STRUBENSVALLEY EXT.24

STORMWATER MANAGEMENT PLAN

Prepared for

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1. SCOPE OF REPORT

The scope of this report is to describe how surface drainage will be accommodated within the site boundary lines and how the 5-year and 25-year post development peak stormwater discharge will be reduces to equal or below the 5 and 25 year pre-developed (Green State) peak stormwater discharge by making use of one attenuation pond namely Pond-A.

The report provides calculation for the development catchment that naturally drains to the proposed attenuation pond. The output calculations to follow in the report are to indicate that the attenuation requirement as set out by Johannesburg Road Agency will be conformed to.

The report therefore addresses the following:

- The conditions prevailing on and around the **Strubensvalley Ext.24** site,
- The impact of the development on pre-development flows,
- The high lying areas contributing flows under Q5,Q25,Q50 and Q100 year storm events naturally draining towards the attenuation pond situated on the North Easter boundary of the development,
- Typical flows, sizes, etc.

2. TOWNSHIP DESCRIPTION

2.1 Locality (Annexure-A)

The proposed Residential development is situated on Strubensvalley Ext.24
The development is bounded by: -

- Strubensvallei Ext.25 to the North,
- Metro Boulevard Servitude to the West,
- Christian De Wet to the South,
- Strubensvallei Ext.3 to the East.

2.2 Topography

The climate of the site is typical for the Highveld region and characterized by warm to hot summers and mild winters. Rainfall occurs predominantly in summer with little to no rainfall in the winter months. The average yearly rainfall is around 750mm and occurs mainly in the form of thundershowers.

The site is currently covered by grass and scattered trees. There is a natural slope over the Erf that falls from the North Eastern higher lying boundary to the South Western lower boundary line and drains to the South Western Boundary low point with a contour interval ranging between 44m and 32, resulting in a level difference of 12m over a distance of +- 201m which results in an average 6% fall over the Erf's.

There are no existing buildings on site and the development is affected by the proposed Metro Boulevard along the Western boundary, the planned on and off ramp to the Metro Boulevard and flood lines along the Southern Boundary.

The total site area is 1.9724 ha but the allowable development size contributing to stormwater discharge is ±1.507ha in extent and will be made up of the following **(Figure.B)**:

- Pervious areas consisting of general landscaping and grasses lawns.
- Impervious areas consisting of paved roadways, paved walkways, building roof structures.

The catchment area consists of: **(Refer to Annexure-B; Figure. A pre-developed/Figure.B post-developed)**

Catchments	Area (ha)	Percentage of Development (%)
Catchment	±1.507 ha @ 6.4% Slope	100%
Pervious Area	±0.452 ha	30%
Impervious Area	±1.055 ha	70%

2.3 Flood Lines

The developable area is not affected by a 100-year flood line as specified in Chapter 14, Part 3 of the Water Act (Act 36 of 1998), as required in terms of the Town Planning and Township Ordinance (Ordinance 15 of 1986).

No building we be constructed below the 100-year flood line.

2.4 Existing Services

Stormwater: (Catchment)
There is no formal stormwater system in close vicinity of the development to which the internal infrastructure can connect to.

3. MANAGEMENT SCHEME

3.1 Objectives

The objectives of stormwater management for this development inter alia include:

- To provide a stormwater drainage system for the conveyance of the stormwater runoff collected within the development 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, and
- To achieve the foregoing objectives at minimal total cost,
- To reduce the peak 5-year and 25-year post development stormwater runoff to pre-development peak stormwater runoff values.

3.2 Drainage Philosophy

The minor and major drainage system situated within the proposed development will be designed to accommodate the Q5-yr and Q25-yr storm event respectively. Roads will form an integral component of both the major and minor system. This will be accomplished by strategically placed stormwater catch pits consisting of junction boxes, grid inlets inlets, energy dissipating structures and erosion control structures.

Collected stormwater within the property boundary lines will be collected within the underground stormwater conveyance system and discharge into the attenuation pond were after it will be attenuated by the choke inlet structures as indicated on drawing **20521-503** before being surface discharged further down within the 100-year flood line.

3.3 Stormwater Attenuation Objective

It is a requirement of Johannesburg Road Agency that provision is made for stormwater attenuation to reduce the increased stormwater run-off from the 5-year and 25-year post development storm event to equal or less than the 5 and 25-year pre-development peak run-off through the incorporation of stormwater attenuation structures situated within the development's boundary lines.

4. DESIGN GUIDELINES

The design of the Township's services will be based on the design principles in the "Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development" published by the Department of Community Development and to the City of Johannesburg requirements for Engineering Services.

A competent contractor through acceptable tender process will install all services. The General Conditions for the Works of Civil Engineering Construction, Standard Specification SABS 1200 and relevant specifications will pertain to the contract.

5. STORMWATER

5.1 Layout and Design (Annexure-C)

Strategically places stormwater structures consisting of cut of grid inlets will be placed at positions best suited to collect the generated stormwater within the developments boundary lines and convey the collated stormwater runoff within the underground stormwater conveyance system which will direct and discharge the collected stormwater into the attenuation pond. Discharge into the pond will be through an energy dissipating structure for energy dissipating and erosion control. **(Refer to Annexure-C Drawing Number: 20521-503 for Attenuation Layout)**.

The internal underground stormwater conveyance system will be designed to have adequate volume available to collect and convey the stormwater generated from a 1 in 25-yr storm event, additional flow from storm events more than 1 in 25 years will be accommodated within the internal roads therefore mitigating the risk of floods, damages and loss of life. All conveyance pipes will be sized and designed at slopes to prevent silting of the pipes under low flow conditions and maintenance of all internal stormwater structures will remain the responsibility of the developer/registered section 21 company.

The conveyed water will be choked by means of the choke inlet structure situated within the attenuation pond. This will reduce the outflow and velocity of the post development storm event to equal or less than the pre-development flood event.

The attenuated stormwater runoff will be conveyed by means of a new 450mm 100D interlocking concrete pipe before being surface discharged further down within the 100-year flood line.

5.2 Design Input Parameters

Output data from the SCS and Horton infiltration method were analyzed and based on the evaluated output data the Hortonian infiltration method was chosen as the most reliable method for the analysis of the Strubensvalley Ext.24 catchments.
Output data has been calculated by making use of
Design Software= PCSWMM version 7.1; 2017 with SWMM 5.1.012

All calculations have been checked by utilizing the Rational method.

- **Properties Pre-Development Input Parameters (Strubensvalley Ext.24)**

Table-1

Property	**Value**			
Rain Gage	Johannesburg Triangular Synthetic Storm			
Area (ha)	Area (ha)	Slope (%)	Width (m)	Imperviousness (%)
Catchment	1.507 ha	6.4 %	301.4m	0 %
Roughness coefficient, impervious areas	0,013			
Roughness coefficient, pervious areas	0.4			
Depression storage, impervious areas	0.5 mm			
Depression storage, pervious areas	5 mm			
% of impervious area without depression storage	25%			
Max Infiltration Rate	127 mm/hr			
Min Infiltration Rate	10.92 mm/hr			
Drying Time	7 days			
Decay Constant	4			

Rainfall Data Pre-Development
Design event rainfall : South Africa SCS Type-3 Synthetic Storm **(Annexure-C)**
Design event 1-day rainfall Depth : JC Smithers and RE Schulze design rainfall software
Smithers, JC & Schulze, RE. (2002) *Design Rainfall and Flood Estimation in South Africa.* Water Research Commission. WRC Project No: K5/1060
SA Weather Station (SAWB) : Sandton / Station Number: 0476093_W 81 Yr
Storm durations modelled : 24 hours

Table-2

Recurrence Interval	Precipitation Over Sub-Catchment (mm)	Peak Intensity
Rainfall 5-year recurrence interval	65 mm	135.6 mm/h
Rainfall 25-year recurrence interval	104 mm	216.9 mm/h
Rainfall 50-year recurrence interval	114 mm	237.8 mm/h
Rainfall 100-year recurrence interval	133 mm	277.4 mm/h

- **Properties Post-Development Input Parameters (Strubensvalley Ext.24)**

Table-3

Property	Value			
Rain Gage	Johannesburg Triangular Synthetic Storm			
Area (ha)	Area (ha)	Slope (%)	Width (m)	Imperviousness (%)
Catchment	1.507 ha	6 %	430.57m	70 %
Roughness coefficient, impervious areas	0,013			
Roughness coefficient, pervious areas	0.4			
Depression storage, pervious areas	1 mm			
Depression storage, impervious areas	7.5 mm			
% of impervious area without depression storage	25%			
Max Infiltration Rate	127 mm/hr			
Min Infiltration Rate	10.92 mm/hr			
Drying Time	7 days			
Decay Constant	4			

Rainfall Data Post-Development

Design event rainfall : South Africa SCS Type-3 Synthetic Storm **(Annexure-D)**
Design event 1-day rainfall Depth : JC Smithers and RE Schulze design rainfall software
Smithers, JC & Schulze, RE. (2002) Design Rainfall and Flood Estimation in South Africa. Water Research Commission. WRC Project No: K5/1060
SA Weather Station (SAWB) : Sandton / Station Number: 0476093_W 81 Yr
Storm durations modelled : 24 hours

Table-4

Recurrence Interval	Precipitation Over Sub-Catchment (mm)	Peak Intensity
Rainfall 5-year recurrence interval	65 mm	135.6 mm/h
Rainfall 25-year recurrence interval	104 mm	216.9 mm/h
Rainfall 50-year recurrence interval	114 mm	237.8 mm/h
Rainfall 100-year recurrence interval	133 mm	277.4 mm/h

5.3 Design Output Results

➢ **Pre-Development (Strubensvalley Ext.24)**

Refer to Annexure-F for Hydrographs

Table-5

Design Storm	Precipitation Over Sub-Catchment (mm)	Peak Intensity (mm/h)	Peak Runoff (m^3/s)
5-Year	65 mm	135.6 mm/h	0.0563 m^3/s
25-Year	104 mm	216.9 mm/h	0.3169 m^3/s
50-Year	114 mm	237.8 mm/h	0.3824 m^3/s
100-Year	133 mm	277.4 mm/h	0.5182 m^3/s

➢ **Post-Development (Strubensvalley Ext.24)**

Refer to Annexure-G for Hydrographs

Table-6

Design Storm	Precipitation Over Sub-Catchment (mm)	Peak Intensity (mm/h)	Peak Runoff (m^3/s)
5-Year	65 mm	135.6 mm/h	0.397 m^3/s
25-Year	104 mm	216.9 mm/h	0.805 m^3/s
50-Year	114 mm	237.8 mm/h	0.900 m^3/s
100-Year	133 mm	277.4 mm/h	1.089 m^3/s

➢ **Post-Development Peak Discharge after Attenuation for the Entire Site**

Refer to Annexure-H for Hydrographs

Table-7

Design Storm	Precipitation Over Sub-Catchment (mm)	Peak Intensity (mm/h)	Peak Runoff (m^3/s)
5-Year	65 mm	135.6 mm/h	0.0390 m^3/s
25-Year	104 mm	216.9 mm/h	0.2936 m^3/s

5.4 Stormwater Attenuation Description

The detailed layout and description of the attenuation pond (Pond-A) can be seen on Drawing number **20521-503**, the pond will be constructed out of concrete infill cavity wall designed by a competent structural engineering specialist with a maximum depth of 3.36m and a surface area of 182m^2 resulting in a total storage volume of **611.52m^3.**

A choke inlet structure has been included in the attenuation pond and sized accordingly to reduce the peak 5-year and 25-year post development storm flows to below the peak 5 and 25-year pre-development flows. A Weir overflow with an overflow capacity of 0.667 m^3/s has been designed and sized to allow for storm events in excess of 1:50 year to surface overflow onto the lower lying grassed area within the property development boundary lines after with the water will discharge through weep hole openings constructed in the boundary wall therefore reducing any risk of flooding or loss of life.

The pond choke inlet structure is situated at an invert level that will allow for the draining of the entire pond therefore the pond will function as a dry pond. The pond will be fenced off and the maintenance of the pond and associated structures will remain the responsibility of the developer/registered section 21 company.

5.5 Stormwater Attenuation Design

JRA recommends 350 m^3 per ha: 350 x 1.507 = 527.45 m^3 as a guideline.
The storage volume provided onsite within the attenuation pond amount to **611.52m^3.**
Therefore, based on the hydraulic calculations there is sufficient volume available within the attenuation pond to meet the attenuation requirements.

➢ **Attenuation Design**

Table-8

Attenuation Details	Max Design Depth (m)	Surface Area (m^2)	Attenuation Volume (m^3)
Pond-A	3.34 m	182 m^2	611.52 m^3

5.6 Stormwater Management During Construction Phase

Sandbags and soil trenches and berms will be implemented during the construction phase at areas that may pose a safety risk due to increased stormwater flow.
These will be maintained during the construction phase and monitored by the site engineer on a weekly basis.

The attenuation pond mass earthworks will start immediately on site and will act as temporary rainwater storage areas during the construction phase all water will be directed to the pond.
The site poses a very low flood risk to adjacent properties.

6. CONCLUSION

There is sufficient space available within the development to attenuate the peak generated stormwater runoff from the post development land use type to pre-development conditions.

Based on the hydrology calculations the attenuated flows will equal or be lower than the pre-developed flows before being discharged downstream from the development at velocity's lower or equal to that of the pre-development conditions.

The output calculations therefore verify that the stormwater management objectives will be met.

