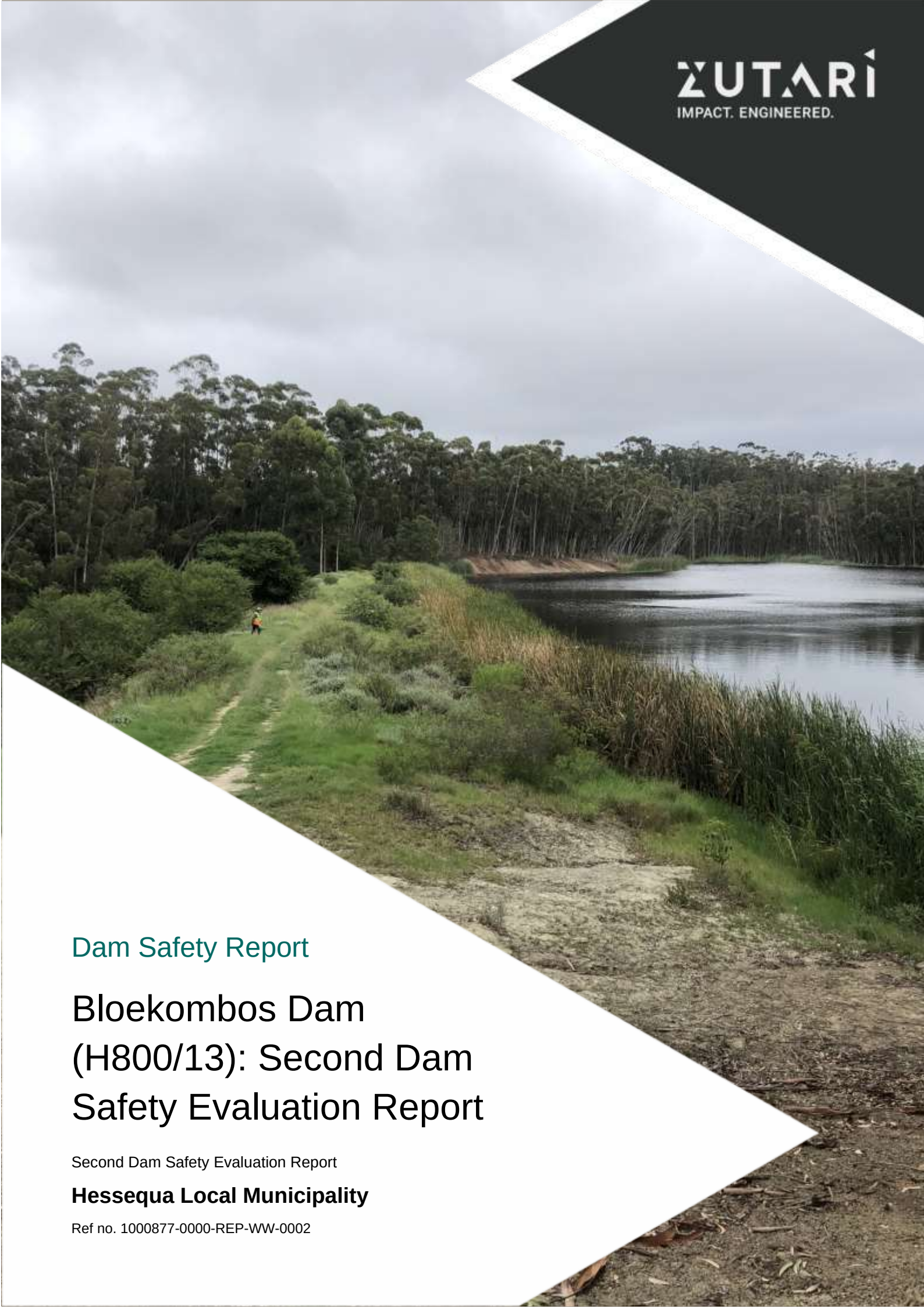

Dam Safety Report

Bloekombos Dam (H800/13): Second Dam Safety Evaluation Report

Second Dam Safety Evaluation Report

Hessequa Local Municipality

Ref no. 1000877-0000-REP-WW-0002

Document control record

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Author		**APP**		**Approver**	
Name	P Ndlovu	**Name**	D Rajna	**Name**	Dr FJM Denys
Title	Dam Technologist	**Title**	Pr Tech Eng	**Title**	Pr. Eng

Executive Summary

Bloekombos Dam is a 78-year-old earth embankment dam situated in the town of Heidelberg. It is approximately 14 m high and has a crest length of 190 m. The dam is effectively an off-channel storage reservoir with a gross storage capacity of 172 000 m^3. The dam was originally connected to a downstream sand filter and used for municipal water, however the facility has been abandoned and the water is currently used only for irrigation. It is owned by the Hessequa Local Municipality and is filled mainly with water from a canal offtake from the Duiwenhoks River. There is some minimal inflow from the tiny catchment of 0.6 km^2.

Zutari was appointed for the second dam safety evaluation and report of Bloekombos Dam. Mr D Rajna was confirmed as the Approved Professional Person (APP). The dam was inspected on 23 March 2023, and was found to be in a poor condition with clear signs of structural distress and a spillway encroached with vegetation.

The entire downstream face was difficult to discern due to excessive vegetation overgrowth, but it is in a poor condition in places. There are extensive downstream slips and longitudinal cracks along the upper third of the downstream face, which have resulted in localised near vertical slopes. The wide crest acts as a buffer for stability nevertheless these slips will continue to erode upstream and need to be attended to.

The slips are likely due to the seepage through the embankment which is evident from the concentration of reeds some 3 m below the crest on the downstream slope. There is also significant seepage running out and ponding at and beyond the downstream toe. This needs to be investigated.

The non-overspill crest is in fair condition, showing signs of erosion damage towards the right flank. It is 4-5 m wide, but narrower in places where downstream slips have occurred. The settlement that was observed during the survey towards the middle and right abutment of the crest has reduced the freeboard and should be reinstated. This settlement may well be related to the seepage.

