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Botanical considerations relevant to potential sites for Cape Town Water Supply Augmentation

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Contents

Appendices

List of figures

1. General issues

The following general botanical issues are relevant to the indicated schemes:

A. *The plant communities in the proposed construction areas additional, new areas to be inundated and general surround would require sampling, description, mapping and relating them to the same or similar plant communities already described from the immediate area. (See* **Appendix 1** *for an abridged definition of the vegetation conservation rating categories.) This issue is relevant to Schemes 1 – 7.*

B. *The SANBI and CapeNature databases require interrogation for collections of threatened plants from the immediate surround of the proposed activity. (See* **Appendix 2** *for an abridged definition of the Red Data Book plants categories.) This issue is relevant to Schemes 1 - 7*

C. *In all instances IFR ecological releases would have to be maintained in the utilized river to ensure that river geomorphic processes, and the survival of instream and riparian vegetation and fauna occurred. In particular the Summer dry season flows must not be utilized further as the rivers are already stressed. In some cases it will be possible to return Summer flows to those rivers where it has largely been removed already (e.g. Michell's Pass Diversion and Upper Wit River).*

Existing larger dams require testing that their management practices are up to standard and especially that they are adhering to established ecological flow reserve release requirements, i.e. that their compliance requires evaluation.

The progress and planning in respect of alien vegetation control requires evaluation that it is taking place at an acceptable rate.

2. Key issues for each dam option

Each water supply option is described briefly followed by the identification of key botanical issues and, in some cases, additional non-botanical comments are also included. Key literature is evaluated and listed for each scheme, while a comprehensive list is presented at the end. South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Western Cape which include the Berg River, Witzenberg, Breede Valley and Breede River Winelands Municipalities together with the Biodiversity Sector Plans are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of each scheme described below, particularly in respect of infrastructure routes such as proposed pipelines. Specific Red Data Book information for each particular scheme is best compiled through on site evaluation of the affected area as experience has shown that data held in the SANBI database is too general to provide the necessary specific information.

2.1 Raising of Lower Steenbras Dam

2.1.1 Scheme description

This scheme entails the raising of the existing Lower Steenbras Dam by approximately 20 m to the same Full Supply Level as that of the Upper Steenbras Dam (370 m asl), effectively creating one Greater Steenbras Dam. The scheme would rely on the existing transfers from the Palmiet Pumped Storage Scheme as well as runoff into the dam from within its own catchment area. There is sufficient capacity in the Palmiet and Rockview Dams to support this scheme.

2.1.2 Key botanical issues

2.1.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 1***) are:*

- *Kogelberg Sandstone Fynbos (FFs 11), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Elgin Shale Fynbos (FFh 6), with a conservation status of Critically Endangered. Almost 80% of the area formerly occupied by this vegetation type is transformed. The Greater Cape Town city at Steenbras supports a large remaining tract of this threatened vegetation type namely, 840.6 ha or 3.76% of its total former extent (Benn, 2008) (the pine plantations are included in this figure because they still support seedbanks and can potentially be rehabilitated at reasonable cost, namely through felling existing plantations and selling the resultant wood to offset costs incurred) (pers. comm. Dr P.M. Holmes, City of Cape Town Environmental Resource Section, 16 April 2009). Impacting this vegetation type may only be done in instances of unavoidable national interest (see* **Appendix 1** *for rating of relationship between disturbance impact and vegetation conservation status).*
- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*

2.1.2.2 Other botanical issues

- *Some area supporting undisturbed natural Kogelberg Sandstone Fynbos and some disturbed Fynbos Riparian Vegetation will be lost and damaged by the proposed new dam wall. This would probably not be a critical impact because of the small area involved, yet it would need to be examined in detail to ascertain whether there were any threatened Red Data Book plants present or not. Local endemic species are regularly found in the greater Kogelberg Biosphere Reserve area.*

- *The new dam wall should contain facilities to allow scientifically determined environmental releases to be made which would be to the advantage of the downstream habitats as no such releases presently occur.*
- *There is a garden present immediately below the present dam wall in the area disturbed originally when the wall was constructed (***Figure 2***). This is an aesthetic loss which can be replaced in the new wall, but with the proviso that only local indigenous species should be used in the stabilization of the wall.*
- *Importantly, Critically Endangered Elgin Shale Fynbos, including wetland communities, will be inundated by the proposed increased inundation area (***Figure 3***). It is worth considering that the current dams have already reduced the area occupied by this vegetation within the Greater Cape Town area by more than 30%. Every care must be taken here to ensure that supporting structures and disturbances follow a full EIA process to assess the degree of impact, and if the dam is enlarged, to ensure that a minimum disturbance to this Shale Fynbos, outside of the dam basin, occurs. If this option is approved, then dam wall construction materials must not to be sourced from surrounding shale areas outside the FSL of the proposed dam as this would reduce the area under this Critically Endangered vegetation type further. Some pine plantations will be lost. These plantations are gradually being phased out on City of Cape Town property and are being reduced by MTO in the South Western Cape as they are uneconomic, with some local sawmills having closed down. Note that the area was farmed (up to 1919) prior to the lower Steenbras Dam being built after which catchment management and plantations became the primary land-use. There is virtually no sign of farming visible now in the remaining diverse natural vegetation.*
- *The City of Cape Town portion of the Steenbras Catchment area is included in the city's Biodiversity Network plan in the highest category, namely, CBA1, inter alia, based on the presence of Elgin Shale Fynbos. Details of the Biodiversity Network Plan can be obtained from the Environmental Resource Management Department.*
- *Threatened Red Data Book plant species are probably present in the area on the shales in the enlarged dam basin.*
- *The removal of additional water from the Palmiet River, albeit within the ecological reserve capacity, would have a negative effect on riparian vegetation downstream of the dam, including that in the core of the Kogelberg Biosphere Reserve.*
- *Building a new wall will allow provision to be made for environmental releases (instead of leakages through present dam wall) to improve the downstream riparian habitat.*

2.1.3 Brief review of botanical issues from the literature

The ¼ degree grid square 3418BB centered on Sir Lowry's Pass and the Hottentots-Holland Mountains is the richest area for plant species in the Cape Floral Kingdom with slightly more than a quarter of the species occurring here (Oliver et al. 1983). This figure is more remarkable as 25% of the grid is in the sea and another 25% is on the highly modified flats.

The Environmental Sensitivity Analysis of areas having potential as well-fields for groundwater supply to Cape Town (Boucher & Brown 2004) rated the environment in the Steenbras catchment bordering on Steenbras Dam as "High" to "Very High" sensitivity implying that the potential inundation area from the raising of Steenbras Dam will have to be examined carefully.

