Environmental Impact Management Services (Pty) Ltd

Preliminary Landform and Cover design for Kangala Colliery Future Co-disposal Facility

REPORT NO: 058_Preliminary Landform and Cover Design

MineLock
Environmental Engineers

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1. INTRODUCTION

1.1. Background

Minelock Environmental Engineers (Pty) Ltd (MineLock) was commissioned by Environmental Impact Management Services (Pty) Ltd (EIMS) to develop a preliminary landform design for a co-disposal facility at Kangala Colliery. A design for the bottom liner system as well as the capacity of the facility has already been done by Triage Business Services (Pty) Ltd (Triage). MineLock was commissioned to conduct a preliminary engineering design for the rehabilitation and closure of the co-disposal facility, which include freedrainage of the facility and a sufficient cover design.

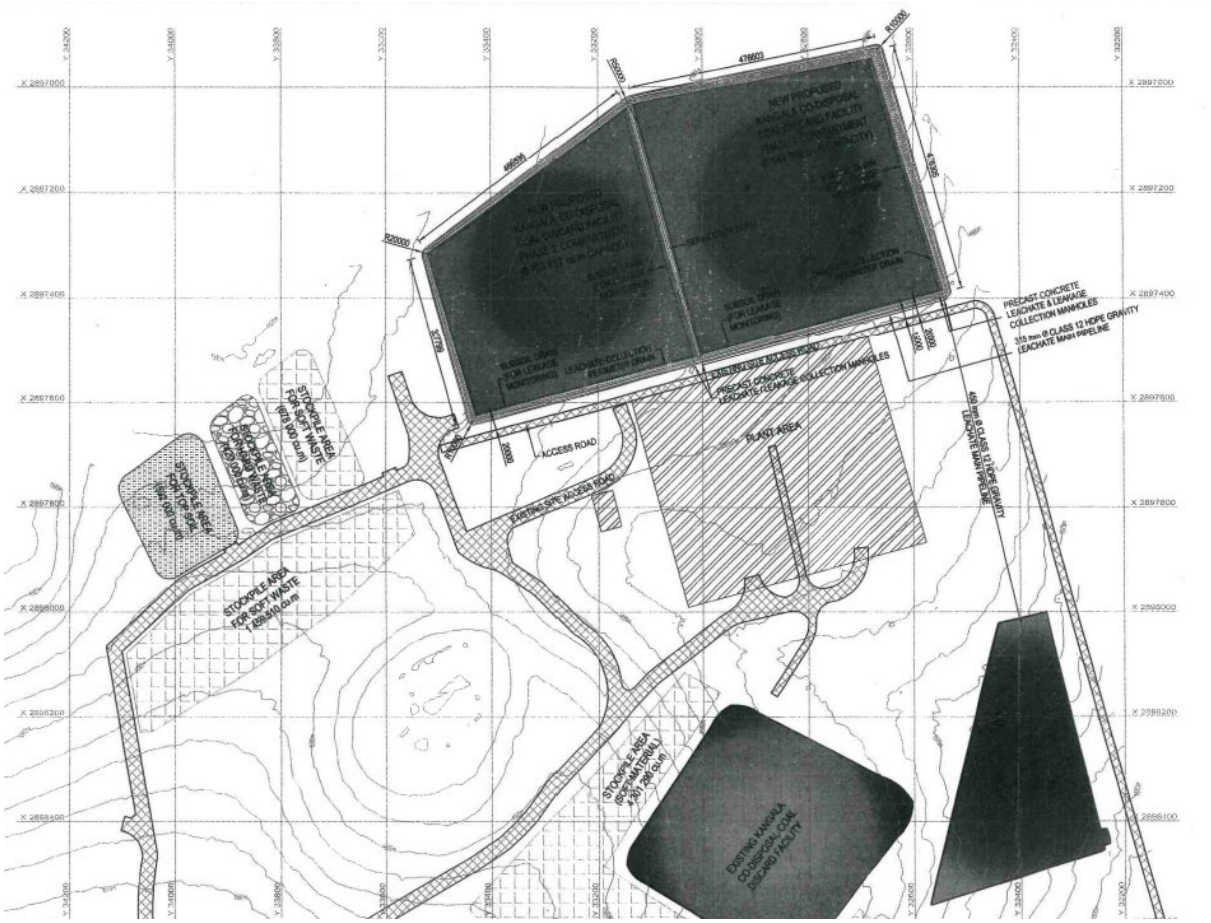

Figure 1: Conceptual design of co-disposal facility as done by Triage Business Services

1.2. Objectives

The overall project objective is to provide the mine with a preliminary rehabilitation plan and closure of the co-disposal facility which includes the following:

- Final landform development;
- Drainage design;
- Cover conceptualisation and composition;
- High level cost estimation;
- Hydrology; and
- Vegetation.

1.3. Regulatory framework

The following engineering standards, codes and reference documents are applicable to this project:

- Best Practice Guidelines for Water Resource Protection in the South African Mining Industry: Directorate: Resource Protection and Waste: Department Water Affairs and Forestry, Republic of South Africa:
    - A5 – Water Management for Surface Mines;
    - G1 – Storm Water Management;
    - G5 – Water Management Aspects for Mine Closure;
    - H1 – Integrated Mine Water Management; and
    - H2 – Pollution Prevention and Minimisation of Impacts.
- Government Notice GN 704 for water resource protection, clean and dirty water separation;
- National Norms and Standards for the assessment of Waste to landfill disposal, NEMWA 2013; and
- Capacity requirements for collection and conveyance systems.

1.4. Scope of work

The scope of work includes the following:

- Preliminary engineering design drawings of a co-disposal rehabilitation landform with sufficient drainage and cover design; and
- High level cost estimation.

1.5. Site location

Kangala Colliery is in the most Southern reach of the Olifants Catchment, which falls within the B20A quaternary catchment. The colliery is situated just South of Delmas.

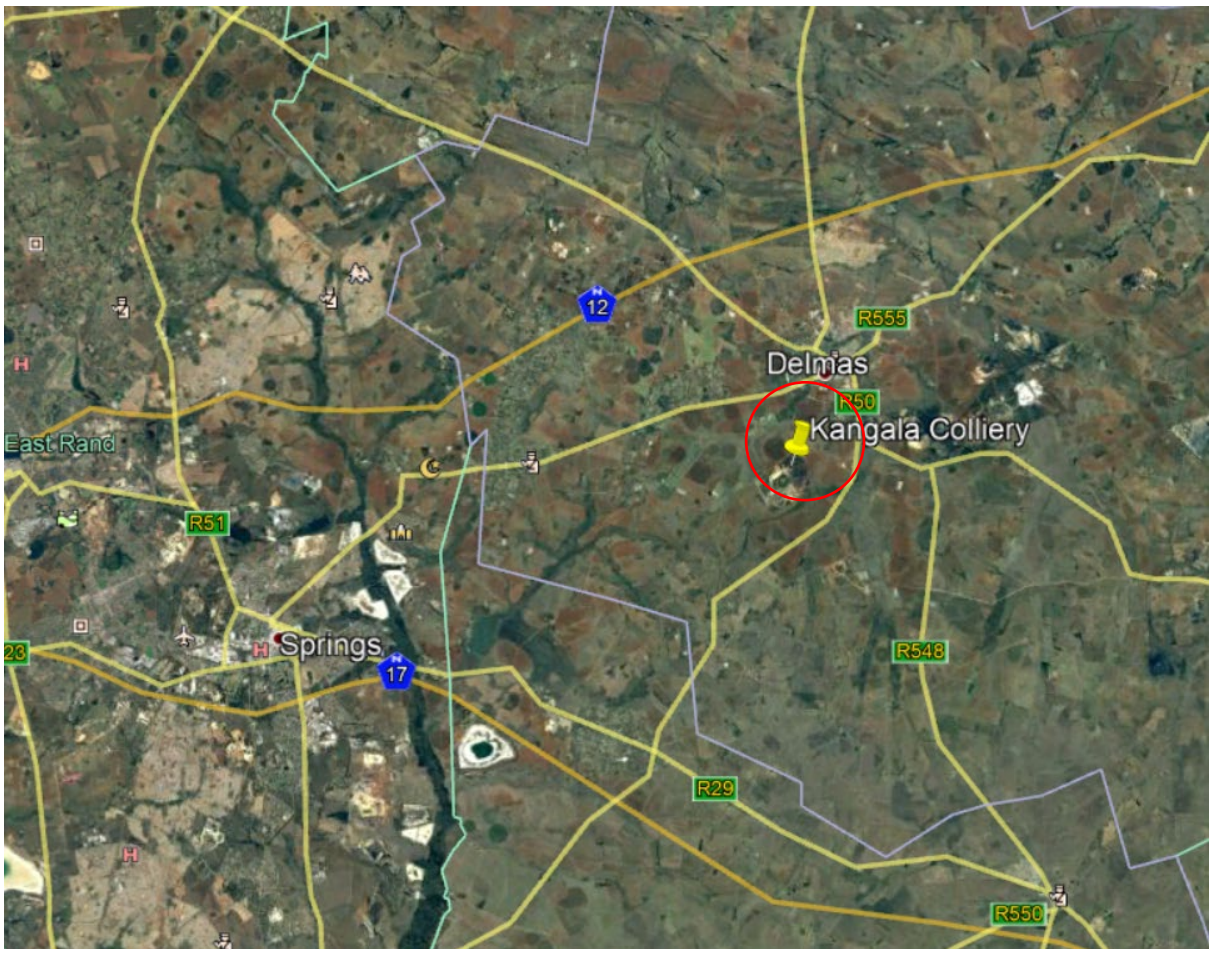

Figure 2: Location map of Kangala Colliery

2. ASSUMPTIONS AND EXCLUSIONS/LIMITATIONS

The following assumptions, qualifications and exclusions were made for the design development (but not limited to):

- It is assumed that the co-disposal facility (pre-landform) design and bottom liner system is sufficient in accordance with the waste classification of a Class C landfill barrier system as done by Triage;
- A geotechnical investigation has been excluded;
- The permeability of the cover soils were not assessed;
- It is assumed that the seismic analysis was covered by the previous design of the bottom liner and capacity as done by Triage;
- The overall stability of the landform is assumed to be stable, and thus a stability analysis is excluded; and
- Authority engagement.

3. CLIMATE DATA

Daily rainfall data was sourced from the Design Rainfall Estimation in South Africa (Ver 3, Natal University) rainfall database (gauge number 0477309 – Delmas). The gauge is located approximately 7.6 km south of the mining rights area. The data that was used contains daily records and patched records between July 1907 and August 2000, or over 93 years. The data is considered representative of the mining rights area and is good quality.

3.1 Peak Rainfall data

The peak 24-hr rainfall depths are presented in Table 1.

Table 1: Peak 24-hr rainfall depths for the mining rights area

Recurrence Interval (year)	24 hour rainfall depth (mm)
2	53.8
10	89.9
20	106.4
50	130.4
100	150.6
200	172.8

4. SHAPING ALTERNATIVES

The current conceptual co-disposal facility, as designed by Triage, (Report No. TBS-201904002-UCKC) consists of a bottom liner system for a Class C landfill and a discard facility capacity of 13 347 326 m³.

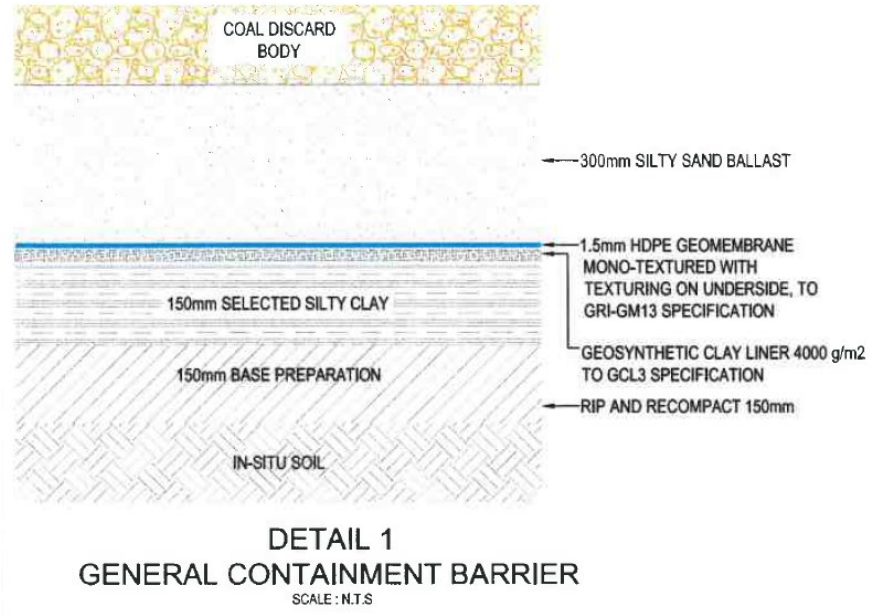

Figure 3: Bottom liner system as designed by Triage Business Services

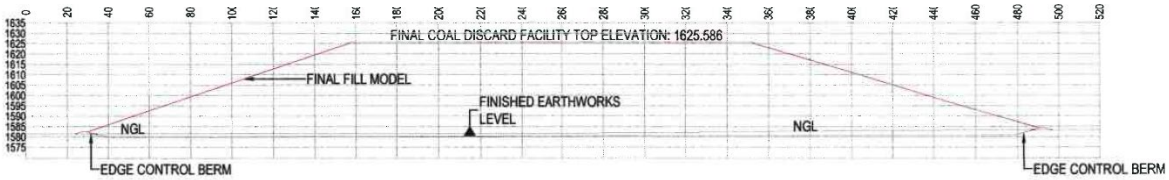

Figure 4: Section view of conceptual facility as designed by Triage Business Services

The design by Triage is sufficient in the fact that the design has an adequate bottom liner system as stated by the Norms and Standards for a Class C landfill site, and the required capacity of the disposal facility.

Although it is a sufficient design, the side slopes of the facility, which is currently 1:3, will lead to a greater risk of erosion and instabilities within the life span of the facility. Two alternatives were assessed with regards to the general shape of the facility to achieve the most beneficial conclusion with regards to current and long term costs and rehabilitation.

4.1 Alternative 1 – Continuation on current

Although a slope of 1:3 is steep, it is still possible to design a sufficient rehabilitation plan. This plan will then need to include more frequent and ongoing monitoring and maintenance on the site. Thus, increasing the long term risk and expenditures connected to this design.

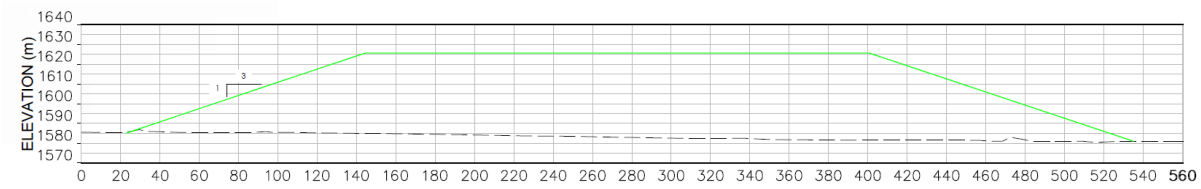

Figure 5: Section view of continuation on current co-disposal facility design

4.1.1 Cut-off drains

To assist with the erosion of the rehabilitated landform during storm events, cut-off drain channels have been implemented along the slopes of the landform every 20m against the slope of the landform.

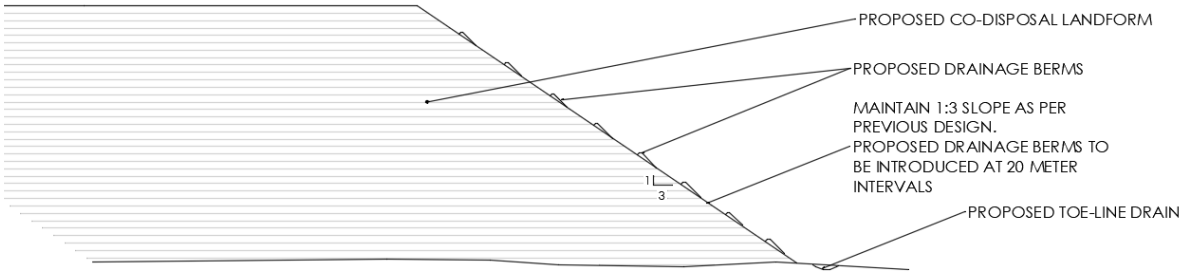

Figure 6: Section view of continuation on current design and cut-off drain channels

The drains were sized according to the catchment size of each area, as well as the applicable rainfall data which can be found in Section 3.

Catchment delineation

The catchments were delineated using 1m contour data, which was supplied by EIMS. The landform was divided into several areas according to the slopes and flow of water.

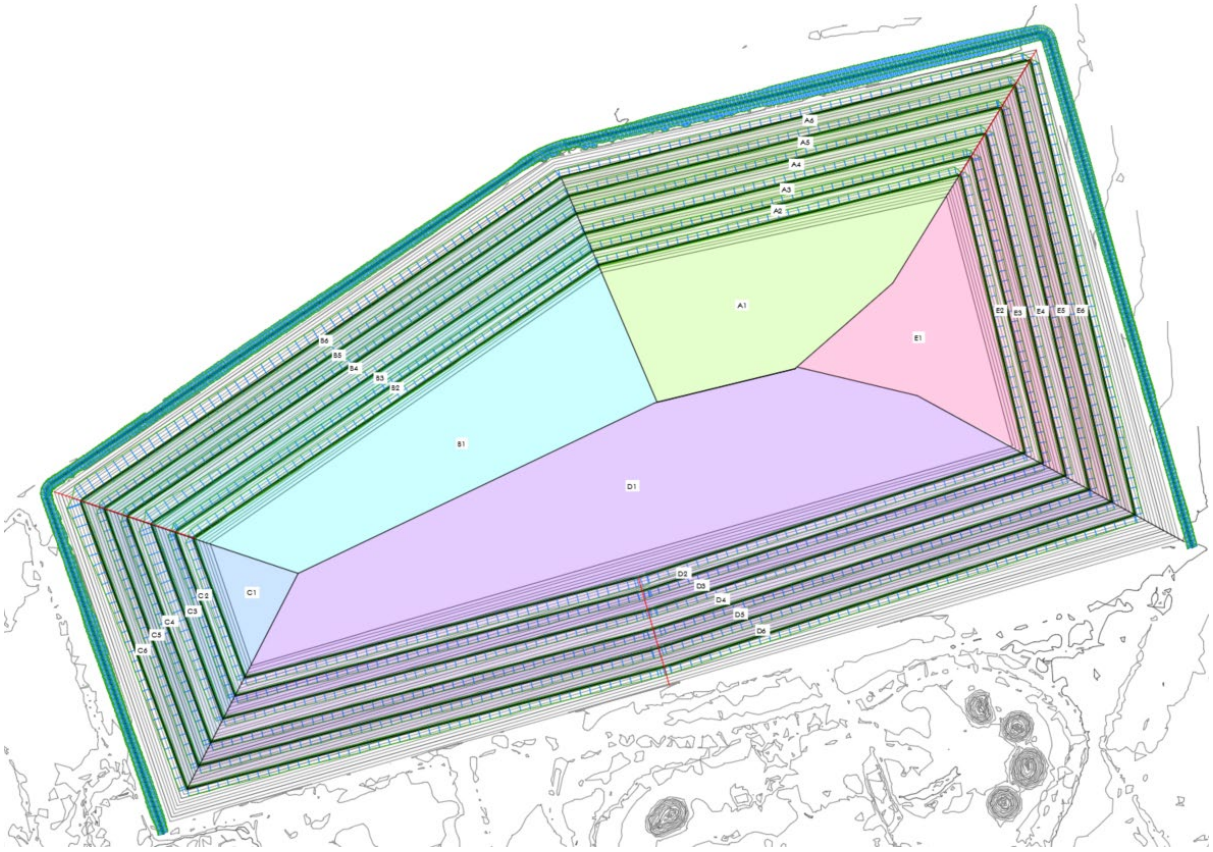

Figure 7: Alternative 1 Catchment delineation

Flood peak calculation

The rational method was used to determine the flood peaks. The mean annual precipitation (MAP) for this site is 661 mm. This data was interpolated to allow for the simulation of a 24 hour storm event with a return period up to 50 years. The Rational Method was used to determine the peak floods for the simulated 24 hour storm event.

The old Department of Water Affairs' calculation sheet was used to determine the runoff coefficients. The time-to-concentration of the sub-catchments was calculated using the SCS method which is suitable for relatively undeveloped catchments. Adamson's TR102 (Adamson, 1981) was used to convert the 24-hour peak rainfall data to rainfall intensities appropriate to the time-to-concentration of the catchments. The 1085 method was used to calculate catchment slopes. The results of these calculations for all sub-catchments are summarised in Table 2.