The flood peaks for the small catchment of 0.6 km^2 were recalculated using the rational method. The discharge capacity of the spillway, given the current freeboard of 0.92 m is not quite enough to handle the routed SEF event and the RDF event with wave action (0.94 m). Furthermore, the vegetation growth currently in the vicinity of the spillway would choke this discharge capacity and cause overtopping.

The spillway and discharge channel structures are in fair condition though they both show general signs of concrete aging. Both structures must be cleared of vegetation and debris.

The upstream face was mostly under water on the day of the inspection. The exposed portion of the face appears to be in fair condition although the face is overgrown with reeds and a few large trees. There is evidence of some sparse rip rap protection.

A valve was located at the downstream toe which is likely the main outlet valve however its status could not be determined due to the thick vegetation.

In the event of a breaching of the dam, there would be risk to life and damage to development immediately downstream of the dam. The previous classification “high” hazard was reviewed, and it

was determined that given the small storage capacity of 172,000 m^3 and consequent short-lived flood, the hazard should be reduced to ‘significant”.

The previous classification of “small” dam height however, is incorrect and has been corrected to “medium “ as the dam is 14 m high. The Category II classification of the dam is still considered appropriate.

The following recommendations are made following this dam safety evaluation:

(a) Infill the crest with a minimum of 200 mm to reinstate the freeboard.

(b) Cut short all trees and remove thick reeds and grass that have been allowed to establish in the vicinity of both the concrete spillway structures and along the discharge channel, giving priority to the spillway sill area which is completely choked.

(c) Clear and thereafter continuously control vegetation on the embankment, including the reed and trees growing on the upstream face as well as the large shrubs and trees on the downstream face. Clear a strip at least 5 m wide downstream of the toe. Maintain remaining vegetation to control erosion but cut and keep short (no more than 0.5 m).

(d) Monitor and investigate the downstream seepage and should it be warranted, take corrective action to address it.

(e) Reinstate the downstream slopes where they have slipped and become near vertical.

(f) Prepare an Operation and Maintenance Manual or update one if it exists. This manual should include all details of the upgrades (if any) at the dam, a register of all available data and drawings and updated emergency contact details in the emergency preparedness plan.

(g) Conduct and record routine inspections of the dam as required by the dam safety regulations.

(h) All valves should be operated through their full range at least quarterly, and any necessary maintenance effected.

(i) Refurbish the wooden handrails alongside the discharge channel.

Contents

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Appendix A - Correspondence
Appendix B - Photos
Appendix C - Additional information

Figures

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Acronyms and Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
APP	Approved Professional Person
dia	Diameter
DSER	Dam Safety Evaluation Report
DSO	Dam Safety Office
DWS	Department of Water and Sanitation
E	East
EPP	Emergency Preparedness Plan
FOS	Factor of Safety
FSL	Full Supply Level
H	Horizontal
h	Height
$H_{2\%}$	2% exceedance wave height
masl	Metres above mean sea level
MCE	Maximum Credible Earthquake
Mm^3	Million m^3
MOL	Minimum Operating Level
No.	Number
NOC	Non-Overspill Crest
OMM	Operation and Maintenance Manual
PMF	Probable Maximum Flood
Pr Eng	Professional Engineer
$R_{2\%}$	2% exceedance wave run-up
RDD	Recommended Design Discharge
RDF	Recommended Design Flood
RI	Recurrence Interval
RL	Relative Level
RMF	Regional Maximum Flood
S	South
SANCOLD	South African National Committee on Large Dams
SED	Safety Evaluation Discharge
SEF	Safety Evaluation Flood
V	Vertical
yr	Year

Glossary

The following table provides an outline of the condition grades used in this report which are broadly based on those developed by the American Society of Civil Engineers.

Grade	Description	Maintenance / Action
Very Good	**Fit for Purpose**	
	The infrastructure is typically new or recently rehabilitated. A few elements show general signs of deterioration that require attention. Meets modern standards for functionality and is resilient to withstand most disasters and severe weather events.	Only normal scheduled maintenance is required. No action required.
Good	**Adequate for Now**	
	The infrastructure is in good to excellent condition; some elements show signs of general deterioration that require attention. A few elements exhibit significant deficiencies. Safe and reliable, with minimal issues and minimal risk.	Some minor maintenance needed. Keep monitoring.
Fair	**Mediocre, Requires Attention**	
	The infrastructure is in fair to good condition; it shows general signs of deterioration and requires attention. Some elements exhibit significant deficiencies in conditions and functionality, with increasing vulnerability to risk.	Action required. Overall repairs needed.
Poor	**At Risk**	
	The infrastructure is in poor to fair condition and mostly below standard, with many elements approaching the end of their service life. A large portion of the system exhibits significant deterioration. Conditions are of serious concern with strong risk of failure. System not functional.	Significant repairs / renewal / upgrades required
Very Poor	**Failing/Critical, Unfit for Purpose**	
	The infrastructure is in unacceptable condition with widespread advanced signs of deterioration. Many of the components of the system exhibit signs of imminent failure. System unsafe.	Major repair or replacement required to restore function

1 Introduction

1.1 Terms of reference

This report is presented in terms of Section 119(3)b of the regulations made by the Minister of Water Affairs in terms of the National Water Act (No. 36 of 1998) and in terms of Regulations 34 and 35 of the Dam Safety Regulations as published under Government Notice R139 in Government Gazette 35062 of 24 February 2012.

1.2 Credentials

Correspondence relating to the approval of Mr D Rajna as the Approved Professional Person is described below (see Appendix A).

- Notification of appointment as APP dated 12 June 2023 from Zutari for Mr D Rajna as the Approved Professional Person for this task.
- Letter dated 13 June 2023 from the Director-General approving Mr D Rajna as the Approved Professional Person

1.3 List of staff contributing to inspection and report

Zutari

Mr. D Rajna	(APP)	Inspection, evaluation, compilation, and review
Mr. P Ndlovu		Inspection, and compilation
Dr. F Denys		Review

Client

Mr. Z Jonker	Information and inspection

1.4 Scope and objectives

The main objective of this dam safety evaluation (DSE) is to assess the safety of the dam and make relevant recommendations to rectify shortcomings in the condition of the dam and to mitigate any identified risks.