Locality

Strubensvalley Ext.24

Annexure-A

DEPARTMENT	APPROVED	DESIGNATION	DATE

CONSULTING ENGINEERS

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PRIVATE DRAWING No 20521-300
APPROVED
Pr. Eng. No.
DATE

SURVEYED		
DESIGNED	G.HUYSAMEN	OCTOBER 2020
DRAWN	G.HUYSAMEN	OCTOBER 2020
CHECKED	KC OOIJKAAS	OCTOBER 2020
SERVICES CHECKED		
GEOTECHNICAL INVESTIGATION		
SERVITUDES		
APPROVED		

JOHANNESBURG WATER (PTY) LTD
Johannesburg Water
17 HARRISON STREET
MARSHALLTOWN
JOHANNESBURG
2107
TEL: (011) 688-1400
FAX: (011) 688-1529

CITY OF JOHANNESBURG

LOCALITY LAYOUT OF STRUBENSVALLEI EXT.24

DESIGN MANAGER
DATE

SCALE
A0
1:N.T.S

	AMENDMENTS	APPROVED	DATE
A	ISSUED FOR COUNCIL INFORMATION		2020/10/06

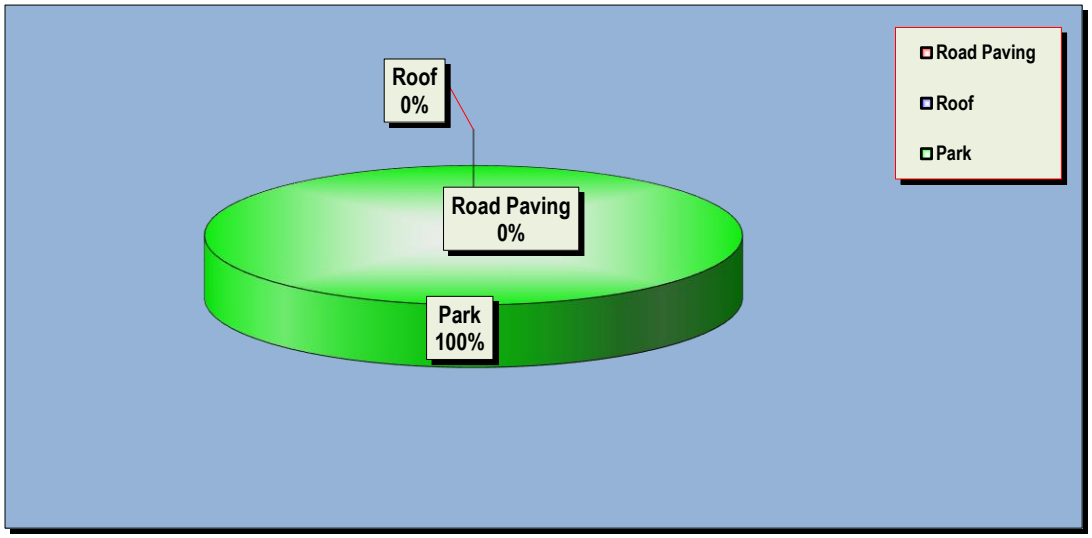
DRAWING No.
20521-300
1 OFF 1

FILE No

Site Description

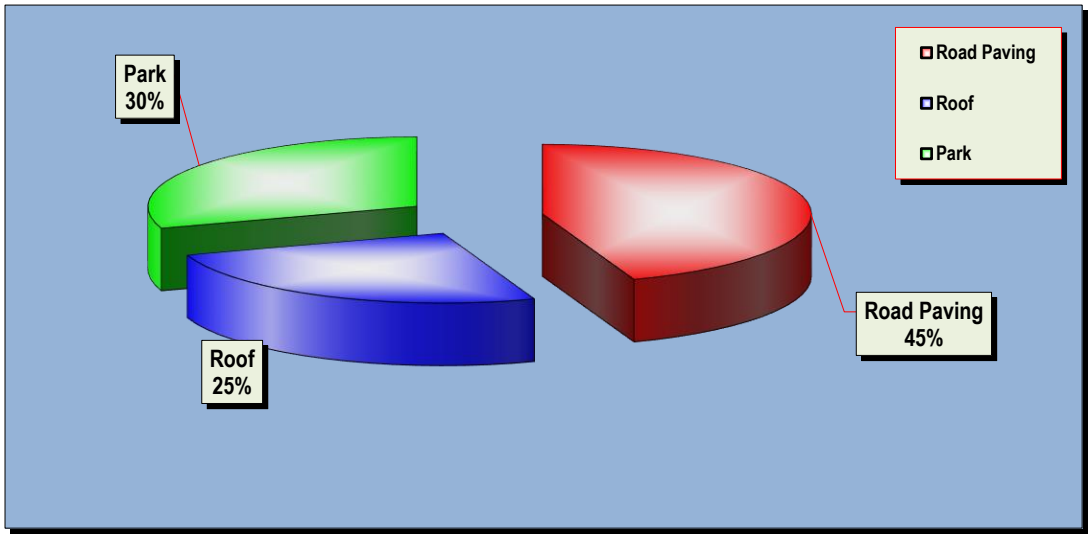
Fig.A / Fig.B

Annexure-B



Indicating the percentage of hydrological catchment areas utilised in the application of specific infiltration rates

Area = 1.507 ha



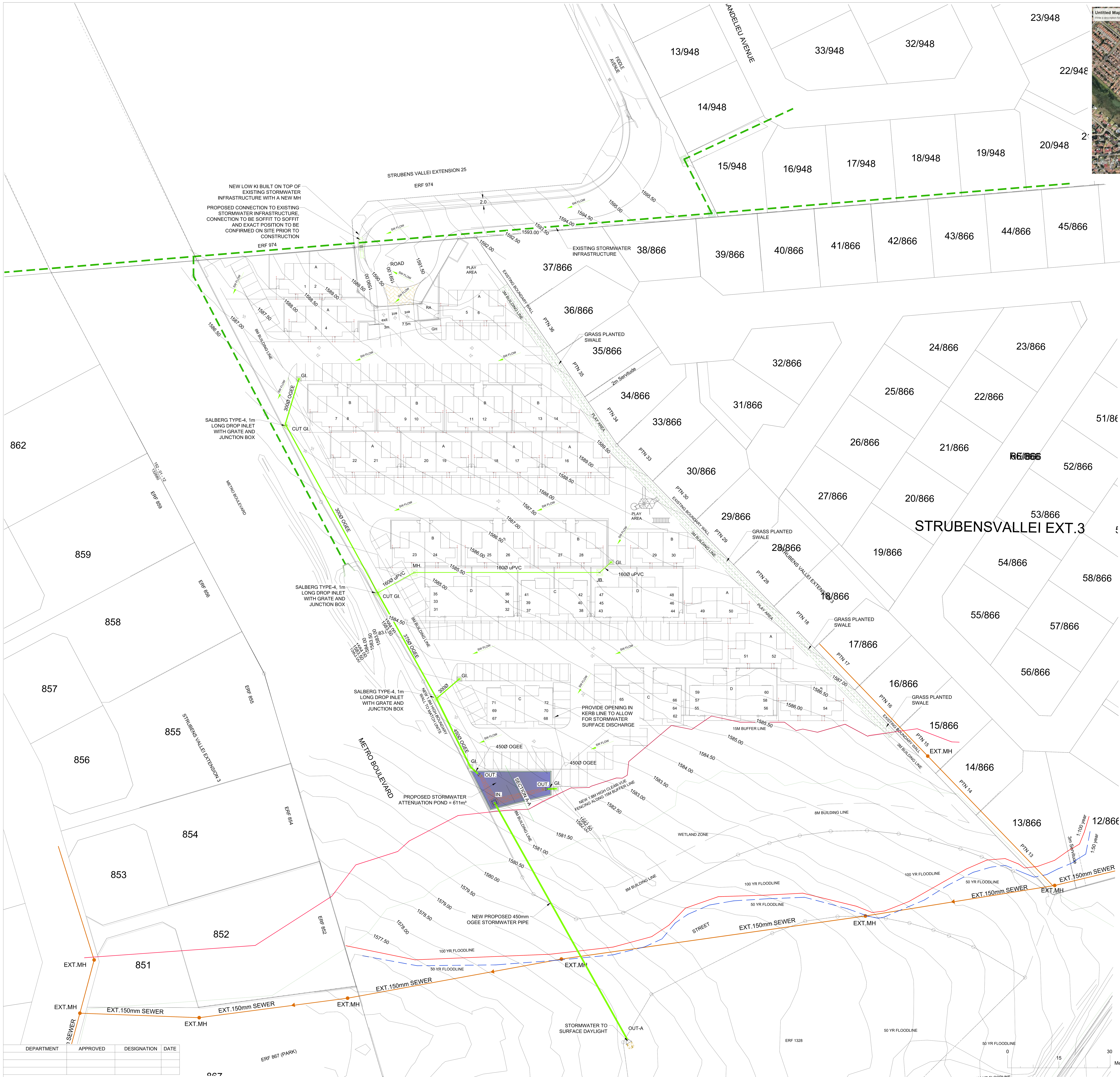
Indicating the percentage of hydrological catchment areas utilised in the application of specific infiltration rates