Design of cut-off drains

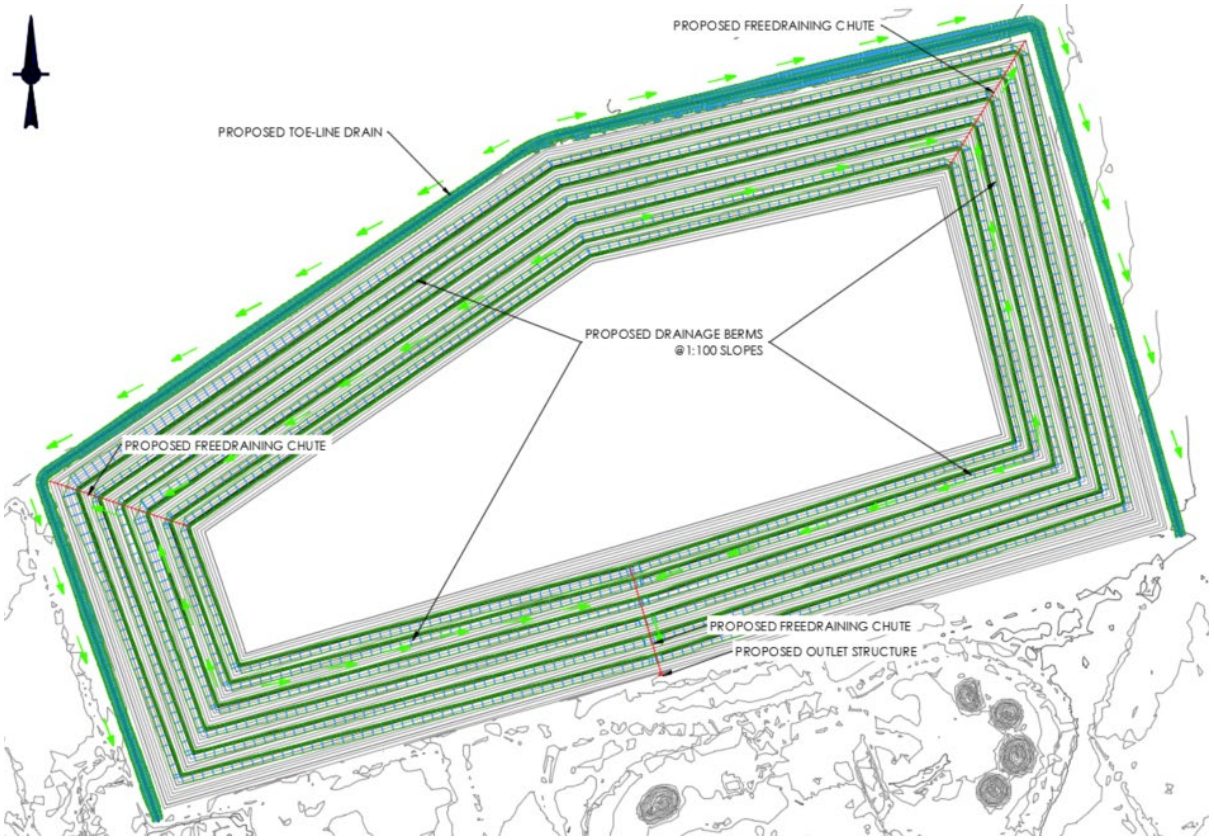

Figure 8: Location of cut-off drains for design alternative 1

The rehabilitated landform includes cut-off drain channels at 20m intervals down the slope to aid in erosion control for the steep slopes. The flood peaks presented in Table 1 were used to size the channels. The flow depth in the channels were calculated with the Mannings open channel flow equation. A mannings n of 0.03 was used as the channels will be hydroseeded and eventually be lined with grass. The channels are trapezoidal with side slopes of 1:2 (V:H).

A 0.3m freeboard was used to allow for wave action and flow surges in the channel (Bosman, Basson, Tente, & Basson, 2011) as well as the capacity to handle the 1:200 year flood without any freeboard. Refer to Table 2 for a summary of the channel sizes.

Table 2: Catchment and channel sizing for Alternative 1

CHANNEL	CATCHMENT AREA	AREA (m^2)	LENGTH (m)	50-yr FLOOD PEAK (m^3/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)
CHANNEL A1	A1	37 507	358	1.24	0.94	0.95
CHANNEL A2	A2	5 300	375	0.18	0.56	0.60
CHANNEL A3	A3	7 050	395	0.23	0.62	0.65
CHANNEL A4	A4	8 275	420	0.27	0.70	0.70
CHANNEL A5	A5	7 874	442	0.26	0.69	0.70
CHANNEL A6	A6	8 764	466	0.28	0.71	0.70
CHANNEL B1	B1	47 579	471	1.57	1.00	1.00
CHANNEL B2	B2	7 019	486	0.23	0.62	0.65
CHANNEL B3	B3	9 264	504	0.31	0.66	0.70
CHANNEL B4	B4	10 147	522	0.34	0.72	0.75
CHANNEL B5	B5	9 779	540	0.31	0.72	0.75
CHANNEL B6	B6	10 386	557	0.32	0.72	0.75
CHANNEL C1	C1	5 889	143	0.19	0.60	0.65
CHANNEL C2	C2	2 226	167	0.07	0.48	0.60
CHANNEL C3	C3	3 466	198	0.11	0.53	0.60
CHANNEL C4	C4	4 143	232	0.14	0.58	0.65
CHANNEL C5	C5	4 584	263	0.15	0.60	0.65
CHANNEL C6	C6	5 177	298	0.17	0.62	0.65
CHANNEL D1	D1	85 762	783	2.29	0.93	1.20
CHANNEL D2	D2	11 265	807	0.37	0.70	0.70
CHANNEL D3	D3	15 524	844	0.51	0.76	0.75
CHANNEL D4	D4	16 646	880	0.54	0.81	0.85
CHANNEL D5	D5	16 838	916	0.56	0.83	0.85
CHANNEL D6	D6	17 488	951	0.58	0.84	0.85
CHANNEL E1	E1	22 805	275	0.75	0.83	0.85
CHANNEL E2	E2	4 182	305	0.14	0.54	0.60
CHANNEL E3	E3	5 944	338	0.20	0.59	0.65
CHANNEL E4	E4	7 149	378	0.24	0.66	0.70
CHANNEL E5	E5	7 216	411	0.24	0.67	0.70
CHANNEL E6	E6	8 320	446	0.28	0.69	0.70

4.2 Alternative 2 - Dome Design

Because of the steep 1:3 slopes of the previous design and the restriction of the size of the available site, the material can't be dozed down to form a flatter slope. Thus, the following methodology is proposed to achieve a dome-like shape, and still maintaining the capacity of the facility:

- A cut to fill balance was performed between the 1:3 slope and a new 1:5 slope. Both these slopes are steep, but can be managed with cut off drains at intervals to manage erosion (cut off drains to be discussed in Section 4.2.1).
- A dome-like design was developed with the final top part of the facility being designed at a slope of 1:10

This methodology serves to achieve the needed capacity of the facility in such a manner that the facility can be successfully rehabilitated with less risk of long term erosion and associated maintenance requirements/costs.

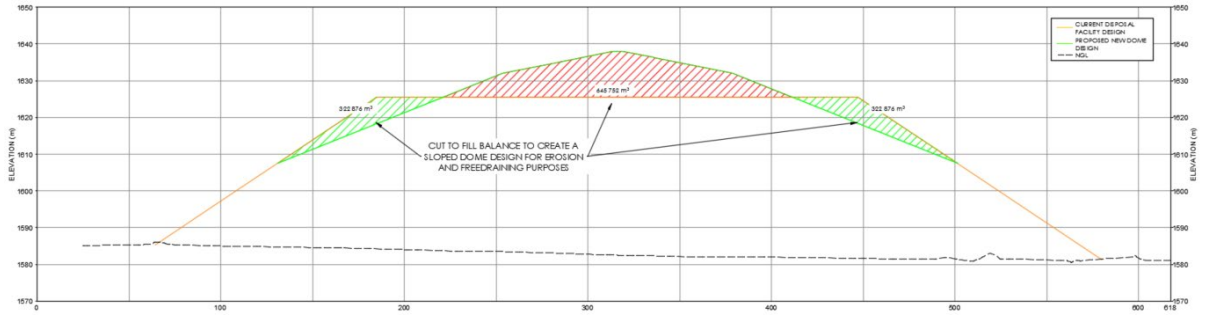

Figure 9: Section view of dome design of co-disposal facility

4.2.1 Cut-off drains

To assist with the erosion of the rehabilitated landform during storm events, cut-off drain channels have been implemented along the slopes of the landform:

- 1:5 slope – every 50m against the slope of the landform
- 1:3 slope – every 20m against the slope of the landform

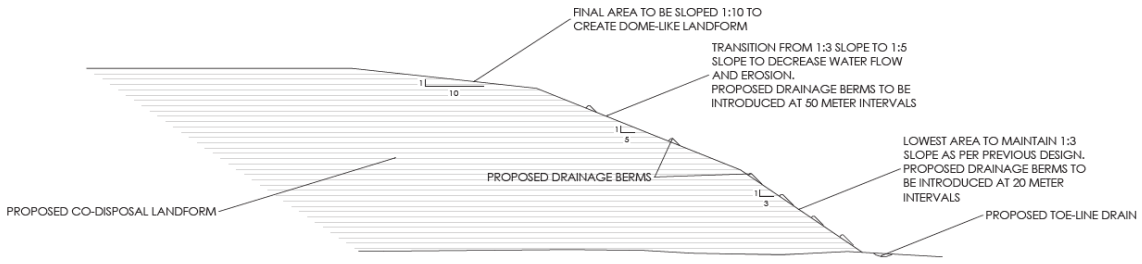

Figure 10: Section view of dome-like design and channels

The drains were sized according to the catchment size of each area, as well as the applicable rainfall data which will be discussed in the rest of this section.

Catchment delineation

The catchments were delineated using 1m contour data, which was supplied by EIMS. The landform was divided into several areas according to the slopes and flow of water.

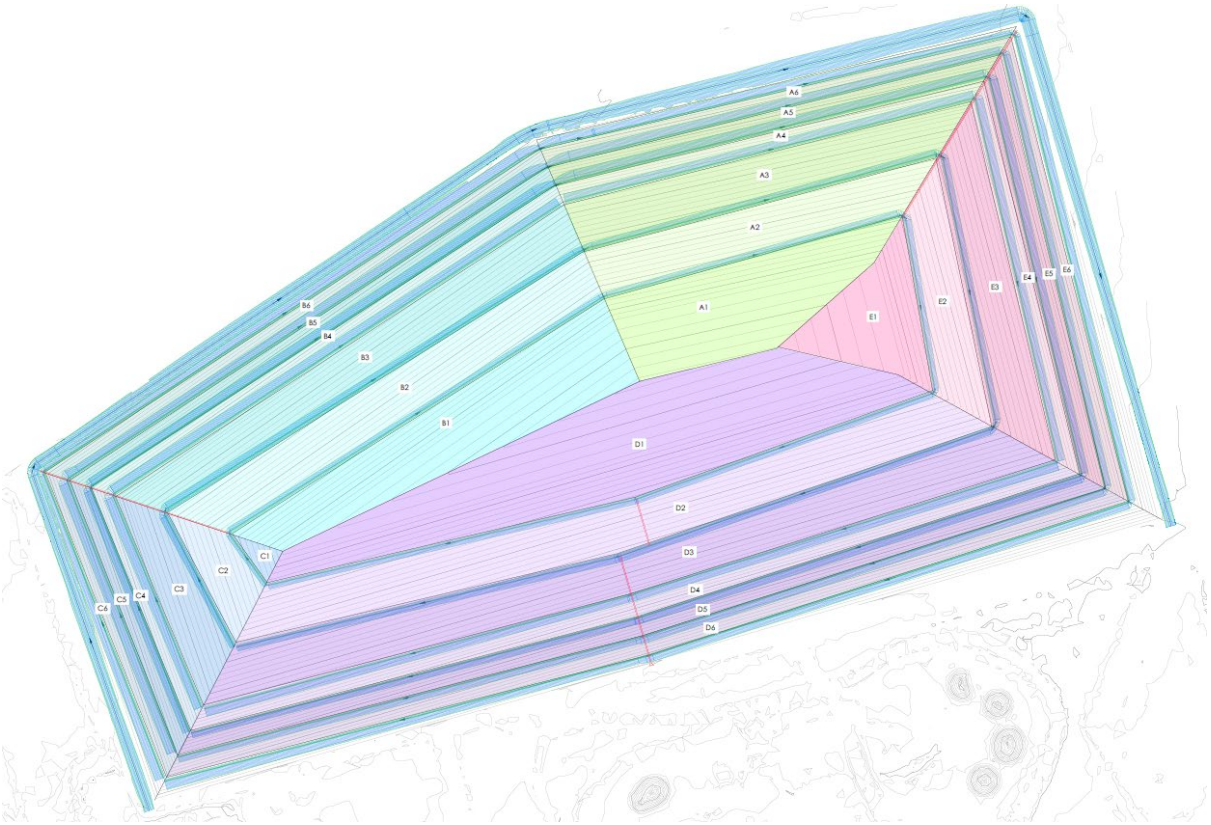

Figure 11: Alternative 2 catchment delineation

Flood peak calculation

The sub-catchments were delineated. The rational method was used to determine the flood peaks.

The mean annual precipitation (MAP) for this site is 661 mm. This data was interpolated to allow for the simulation of a 24 hour storm event with a return period up to 50 years. The Rational Method was used to determine the peak floods for the simulated 24 hour storm event (Appendix B).

The old Department of Water Affairs' calculation sheet was used to determine the runoff coefficients. The time-to-concentration of the sub-catchments was calculated using the SCS method which is suitable for relatively undeveloped catchments. Adamson's TR102 (Adamson, 1981) was used to convert the 24-hour peak rainfall data to rainfall intensities appropriate to the time-to-concentration of the catchments. The 1085 method was used to calculate catchment slopes. The results of these calculations for all sub-catchments are summarised in Table 2.

Design of cut-off drains

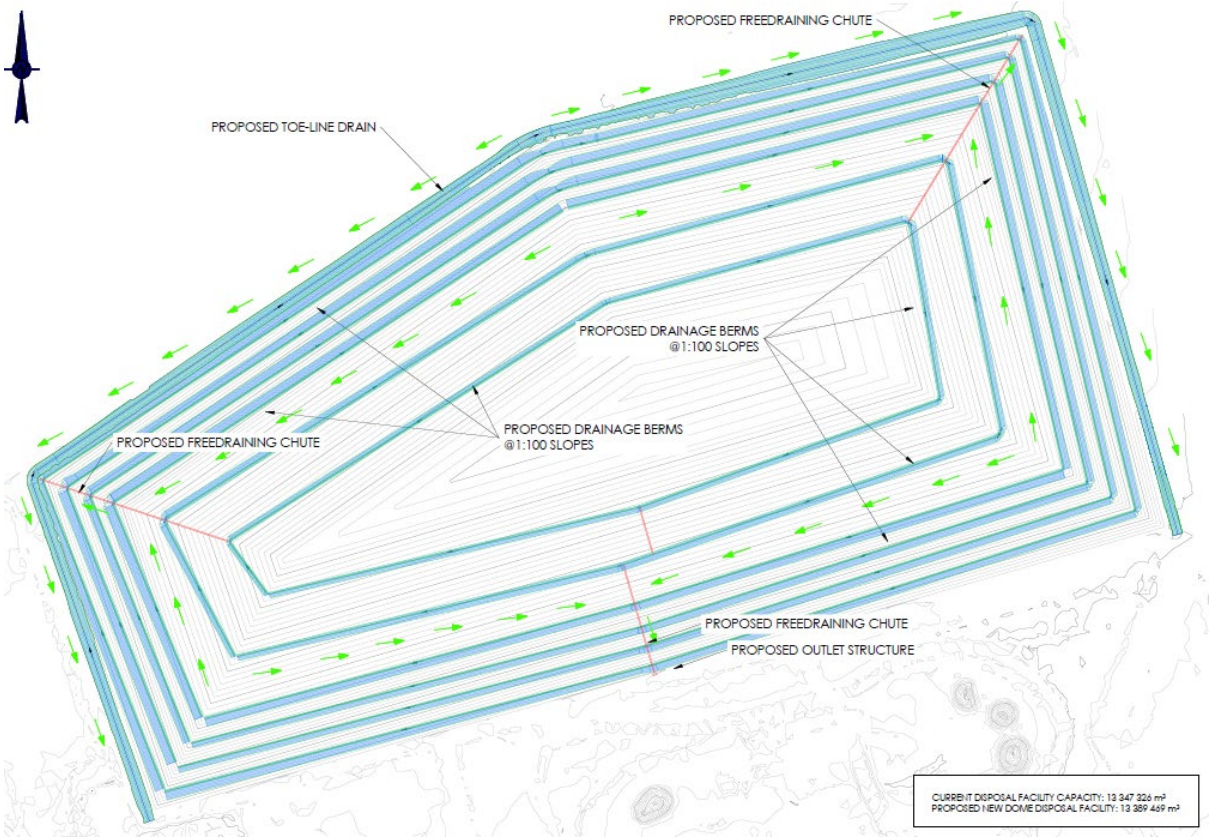

Figure 12: Location of cut-off drains for design alternative 2

The rehabilitated landform includes cut-off drain channels to aid in erosion control for steeper slopes. The flood peaks presented in Table 1 were used to size the channels. The flow depth in the channels were calculated with the Mannings open channel flow equation. A mannings n of 0.03 was used as the channels will be hydroseeded and eventually be lined with grass. The channels are trapezoidal with side slopes of 1:2 (V:H).

A 0.3m freeboard was used to allow for wave action and flow surges in the channel (Bosman, Basson, Tente, & Basson, 2011) as well as the capacity to handle the 1:200 year flood without any freeboard. Refer to Table 3 for a summary of the channel sizes.

Table 3: Catchment and channel sizing for Alternative 2

CHANNEL	CATCHMENT AREA	AREA (m^2)	LENGTH (m)	50-yr FLOOD PEAK (m^3/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)
CHANNEL A1	A1	20 601	302	0.68	0.81	0.80
CHANNEL A2	A2	15 456	358	0.51	0.76	0.75
CHANNEL A3	A3	17 790	415	0.59	0.78	0.80
CHANNEL A4	A4	7 603	432	0.25	0.68	0.70
CHANNEL A5	A5	8 791	453	0.29	0.71	0.70
CHANNEL A6	A6	7 614	473	0.25	0.69	0.70
CHANNEL B1	B1	25 468	429	0.84	0.86	0.85
CHANNEL B2	B2	22 699	480	0.75	0.83	0.85
CHANNEL B3	B3	22 033	525	0.73	0.82	0.85
CHANNEL B4	B4	10 955	541	0.36	0.75	0.75
CHANNEL B5	B5	9 860	559	0.31	0.73	0.75
CHANNEL B6	B6	10 769	577	0.33	0.73	0.75
CHANNEL C1	C1	842	60	0.03	0.34	0.45
CHANNEL C2	C2	4 913	147	0.16	0.57	0.60
CHANNEL C3	C3	8 439	226	0.28	0.65	0.65
CHANNEL C4	C4	4 659	260	0.15	0.61	0.65
CHANNEL C5	C5	5 072	291	0.17	0.61	0.65
CHANNEL C6	C6	5 596	324	0.19	0.62	0.65
CHANNEL D1	D1	45 541	672	1.51	0.99	1.00
CHANNEL D2	D2	35 221	769	1.17	0.92	0.90
CHANNEL D3	D3	37 225	874	1.23	0.94	0.95
CHANNEL D4	D4	19 095	907	0.63	0.85	0.85
CHANNEL D5	D5	18 238	945	0.60	0.85	0.85
CHANNEL D6	D6	18 264	978	0.60	0.85	0.85
CHANNEL E1	E1	10 680	179	0.35	0.69	0.70
CHANNEL E2	E2	10 173	274	0.34	0.67	0.70
CHANNEL E3	E3	15 323	371	0.51	0.75	0.75
CHANNEL E4	E4	6 885	403	0.23	0.66	0.70
CHANNEL E5	E5	8 830	441	0.29	0.71	0.70
CHANNEL E6	E6	7 291	472	0.24	0.68	0.70

5. COVER CONFIGURATION

As specified by Triage, the disposal facility was classified as a Type 3 waste, which calls for a Class C landfill liner and cover configuration. The cover will remain the same for both alternatives.

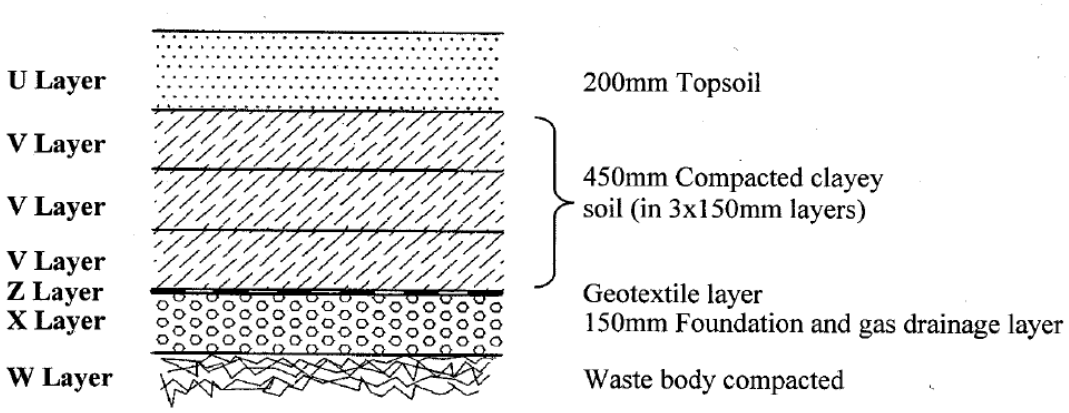

Figure 13: Cover design for Class C landfill according to the Norms and Standards

The following deviations were made form the proposed standard guidelines:

- The gas drainage layer has been removed as this is a mining disposal facility and not a landfill site. No gas will be generated through this waste;
- A layer of 4% lime stabilised material has been added as a lime stabiliser to the coal;
- Due to the slopes and the runoff that will occur, the clay layer has been replaced by layers of coarse and topsoil materials available on site, that will serve as an infiltration layer for the runoff. The infiltrated runoff will be collected in perforated pipes alongside the drainage berms and deposited into the drainage chutes;
- The coarse and fine materials, as a capillary action breaker, will be separated by geotextile to ensure that the fines won't fill the pockets of the coarse material, and will only be encased in a geocell in slopes steeper than 1:5

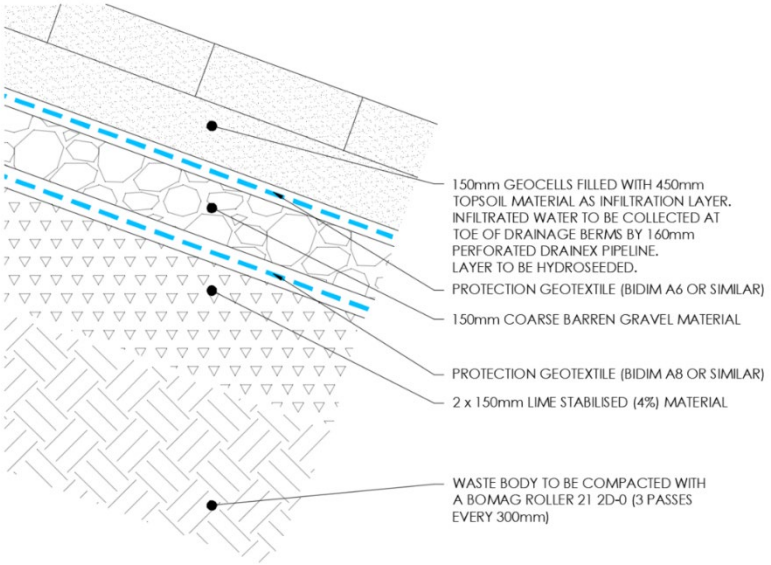

Figure 14: Proposed capillary barrier system design

This proposed capillary barrier will serve as a sufficient cover to divide the possible acidic coal waste from the surrounding area. The coal coarse and fine material will need to be sufficiently compacted to form a tight bond between material and water, releasing all oxygen from the facility, this will ensure that spontaneous combustion of the material will not be possible.

