Yield Analysis for Raising the Steenbras Dam, Constructing the Campanula Dam and Constructing the Doolhof Dam

Introduction

The analyses for the Steenbras Dams options and Campanula Dam were performed on the integrated system, including the other major dams in the system. The operation of the integrated system would ensure the synchronized drawdown and filling of the dams, as can be seen in Figure 1, to minimize the localized spillage or emptying of any one dam.

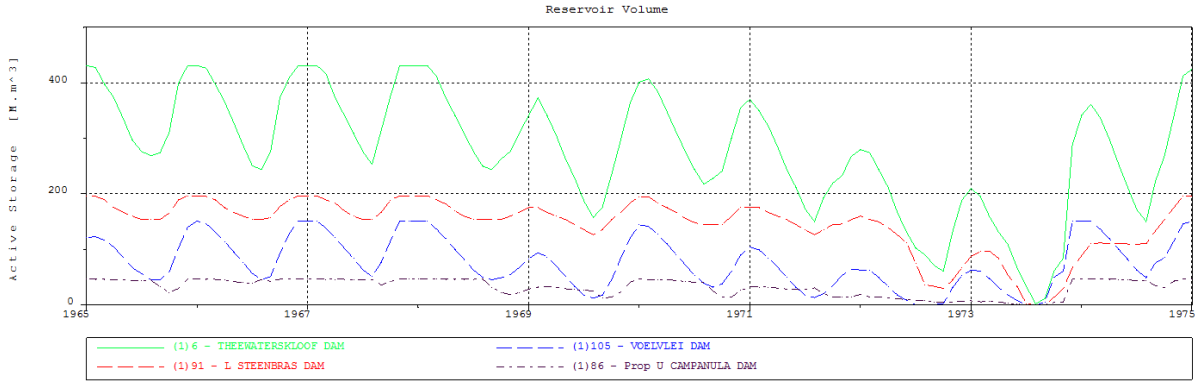

Figure 1 : Drawdown of the Theewaterskloof, Voelvlei, Greater Steenbras Dam and Campanula Dam during the critical drawdown period

This operating rule means that the additional storage of the Steenbras Dam would also be filled by making sensible abstractions from all the dams. For instance abstraction would be switched from the Steenbras Dam to the Theewaterskloof Dam if the Theewaterskloof Dam had a greater risk of spillage. This effectively would allow Steenbras Dam to be filled by switching the demand to Theewaterskloof Dam (or another dam) when this would be likely to spill.

The Environmental Water Requirements (EWR) used for this analysis are based on the flow sequences prepared by Southern Waters as part of the Assessment of the Instream Flow Requirements for the Palmiet River and the Freshwater Requirements for the Palmiet Estuary completed in 2000. Updated information is currently being developed by Southern Waters as part of this study.

The analysis for the Doolhof Dam options was conducted using daily flows at the Wit River diversion site at Bainskloof Village and a spreadsheet model of the Doolhof Dam for various dam sizes.

Raising Steenbras Upper Dam or New Lower Dam

Column D of Table 1 summarizes the increases in yield obtained for the range of increases in the storage at the Steenbras Dams as listed in column C. These increases in storage could be realized either by increasing the storage at the Lower or the Upper Steenbras Dams. The increases in the full supply levels and dam wall heights of the Lower Steenbras Dam are listed in columns E and F respectively and for the Upper Steenbras Dam in columns G and H respectively.

The increases in yield at the Lower and Upper Steenbras Dams for a given increase in wall height are presented graphically in **Figure 2** and **Figure 3** respectively.

Table 1 : Historical Firm Yield obtained by either increasing the volume of the Upper or the Lower Steenbras Dam

SCENARIO ID	Combined Steenbras storage volume (Mm^3)	Increase in storage (Mm^3)	Increase in Yield (Mm^3/a)	Achieving additional storage by raising the Lower Steenbras Dam		Achieving additional storage by raising the Upper Steenbras Dam	
				FSL (m amsl)	Raised dam wall height (m)	FSL (m amsl)	Raised dam wall height (m)
A	B	C	D	E	F	G	H
ie0	*66.4*	*0*	*0*	*346.00*	*0.0*	*370.00*	*0.0*
ie8	*80.00*	*13.6*	*4*	*349.54*	*3.5*	*374.51*	*4.5*
iea	*100.00*	*33.6*	*8*	*354.26*	*8.3*	*380.17*	*10.2*
iea2	*120.00*	*53.6*	*12*	*358.28*	*12.3*	*385.05*	*15.1*
iea4	*140.00*	*73.6*	*16*	*361.82*	*15.8*	*389.30*	*19.3*
iea6	*160.00*	*93.6*	*19*	*365.07*	*19.1*	*393.10*	*23.1*
iea8	*180.00*	*113.6*	*23*	*367.91*	*21.9*	*396.62*	*26.6*
iea9	*196.52*	*130.12*	*26*	*370.22*	*24.2*	*399.37*	*29.4*

