR Tambo International Airport Weather Station and operated by the South African Weather Services, was utilised for the study. The weather station is located 8 km northwest of Reiger Park and Parkdene, and 14 km northwest of Leeuwpoort South.
  - The Project area is dominated by strong winds from the north and northwest. The night-time wind rose recorded high wind speeds from the north and northwest, while the day-time wind rose recorded dominant winds from the north. An average wind speed of 4.2 m/s was measured over the 2013 to 2015 period.
  - Ambient air pollutant levels in the Project area are currently affected by the following sources of atmospheric emission; mining; industries, vehicle tailpipe emissions; agriculture; domestic fuel combustion and open areas exposed to wind erosion.
  - AQSRs around the Project site include residential settlement, townships, schools, mosques and churches.

- Impact of the Project:
  - Construction phase:
    - Sources of emission quantified included area wide construction, materials handling, vehicles entrained PM on unpaved roads, windblown dust from the stockpiles.
    - Construction phase PM emissions ($PM_{2.5}$, PM_{10} and TSP) and metallic compound composition in tailings material were quantified and utilized in dispersion simulations.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of DRD Gold's tailings recovery operation are generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of removal of on-site contaminated tailings material at Reiger Park and Parkdene, are also generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of construction of the three developments phases (Reiger Park, Parkdene and Leeuwpoort South) are generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.
    - Furthermore, maximum simulated annual average and highest daily $PM_{2.5}$ and PM_{10}, as well as dustfall nuisance effects as a result of the worst case scenario – a situation when all three construction sites and DRD Gold's tailings recovery are at peak operation (construction of sites A, B and C + DRD Gold's operation) are also generally low and below their respective standards. A significance rating of 'low' was assigned to potential inhalation health impacts and dustfall effects associated with this scenario.

- Finally, maximum simulated short-term and long-term impacts due to metallic compounds found in gold tailings are also low and below their respective guideline or standards. A significance rating of 'low' was assigned to potential inhalation health impacts associated with these impacts.

In conclusion, it is the specialist opinion that the project may be authorised provided that the recommended air quality management measures are implemented in order to ensure the lowest possible impact on nearby AQSRs and the environment. These air quality management measures include:

- Commissioning of a complaint register on all three construction sites at the commencement of construction activities; and
- Mitigation measures aimed at reducing emissions at sources.

7 REFERENCES

Andreae, M. et al., 1996. Trace gas and aerosol emissions from savanna fires. In: *Biomass Burning and Global Change.* Cambridge: MIT Press.

DEA, 2010. *A Dispersion Modelling Case Study of Section 21 Emission Standards for Industrial Sources in the Highveld Priority Area,* Pretoria, SA: Department of Environmental Affairs.

DEA, 2011. *The Highveld Priority Area Air Quality Management Plan,* Pretoria, SA: Department of Environmental Affairs - Government Gazette.

DEA, 2013. *National Environment Management: Air Quality Act- List of activities which may result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions ecological,* Pretoria, SA: Government Gazette No.33064. 537.

DEA, 2014. *Regulations regarding Air Dispersion Modelling,* s.l.: Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.

Farmer, A. M., 1993. The Effects of Dust on Vegetation – A Review. *Environmental Pollution,* Volume 79, pp. 63-75.

Garstang, M., Tyson, P., Swap, R. & Edwards, M., 1996. Horizontal and vertical transport of air over southern Africa.

Hanna, S. R., Egan, B. A., Purdum, J. & Wagler, J., 1999. *Evaluation of ISC3, AERMOD, and ADMS Dispersion Models with Observations from Five Field Sites,* s.l.: s.n.

IFC, 2007. *General Environmental, Health and Safety Guidelines,* s.l.: s.n.

Marticorena, B. & Bergametti, G., 1995. Modelling the Atmospheric Dust Cycle. 1. Design of a Soil-Derived Dust Emission Scheme. *Journal of Geophysical Research,* pp. 100, 16 415 - 16430.

NPI, 2011. *Emission Estimation Technique Manual for Mining. Version 3..* s.l.:Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Piketh, S., Annegarn, H. & Kneen, M., 1996. Regional scale impacts of biomass burning emissions over southern Africa. In: *Biomass Burning and Global Change.* Cambridge: MIT Press.

SRK Consulting, 2003. *First year State of the Environment Report,* Ekurhuleni: Ekurhuleni Metropolitan Municipallity.

TCEQ, 2013. *Texas Commission on Environmental Quality.* [Online] Available at: www.tceq.state.tx.us [Accessed 08 September 2014].

US EPA, 1995. *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.3 Heavy Construction Operations.* [Online].

US EPA, 1998. *AP 42, 5th Edition, Volume I, Chapter 11: Mineral Products Industry, 11.9 Western Surface Coal Mining,* s.l.: USEPA.

US EPA, 2004. *AERMOD: Description of Model Formulation,* s.l.: United States Environmental Protection Agency.

US EPA, 2006. *AP 42, 5th Edition, Volume 1, Chapter13: Miscellaneous Sources, 13.2.4 Introduction to Fugitive Dust Sources, Aggregate Handling and Storage Piles.* [Online] Available at: http://www.epa.gov/ttn/chief/ap42/

US EPA, 2006. *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.2 Introduction to Fugitive Dust Sources, Unpaved Roads,* http://www.epa.gov/ttnchief/ap42/: s.n.

US EPA, 2006. *AP 42, Fifth Edition, Volume 1, Chapter 13: Miscellaneous Sources, 13.2.5 Industrial Wind Erosion,* s.l.: United States Environmental Protection Agency.

8 APPENDIX

8.1 Appendix A – Compositions of Metallic Compounds in Gold Tailings Sample

667 Viscountstreet
Elarduspark X6
Pretoria
0181

Tel : +27 12 345 5244
Fax : +27 86 637 6838
Email : admin@biograde.co.za

BIOGRADE
CC 2006/212609/23

CERTIFICATE OF ANALYSIS R15-5863

sanas
Testing Laboratory
Accreditation No. T0574

Test # : Metal Elements by ICP/MS

Method : Based on EPA Methods 3050B & 6020A

Sample : TS_S2

Element	mg/kg	Element	mg/kg
Silver, Ag	< 0.01	Sodium, Na	75.04
Aluminium, Al	1733.24	Nickel, Ni	4.31
Arsenic, As	37.90	Phosphorus, P	< 0.01
Gold, Au	0.08	Lead, Pb	25.26
Barium, Ba	15.96	Palladium, Pd	0.22
Beryllium, Be	0.12	Platinum, Pt	0.01
Bismuth, Bi	0.14	Rhodium, Rh	< 0.01
Calcium, Ca	247.80	Ruthenium, Ru	< 0.01
Cadmium, Cd	0.09	Sulfur, S	400.43
Cobalt, Co	1.06	Antimony, Sb	0.07
Chromium, Cr	12.66	Selenium, Se	0.15
Copper, Cu	21.88	Tin, Sn	< 0.01
Iron, Fe	4440.88	Strontium, Sr	4.19
Mercury, Hg	1.86	Tellurium, Te	0.21
Iridium, Ir	0.01	Thorium, Th	1.64
Potassium, K	133.38	Titanium, Ti	16.31
Lanthanum, La	3.40	Thallium, Tl	0.03
Lithium, Li	0.60	Uranium, U	20.80
Magnesium, Mg	156.73	Vanadium, V	4.96
Manganese, Mn	24.54	Zinc, Zn	14.17
Molybdenum, Mo	0.36	Zirconium, Zr	2.94

Results in milligram per kilogram (mg/kg)

Approximate Quantitation Limit signified by " < " followed by the limit value

Note:

Results supplied by a subcontracting laboratory

Willem D. Wiepener
Laboratory Manager

Confidential Page 4 of 6 2015-04-23

This report relates to the specific items tested only and may not be reproduced in part or full without the written consent of Biograde.
Tests marked with # in this report are not included in the SANAS schedule of accreditation for this laboratory

8.2 Appendix B - Impact Assessment Methodology (Bokamoso)

The significance of Environmental Impacts was assessed in accordance with the following method:

Significance is the product of probability and severity. Probability describes the likelihood of the Impact actually occurring, and is rated as follows:

Improbable	Low possibility of impact to occur either because of design or historic experience	Rating = 2
Probable	Distinct possibility that impact will occur	Rating = 3
Highly probable	Most likely that impact will occur	Rating = 4
Definite	Impact will occur, in the case of adverse impacts regardless of any prevention measures	Rating = 5

The ***severity factor*** is calculated from the factors given to “intensity” and “duration”. Intensity and duration factors are awarded to each impact, as described below.

The ***Intensity factor*** is awarded to each impact according to the following method:

Low intensity	natural and manmade functions not affected	Factor 1
Medium intensity	environment affected but natural and manmade functions and processes continue	Factor 2
High intensity	environment affected to the extent that natural or manmade functions are altered to the extent that it will temporarily or permanently cease or become dysfunctional	Factor 4

Duration is assessed and a factor awarded in accordance with the following:

Short term	<1 to 5 years	Factor 2
Medium term	5 to 15 years	Factor 3
Long term	impact will only cease after the operational life of the activity, either because of natural process or by human intervention	Factor 4
Permanent	mitigation, either by natural process or by human intervention, will not occur in such a way or in such a time span that the impact can be considered transient	Factor 4

The ***Severity Rating*** is obtained from calculating a severity factor, and comparing the severity factor to the rating in the table below. For example:

The Severity factor = Intensity factor X Duration factor

= 2 x 3

= 6

A ***Severity factors*** of six (6) equals a Severity Rating of Medium severity (Rating 3) as per table below:

Calculated values 2 to 4	Low Severity	Rating 2
Calculated values 5 to 8	Medium Severity	Rating 3
Calculated values 9 to 12	High Severity	Rating 4
Calculated values 13 to 16	Very High severity	Rating 5

A Significance Rating is calculated by Multiplying the Severity Rating with the Probability Rating.

The ***Significance Rating*** should influence the development project as described below:

Significance Rating 4 to 6	Low significance	Positive impact and negative impacts of low significance should have no influence on the Proposed development Project.
Significance Rating >6 to 15	Medium significance	Positive Impact: Should weigh towards a decision to continue Negative Impact: Should be mitigated to a level where the impact would be of medium significance before project can be approved
Significance Rating 16 and more	High significance	Positive impact: Should weigh towards a decision to continue, should be enhanced in final design. Negative impact: Should weigh towards a decision to terminate proposal, or mitigation should be performed to reduce significance to at least medium significance rating

8.3 Appendix C – Description of Wind Erosion Estimation Technique

Significant emissions arise due to the mechanical disturbance of granular material from open areas and storage piles. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation. The shape of a storage pile or disposal dump influences the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated

An hourly emissions file was created for the discard dump as well as storage pile. The calculation of an emission rate for every hour of the simulation period was carried out using the ADDAS model. This model is based on the dust emission model proposed by (Marticorena & Bergametti, 1995). The model attempts to account for the variability in source erodibility through the parameterisation of the erosion threshold (based on the particle size distribution of the source) and the roughness length of the surface.

In the quantification of wind erosion emissions, the model incorporates the calculation of two important parameters, viz. the threshold friction velocity of each particle size, and the vertically integrated horizontal dust flux, in the quantification of the vertical dust flux (i.e. the emission rate). The equations used are as follows:

$$E(i) = G(i) 10^{(0.134(\%clay)-6)}$$

for

$$G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$$

$$R = \frac{u_*^t}{u^*}$$

And

where,

$E_{(i)}$	=	emission rate (g/m²/s) for particle size class i
P_a	=	air density (g/cm³)
g	=	gravitational acceleration (cm/s³)
u_*^t	=	threshold friction velocity (m/s) for particle size i
u^*	=	friction velocity (m/s)

Dust mobilisation occurs only for wind velocities higher than a threshold value, and is not linearly dependent on the wind friction and velocity. The threshold friction velocity, defined as the minimum friction velocity required to initiate particle motion, is dependent on the size of the erodible particles and the effect of the wind shear stress on the surface. The threshold friction velocity decreases with a decrease in the particle diameter, for particles with diameters >60 µm. Particles with a diameter <60 µm result in increasingly high threshold friction velocities, due to the increasingly strong cohesion forces linking such particles to each other (Marticorena & Bergametti, 1995). The relationship between particle sizes ranging between 1 µm and 500 µm and threshold friction velocities (0.24 m/s to 3.5 m/s), estimated based on the equations proposed by (Marticorena & Bergametti, 1995), is illustrated in Figure 18.

The wind speed variation over the storage piles is based on the work of Cowherd et al. (1988). With the aid of physical modelling, the US-EPA has shown that the frontal face of an elevated pile (i.e. windward side) is exposed to wind speeds of the same order as the approach wind speed at the top of the pile. The ratios of surface wind speed (us) to approach wind speed (ur), derived from wind tunnel studies for two representative pile shapes, are illustrated in Figure 19 (viz. a conical pile, and an oval pile with a flat top and 37° side slope). The contours of normalised surface wind speeds are indicated for the oval, flat top pile for various pile orientations to the prevailing direction of airflow (the higher the ratio, the greater the wind exposure potential). These flow patterns are only applicable with piles that have a height to base ratio of more than 0.25.

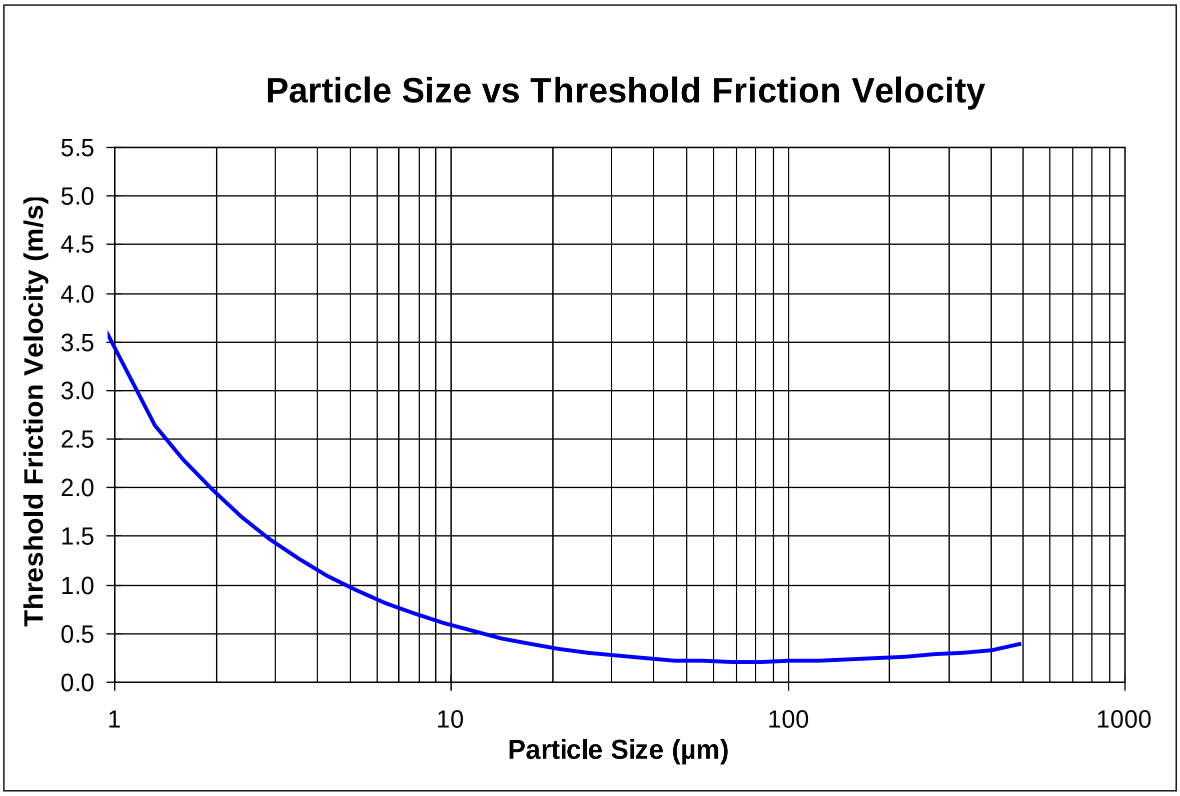


Figure 18: Relationship between particle sizes and threshold friction velocities using the calculation method proposed by Marticorena and Bergametti (1995)

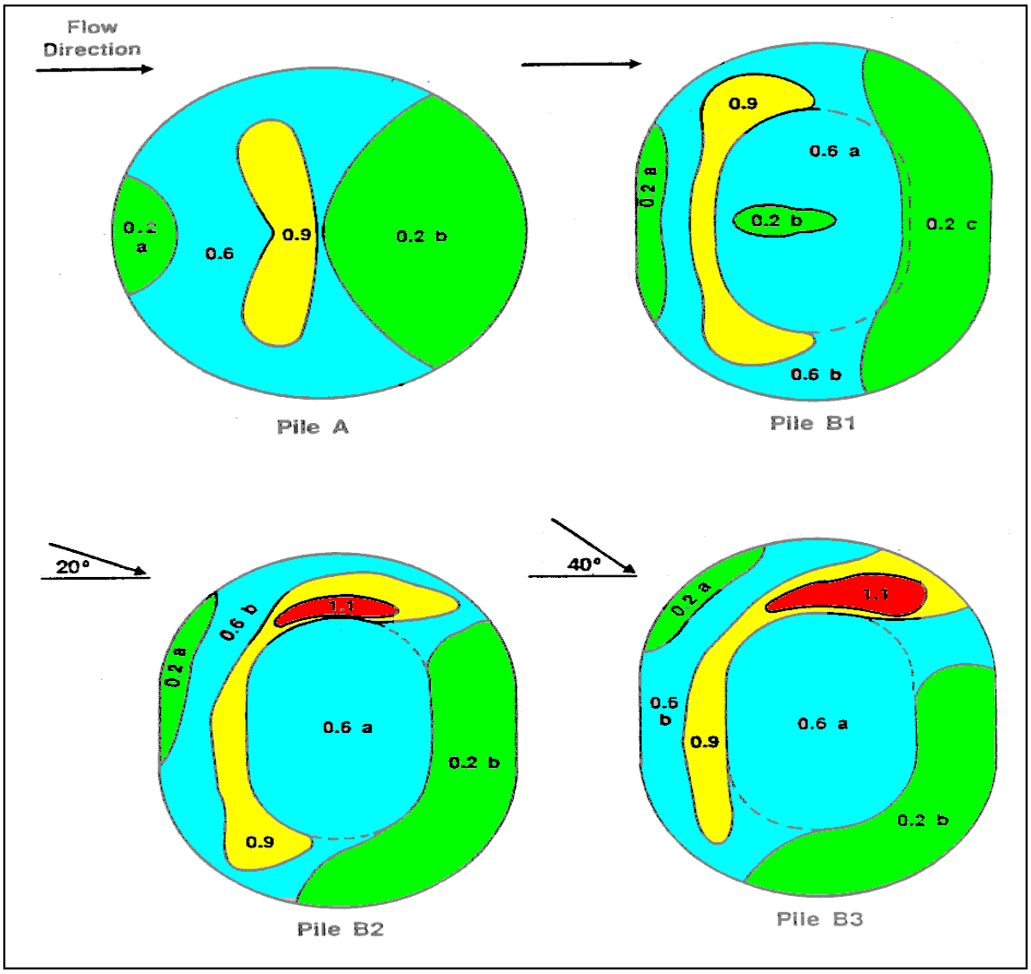


Figure 19: Contours of normalised surface wind speeds – surface wind speed/approach wind speed (US EPA, 2006)

8.4 Appendix D – Curriculum Vitae of Author

CURRICULUM VITAE	OLADAPO B. AKINSHIPE
FULL CURRICULUM VITAE	
Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Oladapo Akinshipe
Profession	Air Quality Specialist
Date of Birth	27 September 1984
Years with Firm/ entity	4 years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

Oladapo has developed professional and technical experience in the following areas:

- Air Quality Impact Assessment,
- AEL and AIR Applications
- Noise monitoring and impact assessment
- Air Quality Monitoring
- Environmental research and Reporting
- Emission Quantification and Inventories (Mining and Ore Handling, Metal Recovery, Petrochemical Industry, Power Generation, Waste Disposal and Recycling etc.)