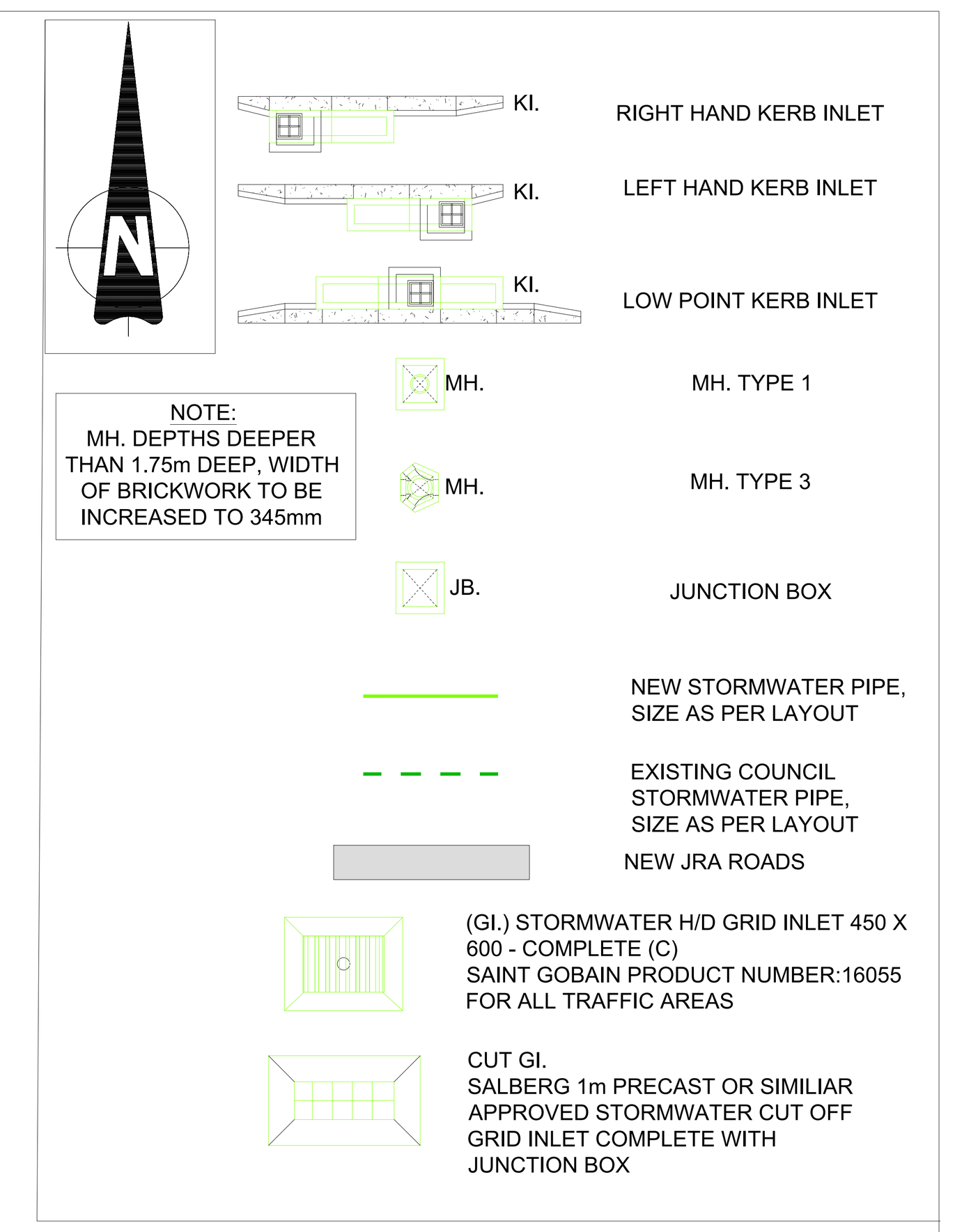
Area = 1.507 ha

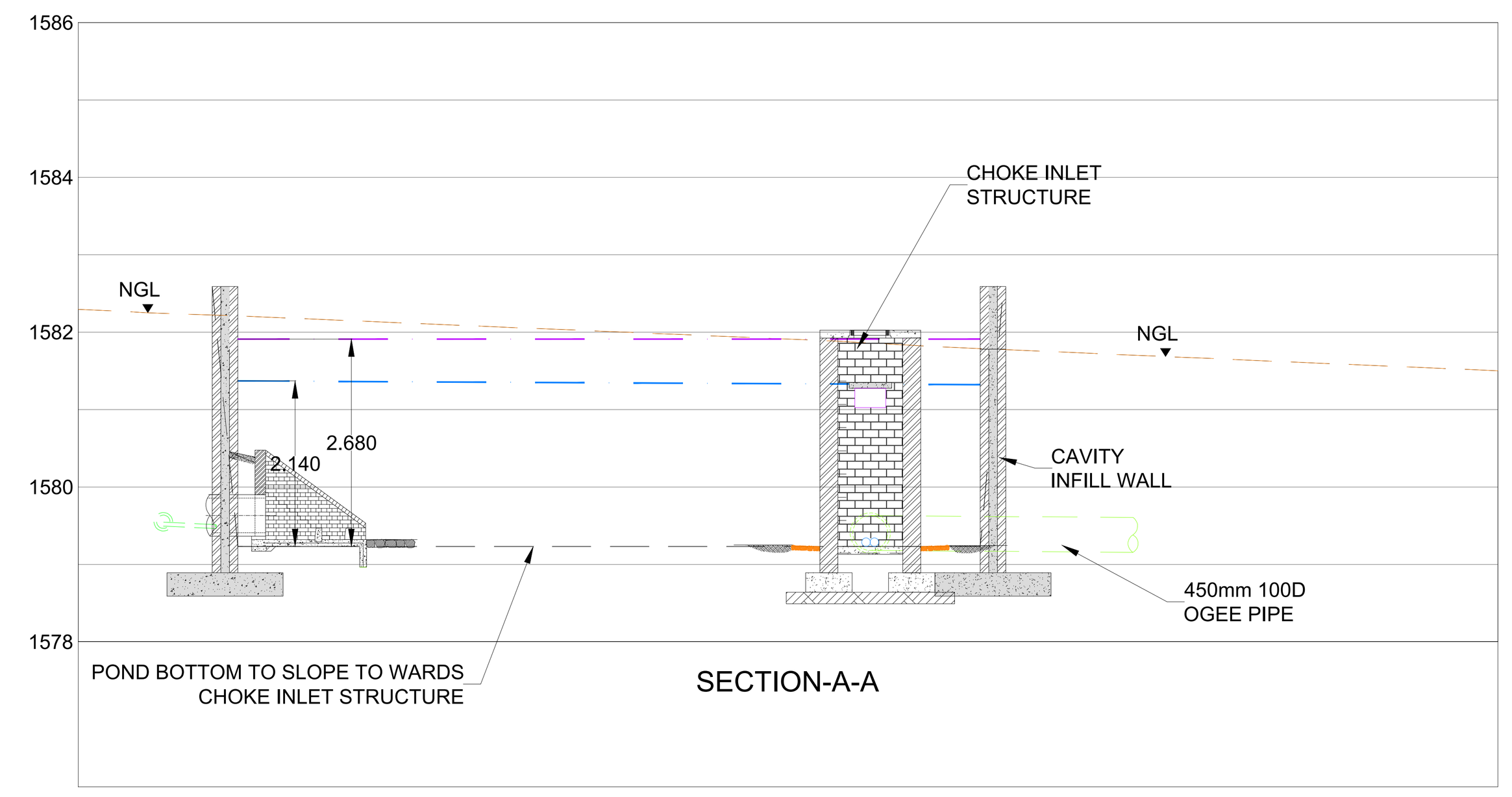
Stormwater Attenuation Layout

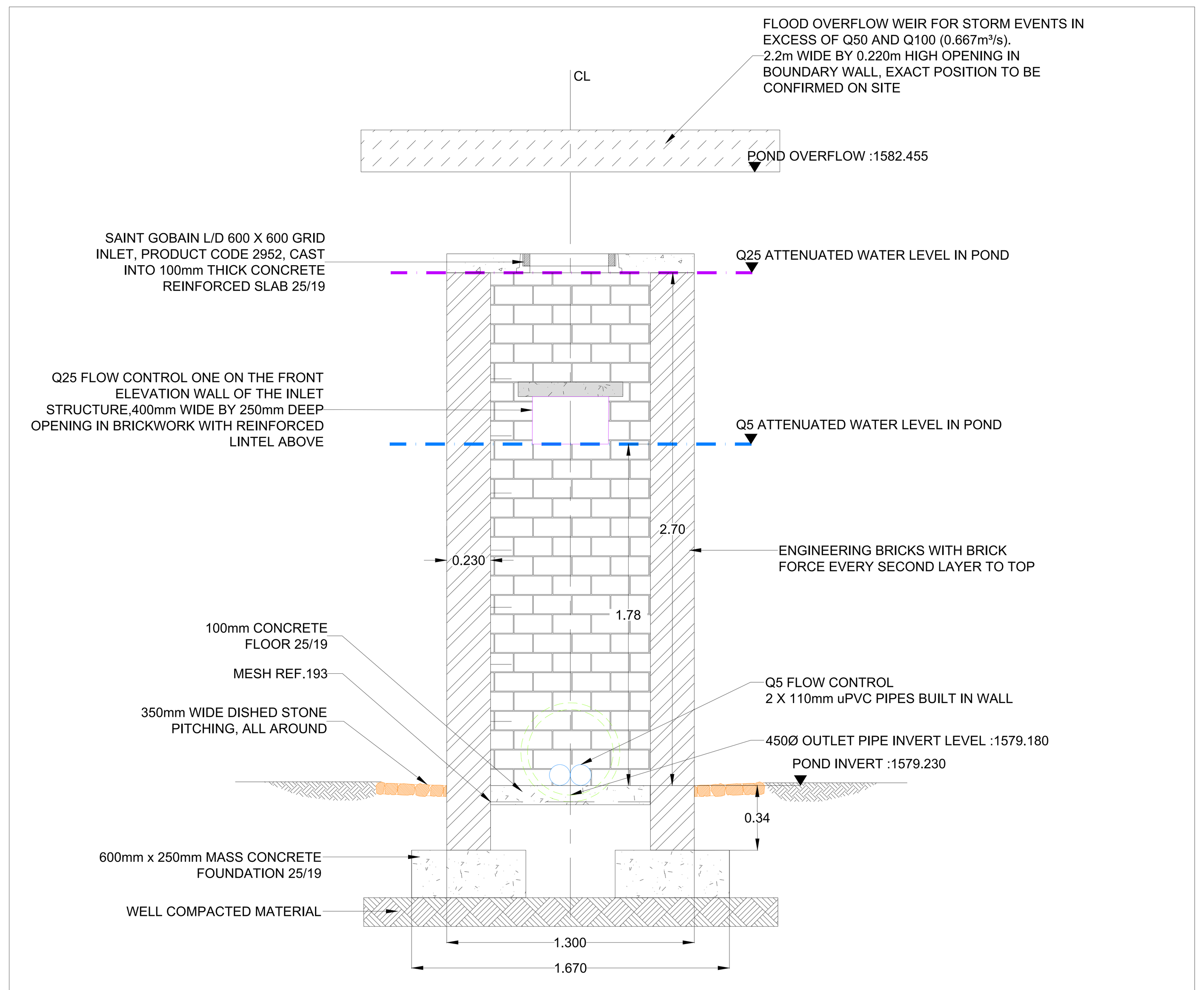
Drawing Number:20521-503

Annexure-C



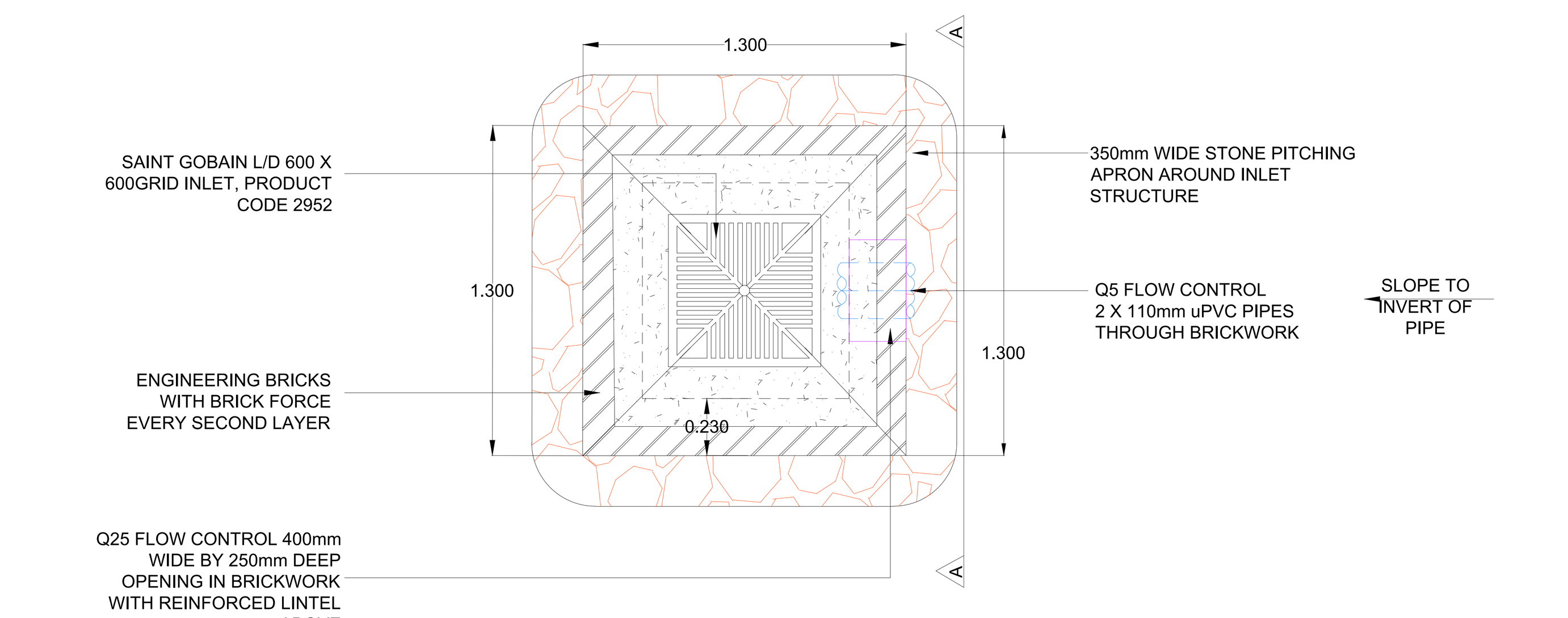






POND-A RETENTION INLET STRUCTURE FRONT ELEVATION

SCALE 1:20



POND-A:RETENTION INLET STRUCTURE PLAN VIEW

SCALE 1:20

DEPARTMENT	APPROVED	DESIGNATION	DATE

CONSULTING ENGINEERS

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PRIVATE DRAWING No 20521-503

SURVEYED		
DESIGNED	G.HUYSAMEN	OCTOBER 2020
DRAWN	G.HUYSAMEN	OCTOBER 2020
CHECKED	KC OOIJKAAS	OCTOBER 2020
SERVICES CHECKED		
GEOTECHNICAL INVESTIGATION		
SERVITUDES		
APPROVED		

APPROVED
Pr. Eng. No.
DATE

JOHANNESBURG ROADS AGENCY
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CITY OF JOHANNESBURG

STORMWATER ATTENUATION POND LAYOUT FOR THE NEW PROPOSED DEVELOPMENT ON STRUBENSVALLEI EXT.24

DESIGN MANAGER	SCALE	AMENDMENTS	APPROVED	DATE
	A0 1:400	A ISSUED FOR COUNCIL APPROVAL		2021/07/14
DATE				

DRAWING No. 20521-503
1 OFF 1
FILE No

Rainfall Data Pre-Development Design Event Rainfall

Annexure-D

DESIGN RAINFALL DEPTHS AT SELECTED STATIONS IN SOUTH AFRICA

SAWB NUMBER	Station Name	Latitude		Longitude		MAP	Altitude	Years	Duration	Return Period (years)																	
										2			5			10			20			50			100			200		
		(°)	(')	(°)	(')	(mm)	(m)		(days)	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U
0476093 W	SANDTON (POL)	26	3	28	3	646	1440	81	1	46	47	47	64	64	65	77	78	78	91	92	93	111	113	114	128	130	133	146	150	153
									2	57	57	57	78	79	79	95	96	97	112	114	117	137	142	147	157	165	173	178	192	204
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									7	84	84	84	113	114	114	134	136	137	156	159	161	185	191	196	208	218	226	232	246	259
0476098 W	JHB-CYDNA (PUR)	26	8	28	4	754	1605	31	1	50	50	50	69	69	69	83	83	84	98	99	99	119	121	122	137	140	142	157	160	164
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0476100 W	JHB-KING EDWARDVII SKL	26	10	28	4	774	1690	62	1	58	58	58	79	80	80	96	97	97	113	114	115	138	140	142	159	162	165	181	186	190
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0476101 W	JHB-REPUBLIEK STEK	26	11	28	4	780	1800	86	1	54	54	54	74	74	75	89	90	90	106	106	107	129	131	132	148	151	153	169	173	177
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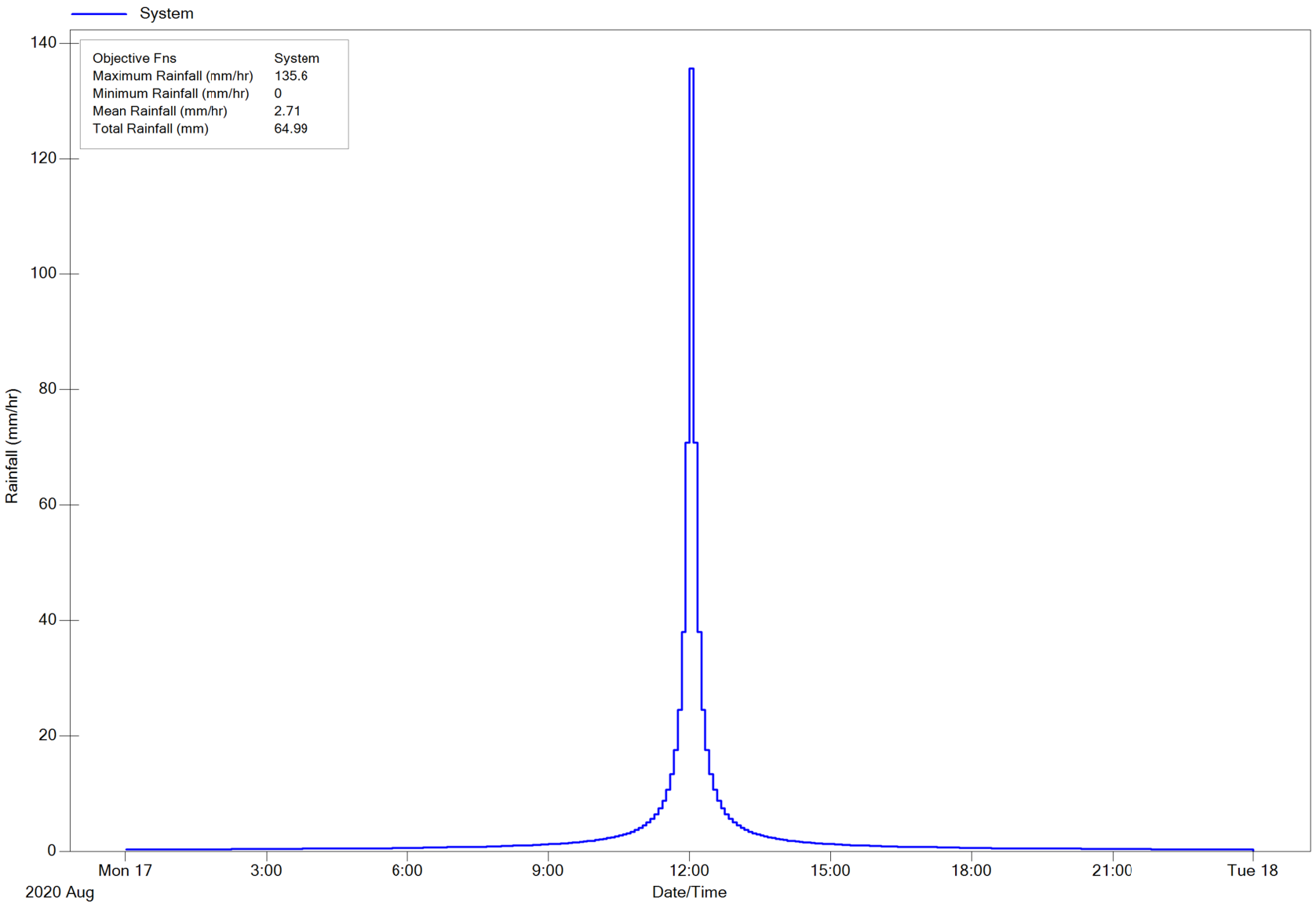
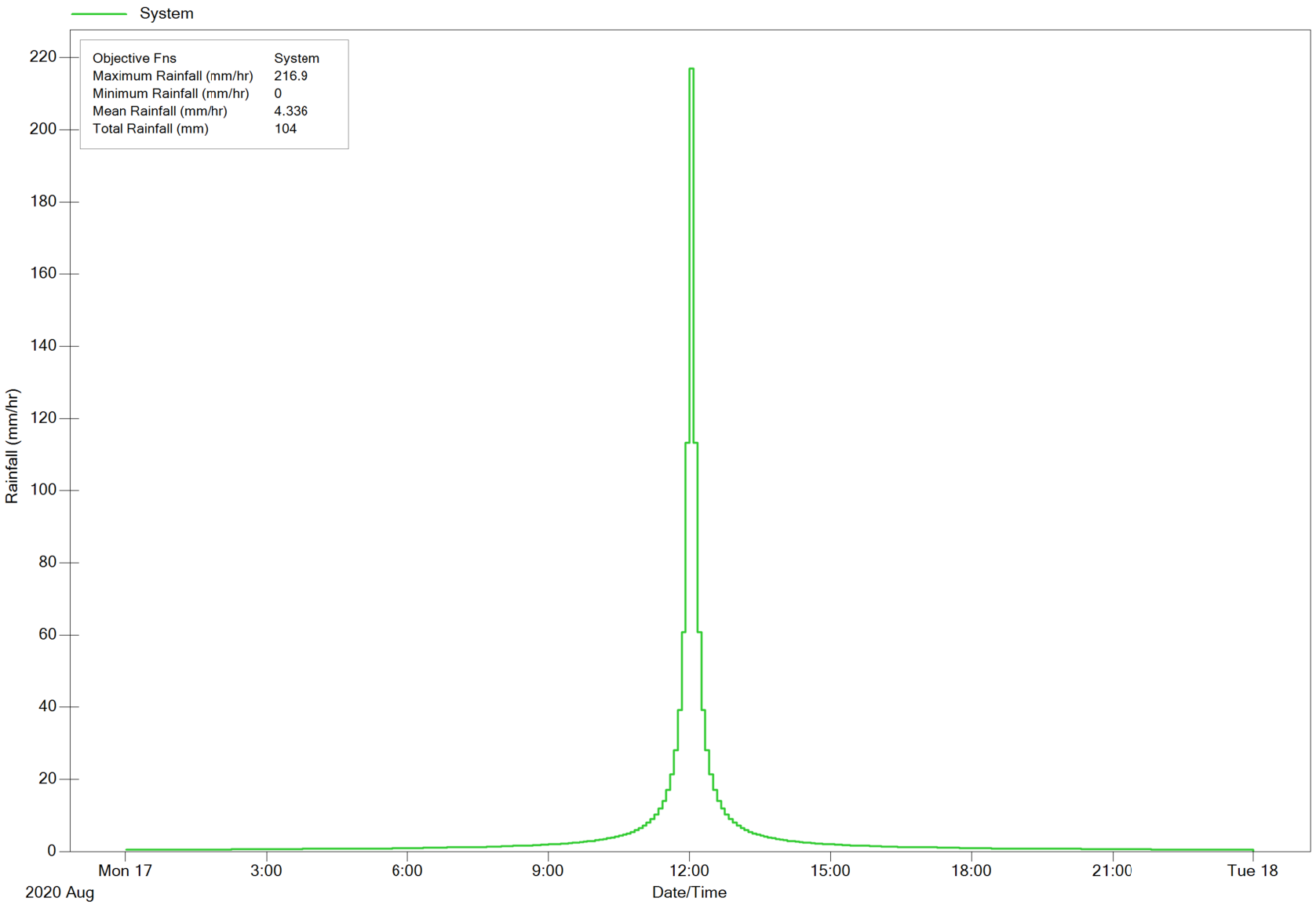
									7	104	105	105	141	142	142	167	169	171	194	197	200	230	238	244	259	271	281	289	307	322
0476103 W	JHB-CITY DEEP (GM)	26	12	28	5	794	1677	74	1	55	55	55	76	76	76	92	92	92	108	109	110	132	134	135	151	154	157	173	177	181
									2	70	71	71	98	98	99	118	119	121	139	142	145	170	177	182	195	206	215	222	239	254
									3	79	79	79	109	109	110	131	132	133	155	157	158	190	194	196	218	225	230	250	260	268
									4	85	85	86	116	116	117	139	140	141	164	165	167	199	203	206	228	234	239	259	269	278
									5	93	93	93	126	126	127	150	151	152	176	178	179	212	216	219	241	248	253	273	283	291
									6	98	98	99	133	134	134	157	160	161	183	187	190	218	226	233	245	258	270	274	293	310
									7	103	103	104	139	140	140	165	167	168	191	195	197	227	234	240	256	267	277	285	302	317
0476111 W	ZWARTKOPJES (RWB)	26	20	28	3	684	1500	92	1	40	40	40	55	55	56	67	67	67	79	79	80	96	97	98	110	112	114	126	129	132
									2	53	53	53	73	73	74	88	89	90	104	106	109	127	132	136	146	154	161	166	179	190
									3	61	61	62	84	84	85	101	102	103	120	121	123	147	150	152	169	174	178	193	201	208
									4	67	67	67	91	91	92	109	110	110	128	130	131	156	159	161	179	184	188	203	211	218
									5	73	74	74	100	100	101	119	120	121	140	141	142	168	171	174	191	197	201	217	224	231
									6	78	78	79	106	106	107	125	127	128	145	149	151	173	180	185	195	205	215	218	233	247
									7	83	83	84	112	113	113	133	135	136	154	157	159	183	189	194	206	216	224	230	244	256
0476128 W	JHB-WAVERLY	26	8	28	4	754	1620	58	1	59	59	60	81	82	82	98	99	99	116	117	118	141	144	145	163	166	169	186	190	194
									2	76	76	77	105	106	106	127	129	130	150	154	156	183	190	197	211	222	232	239	257	274
									3	84	84	85	116	116	117	140	141	141	165	167	169	202	206	209	233	240	245	266	277	286
									4	93	94	94	127	128	129	153	154	155	180	182	184	219	223	227	251	258	264	285	297	306
									5	101	101	102	137	138	138	164	165	166	192	194	195	231	235	239	263	270	276	298	308	317
									6	106	107	108	144	145	146	171	173	175	198	203	207	236	245	253	266	280	293	298	318	337
									7	111	111	112	150	150	151	177	179	181	206	210	213	244	253	259	275	288	298	307	326	342

