Annexure H –Floodline Assessment

FLOODLINES ASSESSMENTS FOR THE UNNAMED STREAM ADJACENT TO THE PROPOSED PENTAGON BUSINESS AND RESIDENTIAL DEVELOPMENT (PBRD)

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CONTACT DETAILS

Cell: 081 701 2276

Fax: 086 552 6800

Email: Phathu.mudau@gomelelo.co.za

Web: www.gomelelo.co.za

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Report Compiled by:	**Phathu Mudau**
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Signature:	....
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Table of Acronyms and Abbreviations

Acronym / Abbreviation	Definition
DDF	Depth Duration-Frequency
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GIS	Geographic Information system
GN 704	Government Notice 704
HEC-RAS	Hydrologic Engineering Centres – River Analysis System
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
SANRAL	South African National Road Agency
SAWS	South African Weather Service
SCS	Soil Conservation System
Tc	Time of Concentration
UPD	Utilities Programme for Drainage
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012 Study

Table of Units

m^3/s	Cubic meters per second
m^3	Cubic metres
Mcm	Million cubic metres
m	meters
Ha	Hectares
m^2	Square metres
Km	Kilometres
Km2	Square kilometres
mm	millimetres
m amsl	Metres above mean sea level

1 Introduction

Gomelelo Environmental Consulting was appointed by KHS (Pty) LTD to undertake a floodline determination study for an unnamed stream adjacent to the proposed Pentagon Business and Residential Development (PBRD) next to Mashishing and Lydenburg Town (hereafter referred to as the project).

1.1 Project Description and Location

The Pentagon Business and Residential Development (PBRD) is situated in the Thaba Chweu local municipality (TCLM) which forms part of the Ehlanzeni District Municipality in Mpumalanga Province, South Africa. TCLM is a Category B municipality and is approximately 350km east of Johannesburg city and 95km north-west of the provincial capital Mbombela, previously known as Nelspruit. The proposed development is located on Portion 453 Lydenburg Townlands No. 31JT south in Thaba Chweu Municipality, south of Lydenburg Town, Mpumalanga Province, the locality map is shown on Figure 1-1 below.

Figure 1-1: Locality Map

1.2 Legislation

1.2.1 National Water Act

National Water Act (Act No. 36 of 1998), Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN 704), was established to provide regulations for the use of water for mining and related activities aimed at the protection of water resources. Regulations 4 of the GN704 are applicable in this study and described below:

- Regulation 4 which defines the restrictions for the locality of mine working and associated infrastructures, any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities;

1.3 Assumptions and Limitations in the Hydraulic Model

The following are assumptions and limitations for this study:

- The obtained topographic data was of a enough accuracy and coverage to enable hydraulic modelling at a suitable level of detail;
- There would be no significant attenuation or storage of floodwater upstream of the project site;
- The study was conducted on a desktop level, and no hydraulic structures (i.e. culverts, bridge or weir) along the stream was modelled as part of this study;
- No abstractions from the river section or discharges into the river section were considered during the modelling;
- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate, this a conservative approach as it ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur. In addition to pure conveyance, in-channel and floodplain flood storage exhibit a large influence in flood levels and floodplain extents within the low gradient watercourses such as the study catchment. As such, the steady state modelling will result in worst case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease if

unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow; and

- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model.

1.4 Methodology and Scope Work

This study included the following:

- Flood hydrology– Section 2 presents a methodology and summary of delineated catchments, and summary of flood hydrology characteristics for the stream adjacent to the proposed pipeline. This includes estimates of the flood hydrology (peak flows) of the catchments of the stream;
- Flood Hydraulics – Section 3 presents a summary of the HECRAS hydraulic mode undertaken on the nearby stream including methodology, software, results and the flood-lines associated with the 1:100 year events A hydrology baseline is not included in the study; and
- Conclusions – Section4 presents a summary of the main conclusions and recommendations of this report

2 Flood Hydrology

2.1.1 Introduction

The study area located within Portion 453 Lydenburg Townlands No. 31JTwhich lies entirely within B42A quaternary catchment of the Lower Olifants Water Management Area (now revised to be Olifants WMA 2). The unnamed stream adjacent to the proposed development is the focus of the floodlines study.