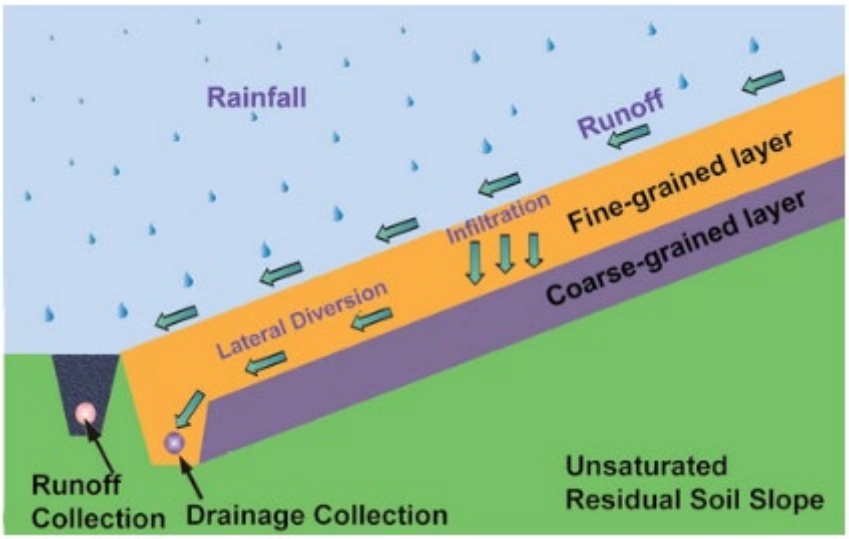

Figure 15: Schematic of proposed capillary barrier system

With Alternative 1, a thicker layer of topsoil (1m) will need to be placed over the flat top of the facility, because of a faster infiltration rate with a flatter slope.

The specific properties of the cover material have not been specified within this report and will need to be addressed during detail design. A full permeability analysis and material balance would need to be performed of all the stockpiles available on site. If there aren't enough suitable material available on site, then a geosynthetic alternative (geomembrane or geosynthetic clay liner) will need to be investigated with regards to its integrity and strength on long high slopes.

5.1 Vegetation

The cover will have to be suitably vegetated to maintain the cover's integrity as well as to contribute to the evaporative functionality of the cover over the long term.

Vegetation performance is dictated by the local climatic conditions, the grass species selected and the soil conditions in the cover material. These performance requirements could be summarised as follows:

- The vegetation mix must include an early sprouting annual grass species (nurse crop) and vegetative plant material that provide the function of stabilising the cover soils against erosion in the event of early season intense rainfall events, and to a lesser extent due to wind erosion;
- The vegetation mix must also include perennial deep rooted grass species that have the potential to mobilise "free" water contained in the cover over the full cover depth; and
- The established vegetation must be able to withstand grazing by livestock and veld fires, as the rehabilitated and closed mine site will most likely be subjected to subsistence community pressures in future.

The grass species included in the vegetation mix were selected for their suitability to Highveld-type conditions, and also for their proven performance under harsh climatic and other conditions. The high intensity rainfall associated with summer thunderstorms in the area necessitates the inclusion of the vegetative planting of contour strips of Kikuyu (Pennisetum clandestinum) on the steeper outer slopes of the co-disposal facility. Installed correctly, these strips will provide immediate storm protection to the slopes. The areas between the planted contour strips should be sown with a seed mixture.

6. STORM WATER DRAINAGE DETAILS

6.1 Design of cut-off drains

Although there are two alternatives with regards to the shape of the co-disposal facility, the general design of the cut-off drain channels do remain the same. An integrated berm channel has been designed with geomat and hydroseeding with a protection geotextile lining to prevent any possible scouring.

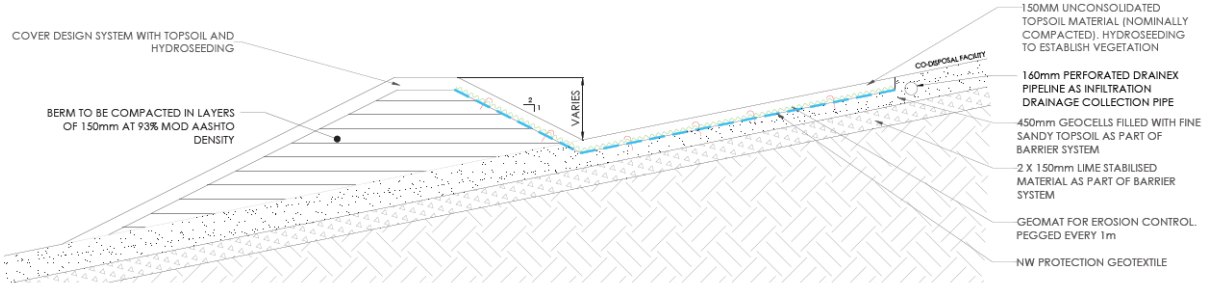

Figure 16: Typical detail of proposed drainage berms

6.2 Channels vegetation

All surface drains will be vegetated to ensure long term integrity that allows for the following:

- To stabilise the channels immediately after construction, by planting bands of vegetative sods of Kikuyu grass to limit the possibility of erosion by providing an immediate average basal cover of 20%;
- To include in the seed mix a fast growing grass (nurse crop) to provide early stabilization of soils between sodded areas to reduce the risk of erosion in these areas;
- To formulate a seed mix biased towards a variety of perennial creeping grasses that will tolerate a wide range of climatic and soil conditions, and which will provide a high basal cover in the long term;
- To include creeping grass species with both rhizomatous (underground) and stoloniferous (above ground) growth characteristics to maximise the protection afforded by the grass cover. The main objective of establishing a grass cove that “bolts” the soil in place and which has high basal cover, is to provide the vegetal retardance within the drains to reduce the erosion potential of the runoff;
- To establish a vegetation cover within the channels that will be persistent in the long term and comprises species that have an inherent ability to recolonize (repair) any areas of potential erosion scour or livestock (hoof) damage; and

- To provide a vegetation cover that will withstand grazing by livestock and that will be resilient to veld fires.

6.3 Chutes

Chutes need to be introduced to assist in the flow of storm water from the channels on the facility back into the surrounding environment. The chutes were designed as a trapezoidal channel that will be placed at strategic locations on the landform for the channels to connect with to flow the water into the surroundings. The locations can be seen in Sections 4.1.1 and 4.2.1 respectively.

The catchment area reporting to the stormwater chute is 49 ha with a peak flow for a return period of 200 years as indicated in Table 4. Allowance was made to construct the stormwater chute with rock mattress to route surface water at steep slopes and high flow velocities to ground level.

Table 4: Catchment and chute sizing

CHUTE	CATCHMENT AREA	AREA (m²)	LENGTH (m)	200-yr FLOOD PEAK (m³/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)	FLOW TYPE AT MAX FLOW VELOCITY
CHUTE 1	A & E	137 037	212	6.32	7.71	0.80	Supercritical flow
CHUTE 2	D	173 584	194	8.01	8.30	0.85	Supercritical flow
CHUTE 3	B & C	131 304	415	6.06	7.61	0.75	Supercritical flow

The infiltration drainage pipeline from the designed cover also daylights within the chute, thus acting as the total drainage channel for the entire facility. A typical section of the discharge chute is indicated on Figure 17.

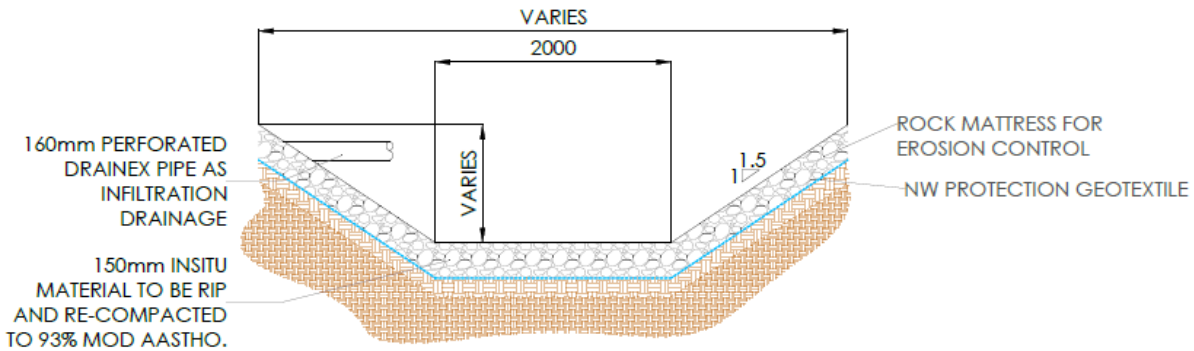

Figure 17: Typical detail of freedraining chute

6.4 Toe-line drain

The co-disposal facility is situated in the north-eastern section of the mine with the natural topography running from north-west to south-eastern direction. Because of the location of the facility a toe-line drain was introduced. This drain will intercept any storm water from the surroundings before it connects with the facility itself as well as the flow of the freedraining chutes.

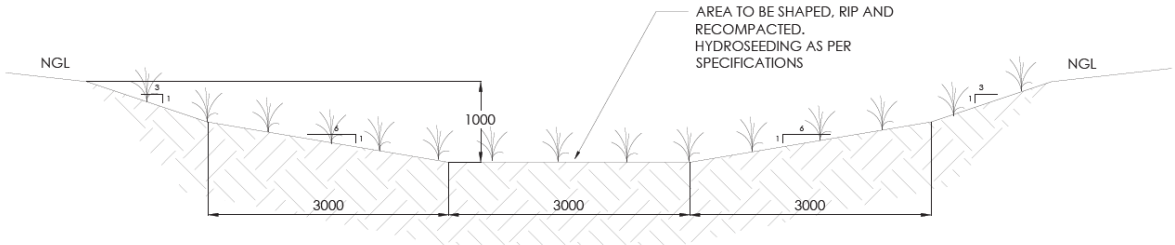

Figure 18: Typical detail of toe-line drain

The catchment area of the toe-line drain has been sized according to the entire facility. The sizing of this drain will need to be further investigated during detail design level, because of the catchments upstream of this channels.

7. SUMMARY

Although both designs are implementable in their own way, a summarising comparison has been done in Table 5.The high level cost estimates can be found in Appendix C.

Table 5: Summary of Alternatives

DESCRIPTION	ALTERNATIVE 1	ALTERNATIVE 2
Engineering	As discussed in Section 4.1, this alternative of maintaining the 1:3 slope design is possible but does come with erosion and long term rehabilitation problems. Cut-off drain channels have been proposed for every 20m down the slope of the facility with a final rehabilitated cover.	As discussed in Section 4.2, shaping the facility from a 1:3 to a 1:5 and 1:10 sloping area will go a long way with erosion control and the monitoring of the facility in long term. Cut-off drain channels have been proposed at different positions down the slope of the facility with a final rehabilitated cover.
Cost		
Site Clearance	R 1 478 730.00	R 1 483 142.13
Storm water channels and berms earthworks	R 23 124 514.70	R 23 349 180.58
Storm water channels and berms geosynthetics	R 72 040 303.96	R 73 401 439.47
Cover	R 143 049 942.63	R 143 409 366.05
Erosion protection	R 40 418 620.00	R -
Subtotal A	**R 280 112 111.29**	**R 241 643 128.24**

30% P's & Gs **Subtotal B** 10% contingency allowance **Estimated Total (excl. Vat)** Additional Earthworks Expense	R 84 033 633.39 **R 394 145 744.68** R 36 414 574.47 **R 400 560 319.15** R -	R 72 492 938.47 **R 314 136 066.71** R 31 413 606.67 **R 345 549 673.38** R 54 850 174.88
	This cost only reflects the immediate capital expenditure and not the cost of long term monitoring and management.	The additional general earthworks reflects the cost of shaping the facility post deposition. A large cost saving aspect for this alternative is if the general earthwork cut to fill shaping exercise of the facility is incorporated into the daily operations of the mine, thus saving about R55 million.
Sustainability	Alternative 1 is not a sustainable option due to the steep slopes of the designed facility. Extra erosion protection and ongoing maintenance will need to be done to counter the erosion that will occur at the toe of the facility. These slopes are also unsafe with respect to animal and human traffic on and around it.	Alternative 2 limits the erosion by shaping the facility to more adequate slopes. This will be very beneficial with regards to erosion protection and safety. This alternative will not require long term maintenance and much less frequent monitoring.

8. CONCLUSION

MineLock has designed a sufficient preliminary landform design with two alternatives for a co-disposal facility at Kangala Colliery as commissioned by EIMS. A design for the bottom liner system as well as the capacity of the facility was done by Triage.

MineLock proposes Alternative 2 preliminary engineering design for the rehabilitation and closure of the co-disposal facility, which include freedrainage of the facility and a sufficient cover design with a high level cost estimation. Alternative 2 is the more beneficial option with regards to long term rehabilitation, monitoring and management of the co-disposal facility, and if it is considered to incorporate the newly shaped facility into the daily operations, a large cost saving can be achieved.

9. REFERENCES

Kruger, E. (2013). *Drainage Manual Sixh Edition.* Pretoria: The South Arfican National Roads Agency.

Robert M. Koerner, Y. G. (2011). Geomembrance Lifetime Prediction: Unexposed and Exposed Conditions. *Geosynthetic Institute*, 24.

Adamson, P.T., Southern African Storm Rainfall, Department of Environment Affairs, Technical Report TR102, Pretoria, 1981.

Middleton, B.J. and Bailey, A.K., Water Resources of South Africa, 2005 study (WR2005), 2009. WRC Report No TT 382/08.

Midgley, D.C., Pitman, W.V., Middleton, B.J. Surface Water Resources of South Africa, 1990. WRC Report No 298/2.1/94, Volume 2.

Bosman, D., Basson, J., Tente, T., & Basson, G. (2011). South African Committee on Large Dams (SANCOLD) Guidelines on Freeboard on Dams. *SA Water Research Commission*, 65.

Kruger, E. (2013). *Drainage Manual Sixh Edition.* Pretoria: The South Arfican National Roads Agency.

Robert M. Koerner, Y. G. (2011). Geomembrance Lifetime Prediction: Unexposed and Exposed Conditions. *Geosynthetic Institute*, 24.

Douglas Richards
Environmental Engineer

Johann Le Roux
Project Manager
Pr. Tech. Eng.

APPENDIX A

CONCEPTUAL LANDFORM DESIGN DRAWINGS ALTERNATIVE 2

KANGALA COLLIERY CO-DISPOSAL FACILITY
PROPOSED LANDFORM AND COVER DESIGN
ALTERNATIVE 2

DRAWING LIST		
DRAWING NR	**DRAWING NAME**	**REV**
P058-000	COVER PAGE	A
P058-001	PRE-DEVELOPMENT GENERAL ARRANGEMENT	A
P058-002	POST DEVELOPMENT GENERAL ARRANGEMENT	A
P058-003	CO-DISPOSAL FACILITY LANDFORM	A
P058-004	CATCHMENT DELINEATION	A
P058-005	FREEDRAINING CHANNEL DETAILS	A

Notes:

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PINE PARK, LINDEN

ENGINEER: JOHANN LE ROUX
PR NR. 2020300713

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TITLE: COVER PAGE AND LIST OF DRAWINGS

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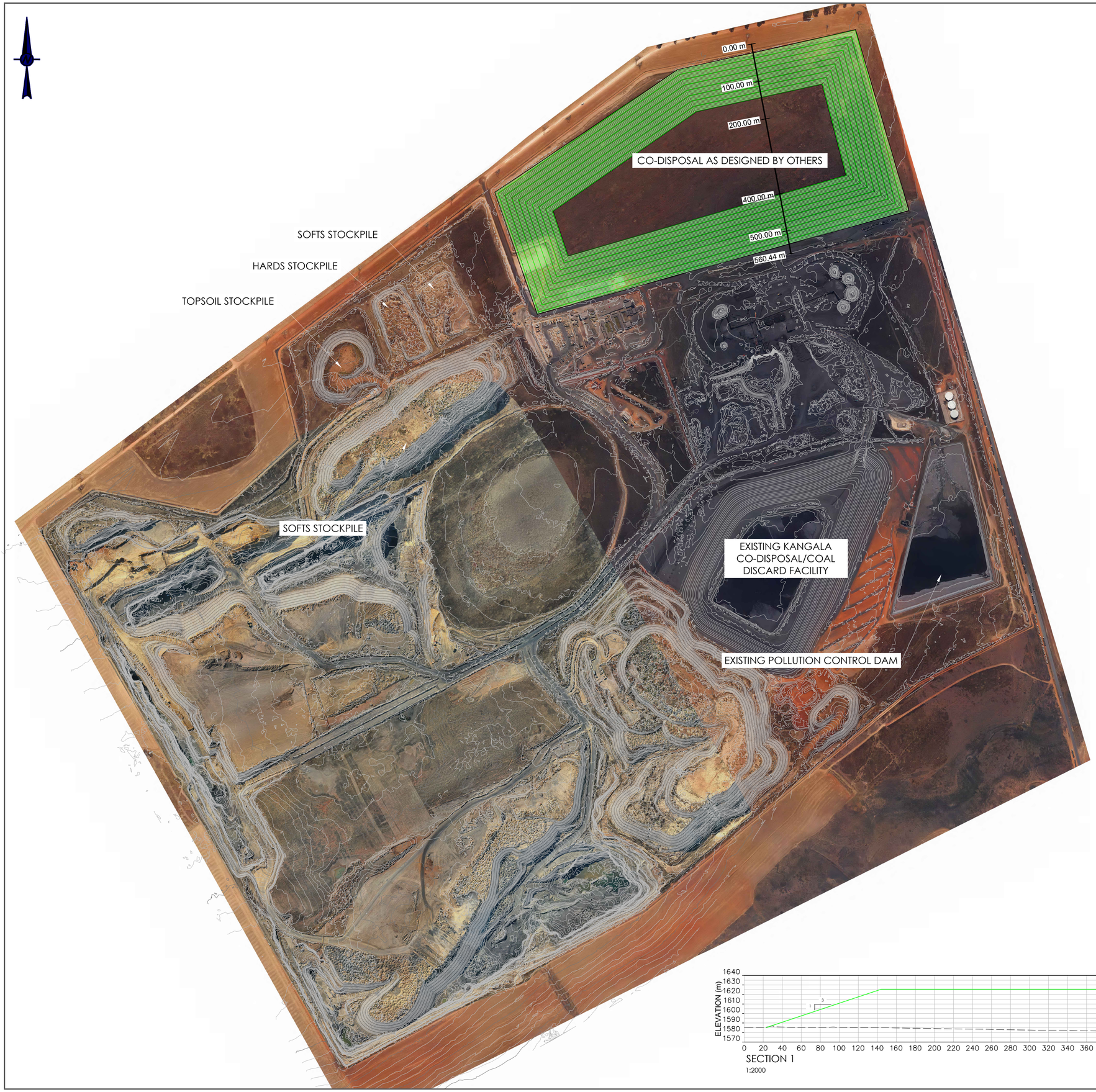

SECTION 1
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Notes:

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5. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

LEGEND

- EXISTING GROUND (1 m CONTOURS)
- CO-DISPOSAL FACILITY
- DRAINAGE BERMS
- FREEDRAINING CHUTES

CATCHMENT AREAS

A1 - 20 601 m²	C4 - 4 659 m²
A2- 15456 m²	C5 - 5 072 m²
A3 - 17 790 m²	C6 - 5 596 m²
A4 - 7 603 m²	D1 - 45 541 m²
A5 - 8 791 m²	D2 - 35 221 m²
A6 - 7 614 m²	D3 - 37 225 m²
B1 - 25 468 m²	D4 - 19 095 m²
B2 - 22 699 m²	D5 - 18 238 m²
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B4 - 10 955 m²	E1 - 10 680 m²
B5 - 9 860 m²	E2 - 10 173 m²
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C2 - 4 913 m²	E5 - 8 830 m²
C3 - 8 439 m²	E6 - 7 291 m²

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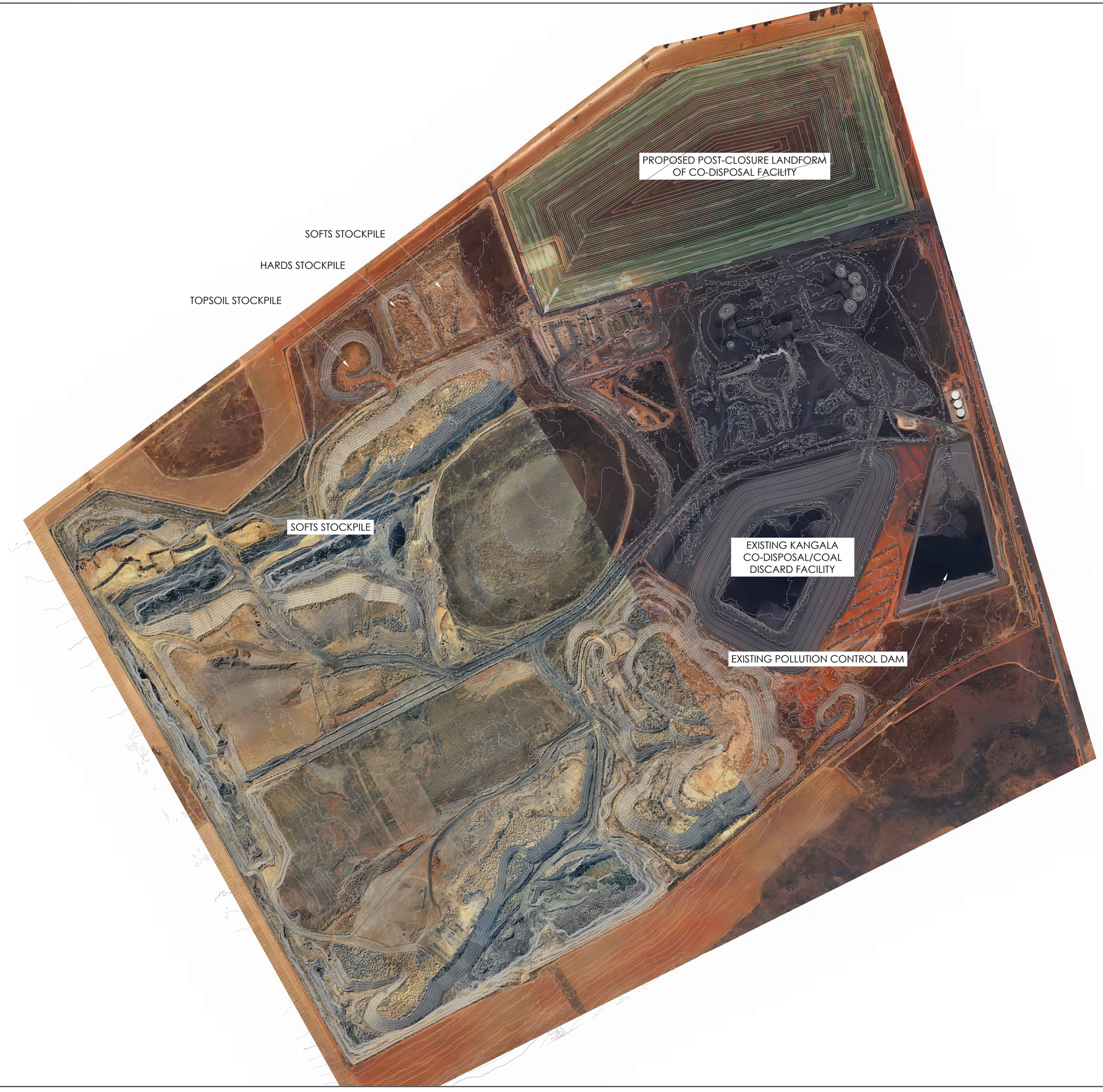