L=lower 90% error bound (mm); D=design rainfall depth (mm); U=upper 90% error bound (mm)

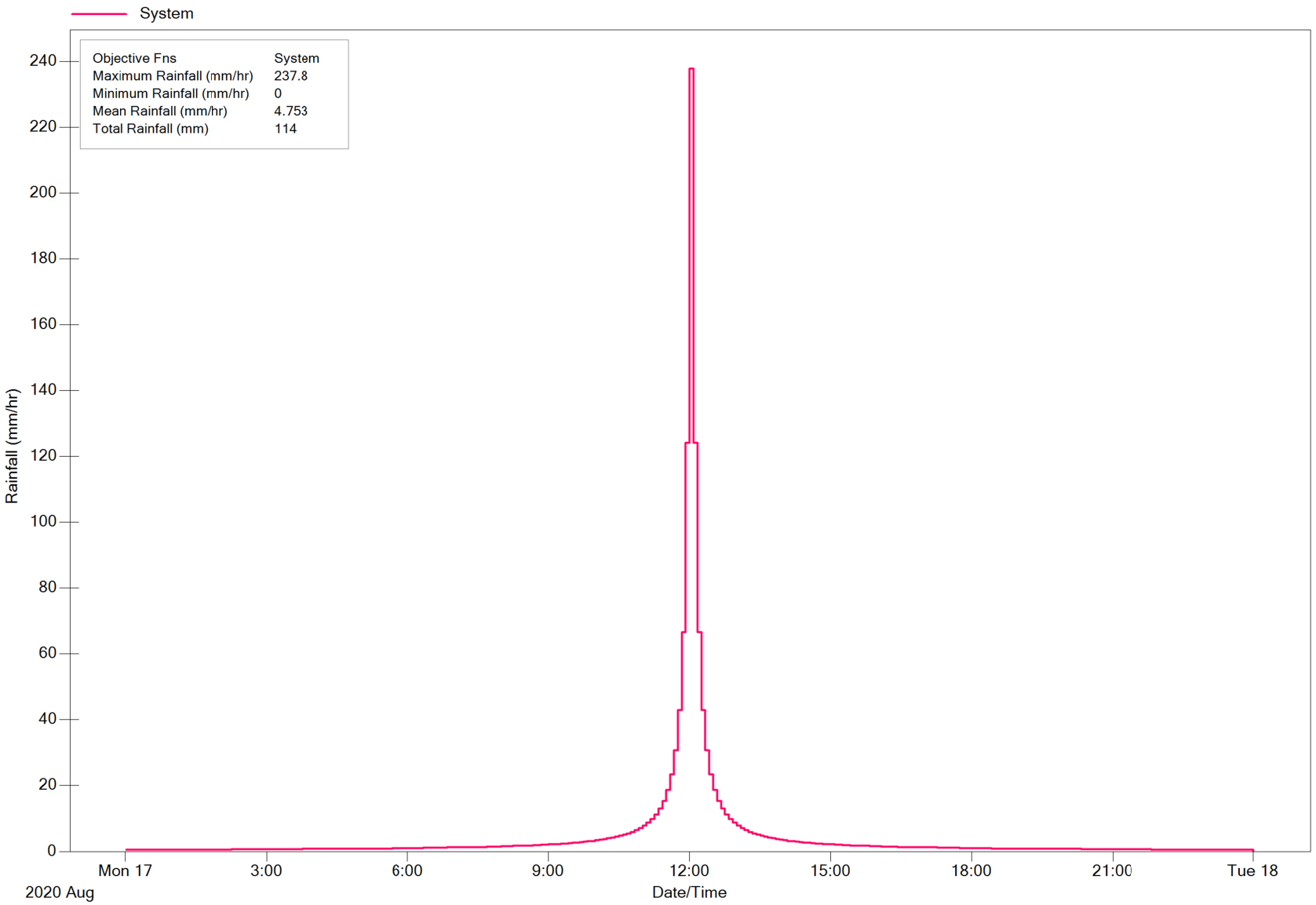
Q5 Rainfall


System
Objective Fns System
Maximum Rainfall (mm/hr) 135.6
Minimum Rainfall (mm/hr) 0
Mean Rainfall (mm/hr) 2.71
Total Rainfall (mm) 64.99
140
120
100
80
60
40
20
0
Rainfall (mm/hr)
Mon 17
2020 Aug
3:00
6:00
9:00
12:00
15:00
18:00
21:00
Tue 18
Date/Time