One sub-catchment of the unnamed stream was delineated to cover the watercourse adjacent to the proposed development project and this was utilised to determine the flood peaks for the 1: 100 year extreme events for the purposes of defining the flood risks.

The following catchment was delineated based on 10m contours sourced for the national database and the 30m elevation contour lines data obtained from the Advanced Land Observing Satellite (ALOS) topographical dataset as shown in Figure 2-1.

2.1.2 Methodology

Design rainfall depths were calculated using the Design Rainfall Programme for South Africa and the modified Hershfield equation for use in determining flood peaks. Widely used and recommended methods including the Rational Method, Rational Method Alternative 3 (RM3) and Standard Design Flood (SDF) were used to calculate the 1:100-year peak flows for the delineated catchment at the project site.

The Rational Method is described by the formula Q = CIA/3.6, where I is rainfall intensity, A the runoff contributing area (usually limited to <15km^2), C the runoff coefficient, 3.6 the conversion factor and Q, the peak flow. To calculate point precipitation depths, the RM3 uses the Design Rainfall software for South Africa which adapts the method to rainfall trends typical of South African conditions (SANRAL, 2013).

The Standard Design Flood (SDF) method is an empirical regionally calibrated version of the Rational Method (SANRAL, 2013). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions. The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013). The information required in this method is the area of the catchment (no limitation), the length and slope of the main stream and the drainage basin in which it is located.

2.1.3 Model Inputs

Catchment characteristics (Table 2-1) were evaluated and used to estimate the flood peaks for the following catchments:

Table 2-1: Catchment Characteristics

Parameter	Unnamed Stream
Catchment area - km^2	8.42
Mean annual precipitation - mm	319
Length of longest stream - km	4.25
Height difference along 10-85 slope -m	108
Average slope along the 10-85 - m/m	0.03388
Distance to catchment centroid - km	3.6
Veld type	9
Kovacs K-Region	5.2
SDF Basin	629

2.1.4 Peak Flow Estimates

In addition, the extreme event rainfall depths/ design rainfall events were determined from the South African Weather Services (SAWS) rainfall information database using data from 6 nearest stations. A 24 hour design rainfall depths model was run on a Design Rainfall Estimation (DRE) in South Africa software (Smithers and Schulze, 2003) for various rainfall return periods.

The calculated 24 hour design rainfall depths and the resulting peak flows from the two catchments are presented in Table 2-2 and Table 2-3 below.

Table 2-2: Estimated 24 hour design rainfall depths (mm)

Design rainfall return period (yrs)	**1:2**	**1:5**	**1:10**	**1:20**	**1:50**	**1:100**	**1:200**
24 Hr design peak rainfall (mm)	28	37	43	49	59	66	74

Table 2-3: Modelling Results and Peak Flow estimates (1:100 years)

Catchment Name	**Unnamed Stream (m3/s)**
Average slope	0.03388
Time of concentration (h)	0.74
Runoff Coefficient (C)	0.311
Catchment area - km^2	8.42
Return period and peaks m^3/s	1:100
Alternative rational	55.92
Standard Design Method (SDF)	125.59