Oladapo has developed technical and specialist skills in various dispersion modelling packages including the industrial source complex models (SCREEN3), EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS).

RELEVANT EXPERIENCE

Mining and Ore Handling

Oladapo has undertaken numerous air quality impact assessments and management plans for coal, manganese, uranium, copper, cobalt and andalusite mines. These include air quality impact assessments for Alexander Coal Mine (Mpumalanga), Delmas coal mine (Delmas), Pumpi copper and cobalt mine (Congo DR), Vlakfontein coal mine (Mpumalanga). Ongoing projects include Mokala manganese project, Panda Hill Niobium project, Rhino Andalusite project, Hattinspruit siding project.

Metal Recovery

Air quality impact assessment has been carried out for the Transalloys ferromanganese furnace (eMalahleni).

Chemical Industry

Air quality impact assessment and Atmospheric impact report has been completed for the Flexilube refinery plant (Meyerton).

Petrochemical Industry

Air quality impact assessments have been completed for Sasol's Petroleum Sharing Agreement Development Project and Liquefied Petroleum Gas in Mozambique – Inhassoro Early Oil Project (Mozambique).

Noise Impact Assessment

Noise impact assessments have been completed for Pumpi copper and cobalt mine (Congo DR), Mokala manganese Project (Hotazel), Panda Hill Niobium Project (Tanzania).

Power Generation

Air quality impact assessment has been completed for the Transalloys coal fired power station (eMalahleni).

Clay brick Industry

Research project and studies conducted in the clay brick industry include; application of Atmospheric Emission Licences (AEL) for over 20 clay brick factories in South Africa.

Monitoring Projects

Various ambient and stack monitoring projects have been undertaken in the following industries: clay brick, mining (coal, copper and cobalt, uranium etc.)

EDUCATION

PhD Environmental Technology	University of Pretoria, Pretoria, South Africa (Ongoing) Title: *Atmospheric emissions from clamp kilns in the South African clay brick industry*
M.Sc. Environmental Technology	University of Pretoria, Pretoria, South Africa (2013) Title: *The Development of an 'emission inventory tool' for Brickmaking Clamp Kilns*
B.Sc. Honours	University of Pretoria, Pretoria South Africa (2011) Environmental Technology
B.Sc.(Hons)	Olabisi Onabanjo University, Nigeria (2008) Microbiology

COUNTRIES OF WORK EXPERIENCE

Countries of work experience include South Africa, Nigeria, Mozambique, Democratic Republic of Congo, Tanzania and Namibia.

EMPLOYMENT RECORD

July 2013 - Present

Airshed Planning Professionals (Pty) Ltd, Senior Air Quality Specialist, Midrand, South Africa.

February 2011 – June 2013

University of Pretoria, Research Associate and Teaching Assistant, Pretoria, South Africa.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- The Development of an 'emission inventory tool' for Brickmaking Clamp Kilns. Akinshipe O., Kornelius G. International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) World Clean Air conference, Cape Town South Africa (2013). Peer reviewed.
- Atmospheric emission from Clamp Kilns in the South African Clay Brick Industry. Akinshipe O., Kornelius G. National Association for Clean Air Conference, Bloemfontein, South Africa

ANNEXURE D7a

LEEUWPOORT SOUTH
BULK WATER & SEWER
REPORT

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

APRIL 2016

Issued by:
Leeuwpoort Development Company (Pty) Ltd
P O Box 49, Bedfordview, 2008
37 Empire Road
PARKTOWN NORTH
Tel: 011 – 482 3666
Fax: 011 – 482 9734
Attention: Mr Hannes Botes

Compiled by:

PRETORIA P O Box 29, The Innovation Hub, Pretoria, 0087

Allan Cormack Street	Tel +27(0)12 842 8700
The Innovation Hub	Fax +27(0)12 843 9000/-9001
PRETORIA	E-mail pretoria@bigenafrica.com

Enquiries: D SMIT Pr Ing

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

WATER AND SANITATION

CONTENTS LIST

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

LIST OF REFERENCES

1. Sewer Master Plan for Boksburg City Engineers Department: Project WW/P10, Goba (Pty), *June 1999.*

2. Computer Analyses and Master Plan of Water Distribution System, Geustyn Loubser Streicher Inc (GLS), *April 2002.*

3. GLS Reports (February and March 2016):

   - Proposed new mixed land use development on the remainder of the Farm Leeuwpoort 113 IR – Boksburg: Assessment of impact on SEWER systems and required works
   - Proposed new mixed land use development on the remainder of the Farm Leeuwpoort 113 IR – Boksburg: Assessment of impact on WATER systems and required works
   - Proposed new mixed land use development on the Remainder of the Farm Leeuwpoort 113 IR (Parkdene X7) and on Portion 51 of Leeuwpoort 113 IR (Reiger Park X19) – Boksburg: Assessment of impact on SEWER systems and required works
   - Proposed new mixed land use development on the Remainder of the Farm Leeuwpoort 113 IR (Parkdene X7) and on Portion 51 of Leeuwpoort 113 IR (Reiger Park X19) – Boksburg: Assessment of impact on WATER supply systems and required works

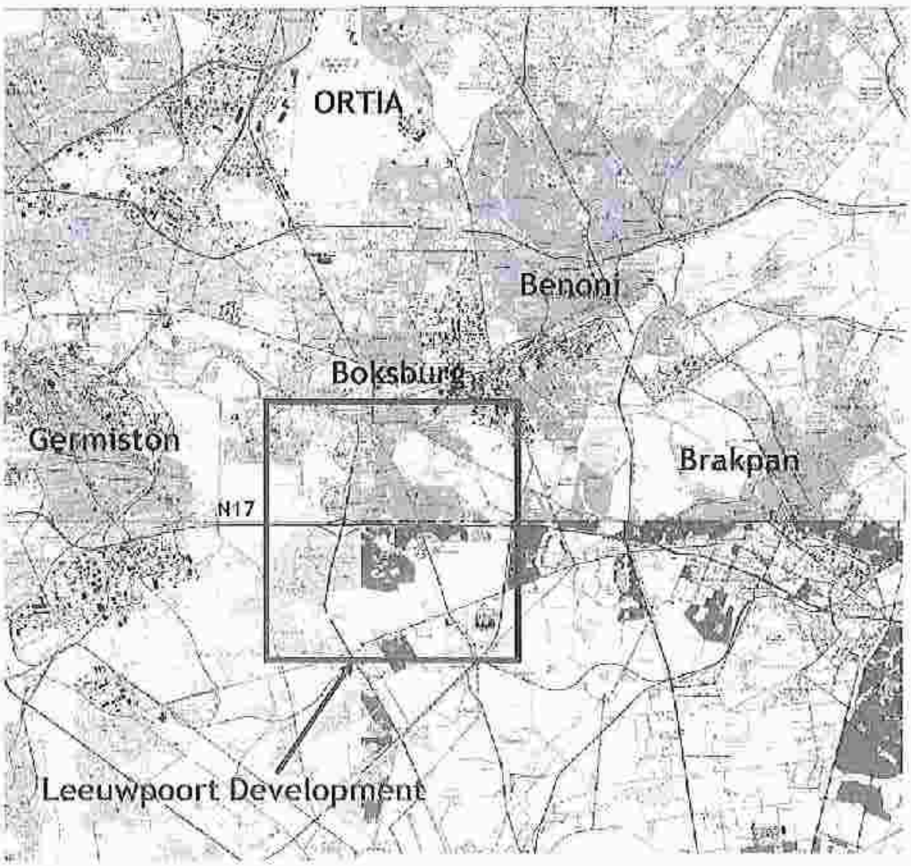
LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

EXECUTIVE SUMMARY

The Ekurhuleni Metropolitan Municipality ("EMM") requested tenders during June 2004 for the development of the Leeuwpoort project. The Leeuwpoort development consists of land owned by EMM. The total project comprises approximately 1,300 Ha. The project is located south of Boksburg as indicated in the figure below.



The development consists of 3 separate land parcels with a scope of approximately 17,800 housing units with a composition of subsidised, institutional and bonded housing. These land parcels are to be known as Reiger Park Extension 19, Parkdene Extension 7 and Leeuwpoort. (Refer to the Locality plan; drawing 0741.00.ZA.01A001 attached in Part H, Annexure H1). The scope of the development will further include ancillary land uses (commercial, etc.) and external infrastructure requirements. Infrastructure is planned in accordance with the design norms and standards of Ekurhuleni Metropolitan Municipality.

Investigations to date show that regional water, sewerage and electrical infrastructure do not have sufficient capacity to accommodate the anticipated demands and discharges of the overall development, but some portions can be accommodated within the existing capacity.

The development falls within three different water supply zones. The Madeley and Vogelfontein Reservoirs supplies the northern areas namely Reiger Park and Parkdene. The Sunward Park reservoir supply will supply the western portion of Leeuwpoort and the Vogelfontein reservoir will supply the eastern portion of Leeuwpoort. Leeuwpoort West will be supplied from the 450mm pipeline that links Sunward Park and Dawn Park Reservoir.

The entire Boksburg municipal area falls within the Rietspruit Sewage Drainage District. ERWAT is responsible for the treatment of the sewage, which takes place outside of the area at the Vlakplaats Water Care Works in Vosloorus and the Waterval Water Care Works near Rand Vaal. The capacity of these plants is under pressure and further extensions are planned.

Stormwater attenuation in line with Ekurhuleni Metropolitan Municipality relevant policy will be provided for.

Ekurhuleni Metropolitan Municipality holds the licence for the distribution of electricity in the mentioned area. Eskom provides bulk supply to the municipality from either 88kV or 11kV infrastructure. The electricity supply to all the pockets will be provided from newly created bulk and link infrastructure fed from the existing electrical infrastructure in the EMM supply area.

Accessibility to the development is very good, but several existing servitudes, planned roads, and rail lines affect the proposed development. The preliminary traffic impact study conducted, highlighted the need for the upgrading of existing roads infrastructure as part of the development and a new impact study is currently underway.

The estimated capital cost for the external civil engineering services for the Leeuwpoort Development split between Ekurhuleni and Leeuwpoort Development is indicated below:

	EMM Contribution	LDCo Contribution	Total
Water and Sanitation	R 156,050,009.44	R 23,172,577.73	R 179,222,587.17

*Base date June 2016

Implementation of the engineering services will largely be dictated by the business planning process of the project.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

Part A Project Brief

The Ekurhuleni Metropolitan Municipality ("EMM") requested tenders during June 2004 for the development of the Leeuwpoort project. Leeuwpoort Development Company (Pty) Ltd was appointed to proceed with the development. The Leeuwpoort development consists of land owned by EMM. The project area, is the Remaining Extent of the Farm Leeuwpoort 113IR, measuring approximately 1 300 Ha.

The development consists of three separate land parcels with a scope of approximately 17,800 building opportunities with a composition of subsidised, institutional and bonded housing. The Leeuwpoort Development is intended for mixed income and will provide a mix of housing products and forms of tenure.

BIGEN AFRICA (PTY) LTD was appointed to do the investigations on the existing and proposed internal and external infrastructure for the Leeuwpoort Development.

The objective of this report is the following:

- To stipulate the design norms and standards on which the estimation of the capital costs of the Engineering Services are based on;
- To establish the status of the existing infrastructure available to the development;
- And to determine the upgrading and new infrastructure needed for the development.

This report is limited to investigation of the engineering services relevant to the development of the three developable land parcels.

The Engineering Services addressed in this report are:

- Water Supply
- Sanitation

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

Part B Layout and Planning

Section B1 Layout Plan

Several existing and future planned infrastructure affects the proposed development of Leeuwpoort. Water, sewer and electricity servitudes on the development area has been taken into account and planned around it.

Roads affecting the layout plan and specifically the southern area are the following:

- Proposed metropolitan road (extension of Matthews drive) extending from K128 and running through Leeuwpoort.
- Re-alignment of Trichardts Road (K165), linking Boksburg CBD and southern residential areas.
- PWV 15 freeway planned on the eastern section of Leeuwpoort. The construction of PWV 15 is not expected to take place in the foreseeable future. However, this reserve must be protected, and the spatial framework determined with this barrier in mind.

Section B2 External Infrastructure Phasing

Three separate development parcels are to be developed. These are shown on the locality plan drawing nr 0741.00.ZA.01A001. Leeuwpoort will be subdivided in six different phases as seen on the Leeuwpoort Phasing Plan from Urban Dynamics attached in Part H, Annexure H1.

Project phasing has been selected by taking cognisance of infrastructure needed for each parcel and to defer the investment in external services as far as is possible. The driving factor was the reservoirs supply zones and the electricity feeding areas. The sewage drainage areas and the roads and stormwater infrastructure had minimum effect on the phasing process.

The three parcels are as follows (See drawing Leeuwpoort Phasing Plan from Urban Dynamics attached in Part H, Annexure H1):

• Reiger Park Extension 19	–	Phase 1
• Parkdene Extension 7	–	Phase 1
• Leeuwpoort Development	–	Phase 1 – Phase 6

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

Part C Water Supply

Section C1 Authority and Provider Arrangements

The Ekurhuleni Metropolitan Municipality is the Water Service Authority for the Leeuwpoort development in terms of the Water Services Act (Act No. 108 of 1997).

Section C2 Design Norms and Standards

The design criteria for the development of the site are based on the standards of Ekurhuleni Metropolitan Municipality: "Developer's Guidelines to Installing Water and Sewer Services" which adopted the standards of the Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development, summarised in Table C2.1 and Table C2.2.

The average annual daily demands that will be used for the different housing compositions are as follows:

- Low Density (8-25 units/ha) 850 ℓ/unit/day
- Medium density (30-40 units/ha) - 680 ℓ/unit/day
- High Density (60-120 units/ha) 600 ℓ/unit/day
- Residential 3&4 (120-180 units/ha) 510 ℓ/unit/day

Table C2.1: Standards and Specifications for Water supply:

PARAMETER	DETAIL	SPECIFICATION
AADD	Refer to section C 2 above	
Peak Factor	Entire Development	3.6
Placement of service	Distribution Network Supply to erven	High side of the street Street front of erven 1.5m from erf boundaries
Flow velocity	Residential areas ø≤150mm ø>200mm	 1,0 m/s – 3.5m/s 1.5m/s – 2.5m/s
Pressure	Static pressure Dynamic pressure	Max - 90m Min - 25m residential 35m business / industrial
Losses	Secondary	10%
Fire flow: **Central Business area and cluster housing** **Risk Category C** **to SANS 090/2003**	Hydrant spacing Flow at hydrant Total flow Minimum pressure: At node Rest of system	Max - 100m from furthest erf 25 ℓ/s 50 ℓ/s 15 m 10 m
Fire flow: **Single residential erven** **Risk Category D4** **to SANS 090/2003**	Hydrant Flow at hydrant Total flow Minimum pressure: At node & rest of system	Max – 100 m from furthest erf 15 ℓ/s 15 ℓ/s 8 m
Pipe-cover	Within road reserves Underneath tarred surfaces Maximum depth	Min – 1000mm Min – 1000mm Max - 2000mm
Piping	Sizes Material	Min – 110ND uPVC class 12 spigot and socket HDPE pipes with welded joints or Hi-Impact pipes with Victaulic joints in dolomitic areas Steel with coatings and linings as agreed with EMM
	Adjacent house connections	1 stand: 25mm minimum 2 stands: 32mm minimum
	House connections across street	1 stand: 25mm minimum 2 stands: 32mm minimum
Valves	ø≤350mm ø≥400mm	RSV – class 16 to SANS664, cap top, non-rising spindle, anti-clockwise closing. Wedge gate valves for larger diameters

The following principles will be given consideration in the design and placement of the reticulation network of the internal water layout:

- Establishing independent bulk water metering zones within the development;
- Monitoring and control of water loss and ease of metering of the supply zones;
- Facilitation of water loss control through pressure control by means of pressure reduction installations; and
- Flexibility within the system to allow for alternate supply routes, specifically in terms of emergency flow requirements, while maintenance procedures may be required.