The scope of this dam safety evaluation entails the following:

- Review all relevant available information on the dam and any observations made by the Dam Owner
- Review aspects of the design that have an important bearing on the safety of the dam
- Conduct a physical inspection of the dam and its structures
- Review the operation, maintenance and management of the dam
- Review the performance of the dam
- Compile a dam safety evaluation report
- Make recommendations concerning the operation and maintenance of the dam
- Propose a programme for the implementation of the recommendations

2 Main Features of the Dam

Bloekombos Dam is a 78-year-old earth embankment dam situated in the town of Heidelberg. It is approximately 14 m high and has a crest length of 190 m. The dam is effectively an off-channel storage reservoir with a gross storage capacity of 172 000 m^3. The dam was originally connected to a downstream sand filter and used for municipal water, however the facility has been abandoned and the water is currently used only for irrigation. It is owned by the Hessequa Local Municipality and is filled mainly with water from a canal offtake from the Duiwenhoks River. There is some minimal inflow from the tiny catchment of 0.6 km^2.

The main details of the dam are presented below. The dam's location can be seen on the locality map in Figure 2-1. A copy of the registration details, with corrections, is attached in Appendix A.

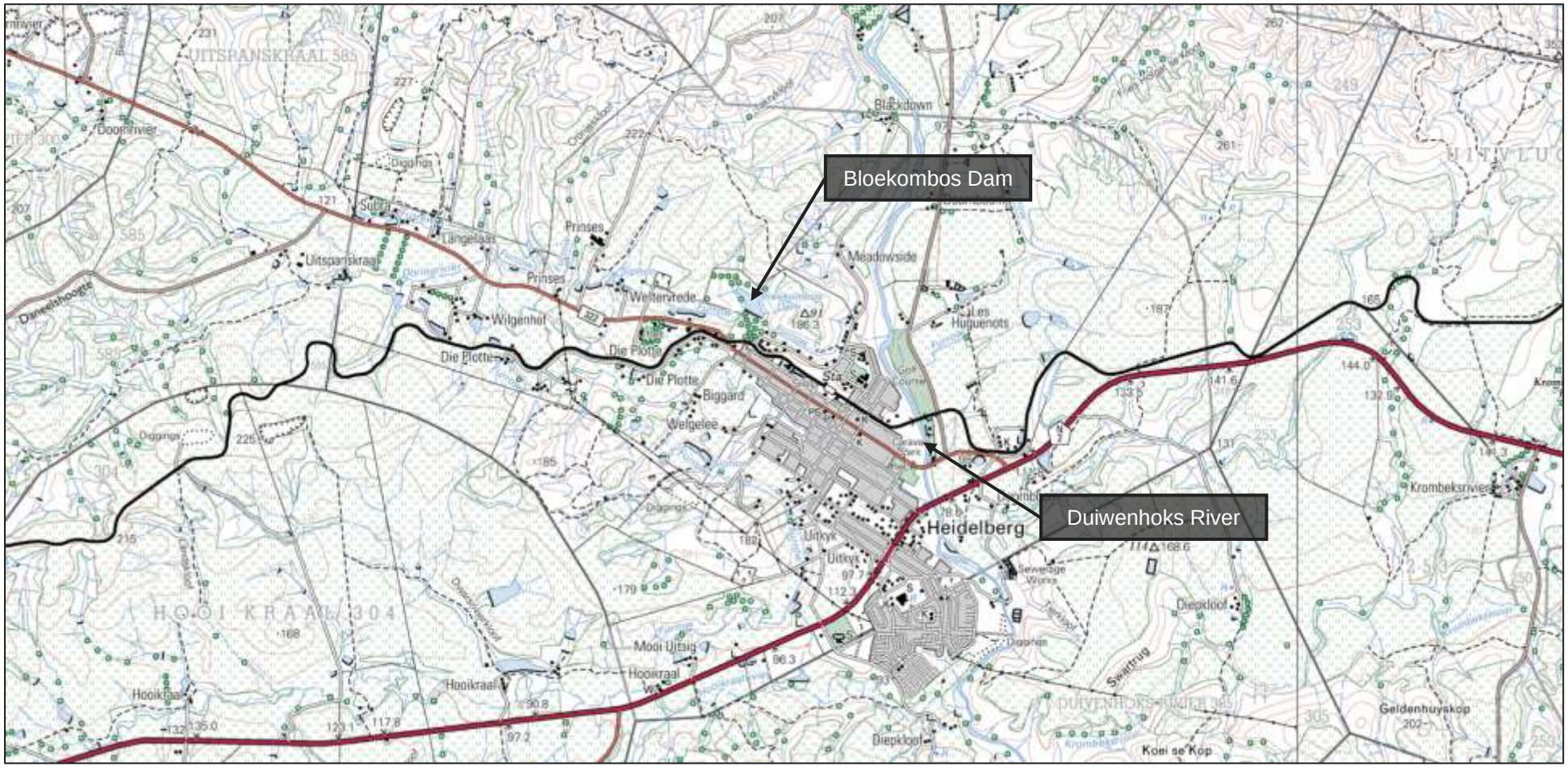
Table 2-1: Main features of Bloekombos Dam

General Information	
Type of dam	Earthfill embankment
DWS registration number	H800/13
Owner	Hessequa Local Municipality
Designer	Hessequa Local Municipality
Contractor	Hessequa Local Municipality
Completion date	1945
Location	34° 04' 52" S 20° 56' 56" E
Nearest town	Heidelberg
Classification	
Size	Medium
Hazard potential	Significant
Category	II
Purpose	Irrigation
Dam characteristics and dimensions	
Gross storage capacity	172 000 m^3
Surface area at full supply level	2.0 ha
River	Doorn river tributary* - Filled mainly by a pipe connected to a canal offtake from the Duiwenhoks River
Catchment area	0.6 km^2 (effectively off-channel)
Maximum wall height	14.0 m
Non-overspill crest (NOC) level	Ranges from RL 120.92 m to RL 121.58 **
Full supply level (FSL)	RL 120 m
Minimum freeboard (m)	0.92 m **
Total crest length	190 m
Crest width	~ 5.0 m
Maximum base width	Unknown
Upstream face slope	±1V: 3.0H
Downstream face slope	Design slopes ±1V: 2.0H. Much steeper near top third of wall where slips have occurred