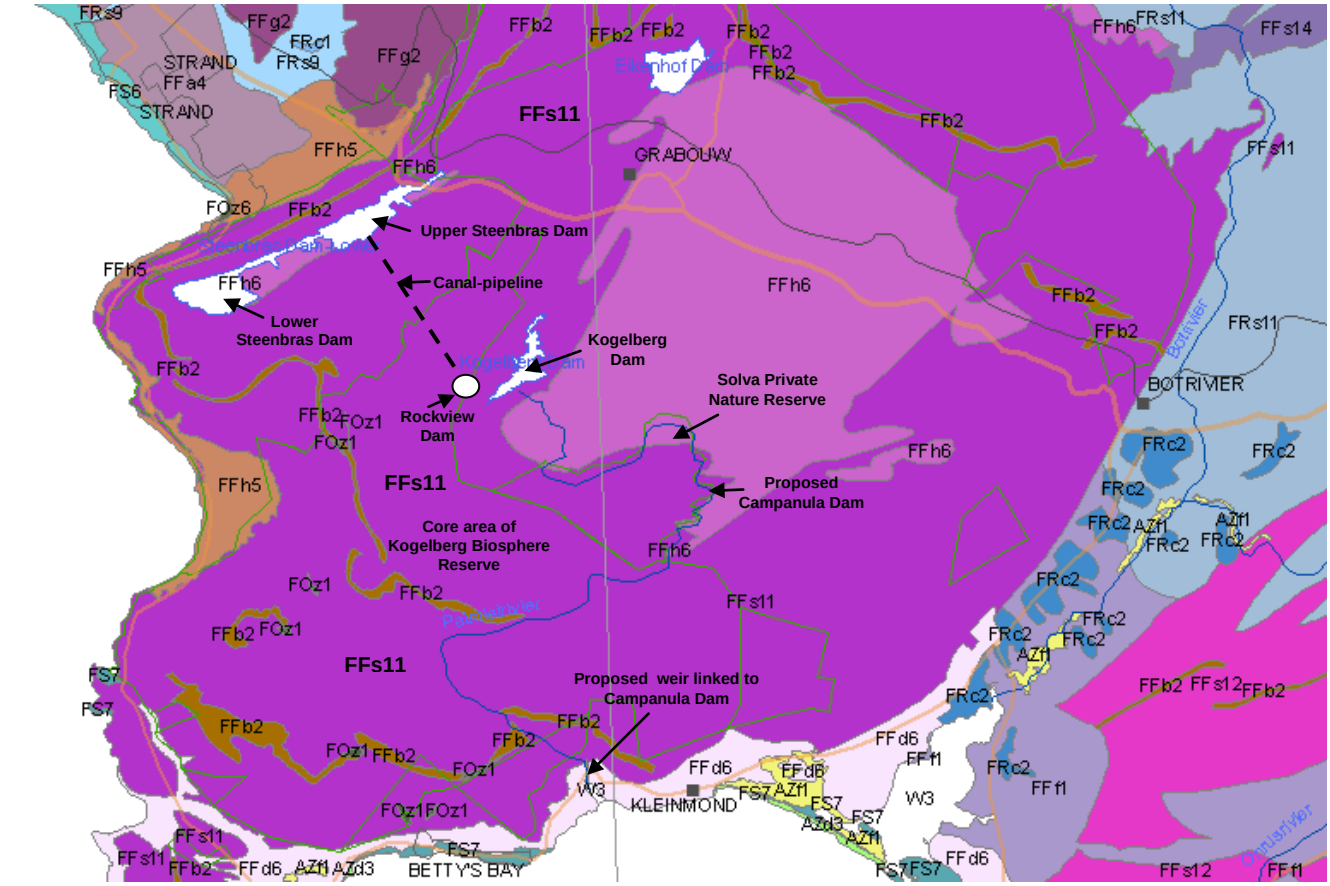

Figure 1. Vegmap of Kogelberg Biosphere Reserve including both Steenbras Dams and the sites of the Campanula Dam and the weir above the Palmiet River Estuary (Mucina & Rutherford 2006).

Figure 2. The lower Steenbras Dam wall with a recreational garden in the disturbed area.

Figure 3. The upper Steenbras Dam wall in the foreground with the bare surround indicating the Full Supply Level inundation area of the present lower dam. Critically Endangered Elgin Shale Fynbos, including wetland communities and pine plantations, will be inundated by the increased inundation area.

2.1.4 Some non-botanical thoughts

- *Limited recreational camping and picnic site at present dam influenced by new wall.*
- *Downstream gorge used for recreation (abseiling, hiking, swimming).*
- *Possibility to add to electricity generation. Generation capacity would be influenced during construction period.*
- *The N2 is being re-aligned with a new N2vToll Road. An opportunity presents itself to increase its storage capacity by raising the upper Steenbras Dam wall with some alteration to the proposed N2 Toll road.*

2.1.5 Literature relevant to scheme

Benn, G. 2008. City of Cape Town BioNet – Terrestrial Systematic Conservation Plan Re-analyis: Methods and Results. Unpublished report produced for the City of Cape Town by GeoCline Consulting CC, August 2008.

Boucher, C. & Brown, C. 2004. Table Mountain Group Aquifer study: Environmental Specialists Report. Ecological Research Report No. 90.

Ekokonsult Inc. 1982. Palmiet River pumped storage scheme Environmental Control Plan. Comprehensive Report August 1982.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Oliver, E.G.H., Linder, H.P. & Rourke, J.P. 1983. Geographical distribution of present-day Cpe taxa and their phytogeographical significance. Bothalia 14 (3 & 4): 427-440.

2.2 Upper Campanula Dam

2.2.1 Scheme description

This is a **further augmentation of the Lower Steenbras Dam Raising***, and is dependent on that dam being raised. As shown in the figure above, the Campanula scheme itself has two possible alternatives. Issues relevant to raising Steenbras Dam (point 1 above) are relevant here as well.*

2.2.2 Alternative 1

*This involves the construction of a small dam (50 million m^3 capacity) on the Lower Palmiet River at the Upper Campanula site (***Figure 4***), close to the northern boundary of the Kogelberg Biosphere Reserve. This would inundate some existing orchards, riparian and Critically Endangered Elgin Shale vegetation. To reduce the extent of environmental impact, the main storage component would be the raised Lower Steenbras Dam although the construction along the water evacuation route would have significant environmental impacts.*

Feasibility Studies – Background to Options January 2009

Water from the Campanula Dam would be conveyed via a pipeline, syphon and canal into the existing Kogelberg Dam (at the Palmiet Pumped Storage Scheme). Most of this route would be outside of irrigable land. From Kogelberg Dam, the water would be transferred into the raised Lower Steenbras Dam (additional storage capacity of 133 million m^3) via the existing Palmiet Pumped Storage Scheme.