Section C3 Service Storage and Supply Areas

The development falls within three different water supply zones. The Madeley reservoir supplies Reiger Park Ext 19 and Vogelfontein Reservoir supplies Parkdene Ext 7. The Sunward Park Reservoir supplies Leeuwpoort West and the Vogelfontein Reservoir supplies Leeuwpoort east.

Each supply point will be metered to enable the carrying out of regular water balance audits. Approximately 10 bulk meters will be required at strategic points throughout the development.

Existing pressure reducing valves in the existing system will need to be adjusted to supply the Leeuwpoort Area.

From the GLS reports the following is deducted with regards to the reservoir capacities:

The existing Madeley Reservoir (with a capacity of 38.1 Mℓ and a top water level of approximately 1,687.75m and bottom water level of 1,675.6m) has sufficient spare capacity to provide the average annual daily demand for the approximately 4,677 residential units of the Reiger Park with a storage period of 18 hours.

Parkdene Ext 7 will be incorporated into the Vogelfontein booster zone – a sub-zone of Vogelfontein reservoir/RW3976 direct Zone.

The existing Sunward Park Reservoir (with a capacity of 15 Mℓ and a top water level of approximately 1,625.13m and bottom water level of 1,615.13) and two pressure towers (with a capacity of 5 Mℓ and a top water level of approximately

1,642.5m and bottom water level of 1,634.5) do not have sufficient spare capacity to provide the average annual daily demand for the approximately 8,061 residential units of Leeuwpoort West. The GLS report proposes the construction of an additional 5Mℓ reservoir (adjacent to the 15 Mℓ reservoir) to accommodate the balance of erven. It is proposed that a connection directly onto the 450ND pipe in Rondebult Road be done to supply Leeuwpoort West.

The existing Vogelfontein Reservoir (with a capacity of 20 Mℓ and a top water level of approximately 1,671.38m and bottom water level of 1,658.72) do not have sufficient spare capacity to provide the average annual daily demand for the approximately 5,850 residential units of Leeuwpoort East. The GLS report further proposes the construction of an additional 31 Mℓ regional reservoir (adjacent to the 20 Mℓ reservoir) to accommodate the balance of erven.

Only a small portion of this capacity will be used by the Leeuwpoort Development.

Section C4 Proposed Water Supply Scheme

The proposed bulk water supply scheme is shown on drawing no.0741.00.ZA.05A001 attached in Part H, annexure H1.

A total of 11.6 km of external (bulk and link) water pipelines will be needed for all three parcels of the development.

The water supply scheme will be discussed referring to the three different parcels.

External pipelines within the boundary of the development site will form a circular supply system passing adjacent to both regional business and light industrial centres where high demands and fire flow conditions are anticipated.

In-line isolating valves, scour valve and air valve installations will be needed at strategic places within the supply system.

Section C4.1 Southern Area

For the purpose of this report Leeuwpoort has been divided into two portions namely Leeuwpoort East (Phases 1 - 3) and West (Phases 4-6).

<u>Leeuwpoort West</u>

The proposed Leeuwpoort West falls in the Sunward Park pressure area and can be supplied by two different supply sources. From the GLS report connections can be made to the existing 450ND pipe in Rondebult Road. This will be sufficient for Phase 1. For Phases 2 and 3 a 400ND pipe needs to be installed form the intersection with Uitkyker and Aquarius Roads across the flood plain. No major upgrading will then be necessary for the pipeline along Rondebult Road.

The supply to Phases 2 and 3 comes from the existing 15 Mℓ Sunward Park reservoir and 2 x 2,5 Mℓ pressure towers. The water supply to this area would come from the north via an existing 500 ND supply line through Sunward Park in Aquarius Road, or from the west in Rondebult Road from a 450ND pipeline that links the Sunward Park and Dawn Park Reservoir supply. The Sunward Park Reservoir does not currently have capacity to supply the approximately 7,700 stands of Leeuwpoort West. A new 5 Mℓ Reservoir will be required to supplement the storage capacity.

GLS confirmed that the pump at the Sunward Park Tower does have sufficient capacity to supply the current demand. The increase in demand can be supplied via the RW direct supply.

Leeuwpoort East

Leeuwpoort East falls in the 20 Mℓ Vogelfontein reservoir supply area.

Leeuwpoort East cannot be supplied from the existing supply pipeline from the Vogelfontein reservoir. A new parallel supply line will have to be installed to supply the approximately 5,400 residential units.

Considerable upgrades to the bulk water supply system of Vogelfontein will be required before any development can take place in Leeuwpoort East.

The immediate requirement is the construction of a proposed 31 Mℓ Reservoir next to the existing Vogelfontein reservoir. The construction of the reservoir is to be followed by the construction of a new 800ND bulk pipeline from the reservoirs to Jubilee Road. This pipe reduces to 500ND and running in Jubilee Road up to Barry Marais adjacent to the existing bulk pipeline in Barry Marais Road and then down Barry Marais Road up to the intersection with Van Wyk Road. A temporary connection will be made to the existing 450ND pipe. Bulk pipelines needed within the boundary of the development will form a circular supply system with the adjacent developments.

Section C4.2 Northern Area

Parkdene Ext 7

Parkdene Ext 7 development can be incorporated into the Vogelfontein booster zone – a sub-zone of the Vogelfontein reservoir/RW3976 zone. Bulk supply to Parkdene Ext 7 is however readily available and the area can be serviced without major upgrades to the existing system. There is a closed, unused 300ND fibre cement pipeline running through the area to Reiger Park. This pipeline is available to supply water to the Parkdene Ext 7 development.

This pipeline was previously used to feed the Reiger Park development, but due to a new 500ND supply to Reiger Park from the Madeley Reservoir, this main is no longer used, except to supply the shopping complex at the corner of Rondebult and Leeuwpoort Street.

Reiger Park Ext 19

Reiger Park Ext 19 will also be supplied from the Madeley Reservoir. The Madeley reservoir is a 38,1 Mℓ reservoir with adequate spare capacity to supply the development.

The western parcel of Reiger Park Ext 19 can be supplied from the 400ND supply pipeline that crosses the area at its north-western corner. This pipe supplies water to Reiger Park from the Madeley Reservoir. The GLS report proposes that an additional 500ND bulk pipe be laid in Leon Ferreira Drive up to Drommedaris Avenue then reduces to 200ND and follows Drommedaris Avenue up to Dahlia Road. Here the pipe will be connected to the existing 300ND FC pipe from Parkdene. A new valve will be installed on this pipe to isolate the Reiger Park network from the Parkdene network. 200ND pipes will be installed to supply the developable land north of the eastern parcel of Reiger Park Ext 19.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

Part D Sanitation

Section D1 Authority and Provider Arrangements

The Ekurhuleni Metropolitan Municipality is the Water Service Authority for the Leeuwpoort development in terms of the Water Services Act (Act No. 108 of 1997).

Section D2 Design Norms and Standards

The design criteria for the development of the site have been based on the standards of Ekurhuleni Metropolitan Municipality: "Developer's Guidelines to Installing Water and Sewer Services" which adopted the Guidelines for the provision of engineering services and amenities in residential township development, summarised in Table D2.1 and Table 2.2.

Sewerage designs will be in line with the Sewer Master Plan of Boksburg. The entire development will be in accordance with conventional level 3 – a metered pressure water connection with water-borne sanitation for each property.

Table D2.1: Sewerage Demands:

Zoning	Density	Unit flow
Residential 1	400m² Bonded	0.85 kℓ/u/d
Residential 2	300m² Bonded & 220m² Flisp	0.68 kℓ/u/d
Residential 2	200m² Bonded	0.60 kℓ/d
Residential 4	Subsidy 120u/ha	0.51 kℓ/d
Business 3	Offices	21.25 kℓ/d/ha
Community Facility	Community Facility	17.00 kℓ/d/ha
Schools	Primary & secondary schools	17.00 kℓ/d/ha

Table D2.2: Standards and Specifications for Sanitation:

PARAMETER	DETAIL	SPECIFICATION
Peak Factor	Entire Development	1.8
Minimum Flow Velocity	Residential areas	0.7 m/s
Minimum depth to invert	Road reserve Other areas	1m 800mm
Manhole spacing	Network sewers	80m
Minimum Gradients	150ND (fewer than 24 dwellings) 150ND 200ND 225ND 250ND 300ND 375ND	1/80 1/140 1/200 1/220 1/240 1/300 1/370
Pipe Material	110mm to 315ND ≥ 355ND	Solid wall uPVC class 400 to SANS 1601 HDPE pipes with welded joints in dolomitic areas Solid wall uPVC class 400 to SANS 1601 HDPE pipes with welded joints in dolomitic areas
Design Capacity	All Pipes	67% at design flow
Minimum Pipe diameter	Gravity sewers	150 mm
Stormwater Infiltration		15% of design flow
Hydraulic Calculations	Manning Equation	n = 0,012
Location of Sewers	All Areas	Sewers 2.5m from road reserve boundaries in major roads and 1.5m from the erf boundary for road reserve boundary in minor roads
Connections	For Stands	110 mm uPVC with slip on couplings

Section D3 Existing Wastewater Treatment Capacity and Sewage Zones

The entire Boksburg municipal area falls within the Rietspruit Drainage District. ERWAT is responsible for the treatment of the sewage, which takes place outside of the area at the Vlakplaats Water Care Works (WCW) in Vosloorus and the Waterval Water Care Works (WCW) near Rand Vaal.

The bulk of the runoff contributes to the Boksburg North outfall sewer and is treated at the Vlakplaats works. The remaining flow is collected by the newly constructed Klippoortjie outfall sewer and treated at the Vlakplaats and Waterval works respectively.

The Vlakplaats WWTP currently has a treating capacity of approximately 83 Ml/day. The current measured dry weather inflow into the plant is approximately 113 Ml/day. The plant, however, is capped at 83 Ml/day and all excess flow is currently bypassed to the Waterval WWTP. The Waterval WWTP currently has a treating capacity of 155 Ml/day. The current dry weather inflow into the plant is measured at approximately 195 Ml/day with the measured wet weather inflow reaching flows of up to 242 Ml/day. ERWAT has recently completed the extension of the plant from 105 Ml/day to 155 Ml/day. The plant will, however, have to be extended further as soon as possible. The effect that the additional sewage flow from the proposed development has on the required extension of the plant is insignificantly small.

The Leeuwpoort development will generate a peak wet weather flow of approximately 282ℓ/sec once fully developed.

Section D4 Proposed Sewerage Scheme

Approximately 77km pipes of varying diameters will be installed internally on the Leeuwpoort development over the six phases.

Sewers will be laid in the road reserves or in municipal erven (earmarked for this purpose) to provide access for maintenance purposes. See drawing no 0741.00.GZA.03D001 for placement of services within the road reserves.

As indicated by Ekurhuleni Metropolitan Municipality sewerage systems without pump stations are preferred due to the excessive cost and management requirements of operating and maintaining such systems.

Refer to drawing 0741.00.GZA.06A001 for the layout of the bulk sewers.

Section D4.1 Southern Area

Leeuwpoort

The Leeuwpoort development will drain into two different outfall sewers running to different water treatment works. A portion will discharge into the newly constructed

Klippoortjie outfall sewer and the rest into the existing Boksburg North outfall sewer east of Rondebult Road.

According to the GLS report Leeuwpoort can be divided into three drainage zones. The existing Van Dyk Park outfall sewer transects the area from east to west. This is a bulk outfall sewer 300/500/600ND with ample capacity. The area south of this line will drain directly into this line by making multiple connections. The area to the east/north of this line will drain into a new outfall sewer to be constructed along the southern floodline and will drain into the Klippoortjie outfall sewer. This sewer will cross Rondebult Road to be connected to the Klippoortjie outfall sewer west of Rondebult Road. The north-eastern area will drain into the existing Sunward Park sewer that runs on the southern boundary of Sunward Park. The Sunward Park (Gesternte) pump station has been taken out of commission and a link to the Klippoortjie outfall sewer made. A new sewer will be laid along the northern floodline to service the stands on the northern side of the river.

Section D4.2 Northern Area

Reiger Park Ext 19

The Western portion of Reiger Park Ext 19 will drain in an easterly direction through the existing network and according to the GLS report no upgrading to the existing sewer network will be required. The report however point out that an additional inflow of 30 ℓ /sec should be allowed for the future development on the western side of Reiger Park. It is doubtful if the existing sewer network can accommodate this additional flow and no allowance has been made for this flow. The eastern portion will drain directly into the outfall by means of a new 450m x 200ND external sewer line. It was recommended by GLS that the existing 600ND bulk Boksburg outfall sewer pipe running past Reiger Park be surveyed to confirm whether upgrading will be required. The proposed development will not have any influence on the capacity of the sewer. The existing Boksburg Outfall sewer runs North – South, west of the Cinderella dam.

Parkdene Ext 7

Parkdene Ext 7 will drain by means of a new 200/315ND bulk line around the eastern side of the Cinderella Dam through Parkdene Ext 6 and will connect to an existing outfall in from the East of Boksburg which connects to the Boksburg North Outfall Sewer south of the Cinderella Dam.

According to initial investigations by GLS, adequate capacity is available in the outfall system to accommodate sewage from Reiger Park 19 and Parkdene Ext 7.

LEEUWPOORT DEVELOPMENT COMPANY (PTY) LTD

LEEUWPOORT DEVELOPMENT

ENGINEERING SERVICES REPORT

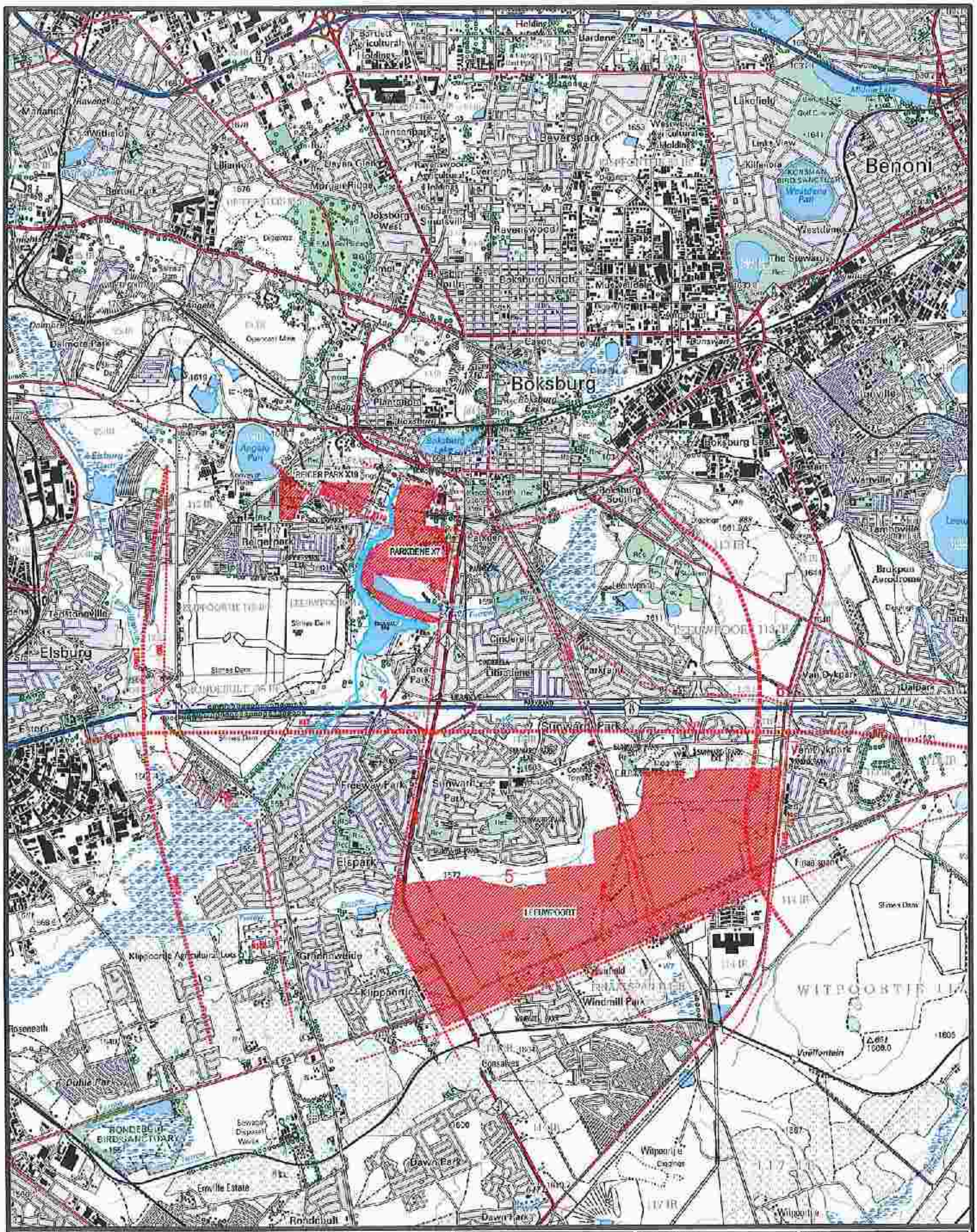
Part H **Appendices**

Section H1 **Report Drawings**

0741.00.GZA.01A001	Leeuwpoort Development – Locality Plan
0741.00.GZA.03D001	Leeuwpoort Development – Road Cross Sections
0741.00.GZA.05A001	Leeuwpoort Development – Bulk Water Layout
0741.00.GZA.06A001	Leeuwpoort Development – Bulk Sewer Layout

