ADDENDUM 5

Rational Method DWA

Project	**= DE WILDT PV PROJECT**
Analysed by	= CAS COETZER
Name of river	= DE WILDT PV PROJECT
Description of site	= DE WILDT PV PROJECT
Date	= 4/25/2016
Area of catchment	= 14.68 km²
Dolomitic area	= 0.0 %
Mean annual rainfall (MAR)	= 664.00 mm
Length of longest watercourse	= 3.5 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 38.7 m
Rainfall region	= Coastal
Area distribution	= Rural: 100 %, Urban: 0 %, Lakes: 0 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0

Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	0	Very permeable	0	Thick bush & forests	0
Flat area	0	Permeable	0	Light bush & cultivated land	0
Hilly	85	Semi-permeable	95	Grasslands	95
Steep areas	15	Impermeable	5	Bare	5

Average slope = 0.01474 m/m

Time of concentration = 53.0 min

Run-off factor

Rural - C1 = 0.554

Urban - C2 = 0.000

Lakes - C3 = 0.000

Combined - C = 0.554

The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.

Return Period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m^3/s)
1:2	0.88	19.9	98.8	22.2	0.75	41.5	37.66
1:5	0.88	27.1	98.4	30.2	0.80	44.3	54.47
1:10	0.88	34.2	98.0	38.0	0.85	47.0	72.93
1:20	0.88	42.3	97.5	46.7	0.90	49.8	94.88
1:50	0.88	54.9	96.8	60.3	0.95	52.6	129.21
1:100	0.88	67.6	96.1	73.6	1.00	55.4	166.12

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Alternative Rational Method

Project = DE WILDT PV PROJECT

Analysed by	= CAS COETZER
Name of river	= DE WILDT PV PROJECT
Description of site	= DE WILDT PV PROJECT
Date	= 4/25/2016
Area of catchment	= 14.68 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.5 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 38.7 m
Area distribution	= Rural: 100 %, Urban: 0 %, Lakes: 0 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	0	Very permeable	0	Thick bush & forests	0
Flat area	0	Permeable	0	Light bush & cultivated land	0
Hilly	85	Semi-permeable	95	Grasslands	95
Steep areas	15	Impermeable	5	Bare	5

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 512613
Weather Services station location	= HARTEBEESPOORT DAM

Mean annual precipitation (MAP) = 664 mm

Duration	2	5	10	20	50	100	200
1 day	58	82	100	120	150	175	203
2 days	73	105	129	156	196	230	268
3 days	82	117	145	176	220	259	301
7 days	105	152	188	227	284	332	384

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope = 0.01474 m/m

Time of concentration = 53.0 min

Run-off factor

Rural - C1 = 0.554

Urban - C2 = 0.000

Lakes - C3 = 0.000

Combined - C = 0.554

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m^3/s)
1:2	0.88	27.38	97.8	30.35	0.75	41.5	51.37
1:5	0.88	46.19	97.8	51.19	0.80	44.3	92.44
1:10	0.88	60.42	97.8	66.96	0.85	47.0	128.47
1:20	0.88	74.65	97.8	82.73	0.90	49.8	168.06
1:50	0.88	93.46	97.8	103.58	0.95	52.6	222.10
1:100	0.88	107.68	97.8	119.35	1.00	55.4	269.38
1:200	0.88	121.91	97.8	135.12	1.00	55.4	304.97

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Standard Design Flood method

Project name = DE WILDT PV PROJECT

Analysed by	= CAS COETZER
Name of river	= DE WILDT PV PROJECT
Description of site	= DE WILDT PV PROJECT
Date	= 4/25/2016
Catchment characteristics:	
Area of catchment	= 14.68 km^2
Length of longest watercourse	= 3.5 km
1085 height difference	= 38.7 m
Average slope	= 0.0147 m/m
Drainage basin characteristics:	
Drainage basin number	= 1
Mean annual daily max rain	= 56 mm
Days on which thunder was heard	= 30 days
Runoff coefficient C2	= 10 %
Runoff coefficient C100	= 40 %
Basin mean annual precipitation	= 550 mm
Basin mean annual evaporation	= 1800 mm
Basin evaporation index MAE/MAP	= 3.27

RAINFALL DATA

The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 546204 @ STRUAN

Point mean annual precipitation = 550 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	15	25	33	41	51	59	67
.50 h	20	33	43	53	67	77	87
1 h	24	41	53	66	82	95	107
2 h	29	48	63	78	98	113	127
4 h	33	56	73	90	113	130	148
1 day	56	80	99	119	150	177	206
2 days	71	105	132	161	205	243	286
3 days	80	117	146	177	224	263	308
7 days	102	154	196	242	310	369	435

CAUTION. The time of concentration is less than one hour.