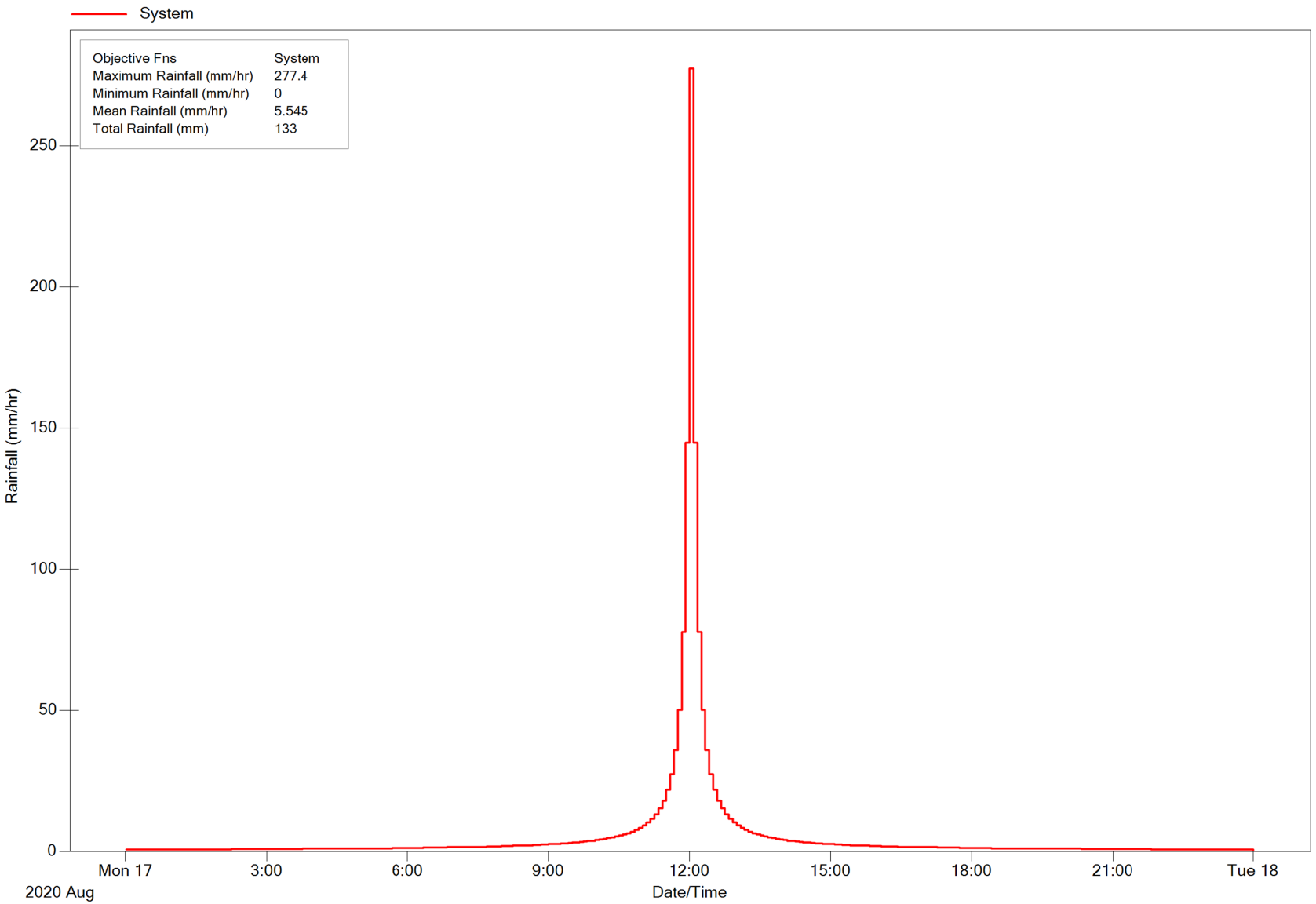
Q25 Rainfall



Q50 Rainfall



Q100 Rainfall



Rainfall Data Post-Development Design Event Rainfall

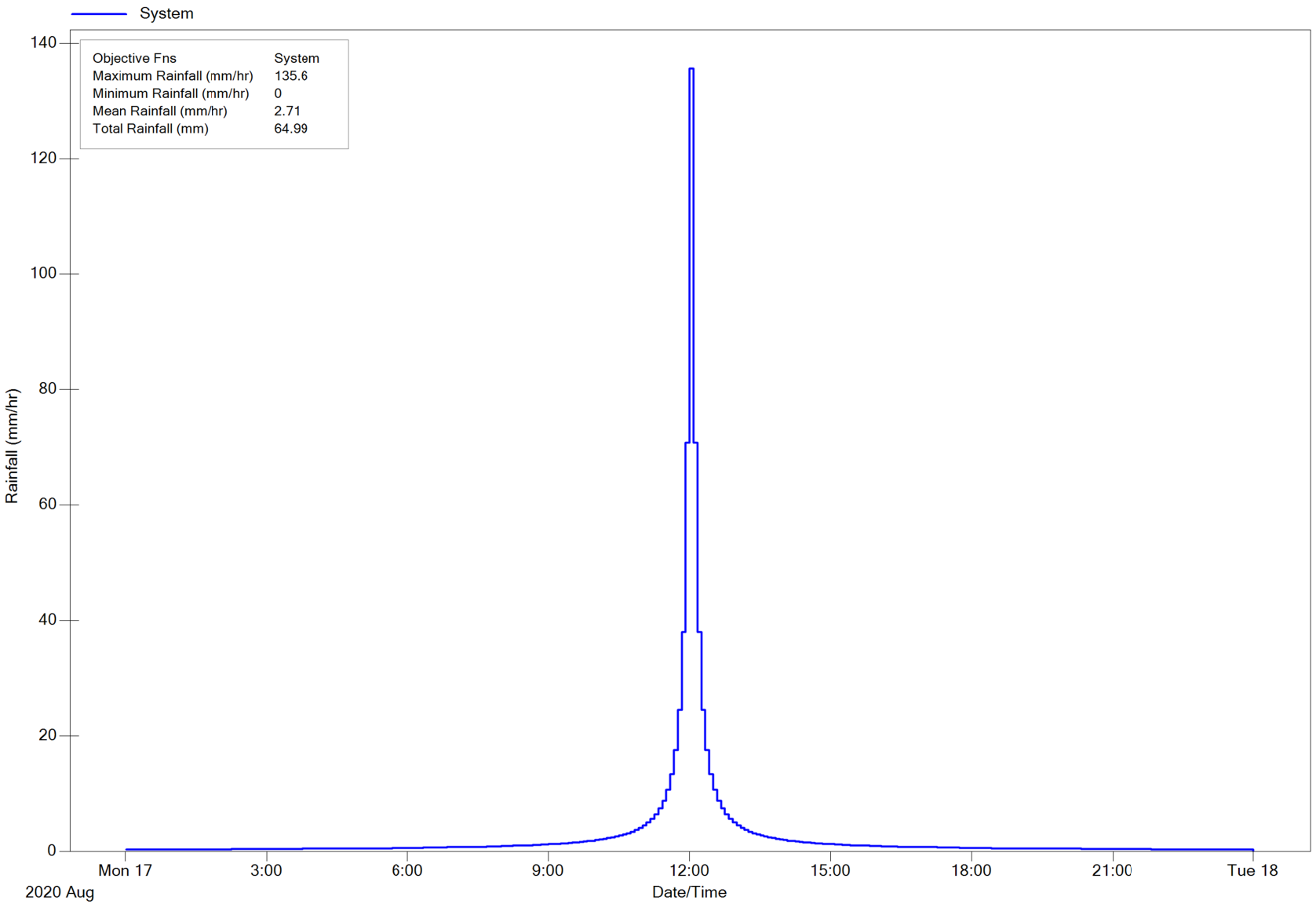
Annexure-E

DESIGN RAINFALL DEPTHS AT SELECTED STATIONS IN SOUTH AFRICA

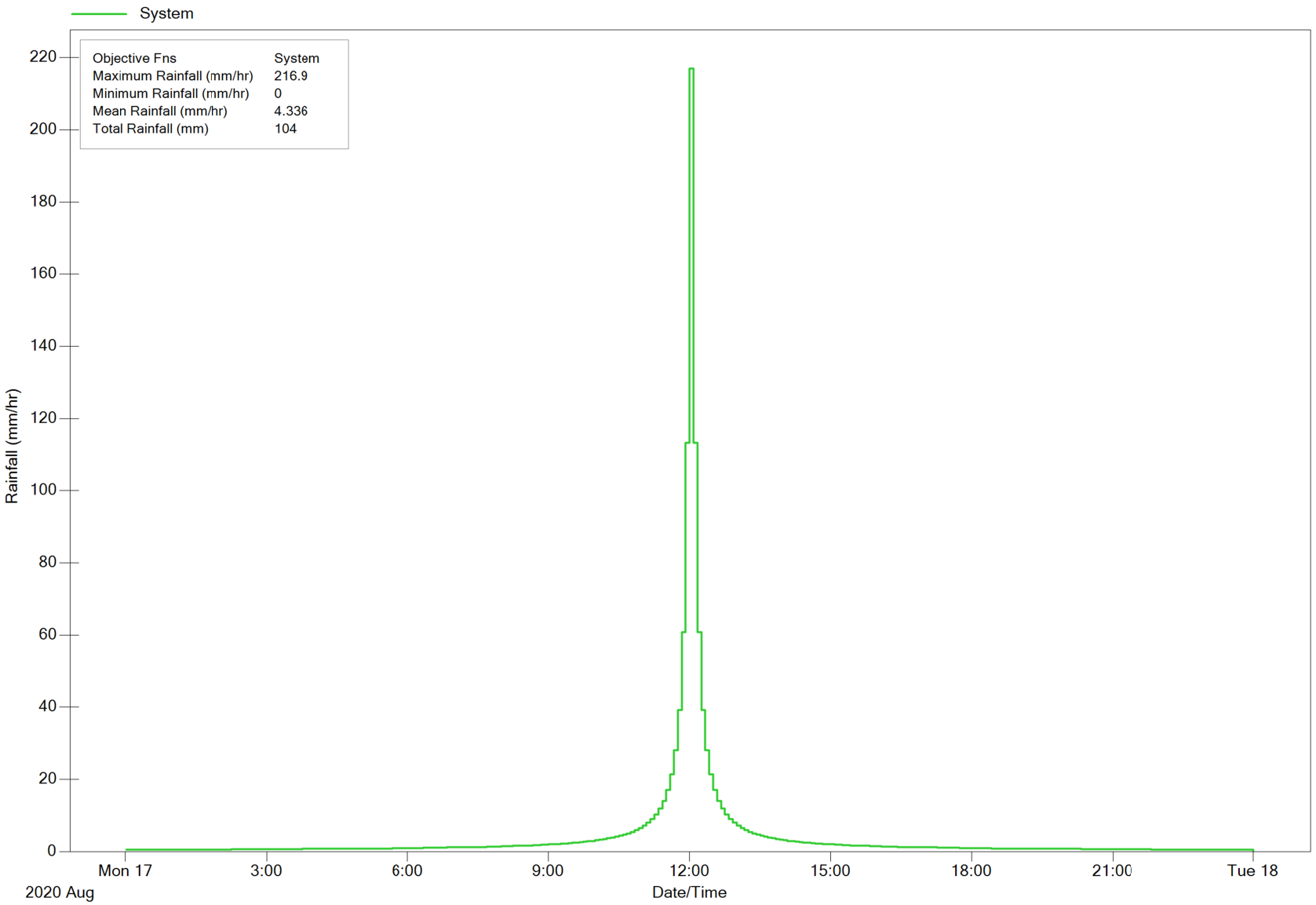
SAWB NUMBER	Station Name	Latitude		Longitude		MAP	Altitude	Years	Duration	Return Period (years)																	
										2			5			10			20			50			100			200		
		(°)	(')	(°)	(')	(mm)	(m)		(days)	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U	L	D	U
0476093 W	SANDTON (POL)	26	3	28	3	646	1440	81	1	46	47	47	64	64	65	77	78	78	91	92	93	111	113	114	128	130	133	146	150	153
									2	57	57	57	78	79	79	95	96	97	112	114	117	137	142	147	157	165	173	178	192	204
									3	64	64	64	88	88	89	106	107	108	126	127	128	154	157	159	177	182	187	203	211	218
									4	71	71	72	97	97	98	116	117	118	137	138	140	166	170	172	191	196	201	217	225	232
									5	76	76	77	103	104	104	123	124	125	144	146	147	174	177	180	198	203	208	224	232	239
									6	80	80	81	108	109	110	128	130	132	149	152	155	178	184	190	200	211	220	224	239	253
									7	84	84	84	113	114	114	134	136	137	156	159	161	185	191	196	208	218	226	232	246	259
0476098 W	JHB-CYDNA (PUR)	26	8	28	4	754	1605	31	1	50	50	50	69	69	69	83	83	84	98	99	99	119	121	122	137	140	142	157	160	164
									2	68	69	69	94	95	96	114	116	117	135	138	140	165	171	176	189	199	208	215	231	246
									3	77	77	77	106	106	107	128	128	129	151	153	154	185	188	191	213	219	224	243	253	261
									4	84	85	85	115	116	116	138	139	140	163	165	166	198	202	205	227	233	238	258	268	276
									5	94	94	95	127	128	129	152	153	154	178	180	182	215	219	222	245	251	257	277	287	295
									6	99	99	100	134	135	136	159	161	163	185	189	192	220	229	236	248	261	273	277	297	314
									7	104	105	105	141	142	142	167	169	171	194	197	200	230	238	244	259	271	281	289	307	322
0476100 W	JHB-KING EDWARDVII SKL	26	10	28	4	774	1690	62	1	58	58	58	79	80	80	96	97	97	113	114	115	138	140	142	159	162	165	181	186	190
									2	73	73	74	101	102	102	122	123	125	144	147	150	176	183	189	202	213	223	230	247	263
									3	80	81	81	111	111	112	134	135	135	158	160	162	194	198	201	223	229	235	255	265	274
									4	87	88	88	119	119	120	143	144	145	168	170	171	204	208	211	234	241	246	266	277	285
									5	95	95	96	129	129	130	154	155	156	180	182	184	217	221	224	247	254	259	280	289	298
									6	100	101	102	136	137	138	161	164	165	187	192	195	223	232	239	251	265	277	281	301	318
									7	105	106	106	142	143	144	169	171	172	196	199	202	232	240	246	262	273	283	292	310	325
0476101 W	JHB-REPUBLIEK STEK	26	11	28	4	780	1800	86	1	54	54	54	74	74	75	89	90	90	106	106	107	129	131	132	148	151	153	169	173	177
									2	69	69	70	96	96	97	115	117	118	136	139	142	167	173	179	191	202	211	218	234	249
									3	79	79	80	109	109	110	131	132	133	155	157	159	190	194	197	219	225	230	250	260	269
									4	85	86	86	117	117	118	140	141	142	165	167	168	200	204	207	230	236	241	261	271	280
									5	94	94	95	128	128	129	152	154	154	179	180	182	215	219	222	245	252	257	277	287	295
									6	99	99	100	134	135	136	159	161	163	185	189	193	220	229	236	248	261	273	277	297	314
									7	104	105	105	141	142	142	167	169	171	194	197	200	230	238	244	259	271	281	289	307	322
0476103 W	JHB-CITY DEEP (GM)	26	12	28	5	794	1677	74	1	55	55	55	76	76	76	92	92	92	108	109	110	132	134	135	151	154	157	173	177	181
									2	70	71	71	98	98	99	118	119	121	139	142	145	170	177	182	195	206	215	222	239	254
									3	79	79	79	109	109	110	131	132	133	155	157	158	190	194	196	218	225	230	250	260	268
									4	85	85	86	116	116	117	139	140	141	164	165	167	199	203	206	228	234	239	259	269	278
									5	93	93	93	126	126	127	150	151	152	176	178	179	212	216	219	241	248	253	273	283	291
									6	98	98	99	133	134	134	157	160	161	183	187	190	218	226	233	245	258	270	274	293	310
									7	103	103	104	139	140	140	165	167	168	191	195	197	227	234	240	256	267	277	285	302	317
0476111 W	ZWARTKOPJES (RWB)	26	20	28	3	684	1500	92	1	40	40	40	55	55	56	67	67	67	79	79	80	96	97	98	110	112	114	126	129	132
									2	53	53	53	73	73	74	88	89	90	104	106	109	127	132	136	146	154	161	166	179	190
									3	61	61	62	84	84	85	101	102	103	120	121	123	147	150	152	169	174	178	193	201	208
									4	67	67	67	91	91	92	109	110	110	128	130	131	156	159	161	179	184	188	203	211	218
									5	73	74	74	100	100	101	119	120	121	140	141	142	168	171	174	191	197	201	217	224	231
									6	78	78	79	106	106	107	125	127	128	145	149	151	173	180	185	195	205	215	218	233	247
									7	83	83	84	112	113	113	133	135	136	154	157	159	183	189	194	206	216	224	230	244	256
0476128 W	JHB-WAVERLY	26	8	28	4	754	1620	58	1	59	59	60	81	82	82	98	99	99	116	117	118	141	144	145	163	166	169	186	190	194
									2	76	76	77	105	106	106	127	129	130	150	154	156	183	190	197	211	222	232	239	257	274
									3	84	84	85	116	116	117	140	141	141	165	167	169	202	206	209	233	240	245	266	277	286
									4	93	94	94	127	128	129	153	154	155	180	182	184	219	223	227	251	258	264	285	297	306
									5	101	101	102	137	138	138	164	165	166	192	194	195	231	235	239	263	270	276	298	308	317
									6	106	107	108	144	145	146	171	173	175	198	203	207	236	245	253	266	280	293	298	318	337
									7	111	111	112	150	150	151	177	179	181	206	210	213	244	253	259	275	288	298	307	326	342

L=lower 90% error bound (mm); D=design rainfall depth (mm); U=upper 90% error bound (mm)

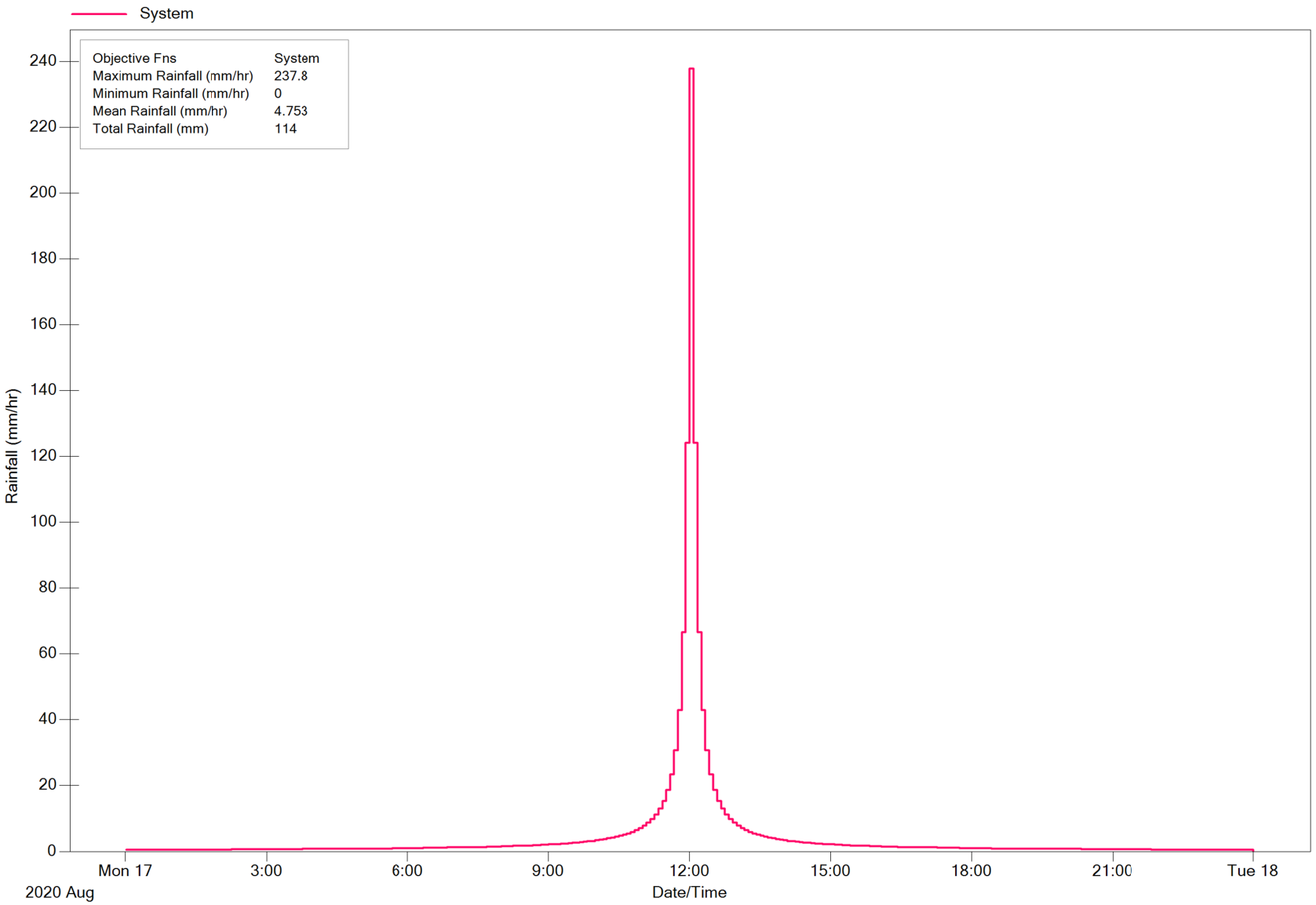
Q5 Rainfall


System
Objective Fns System
Maximum Rainfall (mm/hr) 135.6
Minimum Rainfall (mm/hr) 0
Mean Rainfall (mm/hr) 2.71
Total Rainfall (mm) 64.99
140
120
100
80
60
40
20
0
Rainfall (mm/hr)
Mon 17
2020 Aug
3:00
6:00
9:00
12:00
15:00
18:00
21:00
Tue 18
Date/Time