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Figure 2: Increase in the historical firm yield of the integrated system from raising the Lower Steenbras Dam

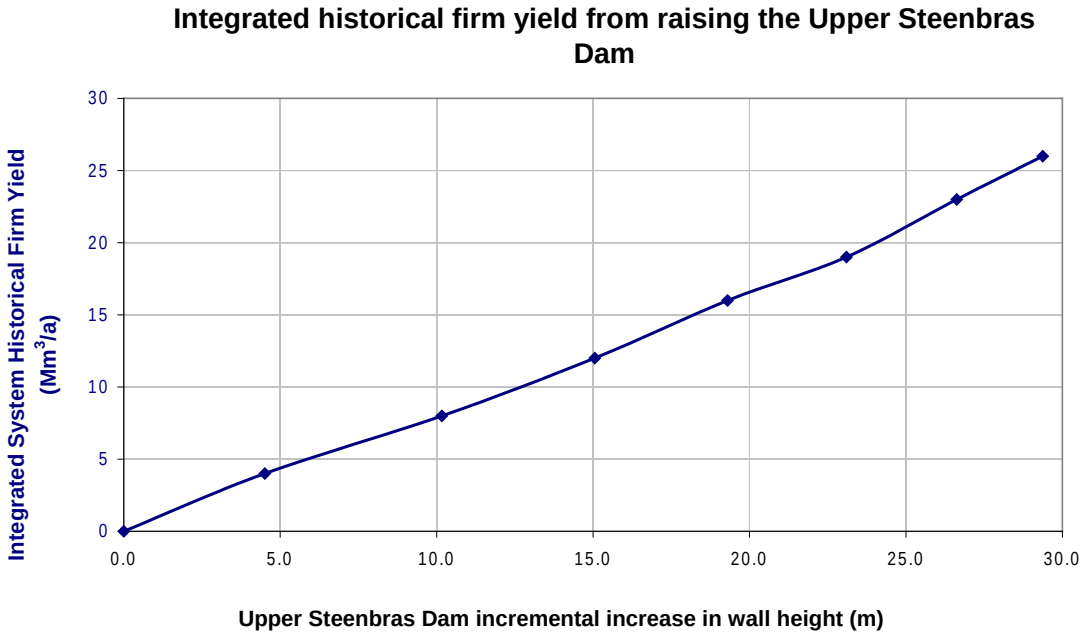

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Figure 3: Increase in the historical firm yield of the integrated system from raising the Upper Steenbras Dam

An additional freeboard allowance must be added to these levels to obtain the embankment height. The existing Upper Steenbras Dam has an allowance of 3.0m and the existing Lower Steenbras Dam 2.6m. For this prefeasibility study it is suggested that the following freeboards would be provided for the raising of the Upper Dam and a new dam constructed below existing Lower Dam:

- Upper Dam (earthfill) 3.0 m
- Lower Dam (rockfill) 3.0 m
- Lower Dam (rollcrete) 2.5 m

Campanula Dam

Column H of Table 2 summarizes the increase in the yield of the Western Cape Water Supply System (WCWSS) from constructing a dam at the proposed Upper Campanula Dam site, assuming that the combined capacity of the Steenbras Dams has already been increased to 197 million m^3. The first four scenarios assumed that water would be pumped to the Steenbras Dams via Rockview Dam from Campanula Dam, while the last scenario assumed that the Campanula Dam would supply water to satisfy the EWR only and would not be linked into the WCWSS. The last scenario is included for interest only and does not need to be costed.