General Information	
Upstream slope protection	Gravelly riprap
Downstream slope protection	Thick vegetation
Spillway Characteristics	
Spillway type	Concrete sill with uncontrolled open channel on right flank under bridge and discharge channel
Spillway crest length	~ 8.0 m
Freeboard above FSL	0.92 m (there has been settlement)
Spillway capacity with zero freeboard i.e. water level at NOC level RL 120.92 m	13.1 m^3/s
Flood hydrology	
Recommended Design Flood (RDF)	1:200-year flood
RDF peak inflow	6.9 m^3/s
RDF peak outflow	2.0 m^3/s
RDF level	RL 120.29 m
Safety Evaluation Flood (SEF)	Probable Maximum Flood
SEF peak inflow	35.5 m^3/s
SEF peak outflow	18.5
SEF level	RL 120.85 m
Other aspects	
Drainage and pressure relief systems	Unknown
Outlet works	Downstream valve with spindle – details unknown
Monitoring instruments	None

* According to the dam safety register

** March 2023 crest survey



ZUTARI	**Figure 2-1: Bloekombos Dam Locality Map** ***Locality Map – Bloekombos Dam (34º 04' 52" S, 20º 56' 56" E)*** ***CD:NGI – 3420BB***

3 Review of Existing Data

3.1 Applicable documents and drawings

No documents were made available from the Client or the Dam Safety Office however a copy of the 1st dam safety report (2002) is reportedly held in the archives of the Dam Safety Office.

3.2 Original design assumptions

No original design assumptions exist besides the information on the description of the dam and spillway from the dam safety register which also states that a first dam safety report was conducted in 2002. This report could however not be found.

3.3 Notable historic observations

A few records detailing historical events at the dam are listed below:

- 1945: Construction of dam completed.
- 2002: First dam safety inspection report.

3.4 Recommendations made in previous report

The previous report was not available and consequently the recommendations made during the first dam safety evaluation in 2002 could not be reviewed. This resulted in a more detailed analysis of the floods and spillway discharge being done for this report.

4 On-site Inspection

The second dam safety inspection of Bloekombos Dam was carried out on 23 March 2023 by the APP, Mr D Rajna, accompanied by Mr P Ndlovu from Zutari. Mr Z Jonker allowed for access to the site for the inspection on behalf of the owner and provided some information.

A general layout of the dam showing the location of the wall and spillway is shown in Figure 4-1 below.

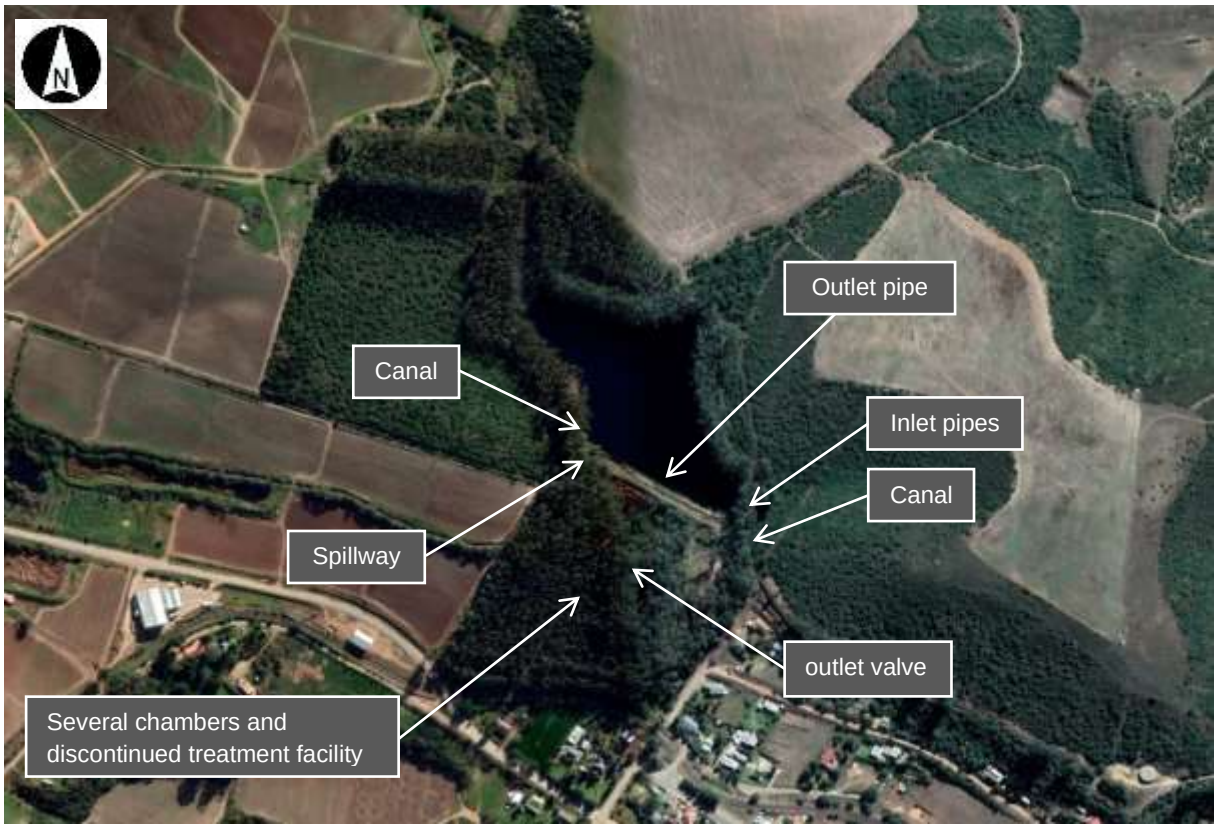


Figure 4-1: Layout of the Bloekombos Dam

The following observations were made during the inspection:

4.1 General

Access: The dam is accessible via public roads. Driving from Cape Town along the N2 turn left onto the R322 and then right onto Park Street. Access to the dam is located on Muir Street. There is an access control boom at the entrance, but it is open to the public.