2.2.2.1 Key botanical issues

2.2.2.1.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 1***) are :*

- *Kogelberg Sandstone Fynbos (FFs 11), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Elgin Shale Fynbos (FFh 6), with a conservation status of Critically Endangered. Almost 80% of the area formerly occupied by this vegetation type is transformed. The privately owned Solva Farm has probably the best preserved patch of this rare fynbos type. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted.*
- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*

2.2.2.1.2 Other botanical issues

- *The Campanula Dam as proposed here would capture flow from the Klein Palmiet River that bypasses the Arieskraal Dam and which provides an important natural flow regime in the summer months to the lower Palmiet River in the Kogelberg Reserve.*
- *Threatened Red Data Book plant species are probably present in all the areas affected by different aspects of this development. This will have to be assessed on site beforehand as the literature does not contain adequate site specific information.*
- *Solva Farm portion with Elgin Shale Fynbos represents ±0.54% of original area, and now, given transformation, ±5.4% of remaining area. Four Elgin Shale Fynbos endemic taxa are known, two of these occur on Solva: Freylinia longiflora (Solva) and Paranomus sp. nov. The property also contains several hundred hectares of near-pristine Kogelberg Sandstone Fynbos, as well as important Shale – Sandstone Interface largely destroyed elsewhere (Turner 2009).*

- *The Solva Farm supporting, inter alia, Elgin Shale Fynbos, is to be donated to the WWF once the Stewardship contract being drafted at present is finalized. This area will then be managed as part of the core area of the Kogelberg Reserve. The natural areas on the adjacent farm Monteith owned by Mr Erwee are also the subject of similar negotiations (pers. comm. Julia Wood, City of Cape Town, Environmental Resource Management Department, 16 April 2009).*
- *Part of the Campanula Dam inundation area and the water evacuation routes will have negative destructive impacts on the core area of the Kogelberg Biosphere Reserve. This is particularly negative in the Solva Farm with Critically Endangered Elgin Shale Fynbos as its linkage to the rest of the core of the Kogelberg Reserve would be interrupted and disturbed. Red Data Book species are known to occur in the vicinity of the proposed water evacuation route.*
- *Further reduction of flows in the Palmiet River would exacerbate conditions suitable for an increase in invasive alien species into the core area of the Kogelberg Biosphere Reserve.*
- *Note that the canal and pipeline from Rockview Dam to Upper Steenbras Dam is designed to take the increased capacity (***Figure 5***). Potentially water could be transferred from the Upper to the Lower Steenbras Dam using existing structures.*

Figure 4. DWAF weir in the vicinity of the proposed Campanula Dam.

Figure 5. The existing canal and pipeline from the Rockview Dam illustrated here is designed to take all the anticipated additional flows resulting from either of the proposed Campanula Dam schemes thus no further disturbance is anticipated along this section.

Figure 6. The location of the potential abstraction weir immediately above the Palmiet River estuary which will supply the Campanula Dam.

2.2.3 Alternative 2

*A further potential phase includes a possible abstraction weir just upstream of the Palmiet River estuary (***Figure 6***). This would enable full advantage to be taken of the surplus flow in the tributaries downstream of the Campanula Dam site. Water would be pumped from the weir into the Campanula Dam, via a tunnel or a pipeline.*

2.2.3.1 Key botanical issues

2.2.3.1.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 1***) are:*

- *Kogelberg Sandstone Fynbos (FFs 11), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Elgin Shale Fynbos (FFh 6), with a conservation status of Critically Endangered. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted.*
- *Western Coastal Shale Band Vegetation (FFb 2), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*

2.2.3.1.2 Other botanical issues

- *Threatened Red Data Book plant species are present in the effected area. The extent of the impact will have to be assessed on site beforehand including the effect of both the weir wall the weir impoundment as well as for canals, pipelines and tunnels would also have a potential negative draw-down on wetlands with threatened Red Data Book species plus access and other infrastructural routes (such as during drilling).*
- *Part of the Campanula Dam inundation area and the water evacuation routes will have negative destructive impacts on the core area of the Kogelberg Biosphere Reserve. This is particularly negative in the Solva Private Nature Reserve with Critically Endangered Elgin Shale Fynbos as its linkage to the rest of the core of the Kogelberg Reserve would be interrupted and disturbed.*
- *Alternative 2 has a dual impact on the core area of the Kogelberg Biosphere Reserve as the lower weir/dam would impact on the area between Oudebos and the Palmiet Estuary as well as on the Solva area.*
- *The Kogelberg Biosphere Reserve is of considerable international significance being one of the richest areas for floral biodiversity in the Cape Floral Kingdom (there are only six kingdoms in the world).*
- *The Palmiet Ecological Worksessions (Rothman 1991) describe the engineering option and identifies the impact of this alternative on the environment.*

2.2.4 Brief review of botanical issues from the literature

The Kogelberg Biosphere Core area supports at least 1 407 plant species out of a total estimated 9 000 vascular plant species in the Cape Floral Kingdom (Boucher 1977, Goldblatt & Manning 2000). Any dam constructed immediately above the estuary would impact upon this diversity. Boucher et al. (1983) evaluated, inter alia, the impact of a weir constructed immediately above the Palmiet River Estuary which inundated 13 km or 197 ha of the then Kogelberg State Forest. They list four Red Data Book species that will be inundated. They record that Brabejum-Rhus Riverine Scrub (51% of that found in the Kogelberg State Forest) and

Prionium-Wachendorfia Swamp plant communities in excellent near-pristine condition would be inundated or impacted upon (plant community names following (Boucher 1978)).

2.2.5 Some non-botanical thoughts

- *Holiday cottages and an historic pulley system for conveying goods across the Palmiet River would be affected.*
- *Various reports listed below give detail relating to the effect of various proposed dams on the Palmiet River environment.*
- *The aesthetic biological and terrain diversity, attractive to visitors entering the Kogelberg State Forest through both the southern and eastern entrances, would be irreparably spoilt by both Campanula Dam phases proposed here. Bleak bare areas would replace the dense covering of diverse fynbos in the dam basin area during low water periods. The lower weir wall would be visible from the scenic Faure-Marine coastal drive between Kleinmond and Betty's Bay.*
- *The overall conclusion of the Socio-Economic evaluation undertaken for the ministerial appointed Palmiet River Environmental Committee in 1989 is that "serious consideration should be given to the earlier implementation of desalination technology in preference to another dam in the Palmiet Valley. This conclusion is based upon:*
    - *the desire expressed by the general public that the Kogelberg State Forest continue to be conserved;*
    - *the willingness of water consumers to contribute towards the cost of this (although the amount offered by the local population at present may be inadequate and this might have to be subsidized); and*
    - *the considered opinion of the participants in the Delphi evaluation that a dam would be preferable in the* **short term** *only and that desalination would be more sustainable and efficient in the longer term.*

Has the short term not reached its "sell-by-date" by now emphasizing the urgent need to resource demand for water from non-conventional (to South Africa) alternative sources. As concluded by A. Gubb in the Rothman (1991) report: "In conclusion, water is a renewable resource which must be used carefully according to the principle of sustainability. The Palmiet River Ecosystem is effectively a non-renewable natural resource in the sense that what is lost to river impoundment will not be regained. It is imperative that this loss be minimized, and that the environmentally sound strategies of saving and recycling be implemented as a matter of urgency." – Have we done this adequately in the interval since 1991? Do these arguments not hold for the whole of the Western Cape, or South Africa for that matter?

2.2.6 Literature relevant to schemes

Boucher, C., 1977. A provisional checklist of the flowering plants and ferns in the Cape Hangklip area. Jl. S. Afr. Bot., 43: 57-80.

Boucher, C., 1978. The Cape Hangklip area. Part 2. The vegetation. Bothalia, 12: 455-497.