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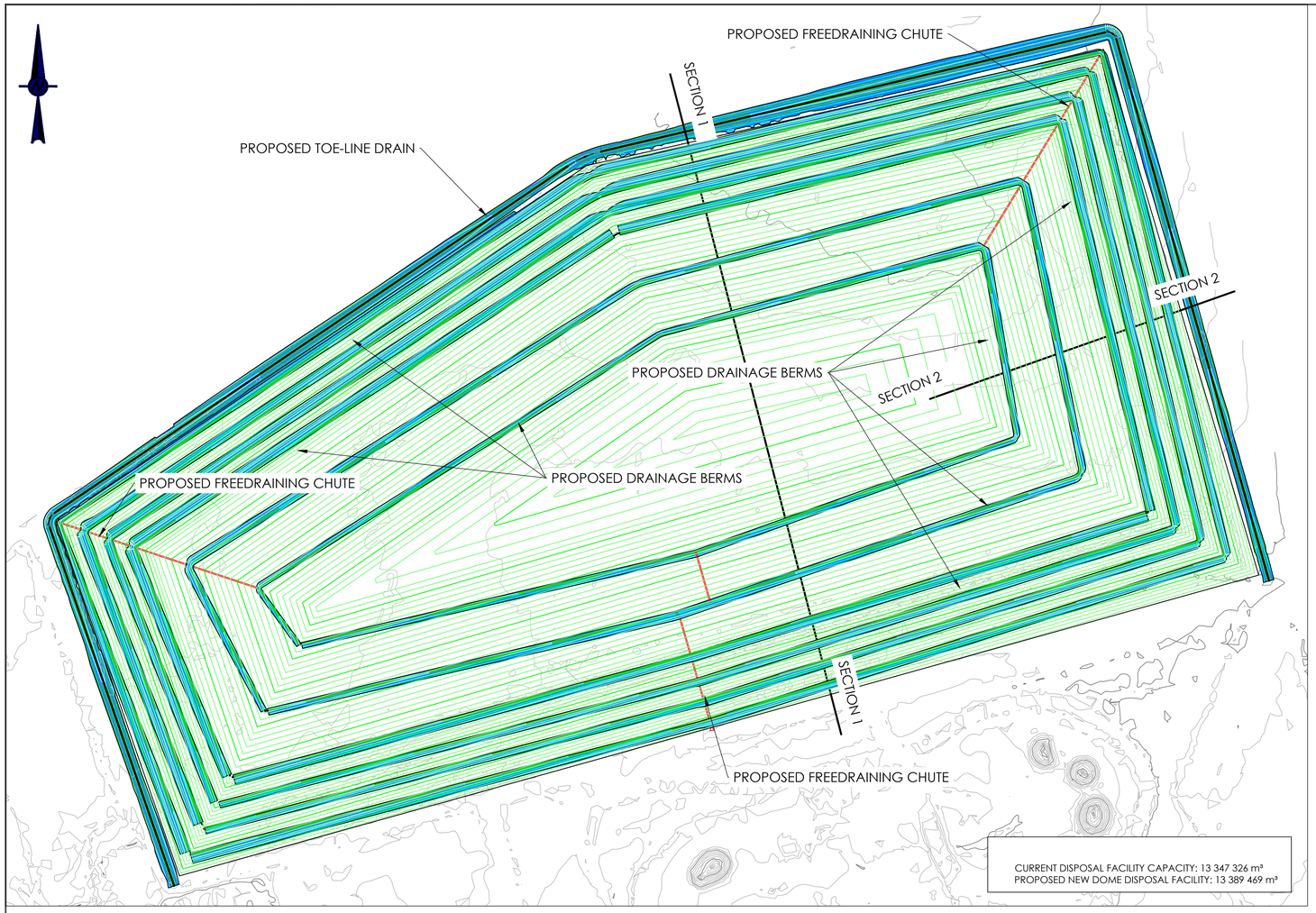

KEY PLAN - KHUTALA FUTURE CO-DISPOSAL FACILITY

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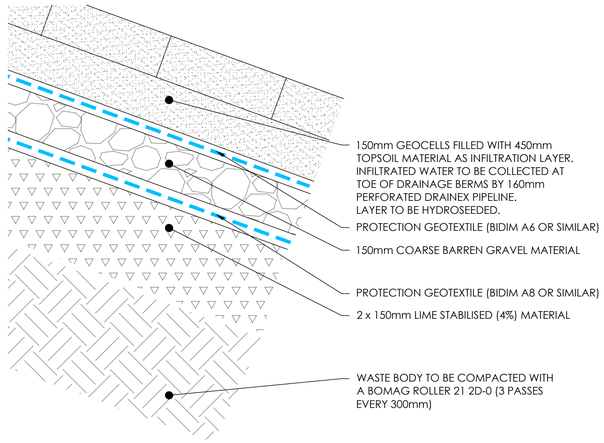

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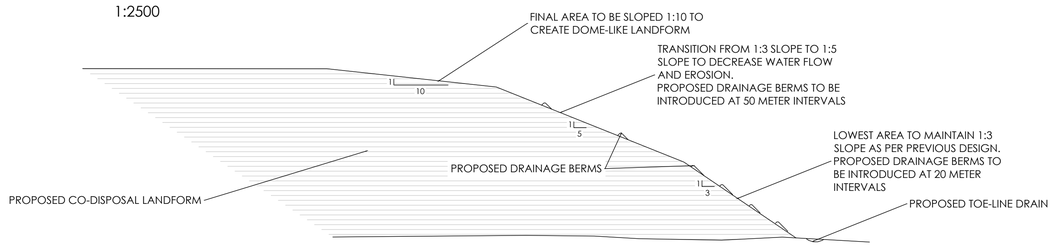

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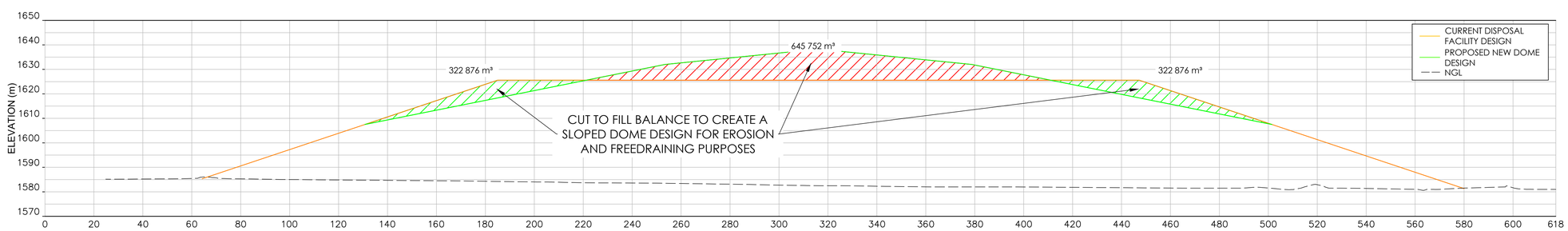

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LEGEND

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- CO-DISPOSAL FACILITY
- DRAINAGE BERMS
- FREEDRAINING CHUTES

CATCHMENT AREAS

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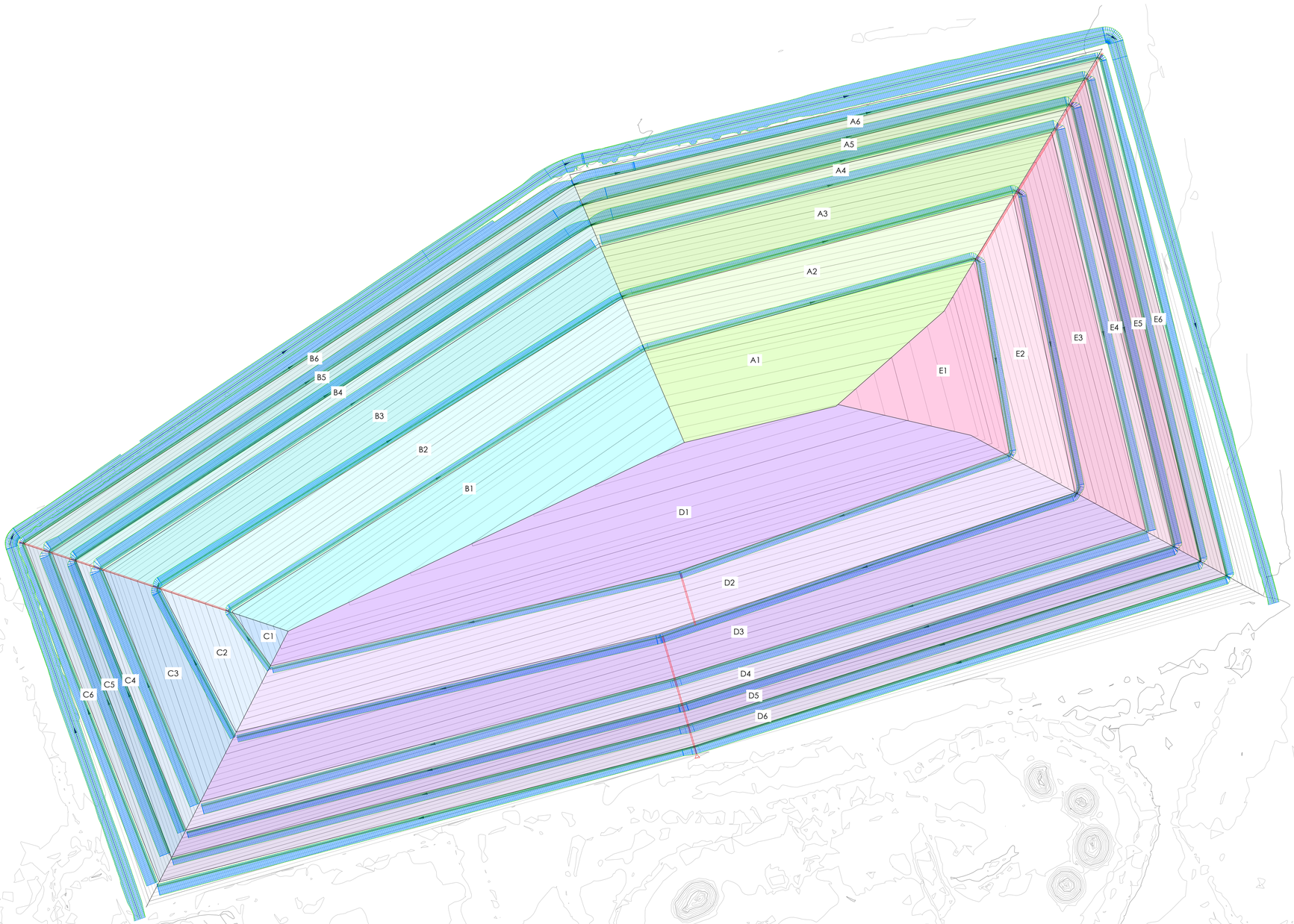

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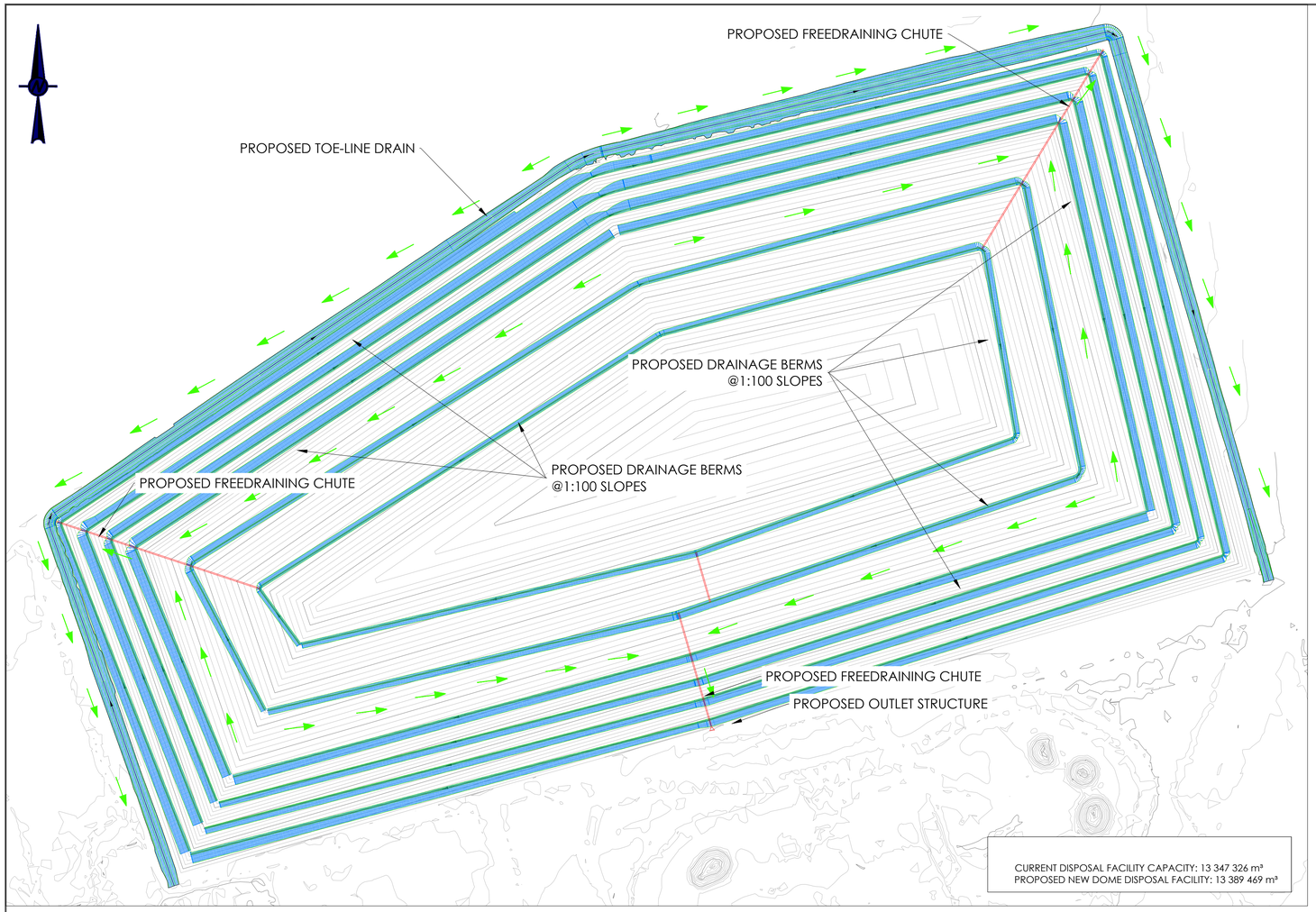

KEY PLAN - KHUTALA FUTURE CO-DISPOSAL FACILITY

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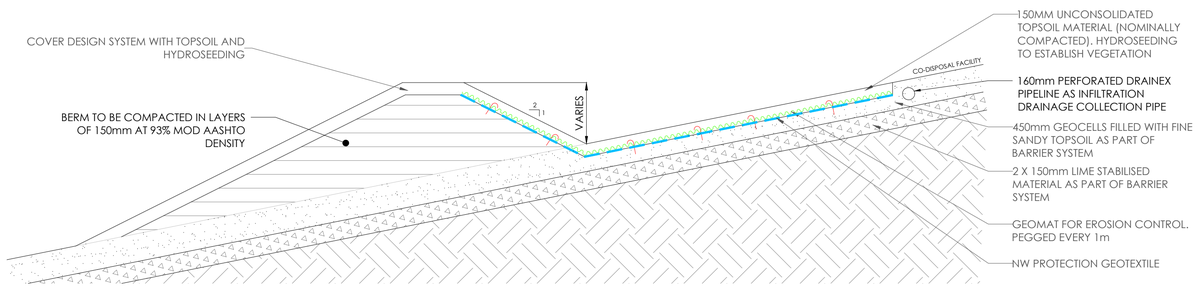

TYPICAL DETAIL OF DRAINAGE BERMS

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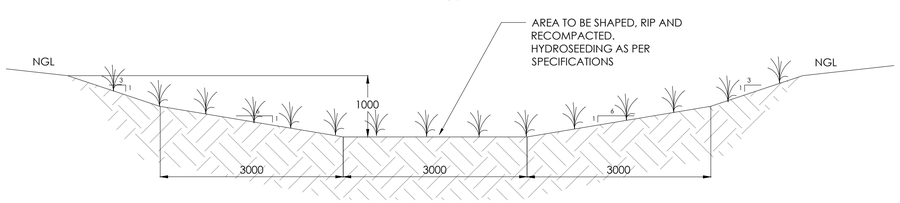

TYPICAL DETAIL OF TOE-LINE DRAIN

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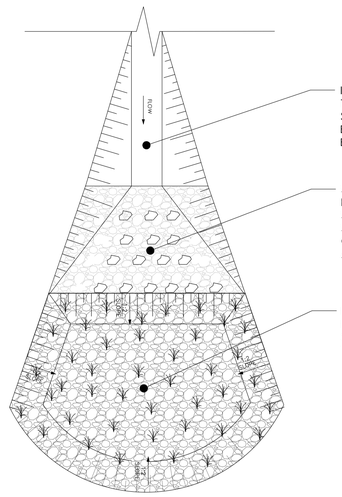

PROPOSED OUTLET STRUCTURE

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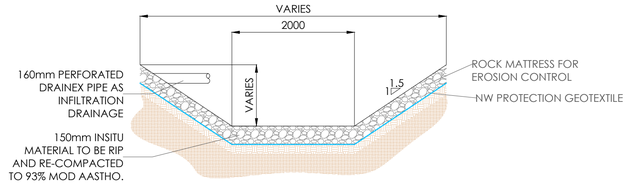

TYPICAL DETAIL OF CHUTE

1:50

CHANNEL	CATCHMENT AREA	AREA (m²)	LENGTH (m)	50-yr FLOOD PEAK (m³/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)	FLOW TYPE AT MAX FLOW VELOCITY
CHANNEL A1	A1	20 601	302	0.68	0.81	0.80	Supercritical flow
CHANNEL A2	A2	15 456	358	0.51	0.76	0.75	Supercritical flow
CHANNEL A3	A3	17 790	415	0.59	0.78	0.80	Supercritical flow
CHANNEL A4	A4	7 603	432	0.25	0.68	0.70	Supercritical flow
CHANNEL A5	A5	8 791	453	0.29	0.71	0.70	Supercritical flow
CHANNEL A6	A6	7 614	473	0.25	0.69	0.70	Supercritical flow
CHANNEL B1	B1	25 468	429	0.84	0.86	0.85	Supercritical flow
CHANNEL B2	B2	22 699	480	0.75	0.83	0.85	Supercritical flow
CHANNEL B3	B3	22 033	525	0.73	0.82	0.85	Supercritical flow
CHANNEL B4	B4	10 955	541	0.36	0.75	0.75	Supercritical flow
CHANNEL B5	B5	9 860	559	0.31	0.73	0.75	Supercritical flow
CHANNEL B6	B6	10 769	577	0.33	0.73	0.75	Supercritical flow
CHANNEL C1	C1	842	60	0.03	0.34	0.45	Supercritical flow
CHANNEL C2	C2	4 913	147	0.16	0.57	0.60	Supercritical flow
CHANNEL C3	C3	8 439	226	0.28	0.65	0.65	Supercritical flow
CHANNEL C4	C4	4 659	260	0.15	0.61	0.65	Supercritical flow
CHANNEL C5	C5	5 072	291	0.17	0.61	0.65	Supercritical flow
CHANNEL C6	C6	5 596	324	0.19	0.62	0.65	Supercritical flow
CHANNEL D1	D1	45 541	672	1.51	0.99	1.00	Supercritical flow
CHANNEL D2	D2	35 221	769	1.17	0.92	0.90	Supercritical flow
CHANNEL D3	D3	37 225	874	1.23	0.94	0.95	Supercritical flow
CHANNEL D4	D4	19 095	907	0.63	0.85	0.85	Supercritical flow
CHANNEL D5	D5	18 238	945	0.60	0.85	0.85	Supercritical flow
CHANNEL D6	D6	18 264	978	0.60	0.85	0.85	Supercritical flow
CHANNEL E1	E1	10 680	179	0.35	0.69	0.70	Supercritical flow
CHANNEL E2	E2	10 173	274	0.34	0.67	0.70	Supercritical flow
CHANNEL E3	E3	15 323	371	0.51	0.75	0.75	Supercritical flow
CHANNEL E4	E4	6 885	403	0.23	0.66	0.70	Supercritical flow
CHANNEL E5	E5	8 830	441	0.29	0.71	0.70	Supercritical flow
CHANNEL E6	E6	7 291	472	0.24	0.68	0.70	Supercritical flow

CHUTE	CATCHMENT AREA	AREA (m²)	LENGTH (m)	200-yr FLOOD PEAK (m³/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)	FLOW TYPE AT MAX FLOW VELOCITY
CHUTE 1	A & E	137 037	212	6.32	7.71	0.80	Supercritical flow
CHUTE 2	D	173 584	194	8.01	8.30	0.85	Supercritical flow
CHUTE 3	B & C	131 304	415	6.06	7.61	0.75	Supercritical flow