Routine inspections reports: No routine inspections done, and no records are kept.

Emergency warning: No procedure for emergency planning was available.

Operating procedures: Unknown.

Illumination of the wall: No lighting on the dam wall exists.

Water level on day of inspection: ~1.0 m below full supply level.

Weather condition during inspection: Cool and cloudy. Light drizzle.

General condition of dam: The dam is in a fair to poor condition in some instances. Photographs are provided in Appendix B.

4.2 Non-Overspill Crest

Condition of crest: In fair condition. Approximately 4-5 m wide crest, but narrower in places where downstream slips have occurred. The crest appears to be frequently used for access and has visible wheel rutting on it (see Figure 4-2).

Figure 4-2: View of embankment crest from the left abutment

Cracking: Evidence of desiccation cracks due to lack of a gravel capping layer were observed (see Figure 4-3).

Figure 4-3: Desiccation cracks observed along length of the crest

Alignment / Movement: The alignment appears largely straight with no significant signs of movement evident however, undulations and unevenness were observed.

Vegetation: The crest is covered in thick grass, shrubs and some small trees.

Animal burrows: Termite, ant and mole digging activity was observed on the crest. One of the holes was measured to be 100 mm deep.

Settlement: The crest was surveyed and found to have settled significantly towards the middle and right flank (see Section 4.9).

Erosion: Some erosion was observed towards the right flank of the dam.

4.3 Upstream face of dam

Slope protection: There is evidence of small sized gravelly rip rap protection. The face was mostly under water on the day of the inspection (see Figure 4-4).

Figure 4-4: View of the upstream face from the left abutment

Condition of face: The upstream face was mostly under water on the day of the inspection however, the exposed portion of the face appears to be in a fair condition. The water line could not be inspected due to vegetation (reeds) growing on upstream face.

Cracking/movement: No significant cracking was observed on the visible portions of the face.

Vegetation: The face is overgrown with reeds. There are also some young trees and large shrubs growing. These need to be removed.

Animal action: No digging activity by animals was observed.

4.4 Downstream face of dam

Slope protection: The downstream face is protected by vegetation (grass, some thick thorn bushes, and large trees).

Condition of face: The downstream face is in a poor condition in places. The face was difficult to discern in some places due to the vegetation overgrowth.

Near the middle and towards the right flank, the slopes have slipped and are **near vertical** about a third of the way down the slope (see Figure 4-5 -and Figure 4-6). Longitudinal cracks are forming near the crest where the slipping is starting. This is likely due to the seepage which is evident from the

concentration of reeds some 3 m below the crest. There is also seepage near the bottom of the downstream slope and at the toe.

The very steep slopes, now covered in vegetation need to be rehabilitated to ensure the long-term stability of the structure.

Figure 4-5: Surface slip near right abutment. Note reeds growing where seepage likely daylights.

Figure 4-6: Steep sections caused by surface slips. Note thick vegetation and large trees on DS face.

Seepage, drainage and pressure relief: There is evidence of significant leakage near the upper third of the slope with a concentration of reeds on these slopes. There is also seepage at the bottom of the slopes. The exact cause of this seepage needs to be investigated.

Vegetation: Thick grass cover with reads, thick thorn bushes, and large trees were observed. The entire face is thickly vegetated and is difficult to inspect.

Animal burrows: No digging activity by animals was observed.

4.5 Downstream toe

Condition: The downstream toe is in a fair condition with no obvious erosion observed. It is overgrown with trees and vegetation and is difficult to access.

Figure 4-7: Audible stream and ponding at downstream toe

Seepage, drainage and pressure relief: An audible stream of water was noted flowing down and away from the toe of the dam as seen in Figure 4-7 above and in the vicinity of the outlet pipe. The exact source could be a combination of seepage, valve leakage and runoff and needs to be further investigated.

Vegetation: The downstream toe is overgrown with trees and vegetation (thick grass and some bushes) and is very difficult to access.

Animal burrows: No animal activity was observed.

4.6 Spillway

Description: Located on the right flank, it consists of an 8 m wide sill. Flow is directed down from the sill and under a bridge which spans the 8 m wide, 1.7 m discharge channel with two concrete piers (see Figure 4-9).

Figure 4-8: Looking upstream towards overflow sill. Note clogged with vegetation

Figure 4-9: Looking downstream along spillway discharge channel

Condition: In fair condition, with a lot of cracking concrete

Ageing of materials: The concrete on the spillway structure is showing signs of ageing and will eventually require refurbishment (see Figure 4-10).

Figure 4-10: Damaged concrete channel walls

Condition of discharge channel: In fair condition. The discharge channel is concrete lined, and the foundations downstream have been undercut by erosion. The channel is semi-blocked by debris and vegetation. The wooden handrails alongside the discharge channel should be refurbished.

Figure 4-11: Discharge channel

Vegetation: Vegetation has been allowed to establish around the spillway inlet sill to such an extent that it will severely restrict the approach flow toward the spillway.

4.7 Outlet works

Description: An outlet chamber could not be located however a valve was identified at the downstream toe. (See Figure 4-12). The outlet pipe extension to the abandoned sand filters has clearly been discontinued. It appears that water is pumped out from the dam by local farmers.

Condition: Not able to confirm

Leakage / seepage: Ponding and flowing water was observed in the vicinity of the downstream area where the outlet pipe is located. This could be the result of several causes including valve leakage and needs to be investigated.

Access to outlet works: The downstream area in the vicinity the outlet valve is overgrown and needs to be cleared.

Figure 4-12: Spindle of suspected main outlet valve located at downstream toe of dam.

4.8 Reservoir basin slopes

Stability: The slopes are relatively flat and well vegetated above full supply level. No signs of instability were observed.

Erosion: No significant erosion or signs thereof were observed.