Boucher, C., Hall, A.V. & Ashton, E.R. 1983. Assessment of the direct impact of the various possible dams on features of botanical importance in the Kogelberg State Forest. Document 44 for the Dept of Water Affairs Palmiet River Environmental Committee.

Branch, G.M. & Day, J.A. 1980. The ecology of Palmiet River Estuary. Unpublished report produced for the Dept Environmental Planning & Energy.

Bruwer, CA. 1995. Report of the Palmiet River Instream Flow Requirement meeting, Jonkershoek. Subdirectorate: Environment Studies, DWAF.

CSIR Report C/Sea 8048. 1980. Effect of proposed Hangklip Dam on Palmiet River mouth. Report produced by the Coastal Engineering & Hydraulics Division, National Research Institute for Oceanology, CSIR, Stellenbosch, December 1980.

Goldblatt, P. & Manning J. 2000. Cape Plants: a conspectus of the Cape Flora of South Africa. Strelitzia 9.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Palmiet River Environmental Committee (Chairman C.P.R. Roberts). 1989. Final Report considering the environmental impacts of seven water supply projects in the Palmiet River submitted to the Minister of Environment Affairs in November 1989.

Rode E. 1994. Die plantegroei van die plaas Solva in die Elgin-kom, Suidwes-Kaap. B.Sc. (Hons) project report, University of Stellenbosch.

Rothman, C.E. 1991. Water Resource Development in the Palmiet River. Impacts of development options on the ecological environment. Report on proceedings of Palmiet Ecological Worksession, Kleinmond, July 1991.

Southern Waters Ecological Research & Consulting. 1998. Palmiet River Instream Flow Requirements for the riverine ecosystem.

Turner, R.C. 2009. Botanical Scoping Report of Proposed Housing Development Sites on Solva Farm, Elgin Valley, Overberg. Unpublished report prepared for the Wood Family.

2.3 Phase 1 Augmentation of Voëlvlei Dam

2.3.1 Scheme description

The scheme entails the abstraction of surplus winter water from the Berg River at Spes Bona, via a potential weir and pump station. The water would be pumped via a proposed pipeline to the Voëlvlei WTW where it would either be:

A. *Pre-treated for storage in the existing Voëlvlei Dam, or*
B. *Treated to potable standards for direct delivery to CCT.*

The infrastructure requirements for direct treatment and supply to the CCT would be:

C. *a weir and intake at Spes Bona;*
D. *3.16 m^3/s pump station*
E. *1 500 mm dia steel delivery pipeline of up to 5 km long to the existing WTW;*
F. *a desilting facility;*
G. *a pipeline from the desilting facility to the existing Voëlvlei Dam intake;*
H. *alterations to the existing chemical feed arrangements at the WTW.*

For storage in Voëlvlei Dam, the last two items above would be replaced by pre-treatment and discharge into Voëlvlei Dam.

The key characteristics of the scheme are that:

i) Only surplus winter water would be abstracted;

ii) 20 million m^3/a would be available to take up the spare capacity in the existing Voëlvlei WTW and pipeline to CCT.

iii) Any surplus yield (over and above ii) could be used to improve the assurance of supply to other users currently reliant on Voëlvlei Dam (current shortfall of about 30 million m^3/a).

iv) When river flows are too low to permit abstraction, water will be drawn directly from Voëlvlei Dam.

2.3.2 Key botanical issues

2.3.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 7***) are:*

- *Cape Lowland Alluvial Vegetation (AZa 2), with a conservation status of Critically Endangered. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted.*
- *Swartland Shale Renosterveld (FRs 9), with a conservation status of Critically Endangered. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted.*

2.3.2.2 Other botanical issues

- *Threatened Red Data Book plant and animal species occur along the present abstraction pipeline route.*
- *Areas to be effected, such as for instance, the enlargement of the Treatment Works, will have to be assessed on site beforehand as the literature does not contain adequate site specific information outside the reserve here.*
- *Any work to enlarge the delivery pipeline to Cape Town will require botanical assessment and potential rehabilitation in places.*
- *Effects of abstraction on the Environmental Flow Releases in the Berg River will need re-assessing. The proposed abstraction point is in a pool above a natural bank with riffle (***Figure 8***).*
- *Woody alien vegetation control remains poor along the Berg River and considerable loss of water through transpiration, particularly by dense stands of Eucalyptus camaldulensis, remains a point of controversy that requires long term management action (***Figure 9***).*

2.3.3 Brief review of botanical issues from the literature

The following extracts from Boucher & Jones (2007) are directly relevant to the present study:

- *They note that during their three year monitoring study of the Berg River prior to the Berg River dam being completed, that the river showed "a general degradation trend which was caused by a drought cycle accompanied by over-utilization of the river bank vegetation by the adjacent farming community. Low water levels caused the Wet Bank zone in particular to react by extending downward, while the floating vegetation in the Aquatic zone at the lower sites increased from lack of flushing flows. These reactions reflect those what can be expected should adequate, seasonally variable, environmental flows not be released from upstream dams, or with a reduction in flows predicted with climate change. Relatively constant releases in the dry season in the middle reaches to provide irrigation water resulted in the Wet Bank zone narrowing its amplitude. "*
- *"Placing the riparian vegetation under stress whether from reduced flows, particularly in the dry season, and from over-utilization of the habitat, results in an increase in the exotic alien vegetation component. This downward cycle in vegetation condition, as experienced over the monitoring period, is regularly accompanied by bank erosion as a result of insufficient indigenous vegetation to protect the banks from irregular higher flows in winter. It is particularly interesting to find that relatively undisturbed bank vegetation was able to resist invasion by exotic alien invader plants …"*
- *"The regular dominance by alien invasive trees, particularly of Eucalyptus camaldulensis is cause for concern as gums are known to be particularly wasteful of water with a mature tree transpiring about 250 l of water per day. This tree was recorded being dominant along about 200 km of the Berg River. Gum trees were regularly found fallen into the river where they catch debris during high flows and cause blockages that result in the river over-topping the banks accompanied by lateral erosion often forming new channels under these conditions."*

- *Walton (2006) studied the vegetation surrounding the west, south and east sides of Voëlvlei Dam in the Voëlvlei Provincial Nature Reserve. He found two basic communities to be present here, namely the Ursinia anthemoides – Cyndon dactylon Grassland, with two variants, and the Pterygodium catholicum-Elytropappus rhinocerotis Shrubland, with two sub-communities. Of particular relevance is that this vegetation has been degraded in the past from heavy grazing and ploughing. The main degradation topped about 30 years ago when CapeNature took over the management of the area. Walton (2006) found that the old ploughed lands show particularly slow recovery as they have largely lost their soil borne seedbanks and geophyte complement.*
- *South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Berg River Municipality, together with the Biodiversity Sector Plans, are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.*