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A2- 15456 m²	C5 - 5 072 m²
A3 - 17 790 m²	C6 - 5 596 m²
A4 - 7 603 m²	D1 - 45 541 m²
A5 - 8 791 m²	D2 - 35 221 m²
A6 - 7 614 m²	D3 - 37 225 m²
B1 - 25 468 m²	D4 - 19 095 m²
B2 - 22 699 m²	D5 - 18 238 m²
B3 - 22 033 m²	D6 - 18 264 m²
B4 - 10 955 m²	E1 - 10 680 m²
B5 - 9 860 m²	E2 - 10 173 m²
B6 - 10 769 m²	E3 - 15 323 m²
C1 - 842 m²	E4 - 6 885 m²
C2 - 4 913 m²	E5 - 8 830 m²
C3 - 8 439 m²	E6 - 7 291 m²

REV.	DESCRIPTION:	BY:	DATE:
A	ISSUED FOR INFORMATION	IW	12/02

STATUS: ISSUED FOR INFORMATION

MineLock Pty Ltd
30 Winston Road
Eldoraigne
Centurion
0157
www.minelock.co.za

CLIENT: EIMS (PTY) LTD
8 DALMERY ROAD
PINE PARK, LINDEN

ENGINEER: JOHANN LE ROUX
PR NR. 2020300713

SITE: KANGALA COLLIERY CO-DISPOSAL FACILITY ALT. 2

TITLE: PROPOSED CO-DISPOSAL FACILITY DRAINAGE

SCALE AT A1:	DATE:	DRAWN:	CHECKED:
AS SHOWN	12/02	IW	DR

PROJECT NO:	DRAWING NO:	REVISION:
P058	005	A

APPENDIX B

RATIONAL METHOD CALCULATIONS FOR CHANNEL DESIGN ALT 2

Channel	Corresponding Area	Area (m²)	Longest watercourse (m)	50-yr flood peak (m³/s)	Total Area (m²)	Longest watercourse (km)	Lining	Flat Longitudinal Slopes (V:H)	Flow depth (m)	Max flow velocity (m/s)	Froude	Flow type at max velocity	Comments	Proposed channel depth (m)
A1	A1	20 600.99	315.125	0.68	20600.993	0.315125	MACMAT	0.01	0.49	0.81	4.65	Supercritical flow		0.79
A2	A2	15 456.35	364.635	0.51	15456.347	0.364635	MACMAT	0.01	0.44	0.76	4.49	Supercritical flow		0.74
A3	A3	17 790.40	416.315	0.59	17 790.40	0.416315	MACMAT	0.01	0.47	0.78	4.52	Supercritical flow		0.77
A4	A4	7603.201	430.645	0.25	7 603.20	0.430645	MACMAT	0.01	0.38	0.68	6.91	Supercritical flow		0.68
A5	A5	8790.691	453.934	0.29	8 790.69	0.453934	MACMAT	0.01	0.40	0.71	7.01	Supercritical flow		0.70
A6	A6	7613.823	469.443	0.25	7 613.82	0.469443	MACMAT	0.01	0.38	0.69	6.93	Supercritical flow		0.68
B1	B1	25468.414	435.376	0.84	25 468.41	0.435376	MACMAT	0.01	0.53	0.86	4.78	Supercritical flow		0.83
B2	B2	22699.435	489.369	0.75	22 699.44	0.489369	MACMAT	0.01	0.51	0.83	4.69	Supercritical flow		0.81
B3	B3	22033.17	526.4	0.73	22 033.17	0.5264	MACMAT	0.01	0.51	0.82	4.64	Supercritical flow		0.81
B4	B4	10954.508	537.17	0.36	10 954.51	0.53717	MACMAT	0.01	0.44	0.75	7.26	Supercritical flow		0.74
B5	B5	9859.601	555.838	0.31	9 859.60	0.555838	MACMAT	0.01	0.41	0.73	7.24	Supercritical flow		0.71
B6	B6	10768.642	575.875	0.33	10 768.64	0.575875	MACMAT	0.01	0.42	0.73	7.04	Supercritical flow		0.72
C1	C1	841.694	50.182	0.03	841.69	0.050182	MACMAT	0.01	0.15	0.34	2.65	Supercritical flow		0.45
C2	C2	4912.836	121.826	0.16	4 912.84	0.121826	MACMAT	0.01	0.29	0.57	3.95	Supercritical flow		0.59
C3	C3	8439.193	194.537	0.28	8 439.19	0.194537	MACMAT	0.01	0.35	0.65	4.12	Supercritical flow		0.65
C4	C4	4658.899	250.62	0.15	4 658.90	0.25062	MACMAT	0.01	0.32	0.61	6.73	Supercritical flow		0.62
C5	C5	5071.82	276.951	0.17	5 071.82	0.276951	MACMAT	0.01	0.33	0.61	4.73	Supercritical flow		0.63
C6	C6	5595.932	313.98	0.19	5 595.93	0.31398	MACMAT	0.01	0.34	0.62	6.27	Supercritical flow		0.64
D1	D1	45541.427	554.503	1.51	45 541.43	0.554503	MACMAT	0.01	0.67	0.99	5.09	Supercritical flow		0.97
D2	D2	35220.901	350.772	1.17	35 220.90	0.350772	MACMAT	0.01	0.60	0.92	4.91	Supercritical flow		0.90
D3	D3	37225.311	424.401	1.23	37 225.31	0.424401	MACMAT	0.01	0.62	0.94	5.00	Supercritical flow		0.92
D4	D4	19094.655	456.439	0.63	19 094.66	0.456439	MACMAT	0.01	0.54	0.85	7.60	Supercritical flow		0.84
D5	D5	18237.634	469.368	0.60	18 237.63	0.469368	MACMAT	0.01	0.53	0.85	7.72	Supercritical flow		0.83
D6	D6	18264.328	492.064	0.60	18 264.33	0.492064	MACMAT	0.01	0.53	0.85	7.74	Supercritical flow		0.83
E1	E1	10680.403	173.201	0.35	10 680.40	0.173201	MACMAT	0.01	0.38	0.69	4.36	Supercritical flow		0.68
E2	E2	10172.936	239.427	0.34	10 172.94	0.239427	MACMAT	0.01	0.38	0.67	4.18	Supercritical flow		0.68
E3	E3	15322.626	331.211	0.51	15 322.63	0.331211	MACMAT	0.01	0.44	0.75	4.41	Supercritical flow		0.74
E4	E4	6885.293	386.725	0.23	6 885.29	0.386725	MACMAT	0.01	0.37	0.66	6.63	Supercritical flow		0.67
E5	E5	8830.087	423.122	0.29	8 830.09	0.423122	MACMAT	0.01	0.40	0.71	7.09	Supercritical flow		0.70
E6	E6	7290.671	456.945	0.24	7 290.67	0.456945	MACMAT	0.01	0.38	0.68	6.87	Supercritical flow		0.68
CHUTE 1	A & E	137 037.47	532.395	6.32	137 037.47	0.532395	RENO	0.1	0.46	7.71	4.696113719	Supercritical flow	CATCHMENT A & E	0.76
CHUTE 2	D	173584.256	624.181	8.01	173 584.26	0.624181	CONCRETE	0.1	0.53	8.30	4.768503536	Supercritical flow	CATCHMENT D	0.83
CHUTE 3	B & C	131304.144	972.503	6.06	131 304.14	0.972503	RENO	0.1	0.45	7.61	4.682912604	Supercritical flow	CATCHMENT B & C	0.75

CHANNEL	CATCHMENT AREA	AREA (m^2)	LENGTH (m)	50-yr FLOOD PEAK (m^3/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)	FLOW TYPE AT MAX FLOW VELOCITY
CHANNEL A1	A1	20 601	302	0.68	0.81	0.80	Supercritical flow
CHANNEL A2	A2	15 456	358	0.51	0.76	0.75	Supercritical flow
CHANNEL A3	A3	17 790	415	0.59	0.78	0.80	Supercritical flow
CHANNEL A4	A4	7 603	432	0.25	0.68	0.70	Supercritical flow
CHANNEL A5	A5	8 791	453	0.29	0.71	0.70	Supercritical flow
CHANNEL A6	A6	7 614	473	0.25	0.69	0.70	Supercritical flow
CHANNEL B1	B1	25 468	429	0.84	0.86	0.85	Supercritical flow
CHANNEL B2	B2	22 699	480	0.75	0.83	0.85	Supercritical flow
CHANNEL B3	B3	22 033	525	0.73	0.82	0.85	Supercritical flow
CHANNEL B4	B4	10 955	541	0.36	0.75	0.75	Supercritical flow
CHANNEL B5	B5	9 860	559	0.31	0.73	0.75	Supercritical flow
CHANNEL B6	B6	10 769	577	0.33	0.73	0.75	Supercritical flow
CHANNEL C1	C1	842	60	0.03	0.34	0.45	Supercritical flow
CHANNEL C2	C2	4 913	147	0.16	0.57	0.60	Supercritical flow
CHANNEL C3	C3	8 439	226	0.28	0.65	0.65	Supercritical flow
CHANNEL C4	C4	4 659	260	0.15	0.61	0.65	Supercritical flow
CHANNEL C5	C5	5 072	291	0.17	0.61	0.65	Supercritical flow
CHANNEL C6	C6	5 596	324	0.19	0.62	0.65	Supercritical flow
CHANNEL D1	D1	45 541	672	1.51	0.99	1.00	Supercritical flow
CHANNEL D2	D2	35 221	769	1.17	0.92	0.90	Supercritical flow
CHANNEL D3	D3	37 225	874	1.23	0.94	0.95	Supercritical flow
CHANNEL D4	D4	19 095	907	0.63	0.85	0.85	Supercritical flow
CHANNEL D5	D5	18 238	945	0.60	0.85	0.85	Supercritical flow
CHANNEL D6	D6	18 264	978	0.60	0.85	0.85	Supercritical flow
CHANNEL E1	E1	10 680	179	0.35	0.69	0.70	Supercritical flow
CHANNEL E2	E2	10 173	274	0.34	0.67	0.70	Supercritical flow
CHANNEL E3	E3	15 323	371	0.51	0.75	0.75	Supercritical flow
CHANNEL E4	E4	6 885	403	0.23	0.66	0.70	Supercritical flow
CHANNEL E5	E5	8 830	441	0.29	0.71	0.70	Supercritical flow
CHANNEL E6	E6	7 291	472	0.24	0.68	0.70	Supercritical flow

CHUTE	CATCHMENT AREA	AREA (m^2)	LENGTH (m)	200-yr FLOOD PEAK (m^3/s)	MAX VELOCITY (M/S)	CHANNEL DEPTH (m)	FLOW TYPE AT MAX FLOW VELOCITY
CHUTE 1	A & E	137 037	212	6.32	7.71	0.80	Supercritical flow
CHUTE 2	D	173 584	194	8.01	8.30	0.85	Supercritical flow
CHUTE 3	B & C	131 304	415	6.06	7.61	0.75	Supercritical flow

Rational Method

Description of catchment				CA1				
River Detail				Channel A1				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.020600993	km^2					
Longest watercourse (L)		0.315125	km					
Average slope (Sav)		0.038418617	m/m					
Height at 0.85 of length (H0.85L)		13.598	m					
Height at 0.1 of length (H0.1L)		4.518	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.7)**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	

Time of concentration (Tc)				Notes:	t=Tc*60
Overland flow		Define watercourse			
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$			
	hous	0.25	hours	15	

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56325				0.71345	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56325				0.71345	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.37				0.68	0.8	1.0

Q	0.68	m3/s	0.6799127
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.52	m	
b	1.102926778	m	
c	3.406990589	m	
y	0.49324385	m	
ANGLE C	142.12	drgee	
AREA	0.840238577	m2	
WETTED PERIMETER	7.024977382	m	
VELOCITY	0.81102481	m/s	
FROUDE	0.271873945		Subcriticalflow

Q	0.68	m3/s	0.679926418
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.39	m	
b	0.610487345	m	
c	2.00107469	m	
y	0.27301824	m	
ANGLE C	147.74	drgee	
AREA	0.273164945	m2	
WETTED PERIMETER	4.00368737	m	
VELOCITY	2.494662453	m/s	
FROUDE	4.647216504		Supercritical flow

Colour coding

**Designer must choose*
****Spreadsheet calculates***
**Value from input sheet*
**Value calculated in other sheets*
**** Final answer***
**** Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

*Drainage manual, 6th edition, chapter 3

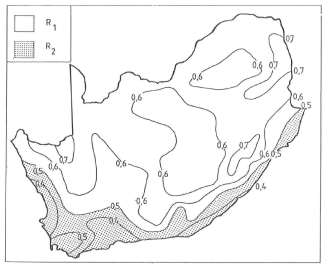
Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 – 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0.01	0.03	0.05	*Lawns*	
	Flat areas (3 to 10%)	0.06	0.08	0.11	- Sandy, flat (<2%)	0.05 – 0.10
	Hilly (10 to 30%)	0.12	0.16	0.20	- Sandy, steep (>7%)	0.15 – 0.20
	Steep areas (>30%)	0.22	0.26	0.30	- Heavy soil, flat (<2%)	0.13 – 0.17
					- Heavy soil, steep (>7%)	0.25 – 0.35
Permeability (C_p)	Very permeable	0.03	0.04	0.05	*Residential areas*	
	Permeable	0.06	0.08	0.10	- Houses	0.30 – 0.50
	Semi-permeable	0.12	0.16	0.20	- Flats	0.50 – 0.70
	Impermeable	0.21	0.26	0.30		
					Industry	
					- Light industry	0.50 – 0.80
	Thick bush and plantation	0.03	0.04	0.05	- Heavy industry	0.60 – 0.90
Vegetation (C_v)	Light bush and farm lands	0.07	0.11	0.15	*Business*	
					- City centre	0.70 – 0.95
	Grasslands	0.17	0.21	0.25	- Suburban	0.50 – 0.70
	No vegetation	0.26	0.28	0.30	- Streets	0.70 – 0.95
					- Maximum flood	1.00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00

0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x



Rational Method

Description of catchment		CA2	
River Detail		Channel A2	
Calculated by	IK	**Date**	2020/11/23

Physical characteristics

Size of catchment (A)	0.015456347	km^2
Longest watercourse (L)	0.364635	km
Average slope (Sav)	0.015328571	m/m
Height at 0.85 of length (H0.85L)	11	m
Height at 0.1 of length (H0.1L)	6.808	m
Dolomite area (D%)	0	%

Area distribution factors

Rural (α)	Urban (β)	Lakes (γ)
100	0	0

Rural				Urban			
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**
Vleis and pans	0	0.05	0	**Lawns**			
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0
Permiability	**%**	**Factor**	**Cp**	**Residential areas**			
Very permiable	0	0.05	0	Houses	0	0.5	0
Permeable	10	0.1	0.01	Flats	0	0.7	0
Semi-permiable	70	0.2	0.14	**Industry**			
Impermeable	20	0.3	0.06	Light industry	0	0.8	0
Total	100	-	0.21	Heavy industry	0	0.9	0
Vegetation	**%**	**Factor**	**Cv**	**Business**			
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0
Grasslands	20	0.25	0.05	Streets	0	0.95	0
No vegetation	80	0.3	0.24	Maximum flood	0	1	0
Total	100	-	0.29	**Total (C_2)**	0	-	0

Time of concentration (Tc)

Overland flow	Define watercourse	Notes:	t=Tc*60
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$	$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$		
hous	0.25 hours	15	

Run-off coefficient

Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.28				0.51	0.6	0.7

Q	0.51	m3/s	0.509838137
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.26	m	
b	0.990065365	m	
c	3.058356591	m	
y	0.442770692	m	
ANGLE C	142.12	drgee	
AREA	0.677075331	m2	
WETTED PERIMETER	6.306118352	m	
VELOCITY	0.755124343	m/s	
FROUDE	0.262554257		Subcriticalflow

Q	0.51	m3/s	0.509817519
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.25	m	
b	0.548004318	m	
c	1.796265852	m	
y	0.245074981	m	
ANGLE C	147.74	drgee	
AREA	0.22010991	m2	
WETTED PERIMETER	3.593912282	m	
VELOCITY	2.322821651	m/s	
FROUDE	4.488422604		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

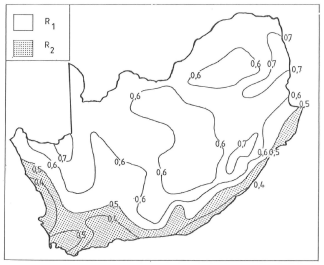
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_{1s})	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_{2p})	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_{2v})	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CA3					
River Detail				Channel A3					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.017790403	km^2						
Longest watercourse (L)		0.416315	km						
Average slope (Sav)		0.012058177	m/m						
Height at 0.85 of length (H0.85L)		11.391	m						
Height at 0.1 of length (H0.1L)		7.626	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)		0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.32				0.59	0.7	0.8	

Q	0.59	m3/s	0.589979628
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.38	m	
b	1.045780716	m	
c	3.230463825	m	
y	0.467687354	m	
ANGLE C	142.12	drgee	
AREA	0.755423539	m2	
WETTED PERIMETER	6.660991486	m	
VELOCITY	0.779011511	m/s	
FROUDE	0.264541073		Subcriticalflow

Q	0.59	m3/s	0.589977828
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.32	m	
b	0.578851058	m	
c	1.89737627	m	
y	0.258870063	m	
ANGLE C	147.74	drgee	
AREA	0.245586957	m2	
WETTED PERIMETER	3.796210829	m	
VELOCITY	2.396233254	m/s	
FROUDE	4.522070626		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

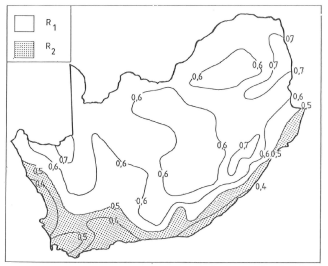
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CA4						
River Detail			Channel A4						
Calculated by			IK	**Date**	2020/11/23				
Physical characteristics									
Size of catchment (A)	0.007603201	km^2							
Longest watercourse (L)	0.430645	km							
Average slope (Sav)	0.010399904	m/m							
Height at 0.85 of length (H0.85L)	6.279	m							
Height at 0.1 of length (H0.1L)	2.92	m	**Area distribution factors**						
Dolomite area (D%)	0	%	Rural (α)	Urban (β)	Lakes (γ)				
			100	0	0				
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3**	**C_2**		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
hous		0.25	hours		15				

Run-off coefficient								
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{10}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{10} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.14				0.25	0.3	0.4

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Gool Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

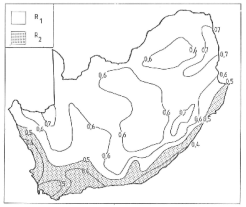
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
					- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05		
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.25	m3/s	0.249989114
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.21	m	
b	0.85422423	m	
c	1.923948192	m	
y	0.382020689	m	
ANGLE C	142.12	drgee	
AREA	0.367494007	m2	
WETTED PERIMETER	3.986227914	m	
VELOCITY	0.684376066	m/s	
FROUDE	0.249956094		Subcriticalflow

Q	0.25	m3/s	0.250434107
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.61	m	
b	0.427927604	m	
c	1.032200117	m	
y	0.191375043	m	
ANGLE C	147.74	drgee	
AREA	0.098768671	m2	
WETTED PERIMETER	2.065308743	m	
VELOCITY	2.546395544	m/s	
FROUDE	6.907603793		Supercritical flow

Tipo de sección	Área A (m2)	Perimetro mojado P (m)	Radio hidráulico Rh (m)	Espejo de agua T (m)
Rectangular	by	b+2y	$\frac{by}{b+2y}$	b
Trapezoidal	(b+zy)y	$b+2y\sqrt{1+z^2}$	$\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$	b + 2zy
Triangular	zy^2	$2y\sqrt{1+z^2}$	$\frac{zy}{2\sqrt{1+z^2}}$	2zy
Circular	$\frac{(\theta-sen\theta)D^2}{8}$	$\frac{\theta D}{2}$	$(1-\frac{sen\theta}{\theta})\frac{D}{4}$	$(sen\frac{\theta}{2})D$ ó $2\sqrt{y(D-y)}$
Parabólica	2/3 Ty	$T+\frac{8y^2}{3T}$	$\frac{2T^2y}{3T+8y^2}$	$\frac{3A}{2y}$

Rational Method

Description of catchment			CA5					
River Detail			Channel A5					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.008790691	km^2					
Longest watercourse (L)		0.453934	km					
Average slope (Sav)		0.007398139	m/m					
Height at 0.85 of length (H0.85L)		5.9787	m					
Height at 0.1 of length (H0.1L)		3.46	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.16				0.29	0.4	0.4

Q	0.29	m3/s	0.289961479
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.28	m	
b	0.903085959	m	
c	2.033998259	m	
y	0.403872319	m	
ANGLE C	142.12	drgee	
AREA	0.410737797	m2	
WETTED PERIMETER	4.214240629	m	
VELOCITY	0.707957111	m/s	
FROUDE	0.253005986		Subcriticalflow

Q	0.29	m3/s	0.290042935
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.64	m	
b	0.452151117	m	
c	1.090629422	m	
y	0.202208127	m	
ANGLE C	147.74	drgee	
AREA	0.110267066	m2	
WETTED PERIMETER	2.182218781	m	
VELOCITY	2.637095134	m/s	
FROUDE	7.011549062		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

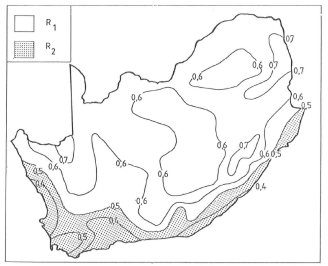
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CA6					
River Detail			Channel A6					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.007613823	km^2					
Longest watercourse (L)		0.469443	km					
Average slope (Sav)		0.00706085	m/m					
Height at 0.85 of length (H0.85L)		4.961	m					
Height at 0.1 of length (H0.1L)		2.475	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.14				0.25	0.3	0.4

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

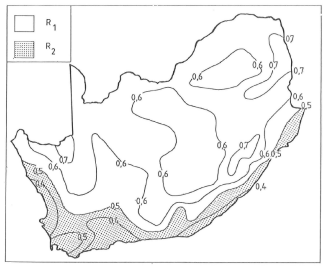
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.25	m3/s	0.249989114
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.21	m	
b	0.85422423	m	
c	1.923948192	m	
y	0.382020689	m	
ANGLE C	142.12	drgee	
AREA	0.367494007	m2	
WETTED PERIMETER	3.986227914	m	
VELOCITY	0.685332169	m/s	
FROUDE	0.250654981		Subcriticalflow