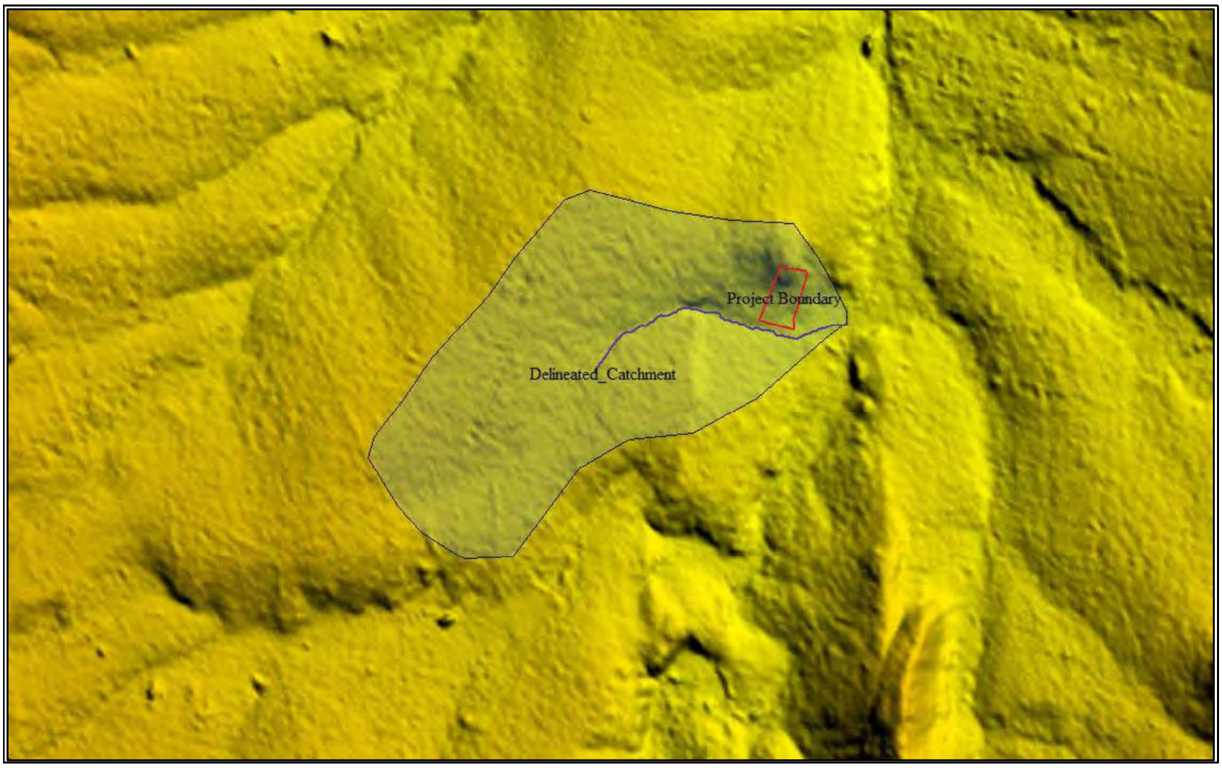

Figure 2-1: Delineated Sub-Catchment and Elevation Profile

3 Flood Hydraulics

GN704 regulation 4 (presented in Section 1.3) stipulates restrictions on mine related infrastructure or operations relative to the 1:100 year flood-line or a horizontal distance of 100 metres from any watercourse. The following section details the approach and the methods used in the development of a hydraulic model for the purposes of defining the 1:100 year flood extents for a section of the unnamed river and it tributary.

3.1.1 Choice of Software

HEC-RAS 5.0 was used for the purpose of modelling the flood elevation profile for the 1: 100 year flood event. HEC-RAS is a hydraulic programme designed to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

In this study the pre-processing and GIS operations were undertaken in HEC-GeoRAS, an extension of HEC-RAS in the ArcGIS environment and ArcMap 10.2 respectively. HEC-GeoRAS was used to extract the cross-sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling. It is further used in post processing to import HEC-RAS results back into ArcMap, to perform flood inundation mapping.

3.1.2 Topographic Profile Data

The 30m contours Data obtained from the Advanced Land Observing Satellite (ALOS) topographical dataset used to create a digital elevation model (DEM). The ALOS data showed a higher resolution than a Digital Elevation Model (DEM) generated from 10 m contours (National Geospational Institute, 2013) of the area, the unnamed river along the project site was not visible in the 10 m contour data set. Pre-processing of this data as well as accuracy of elevation data was not assessed, and it was assumed to be adequate for the flood lines modelling. This available data was therefore considered adequate and fit for the environmental purposes for which the floodlines are required.

The DEM model forms the foundation for the HEC-RAS model and was used to extract elevation data for the river profile together with the river cross-sections. The DEM was also used to determine placement positions for the cross-sections along the river profile, such that the watercourse can be accurately modelled.

3.1.3 Roughness Coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplains resistance to flow. Based on observations of the channel and floodplain characteristics from aerial topography and the elevation data, a Manning's n coefficient of 0.04 was assigned to the banks or floodplain areas while a Manning's n coefficient of 0.035 was assigned to the channel.