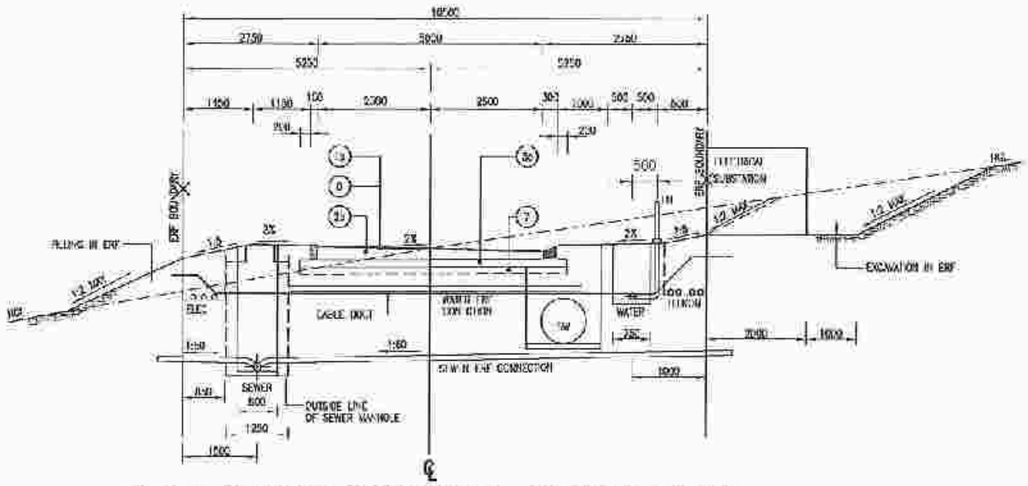
Urban Dynamics Drawings

LeeuwSouthOLay D7/2015.11.18
Parkdene7Lay C4/2016.03.09
Reiger19 C5/2016.04.13



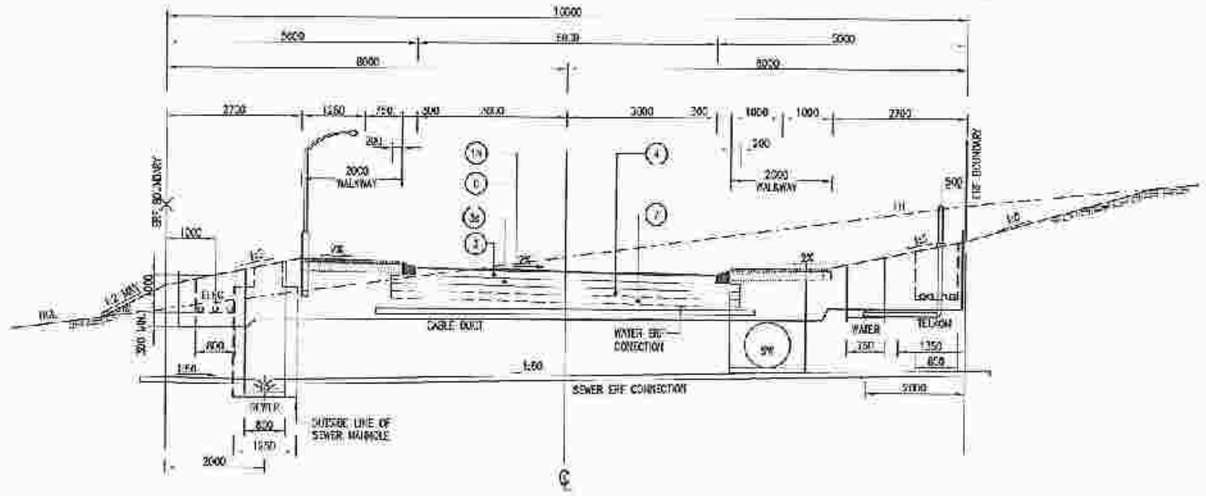
CONSULTING ENGINEERS PROJECT MANAGEMENT & MUNICIPAL SERVICES PRETORIA PO BOX 40193 Arcadia 0007 Casa Labora, 102 Watermeyer Street, Meyerspark 0184 Tel. +27 (0) 12 842 8700 Fax +27 (0) 12 803 8328/8006 E-mail pretoria@bigenafrica.com	SCALE: NOT TO SCALE	APPROVED: P J KOELEWYN	DATE: APRIL 2016
	BIGEN DETAIL No: / VER:	CHECKED: D SMIT	DRAWING No.: 0741.00.ZA.01.A001 / VER: 1.0

DRAWING TITLE: **LEEUWPOORT DEVELOPMENT – LOCALITY PLAN**



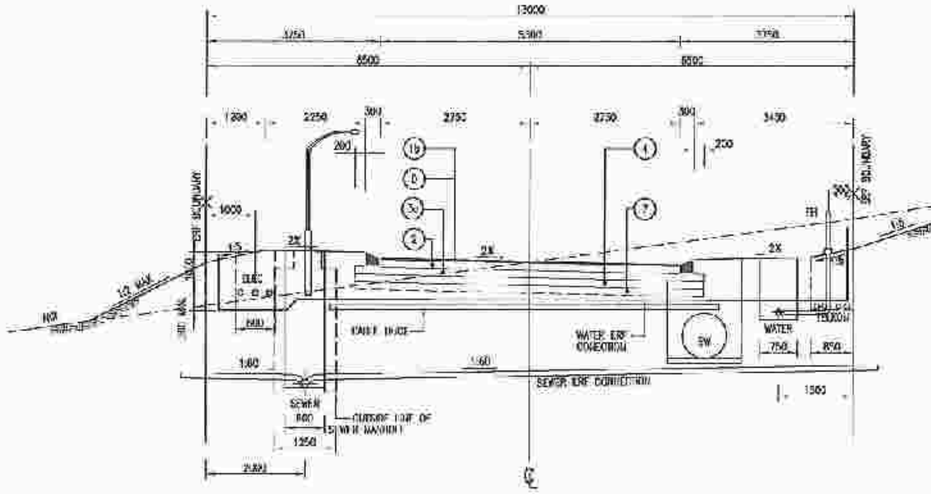
TYPICAL SERVICES POSITIONS AND PAVEMENT DETAILS
FOR 10.5m ROAD RESERVE

SCALE 1:75



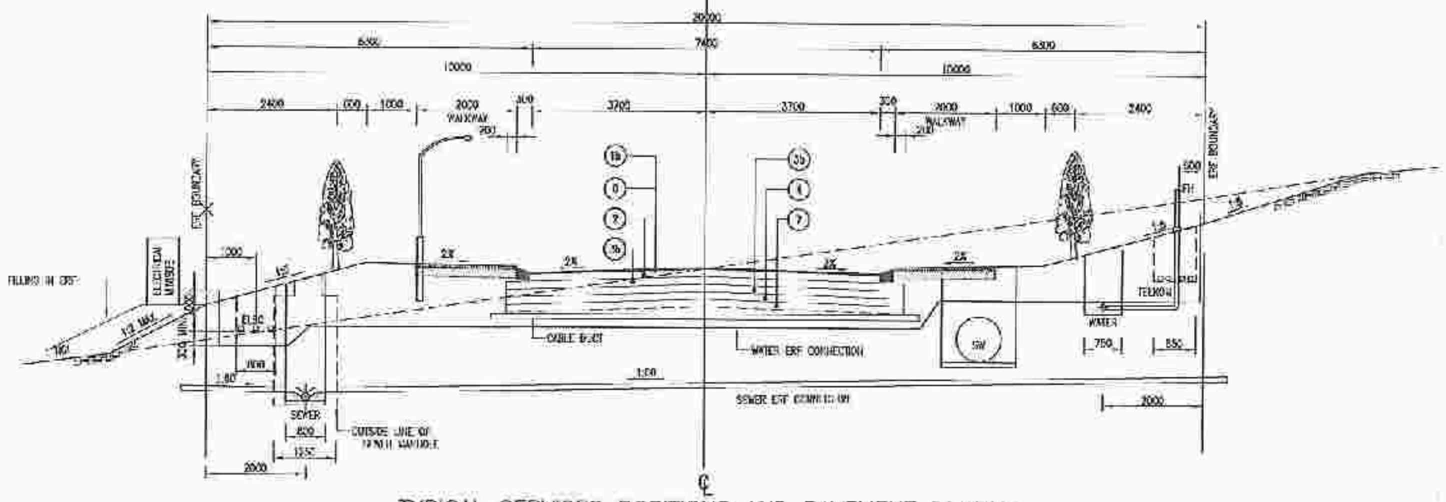
TYPICAL SERVICES POSITIONS AND PAVEMENT DETAILS
FOR 16m ROAD RESERVE

SCALE 1:75



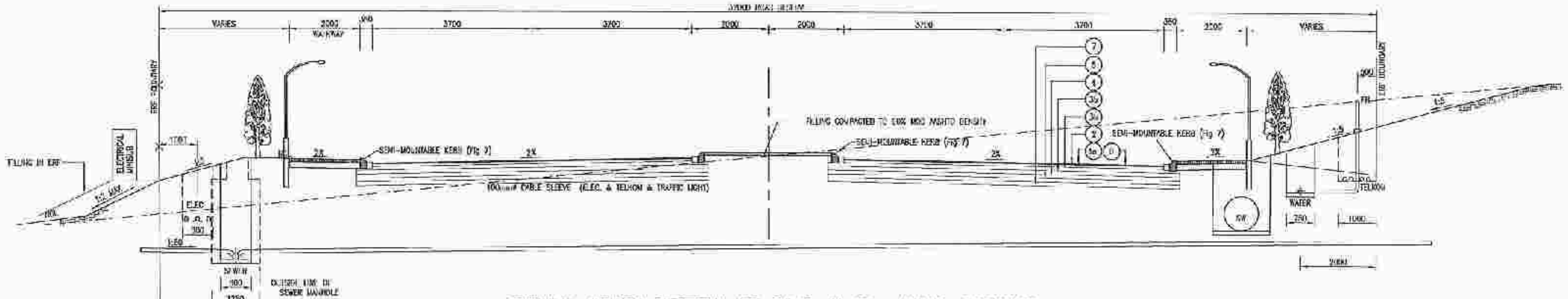
TYPICAL SERVICES POSITIONS AND PAVEMENT DETAILS
FOR 13m ROAD RESERVE

SCALE 1:75



TYPICAL SERVICES POSITIONS AND PAVEMENT DETAILS
FOR 20m ROAD RESERVE

SCALE 1:75



TYPICAL CROSS SECTION OF ROAD IN 32m ROAD RESERVE

SCALE 1:75

DESCRIPTION OF PAVEMENT LAYERS:

- (1) CUTBACK BITUMEN PRIME TO SANS 303
- (1a) 40mm CONTINUOUSLY GRADED MEDIUM ASPHALT.
- (1b) 30mm CONTINUOUSLY GRADED MEDIUM ASPHALT.
- (2) 150 G1 @ 88% GR-TR14/6 : BASE
- (3a) 150/NG/45 @ 95%/1.5/10 : SUBBASE (G5)
- (3b) 150/SG/15 @ 95%/1.5/SP : SUBBASE (C4)
- (4) 150/NG/15 @ 93%/0.75/12 : USSG (G7) – (SEE NOTE 2)
- (5) 150/NG/7 @ 93%/0.5/– : LSSG (G9) – (SEE NOTE 2)
- (7) ROADBED PREPERATION TO 90%.
- (8) FINISHING OFF/TRIMMING OF SIDEWALK
- (9) 50mm INTERLOCKING PAVING BRICKS ON 20mm SAND BEDDING

LEGEND:

1. REQUIREMENTS ARE GIVEN IN THE FOLLOWING ORDER: LAYER THICKNESS / MATERIAL / MIN STRENGTH (CBR OR UCS) @ MIN DENSITY/ MIN GM / MAX PI.
2. MIN UNCONFINED COMPRESSIVE STRENGTH (UCS) IS SHOWN IN kPa.
3. MIN DENSITY IS GIVEN AS % OF MAX MODIFIED AASHTO DENSITY.
4. SG = STABILISED GRAVEL
   NG = NATURAL GRAVEL
   PI = PLASTICITY INDEX
   NP = NON PLASTIC
   SP = SLIGHTLY PLASTIC
   GM = GRADING MODULUS
   GR-UF = GRADING AS PER SABS 1200 UF
   CG = CONTINUOUSLY GRADED
   G1 = GRADED CRUSHED STONE
   SSG = SELECTED SUBGRADE
   GR-TR14 = GRADING AS PER TRH14

NOTES:

1. WHERE THE SUBGRADE IS TOO WET FOR THE ROADBED TO BE PROPERLY COMPACTED, THE ENGINEER SHALL ORDER THAT THE ROADBED BE SCARIFIED, LEFT TO DRY AND RECOMPACTED TO THE DENSITY SHOWN.
2. SUBGRADE LAYERS AND ROADBED AS PER ENGINEER'S INSTRUCTIONS ON SITE, DEPENDING ON FORMATION CONDITIONS ENCOUNTERED.
3. WHERE COLLAPSIBLE SOILS ARE ENCOUNTERED THE ROADBED SHALL BE COMPACTED USING A IMPACT-OR PNEUMATIC ROLLER TO COLLAPSE THE INSITU MATERIAL.
4. PRECAST KERBS SHALL BE LAYED ON AN 50mm CONCRETE BED.
5. MOUNTABLE KERBS TO BE FIG 3, UNLESS OTHERWISE SPECIFIED.
6. ALL KERB SHAPES AND STRENGTH TO COMPLY WITH SANS 927.
7. ALL KERBING ON CURVES TO BE CONTINUOUSLY HAUNCHED. KERBS ON STRAIGHT SECTIONS HAUNCHED ONLY AT JOINTS.

BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel: +27 (0) 12 842 8700
Fax: +27 (0) 12 843 9000/9001
Email: pretoria@bigenafrica.com
www.bigenafrica.com

BIGEN AFRICA

SURVEYED		APPROVED ON BEHALF OF BIGEN AFRICA:	
DESIGNED	P J KOELEWYN	NAME: D SMIT	
DRAWN	M STEENBERG	SIGNATURE:	
CHECKED	J D SMIT		
SERVICES CHECKED	–	DATE:	
GEOTECHNICAL INVESTIGATION			
COORDINATE SYSTEM	WG29		
APPROVED	D SMIT		

BIGEN AFRICA DRAWING No.	REVISION	APPROVED	D SMIT
0741.00.CZA.03D001	1.0	Pr.Eng. No.	

AMENDMENTS	APPROVED	DATE

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENT AREA

TYPICAL ROAD CROSS SECTIONS

Ekurhuleni
METROPOLITAN MUNICIPALITY

SCALE 1:75 ON ORIGINAL DRAWING

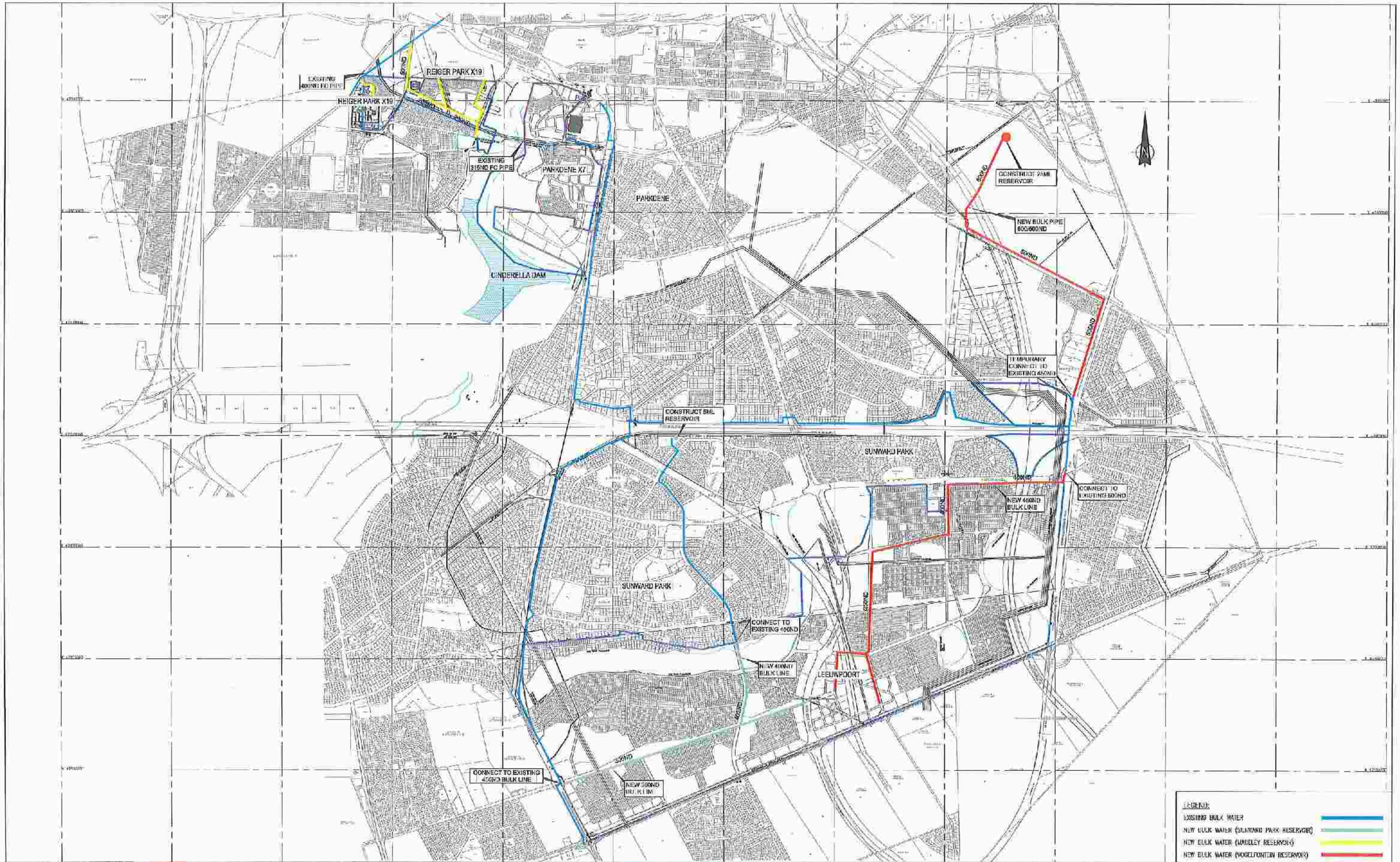
AS-BUILT RECORD			
CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS-BUILT FOR CONTRACT :

ENGINEER DATE

DRAWING No.