4.9 Monitoring instruments

There are no monitoring instruments at Bloekombos Dam, however, a crest survey was conducted as part of the dam safety evaluation to verify the existing freeboard. No benchmarks were found or known and as such, a relative datum level of RL 120 m was chosen for the spillway sill, for the crest survey.

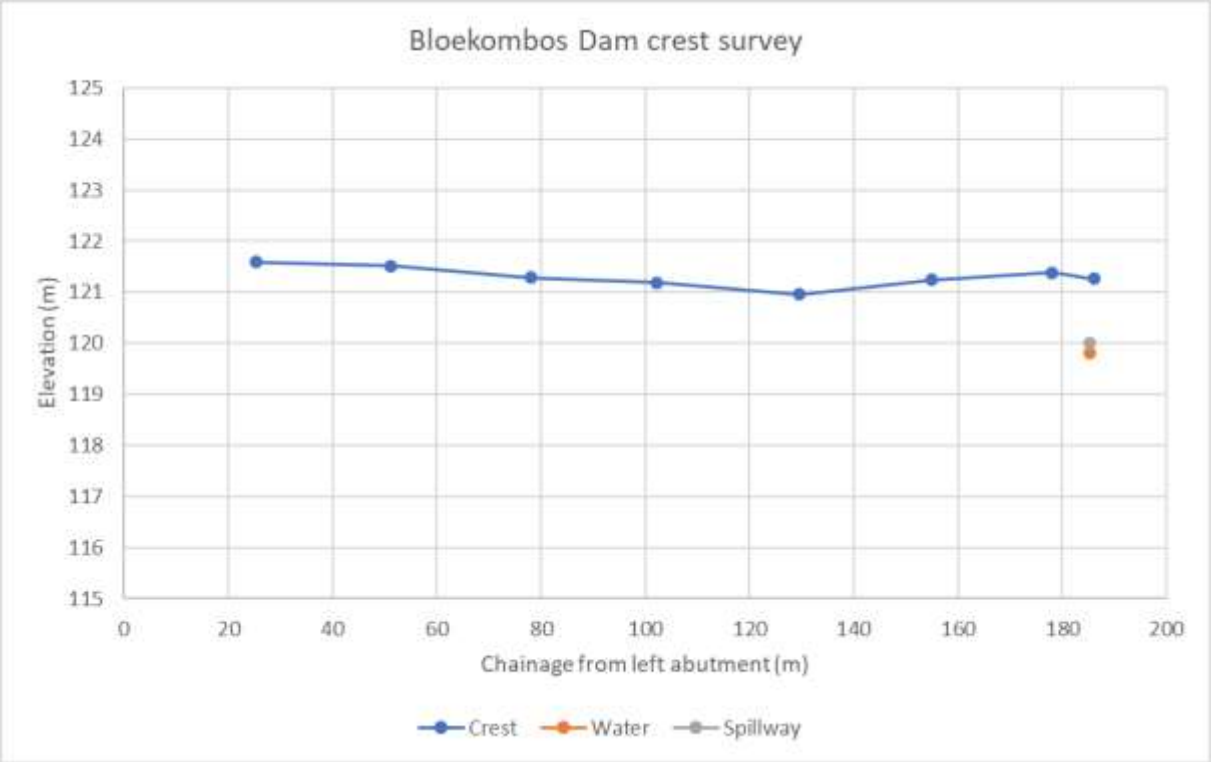


Figure 4-13: Embankment Non-Overspill Crest levels

It can be seen from Figure 4-13 that there appears to have been significant settlement towards the middle and right abutment. This is in the region noted as showing signs of undulations and this settlement could be attributed to erosion and slips. According to the crest survey, the dam has a minimum freeboard of 0.92 m with the level of the crest nearer the abutments having about 1.2 m to 1.5 m freeboard.

5 Technical Review

5.1 Flood hydrology and spillway

5.1.1 Flood Magnitudes

Bloekombos dam is effectively an off-channel dam located within a hilly catchment area. The dam has a tiny catchment area in the order of 0.6 km^2 directly upstream from it (refer to Figure 5-1). The dam is reportedly filled by canal / pipes from the Doorn River. There is some but very little runoff from its catchment.

Figure 5-1: Approximate catchment area of the Bloekombos Dam

The flood hydrology was reviewed and redone in this current safety evaluation.

The guidelines used for the selection and determination of suitable design floods are contained in the SANCOLD publication “Guidelines on safety in relation to floods” (SANCOLD, 1991). According to these guidelines, the design flood selection is dependent on the dam size, class and hazard as assigned by the Department of Water and Sanitation (DWS). The current hazard and size are incorrect on the register, though the category II rating is correct. Bloekombos Dam is a “Medium” sized dam with a “Significant” hazard rating and is classified as a Category II dam. At the first assessment level, the recommended floods are based on the Regional Maximum Flood (RMF) and the second assessment level the floods should be determined by using site specific methods. As the concept of the RMF cannot be applied to the dam (a small area of 0.6 km^2 < 10 km^2), the second assessment level was used for evaluating the spillway capacity.

The recommended flood peaks for the Bloekombos Dam are:

- Recommended Design Flood (RDF) should be 1 in 100-year flood, and
- the Safety Evaluation Flood (SEF) should be equal to the Probable Maximum Flood (PMF) multiplied by a factor which is dependent on the RMF. Since the RMF concept is not considered applicable, it was decided to revert to the 1986 Guidelines (SANCOLD, 1986) to determine the SEF. The factor for a medium dam with a significant hazard rating according to these guidelines is 0.7, meaning the SEF = 0.7 PMF.

The estimated flood peaks were calculated using the Rational method and then routed through an approximation of the dam basin to obtain outflow results shown in Table 5-1. Pipe inflow was neglected for this flood estimation as the rational method is conservative and pipe inflow is minor.