The actual increase in yield is very low if water is pumped to the Steenbras Dams, being 13 million m^3/a for an increase in storage of 100 million m^3 at Upper Campanula. If it is assumed that the Campanula Dam is only used to regulate the streamflows to meet the EWR requirement and not to pump water into the Steenbras Dams, thereby enabling

increased pumping from Kogelberg Dam upstream to the Steenbras Dams, then the contribution from the Campanula Dam to the system yield is even less. In the case of a dam of 50 million m^3 storage, the yield benefit reduces from 10 million m^3/a where water is pumped to the Steenbras Dams (scenario ce5), to 6 million m^3/a where the Campanula Dam is used solely to supply the EWR (scenario c_e5).

Figure 4 provides the FSL and wall height (columns F and G) for different historical firm yields (column H), where a wall height of 0 m corresponds to RL 95.00 m. Scenario c_e5 is included for interest only and does not need to be costed. Freeboard of say 2.5 m for an earthfill or rockfill dam can be added to these levels.

Table 2: Additional historical firm yield from increasing the capacity of the Upper Campanula Dam

Scenario	Steenbras storage volume (Mm^3)	Campanula storage volume (Mm^3)	Pump to Steenbras?	Environmental Water Requirements	Upper Campanula FSL (m amsl)	Upper Campanula dam wall height (m)	Increase in yield (Mm^3/a)
A	B	C	D	E	F	G	H
iea9	*196.52*	*0*	*n.a*	*Damage control with restrictions*	*95.00*	*0*	*0*
ce2	*196.52*	*20*	*Y*	*Damage control with restrictions*	*128.46*	*28.46*	*7*
ce5	*196.52*	*50*	*Y*	*Damage control with restrictions*	*140.10*	*40.10*	*10*
Cea	*196.52*	*100*	*Y*	*Damage control with restrictions*	*150.84*	*50.84*	*13*
c_e5	*196.52*	*50*	*N*	*Damage control with restrictions*	*140.10*	*40.10*	*6*

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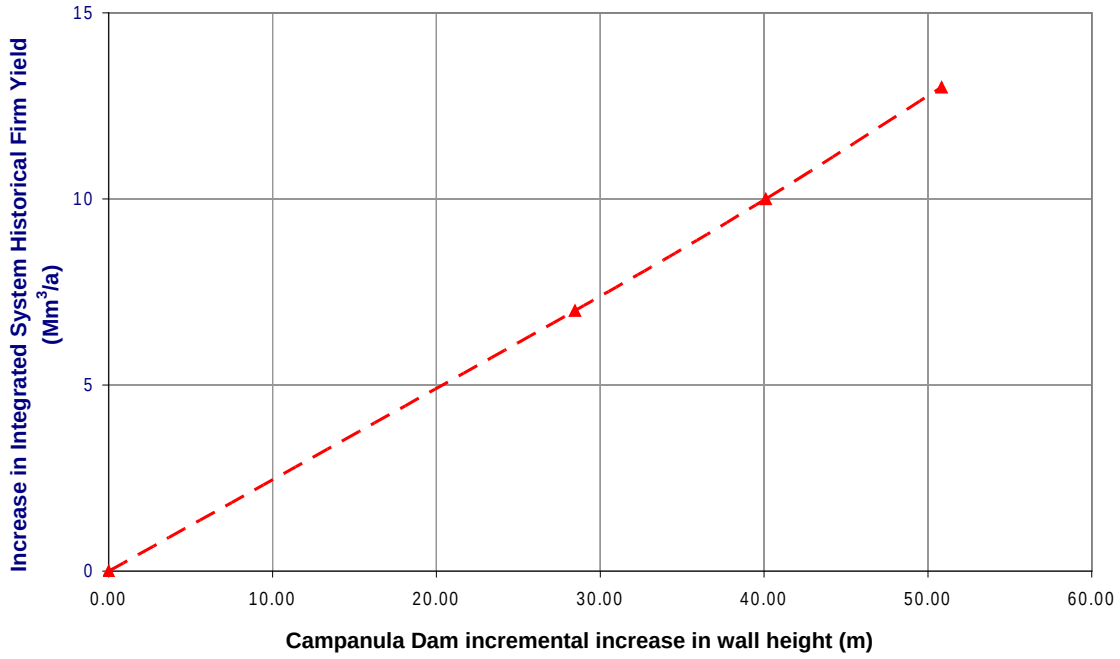

Figure 4 : Increase in historical firm yield for the integrated WCWSS for a given wall height of the proposed Campanula Dam

Doolhof Dam

Table 3 gives various estimates of yields from the Doolhof Dam for three diversion capacities off the Upper Wit River (2, 4 and 5 m^3/s). This option still needs to be included in the yield model to confirm the increase in yield for the WCWSS, but these estimates should be fairly accurate as they have been calculated using the critical period of the WCWSS and have been factored to account for the annual demand pattern of the WCWSS.