REV. No.



BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel: +27 (0) 12 842 8700
Fax: +27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

BIGEN AFRICA

SURVEYED	–
DESIGNED	P J KOELEWYN
DRAWN	M SteenBERG
CHECKED	J SMIT
SERVICES CHECKED	–
GEOTECHNICAL INVESTIGATION	–
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE:
DATE:

AMENDMENTS	APPROVED	DATE

PRIVATE DRAWING No. 0741.00.GZA.05A001
REVISION 1.0
APPROVED: D SMIT

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENT AREA

BULK WATER LAYOUT

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE
– ON ORIGINAL – DRAWING

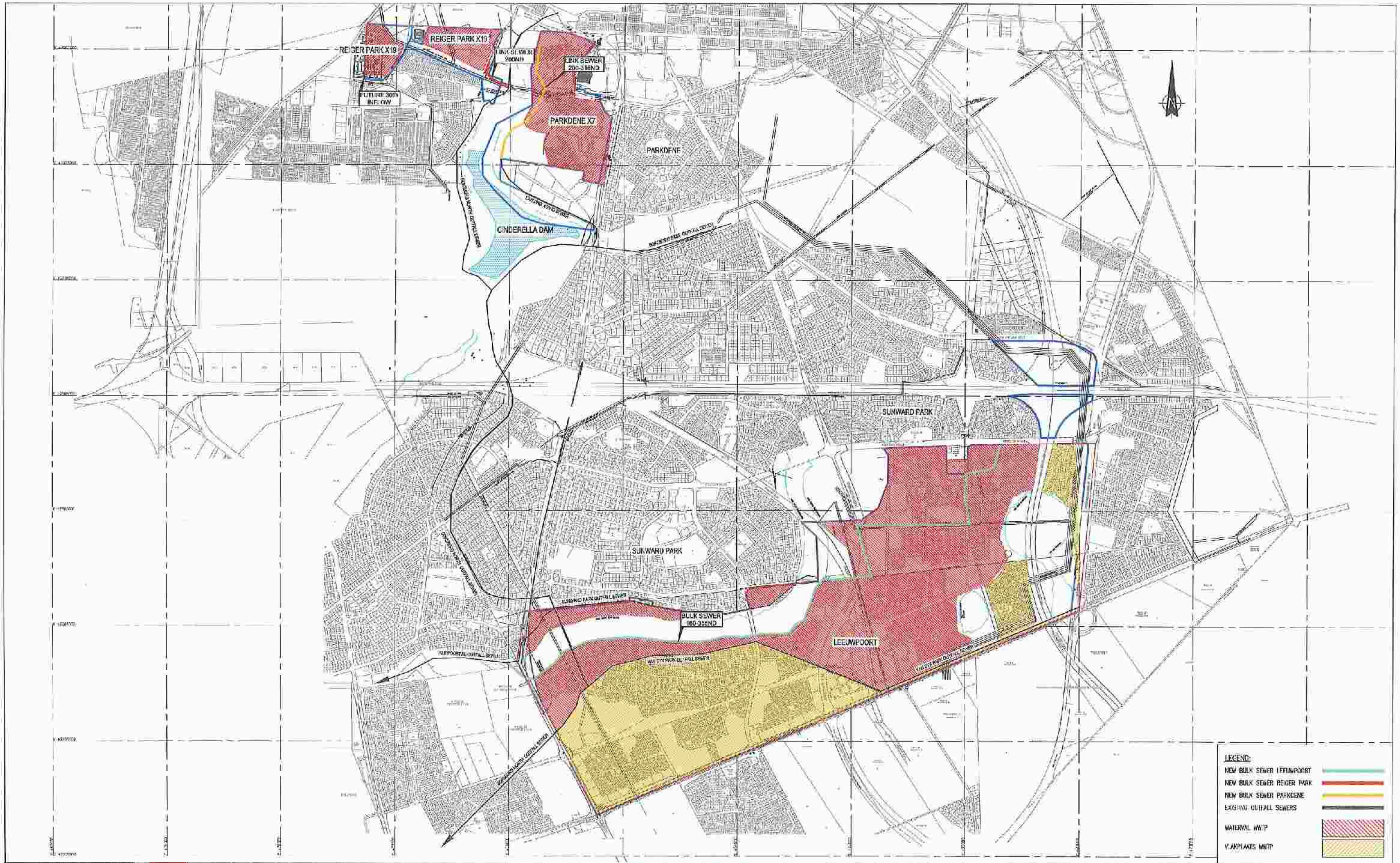
AS-BUILT RECORD

CONTRACT No.	CONTRACT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS-BUILT FOR CONTRACT :
ENGINEER DATE

DRAWING No.

FILE No.



BIGEN AFRICA Services (PTY) LTD
Allan Cormack Street
The Innovation Hub Persequor Pretoria
PO Box 29 The Innovation Hub Pretoria 0087
Tel: +27 (0) 12 842 8700
Fax: +27 (0) 12 843 9000/9001
E-mail: pretoria@bigenafrica.com
www.bigenafrica.com

BIGEN AFRICA

SURVEYED	-
DESIGNED	P J XOELEWYN
DRAWN	M STEENBERG
CHECKED	J D SMIT
SERVICES CHECKED	-
GEOTECHNICAL INVESTIGATION	-
COORDINATE SYSTEM	WG29
APPROVED	D SMIT

APPROVED ON BEHALF OF BIGEN AFRICA:
NAME: D SMIT
SIGNATURE:
DATE:

AMENDMENTS	APPROVED	DATE

BIGEN'S DRAWING No. 0741.00.GZA.06A001 — REVISION 1.0

LEEUWPOORT DEVELOPMENTS

LEEUWPOORT DEVELOPMENT AREA

BULK SEWER LAYOUT

Ekurhuleni METROPOLITAN MUNICIPALITY

SCALE

ON ORIGINAL DRAWING

AS-BUILT RECORD

COMMENT No.	COMMENT DESCRIPTION	CERTIFIED	DATE

CERTIFIED AS-BUILT FOR CONTRACT :

ENGINEER DATE

DRAWING No.

FILE No.

PROJECT

PROPOSED TOWNSHIP

PARKDENE EXTENSION 7

SITUATED ON THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113 IR

LOCAL AUTHORITY : EKURHULENI MM
DISTRICT : BOKSBURG
GEODETICAL SYSTEM : WG 29

LOCALITY

LAND USE TABLE

GENERAL NOTES

REVISIONS

CLIENT:

LEEUWPOORT DEVELOPMENTS (PTY)LTD

CLIENT REF. No:

SCALE: 1:2 500

DRAWING REF:

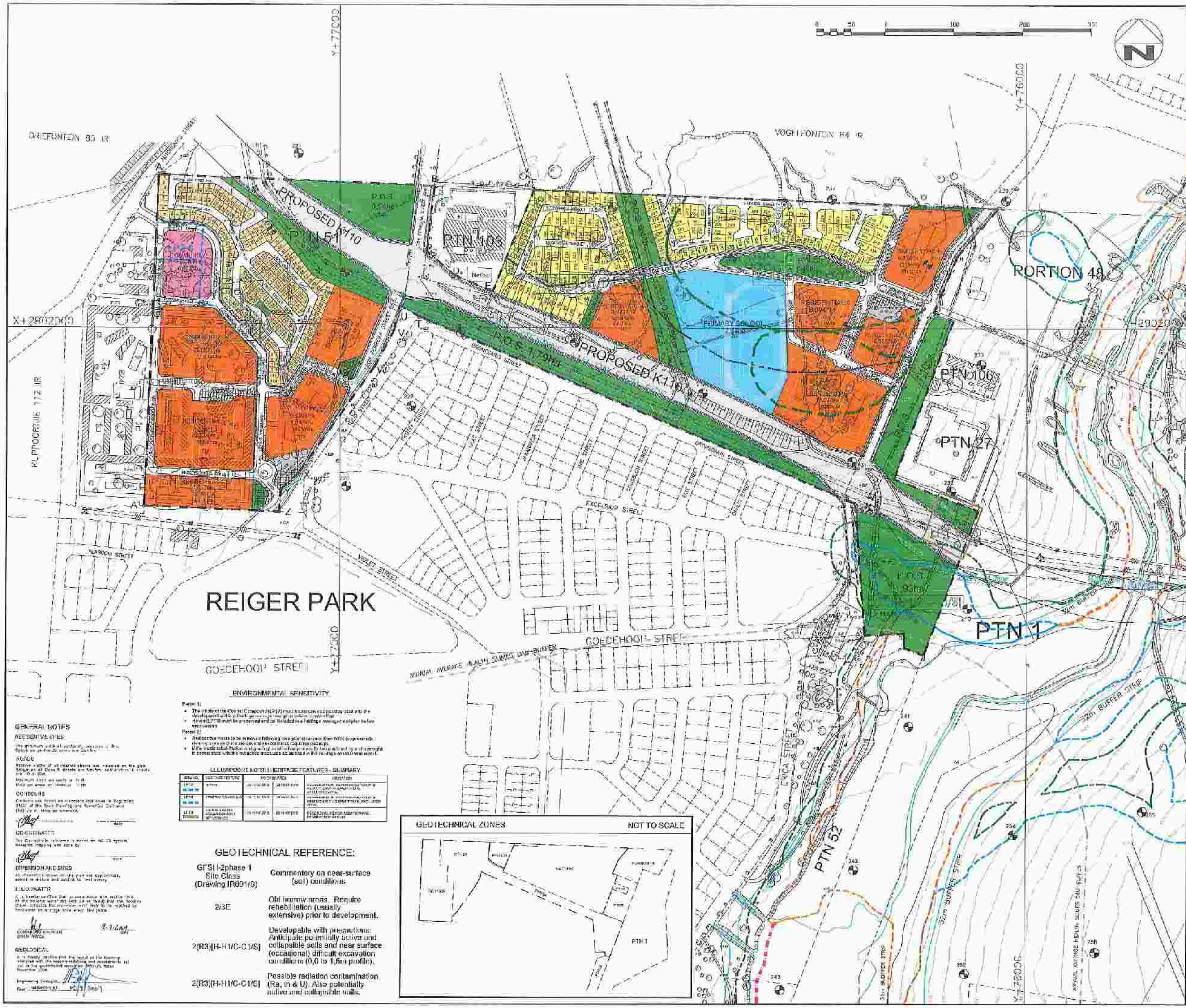
Parkdene7Lay D1/2015.02.10

DRAWING STATUS:

DRAFT

COPYRIGHT RESERVED

URBAN DYNAMICS



PROJECT

PROPOSED TOWNSHIP

REIGER PARK EXTENSION 19

SITUATED ON THE REMAINING EXTENT AND PORTION 51 OF THE FARM LEEUWPOORT 113 IR

LOCAL AUTHORITY : EKURHULENI MM
DISTRICT : BOKSBURG
GEODETICAL SYSTEM : WG 29

LOCALITY SCALE 1:50 000

LAND USE TABLE

ZONING	LAND USE	ERF NUMBERS	No. OF STANDS	AREA OF STANDS & STREETS	% OF AREA
RESIDENTIAL 3	RESIDENTIAL 220m²	180-263,271-355	170	3,51	8,40
RESIDENTIAL 3	RESIDENTIAL 112m²	1-172	172	2,11	5,16
RESIDENTIAL 4		176, 269, 270	3	2,35	5,84
RESIDENTIAL 4		177, 266, 267	4	3,05	7,35
RESIDENTIAL 4		176, 268	2	1,38	3,34
RESIDENTIAL 4		174, 175	2	3,87	5,82
EDUCATIONAL PURPOSES	PRIMARY SCHOOL	265	1	2,63	6,43
	COMMUNITY FACILITY	173	1	0,65	1,58
TRANSPORTATION	PUBLIC TRANSPORT STOP	179, 268	2	0,31	0,76
PARK	POS	357-369	12	7,51	18,17
PROVINCIAL ROAD	K110 PROVINCIAL RD			5,83	14,10
STREETS				8,76	21,17
TOTAL			359	41,31	100%

GENERAL NOTES

- OUTSIDE BOUNDARY OF TOWNSHIP
- GEOTECHNICAL ZONES
- 1:100 YEARS FLOODLINE
- LINE OF NO ACCESS
- FARM PORTIONS
- BUILDING LINE
- TEST PITS
- 30m WETLAND BUFFER
- SLIMES DAM BUFFER
- HERITAGE SITES TO BE RECORDED

REVISIONS

DRAFT CIRCULATED APPROVED

CLIENT:

LEEUWPOORT DEVELOPMENTS (PTY)LTD

CLIENT REF No:

TOWN PLANNER: D. vd Merwe

COPYRIGHT RESERVED

SCALE: 1:2 500

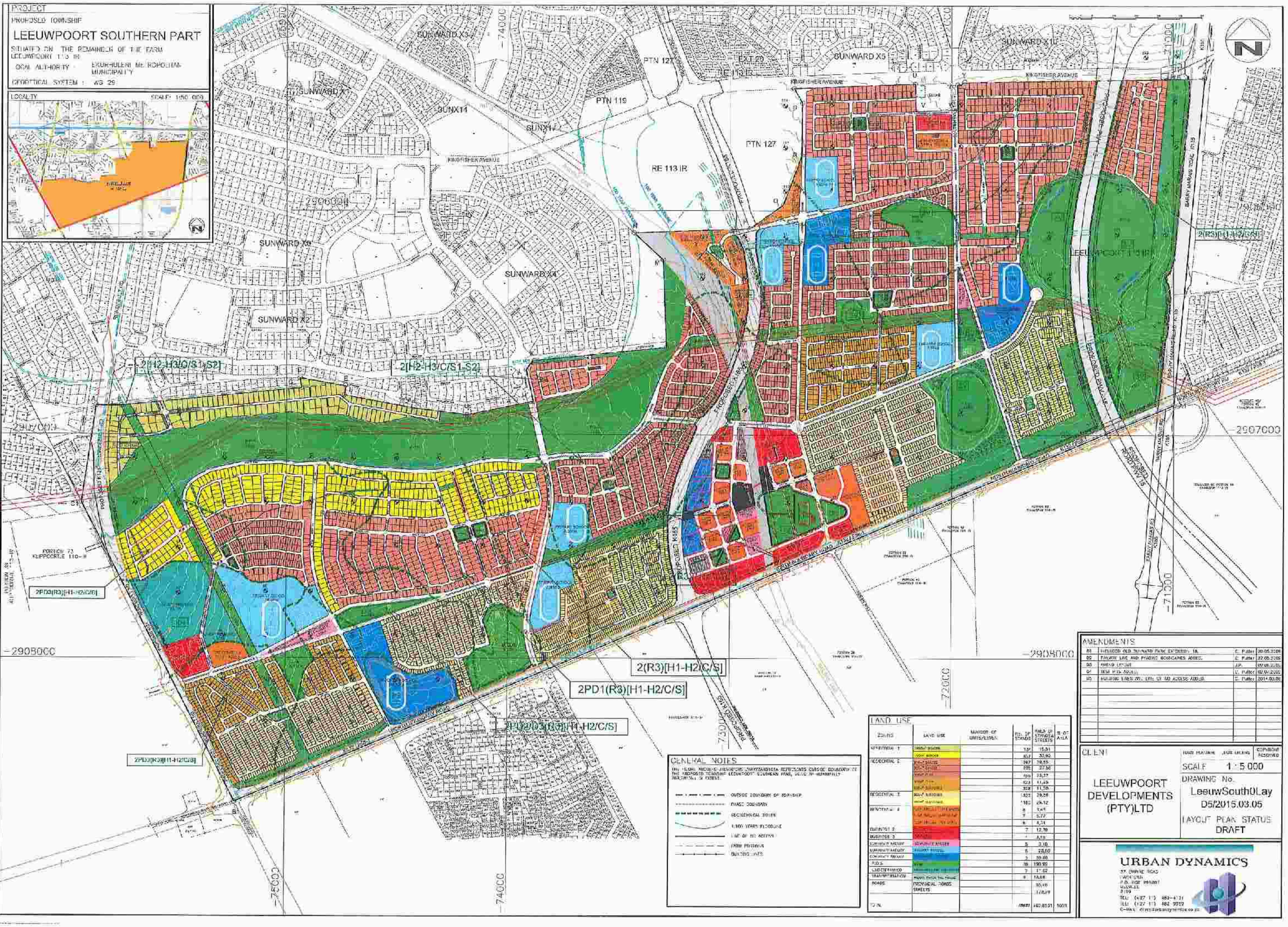
DRAWING REF: Reiger19Lay D1/2015.02.10

DRAWING STATUS: DRAFT

URBAN DYNAMICS
17 EMPIRE ROAD
PARKTOWN
P.O. BOX 291803
MELVILLE
2109
TEL: (+27 11) 482-4131
TEL: (+27 11) 482-9959

GEOTECHNICAL REFERENCE:

GFSH-2phase 1 Site Class (Drawing IR801/S)	Commentary on near-surface (soil) conditions.
2/3E	Old borrow areas. Require rehabilitation (usually extensive) prior to development.
2(R3)[H-H1/C-C1/S]	Developable with precautions: Anticipate potentially active and collapsible soils and near surface (occasional) difficult excavation conditions (0,0 to 1,5m profile).
2(R3)[H-H1/C-C1/S]	Possible radiation contamination (Ra, th & U). Also potentially active and collapsible soils.


