APPENDIX U

Surface Water Assessment

APPENDIX B

Detailed Channel Input Parameters

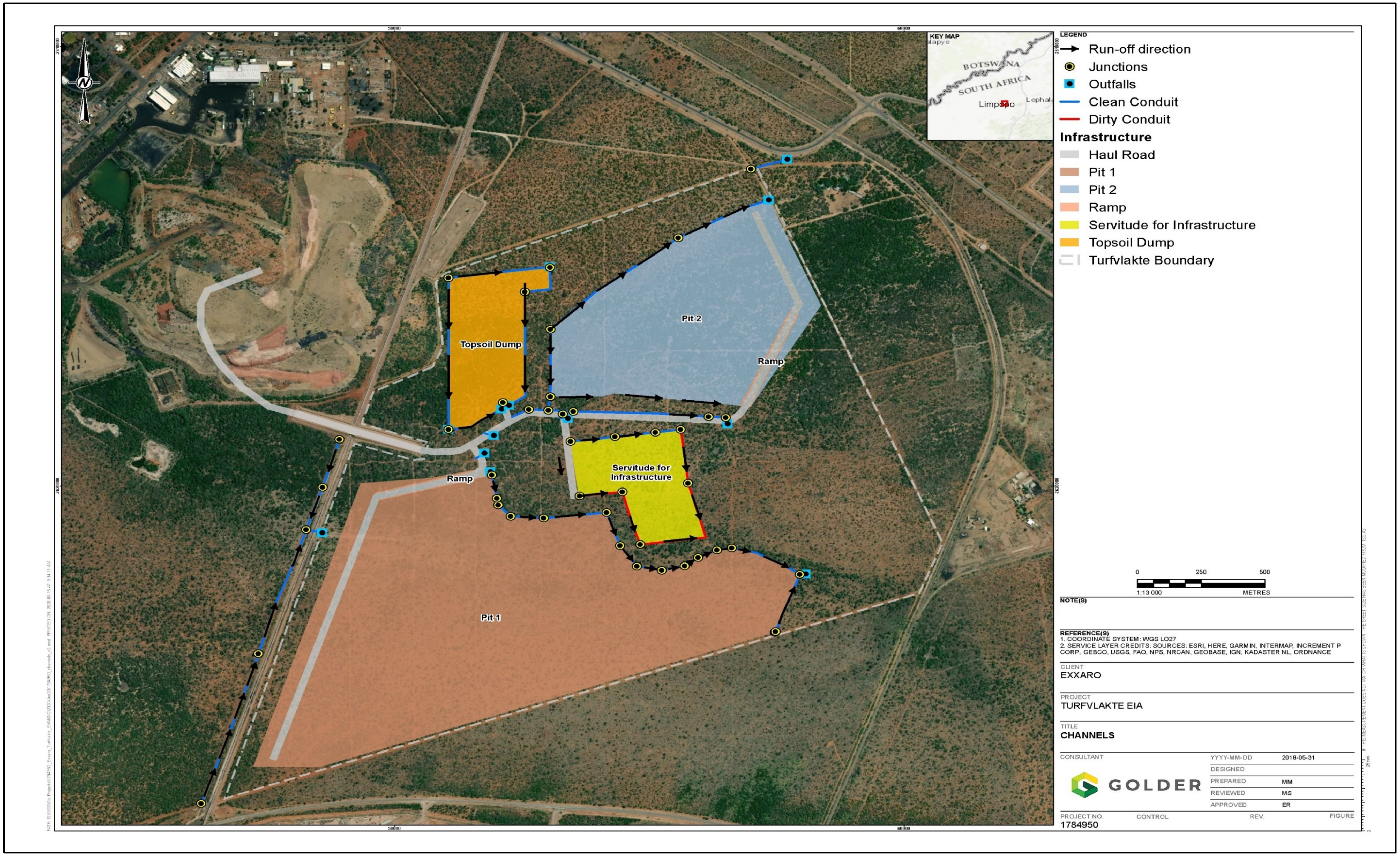

Figure B 1: Clean and dirty channels layout

Table B1: Channel input parameters

Name	Water Type	Length (m)	Roughness	Cross-Section	Depth (m)	Width (m)	Side Slope 1:X	Barrels	Slope (m/m)
C1	Clean	175.49	0.03	TRAPEZOIDAL	2.8	2.5	2	1	0.0043
C2	Clean	160.69	0.03	TRAPEZOIDAL	2.8	2.5	2	1	0.0073
C20	Clean	234.477	0.03	TRAPEZOIDAL	1.5	1	1.5	1	0.0054
C23	Clean	149.856	0.03	TRAPEZOIDAL	3	6	2	1	0.0030
C26	Clean	65.325	0.03	RECT_CLOSED	2.5	2.4	0	6	0.0031
C28	Clean	40.298	0.03	RECT_CLOSED	1.5	1.5	0	3	0.0164
C3	Clean	99.657	0.03	TRAPEZOIDAL	2.8	2.5	2	1	0.0085
C30	Clean	42.247	0.03	RECT_CLOSED	2	2.5	0	6	0.0143
C33	Clean	33.079	0.03	RECT_CLOSED	2.5	2.5	0	1	0.0006
C34_1	Clean	227.248	0.03	TRAPEZOIDAL	2	6	2	1	0.0022
C34_2	Clean	203.81	0.03	TRAPEZOIDAL	2	6	2	1	0.0015
C35_1	Clean	717.238	0.03	TRAPEZOIDAL	2.5	6	2	1	0.0040
C35_2	Clean	594.803	0.03	TRAPEZOIDAL	2.5	6	2	1	0.0009
C38_2	Clean	550.819	0.03	TRAPEZOIDAL	1	1	1.5	1	0.0124
C39	Clean	29.49	0.03	RECT_CLOSED	1.5	1.5	0	2	0.0063

Name	Water Type	Length (m)	Roughness	Cross-Section	Depth (m)	Width (m)	Side Slope 1:X	Barrels	Slope (m/m)
C40	Dirty	168.909	0.03	TRAPEZOIDAL	1	0.5	1.5	1	0.0048
C42	Clean	23.491	0.03	TRAPEZOIDAL	2	8.5	2	1	0.0003
C451	Clean	396.6	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0038
C452	Clean	652.52	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0045
C453	Clean	368.691	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0114
C458_1	Clean	402.578	0.03	TRAPEZOIDAL	1	0.5	1.5	1	0.0028
C458_2	Clean	200.091	0.03	TRAPEZOIDAL	1	1	1.5	1	0.0025
C460	Clean	689.026	0.03	TRAPEZOIDAL	1	1	1.5	1	0.0104
C462_1	Dirty	244.145	0.03	TRAPEZOIDAL	1.2	1	2	1	0.0029
C464_2	Dirty	255.435	0.03	TRAPEZOIDAL	1.2	1.2	2	1	0.0009
C464_3	Dirty	248.719	0.03	TRAPEZOIDAL	1.2	1.2	2	1	0.0049
C464_4	Dirty	256.781	0.03	TRAPEZOIDAL	1.2	1.2	2	1	0.0045
C53	Clean	75.38	0.03	TRAPEZOIDAL	1.5	1	1.5	1	0.0027
C535_1	Clean	277.799	0.03	TRAPEZOIDAL	1	0.5	1.5	1	0.0012
C537	Clean	71.824	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0035
C537_2	Clean	30.215	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0040

Name	Water Type	Length (m)	Roughness	Cross-Section	Depth (m)	Width (m)	Side Slope 1:X	Barrels	Slope (m/m)
C537_4	Clean	107.751	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0036
C538	Clean	129.474	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0040
C539	Clean	247.818	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0039
C54_1	Clean	76.252	0.03	TRAPEZOIDAL	1.5	1	2	1	0.0047
C54_2	Clean	97.758	0.03	TRAPEZOIDAL	1.5	1	1.5	1	0.0047
C540	Clean	159.913	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0039
C541	Clean	115.916	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0032
C542	Clean	104.079	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0039
C543	Clean	92.003	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0034
C544	Clean	65.51	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0033
C545	Clean	80.874	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0038
C546	Clean	59.258	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0044
C548	Clean	295.892	0.03	TRAPEZOIDAL	1.5	2	1.5	1	0.0038
C55	Clean	333.759	0.03	TRAPEZOIDAL	1.5	1	2	1	0.0082
C56	Clean	197.844	0.03	TRAPEZOIDAL	1.5	1	2	1	0.0102
C57	Clean	67.597	0.03	TRAPEZOIDAL	1.5	1	2	1	0.0105

APPENDIX C

Detail Berm Input Parameters

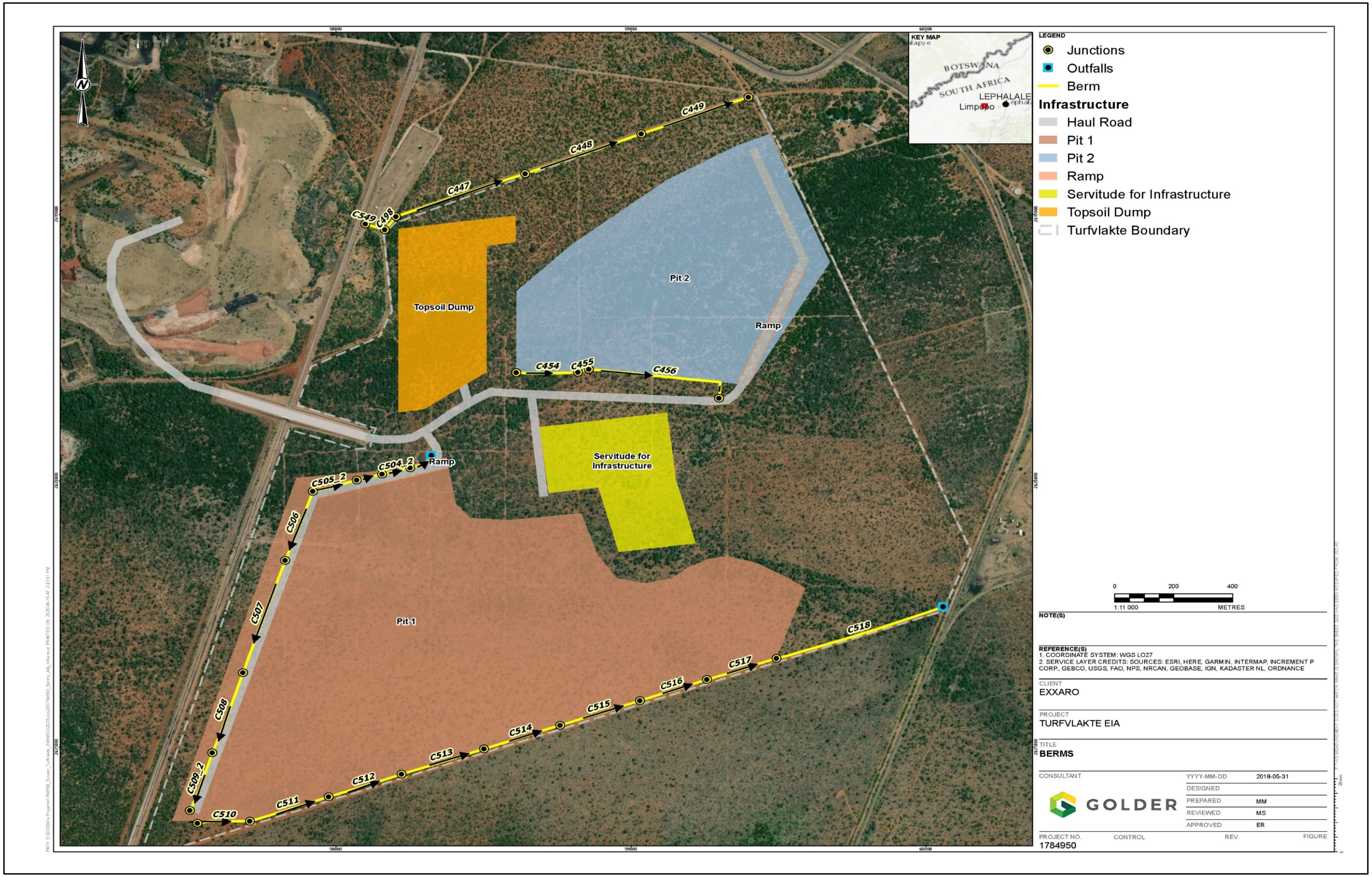

Figure C1: Berm layout

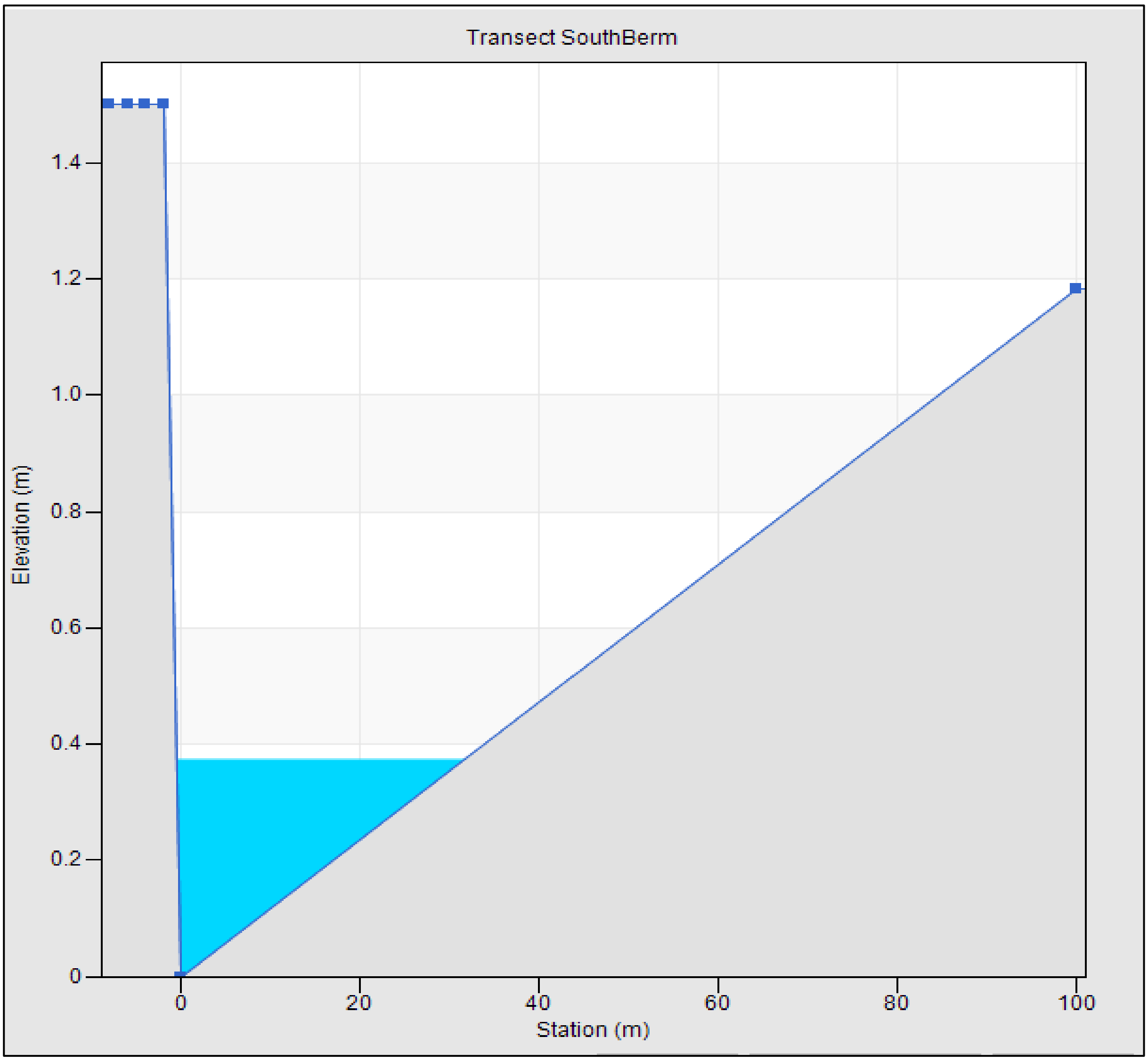

Figure C2: Berm south of Pit 1

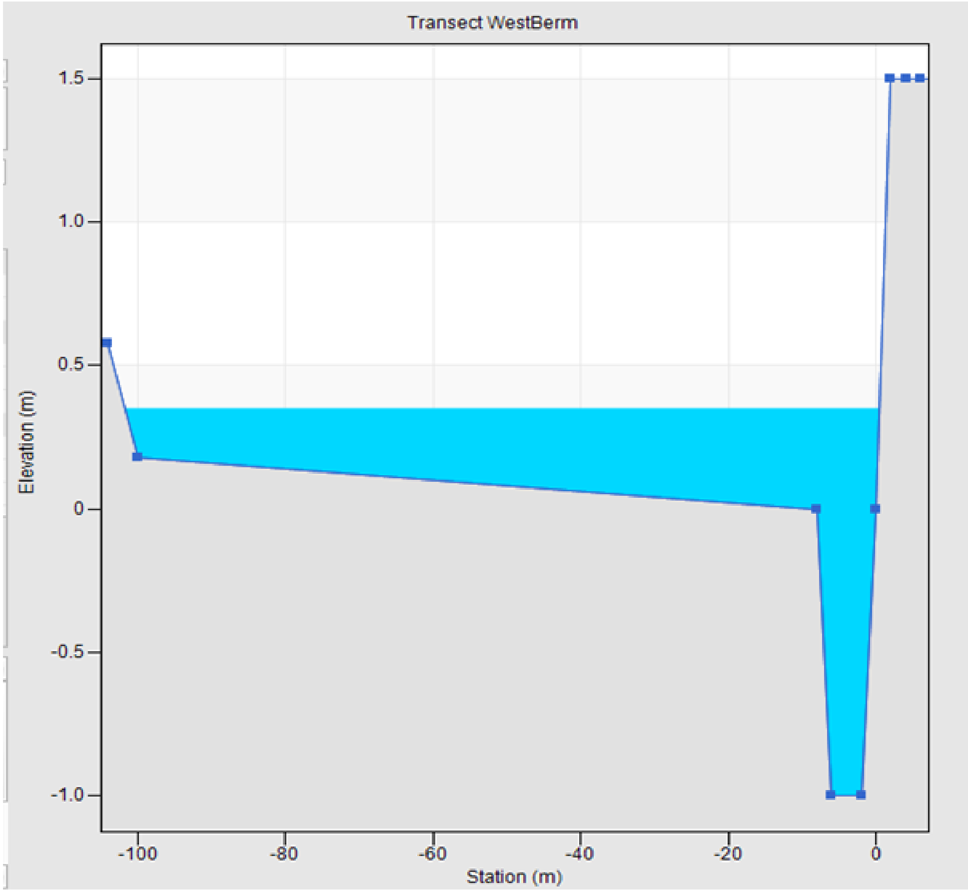

Figure C3: Berm West of Pit 1

Table C1 gives the berm input parameters. For all irregular shaped berms (**Figure C2 and Figure C3**) the slope leading to the berm takes the slope of the catchment contributing runoff. The layout of each berm in relation to the mine infrastructure is shown in **Figure C1**.