Table 3: Estimate of historical firm yield from the Wit River diversion to the Doolhof Dam scheme

Dam storage capacity (Mm^3)	Dam wall height (m)	Dam FSL (m amsl)	Yield for various diversion capacities (Mm^3/a)		
			2 m^3/s	4 m^3/s	5 m^3/s
A	B	C	D	E	F
3	*25*	*298*	*4*	*4*	*4*
5	*30*	*303*	*7*	*7*	*7*
8	*35*	*308*	*8*	*10*	*10*
11	*40*	*313*	*9*	*12*	*12*
15	*45*	*318*	*10*	*13*	*14*

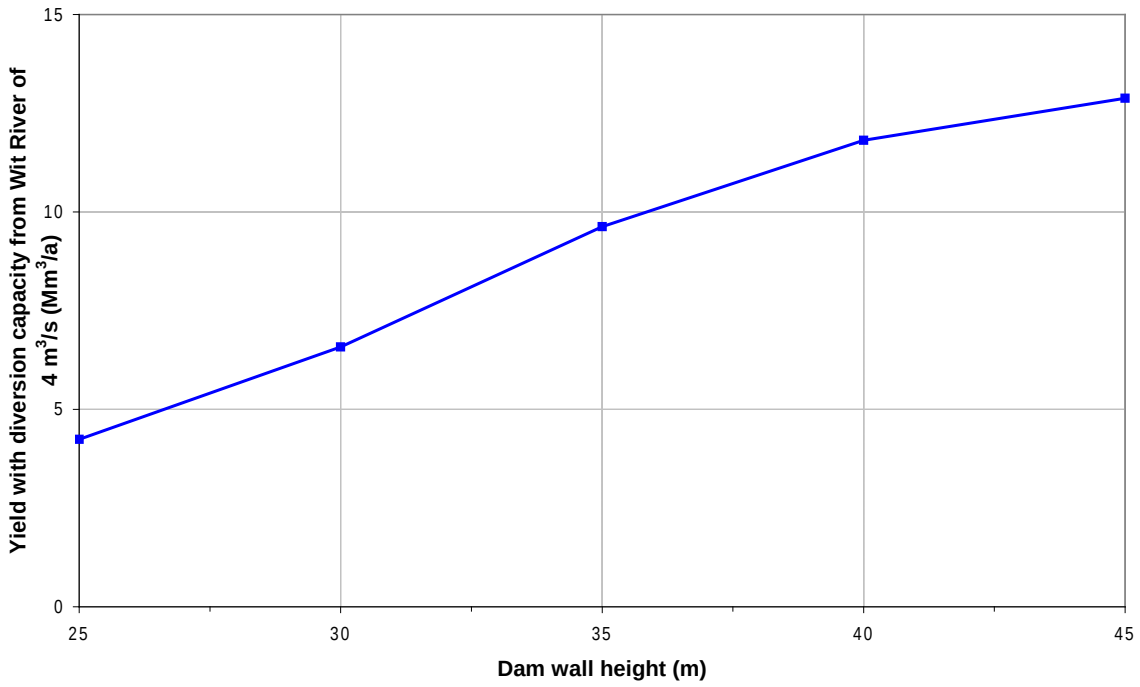

Figure 5 : Historical firm yield for given wall heights of the proposed Wit River diversion into Doolhof Dam scheme for a diversion capacity off the Wit River of 4 m^3/s

It is recommended to investigate the option of a 4 m^3/s diversion capacity (column E) and dam wall heights of 35, 40 and 45 m. These options would result in yields of 10, 12 and 13 Mm^3/a respectively.

Figure 5 shows the dam wall height versus yield relationship for the Doolhof Dam site for a diversion capacity of 4 m^3/s from the Upper Wit River.

References

Palmiet River Instream Flow Assessment: IFR for the Riverine Ecosystem -Proceedings of the IFR Workshop and determination of associated dam yields (2000) by Southern Waters for the Department of Water Affairs and Forestry