2.3.4 Some non-botanical thoughts

- *The Berg River is densely infested with alien vegetation around the abstraction point. Erosion and bank modification is commonplace here. These issues would need individual attention to rectify this problem.*
- *The pipeline from the Berg River would have to be diverted slightly to a more northerly path through CapeNature's Voëlvlei Nature Reserve than that proposed at present, to avoid the main habitats occupied by the Geometric Tortoise (listed Red Data Book species) (Baard, 1995). An assessment is necessary about the suitability of using the present pipeline route to evacuate water from the dam as the present route crosses a prime tortoise habitat (an alternative new route might be necessary – tortoise habitat detail is obtainable from E.H.W. Baard, CapeNature, Jonkershoek, pers comm. 23 April 2009). Restoration of damaged areas would be a prerequisite in both instances (note Walton's research findings referred to in paragraph 2.3.3).*
- *There are ethical considerations at the acceptability of taking any further water from the Berg River, winter flow included, as the present flows in the river have already been apportioned as part of the Berg River Dam operation.*

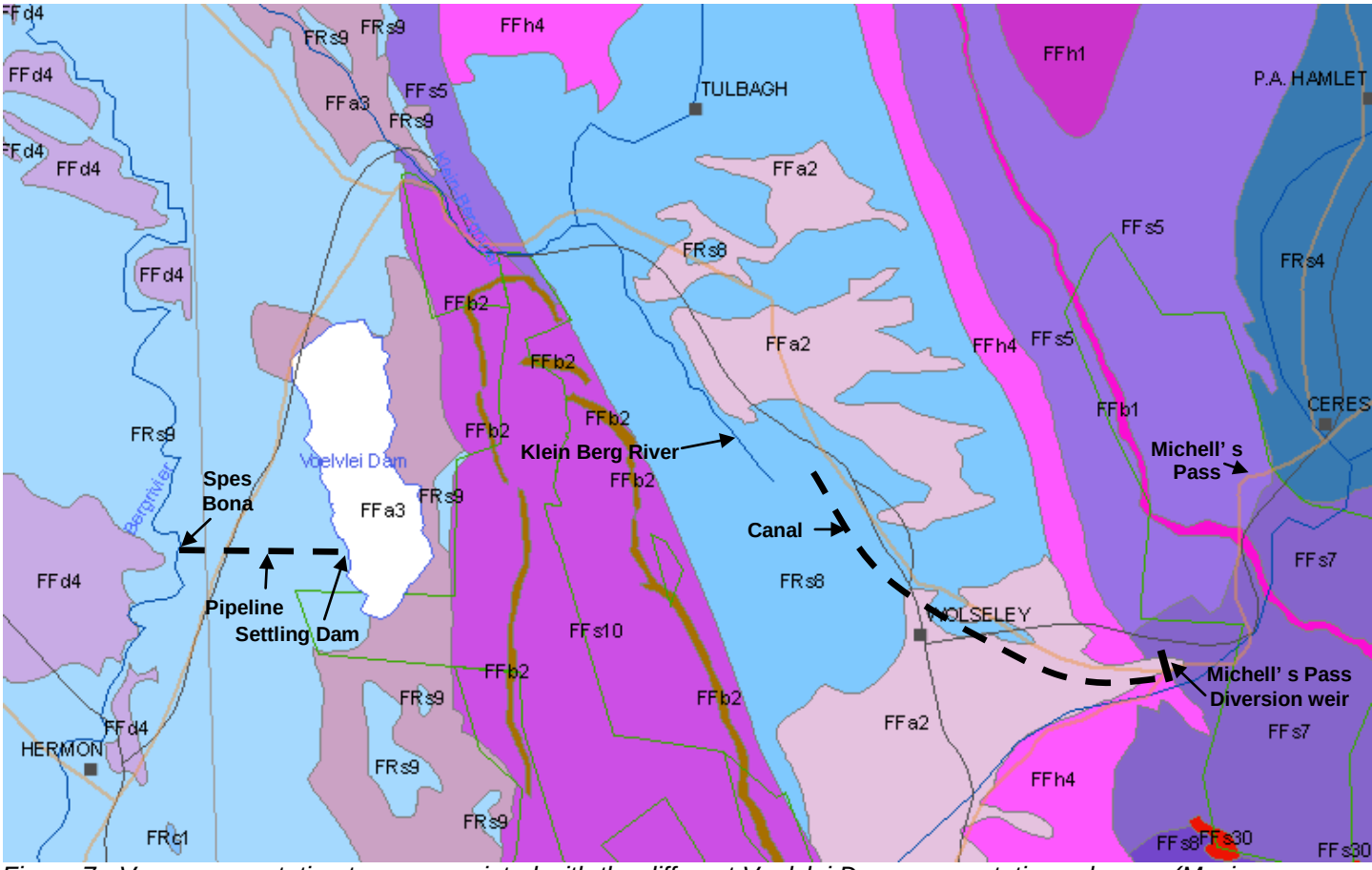

Figure 7. Vegmap vegetation types associated with the different Voelvlei Dam augmentation schemes (Mucina & Rutherford 2006).

Figure 8. The proposed abstraction point is in this pool above a natural bank with riffle clearly illustrated above.

Figure 9. Dense stands of Eucalyptus camaldulensis along the river remain a point of controversy. Their control which will reduce water loss from the river requires a long term management action plan.

2.3.5 Literature relevant to scheme

Baard, E.H.W. 1995. A preliminary analysis of the habitat of the geometric tortoise, Psammobates geometricus. South African Journal of Wildlife Research 25(1): 8-13.

Boucher, C. 1987. A phytosociological study of transects through the western Cape coastal foreland, South Africa. Ph.D. Thesis (Botany), Univ. of Stellenbosch, Stellenbosch.

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2.4 Further Augmentation of Voëlvlei Dam

2.4.1 Scheme description

Phases II and III involve a potential raising of Voëlvlei Dam (up to 9 m has previously been considered) and an increased diversion capacity from 3 m^3/s (Phase I) to 20 m^3/s. Increased pumping and pipeline conveyance capacity to Voëlvlei Dam would be required. Abstraction would be restricted to winter months (to allow for the ecological water requirements). The existing infrastructure would not be sufficient and the Water Treatment

Works would need to be expanded, as would the pumping capacity of the pump station on the delivery line to Cape Town, and a second pipeline to Cape Town would also be required.

2.4.2 Key botanical issues

The same issues as are raised for Phase 1 above are relevant here. The effect of abstraction from the Berg River is compounded here because of the increased abstraction.

2.4.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 7***) are:*

- *Swartland Shale Renosterveld (FRs 9), with a conservation status of Critically Endangered. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted.*

2.4.2.2 Other botanical issues

See Phase 1 (paragraph 2.3) above.

- *Loss of Critically Endangered Renosterveld vegetation with raising of dam to store extra supply.*
- *Threatened Red Data Book flora and fauna are very probably present in the affected areas. This will have to be assessed on site beforehand as the exact extent of inundation needs in situ correlation to species distributions.*
- *South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Berg River and Witzenberg Municipalities, together with the Biodiversity Sector Plans, are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.*

2.4.3 Brief review of botanical issues from the literature

See Phase 1 (paragraph 2.3) above.

2.4.4 Some non-botanical thoughts

See Phase 1 (paragraph 2.3) above.