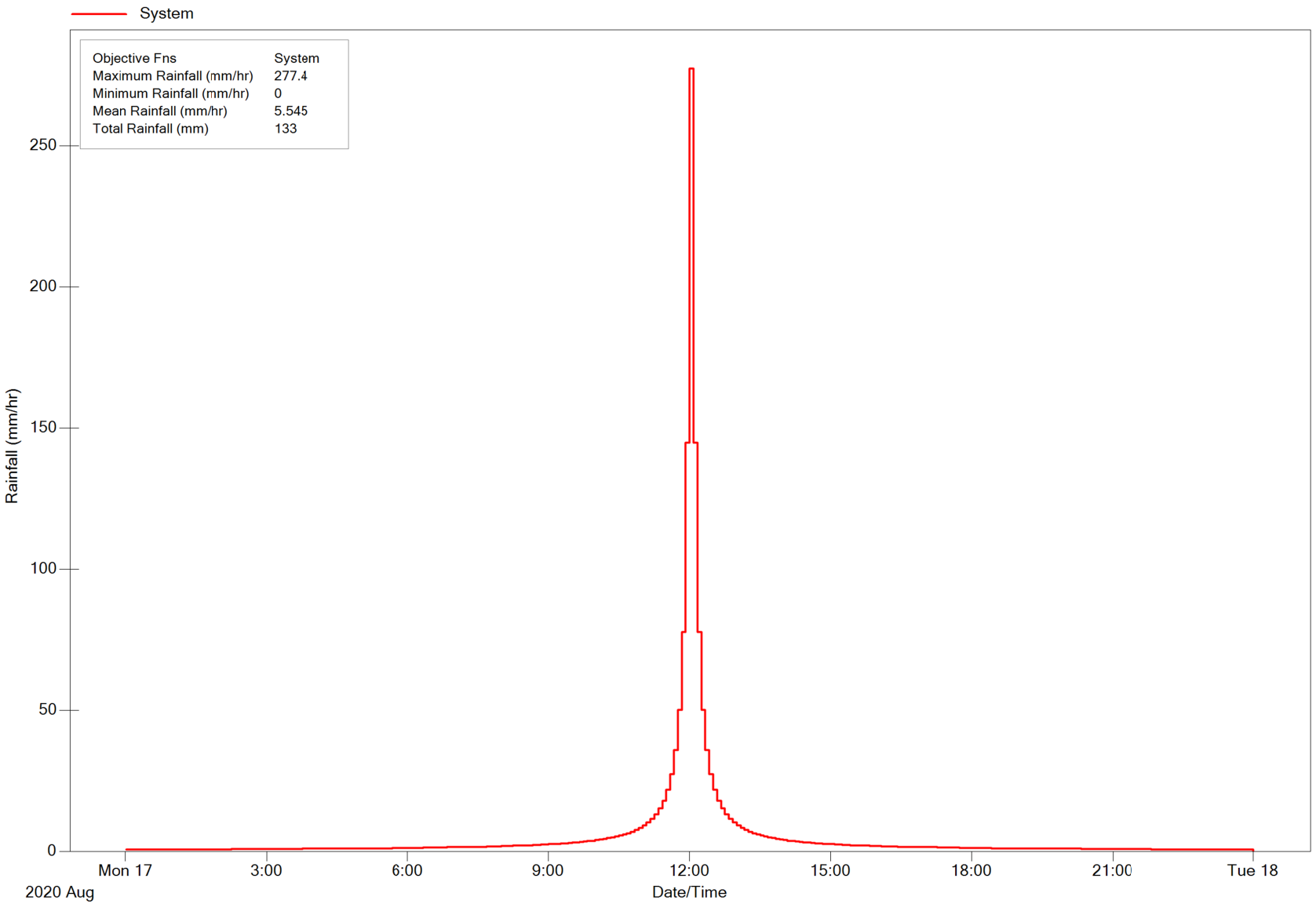
Q25 Rainfall



Q50 Rainfall



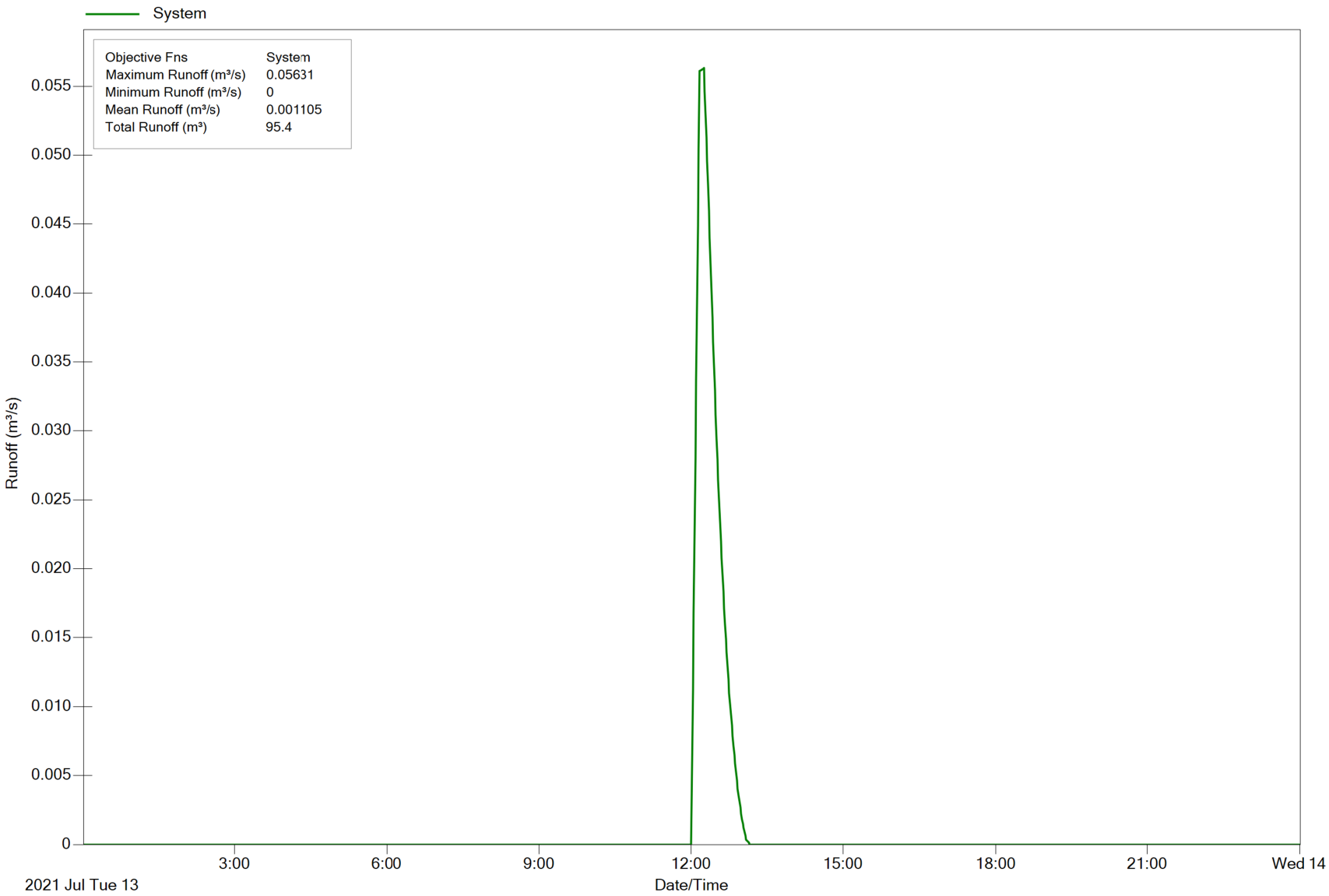
Q100 Rainfall



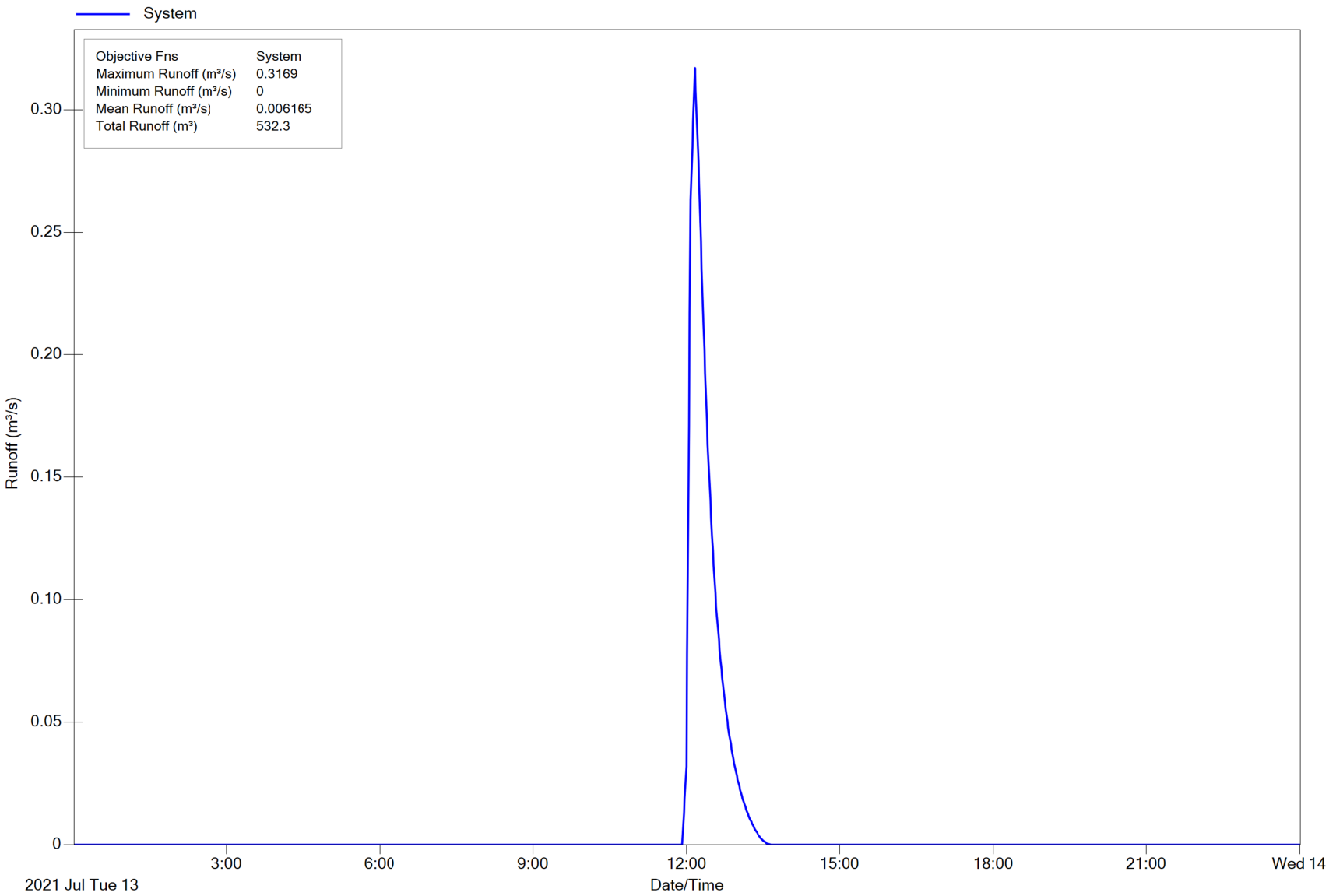
Pre-Development Hydrographs

Annexure-F

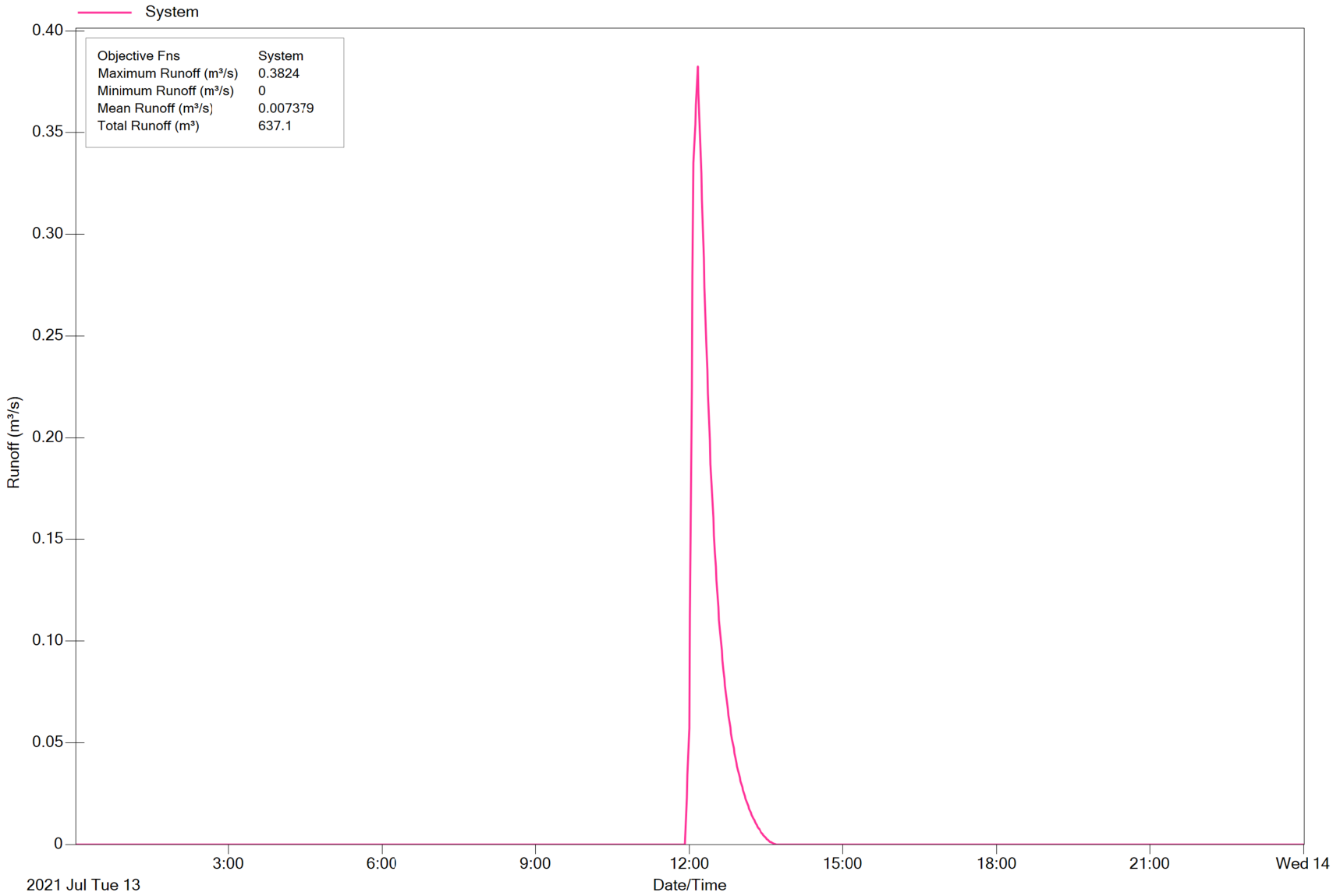
Pre-Development Q5 Peak Runoff



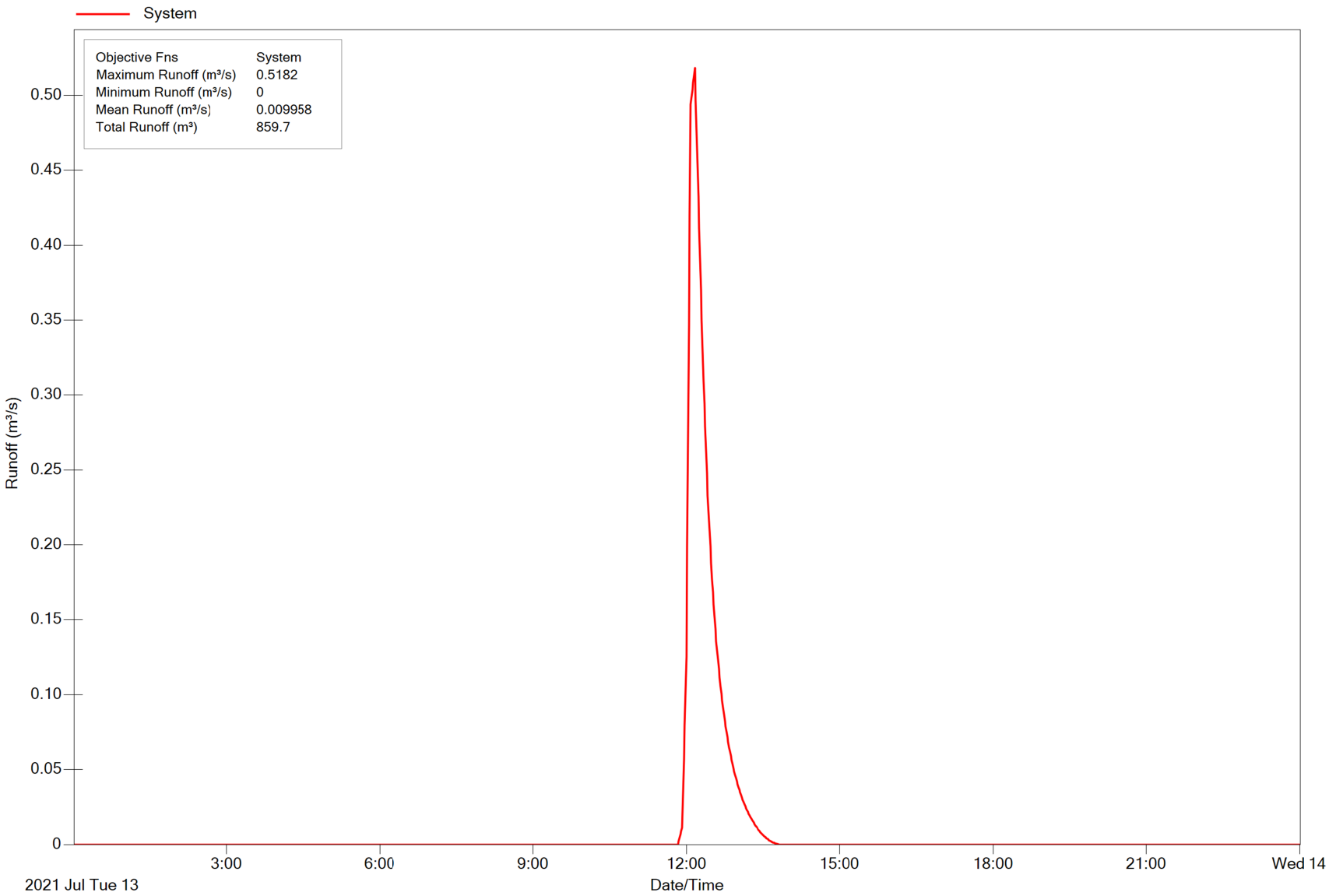
Pre-Development Q25 Peak Runoff



Pre-Development Q50 Peak Runoff