Table C1: Berm input parameters

Name	Water	Length (m)	Roughness	Cross-Section	Depth (m)	Width (m)	Side Slope 1:X	Slope (m/m)
C447	Berm	466.886	0.3	TRAPEZOIDAL	3	6	2	0.0006
C448	Berm	421.32	0.3	TRAPEZOIDAL	3	6	2	0.0083
C449	Berm	388.516	0.3	TRAPEZOIDAL	3	6	1.5	0.0069
C454	Berm	209.749	0.3	FIGURE C3	0	0	0	0.0070
C455	Berm	37.718	0.3	FIGURE C3	0	0	0	0.0074
C498	Berm	61.864	0.3	TRAPEZOIDAL	3	6	2	0.0018
C506	Berm	275.887	0.3	FIGURE C3	0	0	0	0.0008
C507	Berm	445.545	0.3	FIGURE C3	0	0	0	0.0027
C508	Berm	317.414	0.3	FIGURE C3	0	0	0	0.0032
C510	Berm	264.971	0.3	FIGURE C2	0	0	0	0.0010
C511	Berm	283.152	0.3	FIGURE C2	0	0	0	0.0059
C512	Berm	260.561	0.3	FIGURE C2	0	0	0	0.0063
C513	Berm	294.946	0.3	FIGURE C2	0	0	0	0.0075
C514	Berm	273.617	0.3	FIGURE C2	0	0	0	0.0075
C515	Berm	285.222	0.3	FIGURE C2	0	0	0	0.0057

Name	Water	Length (m)	Roughness	Cross-Section	Depth (m)	Width (m)	Side Slope 1:X	Slope (m/m)
C516	Berm	240.03	0.3	FIGURE C2	0	0	0	0.0057
C517	Berm	248.724	0.3	FIGURE C2	0	0	0	0.0052
C518	Berm	597.457	0.3	FIGURE C2	0	0	0	0.0005
C549	Berm	69.253	0.3	TRAPEZOIDAL	3	6	2	0.0036
C504_1	Berm	89.625	0.3	FIGURE C3	0	0	0	0.0102
C504_2	Berm	69.94	0.3	FIGURE C3	0	0	0	0.0073
C505_1	Berm	88.541	0.3	FIGURE C3	0	0	0	0.0055
C505_2	Berm	154.511	0.3	FIGURE C3	0	0	0	0.0038
C509_2	Berm	230.274	0.3	FIGURE C3	0	0	0	0.0062
C456	Berm	508.201	0.3	FIGURE C3	0	0	0	0.0094

APPENDIX D

Detailed Haul Road Input Parameters

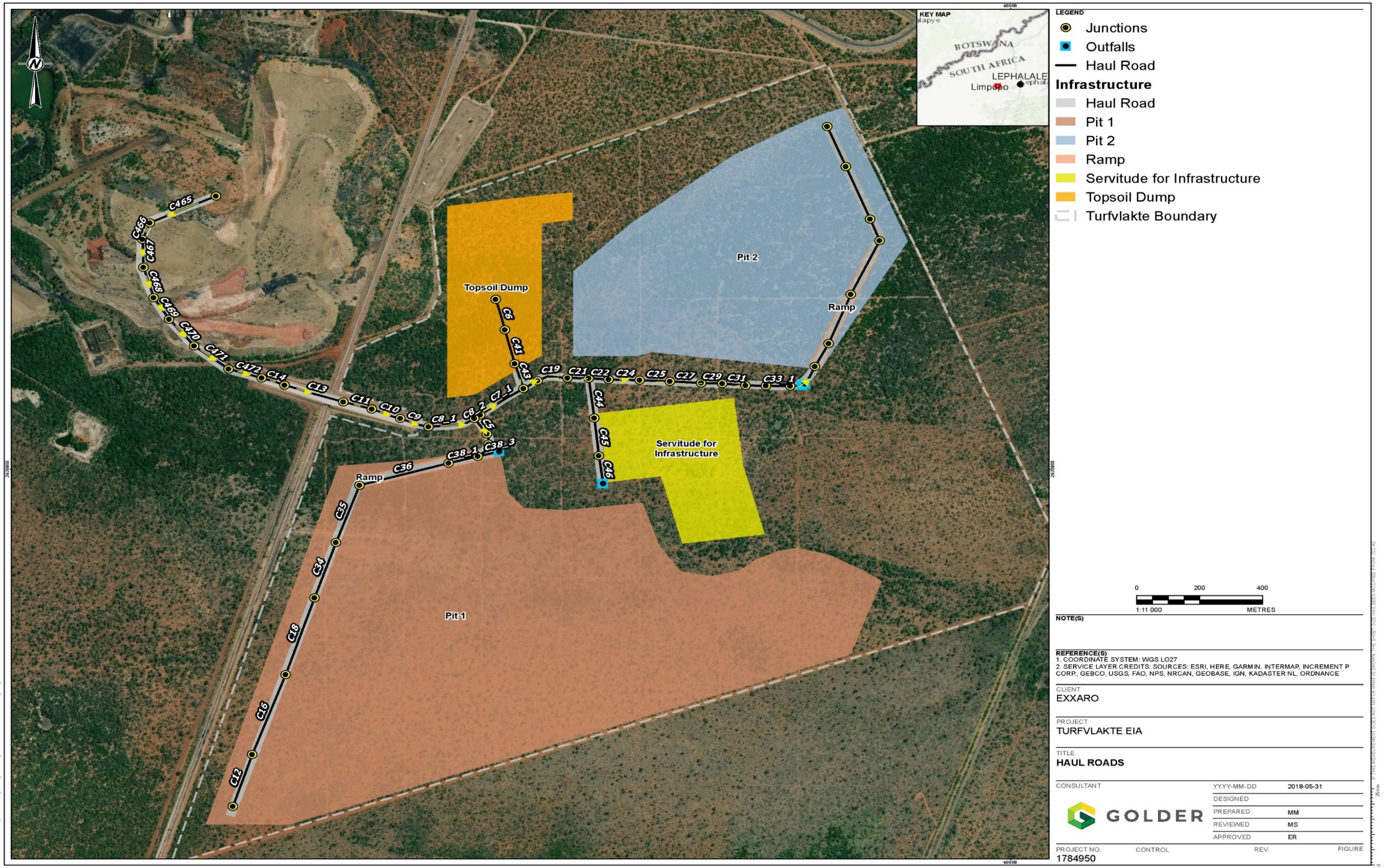

Figure D1: Haul road drainage model layout

The haul road design is based on the typical haul road layerworks design recommended by Aurecon South Africa (Pty) Ltd (May 2018). **Figure D1** specifies the layerworks cross section as shown in the Aurecon report and **Figure D2** displays how the haul roads are modelled in PCSWMM. **Table D1** shows the channel dimensions and computed velocities for the haul roads for a 1:100-year recurrence interval 24-hour storm event. **Figure D3** displays the haul road as modelled in PCSWMM.

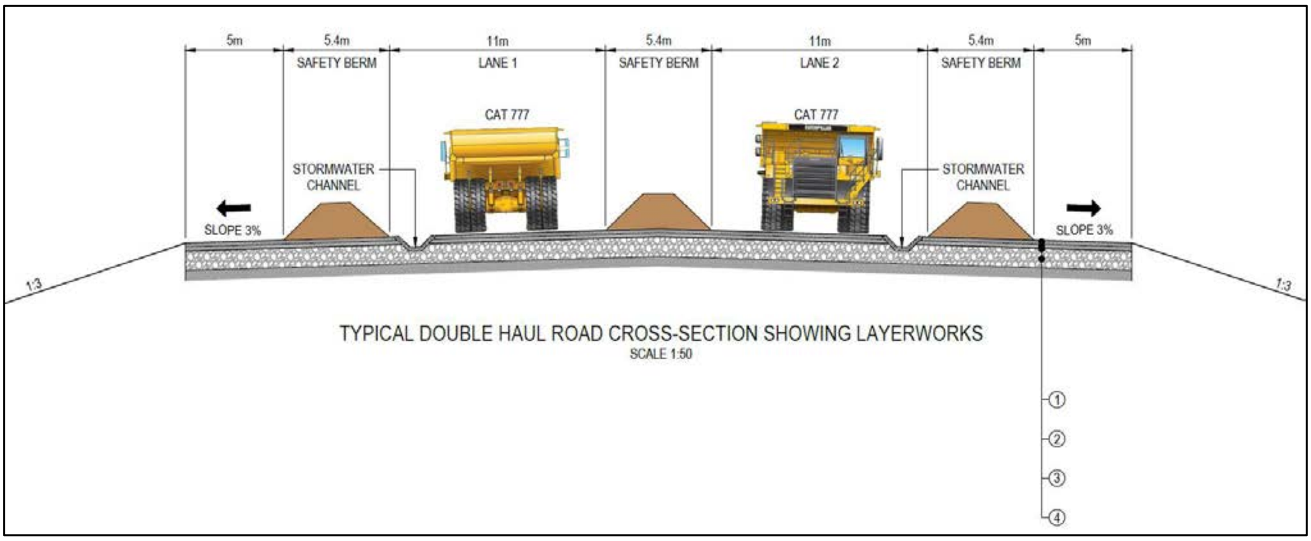

Figure D1: Typical Double haul Road Cross section

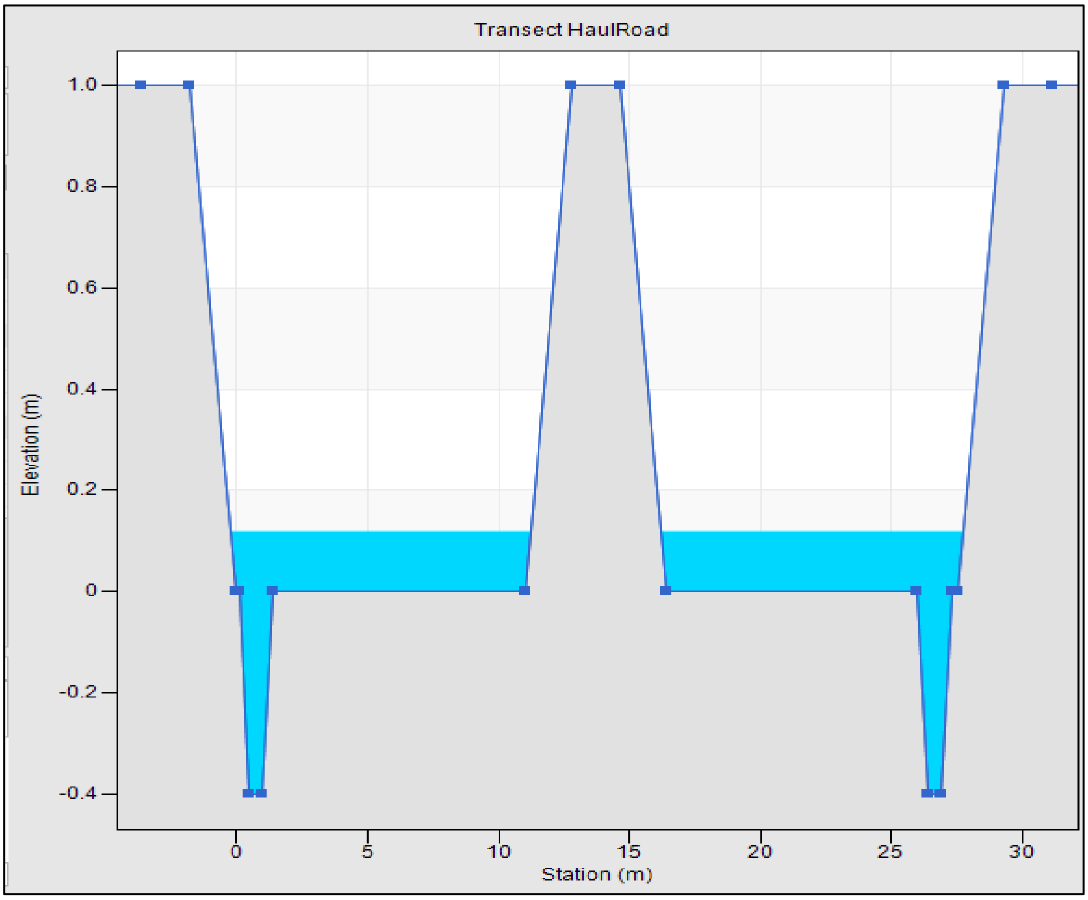

Figure D2: Haul road modelling in PSCWMM

Table D1: Haul road input parameters

Name	Water Type	Length (m)	Roughness	Cross-Section	Slope (m/m)
C465	Dirty	231.099	0.025	FIGURE D2	0.008
C466	Dirty	52.348	0.025	FIGURE D2	0.015
C467	Dirty	97.005	0.025	FIGURE D2	0.027
C468	Dirty	114.934	0.025	FIGURE D2	0.050
C469	Dirty	97.45	0.025	FIGURE D2	0.006
C470	Dirty	112.519	0.025	FIGURE D2	0.007
C471	Dirty	128.066	0.025	FIGURE D2	0.196
C472	Dirty	110.571	0.025	FIGURE D2	0.003
C9	Dirty	93.875	0.025	FIGURE D2	0.009
C10	Dirty	96.93	0.025	FIGURE D2	0.007
C11	Dirty	94.06	0.025	FIGURE D2	0.008
C14	Dirty	76.224	0.025	FIGURE D2	0.006
C5	Dirty	68.603	0.025	FIGURE D2	0.011
C19	Dirty	98.735	0.025	FIGURE D2	0.001
C21	Dirty	67.643	0.025	FIGURE D2	0.006
C22	Dirty	63.115	0.025	FIGURE D2	0.001
C24	Dirty	99.129	0.025	FIGURE D2	0.009
C25	Dirty	95.236	0.025	FIGURE D2	0.007
C27	Dirty	100.336	0.025	FIGURE D2	0.009
C29	Dirty	67.043	0.025	FIGURE D2	0.009
C31	Dirty	73.388	0.025	FIGURE D2	0.009
C32	Dirty	65.229	0.025	FIGURE D2	0.009
C37	Dirty	70.702	0.025	FIGURE D2	0.424
C13	Dirty	196.666	0.025	FIGURE D2	0.006
C15	Dirty	37.656	0.025	FIGURE D2	0.007
C17	Dirty	58.983	0.025	FIGURE D2	0.004