Q	0.25	m3/s	0.250434107
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.61	m	
b	0.427927604	m	
c	1.032200117	m	
y	0.191375043	m	
ANGLE C	147.74	drgee	
AREA	0.098768671	m2	
WETTED PERIMETER	2.065308743	m	
VELOCITY	2.549952969	m/s	
FROUDE	6.926917716		Supercritical flow

Rational Method

Description of catchment			CB1					
River Detail			Channel B1					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.025468414	km^2					
Longest watercourse (L)		0.435376	km					
Average slope (Sav)		0.021014786	m/m					
Height at 0.85 of length (H0.85L)		13.657	m					
Height at 0.1 of length (H0.1L)		6.795	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.46				0.84	1.0	1.2

Q	0.84	m3/s	0.839394346
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.72	m	
b	1.1936143	m	
c	3.687128438	m	
y	0.533800543	m	
ANGLE C	142.12	drgee	
AREA	0.98409558	m2	
WETTED PERIMETER	7.602602121	m	
VELOCITY	0.856077775	m/s	
FROUDE	0.279903559		Subcriticalflow

Q	0.84	m3/s	0.839394537
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.51	m	
b	0.660679375	m	
c	2.16559571	m	
y	0.295464799	m	
ANGLE C	147.74	drgee	
AREA	0.31992865	m2	
WETTED PERIMETER	4.332855858	m	
VELOCITY	2.633281996	m/s	
FROUDE	4.784647869		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet*
- *Value calculated in other sheets*
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

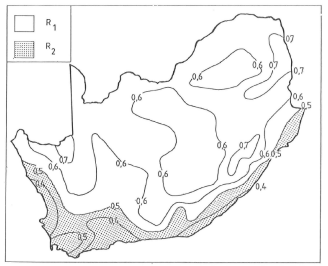
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CB2					
River Detail			Channel B2					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.022699435	km^2					
Longest watercourse (L)		0.489369	km					
Average slope (Sav)		0.011048241	m/m					
Height at 0.85 of length (H0.85L)		11.942	m					
Height at 0.1 of length (H0.1L)		7.887	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.41				0.75	0.9	1.0

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet*
- *Value calculated in other sheets*
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

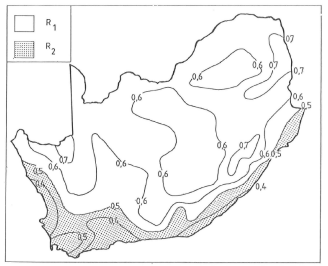
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.75	m3/s	0.749962835
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.61	m	
b	1.144238751	m	
c	3.53460514	m	
y	0.511719126	m	
ANGLE C	142.12	drgee	
AREA	0.904362527	m2	
WETTED PERIMETER	7.2881097	m	
VELOCITY	0.830273337	m/s	
FROUDE	0.274644889		Subcriticalflow

Q	0.75	m3/s	0.749962864
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.44	m	
b	0.63334939	m	
c	2.076012624	m	
y	0.283242458	m	
ANGLE C	147.74	drgee	
AREA	0.294007459	m2	
WETTED PERIMETER	4.153620835	m	
VELOCITY	2.553908309	m/s	
FROUDE	4.694758272		Supercritical flow

Rational Method

Description of catchment			CB3					
River Detail			Channel B3					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.02203317	km^2					
Longest watercourse (L)		0.5264	km					
Average slope (Sav)		0.010422999	m/m					
Height at 0.85 of length (H0.85L)		12.027	m					
Height at 0.1 of length (H0.1L)		7.912	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.40				0.73	0.9	1.0

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

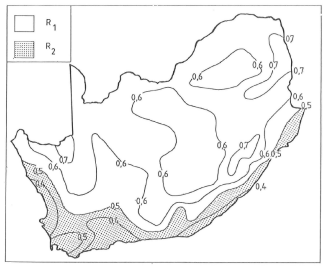
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.73	m3/s	0.730726071
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.58	m	
b	1.133143011	m	
c	3.500329896	m	
y	0.50675696	m	
ANGLE C	142.12	drgee	
AREA	0.886908269	m2	
WETTED PERIMETER	7.217436535	m	
VELOCITY	0.821763569	m/s	
FROUDE	0.271678352		Subcriticalflow

Q	0.73	m3/s	0.730725535
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.43	m	
b	0.627207588	m	
c	2.05588083	m	
y	0.28049576	m	
ANGLE C	147.74	drgee	
AREA	0.288332928	m2	
WETTED PERIMETER	4.113341774	m	
VELOCITY	2.527733854	m/s	
FROUDE	4.644055238		Supercritical flow

Rational Method

Description of catchment			CB4					
River Detail			Channel B4					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.010954508	km^2					
Longest watercourse (L)		0.53717	km					
Average slope (Sav)		0.00958604	m/m					
Height at 0.85 of length (H0.85L)		7.639	m					
Height at 0.1 of length (H0.1L)		3.777	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.20				0.36	0.4	0.5

Q	0.36	m3/s	0.360897206
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.39	m	
b	0.980325489	m	
c	2.20796295	m	
y	0.438414887	m	
ANGLE C	142.12	drgee	
AREA	0.484001913	m2	
WETTED PERIMETER	4.574678042	m	
VELOCITY	0.748676844	m/s	
FROUDE	0.260654062		Subcriticalflow

Q	0.36	m3/s	0.360019836
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.69	m	
b	0.490323445	m	
c	1.182704533	m	
y	0.219279311	m	
ANGLE C	147.74	drgee	
AREA	0.129671317	m2	
WETTED PERIMETER	2.366450044	m	
VELOCITY	2.794457804	m/s	
FROUDE	7.260364808		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

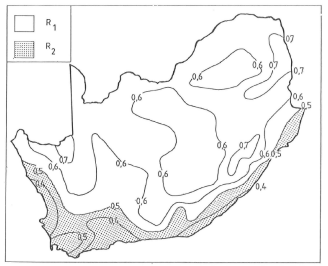
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CB5				
River Detail				Channel B5				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.009859601	km^2					
Longest watercourse (L)		0.555838	km					
Average slope (Sav)		0.008323768	m/m					
Height at 0.85 of length (H0.85L)		6.551	m					
Height at 0.1 of length (H0.1L)		3.081	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.27	hours	16.00122056				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	29.61				42.95	49.60	56.91
Point rainfall (mm/hr)	111.02				161.04	186.0	213.4
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.17				0.31	0.4	0.4

Q	0.31	m3/s	0.310310249
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.31	m	
b	0.926349816	m	
c	2.086394871	m	
y	0.414276232	m	
ANGLE C	142.12	drgee	
AREA	0.432171903	m2	
WETTED PERIMETER	4.32280116	m	
VELOCITY	0.728098768	m/s	
FROUDE	0.260886474		Subcriticalflow

Q	0.31	m3/s	0.310096865
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.66	m	
b	0.46363025	m	
c	1.118318131	m	
y	0.207341751	m	
ANGLE C	147.74	drgee	
AREA	0.11593702	m2	
WETTED PERIMETER	2.23762057	m	
VELOCITY	2.71409279	m/s	
FROUDE	7.243085443		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

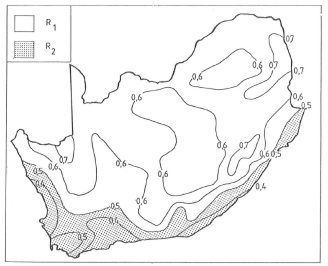
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.27	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.329	x

Rational Method

Description of catchment			CB6					
River Detail			Channel B6					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.010768642	km^2					
Longest watercourse (L)		0.575875	km					
Average slope (Sav)		0.007233051	m/m					
Height at 0.85 of length (H0.85L)		7.116	m					
Height at 0.1 of length (H0.1L)		3.992	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	

Time of concentration (Tc)				Notes:	t=Tc*60
Overland flow		Define watercourse			
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$			
	hous	0.29	hours	17.35721746	

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	30.75				44.60	51.51	59.10
Point rainfall (mm/hr)	106.28				154.16	178.0	204.3
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.18				0.33	0.4	0.5

Q	0.33	m3/s	0.330102234
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.34	m	
b	0.948079266	m	
c	2.135335576	m	
y	0.423993937	m	
ANGLE C	142.12	drgee	
AREA	0.452684669	m2	
WETTED PERIMETER	4.424201397	m	
VELOCITY	0.72677825	m/s	
FROUDE	0.253983314		Subcriticalflow

Q	0.33	m3/s	0.330054137
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.67	m	
b	0.47460214	m	
c	1.14478332	m	
y	0.212248529	m	
ANGLE C	147.74	drgee	
AREA	0.121489288	m2	
WETTED PERIMETER	2.290574242	m	
VELOCITY	2.708068972	m/s	
FROUDE	7.044265906		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

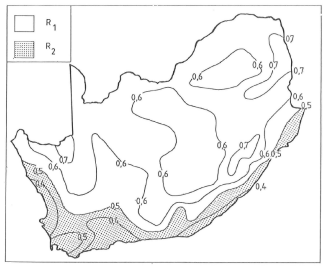
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.29	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.342	x

Rational Method

Description of catchment				CC1				
River Detail				Channel C1				
Calculated by				IK	**Date**	2020/11/23		
Physical characteristics								
Size of catchment (A)		0.000841694	km^2					
Longest watercourse (L)		0.050182	km					
Average slope (Sav)		0.158914883	m/m	42.6547				
Height at 0.85 of length (H0.85L)		6.752	m	5.0182				
Height at 0.1 of length (H0.1L)		0.771	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.02				0.03	0.0	0.0

Q	0.03	m3/s	0.030269604
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	0.78	m	
b	0.343363617	m	
c	1.060665709	m	
y	0.153556878	m	
ANGLE C	142.12	drgee	
AREA	0.081436257	m2	
WETTED PERIMETER	2.187018843	m	
VELOCITY	0.341888921	m/s	
FROUDE	0.155189299		Subcriticalflow

Q	0.03	m3/s	0.030269604
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	0.43	m	
b	0.190055733	m	
c	0.622970683	m	
y	0.084995508	m	
ANGLE C	147.74	drgee	
AREA	0.026474855	m2	
WETTED PERIMETER	1.246420169	m	
VELOCITY	1.051645208	m/s	
FROUDE	2.652793895		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

*Drainage manual, 6th edition, chapter 3

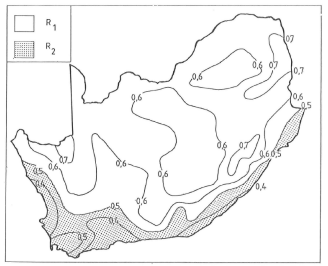
Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00

0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x



Rational Method

Description of catchment				CC2					
River Detail				Channel C2					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.004912836	km^2						
Longest watercourse (L)		0.121826	km						
Average slope (Sav)		0.108373144	m/m	103.5521					
Height at 0.85 of length (H0.85L)		11.848	m	12.1826					
Height at 0.1 of length (H0.1L)		1.946	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous		0.25 hours	15					
Run-off coefficient									
Retun period (years), T			**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)			0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}			0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)			0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)			0.56				0.71	0.751	0.751
Combined run-off coefficient, CT		(=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall									
Retun period (years), T			**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)			28.77				41.73	48.19	55.30
Point rainfall (mm/hr)			115.07				166.91	192.8	221.2
Peak flow (m^3/s)		$Qt = \frac{Ct\ It\ A}{3.6}$	0.09				0.16	0.2	0.2

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

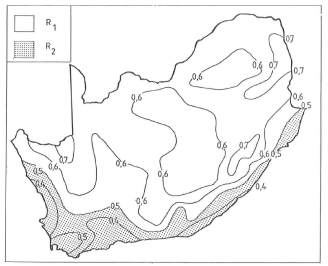
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.16	m3/s	0.160610002
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.46	m	
b	0.64200952	m	
c	1.983196381	m	
y	0.287115386	m	
ANGLE C	142.12	drgee	
AREA	0.284703097	m2	
WETTED PERIMETER	4.089212857	m	
VELOCITY	0.570806195	m/s	
FROUDE	0.231356592		Subcriticalflow

Q	0.16	m3/s	0.160610002
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	0.81	m	
b	0.355359695	m	
c	1.164809224	m	
y	0.158921687	m	
ANGLE C	147.74	drgee	
AREA	0.092556723	m2	
WETTED PERIMETER	2.3305137	m	
VELOCITY	1.755791321	m/s	
FROUDE	3.954791742		Supercritical flow

Rational Method

Description of catchment				CC3					
River Detail				Channel C3					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.008439193	km^2						
Longest watercourse (L)		0.194537	km						
Average slope (Sav)		0.052637802	m/m	165.3565					
Height at 0.85 of length (H0.85L)		12.453	m	19.4537					
Height at 0.1 of length (H0.1L)		4.773	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)		0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.15				0.28	0.3	0.4	

Q	0.28	m3/s	0.280019399
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.80	m	
b	0.790810256	m	
c	2.442848567	m	
y	0.353661098	m	
ANGLE C	142.12	drgee	
AREA	0.431970253	m2	
WETTED PERIMETER	5.036983661	m	
VELOCITY	0.646242746	m/s	
FROUDE	0.240749315		Subcriticalflow

Q	0.28	m3/s	0.280019399
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.00	m	
b	0.437722622	m	
c	1.434781027	m	
y	0.195755507	m	
ANGLE C	147.74	drgee	
AREA	0.140433144	m2	
WETTED PERIMETER	2.870664801	m	
VELOCITY	1.987833031	m/s	
FROUDE	4.115350261		Supercritical flow

Colour coding

Designer must choose
**Spreadsheet calculates*
Value from input sheet
Value calculated in other sheets
** Final answer*
** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

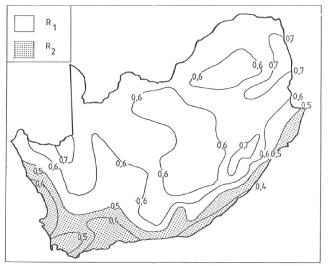
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CC4				
River Detail				Channel C4				
Calculated by				IK	**Date**	2020/11/23		
Physical characteristics								
Size of catchment (A)		0.004658899	km^2					
Longest watercourse (L)		0.25062	km					
Average slope (Sav)		0.024919533	m/m	213.027				
Height at 0.85 of length (H0.85L)		7.463	m	25.062				
Height at 0.1 of length (H0.1L)		2.779	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.08				0.15	0.2	0.2

Q	0.15	m3/s	0.150098141
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.00	m	
b	0.705492202	m	
c	1.588962708	m	
y	0.315505704	m	
ANGLE C	142.12	drgee	
AREA	0.250663399	m2	
WETTED PERIMETER	3.29217155	m	
VELOCITY	0.614810072	m/s	
FROUDE	0.244250645		Subcriticalflow

Q	0.15	m3/s	0.150615247
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.50	m	
b	0.353639771	m	
c	0.853011138	m	
y	0.158152513	m	
ANGLE C	147.74	drgee	
AREA	0.067452928	m2	
WETTED PERIMETER	1.706773068	m	
VELOCITY	2.284710059	m/s	
FROUDE	6.728946536		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

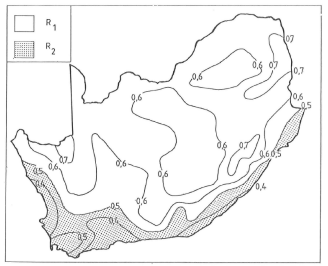
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CC5					
River Detail				Channel C5					
Calculated by			IK	**Date**	2020/11/23				
Physical characteristics									
Size of catchment (A)		0.00507182	km^2						
Longest watercourse (L)		0.276951	km						
Average slope (Sav)		0.019478777	m/m	235.4084					
Height at 0.85 of length (H0.85L)		7.209	m	27.6951					
Height at 0.1 of length (H0.1L)		3.163	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)		0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.09				0.17	0.2	0.2	

Q	0.17	m3/s	0.170046551
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.05	m	
b	0.739289282	m	
c	1.665083039	m	
y	0.330620218	m	
ANGLE C	142.12	drgee	
AREA	0.275255059	m2	
WETTED PERIMETER	3.449885252	m	
VELOCITY	0.609504793	m/s	
FROUDE	0.229079291		Subcriticalflow

Q	0.17	m3/s	0.170516892
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	3.67	m	
b	0.1548278	m	
c	3.824720894	m	
y	0.069241097	m	
ANGLE C	147.74	drgee	
AREA	0.132413936	m2	
WETTED PERIMETER	7.649980013	m	
VELOCITY	1.267006199	m/s	
FROUDE	4.726661768		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

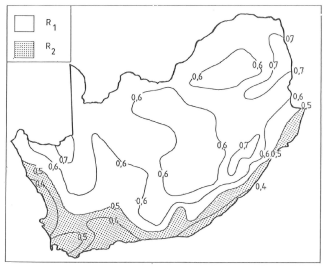
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CC6					
River Detail				Channel C6					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.005595932	km^2						
Longest watercourse (L)		0.31398	km						
Average slope (Sav)		0.017640189	m/m	266.883					
Height at 0.85 of length (H0.85L)		7.247	m	31.398					
Height at 0.1 of length (H0.1L)		3.093	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT	($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.10				0.19	0.2	0.3	

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

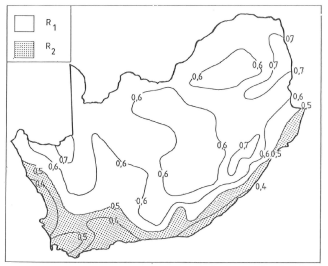
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.19	m3/s	0.190023033
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.09	m	
b	0.770732757	m	
c	1.735902402	m	
y	0.344682167	m	
ANGLE C	142.12	drgee	
AREA	0.299167301	m2	
WETTED PERIMETER	3.596615876	m	
VELOCITY	0.618738169	m/s	
FROUDE	0.226441482		Subcriticalflow

Q	0.19	m3/s	0.190162084
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.55	m	
b	0.385950602	m	
c	0.930947786	m	
y	0.172602356	m	
ANGLE C	147.74	drgee	
AREA	0.080341891	m2	
WETTED PERIMETER	1.862714963	m	
VELOCITY	2.303981477	m/s	
FROUDE	6.270067767		Supercritical flow

Rational Method

Description of catchment				CD1				
River Detail				Channel D1				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.045541427	km^2					
Longest watercourse (L)		0.554503	km					
Average slope (Sav)		0.013482344	m/m	471.3276				
Height at 0.85 of length (H0.85L)		10.464	m	55.4503				
Height at 0.1 of length (H0.1L)		4.857	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.82				1.51	1.8	2.1

Q	1.51	m3/s	1.509911179
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	3.39	m	
b	1.487590936	m	
c	4.595235534	m	
y	0.665270891	m	
ANGLE C	142.12	drgee	
AREA	1.52853822	m2	
WETTED PERIMETER	9.475055728	m	
VELOCITY	0.985550619	m/s	
FROUDE	0.297659903		Subcriticalflow

Q	1.51	m3/s	1.509911179
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.88	m	
b	0.823398786	m	
c	2.698962534	m	
y	0.368235132	m	
ANGLE C	147.74	drgee	
AREA	0.496926412	m2	
WETTED PERIMETER	5.399999442	m	
VELOCITY	3.03153898	m/s	
FROUDE	5.088175489		Supercritical flow

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet*
- *Value calculated in other sheets*
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

*Drainage manual, 6th edition, chapter 3

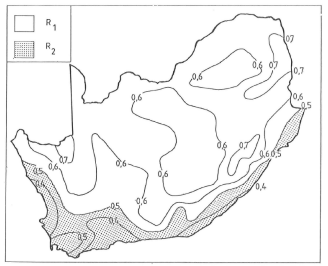
Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00

0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x



Rational Method

Description of catchment				CD2				
River Detail				Channel D2				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.035220901	km^2					
Longest watercourse (L)		0.350772	km					
Average slope (Sav)		0.011430027	m/m	298.1562				
Height at 0.85 of length (H0.85L)		10.744	m	35.0772				
Height at 0.1 of length (H0.1L)		7.737	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.63				1.17	1.4	1.6

Q	1.17	m3/s	1.170024871
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	3.08	m	
b	1.351916624	m	
c	4.176131462	m	
y	0.604595494	m	
ANGLE C	142.12	drgee	
AREA	1.262435133	m2	
WETTED PERIMETER	8.61089231	m	
VELOCITY	0.92286886	m/s	
FROUDE	0.287194465		Subcriticalflow

Q	1.17	m3/s	1.170024871
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.71	m	
b	0.748301485	m	
c	2.452806231	m	
y	0.334650598	m	
ANGLE C	147.74	drgee	
AREA	0.410416536	m2	
WETTED PERIMETER	4.907497645	m	
VELOCITY	2.838730827	m/s	
FROUDE	4.909280092		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

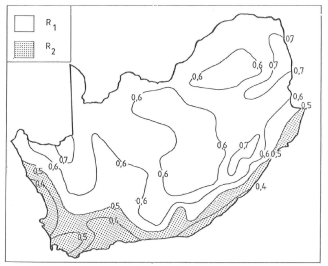
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CD3				
River Detail				Channel D3				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)	0.037225311	km^2						
Longest watercourse (L)	0.424401	km						
Average slope (Sav)	0.007983016	m/m	360.7409					
Height at 0.85 of length (H0.85L)	10.439	m	42.4401					
Height at 0.1 of length (H0.1L)	7.898	m	**Area distribution factors**					
Dolomite area (D%)	0	%	Rural (α)	Urban (β)	Lakes (γ)			
			100	0	0			
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.67				1.23	1.5	1.7

Q	1.23	m3/s	1.229365317
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	3.14	m	
b	1.377232007	m	
c	4.254331821	m	
y	0.615916878	m	
ANGLE C	142.12	drgee	
AREA	1.310157386	m2	
WETTED PERIMETER	8.772136006	m	
VELOCITY	0.939860652	m/s	
FROUDE	0.292392224		Subcriticalflow

Q	1.23	m3/s	1.229365317
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.74	m	
b	0.762313842	m	
c	2.498736377	m	
y	0.340917114	m	
ANGLE C	147.74	drgee	
AREA	0.425930998	m2	
WETTED PERIMETER	4.999393238	m	
VELOCITY	2.890997325	m/s	
FROUDE	4.998130187		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