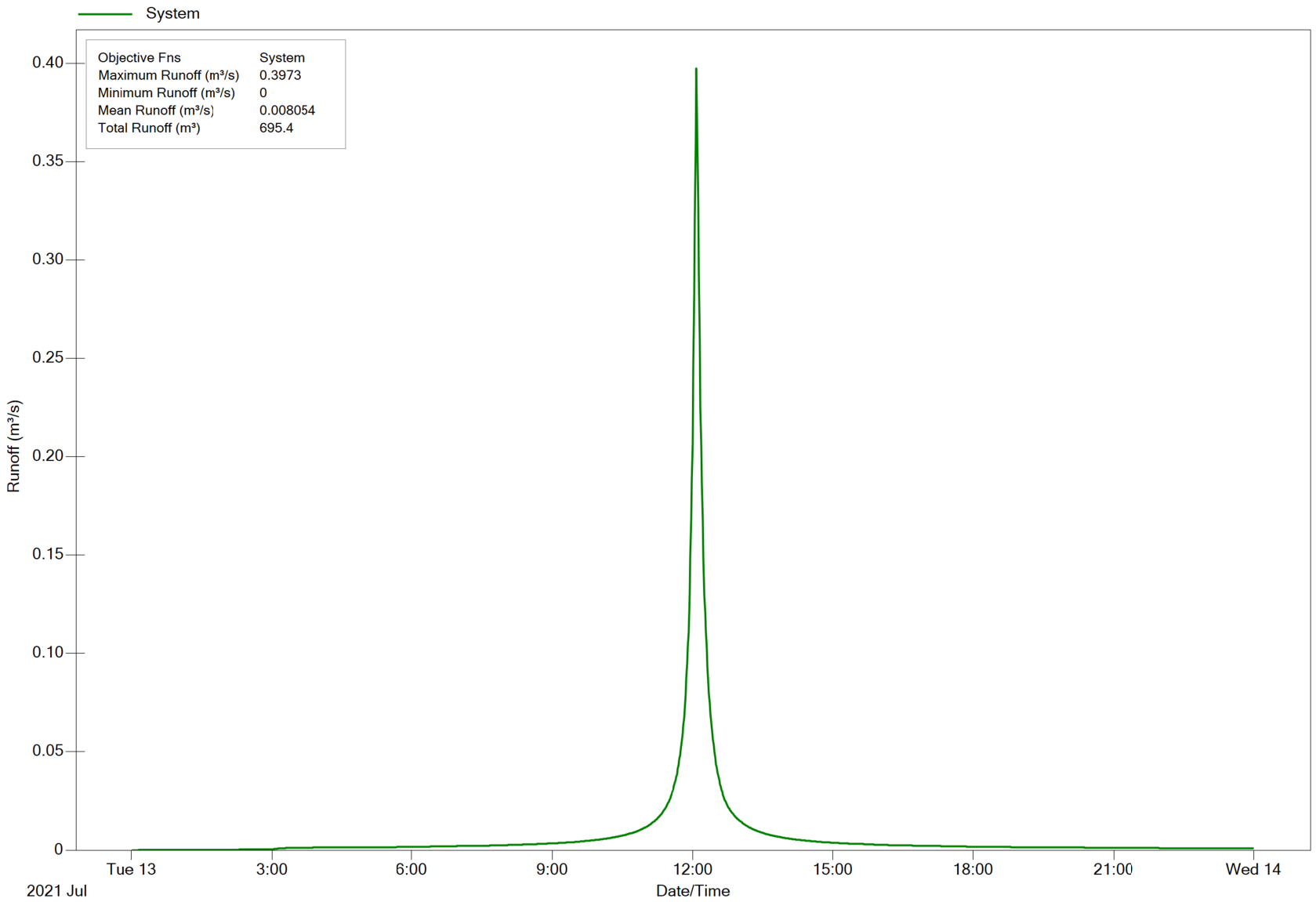
Pre-Development Q100 Peak Runoff



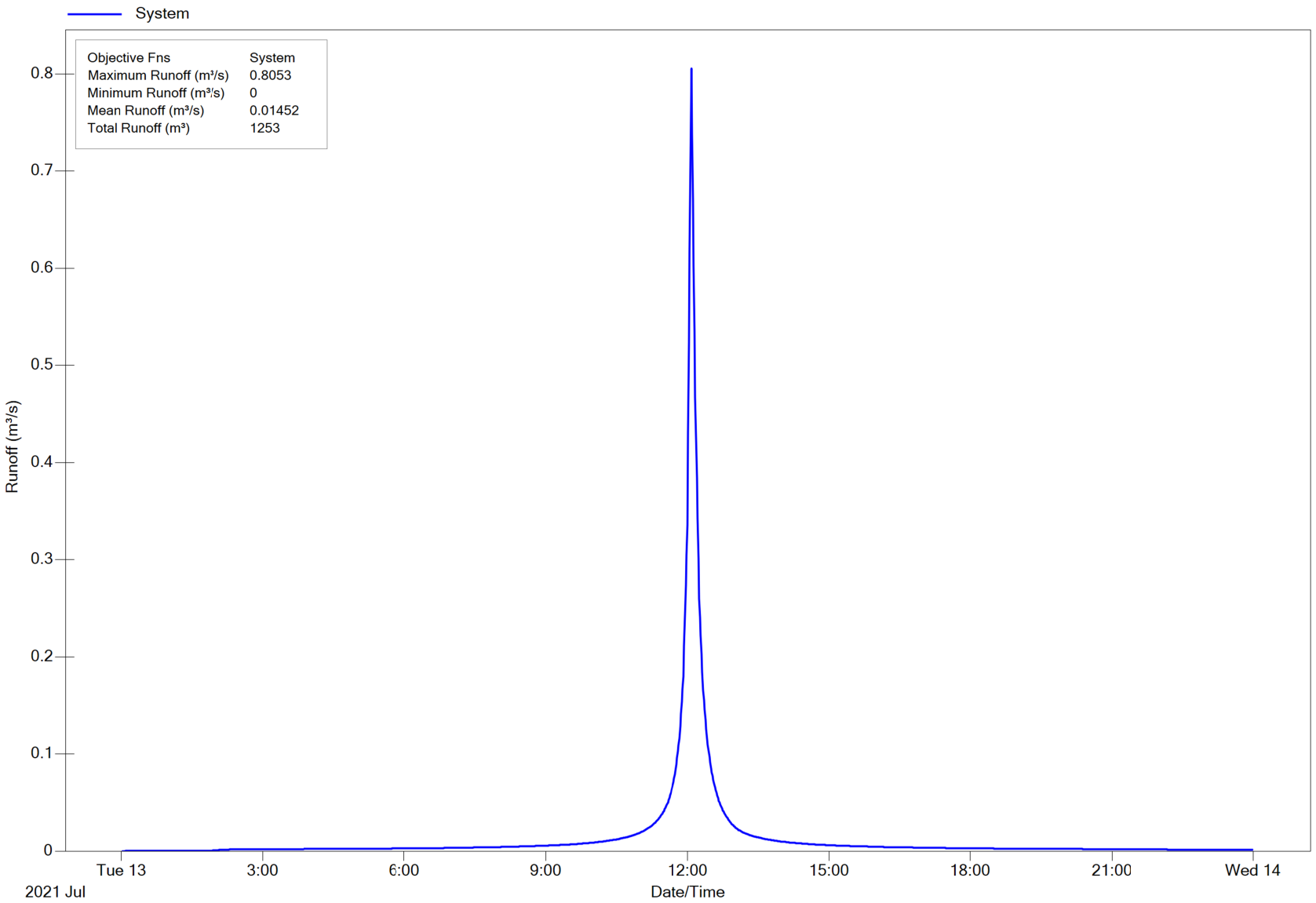
Post-Development Hydrographs

Annexure-G

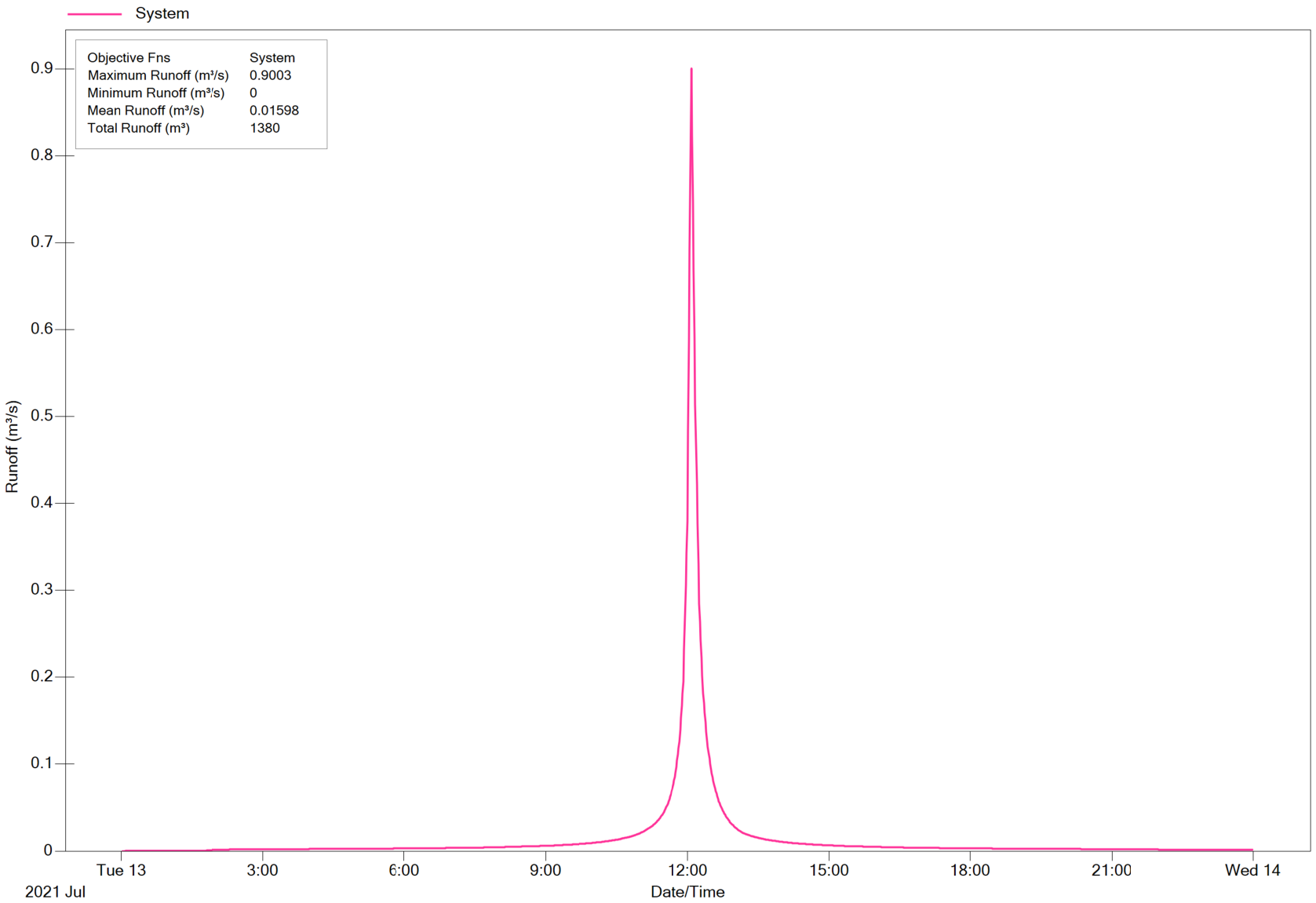
Post Development Q5 Peak Flow



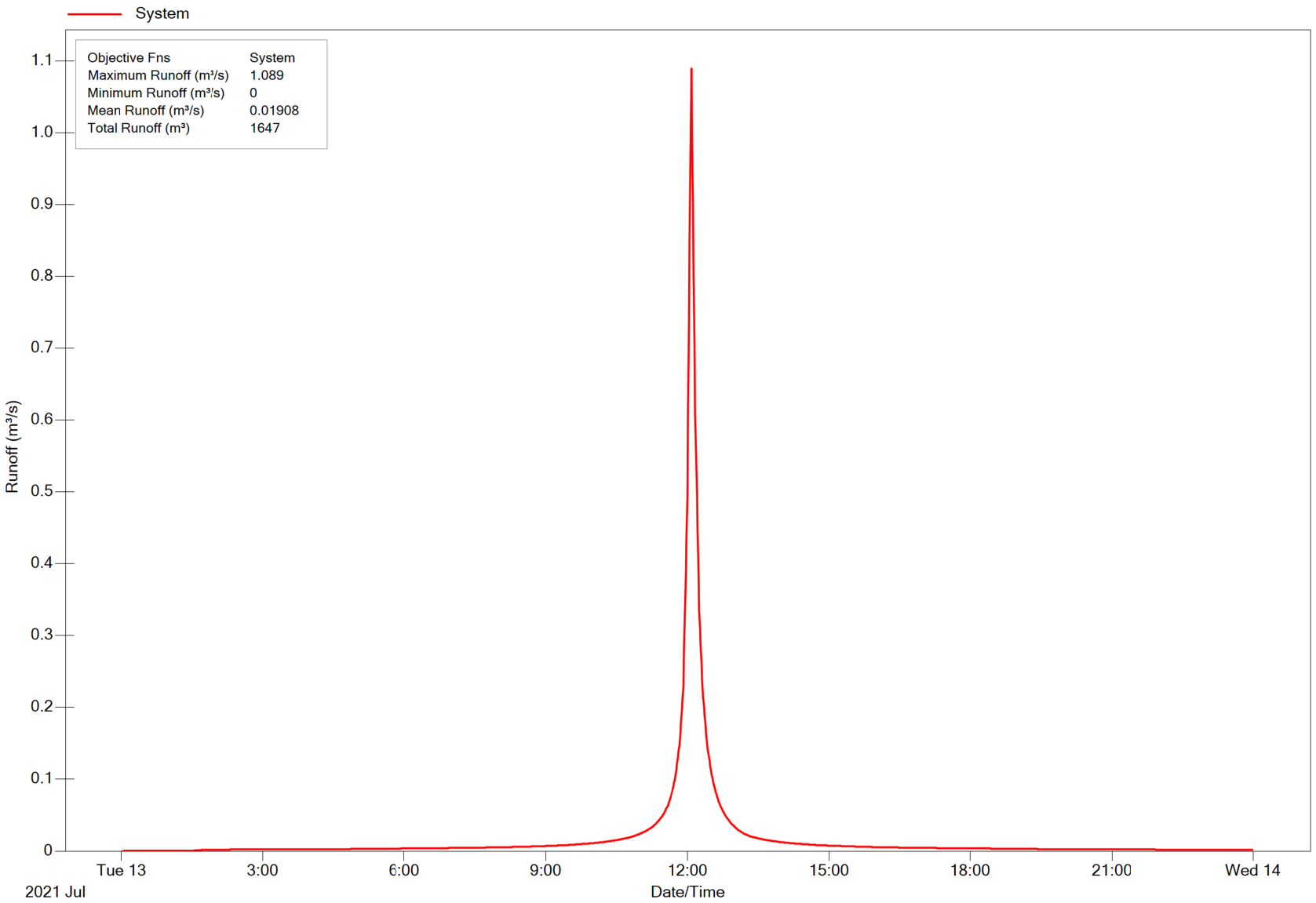
Post Development Q25 Peak Flow



Post Development Q50 Peak Flow



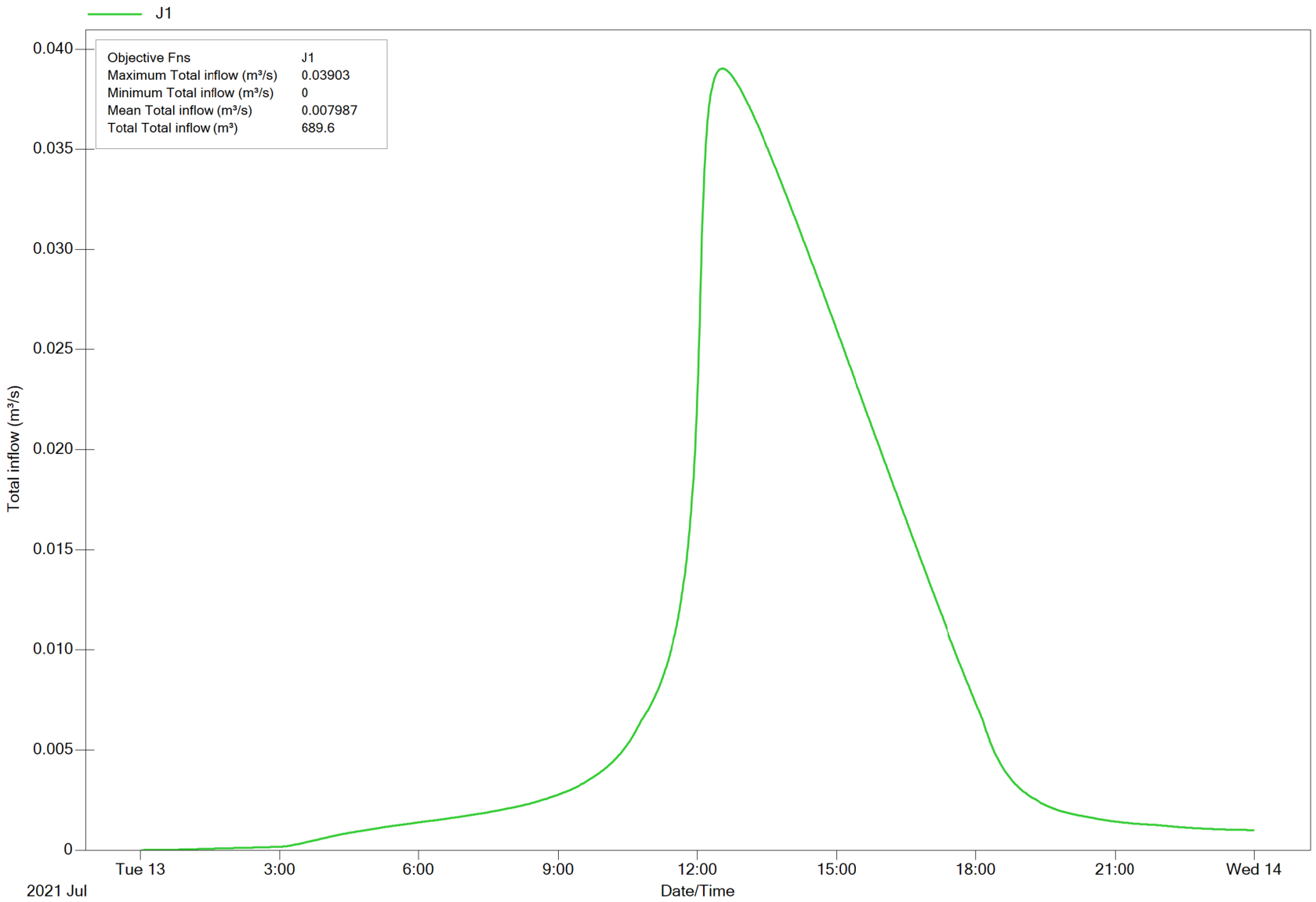