Table 5-1: Flood peak and volume estimates

Design flood	Flood recurrence interval	Flood peak (inflow) (m^3/s)	Flood peak (outflow) (m^3/s)	Max Water Level (m)	Height above FSL, i.e. 120.0 m (m)	Height above min NOC, i.e. 120.92 m (m)
Recommended Design Flood	1:100 yr	5.9	2.0	120.29	0.29	-0.63
Safety Evaluation Flood	0.7 PMF	24.9	10.5	120.85	0.85	-0.07

5.1.2 Spillway capacity

The spillway at the Bloekombos Dam consists of a sill and uncontrolled open channel on the right abutment with three openings, each approximately 2.5 m long, leading to a lined discharge channel.

The discharge capacity of the spillway, with a maximum head of 0.92 (lowest area of NOC) (i.e. zero freeboard) was calculated as 13.1 m^3/s. It almost accommodates the routed SEF, assuming it is not severely clogged as was seen on site. It is likely that the original design NOC had a higher freeboard of closer to 1.3 m which would then comfortably accommodate the SEF. The settlement that has occurred has rendered the existing freeboard less than the design freeboard and the crest should be infilled to counter this.

5.2 Freeboard

Various combinations of conditions are recommended in the SANCOLD Guidelines (2011) for determining the minimum recommended freeboard allowance. These account for both the flooding in the dam in addition to several other aspects such as wave run-up, earthquakes and wind setup among others.

The results of calculations for the wave runup portion of the freeboard are set out below.

Table 5-2: Summary of Bloekombos Dam freeboard requirements

Aspect	Value
Full supply elevation	RL 120.0 m
Non overspill crest elevation (minimum)	RL 120.92 m
RDF water surface elevation	RL 120.29 m
RDF water level above FSL	0.29 m
SEF water surface elevation	RL 120.85 m
SEF water level above FSL	0.85 m
Wave height, $H_{2\%}$ (100yr)	0.59 m
Design wave run-up, $R_{2\%}$	0.65 m
Wind setup	0.01 m
Freeboard combination:	
5. RDF + wave run-up, set-up, surges & gates	0.94 m
6. SEF	0.85 m

Calculated freeboard required	0.94 m
Freeboard provided to NOC	0.92 m

As seen from the summary above, the freeboard is almost enough to pass the SEF assuming that the spillway is not clogged. The RDF combination yields a height just above the required requirement and thus minimal wave overtopping would be experienced. Filling in of the lower sections of the crest by 200 mm is advised.

5.3 Regional Geology

The dam is founded on mudstone / sandstone of the Uitenhage Group of the Kirkwood formation. A snip of the regional geology map (3420 Riverside) is presented in Figure 5-2 below, which shows that the dam is on reddish and greenish mudstone, sandstone with subordinate conglomerate lenses; grey mudstone with tuff / bentonite layers.

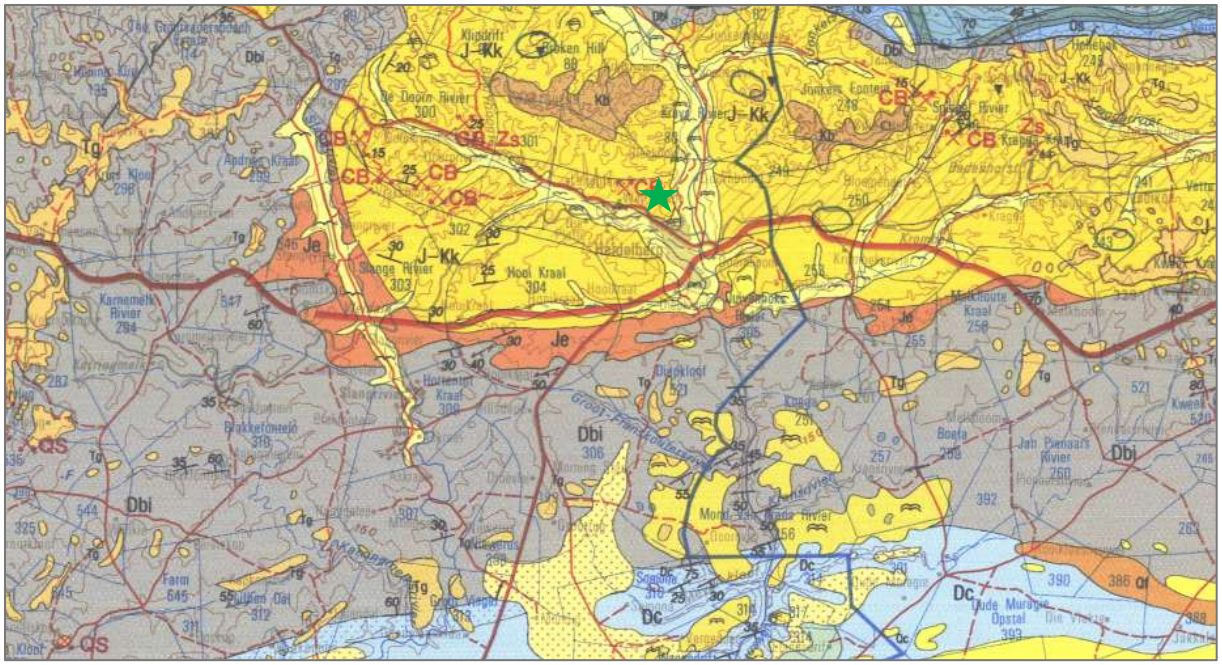


Figure 5-2: Regional geology at dam site (dam position indicated by green star)

5.4 Structural adequacy and stability

There is no record of any formal stability analysis that has been done. The downstream slopes, that have not suffered slips, appear adequate and the crest width of 5 m is fairly wide adding redundancy to the stability. However, the areas where surface slips have occurred on the upper parts of the downstream slopes, are a clear sign of structural distress. These are eating back into the crest and will eventually pose a risk to the stability. There is a possibility that these slope slips are related to the seepage through the embankment, i.e. the high phreatic surface through the dam. This needs to be investigated further and the slopes need to be re-instated with the inclusion of a filter drainage system if deemed necessary.

6 Operational Procedures and Maintenance

6.1 Operational procedures

The Operation and Maintenance Manual (OMM) which would provide the operational procedures and details of the inspection programme and emergency planning was not found. It is unknown whether one exists and when it was last updated.

It should be noted that an OMM is a statutory requirement.