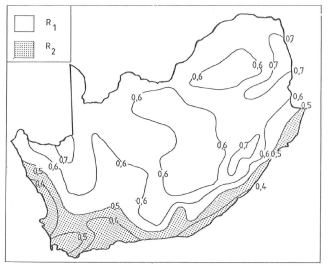
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CD4					
River Detail			Channel D4					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)	0.019094655	km^2						
Longest watercourse (L)	0.456439	km						
Average slope (Sav)	0.006385665	m/m	387.9732					
Height at 0.85 of length (H0.85L)	7.661	m	45.6439					
Height at 0.1 of length (H0.1L)	5.475	m	**Area distribution factors**					
Dolomite area (D%)	0	%	Rural (α)	Urban (β)	Lakes (γ)			
			100	0	0			
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15.22602397				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.96				42.00	48.51	55.66
Point rainfall (mm/hr)	114.11				165.52	191.2	219.3
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.34				0.63	0.8	0.9

Q	0.63	m3/s	0.630342704
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.71	m	
b	1.208350006	m	
c	2.721536954	m	
y	0.540390551	m	
ANGLE C	142.12	drgee	
AREA	0.735346427	m2	
WETTED PERIMETER	5.638751927	m	
VELOCITY	0.851778776	m/s	
FROUDE	0.273720214		Subcriticalflow

Q	0.63	m3/s	0.630092269
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.86	m	
b	0.604834848	m	
c	1.458916402	m	
y	0.270490367	m	
ANGLE C	147.74	drgee	
AREA	0.197311417	m2	
WETTED PERIMETER	2.919116896	m	
VELOCITY	3.174436076	m/s	
FROUDE	7.595254962		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

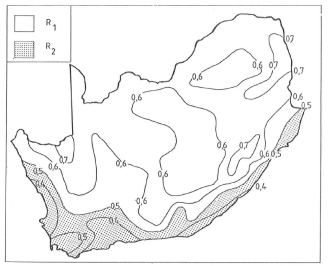
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.322	x

Rational Method

Description of catchment				CD5				
River Detail				Channel D5				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.018237634	km^2					
Longest watercourse (L)		0.469368	km					
Average slope (Sav)		0.01060149	m/m	398.9628				
Height at 0.85 of length (H0.85L)		7.594	m	46.9368				
Height at 0.1 of length (H0.1L)		3.862	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.33				0.60	0.7	0.8

Q	0.60	m3/s	0.600404121
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.68	m	
b	1.186500291	m	
c	2.672325377	m	
y	0.530619061	m	
ANGLE C	142.12	drgee	
AREA	0.708993391	m2	
WETTED PERIMETER	5.536790471	m	
VELOCITY	0.850892923	m/s	
FROUDE	0.27818132		Subcriticalflow

Q	0.60	m3/s	0.600054019
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.84	m	
b	0.593856658	m	
c	1.432436013	m	
y	0.265580771	m	
ANGLE C	147.74	drgee	
AREA	0.190213731	m2	
WETTED PERIMETER	2.866132811	m	
VELOCITY	3.171576822	m/s	
FROUDE	7.721733901		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

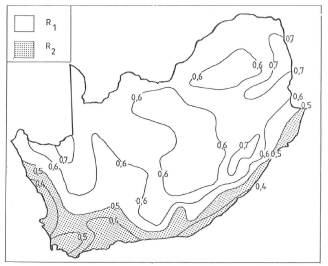
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CD6					
River Detail			Channel D6					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.018264328	km^2					
Longest watercourse (L)		0.492064	km					
Average slope (Sav)		0.009416119	m/m	418.2544				
Height at 0.85 of length (H0.85L)		7.312	m	49.2064				
Height at 0.1 of length (H0.1L)		3.837	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.33				0.60	0.7	0.8

Q	0.60	m3/s	0.600404121
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.68	m	
b	1.186500291	m	
c	2.672325377	m	
y	0.530619061	m	
ANGLE C	142.12	drgee	
AREA	0.708993391	m2	
WETTED PERIMETER	5.536790471	m	
VELOCITY	0.852138355	m/s	
FROUDE	0.278996251		Subcriticalflow

Q	0.60	m3/s	0.600054019
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.84	m	
b	0.593856658	m	
c	1.432436013	m	
y	0.265580771	m	
ANGLE C	147.74	drgee	
AREA	0.190213731	m2	
WETTED PERIMETER	2.866132811	m	
VELOCITY	3.176218985	m/s	
FROUDE	7.744354688		Supercritical flow

Colour coding

Designer must choose
**Spreadsheet calculates*
Value from input sheet
Value calculated in other sheets
** Final answer*
** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

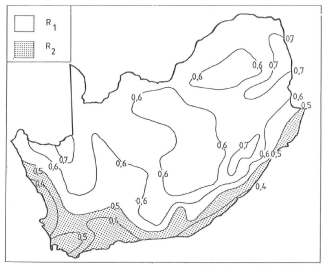
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CE1					
River Detail				Channel E1					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.010680403	km^2						
Longest watercourse (L)		0.173201	km						
Average slope (Sav)		0.070176654	m/m	147.2209					
Height at 0.85 of length (H0.85L)		11.746	m	17.3201					
Height at 0.1 of length (H0.1L)		2.63	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T			**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)			0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}			0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)			0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)			0.56				0.71	0.751	0.751
Combined run-off coefficient, CT		($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall									
Retun period (years), T			**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)			28.77				41.73	48.19	55.30
Point rainfall (mm/hr)			115.07				166.91	192.8	221.2
Peak flow (m^3/s)		$Qt = \frac{Ct\ It\ A}{3.6}$	0.19				0.35	0.4	0.5

Colour coding

- *Designer must choose*
- **Spreadsheet calculates*
- *Value from input sheet
- *Value calculated in other sheets
- ** Final answer*
- ** Use Goal Seek*

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

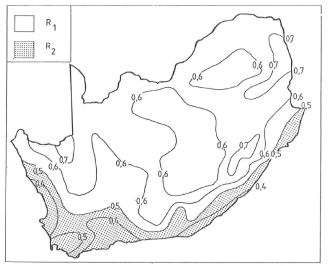
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.35	m3/s	0.350841483
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.96	m	
b	0.860584164	m	
c	2.658383319	m	
y	0.384864938	m	
ANGLE C	142.12	drgee	
AREA	0.511559266	m2	
WETTED PERIMETER	5.481401313	m	
VELOCITY	0.690621807	m/s	
FROUDE	0.252658094		Subcriticalflow

Q	0.35	m3/s	0.349039874
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.08	m	
b	0.475424533	m	
c	1.558361542	m	
y	0.212616315	m	
ANGLE C	147.74	drgee	
AREA	0.165666544	m2	
WETTED PERIMETER	3.117920812	m	
VELOCITY	2.132560841	m/s	
FROUDE	4.36081098		Supercritical flow

Rational Method

Description of catchment			CE2					
River Detail			Channel E2					
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.010172936	km^2					
Longest watercourse (L)		0.239427	km					
Average slope (Sav)		0.038258008	m/m	203.513				
Height at 0.85 of length (H0.85L)		10.425	m	23.9427				
Height at 0.1 of length (H0.1L)		3.555	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.18				0.34	0.4	0.5

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

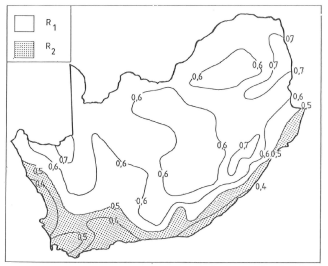
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Q	0.34	m3/s	0.340961112
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.94	m	
b	0.851414548	m	
c	2.630057961	m	
y	0.380764161	m	
ANGLE C	142.12	drgee	
AREA	0.500715907	m2	
WETTED PERIMETER	5.422996396	m	
VELOCITY	0.672053004	m/s	
FROUDE	0.241831003		Subcriticalflow

Q	0.34	m3/s	0.339052954
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.07	m	
b	0.470277036	m	
c	1.541488912	m	
y	0.210314284	m	
ANGLE C	147.74	drgee	
AREA	0.162098568	m2	
WETTED PERIMETER	3.084162586	m	
VELOCITY	2.075944485	m/s	
FROUDE	4.177569555		Supercritical flow

Rational Method

Description of catchment				CE3				
River Detail				Channel E3				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.015322626	km^2					
Longest watercourse (L)		0.331211	km					
Average slope (Sav)		0.022201356	m/m	281.5294				
Height at 0.85 of length (H0.85L)		11.795	m	33.1211				
Height at 0.1 of length (H0.1L)		6.28	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient

Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.28				0.51	0.6	0.7

Q	0.51	m3/s	0.509961936
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	2.26	m	
b	0.990155511	m	
c	3.058635056	m	
y	0.442811006	m	
ANGLE C	142.12	drgee	
AREA	0.677198633	m2	
WETTED PERIMETER	6.306692527	m	
VELOCITY	0.748455064	m/s	
FROUDE	0.257913481		Subcriticalflow

Q	0.51	m3/s	0.509983274
n	0.03		
S	0.2	m/m	STEEP SLOPE
a	1.25	m	
b	0.548071125	m	
c	1.796484835	m	
y	0.245104858	m	
ANGLE C	147.74	drgee	
AREA	0.220163581	m2	
WETTED PERIMETER	3.594350415	m	
VELOCITY	2.30216435	m/s	
FROUDE	4.408407344		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

*Drainage manual, 6th edition, chapter 3

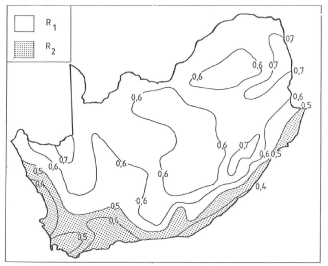
Table 3.7: Recommended values of run-off factor C for use in the Rational method

Component	Classification	Rural (C_1) Mean annual rainfall (mm) < 600	600 - 900	> 900	Urban (C_2) Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00

0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x



Rational Method

Description of catchment				CE4				
River Detail				Channel E4				
Calculated by			IK	**Date**	2020/11/23			
Physical characteristics								
Size of catchment (A)		0.006885293	km^2					
Longest watercourse (L)		0.386725	km					
Average slope (Sav)		0.010312237	m/m	328.7163				
Height at 0.85 of length (H0.85L)		6.249	m	38.6725				
Height at 0.1 of length (H0.1L)		3.258	m	**Area distribution factors**				
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)		
				100	0	0		
Rural				**Urban**				
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	**C_2**	
Vleis and pans	0	0.05	0	**Lawns**				
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0	
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0	
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0	
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0	
Permiability	**%**	**Factor**	**Cp**	**Residential areas**				
Very permiable	0	0.05	0	Houses	0	0.5	0	
Permeable	10	0.1	0.01	Flats	0	0.7	0	
Semi-permiable	70	0.2	0.14	**Industry**				
Impermeable	20	0.3	0.06	Light industry	0	0.8	0	
Total	100	-	0.21	Heavy industry	0	0.9	0	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0	
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0	
Grasslands	20	0.25	0.05	Streets	0	0.95	0	
No vegetation	80	0.3	0.24	Maximum flood	0	1	0	
Total	100	-	0.29	**Total (C_2)**	0	-	0	
Time of concentration (Tc)				Notes:	t=Tc*60			
Overland flow		Define watercourse						
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$						
	hous	0.25	hours	15				

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{1D}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} ($=C_{1D}$ x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT ($=\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	0.12				0.23	0.3	0.3

Q	0.23	m3/s	0.230024209
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.17	m	
b	0.827973724	m	
c	1.864824823	m	
y	0.370281106	m	
ANGLE C	142.12	drgee	
AREA	0.345254699	m2	
WETTED PERIMETER	3.863730217	m	
VELOCITY	0.659677134	m/s	
FROUDE	0.239603025		Subcriticalflow

Q	0.23	m3/s	0.230202303
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.59	m	
b	0.414621075	m	
c	1.000103563	m	
y	0.185424182	m	
ANGLE C	147.74	drgee	
AREA	0.092721692	m2	
WETTED PERIMETER	2.001087385	m	
VELOCITY	2.456346779	m/s	
FROUDE	6.633977216		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

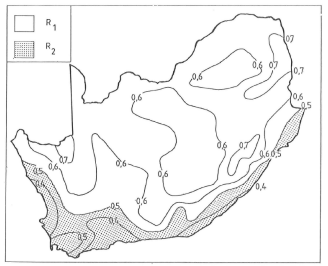
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
					- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	*Business*	
	Light bush and farm lands	0,07	0,11	0,15	- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CE5					
River Detail				Channel E5					
Calculated by			IK	**Date**	2020/11/23				
Physical characteristics									
Size of catchment (A)		0.008830087	km^2						
Longest watercourse (L)		0.423122	km						
Average slope (Sav)		0.008527091	m/m	359.6537					
Height at 0.85 of length (H0.85L)		5.874	m	42.3122					
Height at 0.1 of length (H0.1L)		3.168	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)		0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.16				0.29	0.4	0.4	

Q	0.29	m3/s	0.289717402
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.28	m	
b	0.902800817	m	
c	2.03335604	m	
y	0.403744799	m	
ANGLE C	142.12	drgee	
AREA	0.410478463	m2	
WETTED PERIMETER	4.212910016	m	
VELOCITY	0.711579142	m/s	
FROUDE	0.255682183		Subcriticalflow

Q	0.29	m3/s	0.289720486
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.64	m	
b	0.45196255	m	
c	1.090174582	m	
y	0.202123797	m	
ANGLE C	147.74	drgee	
AREA	0.110175113	m2	
WETTED PERIMETER	2.181308702	m	
VELOCITY	2.651124236	m/s	
FROUDE	7.089305629		Supercritical flow

Colour coding

Designer must choose
Spreadsheet calculates
Value from input sheet
Value calculated in other sheets
Final answer
Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

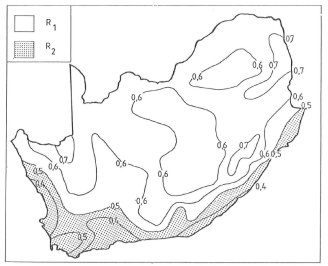
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Light bush and farm lands	0,07	0,11	0,15	*Business*	
	Grasslands	0,17	0,21	0,25	- City centre	0,70 – 0,95
	No vegetation	0,26	0,28	0,30	- Suburban	0,50 – 0,70
					- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CE6					
River Detail				Channel E6					
Calculated by				IK	**Date**	2020/11/23			
Physical characteristics									
Size of catchment (A)		0.007290671	km^2						
Longest watercourse (L)		0.456945	km						
Average slope (Sav)		0.011324485	m/m	388.4033					
Height at 0.85 of length (H0.85L)		6.303	m	45.6945					
Height at 0.1 of length (H0.1L)		2.422	m	**Area distribution factors**					
Dolomite area (D%)		0	%	Rural (α)	Urban (β)	Lakes (γ)			
				100	0	0			
Rural				**Urban**					
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3.**	C_2		
Vleis and pans	0	0.05	0	**Lawns**					
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0		
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0		
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0		
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0		
Permiability	**%**	**Factor**	**Cp**	**Residential areas**					
Very permiable	0	0.05	0	Houses	0	0.5	0		
Permeable	10	0.1	0.01	Flats	0	0.7	0		
Semi-permiable	70	0.2	0.14	**Industry**					
Impermeable	20	0.3	0.06	Light industry	0	0.8	0		
Total	100	-	0.21	Heavy industry	0	0.9	0		
Vegetation	**%**	**Factor**	**Cv**	**Business**					
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0		
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0		
Grasslands	20	0.25	0.05	Streets	0	0.95	0		
No vegetation	80	0.3	0.24	Maximum flood	0	1	0		
Total	100	-	0.29	**Total (C_2)**	0	-	0		
Time of concentration (Tc)				Notes:	t=Tc*60				
Overland flow		Define watercourse							
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$							
	hous	0.25	hours	15					
Run-off coefficient									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Run-off coefficient, C_1 (= Cs + Cp + Cv)		0.751				0.751	0.751	0.751	
Adjusted for dolomite aeas , C_{1D}		0.751				0.751	0.751	0.751	
Adjusted factor for initial saturation, Ft (T3.8)		0.75				0.95	1	1	
Adjusted run-off coefficient, C_{1T} (=C_{1D} x Ft)		0.56				0.71	0.751	0.751	
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)		0.56				0.71	0.751	0.751	
Rainfall									
Retun period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**Max**	
Point rainfall (mm) (mm rain falling in Tc)		28.77				41.73	48.19	55.30	
Point rainfall (mm/hr)		115.07				166.91	192.8	221.2	
Peak flow (m^3/s)	$Qt = \frac{Ct\ It\ A}{3.6}$	0.13				0.24	0.3	0.3	

Q	0.24	m3/s	0.240112412
n	0.03		
S	0.01	m/m	FLAT SLOPE
a	1.19	m	
b	0.841408614	m	
c	1.895083895	m	
y	0.376289372	m	
ANGLE C	142.12	drgee	
AREA	0.356549964	m2	
WETTED PERIMETER	3.926423983	m	
VELOCITY	0.676387708	m/s	
FROUDE	0.2478737		Subcriticalflow

Q	0.24	m3/s	0.240112433
n	0.03		
S	0.333333333	m/m	STEEP SLOPE
a	0.60	m	
b	0.421226555	m	
c	1.016036579	m	
y	0.188378242	m	
ANGLE C	147.74	drgee	
AREA	0.095699592	m2	
WETTED PERIMETER	2.032967441	m	
VELOCITY	2.520031766	m/s	
FROUDE	6.872935668		Supercritical flow

Colour coding

- *Designer must choose*
- ***Spreadsheet calculates***
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

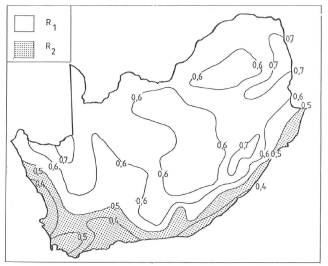
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm) < 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30	*Industry*	
					- Light industry	0,50 – 0,80
					- Heavy industry	0,60 – 0,90
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05		
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	R1	R2
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CHUTE 1		
River Detail			CHUTE 1		
Calculated by		IK	**Date**	2020/11/23	

Physical characteristics

Size of catchment (A)	0.137037474	km^2			
Longest watercourse (L)	0.532395	km			
Average slope (Sav)	0.101839173	m/m	452.5358		
Height at 0.85 of length (H0.85L)	53.227	m	53.2395		
Height at 0.1 of length (H0.1L)	12.563	m	**Area distribution factors**		
Dolomite area (D%)	0	%	Rural (α)	Urban (β)	Lakes (γ)
			100	0	0

Rural				**Urban**			
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3**	**C_2**
Vleis and pans	0	0.05	0	**Lawns**			
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0
Permiability	**%**	**Factor**	**Cp**	**Residential areas**			
Very permiable	0	0.05	0	Houses	0	0.5	0
Permeable	10	0.1	0.01	Flats	0	0.7	0
Semi-permiable	70	0.2	0.14	**Industry**			
Impermeable	20	0.3	0.06	Light industry	0	0.8	0
Total	100	-	0.21	Heavy industry	0	0.9	0
Vegetation	**%**	**Factor**	**Cv**	**Business**			
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0
Grasslands	20	0.25	0.05	Streets	0	0.95	0
No vegetation	80	0.3	0.24	Maximum flood	0	1	0
Total	100	-	0.29	**Total (C_2)**	0	-	0

Time of concentration (Tc) — Notes: t=Tc*60

Overland flow	Define watercourse	
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$	$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$	
hous	0.25	hours
		15

Run-off coefficient

Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{10}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{10} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=αC_{1T} + βC_2 + γC_3)	0.56				0.71	0.751	0.751

Rainfall

Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	2.47				4.53	5.5	6.3

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	6.32	m3/s		Slope	1	1.5
Channel width	2	m	Flat		
Slope	0.10000	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.462446781	m	Solve with Manning equation		
Right side of mannings equation	0.030327938				
Freeboard	0.3	m			
Channel depth	0.762446781	m	0.6		
Velocity	5.076031527	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	2.672490287		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	6.32	m3/s		Slope	1	1.5
Channel width	2	m	STEEP		
Slope	0.33333	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.328984719	m	Solve with Manning equation		
Right side of mannings equation	0.030313167				
Freeboard	0.3	m			
Channel depth	0.628984719	m	0.6		
Velocity	7.708136256	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	4.696113719		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Colour coding

*Designer must choose
*Spreadsheet calculates
*Value from input sheet
*Value calculated in other sheets
* Final answer
* Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

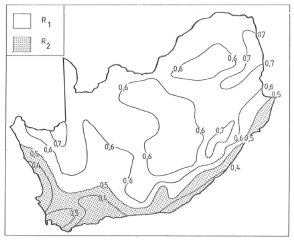
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment				CHUTE 2					
River Detail				CHUTE 2					
Calculated by			IK	**Date**	2020/11/23				
Physical characteristics									
Size of catchment (A)	0.173584256	km^2							
Longest watercourse (L)	0.624181	km							
Average slope (Sav)	0.077295955	m/m	530.5539						
Height at 0.85 of length (H0.85L)	52.883	m	62.4181						
Height at 0.1 of length (H0.1L)	16.698	m	**Area distribution factors**						
Dolomite area (D%)	0	%	Rural (α)		Urban (β)		Lakes (γ)		
			100		0		0		

Rural				**Urban**			
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3**	**C_2**
Vleis and pans	0	0.05	0	**Lawns**			
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0
Permiability	**%**	**Factor**	**Cp**	**Residential areas**			
Very permiable	0	0.05	0	Houses	0	0.5	0
Permeable	10	0.1	0.01	Flats	0	0.7	0
Semi-permiable	70	0.2	0.14	**Industry**			
Impermeable	20	0.3	0.06	Light industry	0	0.8	0
Total	100	-	0.21	Heavy industry	0	0.9	0
Vegetation	**%**	**Factor**	**Cv**	**Business**			
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0
Grasslands	20	0.25	0.05	Streets	0	0.95	0
No vegetation	80	0.3	0.24	Maximum flood	0	1	0
Total	100	-	0.29	**Total (C_2)**	0	-	0

Time of concentration (Tc)				Notes:	t=Tc*60
Overland flow		Define watercourse			
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$		$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$			
	hous	0.25	hours	15	

Run-off coefficient							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{10}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{10} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=$\alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	3.13				5.74	7.0	8.0

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	8.01	m3/s		Slope	1 : 1.5
Channel width	2	m	Flat		
Slope	0.10000	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.52725106	m	Solve with Manning equation		
Right side of mannings equation	0.030330234				
Freeboard	0.3	m			
Channel depth	0.82725106	m	0.6		
Velocity	5.443063265	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	2.71130053		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	8.01	m3/s		Slope	1 : 1.5
Channel width	2	m	STEEP		
Slope	0.33333	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.3764513	m	Solve with Manning equation		
Right side of mannings equation	0.03032115				
Freeboard	0.3	m			
Channel depth	0.6764513	m	0.6		
Velocity	8.29583312	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	4.768503536		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Colour coding