Name	Water Type	Length (m)	Roughness	Cross-Section	Slope (m/m)
C12	Dirty	196.408	0.025	FIGURE D2	0.005
C16	Dirty	306.289	0.025	FIGURE D2	0.004
C18	Dirty	290.527	0.025	FIGURE D2	0.004
C34	Dirty	210.641	0.025	FIGURE D2	0.009
C35	Dirty	218.843	0.025	FIGURE D2	0.003
C36	Dirty	293.603	0.025	FIGURE D2	0.005
C6	Dirty	113.621	0.025	FIGURE D2	0.017
C41	Dirty	126.332	0.025	FIGURE D2	0.024
C43	Dirty	93.375	0.025	FIGURE D2	0.019
C33_1	Dirty	77.782	0.025	FIGURE D2	0.011
C33_2	Dirty	37.049	0.025	FIGURE D2	0.009
C44	Dirty	143.409	0.025	FIGURE D2	0.007
C45	Dirty	135.625	0.025	FIGURE D2	0.006
C46	Dirty	102.02	0.025	FIGURE D2	0.004
C47	Dirty	156.37	0.025	FIGURE D2	0.020
C48	Dirty	203.464	0.025	FIGURE D2	0.009
C49	Dirty	82.788	0.025	FIGURE D2	0.00002
C50	Dirty	214.49	0.025	FIGURE D2	0.4255
C51	Dirty	190.212	0.025	FIGURE D2	0.0004
C52	Dirty	92.557	0.025	FIGURE D2	0.0015
C38_1	Dirty	96.302	0.025	FIGURE D2	0.0096
C38_3	Dirty	70.081	0.025	FIGURE D2	0.0023
C8_1	Dirty	153.097	0.025	FIGURE D2	0.0055
C8_2	Dirty	22.676	0.025	FIGURE D2	0.0055
C7_1	Dirty	166.483	0.025	FIGURE D2	0.0003
C7_2	Dirty	52.644	0.025	FIGURE D2	0.0003
C34	Dirty	210.641	0.025	FIGURE D2	0.009

APPENDIX E

Sub-catchment Results

Table E1: Catchment model results

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S1	0.00	143.33	44.63	123.16	28.21	0.24
S1_1	0.00	120.84	67.37	2.34	0.72	0.36
S1_10	149.14	134.93	202.60	11.98	2.80	0.60
S1_11	0.00	114.11	74.18	4.34	1.61	0.40
S1_12	0.00	141.30	46.77	0.90	0.17	0.25
S1_13	0.00	132.40	55.70	2.03	0.46	0.30
S1_14	2541.34	293.93	2436.32	129.72	13.28	0.89
S1_15	0.00	133.47	54.63	2.22	0.49	0.29
S1_16	0.00	141.16	46.91	3.08	0.57	0.25
S1_17	0.00	121.18	67.03	2.68	0.82	0.36
S1_18	0.00	119.88	68.34	1.02	0.32	0.36
S1_19	0.00	112.04	76.33	0.64	0.27	0.41
S1_2	0.00	110.03	78.40	0.42	0.19	0.42
S1_20	0.00	94.36	93.75	5.04	1.78	0.50
S1_21	0.00	94.75	93.35	4.94	1.73	0.50

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m³/s)	Runoff Coefficient
S1_22	0.00	95.11	92.99	5.29	1.85	0.50
S1_23	0.00	96.88	91.18	8.68	2.93	0.49
S1_24	0.00	98.26	89.77	10.79	3.56	0.48
S1_25	0.00	98.70	89.33	10.43	3.41	0.48
S1_26	0.00	99.28	88.73	7.35	2.38	0.47
S1_27	0.00	76.98	111.67	5.52	3.75	0.59
S1_29	0.00	97.22	90.83	4.51	1.52	0.48
S1_3	0.00	122.33	65.86	4.49	1.33	0.35
S1_4	0.00	126.24	61.92	7.31	1.94	0.33
S1_5	0.00	54.92	133.32	0.76	0.37	0.71
S1_6	0.00	53.24	135.13	0.22	0.12	0.72
S1_7	0.00	51.36	137.14	0.43	0.27	0.73
S1_8	0.00	59.67	128.17	0.35	0.14	0.68
S1_9	0.00	50.74	137.79	0.35	0.23	0.73
S10_1	0.00	51.68	136.81	0.49	0.30	0.73
S10_2	0.00	49.86	138.68	0.53	0.38	0.74

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S10_4	0.00	53.39	134.97	0.43	0.23	0.72
S10_5	0.00	54.23	134.07	0.70	0.36	0.71
S10_6	0.00	51.72	136.76	0.32	0.19	0.73
S10_7	0.00	81.47	106.95	0.50	0.26	0.57
S10_8	0.00	79.22	109.28	0.46	0.27	0.58
S10_9	0.00	79.67	108.81	0.32	0.18	0.58
S12_2	0.00	79.52	108.98	0.54	0.31	0.58
S12_4	0.00	162.20	25.82	22.35	3.12	0.14
S12_5	0.00	169.62	18.38	32.07	4.92	0.10
S12_6	0.00	148.17	39.87	10.49	1.65	0.21
S13_1	0.00	139.58	48.47	8.61	1.65	0.26
S13_10	0.00	168.94	18.99	3.04	0.62	0.10
S13_11	0.00	25.59	159.11	1.04	0.22	0.85
S13_2	0.00	21.01	166.68	14.10	6.44	0.89
S13_3	0.00	165.17	22.84	30.63	4.40	0.12
S13_4	0.00	175.39	12.59	50.91	8.87	0.07

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S13_5	28542.95	271.04	28473.35	141.43	16.73	0.99
S13_6	7.93	170.07	25.87	36.88	4.12	0.13
S13_7	0.00	121.92	66.28	0.55	0.16	0.35
S13_9	0.00	127.97	60.17	0.68	0.17	0.32
S19_1	0.00	125.99	62.16	0.62	0.17	0.33
S19_2	0.00	125.12	63.04	0.42	0.12	0.34
S19_3	0.00	111.56	76.82	0.51	0.22	0.41
S19_4	0.00	108.38	80.10	0.49	0.24	0.43
S19_6	0.00	115.57	72.72	0.72	0.27	0.39
S2	0.00	101.45	87.07	0.05	0.02	0.46
S2_12	0.00	97.42	91.34	0.18	0.12	0.49
S2_14	0.00	95.74	93.15	0.11	0.08	0.50
S2_2	0.00	127.11	61.04	1.41	0.37	0.33
S2_4	0.00	74.19	114.47	0.84	0.61	0.61
S2_7	3265.91	104.79	3352.00	12.30	2.80	0.97
S2_9	0.00	74.48	114.14	0.43	0.30	0.61

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S21_1	0.00	73.83	114.85	0.29	0.22	0.61
S21_2	0.00	102.38	86.41	0.21	0.14	0.46
S3	0.00	114.19	74.12	0.36	0.14	0.39
S3_1	0.00	102.65	86.11	0.28	0.19	0.46
S3_3	0.00	104.29	84.37	0.26	0.15	0.45
S3_4	0.00	105.13	83.48	0.29	0.16	0.44
S4	0.00	101.95	86.87	0.19	0.14	0.46
S5	0.00	104.81	83.83	0.22	0.13	0.45
S5_10	0.00	102.51	86.28	0.15	0.10	0.46
S5_11	0.00	104.07	84.60	0.19	0.12	0.45
S5_12	0.00	101.77	87.06	0.11	0.08	0.46
S5_13	0.00	103.13	85.61	0.17	0.11	0.46
S5_14	4530.00	291.37	4427.58	138.23	12.27	0.94
S5_15	0.00	111.56	76.82	0.42	0.18	0.41
S5_16	0.00	129.29	58.84	1.96	0.47	0.31
S5_17	0.00	122.45	65.74	3.30	0.96	0.35

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S5_18	0.00	125.41	62.75	3.51	0.95	0.33
S5_19	0.00	121.45	66.75	2.43	0.73	0.36
S5_2	0.00	133.64	54.46	2.77	0.60	0.29
S5_20	336.00	153.31	371.05	6.93	1.25	0.71
S5_21	0.00	119.99	68.22	1.10	0.34	0.36
S5_22	0.00	109.85	78.58	0.29	0.13	0.42
S5_23	0.00	109.77	78.66	0.27	0.12	0.42
S5_24	0.00	113.96	74.35	0.36	0.14	0.40
S5_25	10904.98	295.27	10800.07	136.90	12.17	0.97
S5_26	0.00	108.51	79.97	0.58	0.28	0.43
S5_28	0.00	116.52	71.75	0.91	0.32	0.38
S5_29	565.27	167.91	585.96	10.68	1.84	0.78
S5_3	0.00	157.84	30.18	0.14	0.02	0.16
S5_31	0.00	129.68	58.44	0.67	0.16	0.31
S5_32	0.00	120.53	67.68	1.29	0.40	0.36
S5_33	0.00	116.63	71.65	0.85	0.30	0.38

Name	Runon (mm)	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S5_36	0.00	62.13	126.37	0.68	0.42	0.67
S5_37	0.00	64.40	123.97	0.78	0.40	0.66
S5_38	0.00	61.11	127.48	0.29	0.20	0.68
S5_39	0.00	63.43	124.99	0.88	0.48	0.67
S5_4	0.00	63.03	125.41	0.37	0.21	0.67
S5_40	0.00	62.47	126.00	0.82	0.49	0.67
S5_41	33.49	128.65	93.05	22.63	5.45	0.42
S5_5	0.00	98.62	90.50	0.84	0.84	0.48
S5_6	264.26	144.37	308.38	266.34	67.32	0.68
S5_7	0.00	129.03	59.10	1.92	0.47	0.31
S5_8	16.93	130.40	74.69	42.26	10.06	0.36

APPENDIX F

Channel Results

In **Table F1** below, text in bold indicate culverts.

Table F1: Channel model Results

Name	Water Type	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth
C1	Clean	57.993	3.15	0.88
C2	Clean	58.001	3.52	0.83
C20	Clean	2.45	1.18	0.59
C23	Clean	6.472	1.78	0.17
C26	Clean	70.339	2.8	0.7
C28	Clean	4.886	1.87	0.39
C3	Clean	58.05	3.64	0.81
C30	Clean	63.69	2.83	0.75
C33	Clean	58.514	4.17	0.75
C34_1	Clean	12.748	0.99	0.83
C34_2	Clean	32.302	1.95	0.91
C35_1	Clean	33.777	1.74	0.78
C35_2	Clean	38.908	1.94	0.83
C38_2	Clean	4.559	2.23	0.88
C39	Clean	9.989	2.62	0.85
C40	Dirty	1.441	2.46	0.48
C42	Clean	5.186	1.37	0.2
C451	Clean	9.196	1.98	0.81
C452	Clean	10.32	1.95	0.91
C453	Clean	1.298	0.97	0.36
C458_1	Clean	0.417	0.75	0.46
C458_2	Clean	0.805	0.55	0.72
C460	Clean	2.43	1.89	0.65
C462_1	Dirty	1.9	1.12	0.59
C464_2	Dirty	3.346	1.79	0.6

Name	Water Type	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth
C464_3	Dirty	2.065	1.84	0.42
C464_4	Dirty	3.89	2.84	0.48
C53	Clean	0.797	0.96	0.32
C535_1	Clean	0.043	0.17	0.32
C537	Clean	1.296	1.12	0.29
C537_2	Clean	0.284	0.25	0.29
C537_4	Clean	0.267	0.31	0.23
C538	Clean	1.275	0.77	0.38
C539	Clean	2.934	1.13	0.55
C54_1	Clean	0.773	0.7	0.39
C54_2	Clean	1.87	1.43	0.44
C540	Clean	4.066	1.13	0.68
C541	Clean	4.328	1.32	0.64
C542	Clean	4.387	1.65	0.55
C543	Clean	4.375	1.49	0.59
C544	Clean	4.908	1.5	0.64
C545	Clean	4.898	1.39	0.67
C546	Clean	5.244	1.39	0.7
C548	Clean	5.236	2.1	0.52
C55	Clean	1.869	1.59	0.38
C56	Clean	1.806	1.35	0.45
C57	Clean	1.69	0.54	0.84

APPENDIX G

Berm Results

Table G1: Berm model results

Name	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth
C447	2.306	0.19	0.47
C448	2.013	0.19	0.46
C449	2.385	0.28	0.37
C454	0	0	0.1
C455	0.78	0.45	0.26
C498	1.518	0.13	0.64
C506	22.345	0.96	0.56
C507	2.276	0.36	0.42
C508	0.925	0.69	0.15
C510	1.234	0.24	0.23
C511	2.351	0.62	0.2
C512	3.468	0.68	0.23
C513	5.281	0.81	0.26
C514	7.49	0.88	0.3
C515	9.488	0.92	0.33
C516	10.8	0.99	0.34
C517	11.446	0.64	0.46
C518	10.069	0.56	0.43
C549	0.391	0.04	0.61
C504_1	22.34	2.07	0.49
C504_2	20.834	2.22	0.5
C505_1	20.859	1.89	0.5
C505_2	22.242	1.6	0.52
C509_2	0.456	0.52	0.08
C456	9.955	1.67	0.44

APPENDIX H

Haul Road Results

Name	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)	Max/Full Depth
C465	0.00	0.00	0.18
C466	0.16	0.32	0.23
C467	0.23	1.17	0.11
C468	0.43	0.44	0.37
C469	0.20	0.11	0.40
C470	0.22	1.26	0.10
C471	0.40	0.98	0.20
C472	0.52	0.71	0.30
C9	1.37	1.04	0.35
C10	1.32	1.00	0.33
C11	1.03	1.00	0.33
C14	0.63	0.89	0.29
C5	1.47	1.09	0.33
C19	2.45	0.54	0.41
C21	2.48	1.16	0.37
C22	0.90	0.77	0.30
C24	0.66	1.03	0.26
C25	0.66	1.02	0.27
C27	0.70	1.03	0.28
C29	0.75	1.12	0.28
C31	0.85	1.14	0.30
C32	1.00	1.14	0.32
C37	1.63	0.80	0.38
C13	0.67	0.85	0.32
C15	1.47	0.86	0.35
C17	1.48	0.66	0.39
C12	0.00	0.00	0.07

Name	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)	Max/Full Depth
C16	0.15	0.44	0.17
C18	0.30	0.47	0.27
C34	0.37	0.36	0.34
C35	0.27	0.36	0.30
C36	0.35	0.68	0.22
C6	0.00	0.00	0.17
C41	2.79	1.79	0.34
C43	2.82	1.05	0.41
C33_1	1.01	1.11	0.32
C33_2	1.27	1.22	0.32
C44	1.98	1.00	0.36
C45	1.97	0.71	0.38
C46	2.01	1.00	0.37
C47	0.00	0.00	0.09
C48	0.36	0.74	0.22
C49	0.70	0.89	0.30
C50	0.64	0.27	0.37
C51	0.66	0.27	0.36
C52	0.82	0.40	0.39
C38_1	0.54	0.54	0.32
C38_3	1.95	0.95	0.37
C8_1	1.31	0.93	0.34
C8_2	0.54	0.42	0.38
C7_1	0.48	0.18	0.44
C7_2	2.40	0.39	0.45

APPENDIX I

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APPENDIX B

Water balance report

Golder Report Number: 1784950/323361/8

REPORT

Water and Salt Balance Report

TURFVLAKTE COAL MINE

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July 2020

Distribution List

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FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd was appointed by Exxaro to perform an Environmental Impact Assessment (EIA) on their Turfvlakte Project. The objective of this report is to provide a Basis of Design for the water balance that will be prepared to inform the EIA regarding the water requirements, assess the availability of storage on the project site, identify the surface water impacts than can possibly result from water management on the site and assess surety of supply for mining operations at Turfvlakte.

2.0 BACKGROUND INFORMATION

The Turfvlakte Project is situated approximately 30 km northwest of Lephalale, located in the Waterberg region (which forms part of the Bushveld region) of the Limpopo Province of South Africa. More specifically the Turfvlakte project is located on the Turfvlakte farm directly south of Grootegeluk Mine. The farm area consists of shallow protrusions of Benches 9A ,9B and 11 which will result in high quality coal that can be mined in this area at a favourable stripping ratio.

Exxaro is investigating the business case of opening a Greenfields coal mine on the Turfvlakte farm for a three (3) million tonne per annum (3Mt/a) run of mine (ROM). The coal is destined for either the local energy provider, Eskom or for the export market, or a combination of the two end-users. The objective of this study is to determine the value that mining, and beneficiation of this resource can add to the current Grootegeluk operations.

The study area is situated in the Waterberg region of South Africa which falls within the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent, except for near the surface, is anti-cyclonic throughout the year. The synoptic patterns affecting the typical weather experienced in the area owe their origins to the subtropical, tropical and temperature features of the general atmospheric circulation over South Africa (Golder 2013). The highest temperatures are typically experienced during the summer months of December, January and February, and the lowest during the winter months of June, July and August.