Runoff coefficients C2 = 10 % C100 = 40 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m^3/s)
1:2	0.88	23.3	97.8	22.8	10.0	10.52
1:5	0.88	39.2	97.8	38.4	20.8	36.95
1:10	0.88	51.3	97.8	50.2	26.5	61.49
1:20	0.88	63.4	97.8	62.0	31.1	89.27
1:50	0.88	79.4	97.8	77.7	36.4	130.73
1:100	0.88	91.5	97.8	89.5	40.0	165.55
1:200	0.88	103.6	97.8	101.3	43.2	202.51

ADDENDUM 5

HERBST ALGORITHM DEVELOPED AT THE
DEPARTMENT OF WATER AFFAIRS

$Q_T = C_{HERBST} A^{0,46} P^{0,93} (1+(K_T * C_V)/100)$

With:

C_{HEBST} = Coefficent of variation

A = Catchment area in km^2

P = Mean annual precipitation

K_T = Frequency factor

For this situation:

Coefficent of variation	=	153.6	
Catchment area	=	14.68	km^2
Mean annual precipitatio	=	664	mm
Frequency factor	=	4.3	
Recurrance interval	=	100	year

Q_T : 146 m^3/s

ADDENDUM 6

HRU ALGORITHM DEVELOPED AT THE
THE WITS UNIVERSITY

$Q_T = 0{,}0377 K_T P A^{0,8} (S^{0,5}/(LL_C))^{0,2}$

With:

K_T = Constant dependant on veld zone and T

A = Catchment area in km^2

P = Mean annual precipitation mm

S = Slope of the longest water course in m/m

L = Length of the longest stream in km

L_c = Distance to the centroid of the catchment in km

For this situation:

K_T	=	1.200	
A	=	14.68	km^2
P	=	664	mm
S	=	0.0140	
L	=	3.5	km
L_c	=	5	km
Recurrance interval	=	100	year

Q_T	**=**	**95**	**m^3/s**

ADDENDUM 5

TEN NOORT STEPHENSON ALGORITHM DEVELOPED AT WITS UNIVERSITY

$Q_T = (a_3P + b_3)T^{b2}A^{b1}$

With:

T = Recurrence interval in years

A = Catchment area in km^2

P = Mean annual precipitation mm

b_1 = Coefficient dependant on veld zone, region and P

b_2 = Coefficient dependant on veld zone, region and P

b_3 = Coefficient dependant on veld zone, region and P

a_3 = Coefficient dependant on veld zone, region and P

For this situation:

T	=	100	year
A	=	14.68	km^2
P	=	664	mm
a_3	=	0.0012	
b_1	=	0.69	
b_2	=	0.49	
b_3	=	-0.18	
Q_T	**=**	**60**	**m^3/s**

ADDENDUM 5
UNIT HYDROGRAPH METHOD

$Q = Q_P \times d_e \times F_m$ = Peak flood in m^3/s

With:

Q_P = Peak flood of the 1 hour synthetic hydrograph
$= K_U \times (A / T_L)$

A = Catchment area in km^2

$T_L = C_T [L \times L_C /(S^{0.5})]^{0.36}$ = Basin lag in hour

C_T = Constant depending on the sone

L = Length of the longest stream in km

L_C = Distance to catchment centroid in km

S = Average slope along longest stream

P = Mean annual precipitation

K_U = Constant depending on the sone

d_e = Percentage of storm run-off x d_g

d_g = d x a in mm

d = Design raifall depth in mm

a = Area reduction factor

i = Rainfall intensity mm/hour

and,

F_m = Highest ordinate obtained with the S-curve transformation

For this situation:

A	=	14.68 km^2
T_L	=	2.11 hour
C_T	=	0.35
L	=	3.5 km
L_C	=	5 km
S	=	0.014 m/m
P	=	664 mm
K_U	=	0.277
d_g	=	90.0 mm
d	=	28.8 mm
a	=	1
i	=	100.0 mm/hour
F_m	=	1

T	=	100 year
Q_P	=	1.9229 m^3/s
d_e	=	28.8 mm

Q = 55.38 m^3/s