*Designer must choose
*Spreadsheet calculates
*Value from input sheet
*Value calculated in other sheets
* Final answer
* Use Goal Seek

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

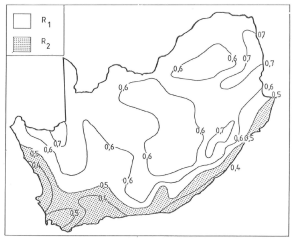
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

Rational Method

Description of catchment			CHUTE 3		
River Detail			CHUTE 3		
Calculated by		IK	**Date**	2020/11/23	

Physical characteristics

Size of catchment (A)	0.131304144	km^2			
Longest watercourse (L)	0.972503	km			
Average slope (Sav)	0.035900489	m/m	826.6276		
Height at 0.85 of length (H0.85L)	55.791	m	97.2503		
Height at 0.1 of length (H0.1L)	29.606	m	**Area distribution factors**		
Dolomite area (D%)	0	%	Rural (α)	Urban (β)	Lakes (γ)
			100	0	0

Rural				**Urban**			
Surface slope	**%**	**Factor (T3.7)**	**Cs**	**Desciption**	**%**	**Factor (T3**	**C_2**
Vleis and pans	0	0.05	0	**Lawns**			
Flat areas	10	0.11	0.011	Sandy, flat (<2%)	0	0.1	0
Hilly	30	0.2	0.06	Sandy, steep (>7%)	0	0.2	0
Steep areas	60	0.3	0.18	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.251	Heavy soil, steep (>7%)	0	0.35	0
Permiability	**%**	**Factor**	**Cp**	**Residential areas**			
Very permiable	0	0.05	0	Houses	0	0.5	0
Permeable	10	0.1	0.01	Flats	0	0.7	0
Semi-permiable	70	0.2	0.14	**Industry**			
Impermeable	20	0.3	0.06	Light industry	0	0.8	0
Total	100	-	0.21	Heavy industry	0	0.9	0
Vegetation	**%**	**Factor**	**Cv**	**Business**			
Thick bush and plantation	0	0.05	0	City centre	0	0.7	0
Light bush and farm-lands	0	0.15	0	Suburban	0	0.7	0
Grasslands	20	0.25	0.05	Streets	0	0.95	0
No vegetation	80	0.3	0.24	Maximum flood	0	1	0
Total	100	-	0.29	**Total (C_2)**	0	-	0

Time of concentration (Tc) — Notes: t=Tc*60

Overland flow	Define watercourse
$Tc = 0.604\left(\frac{rL}{\sqrt{Sav}}\right)^{0.467}$	$Tc = \left(\frac{0.87L^2}{1000Sav}\right)^{0.385}$
hous	0.25 hours
	15

Run-off coefficient

Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (= Cs + Cp + Cv)	0.751				0.751	0.751	0.751
Adjusted for dolomite aeas , C_{10}	0.751				0.751	0.751	0.751
Adjusted factor for initial saturation, Ft (T3.8)	0.75				0.95	1	1
Adjusted run-off coefficient, C_{1T} (=C_{10} x Ft)	0.56				0.71	0.751	0.751
Combined run-off coefficient, CT (=αC_{1T} + βC_2 + γC_3)	0.56				0.71	0.751	0.751
Rainfall							
Retun period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm) (mm rain falling in Tc)	28.77				41.73	48.19	55.30
Point rainfall (mm/hr)	115.07				166.91	192.8	221.2
Peak flow (m^3/s) $Qt = \frac{Ct\ It\ A}{3.6}$	2.36				4.34	5.3	6.1

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	6.06	m3/s		Slope	1 1.5
Channel width	2	m	Flat		
Slope	0.10000	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.451484835	m	Solve with Manning equation		
Right side of mannings equation	0.030321086				
Freeboard	0.3	m			
Channel depth	0.751484835	m	0.6		
Velocity	5.012347495	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	2.665958712		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Checking flow depth, channel depth, flow velocity and Froude

				V	H
Q	6.06	m3/s		Slope	1 1.5
Channel width	2	m	STEEP		
Slope	0.33333	m/m	0.005		
			Use goal seek to solve yn with mannings equation. Follow steps below to use goal seek		Mannings n for smooth HDPE 0,009-0,015
Manning (left side)	0.03				
flow depth (yn)	0.321025362	m	Solve with Manning equation		
Right side of mannings equation	0.030311712				
Freeboard	0.3	m			
Channel depth	0.621025362	m	0.6		
Velocity	7.605176463	m/s	If velocity is > 2m/s, channel needs to be lined with HDPE		
Froude	4.682912604		Supercritical flow		>1 => Supercritical flow <1=> Subcritical flow

Colour coding

- *Designer must choose*
- *Spreadsheet calculates*
- *Value from input sheet*
- *Value calculated in other sheets*
- ***Final answer***
- ***Use Goal Seek***

Notes

*Sheet calculates Channel 1 peak flow
* Rational method alternative 2 is used

References

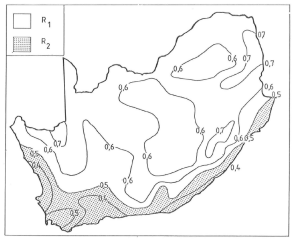
*Drainage manual, 6th edition, chapter 3

Table 3.7: Recommended values of run-off factor C for use in the Rational method

Rural (C_1)					Urban (C_2)	
		Mean annual rainfall (mm)				
Component	Classification	< 600	600 - 900	> 900	Use	Factor
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 – 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**
Ft - steep and impermeable	0.75	0.8	0.85	0.9	0.95	1
Ft - flat and permeable	0.5	0.55	0.6	0.67	0.83	1

Tc	**R1**	**R2**
0.10	0.17	0.14
0.25	0.32	0.23
0.50	0.46	0.32
1.00	0.60	0.41
2.00	0.72	0.53
3.00	0.78	0.60
4.00	0.82	0.67
5.00	0.84	0.71
6.00	0.87	0.75
8.00	0.90	0.81
10.00	0.92	0.85
12.00	0.94	0.89
18.00	0.98	0.96
24.00	1.00	1.00



0.25	want
0.25	first
0.5	second
0.32	firstcor
0.46	seccor
0.320	x

APPENDIX C
HIGH LEVEL COST ESTIMATE

Kangala - Landform and cover design - ALT1

SUMMARY	
SITE CLEARANCE	1 478 730.00
STORM WATER CHANNELS AND BERMS EARTHWORKS	23 124 514.70
STORM WATER CHANNELS AND BERMS GEOSYNTHETICS	72 040 303.96
COVER	143 049 942.63
EROSION PROTECTION	40 418 620.00
SUBTOTAL A	**280 112 111.29**
30% P's & Gs	84 033 633.39
SUBTOTAL B	**364 145 744.68**
10% Contingency allowance	36 414 574.47
TOTAL (EXCL. VAT)	**400 560 319.15**

* Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors

*Note: All material quantities excludes wastage

Kangala - landform ALT1

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2		**SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE**				
2.1	SANS 1200C, PSC	**SITE CLEARANCE**				
	8.2.1	**Clear and grub of site and remove all obstructions (spoil to be spread neatly within 1 km freehaul as directed by Engineer) at:**				
2.1.1		Spillage Collection Pond Boundary. Quantity to be confirmed during geotechnical assessment	m²	492 910.0	R3.00	1 478 730.00
2.2	SANS 1200D, PSD	**EARTHWORKS**				
	8.3.2	**Bulk excavation in all material. Stockpile, sort (selected material to be used for Pollution Control Dam embankments) or disposed of as directed by the Engineer within 1 km freehaul. (Rate to allow for load, haul and stockpiling of materials):**				
2.2.1		Cut to fill for shaping of landform	m^3		R34.39	-
	8.3.2	**Construct compacted fill with selected and approved material from excavations or stockpiles and compact to required specification or Engineers approval (placed volumes excludes bulking and compaction factors. Rate to include excavations, compaction, load, haul [free haul 1 km], spread, level, trim, tie-in, form side slopes etc) to form:**				
2.2.2		Cut to fill for shaping of landform	m^3	-	R50.55	-
	8.3.4	**Importing of materials:**				
2.2.3		Extra over items for 2.2.4 for importation of materials from stockpile	m^3	Rate only	R9.00	
	8.3.6	**Overhaul**				
2.2.4		Limited overhaul	m^3	Rate only	R9.00	
2.2.5		Long overhaul	m^3 - km	Rate only	R4.50	
	8.3.10	**Importing and placement of topsoil from stockpile**				
2.2.6		channels	m^3	78 569.1	R87.00	6 835 507.89
		toe-line drain	m^3	3 499.4	R87.00	304 446.06
	8.3.11	**Grassing or other vegetation cover with hydroseeding:**				
2.2.7		channels	m²	392 845.3	R18.50	7 267 637.69
		toe-line drain	m²	17 496.9	R18.50	323 692.65
2.3	SANS 1200DB PSDB	**GENERAL EARTHWORKS**				
	8.3.2	**Cut and fill in all materials:**				
2.3.1		fill of berms for drainage channels	m^3	65 153.9	R95.63	6 230 669.37
2.3.2		cut of toe line drain	m^3	20 861.0	R95.63	1 994 937.43
2.3.3		cut of drainage chutes	m^3	1 752.8	R95.63	167 623.61
2.4		**GEOSYNTHETICS**				
	PS GT	**Supply and install MACMAT R Polymer (or similar) for channels to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.4.1		channels	m²	392 845.3	R120.00	47 141 433.69

Kangala - landform ALT1

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
	PS GT	**Supply and install non-woven 100 g/m² protection geotextile (A10 Bidim or similar) for Rock mattress channels to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.4.2		channels	m^2	392 845.3	R58.00	22 785 026.28
2.4.3		drainage chutes	m^2	3 710.9	R95.63	354 875.28
	8.2.2	ROCK MATTRESSES				
		Rock mattresses to be supplied and installed as erosion control in channels				
2.4.4		drainage chutes	m²	3 710.9	R450.00	1 669 914.00
2.5	SABS 1200GA	**CONCRETE STRUCTURAL**				
		SCHEDULED FORMWORK ITEMS				
	8.2.2	**Smooth formwork:**				
2.5.1		Outlet structure 1	m²	18.1	R3 000.00	54 246.52
		SCHEDULED REINFORCEMENT ITEMS				
	8.3.1	**High tensile welded mesh in the following, 400mm lap length (quantity excludes all wastage):**				
2.5.2		Ref Mesh 395 in Floor of outlet structure 1	m²	18.1	R50.00	904.11
		SCHEDULED CONCRETE ITEMS				
	8.4.3	**Strenght concrete class 30MPa/19 mm concrete in:**				
2.5.3		Floor of outlet structure 1	m^3	5.4	R3 200.00	17 358.89
	8.4.4	**Uniformed wood floated surface finishes:**				
2.5.4		Floor of outlet structure 1	m²	18.1	R35.00	632.88
	8.2.5	PITCHING				
		Stone pitching to be done with 300mm dia boulders with a relevant density of 2.65 and higher. All stones to be uniform in size and to protrude by a min. of 100mm.				
2.5.5		Floor of outlet structure 1	m²	18.1	R280.00	5 063.01
	8.2.2	GABIONS				
		Gabion baskets to be supplied and installed as erosion control				
2.5.6		Floor of outlet structure 1	m^3	9.0	R1 200.00	10 849.30
** Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors *Note: All material quantities excludes wastage*						
		Total Section 2				96 643 548.66

Kangala - landform ALT1

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
		SUMMARY				
SECTION 1 : PRELIMINARY AND GENERAL						34 291 824.97
SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE						96 643 548.66
SUBTOTAL A						**130 935 373.64**
10% Contingency allowance						13 093 537.36
SUBTOTAL B						**144 028 911.00**
Add 15% V.A.T.						**21 604 336.65**
LANDFORM ALT 1 TOTAL						**165 633 247.65**

Kangala - Cover Design ALT1

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2		**SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE**				
2.1	SANS 1200D, PSD	**EARTHWORKS**				
	8.3.2	**Construct compacted fill with selected and approved material from excavations or stockpiles and compact to required specification or Engineers approval (placed volumes excludes bulking and compaction factors. Rate to include excavations, compaction, load, haul [free haul 1 km], spread, level, trim, tie-in, form side slopes etc) to form:**				
2.1.1		Load, haul and place coarse (barren) gravel material	m^3	73 936.5	R50.55	3 737 490.08
2.1.2		Load, haul and place fine sandy material	m^3	221 809.5	R50.55	11 212 470.23
2.1.3		Load, haul and place 2 X 150mm lime stabilised material (4%)	m^3	147 873.0	R50.55	7 474 980.15
	8.3.11	**Grassing or other vegetation cover with hydroseeding:**				
2.1.4		Landfill area	m^2	492 910.0	R18.50	9 118 835.00
2.2	SABS 1200LE	**STORM WATER DRAINAGE**				
	8.2.1	**Supply and install infiltration drain system pipes:**				
2.2.1		Wastex DN160 HDPE perforated pipe (or similar) as cover infiltration pipeline. Rate to include connections and junctions	m	14 222.0	R528.89	7 521 873.58
2.3		**GEOSYNTHETICS**				
	PS GT	**Supply and install non-woven protection geotextile (A8 Bidim or similar) for barrier system to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.3.1		Landfill area	m^2	985 820.0	R40.48	39 905 993.60
		GEO CELLS				
2.3.2	PS	Supply and installation of 450mm Geocells that should be filled with coarse or fine material respectively for infiltration drainage	m^2	492 910.00	R130.00	64 078 300.00
		GEOGRID				
2.3.3	PS	Supply and installation of Geogrid as erosion protection on steep slopes	m^2	492 910.00	R75.00	36 968 250.00
		SOIL SAVER				
2.3.4	PS	Supply and installation of Soil saver as erosion protection on steep slopes on top of topsoil	m^2	492 910.00	R7.00	3 450 370.00
** Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors *Note: All material quantities excludes wastage*						
		Total Section 2				183 468 562.63

Kangala - Cover Design ALT1

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
		SUMMARY				
SECTION 1 : PRELIMINARY AND GENERAL						-
SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE						183 468 562.63
SUBTOTAL A						**183 468 562.63**
10% Contingency allowance						18 346 856.26
SUBTOTAL B						**201 815 418.89**
Add 15% V.A.T.						**30 272 312.83**
COVER ALT 1 TOTAL						**232 087 731.73**

Kangala - Landform and cover design - ALT2

SUMMARY	
SITE CLEARANCE	1 483 142.13
EARTHWORKS (ADDITIONAL EXPENSE)	54 850 174.88
STORM WATER CHANNELS AND BERMS EARTHWORKS	23 349 180.58
STORM WATER CHANNELS AND BERMS GEOSYNTHETICS	73 401 439.47
COVER	143 409 366.05
SUBTOTAL A	**241 643 128.24**
30% P's & Gs	72 492 938.47
SUBTOTAL B	**314 136 066.71**
10% Contingency allowance	31 413 606.67
TOTAL (EXCL. VAT)	**345 549 673.38**

* Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors

*Note: All material quantities excludes wastage

Kangala - landform ALT2

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2		**SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE**				
2.1	SANS 1200C, PSC	**SITE CLEARANCE**				
	8.2.1	**Clear and grub of site and remove all obstructions (spoil to be spread neatly within 1 km freehaul as directed by Engineer) at:**				
2.1.1		Spillage Collection Pond Boundary. Quantity to be confirmed during geotechnical assessment	m²	494 380.7	R3.00	1 483 142.13
2.2	SANS 1200D, PSD	**EARTHWORKS**				
	8.3.2	**Bulk excavation in all material. Stockpile, sort (selected material to be used for Pollution Control Dam embankments) or disposed of as directed by the Engineer within 1 km freehaul. (Rate to allow for load, haul and stockpiling of materials):**				
2.2.1		Cut to fill for shaping of landform	m^3	645 752.0	R34.39	22 207 411.28
	8.3.2	**Construct compacted fill with selected and approved material from excavations or stockpiles and compact to required specification or Engineers approval (placed volumes excludes bulking and compaction factors. Rate to include excavations, compaction, load, haul [free haul 1 km], spread, level, trim, tie-in, form side slopes etc) to form:**				
2.2.2		Cut to fill for shaping of landform	m^3	645 752.0	R50.55	32 642 763.60
	8.3.4	**Importing of materials:**				
2.2.3		Extra over items for 2.2.4 for importation of materials from stockpile	m^3	Rate only	R9.00	
	8.3.6	**Overhaul**				
2.2.4		Limited overhaul	m^3	Rate only	R9.00	
2.2.5		Long overhaul	m^3 - km	Rate only	R4.50	
	8.3.10	**Importing and placement of topsoil from stockpile**				
2.2.6		channels	m^3	80 098.4	R87.00	6 968 562.70
		toe-line drain	m^3	3 499.4	R87.00	304 446.06
	8.3.11	**Grassing or other vegetation cover with hydroseeding:**				
2.2.7		channels	m²	400 492.1	R18.50	7 409 104.03
		toe-line drain	m²	17 496.9	R18.50	323 692.65
2.3	SANS 1200DB PSDB	**GENERAL EARTHWORKS**				
	8.3.2	**Cut and fill in all materials:**				
2.3.1		fill of berms for drainage channels	m^3	65 153.9	R95.63	6 230 669.37
2.3.2		cut of toe line drain	m^3	20 861.0	R95.63	1 994 937.43
2.3.3		cut of drainage chutes	m^3	1 231.5	R95.63	117 768.35
2.4		**GEOSYNTHETICS**				
	PS GT	**Supply and install MACMAT R Polymer (or similar) for channels to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.4.1		channels	m²	400 492.1	R120.00	48 059 053.14

Kangala - landform ALT2

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
	PS GT	**Supply and install non-woven 100 g/m² protection geotextile (A10 Bidim or similar) for Rock mattress channels to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.4.2		channels	m^2	400 492.1	R58.00	23 228 542.35
2.4.3		drainage chutes	m^2	3 710.9	R95.63	354 875.28
	8.2.2	ROCK MATTRESSES				
		Rock mattresses to be supplied and installed as erosion control in channels				
2.4.4		drainage chutes	m²	3 710.9	R450.00	1 669 914.00
2.5	SABS 1200GA	**CONCRETE STRUCTURAL**				
		SCHEDULED FORMWORK ITEMS				
	8.2.2	**Smooth formwork:**				
2.5.1		Outlet structure 1	m²	18.1	R3 000.00	54 246.52
		SCHEDULED REINFORCEMENT ITEMS				
	8.3.1	**High tensile welded mesh in the following, 400mm lap length (quantity excludes all wastage):**				
2.5.2		Ref Mesh 395 in Floor of outlet structure 1	m²	18.1	R50.00	904.11
		SCHEDULED CONCRETE ITEMS				
	8.4.3	**Strenght concrete class 30MPa/19 mm concrete in:**				
2.5.3		Floor of outlet structure 1	m^3	5.4	R3 200.00	17 358.89
	8.4.4	**Uniformed wood floated surface finishes:**				
2.5.4		Floor of outlet structure 1	m²	18.1	R35.00	632.88
	8.2.5	PITCHING				
		Stone pitching to be done with 300mm dia boulders with a relevant density of 2.65 and higher. All stones to be uniform in size and to protrude by a min. of 100mm.				
2.5.5		Floor of outlet structure 1	m²	18.1	R280.00	5 063.01
	8.2.2	GABIONS				
		Gabion baskets to be supplied and installed as erosion control				
2.5.6		Floor of outlet structure 1	m^3	9.0	R1 200.00	10 849.30
** Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors *Note: All material quantities excludes wastage*						
		Total Section 2				153 083 937.07

Kangala - landform ALT2

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
		SUMMARY				
SECTION 1 : PRELIMINARY AND GENERAL						34 291 824.97
SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE						153 083 937.07
SUBTOTAL A						**187 375 762.04**
10% Contingency allowance						18 737 576.20
SUBTOTAL B						**206 113 338.25**
Add 15% V.A.T.						**30 917 000.74**
LANDFORM ALT 2 TOTAL						**237 030 338.98**

Kangala - Cover Design ALT2

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2		**SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE**				
2.1	SANS 1200D, PSD	**EARTHWORKS**				
	8.3.2	**Construct compacted fill with selected and approved material from excavations or stockpiles and compact to required specification or Engineers approval (placed volumes excludes bulking and compaction factors. Rate to include excavations, compaction, load, haul [free haul 1 km], spread, level, trim, tie-in, form side slopes etc) to form:**				
2.1.1		Load, haul and place coarse (barren) gravel material	m^3	74 157.1	R50.55	3 748 641.73
2.1.2		Load, haul and place fine sandy material	m^3	222 471.3	R50.55	11 245 925.20
2.1.3		Load, haul and place 2 X 150mm lime stabilised material (4%)	m^3	148 314.2	R50.55	7 497 283.47
	8.3.11	**Grassing or other vegetation cover with hydroseeding:**				
2.1.4		Landfill area	m^2	494 380.7	R18.50	9 146 043.14
2.2	SABS 1200LE	**STORM WATER DRAINAGE**				
	8.2.1	**Supply and install infiltration drain system pipes:**				
2.2.1		Wastex DN160 HDPE perforated pipe (or similar) as cover infiltration pipeline. Rate to include connections and junctions	m	14 137.0	R528.89	7 476 917.93
2.3		**GEOSYNTHETICS**				
	PS GT	**Supply and install non-woven protection geotextile (A8 Bidim or similar) for barrier system to Project Specification (rate to include cutting, strapping, wastage & seaming at:**				
2.3.1		Landfill area	m^2	988 761.4	R40.48	40 025 062.28
		GEO CELLS				
2.3.2	PS	Supply and installation of 150mm Geocells that should be filled with coarse or fine material respectively for infiltration drainage	m^2	494 380.71	R130.00	64 269 492.30
** Note: All items are Re-Measurable *Note: Placed volumes excludes bulking and compaction factors *Note: All material quantities excludes wastage*						
		Total Section 2				143 409 366.05

Kangala - Cover Design ALT2

ITEM	PAYMENT	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
		SUMMARY				
SECTION 1 : PRELIMINARY AND GENERAL						-
SECTION 2 : EARTHWORKS, DRAINAGE AND INFRASTRUCTURE						143 409 366.05
SUBTOTAL A						**143 409 366.05**
10% Contingency allowance						14 340 936.60
SUBTOTAL B						**157 750 302.65**
Add 15% V.A.T.						**23 662 545.40**
COVER ALT 2 TOTAL						**181 412 848.05**