PROJECT
PROPOSED TOWNSHIF
LEEUWPOORT SOUTHERN PART
SITUATED ON THE REMAINDER OF THE FARM LEEUWPOORT 113 IR
LOCAL AUTHORITY : EXURHULENI METROPOLITAN MUNICIPALITY
GEODETICAL SYSTEM : WG 29
LOCALITY
SCALE: 1:50 000
SUNWARD X3
SUNWARD X1
SUNX14
SUNX17
KINGFISHER AVENUE
PTN 127
PTN 119
RE 113 IR
EXT 20
SUNWARD X5
SUNWARD X10
SUNWARD X9
SUNWARD X4
SUNWARD X2
LEEUWPOORT 113 IR
2[H2-H3/C/S1-S2]
2(R3)[H1-H2/C/S]
2PD3(R3)[H1-H2/C/S]
2PD1(R3)[H1-H2/C/S]
2PD2/D3(R3)[H1-H2/C/S]
PORTION 73 KLIPPOORTJE 110-IR
PROPOSED K165
–2906000
–2907000
–2908000
–74000
–73000
–72000
–71000
–75000
GENERAL NOTES
LAND USE
ZONING
LAND USE
NUMBER OF UNITS/ERVEN
NO. OF STANDS
AREA OF STANDS & STREETS
% OF AREA
TOTAL
100%
AMENDMENTS
01 C. Putter
02 RAILWAY LINE AND PHASING BOUNDARIES ADDED. C. Putter
03 AMEND LAYOUT J.P.
04 C. Putter
05 C. Putter
CLIENT
LEEUWPOORT DEVELOPMENTS (PTY)LTD
COPYRIGHT RESERVED
SCALE 1 : 5 000
DRAWING No.
LeeuwSouth0Lay
D5/2015.03.05
LAYOUT PLAN STATUS
DRAFT
URBAN DYNAMICS
37 EMPIRE ROAD
PARKTOWN

ANNEXURE D7b

GLS SERVICES SUMMARY

01 March 2017

Chief Engineer: Water Services Planning
Ekurhuleni Metropolitan Municipality
P O Box 215
BOKSBURG
1460

Attention: Mr. Danie van der Merwe

Dear Sir

PROPOSED NEW MIXED LAND USE DEVELOPMENT ON THE REMAINDER OF THE FARM LEEUWPOORT 113 IR - BOKSBURG: ASSESSMENT OF IMPACT ON WATER SUPPLY SYSTEM AND REQUIRED WORKS

As requested by Bigen Africa Services (Pty) Ltd on behalf of their client Leeuwpoort Developments (Pty) Ltd, we have investigated the capacity of the water supply system to supply the proposed mixed land use development located on the abovementioned property in January 2016. Since the compilation of the original reports we have been made aware of certain changes in the proposed land use and have subsequently been requested to re-perform the capacity investigations based on the latest land use information. Herewith our revised comments:

1. EXTENT OF DEVELOPMENT

The revised proposed development will now comprise of the land use distribution as summarised in the attached spreadsheet entitled "Summary of land use, water demand and sewage flow"

This study was based on the minimum required residual pressure of 24m from the municipal system. Please note that, should any part of the proposed development ultimately have more than two storeys, private boosting to the higher storeys might be required if excess pressure is not available from the municipal system.

The location and layout of existing water supply services in the vicinity of the site are indicated on Figure A included herewith. The future water distribution zones of the area under discussion

GLS Consulting (Pty) Ltd
Tel +27 21 880 0388 **| email:** info@gls.co.za
PO Box 814, Stellenbosch, 7599, South Africa
13 Electron Street, Techno Park, Stellenbosch
www.eoh.co.za | www.gls.co.za
Reg no: 2007/003039/07

are indicated on Figure B. We confirm that the site is located within the urban development boundary as defined in the 2010/2011 Metropolitan Spatial Development Framework (MSDF).

We confirm that provision was made for the proposed development in the Boksburg water master plan as per the original received land use table. The revised proposed development's water demand as calculated below is higher than the anticipated future water demand that was allowed for in the master plan. Therefore the master plan will be updated accordingly.

2. WATER SYSTEM

2.1 Water demand:

The water demand for each of the 6 proposed development phases (see attached layout plan for phasing) was calculated and is also summarised in the attached spreadsheet entitled "Summary of land use, water demand and sewage flow". A summary of the water demand totals for phase 1 to 6 of the proposed development is included in the table below:

WATER DEMAND SUMMARY							
DEVELOPMENT PHASE	ORIGINAL DEVELOPMENT		REVISED DEVELOPMENT		INCREASE		
	AADD (kl/d)	PEAK FLOW (l/s)	AADD (kl/d)	PEAK FLOW (l/s)	AADD (kl/d)	PEAK FLOW (l/s)	%
PHASE 1	2480	98	2763	109	283	11	11%
PHASE 2	1620	64	1667	66	47	2	3%
PHASE 3	2363	93	2457	97	94	4	4%
PHASE 4	2504	99	3330	131	826	33	33%
PHASE 5	1206	47	1591	63	385	15	32%
PHASE 6	845	33	1464	58	619	24	73%
TOTAL	**11018**	**434**	**13273**	**522**	**2255**	**89**	**20%**

2.2 Existing Water Services, Proposed Connection Point and Proposed Upgrading

Water distribution zone (see figure B)

The proposed development site does not fall within any of the current Ekurhuleni water distribution zones. According to the master plan phases 1, 2 and 3 of the development should be incorporated into the Sunward Park tower zone while phases 4, 5 and 6 should be incorporated into the Vogelfontein reservoir/RW3976 direct zone.

The Sunward Park reservoir is supplied directly from the Rand Water system via meter number RW1847 located close to the N17/Rondebult intersection. The Sunward Park reservoir has no direct supply network. From the reservoir water is pumped into the Sunward Park water towers (two towers in parallel operating as one) via the Sunward Park tower pump station. From the towers two 500Ø bulk pipes feed directly into the towers' supply network. An additional connection directly from the Rand Water bulk system into the Sunward Park tower zone exists via a set of PRV's located in Liefland Street. This connection is presumably closed and only being utilised during emergency demand scenarios.

The Vogelfontein reservoir is supplied from Rand Water's meter number RW3976 located next to the reservoir. An additional Rand Water meter, RW0056, located at the intersection of Commissioner and Saint Dominics Street also supplies water directly from the Rand Water system into the supply network of the Vogelfontein reservoir.

Certain changes in water distribution zone boundaries are recommended between the current- and the future demand scenario. None of these changes will have a direct implication on the proposed development.

Reservoir capacities

Sunward Park reservoir:

The AADD of the area currently being supplied from the Sunward Park reservoir was calculated from the latest available Ekurhuleni treasury data in conjunction with the Rand Water bulk meter readings to be approximately 6 330 kl/day. According to Rand Water's supply conditions a balancing volume of 15h x AADD = 3 956 kl is required for the Vogelfontein reservoir. According to the Ekurhuleni Metropolitan Municipality's modelling guidelines a further minimum of 18 h x AADD = 4 748kl is required as emergency storage. This equates to a total required reservoir volume of 8 704 kl. Therefore it can be concluded that the existing reservoir storage capacity of 15 ML is sufficient to supply the current demand.

With the incorporation of phase 1, 2 and 3 of the proposed development the AADD supplied from the Sunward Park reservoir increases to 13 217 kl/d. This equates to an increased reservoir volume requirement of 18 ML. This is more than the 15 ML currently available. An additional demand of approximately 5 000 kl/d can be accommodated before the reservoir's capacity is being fully utilised in terms of its available balancing volume. Therefore phase 1, 2 and a portion of phase 3 of the development can proceed before the storage reserved for emergency will be affected.

Our recommendation is that phase 1, 2 and 3 be given approval to proceed in the interim and that the planning for the new reservoir (master plan item MP - SWP1.1) is commenced as soon as possible. Item number MP - SWP1.1 entails the construction of a new 6 ML reservoir and is a part of master plan project BOK-BLK-011. Construction of the new planned reservoir is therefore not a critical requirement for phase 1, 2 and 3 to proceed. Note that the increase in expected water demand due to the revised development land use has resulted in an increase in the volume required for the future planned reservoir (previously 5 ML).

Vogelfontein reservoir:

The AADD of the area currently being supplied from the Vogelfontein reservoir was calculated from the latest available Ekurhuleni treasury data in conjunction with the Rand Water bulk meter readings to be approximately 22 256 kl/day. Of this demand approximately 15 616 kl/day (70%) is supplied directly from the reservoir. The balance of 6 640 kl/day (30%) is supplied directly into the network via RW0056.

According to Rand Water’s supply conditions a balancing volume of 13h x AADD = 8 459 kl is required for the Vogelfontein reservoir. According to the Ekurhuleni Metropolitan Municipality’s modelling guidelines a further minimum of 18 h x AADD = 11 712kl is required as emergency storage. This equates to a total required reservoir volume of 20 171 kl. Therefore it can be concluded that the existing reservoir storage capacity of 20 ML is being fully utilised for the current demand scenario and that no spare capacity is available.

With the incorporation of the additional demand from phase 4, 5 and 6 of the proposed development the situation changes as follows: Under the assumption that RW0056 is already supplying 6 640 kl/day at full capacity the additional demand of 6 386 kl/day will be supplied directly from the Vogelfontein reservoir. Therefore the required balancing volume will increase to 13h x AADD = 11 918 kl and the required emergency volume will increase to 18h x AADD = 16 501 kl. This equates to a total required reservoir volume of 28 419 kl. As mentioned the Vogelfontein reservoir does not have spare capacity available to accommodate any additional demand. We therefore recommend that planning be commenced for the implementation of master plan item MP - VFR1.1 (a portion of master plan project BOK-BLK-005). This entails the construction of a new 32 ML reservoir at the existing reservoir site. Note that this volume requirement has increased from the original requirement of 31 ML.

Construction of the new planned reservoir is not a critical requirement for the development to proceed as the 18h emergency storage remains available for interim use. Our recommendation is that phase 4, 5 and 6 be given approval to proceed in the interim and that the planning for the new reservoir is commenced as soon as possible. Please note that with the incorporation of phase 4, 5 and 6 the emergency volume will decrease cumulatively as follows:

Scenario	AADD (kl/d)	Cumulative AADD (kl/d)	Emergency (hours x AADD)
Current	15616	15616	18
+ phase 4	3330	18946	13
+ phase 5	1591	20537	11
+ phase 6	1464	22002	9

Water tower capacities

Sunward Park tower:

The AADD of the area currently being supplied from the Sunward Park tower was calculated from the latest available Ekurhuleni treasury data in conjunction with the Rand Water bulk meter readings to be approximately 6 330 kl/day. This equals the demand supplied from the Sunward Park reservoir due to the fact that the reservoir has no direct supply area.

The above demand combined with the current combined tower volume of 5500 kl results in a tower storage time of 20.9h. According to the EMM's modeling guidelines only 4 - 6h are required in water towers. The towers therefore have sufficient volume to supply the current demand.

With the incorporation of phase 1, 2 and 3 of the proposed development the tower zone's AADD increases to 13 217 kl/d which results in a decreased tower storage time of 10h. This remains more than the minimum storage time required and we can therefore confirm that the current tower volume is sufficient to accommodate the additional demand from the proposed development.

For phase 4, 5 and 6 of the development no water towers will be affected.

Pump station capacities

Sunward Park tower pump station:

The current pumping capacity of the Sunward Park tower pump station is estimated to be approximately 200 l/s @ 26m head. The required pumping rate for the pump station to supply the current demand is calculated as follows:

Pumping requirement = 1.1 x PHF x AADD - RW direct supply
= 1.1 x 3.6 x (6330/86.4) - 100
= 190 l/s

From the above it can be concluded that the pump station has sufficient capacity available to supply the current demand. With the incorporation of the additional demand from phase 1, 2 and 3 of the proposed development the peak demand of the tower zone will increase. According to the master plan, however, this increase in demand can be supplied via the RW direct supply.

For phase 4, 5 and 6 of the development no pump stations will be affected.

Bulk pipe capacities:

Existing bulk pipes:

In the Sunward Park tower zone the additional demand from the proposed development will not cause requirements for upgrading to any of the existing affected bulk pipes. Therefore phase 1, 2 and 3 of the development can be accommodated without any upgrading.

In the Vogelfontein reservoir/RW3976 direct zone the additional demand from the proposed development will cause increases in flow velocity to above the maximum allowable velocity of 2.0 m/s in the main reservoir supply pipe feeding southwards from the Vogelfontein reservoir. This increased velocity, in turn, will result in sub-standard peak demand pressures for other more critical sections of the reservoir's supply zone. The implementation of master plan items MP - VFR2.1 and VFR2.5 will address the velocity and pressure problems mentioned above. This entails the construction of approximately 950m of new 800Ø pipe as well as 2350m of new 500Ø pipe as indicated on figure A. Note that the increase in expected water demand due to the revised development land use has not resulted in an increase in the diameters required for the above mentioned bulk pipes.

Phase 4 and 5 of the development can be accommodated before the construction of the above bulk upgrading requirements will become necessary.

Future planned bulk pipes:

The future planned bulk pipes that are required to supply the development are indicated in red on figure A. Note that the required diameters of the internal bulk pipes have been updated from the diameters recommended in the original reports. Please also note that the alignments indicated on figure A are schematic only and can be adjusted by the detail design consultants to suit the internal layout of the developments. Implementation of these bulk pipes have been phased as indicated on figure A and summarised in the table below:

Summary of bulk requirements per development phase

Development phase	Reservoir volume	Tower volume	Pump stations	Existing bulk pipes	Future bulk pipes
Phase 1	No requirement	No requirement	No requirement	No requirement	All pipes marked with P1 on figure A
Phase 2					All pipes marked with P2 on figure A
Phase 3	Commence planning for MP - SWP1.1				All pipes marked with P3 on figure A
Phase 4	Commence planning for MP - VFR1.1				All pipes marked with P4 on figure A
Phase 5					All pipes marked with P5 on figure A
Phase 6				Implement MP - VFR2.1 & 2.5	All pipes marked with P6 on figure A

Network pressures, connection points and required works

The proposed connection points to the existing system are as indicated by the red circles on figure A. With the above connections and phased upgrading requirements in place the expected pressures at the most critical sections of the development site will be as follows:

Scenario	Pressure (m)	Criteria
Peak flow	24	24m minimum
Fire flow	10	5m minimum
Static	71	90m maximum

3. DEVELOPER CONTRIBUTIONS TO CONSTRUCTION OF INFRASTRUCTURE

GLS hereby confirms that any contributions of the developer to the required construction of infrastructure and/or the upgrading of the existing infrastructure, whether it be in the form of a cash contribution or in the form of constructing sections of new infrastructure, is a matter to be discussed and agreed upon between the developer and the Ekurhuleni Metropolitan Municipality.

4. SUMMARY RECOMMENDATIONS

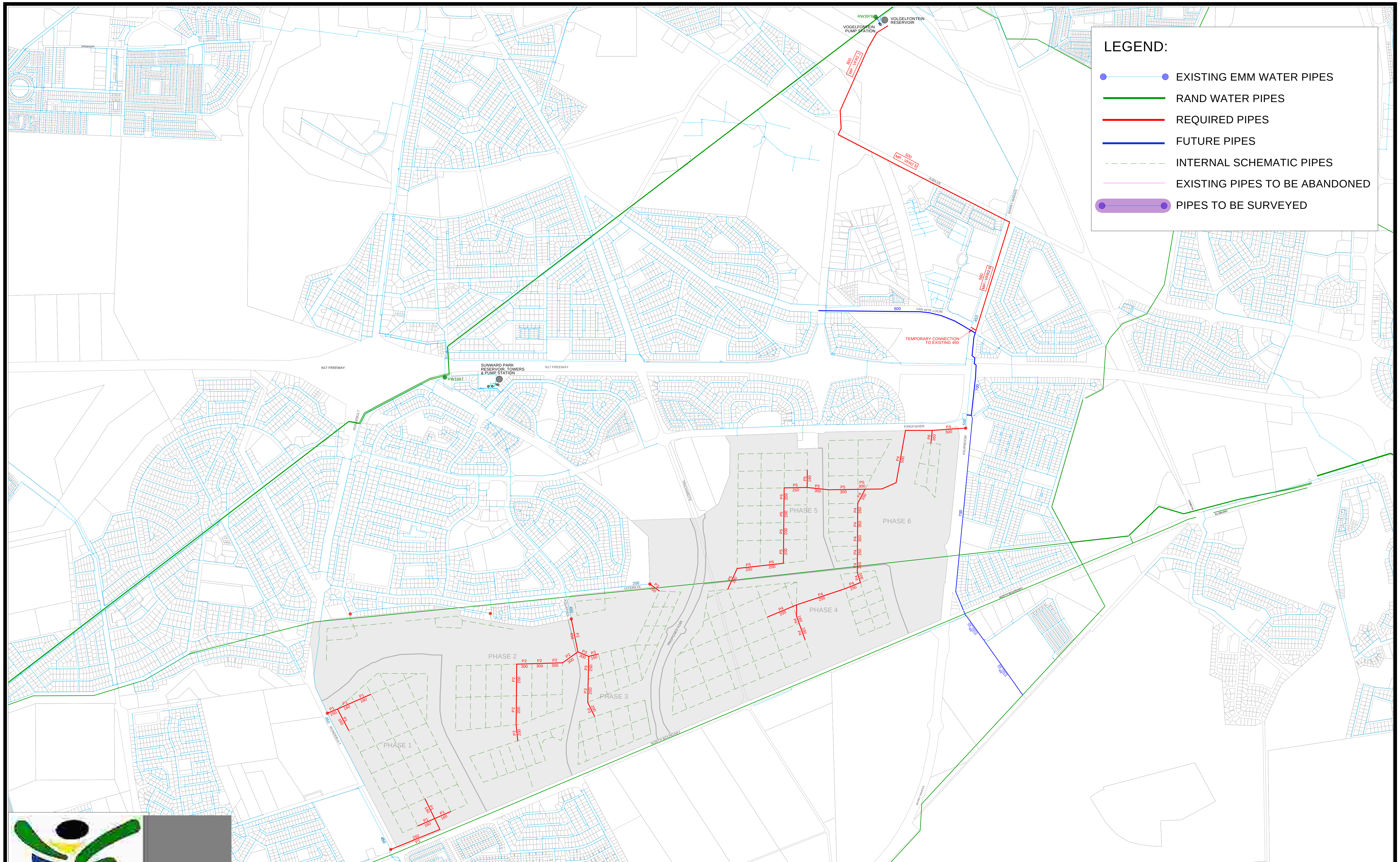
In summary we comment as follows:

- Phase 1, 2 and 3 of the development can be incorporated into the Sunward Park tower zone
- Phase 4, 5 and 6 of the development can be incorporated into the Vogelfontein reservoir/RW3976 direct zone
- Although the construction of additional reservoir volume is not a critical requirement for any of the development phases to proceed, we recommend that planning be commenced for the construction of MP - SWP1.1 (new 6 ML Sunward Park reservoir) and MP - VFR1.1 (new 32 ML Vogelfontein reservoir) as per the master plan
- No additional tower volume is required
- No upgrading to any existing pump stations are required
- For phase 1 to 5 no upgrading is required to any existing affected bulk supply pipes
- The implementation of MP - VFR2.1 and VFR2.5 is required before phase 6 can proceed
- The future bulk pipes required per development phase are as summarised in the bulk requirements table

We trust you will find the above sufficient in terms of your request. Should you have any further queries, please do not hesitate to contact us.