6.2 Maintenance

The Bloekombos Dam is a simple embankment dam, however a significant amount of maintenance is required as should have been set out and detailed in an OMM.

- Ongoing vegetation management, especially in the spillway
- Continuous control of burrowing animals
- Perform routine inspections
- Repairs to erosion as needed, especially the downstream slips
- Regular seepage monitoring and upkeep of these monitoring points
- Exercise and corrosion protection to all valves and other mechanical works

6.3 Routine Inspection reports

The owner's representative has indicated that no formal routine inspections are currently being done, neither is the monitoring of the embankment crest nor seepage monitoring.

It should be noted that these routine inspections are a statutory requirement.

6.4 Occupational health and safety

No warning signs of possible dangers are present.

There is adequate cell phone reception at the dam.

No formal procedures have been established to protect lives and property. In the event of a failure there may not be enough time to warn employees and residents situated within the first kilometre downstream of the dam.

No emergency plan was available

7 Hazard potential and risk

7.1 Consequences of Failure

In the event of a dam break, the residential area of Heidelberg downstream of the dam will be at risk of flooding. The area around and downstream of the dam also includes: the R322, a railway crossing and the SSK Heidelberg Silo. The volume of the dam is small meaning that a flood wave would dissipate quickly into the flat areas below the dam. Furthermore, the relatively slow failure scenarios of a typical earthfill embankment such as this would further reduce the dam break flood peak giving residents time to react in an area that is sparsely populated.

The Bloekombos Dam hazard potential estimates are as follows:

- Potential loss of lives is more than 1 and less than 10
- Potential economic loss is significant
- Potential adverse impact on resource quality is low to significant

The dam is of “medium” size and this report estimates a “significant” hazard potential, it’s classification as a Category II dam is therefore still deemed valid.

Figure 7-1: estimated area downstream of dam at risk of low level inundation

8 Conclusions and Recommendations

8.1 Conclusions

Bloekombos Dam is in a poor condition.

The entire downstream face was difficult to discern due to excessive vegetation overgrowth, but it is in a poor condition in places. There are extensive downstream slips and longitudinal cracks along the upper third of the downstream face, which have resulted in localised near vertical slopes. The wide crest acts as a buffer for stability nevertheless these slips will continue to erode upstream and need to be attended to.

The slips are likely due to the seepage through the embankment which is evident from the concentration of reeds some 3 m below the crest on the downstream slope. There is also significant seepage running out and ponding at and beyond the downstream toe. This needs to be investigated.

The non-overspill crest is in fair condition, showing signs of erosion damage towards the right flank. It is 4-5 m wide, but narrower in places where downstream slips have occurred. The settlement that was observed during the survey towards the middle and right abutment of the crest has reduced the freeboard and should be reinstated. This settlement may well be related to the seepage.

The flood peaks for the small catchment of 0.6 km^2 were recalculated using the rational method. The discharge capacity of the spillway, given the current freeboard of 0.92 m is not quite enough to handle the routed SEF event and the RDF event with wave action (0.94 m). Furthermore, the vegetation growth currently in the vicinity of the spillway would choke this discharge capacity and cause overtopping.

The spillway and discharge channel structures are in fair condition though they both show general signs of concrete aging. Both structures must be cleared of vegetation and debris.

The upstream face was mostly under water on the day of the inspection. The exposed portion of the face appears to be in fair condition although the face is overgrown with reeds and a few large trees. There is evidence of some sparse rip rap protection.

A valve was located at the downstream toe which is likely the main outlet valve however its status could not be determined due to the thick vegetation.

In the event of a breaching of the dam, there would be risk to life and damage to development immediately downstream of the dam. The previous classification “high” hazard was reviewed, and it was determined that given the small storage capacity of 172,000 m^3 and consequent short-lived flood, the hazard should be reduced to ‘significant”. The previous classification of “small” dam height is incorrect and has been corrected to “medium “ as the dam is 14 m high.

The Category II classification of the dam is still considered appropriate.

8.2 Recommendations

The following recommendations should be attended to following the evaluation of the dam’s safety:

(a) Infill the crest with a minimum of 200 mm to reinstate the freeboard.

[Within the next year]

(b) Cut short all trees and remove thick reeds and grass that have been allowed to establish in the vicinity of both the concrete spillway structures and along the discharge channel, giving priority to the spillway sill area which is completely choked.

[Within the next year]

(c) Clear and thereafter continuously control vegetation on the embankment, including the reed and trees growing on the upstream face as well as the large shrubs and trees on the downstream face. Clear a strip at least 5 m wide downstream of the toe. Maintain remaining vegetation to control erosion but cut and keep short (no more than 0.5 m).

[Within the next year]

(d) Monitor and investigate the downstream seepage and should it be warranted, take corrective action to address it.

[Within the next year and then continually]

(e) Reinstate the downstream slopes where they have slipped and become near vertical.

[Within the next two years]

(f) Prepare an Operation and Maintenance Manual or update one if it exists. This manual should include all details of the upgrades (if any) at the dam, a register of all available data and drawings and updated emergency contact details in the emergency preparedness plan.

[Within the next two years, contact numbers updated annually]

(g) Conduct and record routine inspections of the dam as required by the dam safety regulations.

[Quarterly]

(h) All valves should be operated through their full range at least quarterly, and any necessary maintenance effected.

[Quarterly]

(i) Refurbish the wooden handrails alongside the discharge channel.

[Within the next two years]

References

SANCOLD 1986. SANCOLD Safety Evaluation of Dams, Report No 1, Interim Guidelines on Safety in Relation to Floods. Published by South African National Commission on Large Dams. September 1986.

SANCOLD. 1991. *Safety evaluation of dams. Guidelines on safety in relation to floods.* Report No 4. Published by South African National Commission on Large Dams. December 1991

RSA. (1973). Geological Survey Maps. Republic of South Africa.

Smithers, J. and Schulze, R. (2002) Design rainfall and flood estimation in South Africa. Pietermaritzburg.

Appendix A - Correspondence

Appendix B - Photos

Appendix C - Additional information

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MAYA ANGELOU

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