The site is situated in the A42J quaternary catchment of the Limpopo Water Management Area (WMA). The main water resource in this quaternary catchment is the Sandloopspruit that flows east north-east to join the Mokolo River approximately 40 kilometres south of the Limpopo River. Further details are available in Golder Report number: 1784950-322706-6.

3.0 CLIMATE DATA

The rainfall and evaporation analysis on the Turfvlakte site will be discussed in the following sections.

3.1 Rainfall

There are two sources of rainfall data that will be used in this model;

- For **reporting/historic** sequences the actual precipitation depths measured on site should be used. Fortunately, this was provided by the client for a rainfall period of 1988-2018 Provision will be made in the operational model supplied to the client to enter rainfall data captured on site.
- For **future** scenarios (as well as historic periods with missing site data) the model will generate artificial rainfall records using a stochastic rainfall generator. The rainfall data that will be used within the generator was sourced from the Daily Rainfall Data Extraction Utility (Kunz, 2004).

The metadata for the climate stations near the Turfvlakte mine is provided in Table 1. The Turfvlakte mine is at an elevation of 903m.

Table 1: Rainfall station metadata

Station Name	Station ID	Distance from site (km)	Latitude	Longitude	Record (Years)	Patched (%)	Reliable (%)	MAP (mm)	Elevation (mamsl)
Grootegeluk Coal Mine (1988-2018)	N/A	0			30	0	100	495	903
Grootegeluk Coal Mine (1978-2018)	N/A	0			40	0	100	581	903
Ellisras (POL)	0674400 W	17.102	23.41	27.44	33	66.2	33.8	463	837
Grootegeluk	0674100 W	0.000	23.40	27.34	24	76.9	23.0	449	908

3.1.1 Rainfall Analysis

The analysis on rainfall data supplied for the site is presented in this section.

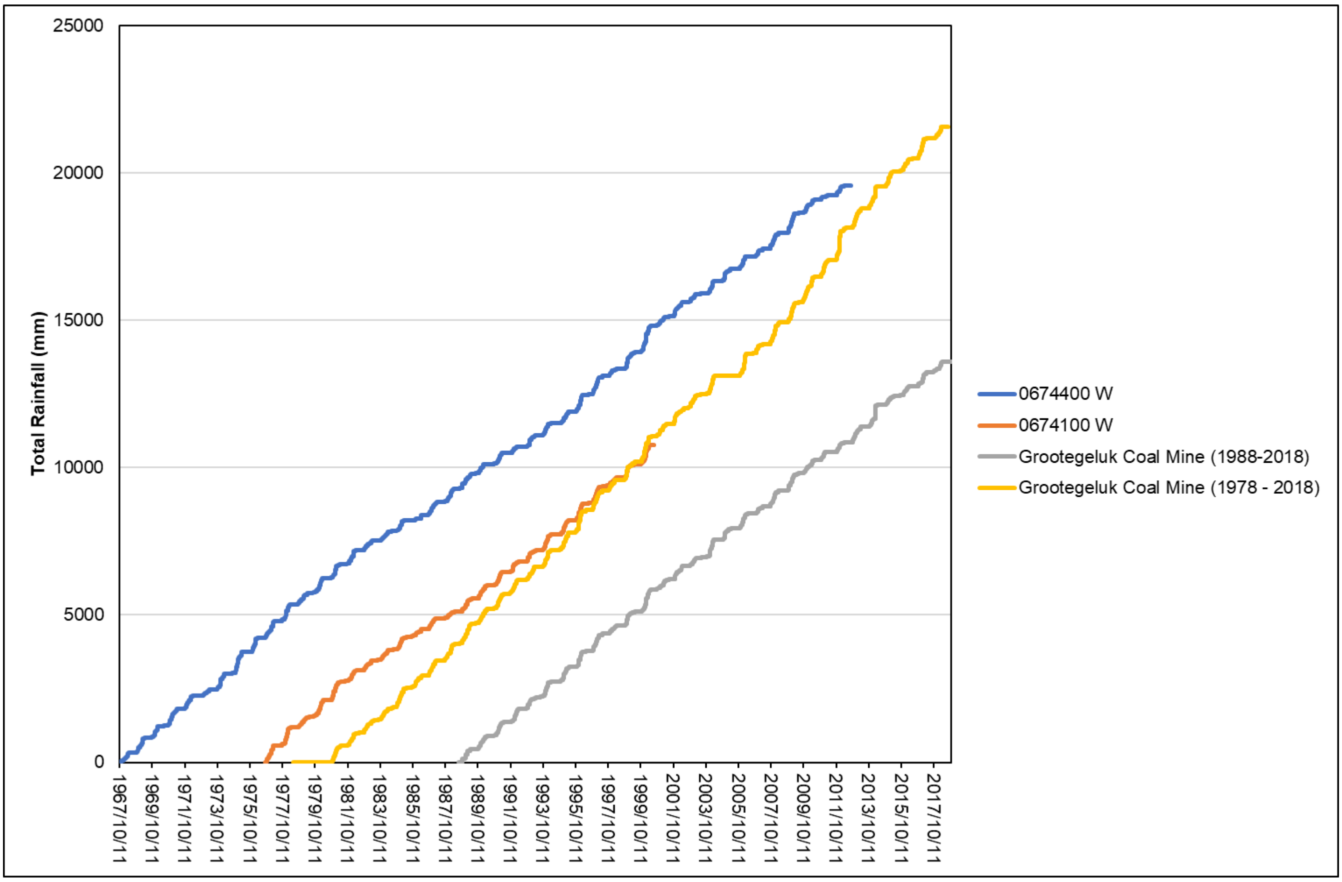

Figure 1: Cumulative Rainfall for Grootegeluk and Ellisras

Figure 1 illustrates the cumulative plot of rainfall data captured for the Grootegeluk, Ellisras and the Grootegeluk Coal Mine rainfall stations. These plots are used to check for any anomalies and irregularities that may occur in the recorded rainfall data. The four rainfall stations show similar trend.

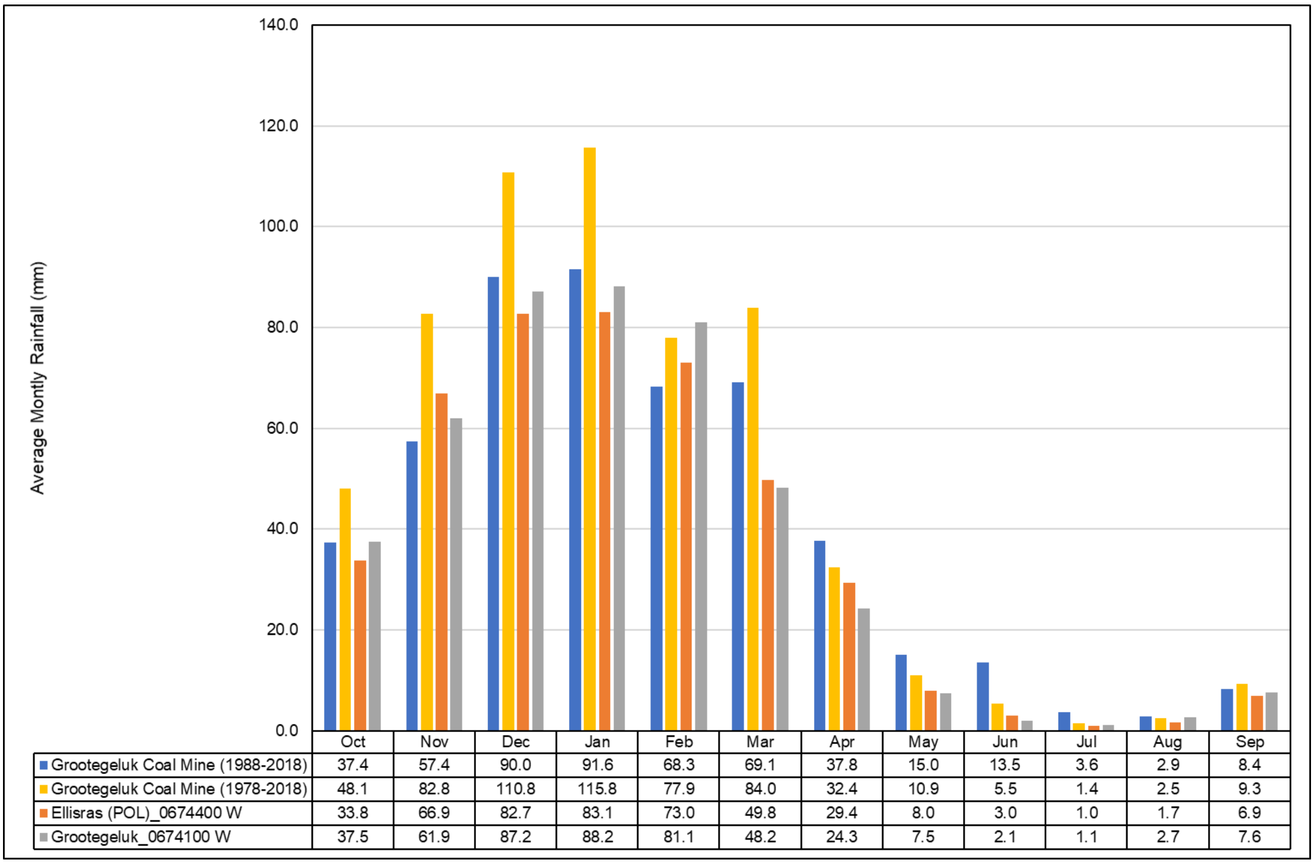

Figure 2: Monthly rainfall distribution for rainfall stations

Table 2: Monthly Annual Precipitations for the rainfall stations in the Turfvlakte area

Map	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Grootegeluk Coal Mine (1988-2018)	37.4	57.4	90.0	91.6	68.3	69.1	37.8	15.0	13.5	3.6	2.9	8.4
Grootegeluk Coal Mine (1978-2018)	48.1	82.8	110.8	115.8	77.9	84.0	32.4	10.9	5.5	1.4	2.5	9.3
Ellisras (POL)	33.8	66.9	82.7	83.1	73.0	49.8	29.4	8.0	3.0	1.0	1.7	6.9
Grootegeluk	37.5	61.9	87.2	88.2	81.1	48.2	24.3	7.5	2.1	1.1	2.7	7.6

Figure 2 shows the monthly rainfall distribution for the four rainfall stations, near the Turfvlakte mine, for the duration of the rainfall period recorded. All weather stations exhibit a similar trend for the wet (October to March) and Dry (April to September). During the wet season January has the maximum average rainfall record and July has the minimum average rainfall record in the dry season.

The Grootegeluk Coal Mine (1978-20178) station was selected as the preferred rainfall data source as it was received from the client, is in the closest proximity to the Turfvlakte Mine and has the longest record length. It also has the least patched data, includes data up to 2018 and has a high reliability. The Grootegeluk Coal Mine data set varied well with the other data sets selected for this study.

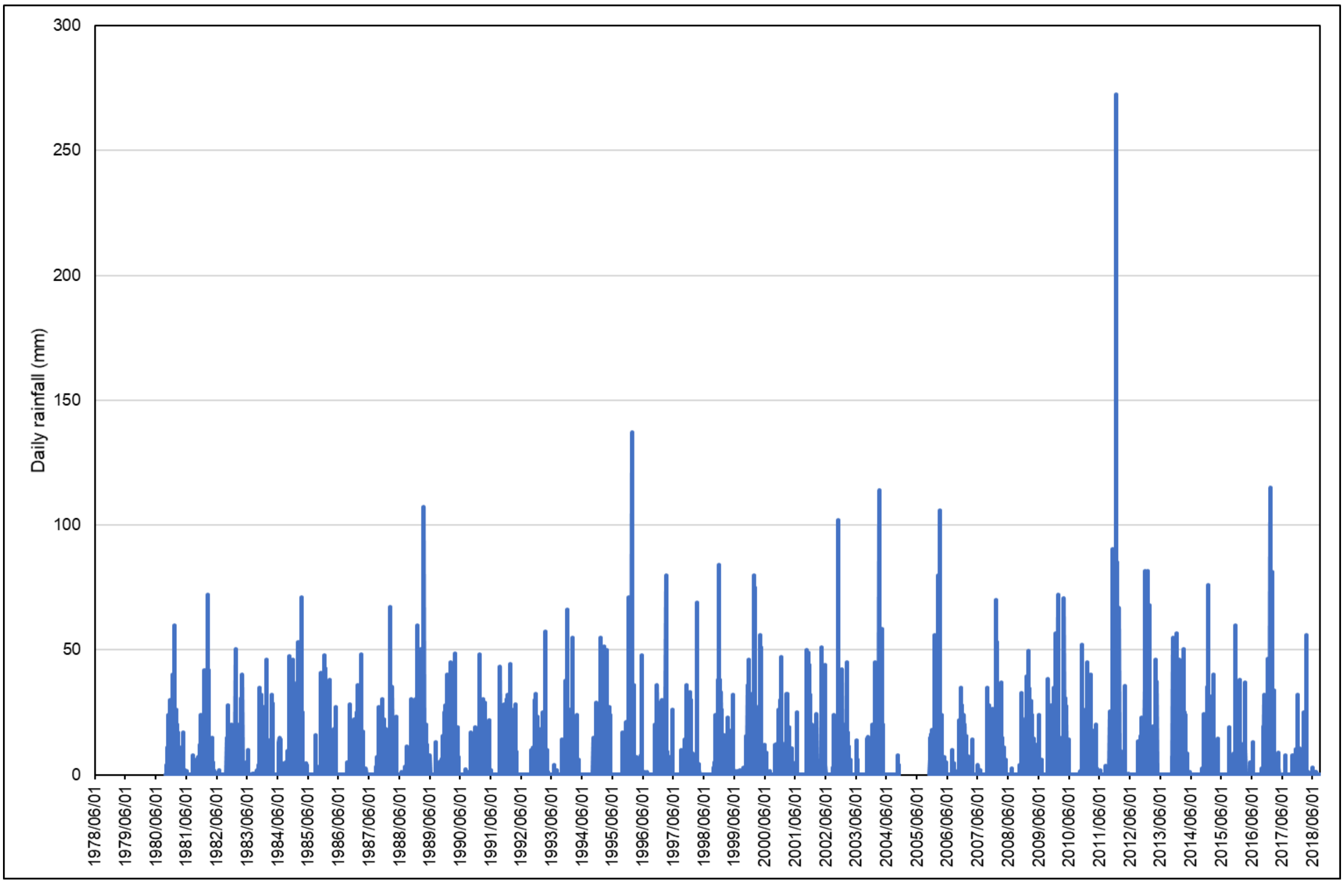

Figure 3: Daily Rainfall at the onsite monitored rainfall station

The daily rainfall data is represented in Figure 3. It illustrates that there are data gaps during the years 1978 – 1980 and 2004 from the selected data. There is also an anomaly which shows a higher than average rainfall data for December 2011.

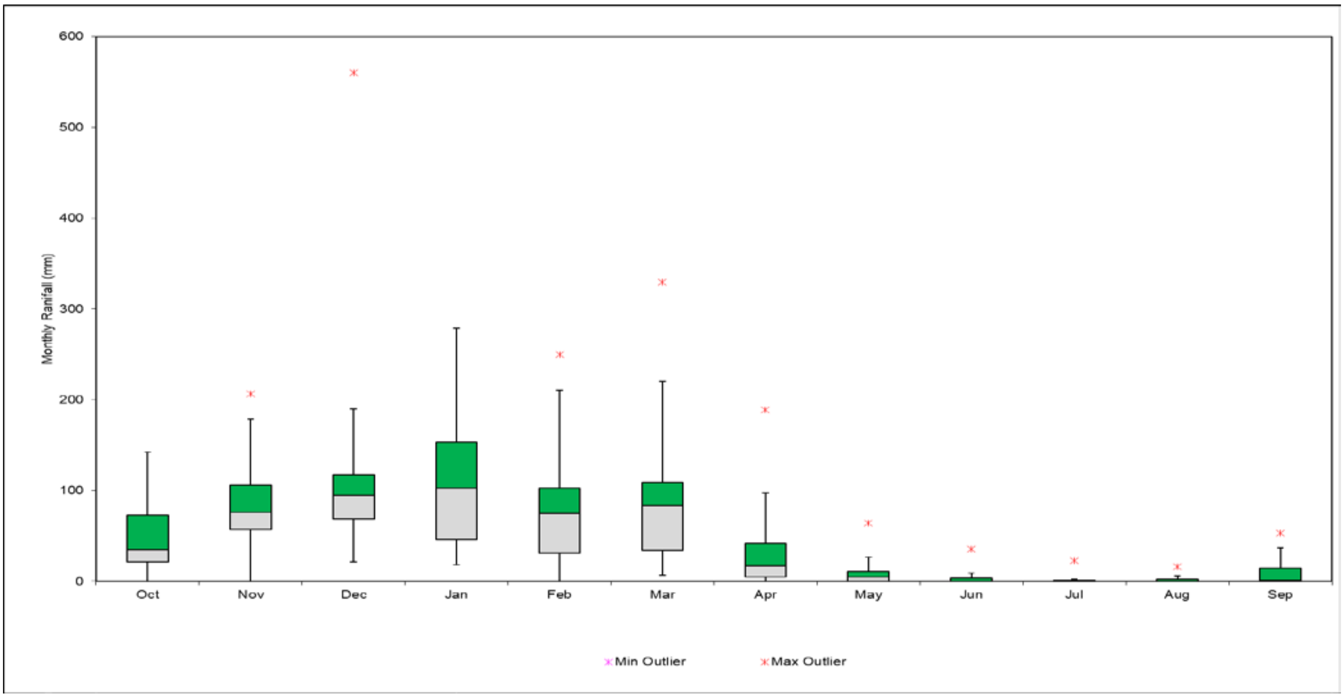

Figure 4: Monthly rainfall statistics for the Grootegeluk Coal Mine

Refer to Figure 4 for the statistical rainfall analysis on the selected rainfall station. The purpose of the plot is to understand the rainfall distribution and depths within the various months. It also displays the 25th and 75th percentile, mean, minimum and maximum values for the Grootegeluk Coal Mine data. The highest rainfall distribution can be seen in November to April with minimal rainfall in the months of May and October.