Yours sincerely
GLS CONSULTING

Per: JL (LOUIS) STRIJDOM

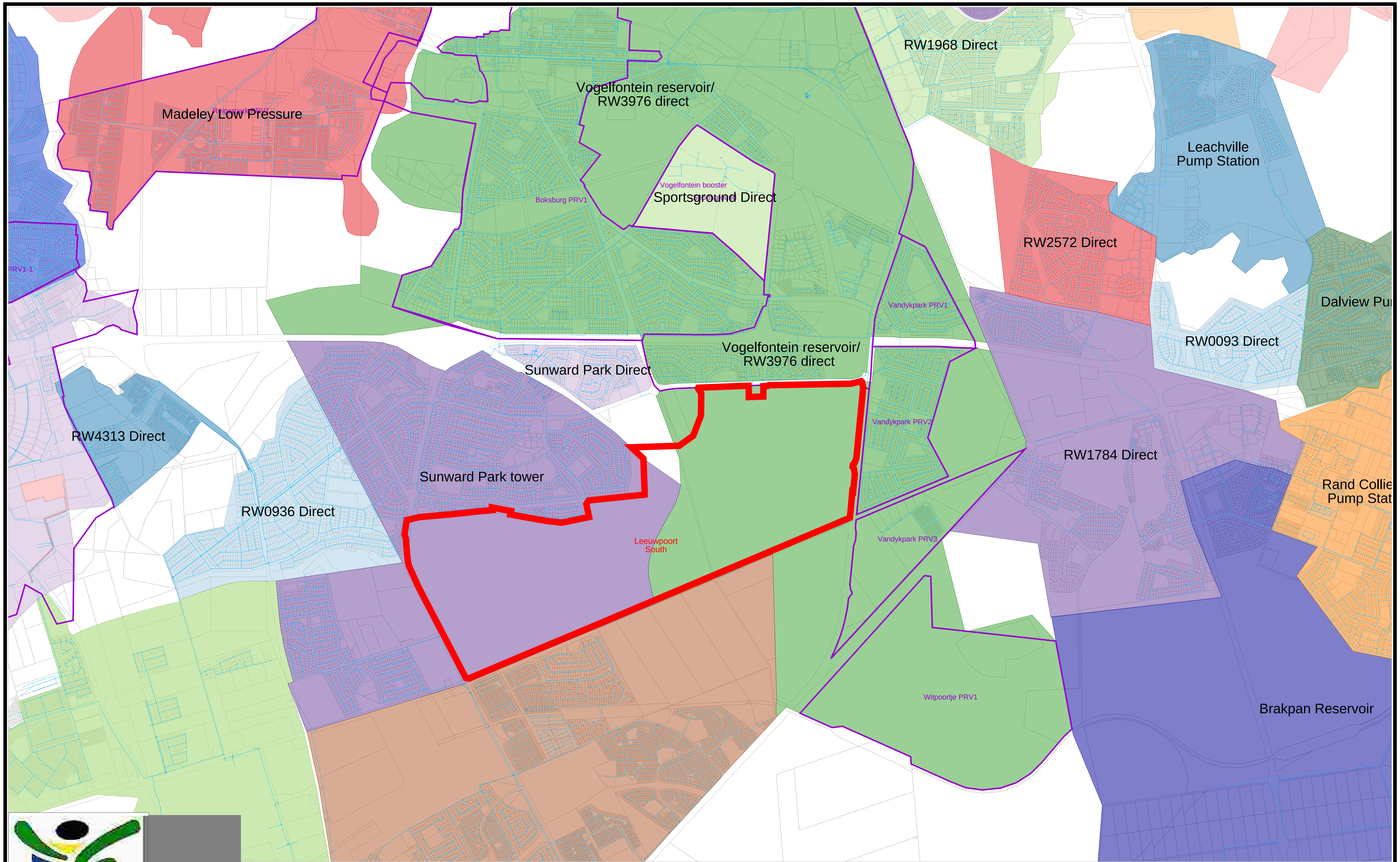


7

Water Supply Capacity Investigation
oort South - Boksburg

Figure A - rev1

Location and layout of existing water supply services & proposed connection points



February 2016

Ad Hoc Water Supply Capacity Investigation
Leeuwpoort South - Boksburg

Figure B

Layout and location of future water distribution zones

02 March 2017

Chief Engineer: Water Services Planning
Ekurhuleni Metropolitan Municipality
P O Box 215
BOKSBURG
1460

Attention: Mr. Danie van der Merwe

Dear Sir

PROPOSED NEW MIXED LAND USE DEVELOPMENT ON THE REMAINDER OF THE FARM LEEUWPOORT 113 IR - BOKSBURG: ASSESSMENT OF IMPACT ON SEWER SYSTEM AND REQUIRED WORKS

As requested by Bigen Africa Services (Pty) Ltd on behalf of their client Leeuwpoort Developments (Pty) Ltd, we have investigated the capacity of the sewer system to drain the proposed mixed land use development located on the abovementioned property in January 2016. Since the compilation of the original reports we have been made aware of certain changes in the proposed land use and have subsequently been requested to re-perform the capacity investigations based on the latest land use information. Herewith our revised comments:

1. EXTENT OF DEVELOPMENT

The revised proposed development will now comprise of the land use distribution as summarised in the attached spreadsheet entitled “Summary of land use, water demand and sewage flow”.

The location and layout of existing sewer services in the vicinity of the site are indicated on Figure A included herewith. The current sewer drainage areas of the area under discussion are indicated on Figure B. We confirm that the site is located within the urban development boundary as defined in the 2010/2011 Metropolitan Spatial Development Framework (MSDF).

We confirm that provision was made for the proposed development in the Vlakplaats- and Waterval sewer master plans as per the original received land use table. The revised proposed development’s water demand and resulting sewage flow as calculated below is higher than the anticipated future sewage flow that was allowed for in the master plans. Therefore the master plans will be updated accordingly.

2. SEWER SYSTEM

2.1 Sewage flow:

The water demand and resulting sewage flow for each of the 6 proposed development phases (see attached layout plan for phasing) were calculated and are also summarised in the attached spreadsheet entitled “Summary of land use, water demand and sewage flow”. A summary of the water demand and sewage flow totals for phase 1 to 6 of the proposed development is included in the table below:

WATER DEMAND AND SEWAGE FLOW SUMMARY										
DEVELOPMENT PHASE	ORIGINAL DEVELOPMENT			REVISED DEVELOPMENT			INCREASE			
	AADD (kl/d)	PEAK DRY WEATHER SEWAGE FLOW (l/s)	PEAK WET WEATHER SEWAGE FLOW (l/s)	AADD (kl/d)	PEAK DRY WEATHER SEWAGE FLOW (l/s)	PEAK WET WEATHER SEWAGE FLOW (l/s)	AADD (kl/d)	PEAK DRY WEATHER SEWAGE FLOW (l/s)	PEAK WET WEATHER SEWAGE FLOW (l/s)	%
PHASE 1	2480	44	63	2763	49	71	283	5	7	11%
PHASE 2	1620	29	41	1667	30	43	47	1	1	3%
PHASE 3	2363	42	60	2457	44	63	94	2	2	4%
PHASE 4	2504	45	64	3330	60	85	826	15	21	33%
PHASE 5	1206	22	31	1591	28	41	385	7	10	32%
PHASE 6	845	15	22	1464	26	37	619	11	16	73%
TOTAL	**11018**	**197**	**282**	**13273**	**237**	**339**	**2255**	**40**	**58**	**20%**

The unit water demand for each unit of development was combined with a unique sewer unit hydrograph for the specific land use (derived over history for the flow pattern of similar types of developments) and yielded the modeled peak dry weather sewage flows as indicated in the table above. For connection point purposes the total site was split into three internal sub-drainage areas with peak daily sewage flows as follows (see figure A):

Sub-drainage area design flows:

SUB-DRAINAGE AREA	ORIGINAL DEVELOPMENT		REVISED DEVELOPMENT	
	PEAK DRY WEATHER SEWAGE FLOW (l/s)	PEAK WET WEATHER SEWAGE FLOW (l/s)	PEAK DRY WEATHER SEWAGE FLOW (l/s)	PEAK WET WEATHER SEWAGE FLOW (l/s)
Zone A (Red)	89	128	108	154
Zone B (Yellow)	23	33	28	39
Zone C (Orange)	85	121	102	146
Total	**197**	**282**	**237**	**339**

2.2 Existing sewer services, proposed connection points and proposed upgrading

Sewer drainage area

The proposed development site can be incorporated into the existing Ekurhuleni sewer drainage areas as follows:

- Zone A (red) into the Waterval WWTP drainage area via the recently constructed Klippoortjie outfall sewer
- Zone B (yellow) into the Waterval WWTP drainage area via the existing Sunward Park outfall sewers
- Zone C (orange) into the Vlakplaats WWTP via the Van Dyk Park and Boksburg North outfall sewers

Currently a portion of the total sewage flow draining towards the Vlakplaats WWTP is also bypassed into the Waterval WWTP drainage area. Ultimately, according to ERWAT's long term vision, the Vlakplaats WWTP will be abandoned and all the incoming flow will be bypassed to the Waterval WWTP. This, however, is not anticipated to be implemented within the next 10 years.

The more likely scenario is that the Vlakplaats WWTP will permanently be capped at its current treating capacity and all excess flow will be bypassed towards the Waterval WWTP where major upgrading for the ultimate future scenario is planned.

Although certain changes in drainage area boundaries between the current- and the ultimate future drainage scenario are proposed, none of these changes will have a direct implication on the proposed development.

Pump station capacities

No existing- or future municipal pump stations will be affected by the proposed development.

Main outfall sewers

The following main outfall sewers will be affected by the proposed increase in sewage flow:

Existing main outfall sewers:

With the incorporation of the additional sewage flow from the proposed development none of the existing affected main outfall sewers downstream of the proposed connection points in close proximity to the development site will experience decreases in spare capacity to below the minimum requirement of 30%.

Future planned main outfall sewers:

No future planned main outfall sewers are affected by or required for the proposed development to proceed. The internal bulk sewers are not indicated and must be designed by the detail design consultants.

Connection to existing system, network pipe capacities and required works

Recommended connection points:

The recommended connection point for zone A (red) is directly to the newly constructed 300/450Ø Klippoortjie outfall sewer draining westwards along the Klippoortjie spruit from the western boundary of the development site as indicated on figure A.

For zone B (yellow) the recommended connection points are as indicated by the red arrows on figure A. Please note that the arrows are schematic only and indicates the recommended sewer to connect to and not necessarily the specific manhole to connect to.

Zone C (orange) can proceed by making multiple connections to the existing 300/500/600Ø Van Dyk Park sewer and to the 1100Ø Boksburg North outfall sewer draining through the development site. Multiple connections to these existing sewers can be made at the locations most suitable for the detail design consultants.

Existing network pipe capacities:

With the above recommended connection points in place no existing network sewers will experience decreases in spare capacity to below the minimum requirement of 30%.

Future provisions:

Due to the general cadastral layout and natural topography of the area no provision has to be made for any further future developments to drain through the site.

Wastewater treatment plant capacities

The Vlakplaats WWTP currently has a treating capacity of approximately 83 Ml/day. The current measured dry weather inflow into the plant is approximately 113 Ml/day. The plant, however, is capped at 83 Ml/day and all excess flow is currently bypassed to the Waterval WWTP.

The Waterval WWTP currently has a treating capacity of 155 Ml/day. The current dry weather inflow into the plant is measured at approximately 195 Ml/day with the measured wet weather inflow reaching flows of up to 242 Ml/day. ERWAT has recently completed the extension of the plant from 105 Ml/day to 155 Ml/day. The plant will, however, have to be extended further as soon as possible. The effect that the additional sewage flow from the proposed development has on the required extension of the plant is insignificantly small.

3. DEVELOPER CONTRIBUTIONS TO UPGRADING OF INFRASTRUCTURE

GLS Consulting hereby confirms that any contributions of the developer to the required upgrading of the existing infrastructure, whether it be in the form of a cash contribution or in the form of constructing sections of new infrastructure, is a matter to be discussed and agreed upon between the developer and the Ekurhuleni Metropolitan Municipality or between the developer and ERWAT.

4. SUMMARY RECOMMENDATIONS

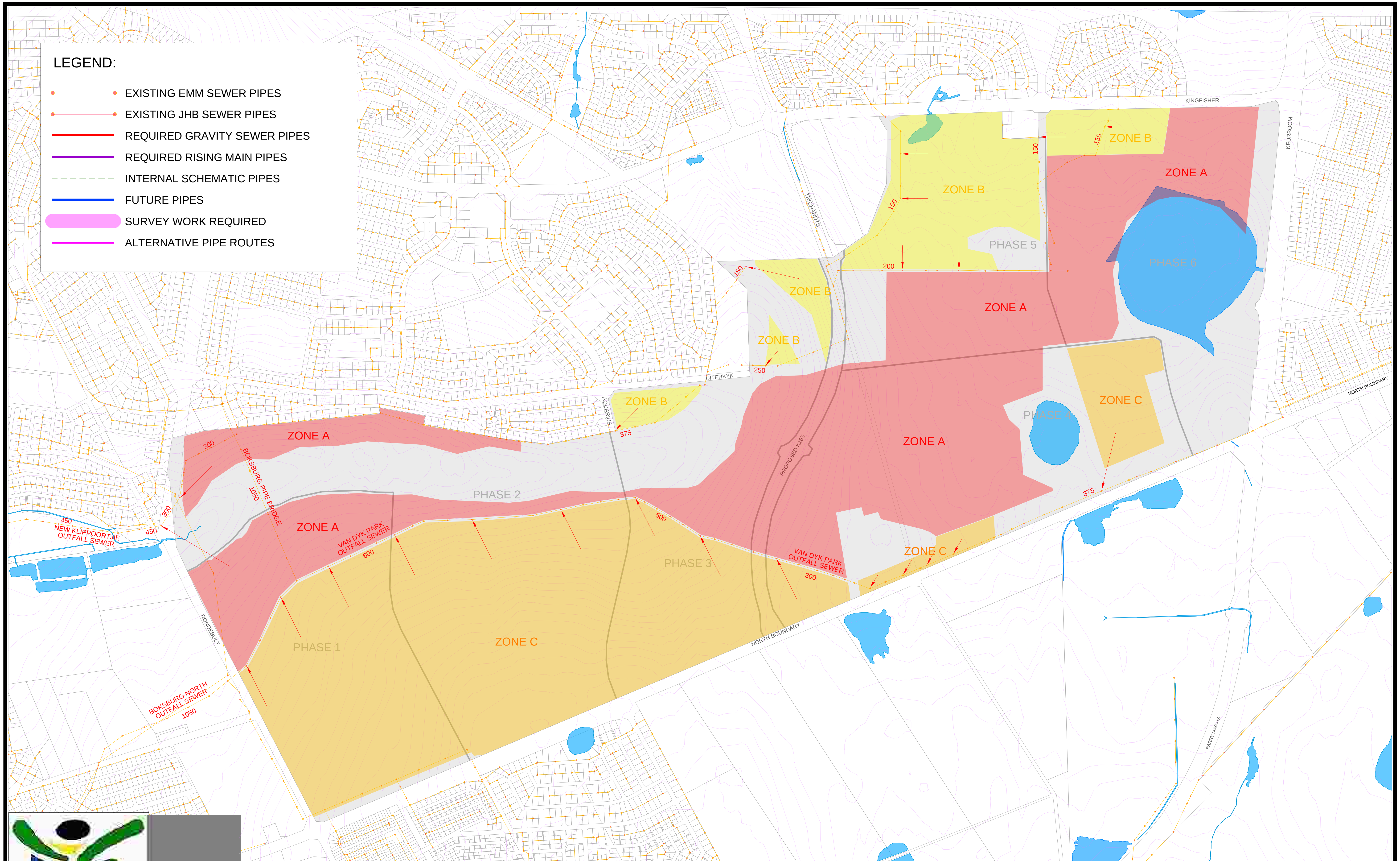
In summary we comment are as follows:

- The proposed development site can be incorporated into the Vlakplaats WWTP and Waterval WWTP drainage areas
- No sewage pump stations are affected by the proposed development
- No upgrading to any existing main outfall sewers are required
- The recommended connection point for zone A is directly to the newly constructed 300/450Ø Klippoortjie outfall sewer draining westwards along the Klippoortjie spruit from the western boundary of the development site as indicated on figure A
- For zone B the recommended connection points are as indicated by the red arrows on figure A
- Zone C can proceed by making multiple connections to the existing 300/500/600Ø Van Dyk Park sewer and to the 1100Ø Boksburg North outfall sewer draining through the development site
- No upgrading to any existing network sewers are required
- Due to the general cadastral layout and natural topography of the area no provision has to be made for any further future developments to drain through the site.
- Further extension of the Waterval WWTP is a critical requirement for all future development within its catchment area.