- *Raising the Voelvlei Dam wall would result in inundation of habitat of the Red Data Book Geometric Tortoise (EHW Baard, CapeNature, Jonkershoek, pers comm. 23 April 2009).*

2.4.5 Literature potentially relevant to scheme

Baard, E.H.W. 1995. A preliminary analysis of the habitat of the geometric tortoise, Psammobates geometricus. South African Journal of Wildlife Research 25(1): 8-13.

Boucher, C. 1987. A phytosociological study of transects through the western Cape coastal foreland, South Africa. Ph.D. Thesis (Botany), Univ. of Stellenbosch, Stellenbosch.

Boucher, C. & Jones, F.E. 2007a. Berg River monitoring project: Riparian vegetation baseline monitoring report for period 2003-2005. Ecological Research Report No. 122.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Ractliffe, G. (ed.) 2005. Berg River Baseline Monitoring Programme. Second Annual Report. Unpublished report submitted to DWAF by Anchor Environmental Consultants, in association with the Freshwater Consulting Group.

Walton, B.A. 2006. Vegetation patterns and dynamics of renosterveld at the Agter-Groeneberg Conservancy, Western Cape, South Africa. M.Sc. thesis, Univ. Stellenbosch.

2.5 Upper Molenaars River Diversion (See Addendum for 2.5.6 Elandspad Diversion)

2.5.1 Scheme description

This option consists of a sump and pump station in the Molenaars River, just downstream of the confluence with the Elandspad River (in close proximity to the east portal of the Huguenot tunnel). Surplus winter water would be pumped to the east portal of the tunnel and conveyed under gravity through the existing 1,2 m dia. pipeline in the tunnel to the west portal. From here the water would be conveyed under gravity via a new pipeline of approximately 26 km to Wemmershoek Dam. The diversion capacity previously considered was about would be 5 m^3/s. As an alternative, a similar option would be possible for gravitating the water to the Berg River Dam via the Berg River Supplement Scheme, either in a new separate pipeline or in a larger supplement scheme pipeline.

2.5.2 Key botanical issues

2.5.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 10***) are:*

- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*
- *Boland Granite Fynbos (FFg 2), with a conservation status of Endangered. Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Hawequas Sandstone Fynbos (FFs 10), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Western Coastal Shale Band Fynbos (FFb 2), with a conservation status of Least Threatened. The presence of this vegetation type is expected but this needs on site geological confirmation. Disturbance of natural undisturbed stands should be avoided.*

2.5.2.2 Other botanical issues

- *It is preferable to keep activities nearest the Huguenot Tunnel eastern exit where the area is already disturbed (***Figure 11***). The further down the river any impoundment structure is built the greater the lateral effect on the adjacent vegetation (valley widens and disturbance is greatest at tunnel exit bridges).*
- *Abstraction design must allow for current natural flow variability to maintain the riparian vegetation as this is an A-class river. The abstraction outlet bottom height must be such that summer flows cannot be utilized at any time during the lifespan of the scheme.*
- *Downstream impact of abstraction on the Breede River or of floods feeding the Papenkuils Wetland needs evaluation in this scheme.*
- *Plant disseminules (e.g. seeds), fauna (e.g. eels) and larvae from Breede Catchment will be transferred to Berg River. This already happens from Riviersonderend through the Berg River Scheme and to a degree lower down the Berg through Gawie-se-Water.*
- *The new pipeline route from the Huguenot Tunnel western portal to the Berg River Dam would have to be aligned to avoid areas of Swartland Alluvium Fynbos (Critically Endangered) and Boland Granite Fynbos (Endangered) supporting colonies of threatened Red Data Book plants. Unavoidable disturbances to this vegetation along the new pipeline route would have to be restored to a near-natural state.*

2.5.3 Brief review of botanical issues from the literature

Boucher (1994) undertook a study of two potential dam sites on the Molenaars River. The Nuwelande site at the Molenaars-Krom-Elands River confluence (8 ha, up to the 445 m contour) is directly relevant to the present

study although some environmental changes have occurred over the intervening 15 years. The following information is extracted from the Boucher (1994) report:

2.5.3.1 Threatened flora

- *Nerine pudica: Status = rare. The lower parts of the steep cliffs at the proposed wier site in Du Toitskloof would have to be examined after fire to determine whether the Nerine plants occurring here belong to this species.*
- *Oldenburgia papionum: Status = rare. It was not observed in either study area although this observation is not conclusive as it has recently been found growing in the river approximately 200 m below the present lower national road bridge crossing the Molenaars River at the exit from the valley.*
- *Protea scorzonerifolia: A colony of this ground protea was observed on Nuweland Farm adjacent to, but outside, the wier impoundment area. An impact on this latter locality is possible should construction material be required from this site.*

2.5.3.2 General comments on impact on flora

- *This study did not find any element in the flora which would be totally lost through the construction of the impoundment. Extensive parts of both areas have already been impacted upon by man or by exotic plants introduced by man.*
- *Colonies of threatened RDB plants along the new pipeline route would require surveying to avoid.*
- *Disturbance resulting from construction would enhance the spread of and invasion by exotic flora already present in the area and would probably introduce new elements.*

2.5.3.3 General comments on impact on vegetation

- *Extensive parts of the vegetation examined during this study have been subjected to some or other type of natural (fire) or artificial disturbance (either physically by man or through the influence of plant species introduced by man). The vegetation is often complex and transitional depending on moisture levels and on the depth of the sandstone- or granite-derived soils. These latter factors have a dominant influence on the vegetation.*

2.5.3.4 Plant communities recorded at the Nuweland weir site

- *Brabejum-Salix River-fringing Shrubland. This community is found along the larger mountain streams in the south-western Cape where it is increasingly becoming reduced in extent through dam-building activities.*
- *Brabejum-Maytenus River-fringing Woodland. This community is infested to varying degrees throughout its range in the Biome. It is in urgent need of careful conservation management to ensure that some of it remains for prosperity to appreciate. (Note: The alien vegetation eradication campaign has been remarkably successful at the Nuweland site – based on the comparison of photographs taken 15 years ago to the present relatively clean condition.)*
- *Heeria-Maytenus Rock Scree Communities. The rocky screes in the valley are of Pleistocene orgin and they contain phytogeographically valuable remnants from earlier wetter periods in the Cape.*
- *Montinia-Cymbopogon Granitic Fynbos Shrubland. The attractive and uncommon ground protea, Protea scorzonerifolia, was recorded in this community. This community is distributed from approximately Groenberg west of Bainskloof to the Helderberg. It is under threat from agriculture where it occurs at lower elevations. The community adjoins the Elands-Krom dam site on granite soils.*

- *Montinia-Protea Lower Slope Sandstone Fynbos Shrubland. This widespread vegetation is commonly found on lower talus slopes on sandy soil derived from weathered Table Mountain Group sandstones.*

2.5.3.5 Implications of dam building on the flora and vegetation

- *Impoundments which upset the normal flow regimes undoubtedly influence the riparian vegetation. Sand accumulations following a reduction in flood-scouring action results in the deposition of new bare sandy areas which become colonised preferentially by exotics, particularly Acacia longifolia and mearnsii. These species form dense stands of trees which impede the growth of the indigenous flora. Fires in the densely infested stands are hotter and the indigenous woodland elements cannot withstand the resulting high temperatures, which then lead to their death. The accumulation of sand leads to changes in the ratios of the different communities present through changing the nature of the river channels.*