3.1.4 Inflows and boundary conditions

The various estimated peak flows (55.92 m^3/s) are described in Section 2.1.4 and the peakflow used in this hydraulic model

3.1.5 Model Development Methodology

Development of the hydraulic model included the following steps:

- Creation of a DEM from the contour data;
- Digitising the stream centre lines and flow paths using HEC-GeoRAS;
- Generating cross-sections approximately regular intervals apart through the watercourses using HEC-GeoRAS;
- Importing geometric data into HEC-RAS and inspection thereof;
- Entering the Manning's values, peak flows, and upstream and downstream slope boundary conditions in HEC-RAS;
- Performing steady, mixed-flow regime hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections followed by inspection of inundations; and
- Importing flood levels and projecting levels onto the DEM using HEC-GeoRAS to determine the flood inundation areas.

3.1.6 Results and Conclusions

The delineated 1:100 year floodlines indicates that the project boundary for the proposed development lies outside the delineated floodlines. Thus the proposed development poses no risk on the adjacent water resource in terms of flooding while the development the development itself will also not be exposed to the risk of flooding during high rainfall events. The delineated 1:100 year floodlines are shown Figure 3-1 and the HEC-RAS model output table is provided in Appendix A.

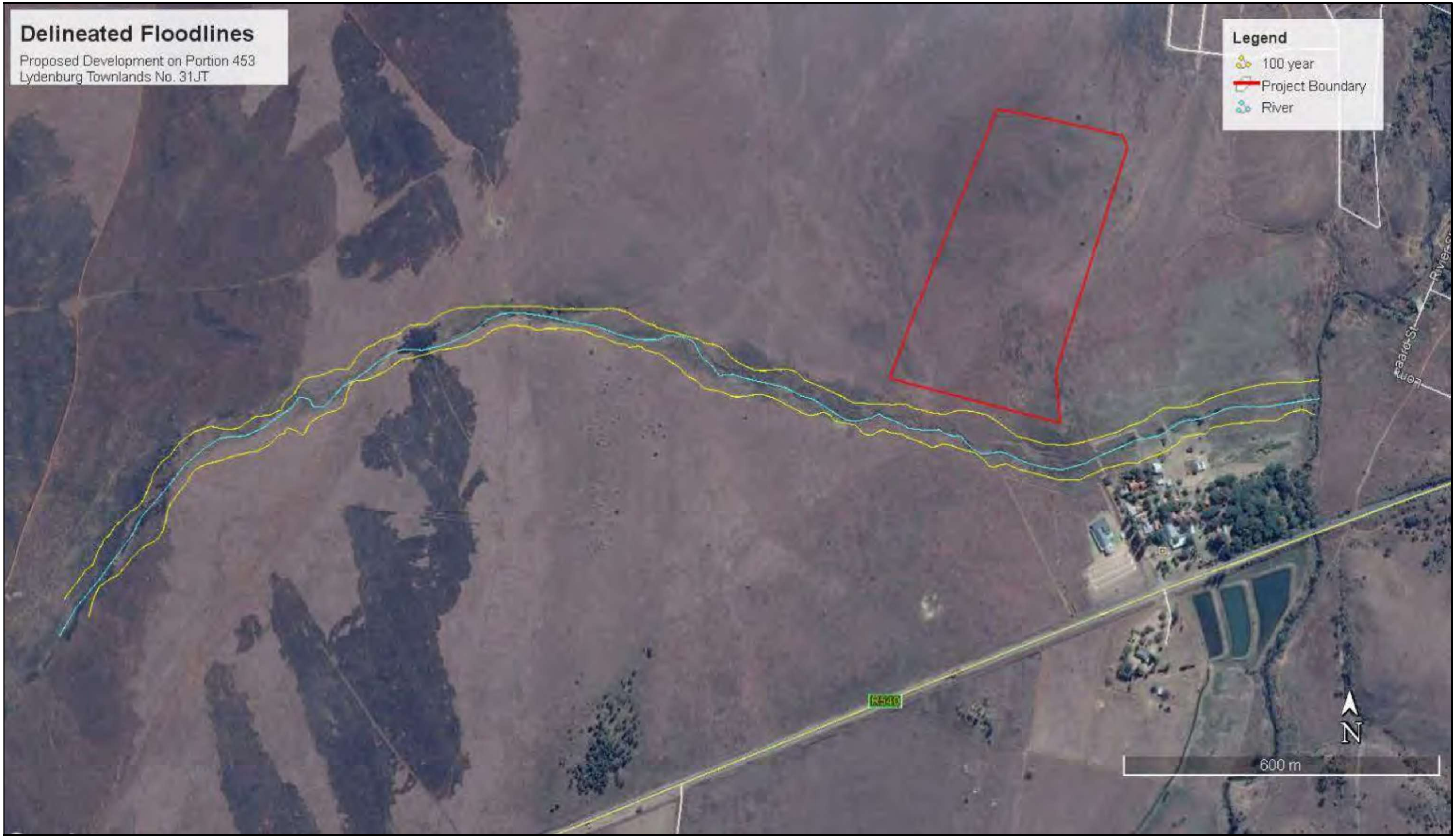

Figure 3-1: Delineated Floodlines (1:100 year)

References

Brunner G.W. 2016. HEC-RAS – *River Analysis System Hydraulic Reference Manual Version 5.0,* US Army Corps of Engineers Hydrologic Engineering Centre (HEC)

Chow V.T. 1959. *Open channel hydraulics*. McGraw-Hill, New York.

Department of Water Affairs and Forestry, 1998. "National Water Act, Act 36 of 1998".

Department of Water Affairs and Forestry, 1999, "Government Gazette 20118 of June 1999: Government Notice 704 (GN 704)."

Department of Water and Sanitation (DWS). 2013. *National Water Resource Strategy 2*, page 64HRU-

Department of Water and Sanitation (DWS), September 2012, "National Water Resource Strategy. Second Edition".

Smithers, J.C and Schulze, R.E., 2002, "*Design Rainfall and Flood Estimation in South Africa*", WRC Report No. K5/1060, Water Research Commission, Pretoria.

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

Utility Programs for Drainage (UPD). 2007. Version 1.1.0. Developed by Sinotech cc. Available online: www.sinotechcc.co.za/software

WR2005, 2009, "*Water Resources of South Africa, 2005 Study (WR2005)*", WRC Report No. TT 380/08, Water Research Commission, Pretoria.

WR2012, "Water Resources of South Africa, 2012 Study (WR2012)", Water Research Commission, Pretoria.