Post Development Q100 Peak Flow



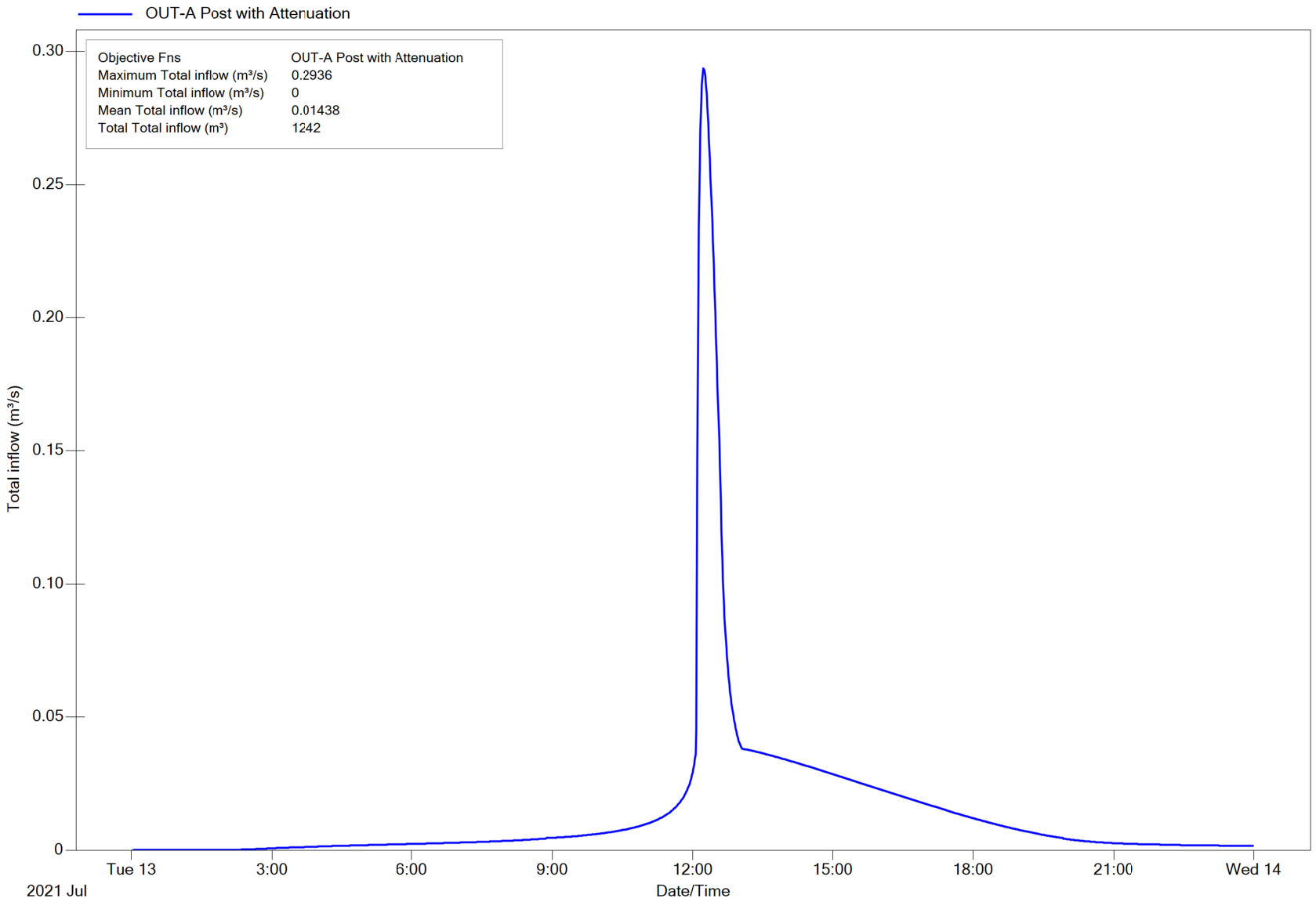
Post-Development Peak Discharge After Attenuation Hydrographs

Annexure-H

Peak Q5 Discharge after Attenuation

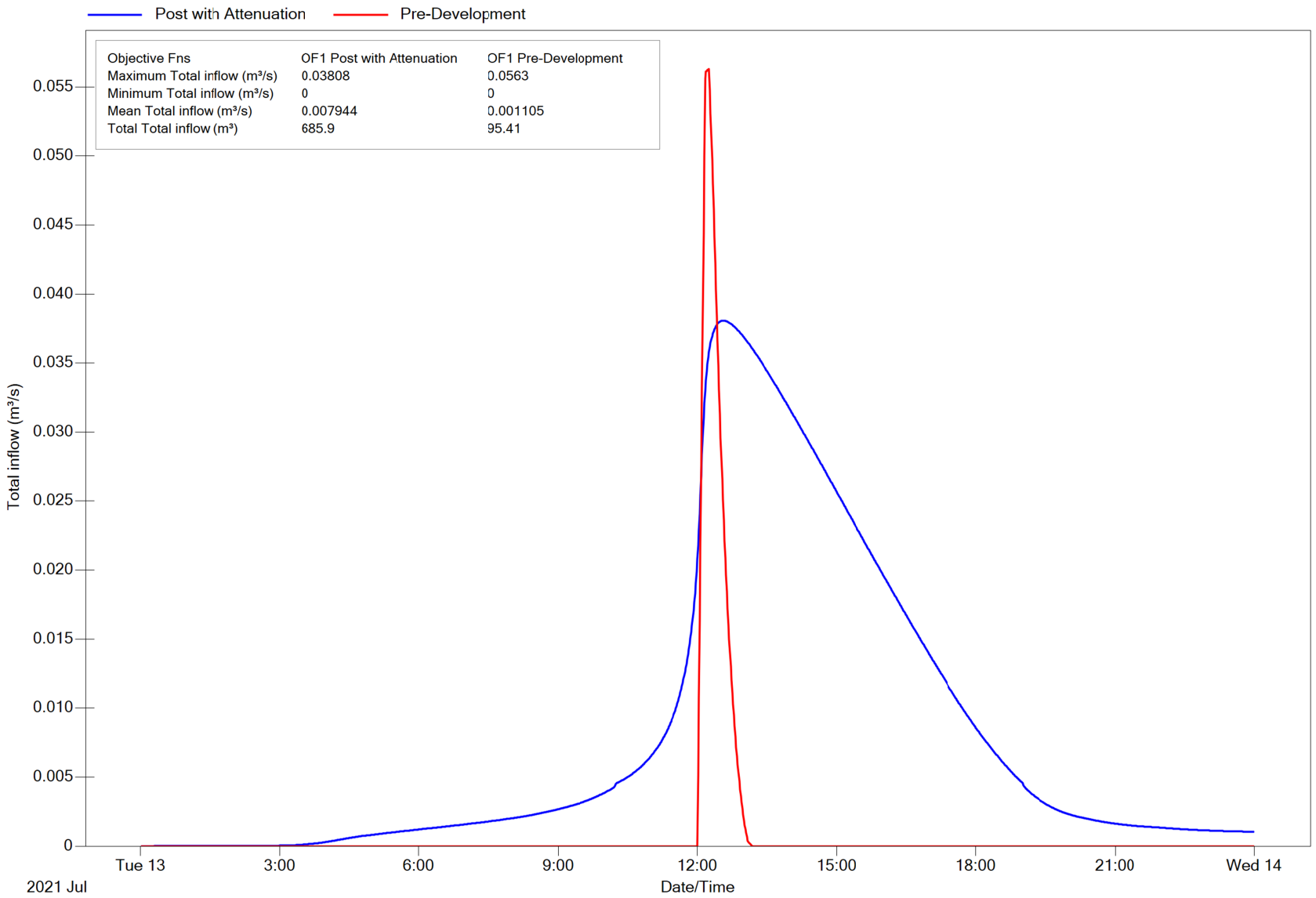


Peak Q25 Discharge after Attenuation



Node OF1

Flow Comparison Pre VS Post Attenuated Q5



Node OF1

Flow Comparison Pre VS Post Attenuated Q25