2.5.3.6 Comments on the wider distribution of communities

- *Not one of the above communities is expected to be limited to Du Toitskloof alone, based on our present level of knowledge. The communities found on the Cape Granites in Du Toitskloof will probably be repeated over the extent of this geological substrate between Bainskloof and Sir Lowry's Pass where it has not been destroyed through agriculture. The communities associated with the boulder screes are more limited in areal extent. They are conspicuous along the Hottentots-Holland divide.*
- *The riverine communities do not appear to be unique to Du Toitskloof, but fairly natural riparian wetlands, similar to other wetlands, are no longer extensive anywhere in the south-western Cape and are recognised as a threatened commodity on which attention has been focused, even on a national basis, since 1987.*
- *Appropriate management techniques should be applied after construction is complete to prevent the advance of alien flora within the areas disturbed during building activities and where at all possible these areas should be re-established using plants from the valley.*

2.5.3.7 Comments on general botanical issues

- *Should the Elands-Krom site be selected, then care will have to be taken to ensure that sufficient volumes of water are released at suitable times to ensure that the integrity of the riparian communities below the impoundment is assured.*
- *It is recommended that a detailed study of the dam site which is finally accepted should be undertaken, over at least a full year, to ensure that the full impact on the inundated flora is assessed and that the effects of extraction on the down-stream ecology of the system be addressed.*
- *South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Winelands Municipality, together with the Biodiversity Sector Plans, are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.*

2.5.4 Some non-botanical thoughts

- *The further downstream the impoundment, the higher the water would need to be lifted to reach the tunnel entrance level.*
- *The Molenaars River has exotic Small-mouth Bass in it. These fish do not occur in Wemmershoek Dam. The transfer of Molenaars River water to Wemmershoek Dam is unacceptable (D. Impson, CapeNature, Jonkershoek, pers. comm.. 23 April 2009).*

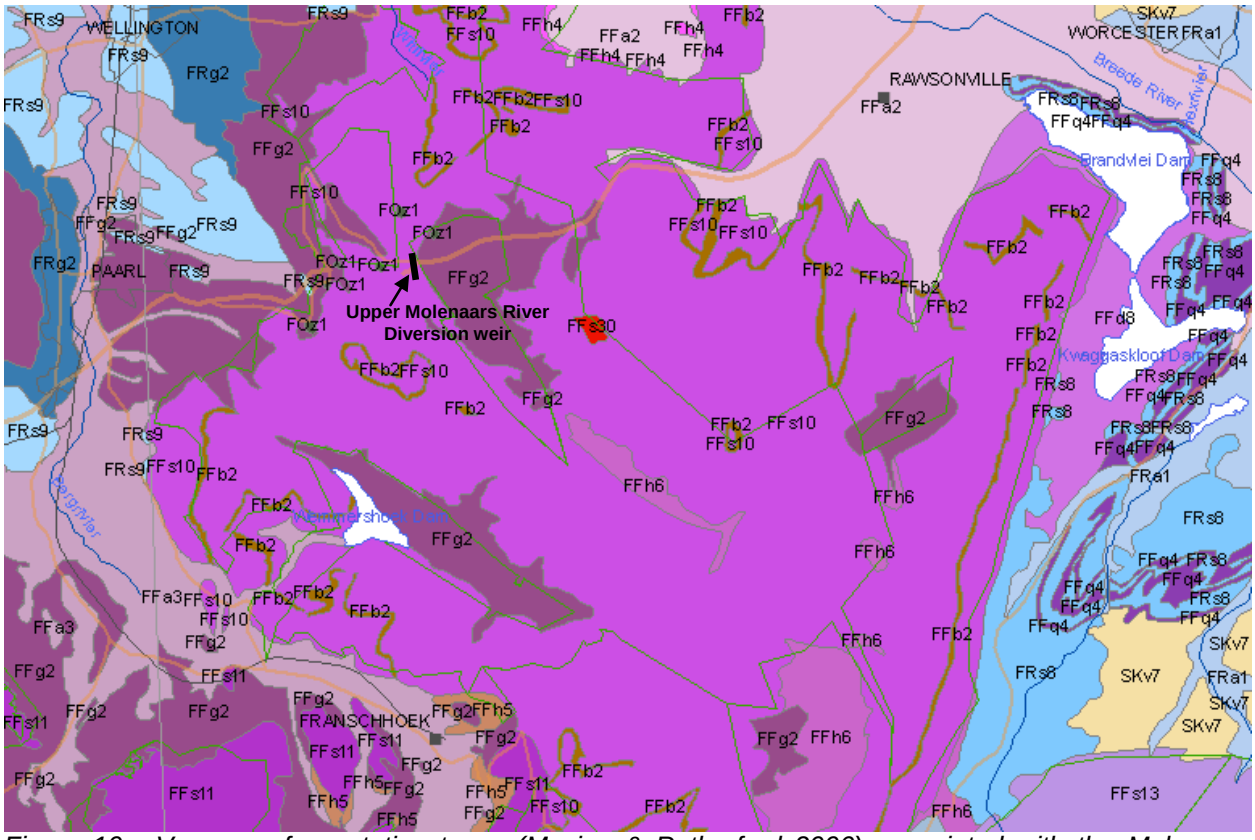

Figure 10. Vegmap of vegetation types (Mucina & Rutherford 2006) associated with the Molenaars River Diversion to Wemmershoek Dam. This diversion would influence flows to Brandvlei Dam.

Figure 11. It is preferable to keep activities nearest the Huguenot Tunnel eastern exit where the area is already disturbed. The further down the river any impoundment structure is built the greater the lateral effect on the adjacent vegetation as the valley widens. Existing disturbance is greatest nearest the tunnel exit bridges.

2.5.5 Literature relevant to scheme

Boucher, C. 1988. Botanical survey of the Lower Du Toitskloof. In: Du Toitskloof Environmental Impact Assessment. National Road route 1, sections 1 & 2 (Huguenot Tunnel to Gevonden). Hill, Kaplan, Scott Inc., Cape Town, part 3, 19 pp. + map.

Boucher, C. 1994. Botanical evaluation of two potential dam sites in the Molenaars River, Du Toitskloof. Report prepared for Ninham Shand Consulting Engineers. Ecological Research Report No. 11.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

2.5.6 See Addendum for an assessment of the Elandspad Diversion

2.6 Michell's Pass Diversion

2.6.1 Scheme description

A weir (~ 10 m high) would be constructed on the Dwars River (tributary of the Breede River). Surplus winter water would be diverted via a 9 km canal across the catchment divide, into a tributary of the Boontjies Rivier, which feeds into the Klein Berg River. The existing Klein Berg diversion weir and canal would then divert the water into Voëlvlei Dam. The Breede River Basin Study assessed three diversion capacities at Michell's Pass, namely 4, 8 and 12 m^3/s, but did not consider the impacts on downstream users and on the abstraction into Greater Brandvlei Dam at the Papenkuils Pumpstation. A 1 m^3/s diversion has also recently been evaluated as well as the downstream implications of that.