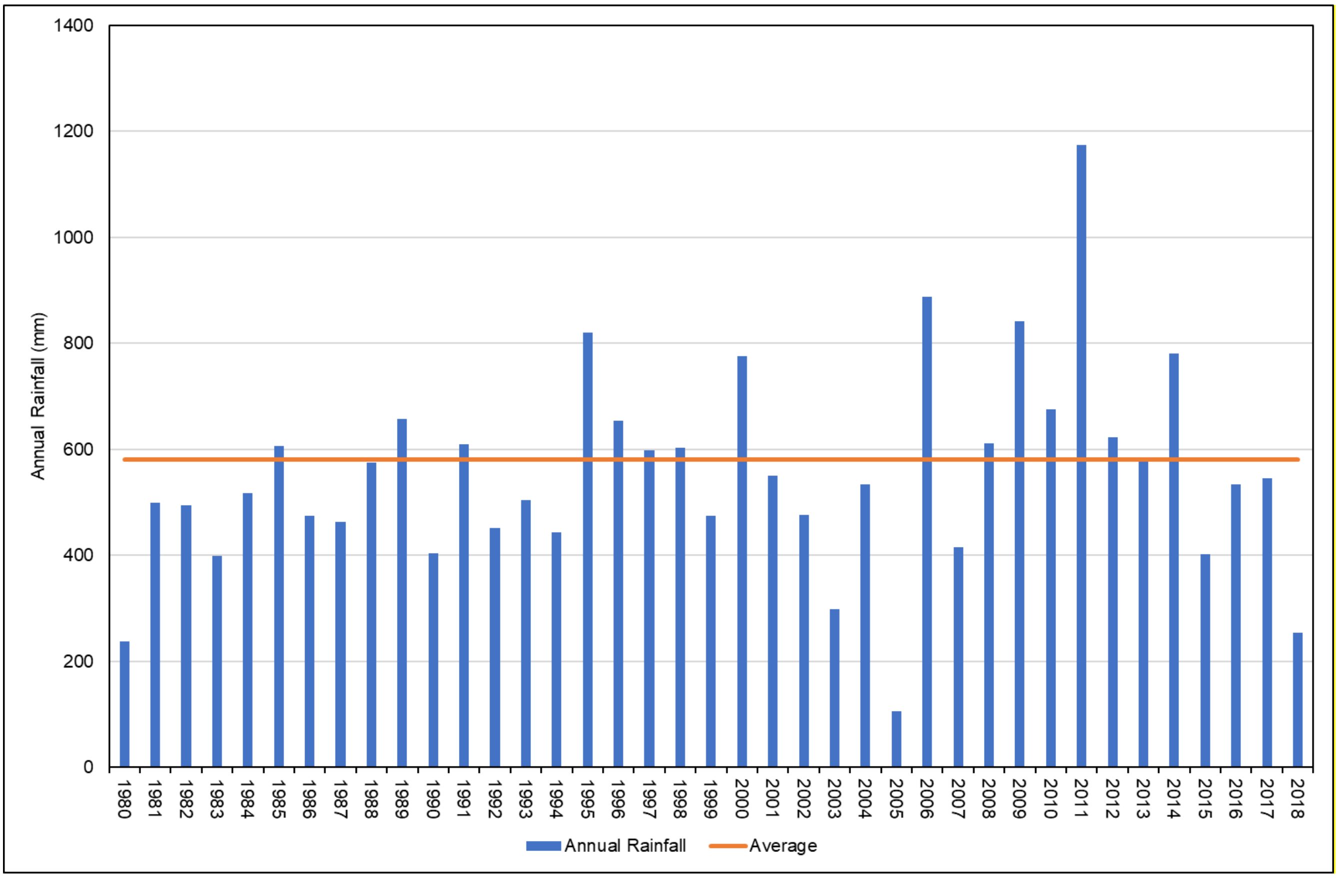

Figure 5: Annual rainfall measured at Grootegeluk Coal Mine

Refer to Figure 5 for the annual rainfall station for the Grootegeluk Coal Mine. From the figure the lowest rainfall was within the year 1980 with an estimated 238 mm of rain. The highest rainfall within for the region was in 2011 with an estimated 1175mm of rain.

Table 3: 5, 50th and 95 percentiles of the annual rainfall totals

Station	5th percentile	50th percentile	95th percentile
Grootegeluk Coal Mine	283	455	686

Table 3 shows the probability of non-exceedance of the annual rainfall totals measured at the Grootegeluk Coal Mine rainfall station.

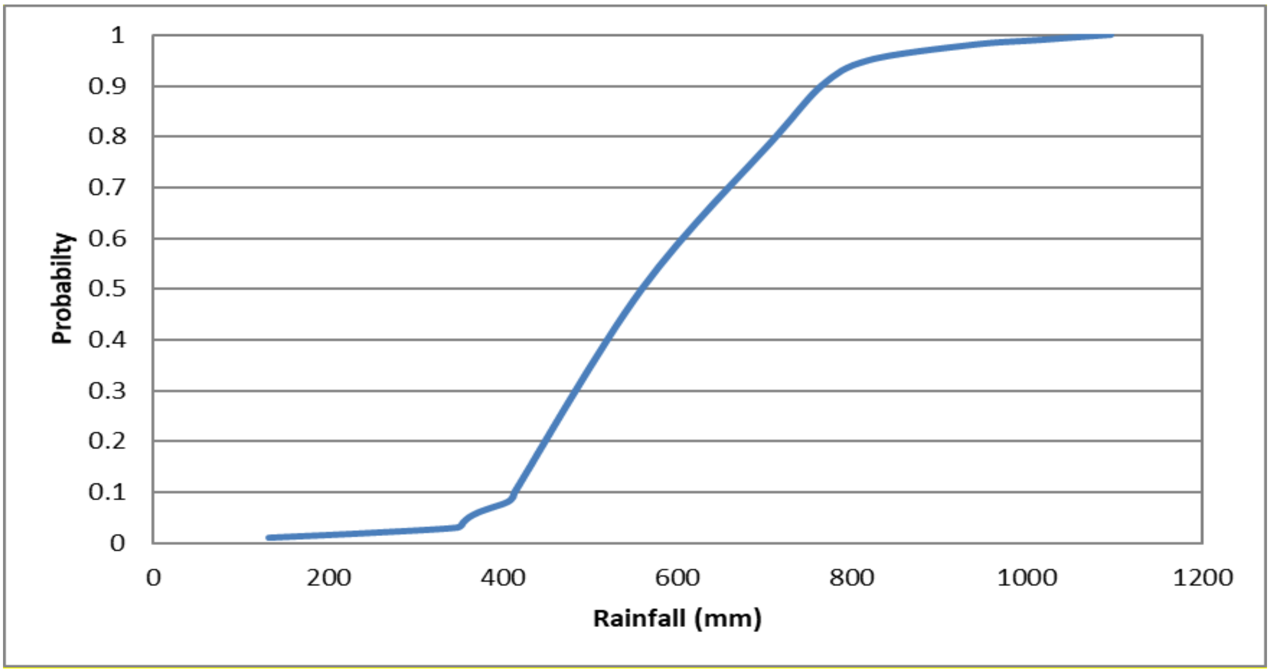

Figure 6: Annual rainfall probability of non-exceedance for the Grootegeluk Coal Mine Station

The distribution curve in Figure 6 was constructed from the annual rainfall measures for the rainfall data period obtained. This shows that over 50% of the annual rainfall data recorded falls below 558.8mm. Table 4 consists of the relevant percentile values from the distribution curve and shows the probability of non-exceedances for the annual rainfall measured at the Grootegeluk Coal Mine.

Table 4: 24-hour rainfall depths for different recurrence intervals in mm/day

Recurrence interval (years)	1 in2	1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200
24-hour rainfall depth (mm)	65	92	116	137	165	188	210

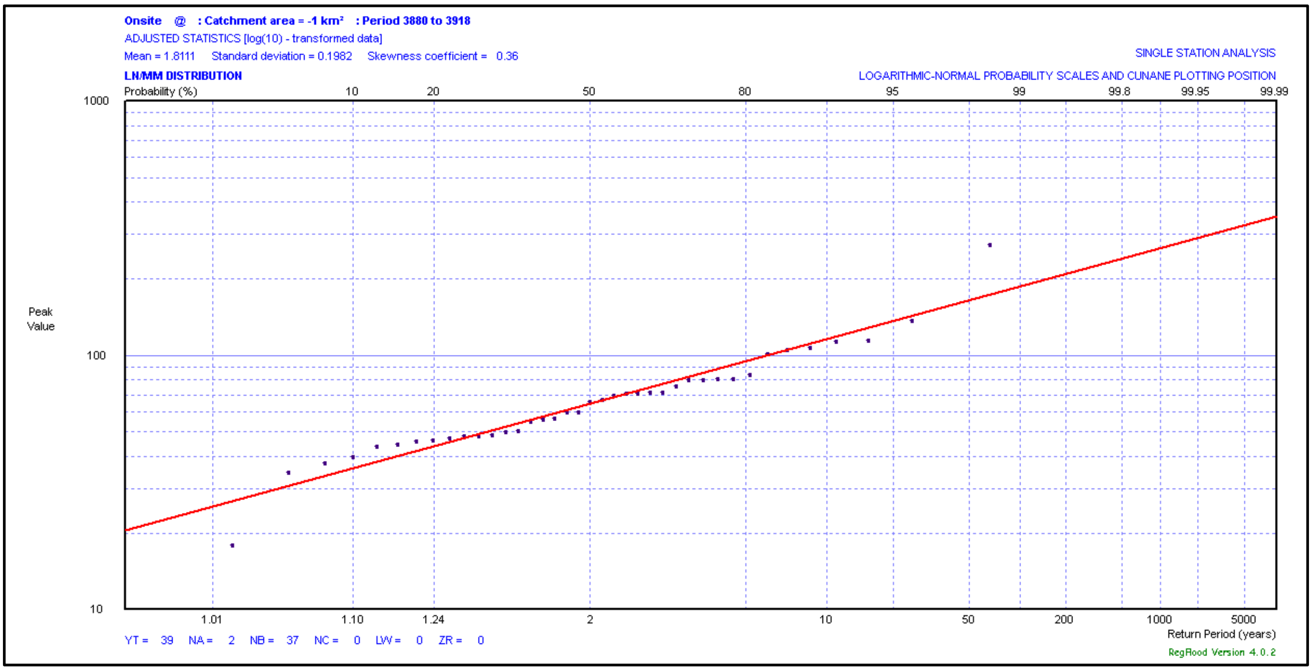

Figure 7: Log Normal probability distribution curve

The rainfall depths were calculated using the statistical analysis programme UPFlood (Alexander, *et al*., 2003)**.** The maximum 24-hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit for this station is the Log normal distribution which resulted in the 24 h storm rainfall depths. The graph in Figure 7 was used to estimate the daily storm rainfall depths associated with the various return periods as summarised in Table 4.

3.2 Evaporation

The Turfvlakte region falls within the 1D evaporative zone with a Mean Annual S-pan evaporation of 2015mm. Table 5 summarises the average monthly evaporation values for station A4E007 and the average monthly S-pan evaporation rates for the area given by Midgley et al., (1994). The mean annual evaporation is almost 4 times higher than the mean annual rainfall data.

Table 5: Average monthly evaporation for station A4007

Month	S-pan
Oct	220.9
Nov	206.1
Dec	215.5
Jan	214.4
Feb	187.7
Mar	179.7
Apr	139.1
May	123.5

Month	S-pan
Jun	99
Jul	105.4
Aug	139.3
Sep	184.3

Figure 8 displays the average monthly evaporation measurements for the Lephalale area. This boxplot assists in observing the monthly evaporation distribution and variation. It also shows the minimum, 25th and 75th percentile, mean and the maximum values. Figure 8 correlates with the rainfall boxplot in Figure 4.

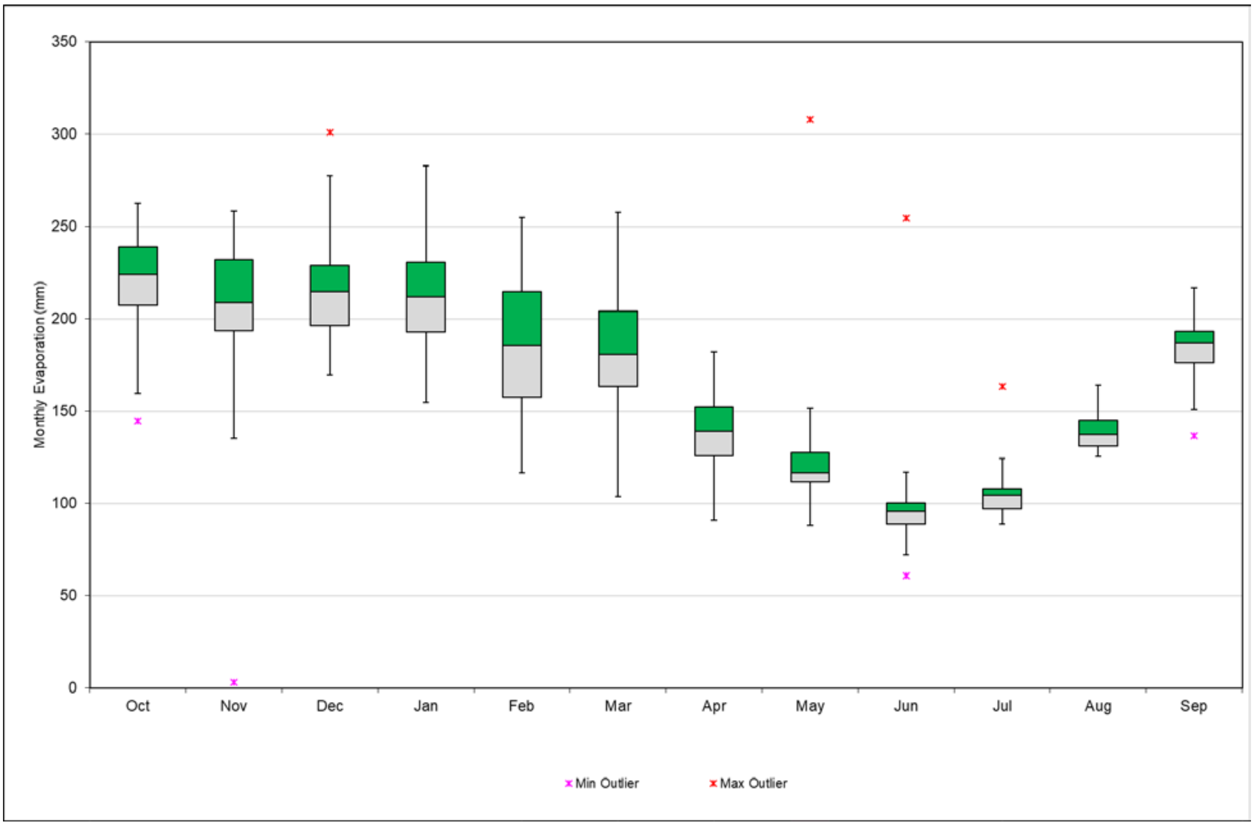

Figure 8: Average monthly evaporation measurements for the Lephalale area

4.0 WATER RETICULATION

A diagram depicting the site wide reticulation network is provided in Figure 9. The Opencast operations for the Turfvlakte Mine consists of Pit 1 and 2. Water collecting in the pit sump will be used for dust suppression in the workings and along the Haul road. Excess water from the pits is pumped to the Grootegeluk Mine PCD's

Topsoil pre-stripped from Pit 1 and Pit 2 will be stored at the topsoil stockpile area.