Appendix A: HEC-RAS Model Output Table

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude #
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	Chl
Reach 1	8935	100year	55.92	1454.19	1454.7	1454.84	1455.16	0.033886	3.35	20.11	55.7	1.57
Reach 1	8599	100year	55.92	1451.38	1452.02	1452.13	1452.42	0.021368	2.96	21.6	51.33	1.28
Reach 1	8164	100year	55.92	1448.22	1448.78	1448.87	1449.13	0.029004	2.78	21.84	58.06	1.41
Reach 1	7782	100year	55.92	1446.12	1446.84	1446.84	1447.09	0.013354	2.19	25.66	54.5	0.99
Reach 1	7312	100year	55.92	1443.39	1444.16	1444.27	1444.54	0.024853	2.86	21.67	55.76	1.34
Reach 1	7045	100year	55.92	1441.73	1442.22	1442.26	1442.48	0.024298	2.21	24.83	63.76	1.25
Reach 1	6661	100year	55.92	1440.06	1440.85	1440.85	1441.08	0.012515	2.22	27.59	63.48	0.97
Reach 1	6393	100year	55.92	1438.28	1438.79	1438.95	1439.3	0.044389	3.32	18.18	53.84	1.73
Reach 1	6096	100year	55.92	1436.72	1437.54	1437.54	1437.77	0.016385	2.32	27.03	62.5	1.09
Reach 1	5662	100year	55.92	1433.73	1434.27	1434.41	1434.75	0.03283	3.24	19.63	56.12	1.54
Reach 1	5360	100year	55.92	1429.12	1429.6	1429.86	1430.48	0.070471	4.37	13.84	37.03	2.2
Reach 1	5020	100year	55.92	1423.43	1424.04	1424.25	1424.76	0.043993	3.86	15.21	34.11	1.79
Reach 1	4640	100year	55.92	1415.58	1415.98	1416.27	1417.08	0.108881	4.79	12.47	43.72	2.66
Reach 1	4163	100year	55.92	1411.03	1411.68	1411.7	1411.9	0.01647	2.38	29.56	83.22	1.1
Reach 1	3816	100year	55.92	1407.02	1407.44	1407.69	1408.35	0.097766	4.71	13.88	46.12	2.54
Reach 1	3627	100year	55.92	1405.79	1406.48	1406.48	1406.71	0.01196	2.39	28.92	65.15	0.98
Reach 1	3338	100year	55.92	1402.29	1402.81	1403.1	1404.03	0.143215	5.35	11.93	41.75	3.03
Reach 1	3085	100year	55.92	1399.74	1400.49	1400.56	1400.82	0.018152	2.67	23.69	57.83	1.17
Reach 1	2911	100year	55.92	1397.79	1398.36	1398.6	1399.16	0.064574	4	14.66	47.87	2.09
Reach 1	2744	100year	55.92	1396.54	1397.35	1397.4	1397.66	0.014461	2.64	25.05	54.26	1.07
Reach 1	2621	100year	55.92	1396.04	1396.77	1396.82	1397.06	0.016997	2.85	26.56	64.3	1.16
Reach 1	2446	100year	55.92	1395.17	1395.88	1395.81	1396.03	0.010252	2.11	34.48	82.24	0.89
Reach 1	2316	100year	55.92	1394.93	1395.3	1395.3	1395.47	0.021373	1.7	30.28	88.96	1.11
Reach 1	2109	100year	55.92	1393.65	1394.15	1394.15	1394.3	0.018524	2.12	34.07	119.19	1.11
Reach 1	2021	100year	55.92	1393.12	1393.46	1393.49	1393.61	0.041165	1.92	32.65	172.75	1.47
Reach 1	1891	100year	55.92	1392.56	1392.37	1392.37	1392.55	0.022535		30.18	87.02	0
Reach 1	1770	100year	55.92	1391.46	1390.9	1391.02	1391.27	0.05886		20.93	71.55	0
Reach 1	1660	100year	55.92	1390.4	1389.63	1389.63	1389.82	0.022424		29.28	80.36	0
Reach 1	1500	100year	55.92	1388.55	1388.26	1388.35	1388.59	0.049693		21.9	70.59	0
Reach 1	1341	100year	55.92	1387.16	1387.38	1387.38	1387.52	0.024007	1.62	33.77	124.87	1.15
Reach 1	1253	100year	55.92	1386.38	1386.8	1386.73	1386.91	0.011753	1.68	38.93	107.41	0.89
Reach 1	1147	100year	55.92	1385.72	1386.25	1386.25	1386.42	0.018568	2.57	33.65	105.78	1.17
Reach 1	1041	100year	55.92	1384.93	1385.45	1385.52	1385.71	0.028107	3.09	27.85	97.49	1.43
Reach 1	954	100year	55.92	1384.27	1384.73	1384.79	1384.97	0.031511	3.13	28.39	105.09	1.5
Reach 1	861	100year	55.92	1383.93	1383.78	1383.81	1383.97	0.030939		28.73	97.52	0
Reach 1	783	100year	55.92	1383.88	1383.22	1383.19	1383.38	0.017528		32.05	83.23	0
Reach 1	668	100year	55.92	1382.89	1382.55	1382.55	1382.73	0.023218		29.87	86.09	0
Reach 1	565	100year	55.92	1382.02	1381.85	1381.74	1382.02	0.013708		30.55	60.92	0
Reach 1	430	100year	55.92	1381.16	1381.31	1381.26	1381.42	0.014465	0.65	37.88	114.73	0.76
Reach 1	280	100year	55.92	1380.03	1380.56	1380.56	1380.7	0.017758	2.57	36.19	123.41	1.15
Reach 1	118	100year	55.92	1379.48	1379.79	1379.54	1379.83	0.002642	0.59	68.68	145.76	0.39
Reach 1	36	100year	55.92	1379.12	1379.52	1379.52	1379.67	0.018578	2.21	33.59	127.43	1.13