We trust you will find the above sufficient in terms of your request. Should you have any further queries, please do not hesitate to contact us.

Yours sincerely
GLS CONSULTING

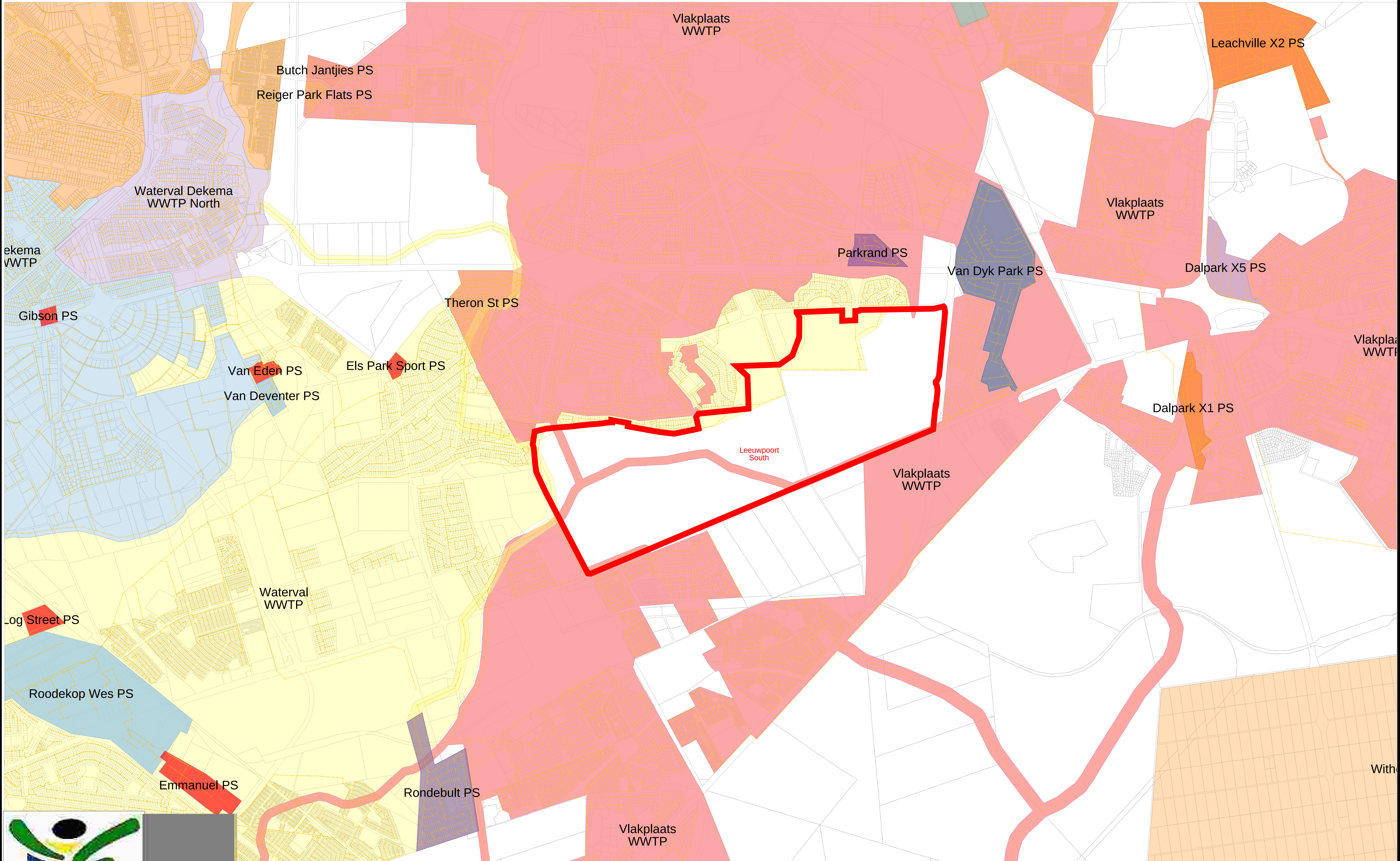
Per: JL (LOUIS) STRIJDOM



Sewer Capacity Investigation
ort South - Boksburg

Figure A - rev1

Layout of existing sewer services, required works and proposed connection points



February 2016

Ad Hoc Sewer Capacity Investigation
Leeuwpoort South - Boksburg

Figure B

Layout and location of existing sewer drainage areas

ANNEXURE D7c
EMM COMMENTS

Ekurhuleni
METROPOLITAN MUNICIPALITY
Office of the Head of Department
Disaster & Emergency
Management Services
3 Hawley Road
Bedfordview
P O Box 145
Germiston 1400

COMMENTS

Tel: (011) 999 – 0193
Fax: (011) 874 – 5164
Enquiries: S DU RAND

Date: 07 April 2017

To: CITY PLANNING DEPARTMENT
BOKSBURG SERVICE DELIVERY CENTRE
Att: ZUNAID OSMAN
Ref: 15/3/3/69/24

Re: **PROPOSED SUNWARD PARK EXTENSION 24 TOWNSHIP: SITUATED ON THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113-IR, BOKSBURG**

DEMS has no objection to the proposal as lodged by the Applicant; and notwithstanding any other information pertaining to the application that may become available or made known after our scrutiny of the submitted application; and in cognizance of any other condition so imposed by the municipality; *approval of the application is subject to the following imposed conditions;*

A) The Applicant in formalizing any submissions for approval should this proposal go ahead; must

(i) Ensure full compliance with the National Building Regulations and Building Standards Act (Act no. 103 of 1977) as it pertains to the various fire protection and public safety requirements and specifically the Fire Protection Regulations as contained in Part T;

(ii) Ensure full compliance with the Emergency Services Bylaws as it applies Water Supply for Firefighting Purposes and in all cases to any other component of the same bylaw as it applies to the development or re-development of townships including any other clause that may applicable before and after such development;

(iii) Where any construction activities occur following formal approval of building plans; such activities that may involve the storage, handling and use of flammable liquids and/or solids must comply with the relevant provisions of the Emergency Services Bylaw and any other related code or regulation so enforced by the Fire Service Authority; and

(iv) Where such development meets the requirement of designated premises as described in the Emergency Service Bylaw; full compliance will be expected with such requirements.

(v) in the event that any risk area developed or redeveloped in such a manner that the risk area falls into the high risk category, adapt the water reticulation accordingly without delay.

(vi) GPS location of hydrants and visible marking of hydrants.

(vii) Distance and comments from the existing MHI in the area.

B) The following points are noted for further consideration of the application. (*DEPENDS ON APPLICABILITY*)

(i) That the proposed development is categorized as Category (**Risk C**) Fire Risk and will be outside the **10-minute** attendance time radius of the fire service response coverage for that category of risk until such time emergency services presence is provided for area concerned; OR

Table 2 – Attendance times at fires

1	2	3	4
Risk category	**Maximum call receipt and turn-out time** Min	**Maximum appliance travel time** Min	**Maximum attendance time** Min
A	3	5	8
B	3	7	10
C	3	10	13
D	3	20	23
E	Within requirement of appropriate risk category		

1. **Fire-risk Categories:**

   A fire area should be divided into sub-areas which fall into one of the following fire-risk categories.

   1.1. **Category C:** Residential areas of conventional construction.

(ii) Any other consideration that should be stated upfront indicating that we have applied our minds in the review of the application.

Kind regards,

S SIBANDE
ACTING HEAD OF DEPARTMENT:
Disaster & Emergency Management Services Department

11/04/2017
Date

Existing zoning	Property size	Coverage	Height	F.A.R.	Density
"Undetermined"	154 hectares	N/A	N/A	N/A	N/A

Proposed zoning	Property size	Coverage	Height	F.A.R.	Density
"Residential 1"; "Residential 4"; "Business 2"; "Special"; "Public Services"; "Community Facility"; "Transportation"; "Public Open Space"	See Table 9 on Page 5 of Memo	See Tables 1 to 8 on Pages 2 to 4 of Memo	See Tables 1 to 8 on Pages 2 to 4 of Memo	See Tables 1 to 8 on Pages 2 to 4 of Memo	See Tables 1 to 8 on Pages 2 to 4 of Memo

PLEASE NOTE that the submission of a Site Development Plan (SDP), as a condition of approval for this application, **is required.**

With reference to the above-mentioned application/proposal, I wish to comment as follows:
(Insert or Attach comments)

PROPOSED SUNWARD PARK EXTENSION 24 TOWNSHIP: SITUATED ON THE REMAINING EXTENT OF THE FARM LEEUWPOORT 113-IR, BOKSBURG.

File No.: 15/3/3/69/24

Energy and Electricity Department has no objections.

Emm has already applied for a substation to supply the above mentioned development at Eskom.

DIRECTORATE: Energy and Electricity

SECTION: Planning and Constructions

NAME: S. Nkanyani

SIGNATURE:

DATE: 03/04/2017

Leonie Gerber (Boksburg)

From: Renate Hooper (Boksburg)
Sent: Wednesday, April 19, 2017 3:49 PM
To: Leonie Gerber (Boksburg); Zunaid Osman (Boksburg)
Cc: Phillip Campher (Boksburg); Khensani Maredi (Boksburg)
Subject: FW: Reminder: Sunward Park Ext 24
Attachments: Sunward Park Ext 24 Original Appl.pdf; SunwardPark24_Lay.pdf

Good afternoon

This Department has no objection to the proposed Sunward Park ext 24, provided that all Environmental Health legislation is complied with.

With kind regards

Renate Hooper
Environmental Health Practitioner

Health and Social Development

Telephone : +27 (0)11 999 5769
Facsimilie +27 (0)11 892 0536
E-mail : Renate.Hooper@ekurhuleni.gov.za
Website : www.ekurhuleni.gov.za
Postal : P O Box 215, Boksburg, 1460
Physical : Environmental Health Building, Krynauw rd, Boksburg

---

From: Khensani Maredi (Boksburg)
Sent: Wednesday, April 19, 2017 3:20 PM
To: Renate Hooper (Boksburg) <Renate.Hooper@ekurhuleni.gov.za>
Subject: FW: Reminder: Sunward Park Ext 24

From: Khensani Maredi (Boksburg)
Sent: 18 April 2017 02:28 PM
To: Renate Hooper (Boksburg) <Renate.Hooper@ekurhuleni.gov.za>
Subject: FW: Reminder: Sunward Park Ext 24

From: Phillip Campher (Boksburg)
Sent: 18 April 2017 02:01 PM
To: Khensani Maredi (Boksburg) <Khensani.Maredi@ekurhuleni.gov.za>
Subject: FW: Reminder: Sunward Park Ext 24

Leonie Gerber (Boksburg)

From: Jaco Burger
Sent: Tuesday, April 18, 2017 2:36 PM
To: Leonie Gerber (Boksburg)
Cc: Denis Ing (Boksburg); Liezl L. Vermaak; Amukelani Madale (Boksburg)
Subject: RE: Reminder: Sunward Park Ext 24

Leonie

Although Metro Parks have no objection to the application, Metro Parks would like to insist on the following two points in regards to Public Open Spaces:

- Metro Parks strongly insist that no area smaller than 5 000m² for a public open space.
- World Urban Parks international median for park provision of 14.2 hectares per 1,000 residents. Of this 6.6 hectares per 1,000 residents is maintained urban parkland, with the balance being natural/conservation area

According to World Urban Parks - the new international organisation representing urban parks, open space and the recreation sector:

Open space per 1,000 residents.

The international median for park provision in 2014 was 14.2 hectares per 1,000 residents. Of this 6.6 hectares per 1,000 residents is maintained urban parkland, with the balance being natural/conservation areas.

Given the increasing evidence that parks benefit city health, sustainability and liveability, agencies with parkland at the lower end of the range may be able to use international data to gain recognition that their city is falling behind other similar cities and has potential to further enhance the city economy, reduce health costs, and create a cleaner environment through greater open space investment.

These standards can also be applied across a city. For example, some studies have shown that low-income neighbourhoods have less access to parks and green space than high-income neighbourhoods and that this can partially explain the often significant difference in life span of residents between neighbourhoods.

How much parkland is reasonable may depend on factors such as population growth, the quality of the city's geography and the desirability of integrated and connected green space, such as rivers and streams, but comparison to similar cities is a good start.

City planning is increasingly taking a long-term view, projecting populations and needs over 10, 20 and sometimes 50 years. A city that has 14 hectares per 1,000 residents now may see that fall to seven hectares in 50 years if the population is projected to double. The time to deal with this issue is now, while land is still available or relatively affordable. It does not have to be immediately developed and can be leased for other purposes such as horticulture, or as unmaintained natural open space.

The second option is to develop existing parkland to increase the capacity of use. This does not always address the need for sufficient access to parkland in neighbourhoods where there are few parks, although there are many creative areas, such as roof gardens and partnerships with other organisations to reclaim streets or broker community access to schools etc. Development can be a good option to save for the future when open space is no longer available or affordable.

Jaco Burger
Metro Parks & Cemeteries

Telephone : +27 (0) 11 999 5926/5254
Email : Jaco.burger@ekurhuleni.gov.za

From: Leonie Gerber (Boksburg)
Sent: Tuesday, April 18, 2017 1:55 PM
To: Johann Marx (Germiston); Mafusi Motaung; Prisca V. Malamule; Toffee Ramokone Mogoerane; Phillip Campher (Boksburg); Edmund Van Wyk; Jaco Burger; Hlawulani Ngobeni; Cecilia Rakgoale; Keleabetswe Lekalakala; Roelof Barnard (Vosloorus); Lidia Joubert roomdg 25; Bruce Reid (DA); Uyanda L. Langa; Pilusa P. Mashamaite
Cc: 'danie@urbandynamics.co.za'; Zunaid Osman (Boksburg)
Subject: Reminder: Sunward Park Ext 24

Good afternoon,

Kindly note herewith a reminder of comments outstanding for the ***Proposed Leeuwpoort South (Human Settlement) Development known as Sunward Park Ext 24***, circulated 14/03/2017.

It would be greatly appreciated if your departmental comments could be forwarded soonest.

Kind Regards

Leonie Gerber
City Planning
Boksburg CCA

Room 246, 2nd floor
Boksburg Civic Centre
c/o Trichardt Road & Market Street
Boksburg

Tel: 011 999 5808
Fax: 086 632 9960
E-mail: Leonie.Gerber@ekurhuleni.gov.za

Memorandum

Ekurhuleni
METROPOLITAN MUNICIPALITY

TO	CITY PLANNING BOKSBURG: AREA MANAGER	**HEAD OFFICE** Transport, Planning & Provision 6th Floor Kempton Park Civic Centre Cnr Pretoria Rd & CR Swart Dr KEMPTON PARK 1619 Private Bag X017 KEMPTON PARK 1620 Tel : +(2711) 999-3661 Fax : +(2711) 975-6545 www.ekurhuleni.com
ATTN	Z Osman	
TEL	(011) 999 6252	
EMAIL	zunaid.osman@ekurhuleni.gov.za	
FROM	Lungile Gamede	
ENQ	Lungile Gamede	
TEL	011 999 4438	
REF	15/3/3/69/24 (LG 04.09/2017)	
DATE	6 April 2017	

APPLICATION FOR TOWNSHIP ESTABLISHMENT: SUNWARD PARK EXTENSION 24

Your memorandum ref: 15/3/3/69/24 dated 16 March 2017 received by this Department on 24 March 2017 has reference.

1. This Department does not have an objection for township establishment to be known as Sunward Park Extension 24.

2. A paved sidewalk must be provided along the property boundary fronting onto the public road in order to facilitate pedestrian movements.

3. The proposed township will generate high transport users i.e. public transport, private motorists and non-motorized transport therefore of a transport study must be submitted to this Department for comments and/or approval before the development can be proceeded with.

4. The proposed location of the transportation erven along Agulas Road & Cingo Street is not supported as they are too close to the intersection.

5. The proposed transportation erf must be developed at the applicant's cost as it will benefit the township.

6. The township must be fenced off along K131 and K132 in order to ensure that pedestrians and motorists don not cross the road midblock.

7. Building lines as per Gautrans standard must be honoured.

8. The access and future road network must be discussed with the Roads Department.

9. Further consultation is recommended with the Transport Planning & Provision Department in order to ensure that this application aligns with the EMM current and future transport policies and strategies.

Yours Sincerely

....

UYANDA LANGA
DH: TRANSPORT PLANNING DIVISION
TRANSPORT PLANNING AND PROVISION DEPARTMENT