4.1 Water Reticulation Diagram

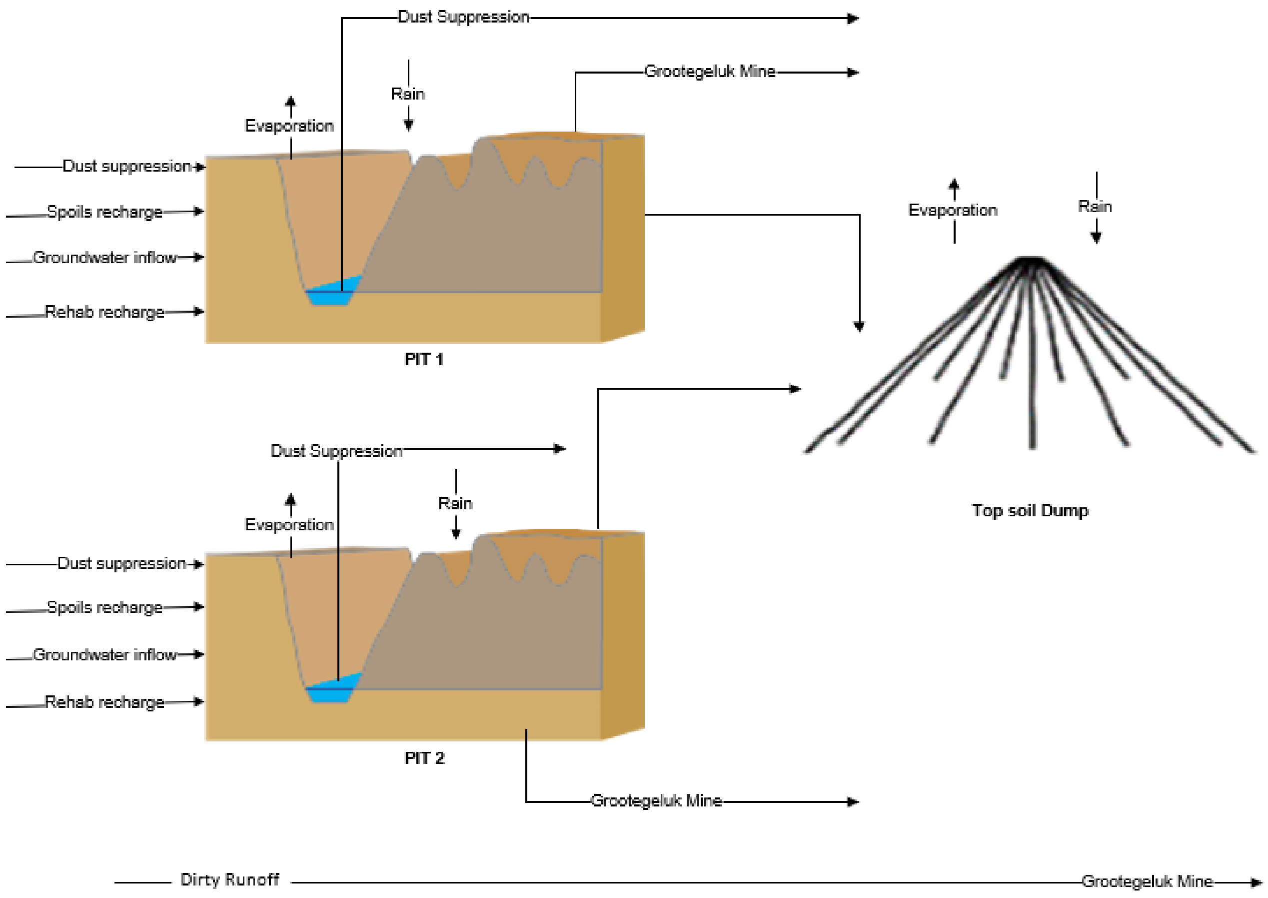

Figure 9: Water Reticulation Diagram for Turfvlakte

5.0 WATER RELATED INFRASTRUCTURE

The Run of Mine (ROM) from these pits is to be carried by haul trucks to the existing Grootegeluk Mine. The ROM material is either temporarily stored on stockpiles or fed directly into tipping bins for use and processing in the plant.

The mine contains temporary in-pit sumps and storm water management infrastructure in the laydown area that receives and collects the runoff from Pit 1, Pit 2 and the laydown area. The contaminated run off that is discharged into the sump is transferred to the Grootegeluk Coal Mine dirty water system. Water from the sump is utilised for dust suppression on roads in the pit.

5.1 Open-Cast Mines

5.1.1 Pit 1 and 2

Two opencast pits, Pit 1 and Pit 2 are proposed for the Turfvlakte Project. The plant at Grootegeluk Mine will process ROM coal from both these pits. Pit 1 is 119 ha and will be 75m deep while Pit 2 is 42 ha and will be 85 m deep. There are two mining options that is considered. The first option is mining Pit 1 in its entirety then proceed to Pit 2 and the second option is to mine the pits simultaneously. The expected ROM production rate for option 1 from pit 1 is 1 million tonnes per annum over 15 years. The expected ROM production rate for option 2 is 3 million tonnes per annum over a period of 7 years (Exxaro, Project Description EIA Project , 2018).

The pit model will account to recharge, direct rainfall into workings, groundwater ingress (if applicable from the Groundwater investigations), evaporation from the pit sump and water pumped out of the pit.

The following assumptions will be made for the pit model;

- Pre-stripping will occur one year ahead of mining;
- Spoils will be levelled within two years of mining;
- Rehabilitation will occur within five years of mining;
- Access ramps (4 m wide) will be included during the mining phase.

The mine plan displayed in Figure 10 and Figure 11 and indicates the Life of Mine Strategy for Option 1 and Option 2.

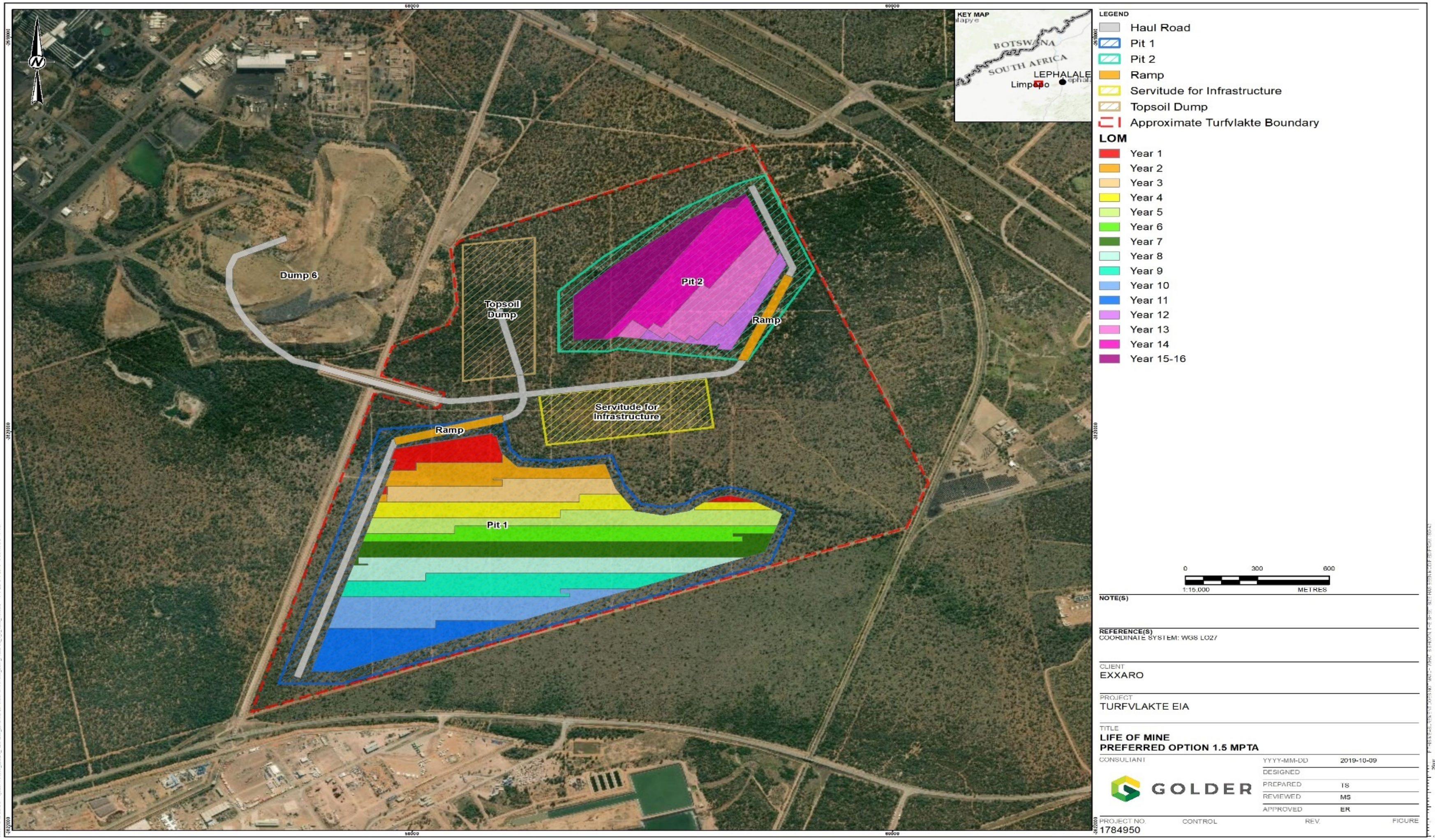

Figure 10: Mine Plan (Option1)

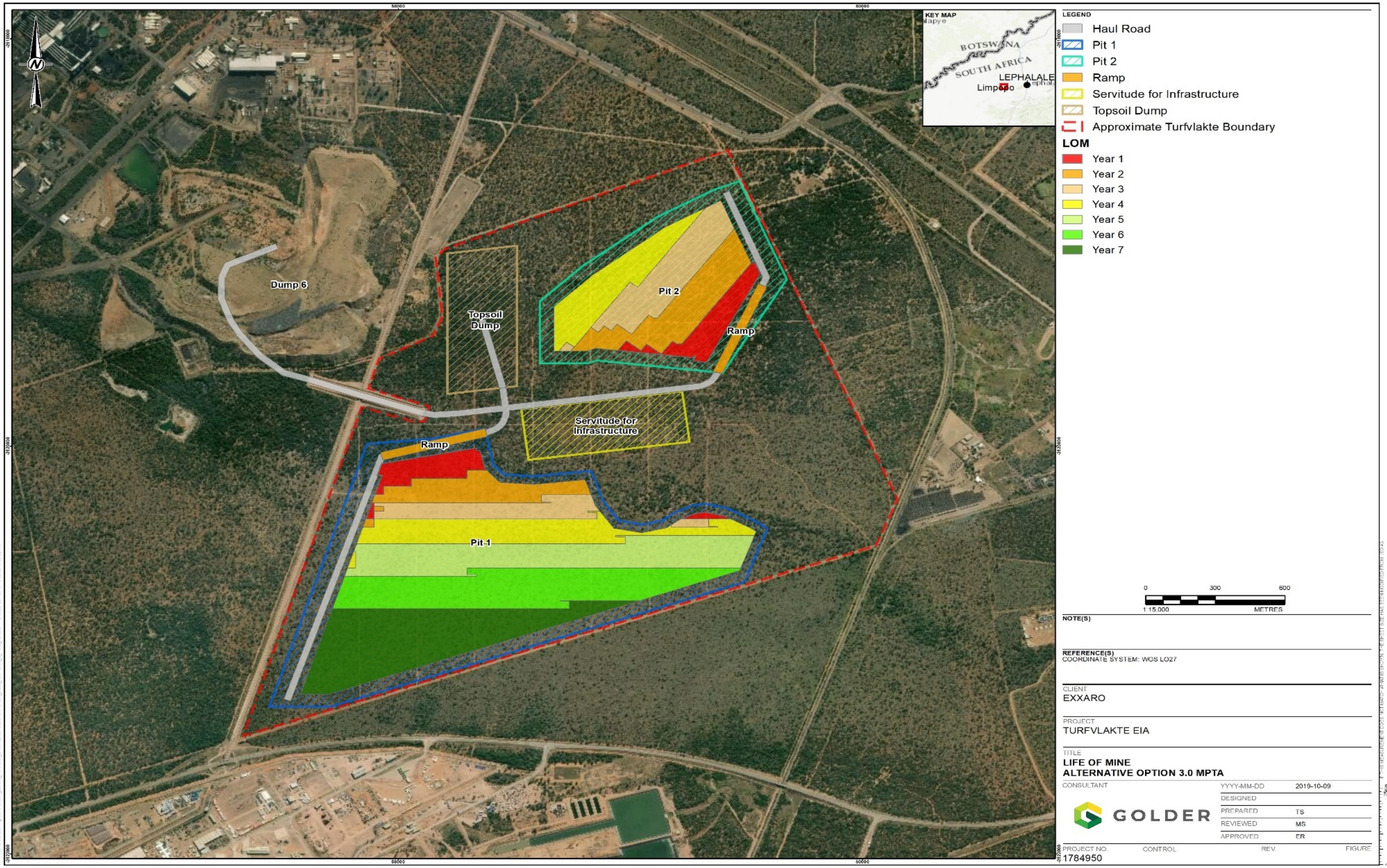

Figure 11: Mine Plan (Option 2)

The following types of wastes will be produced during the proposed mining activities; overburden and interburden. It was suggested that these wastes be deposited into either the Turfvlakte or Grootegeluk pits and used as backfill for these fits (Exxaro, Project Description EIA Project , 2018).

5.2 Water Storage Facilities

Water emanating from the Pits will be used for dust suppression and excess water will be pumped to the Grootegeluk Dirty Water System for reuse at the Grootegeluk Plant. There will be no storage at Turfvlakte mine apart from the temporary sumps constructed within the pit during mining.

5.3 Water Uses

5.3.1 Potable water

A potable water tank will be located at the North of the Turfvlakte project area. The potable water supply is from the existing Grootegeluk Mine potable water system and has a capacity of 25 m^3 (Aurecon, 2018). The potable water will gravitate to the potable water distribution network. The sewage effluent collected from the infrastructure area will gravitate to the existing Grootegeluk Sewage Treatment Plant that is located to the South of the project site.

5.3.2 Fire water

A Fire Water Tank will be situated to the North of the Turfvlakte project area. Water will be pumped to the tank from the existing Grootegeluk Mine fire water system. The tank has a capacity of 25 m^3 and is elevated to allow for the fire water to gravitate to the fire water distribution network (Aurecon, 2018). Depending on the Client's requirements a booster pump might be needed in order to achieve the required pressure.

6.0 PLANNED PRODUCTION DATA

Figure 12 (Option 1) illustrates the planned production data for the 15 year period, and Figure 13 (Option 2) illustrates the planned production data for the 7 year period and Figure 13 sets out the production rate per hour for the coal and waste production values for option 1 and option 2 respectively.

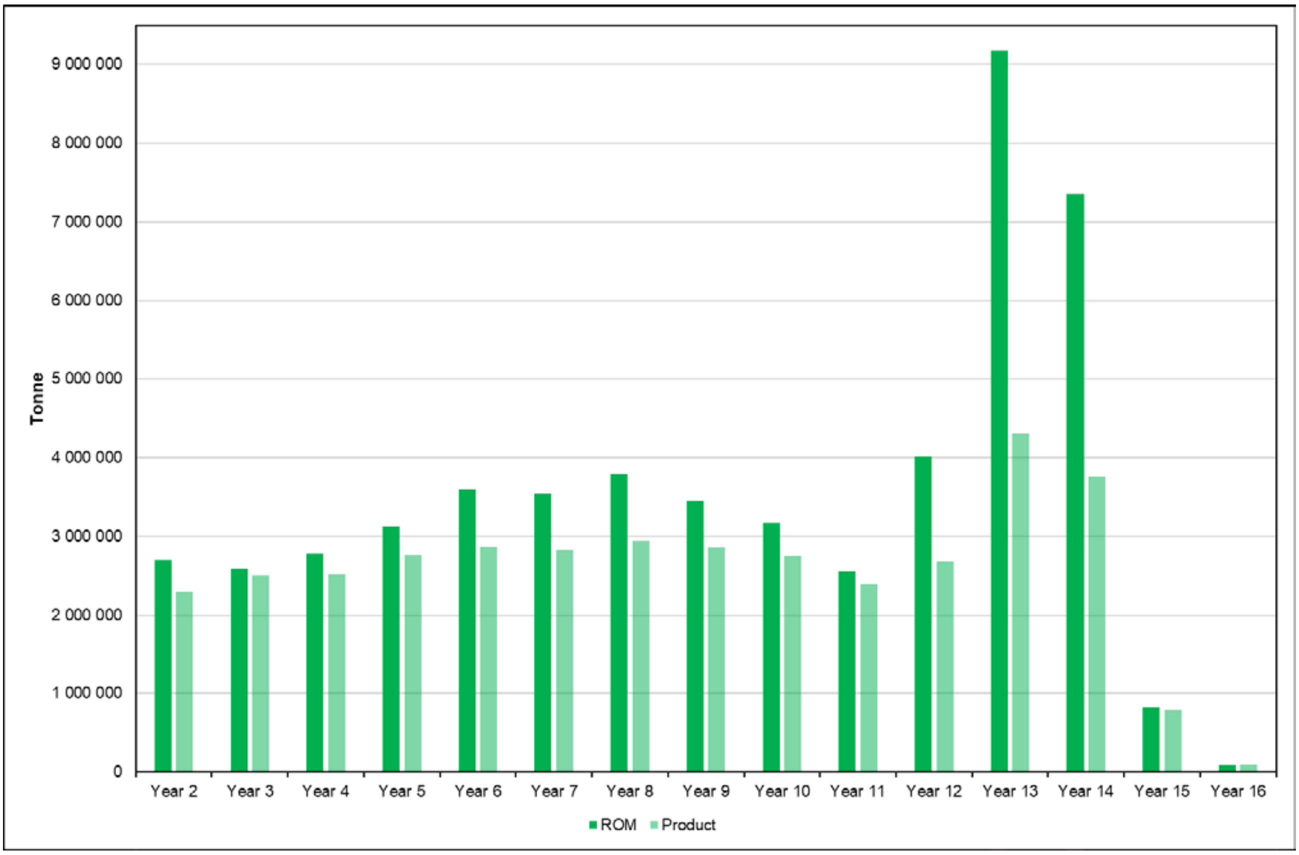

Figure 12: Turfvlakte Production Data (Option 1) (Exxaro, Turfvlakte Coal Mine, 2018)

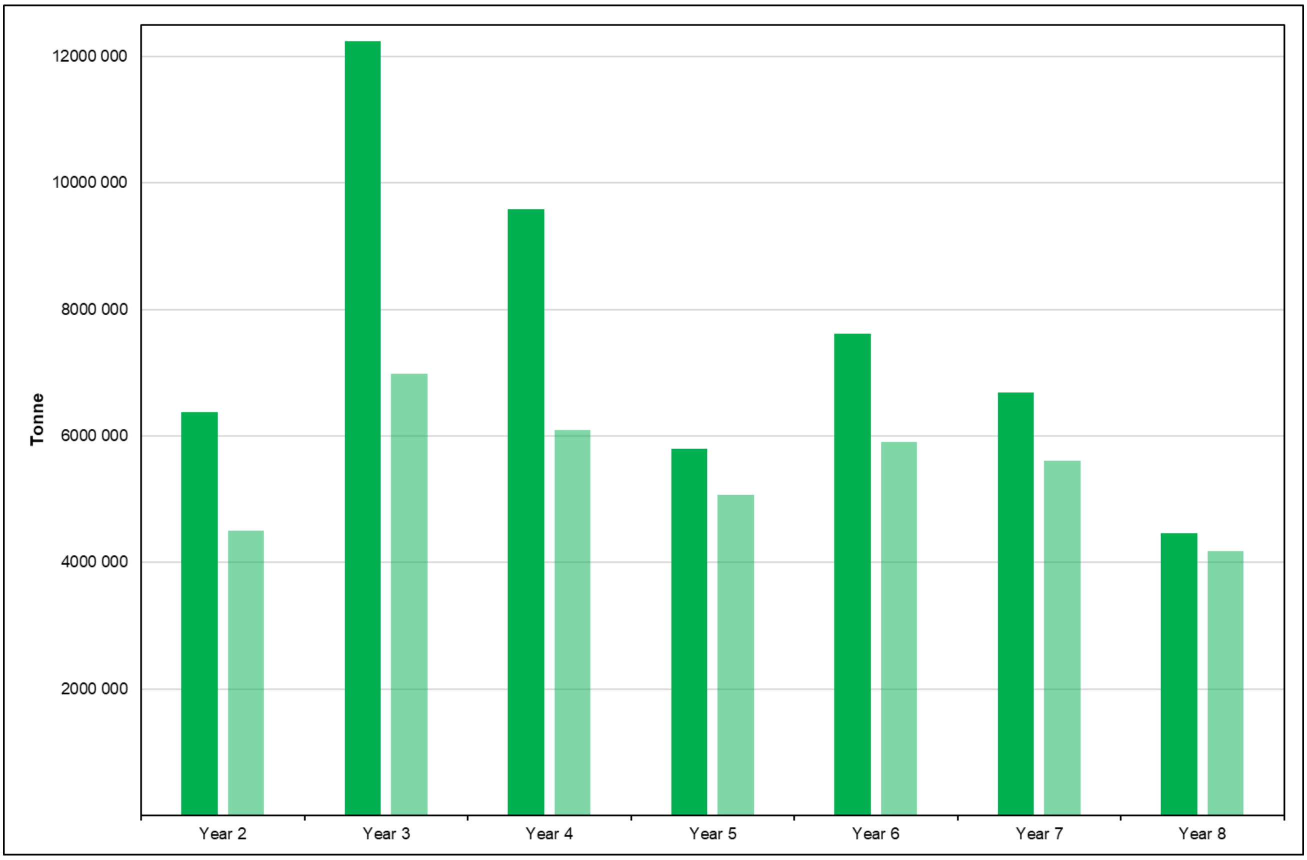

Figure 13: Turfvlakte Production Data (Option 2)

7.0 GROUNDWATER INGRESS

Groundwater ingress data used in the model was supplied by GCS and is presented in Figure 14 and Figure 15.

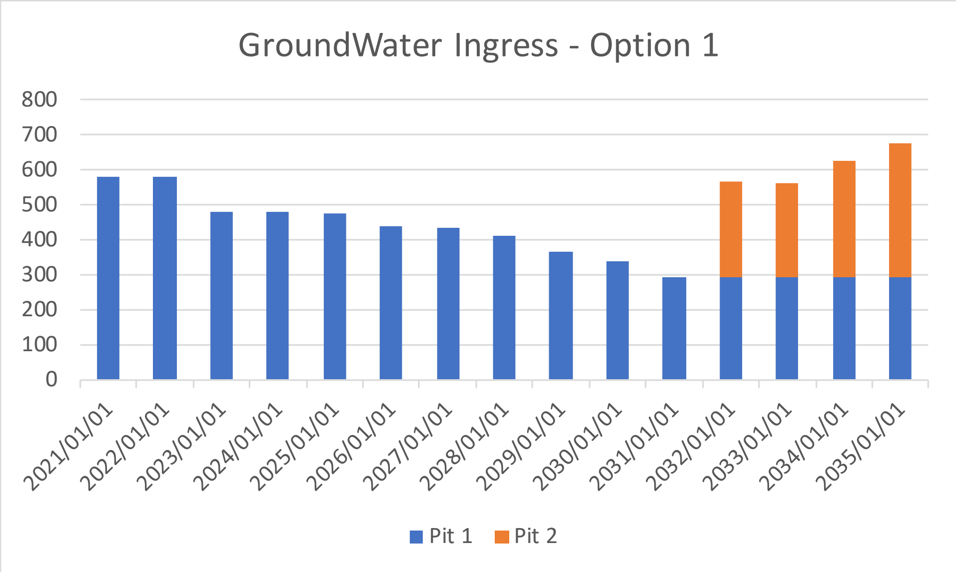

Figure 14: Simulated groundwater ingress obtained for option 1

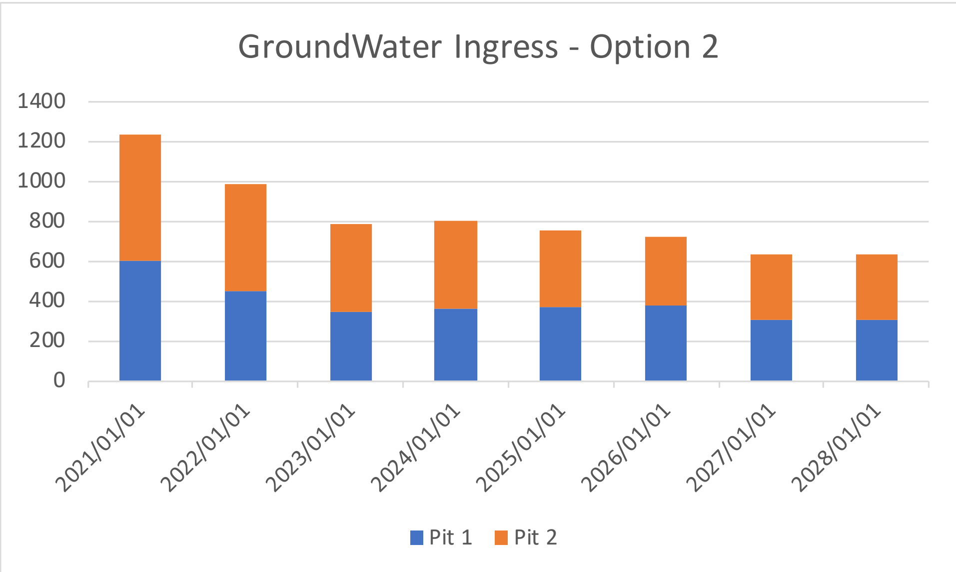

Figure 15: Simulated groundwater ingress obtained for option 2

8.0 MODEL RESULTS

The simulation was run for 100 realisations. Results obtained for the two mining options are presented here. Figure 17 and Figure 19 provides an average balance across the system whilst active mining is taking place. These flows occur during extreme instances and will not be a daily occurrence. They have however been included as the water use license will need to allow for this.

8.1 Option 1

In option 1, mining at Pit 2 only commences after mining at Pit 1 is completed. Results indicate that an average of 607 m^3/day (Figure 16 and Figure 17) will be pumped from Turfvlakte Pit 1 to the Grootegeluk mine during mining and 401 m^3/day (Figure 19) will be pumped from Pit 2 during mining.

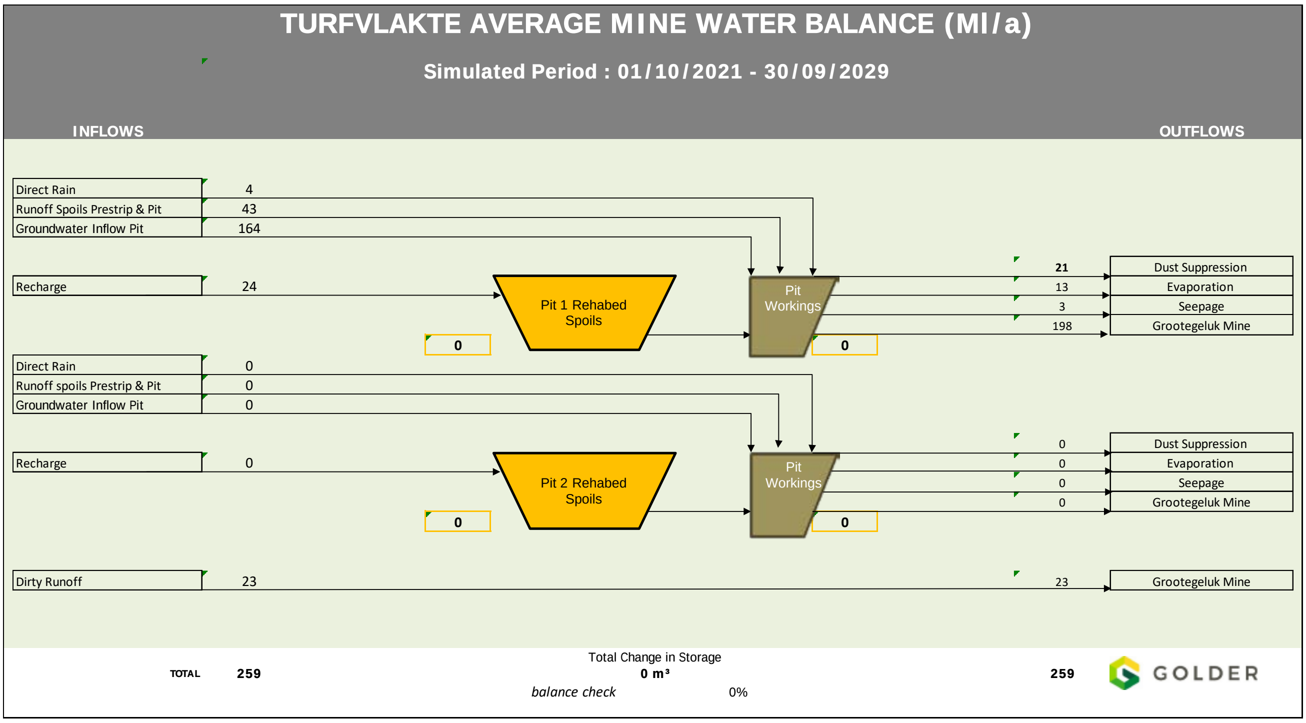

Figure 16: Average balance across Turfvlakte Mine between 2021 and 2029 (Ml/annum) – Option 1

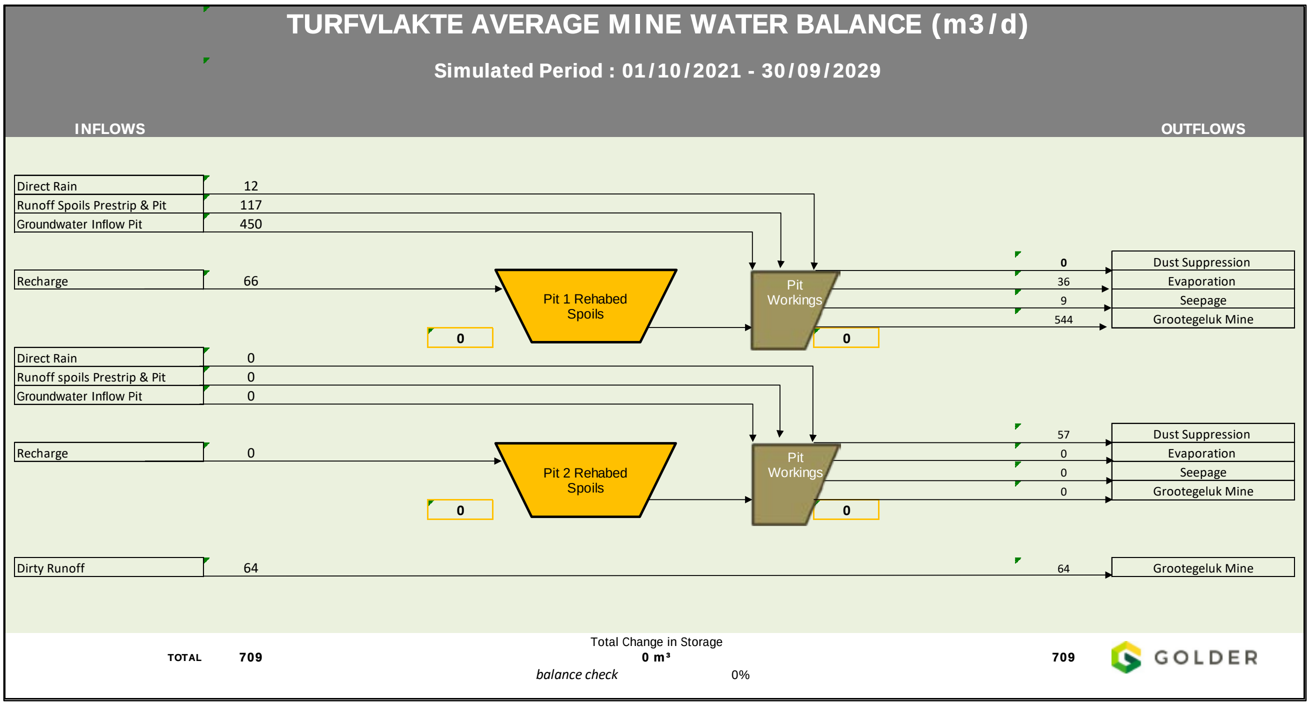

Figure 17: Average balance across Turfvlakte Mine between 2021 and 2029 (m^3/day) – Option 1

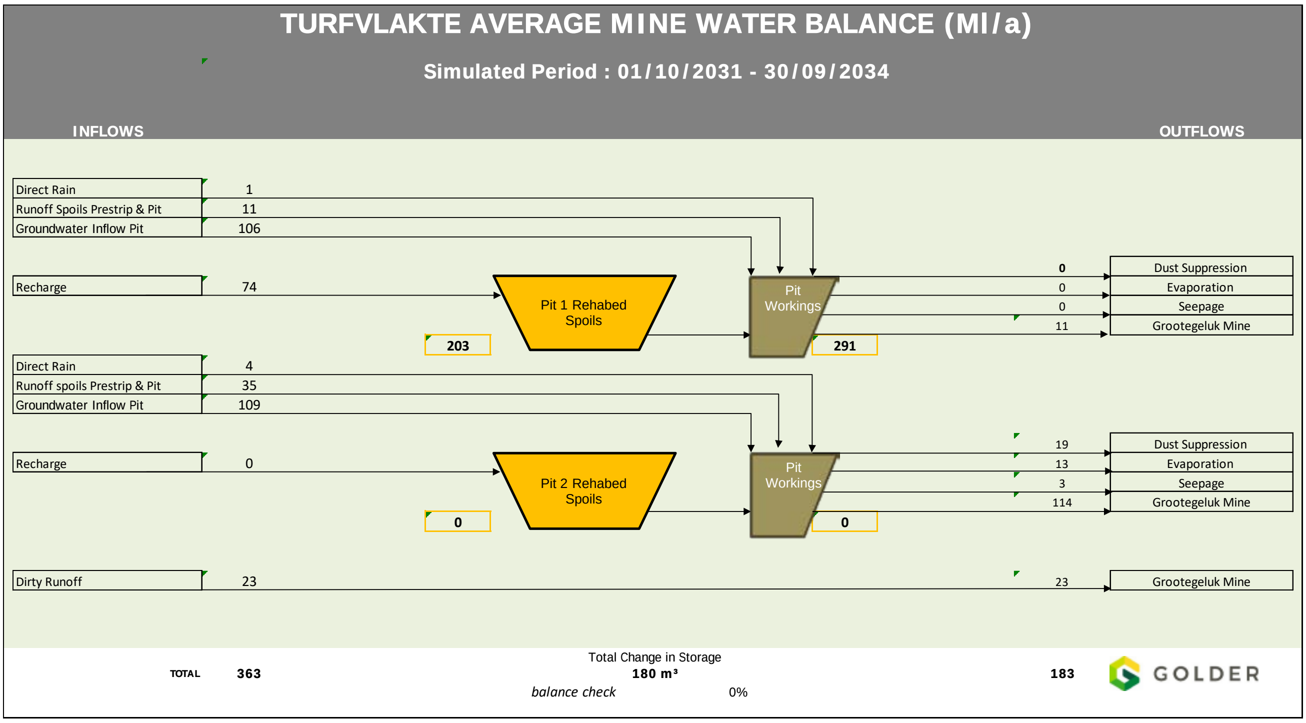

Figure 18: Balance across Turfvlakte Mine between 2031 to 2034 (Ml/annum)

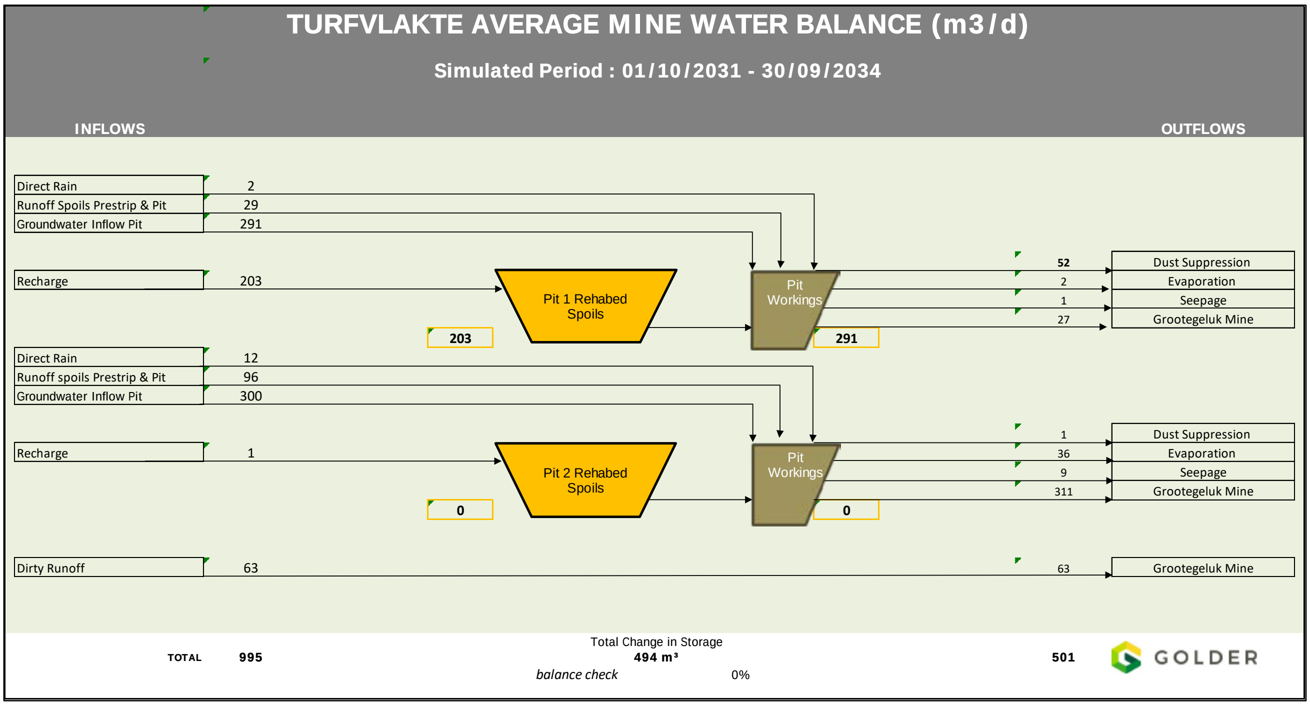

Figure 19: Balance across Turfvlakte Mine between 2031 to 2034

The average pumping profile for water pumped is illustrated in Figure 20. Water pumped to Grootegeluk mine is between 163 m^3/day and 756 m^3/day on average.

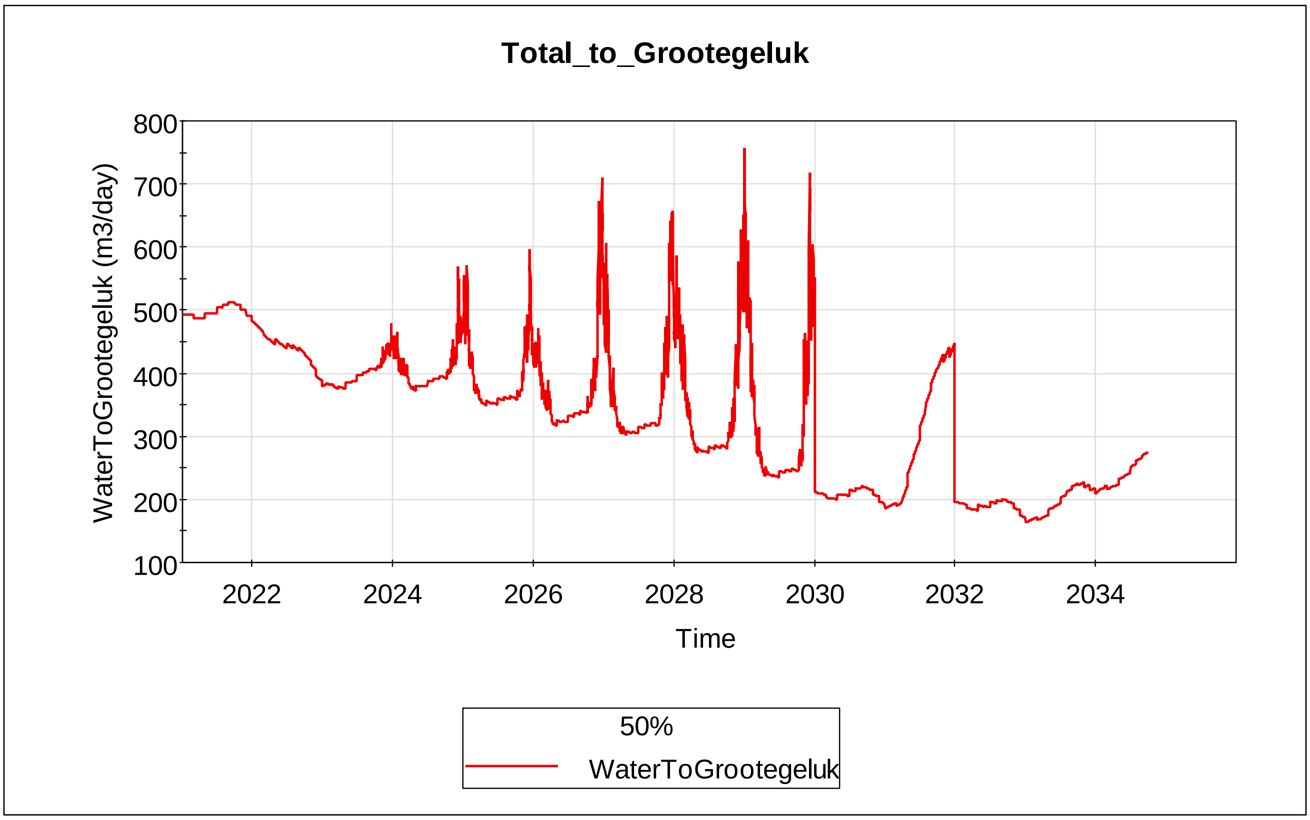

Figure 20: Water pumped to Grootegeluk (50 percentile)

8.2 Option 2

In Option 2, mining of Pit 1 and Pit 2 is carried out concurrently. Results indicate that approximately 1093m^3/day during the mining period (Figure 21)

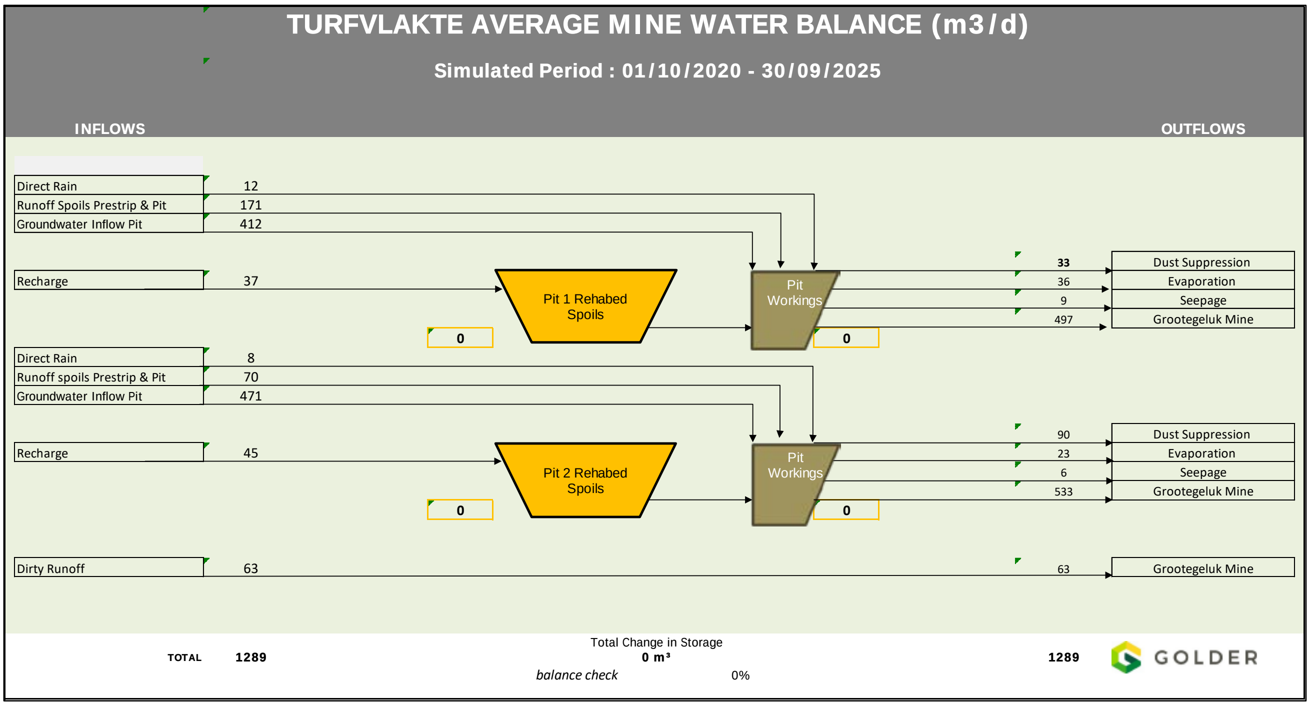

Figure 21: Balance across Turfvlakte Mine between 2020 to 2025

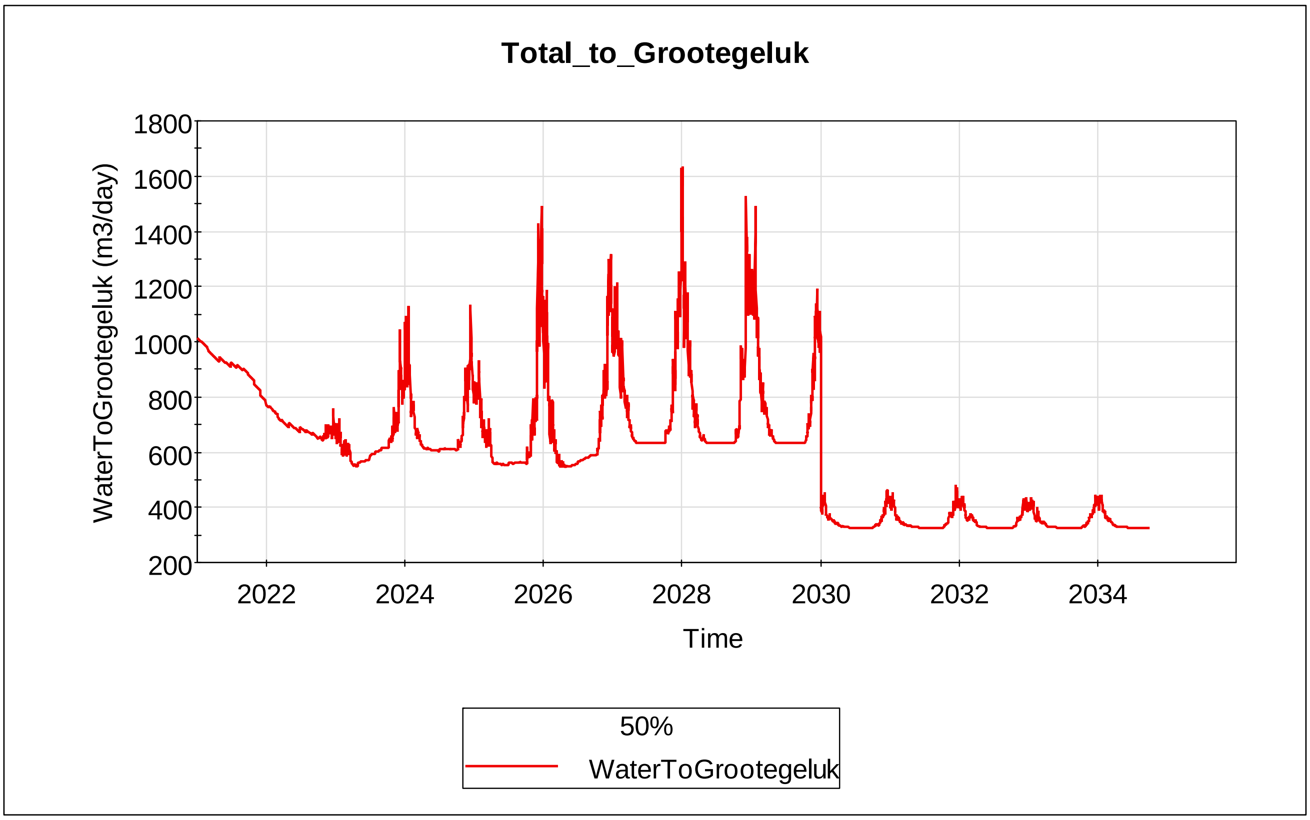

Figure 22: Water pumped to Grootegeluk (50 percentile)

The average pumping profile for water pumped at Figure 22and a 95 percentile. Water pumped to Grootegeluk mine is between 327 m^3/day and 1637 m^3/day on average.

9.0 CONCLUSIONS

Option 2 will result in a larger volume of water reporting to Grootegeluk mine over a shorter period. In Option 1, the mine can pump up to 24.5 Ml/month in January, the wettest month of the year. In Option 2, the mine can pump up to 50 Ml/month in January.

The pit sumps can sustain dust suppression during the wet season, but provision will be required for importing water from the Grootegeluk mine for dust suppression during the dry season.

10.0 REFERENCES

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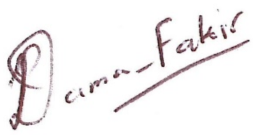

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APPENDIX A

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