2.6.2 Key botanical issues

2.6.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 7***) are:*

- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*
- *Breede Shale Renosterveld (FRs 8), with a conservation status of Vulnerable. Disturbance of natural undisturbed stands of vegetation belonging to this category should be avoided unless in instance of unavoidable regional interest and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Breede Alluvium Fynbos (FFa 2), with a conservation status of Endangered. Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Breede Shale Fynbos (FFh 4), with a conservation status of Vulnerable. Disturbance of natural undisturbed stands of vegetation belonging to this category should be avoided unless in instance of unavoidable regional interest.*
- *North Hex Sandstone Fynbos (FFs 7), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*

2.6.2.2 Other botanical issues

- *Upstream flows have been influenced recently by incomplete alien clearing. This practice would require annual attention as part of new scheme management to ensure sustainability of flows.*
- *Some large indigenous riparian tree flora present in upstream vicinity of present weir (e.g Brabejum stellatifolium, Podocarpus elongatus and Salix mucronata inter alia). These can serve as source of propagation materials for restoration.*

- *Enlarging the off-take weir (***Figure 12***) will have some downstream (and immediately upstream) effect on the riparian vegetation because of flow removal, but the present weir already takes most of summer flow so impact is already present (this requires recording). The new scheme would only take winter water for storage in Voëlvlei Dam. The abstraction outlet bottom height must be such that summer flows cannot be utilized at any time during the lifespan of the scheme.*
- *The canal route rather than the weir itself is an important issue as it potentially influences rare vegetation types with rare species so will require evaluation of whole route (see Low & Pond 2005). Some smaller drainage lines and streams are crossed by it which will require careful construction.*
- *Influence of increased flow on the Boontjies River and Upper Klein Berg needs assessment and environmental flow releases on latter evaluated. The Boontjies River is presently very murky during the dry season. It is questionable whether it will take the strong flow capacity without erosion as the riparian vegetation is degraded and erosion will probably occur and require constant attention until a new reasonably stable ecologically acceptable summer & winter flow situation is attained.*
- *Plant disseminules (e.g. seeds), fauna (e.g. eels) and larvae from Breede Catchment will be transferred to Berg River. This already happens from Riviersonderend through the Berg River Scheme and to a degree lower down the Berg through Gawie-se-Water and there are earlier geomorphological links between the rivers as river capture has taken place here.*
- *If Voelvlei Dam is raised to take additional water, then this would have to be evaluated as the additional flooded area more than likely supports Red Data Book species (fauna & flora).*
- *Compensation flows for Brandvlei abstraction required with this option thus additional impacts require evaluation.*
- *No summer environmental flows are released at the current weir. Off-take from this dam / weir could be designed to improve the dry season flows.*
- *South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Berg River and Witzenberg Municipalities, together with the Biodiversity Sector Plans, are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.*

2.6.3 Brief review of botanical issues from the literature

No specific background studies of the vegetation around the site are available, although the wider Tulbagh-Wolseley Valley has been examined by B. Low of Coastec (B. Low has produced GIS maps for that study. Detail is obtainable directly from him.).

The Dwars River upstream of the site proposed here was not selected as an IFR site in the Breede River Basin study because "Poor, past alien infestation is evident and considerable clearing is ongoing in the catchment." (Southern Waters letter to Hans Beuster of Ninham Shand dated 27.04.2000 reporting back on IFR site selection and recommended sites for the Breede River Basin IFR study). The implication from this comment is that the alien vegetation control measures instituted should improve flow volumes from the catchment.

2.6.4 Some non-botanical thoughts

The weir site is located in a generally disturbed area and little direct terrestrial environmental effect from construction activities is anticipated.

2.6.5 Literature relevant to scheme

Boucher, C. 2006. An assessment of botanically important areas along the R46 road between Tulbagh and Wolseley and the R44 road between Gouda and the Klein Berg River Bridge near Porterville. Ecological Research Report No. 115.

Low, A.B. & Pond, U. 2005. Witzenberg Spatial Development Framework: botanical and ecological assessment. Unpublished report, Coastec, Rondebosch.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Figure 12. Present weir and off-take from Breede River at the downstream entrance to Mitchell's Pass.

2.7 The Upper Wit River Diversion

2.7.1 Scheme description

*This scheme essentially serves as an alternative option to a dam on the Upper Wit River, which has previously been investigated and found to be environmentally undesirable. The diversion scheme would comprise a low weir on the Wit River (Breede River catchment) (***Figure 13***) and one of the following alternatives:*

*I. Enlargement of the Gawie-se-Water diversion channel (***Figure 14***) which was originally constructed in about 1900 and currently diverts water (5million m^3/a) across the catchment divide into the Kromme River tributary of the Berg River (for irrigation);*

II. A new diversion channel constructed adjacent to the original channel if it is decided that the existing channel should be preserved as a heritage site;

III. Construction of a tunnel through the mountain to divert flow in excess of the Reserve from the Wit River into the Kromme River.

For each alternative above, the water would be diverted during periods of surplus flow (winter) and stored in a proposed dam on the Kromme River, for which a possible site has been identified at the farm, Doolhof. The water could either be treated and reticulated to Wellington and Paarl, in exchange for allocations out of Wemmershoek Dam. Alternatively, the water could be released from the dam into the Berg River, utilised by Upper Berg River irrigators in summer, in exchange for their allocations out of Theewaterskloof Dam.

2.7.2 Key botanical issues

2.7.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 15)** *are:*

- *Hawequas Sandstone Fynbos (FFs 10), with a conservation status of Least Threatened. Disturbance of natural undisturbed stands should be avoided.*
- *Boland Granite Fynbos (FFg 2), with a conservation status of Endangered. Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it out.*
- *Cape Winelands Shale Fynbos (FFh 5), with a conservation status of Endangered. This is a poorly studied vegetation type which is mainly transformed for agriculture, such as vineyards and pine plantations, alien invasion and by urban development. Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it out.*
- *Swartland Shale Renosterveld (FRs 9), with a conservation status of Critically Endangered. This vegetation type is mainly transformed by agriculture with an unattainable conservation target. Alien invasion is also common-place. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted. Restoration of disturbed areas is imperative.*
- *Cape Lowland Freshwater Wetlands (foothills) (AZf 1), status not determined as embedded in adjacent types. Some areas under statutory conservation but this vegetation type is mainly threatened by agriculture and alien plant invasions.*
- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*
- *South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Berg River and Winelands Municipalities, together with the Biodiversity Sector Plans, are regularly updated on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.*

2.7.2.2 Other botanical issues

- *Present weir has already changed instream vegetation in the immediate vicinity of the present weir primarily because Gawie-se-Water canal currently diverts most of the summer flow from the Wit River at this point. Isolepis fluitans cover has increased and an invasion of the stream bed by vegetation has happened (effectively narrowing channel until major flood occurs). The Prionium serratum (palmiet) plants are in poorer condition (smaller and less) than immediately upstream of the weir (damming) (***Figures 16 & 17)**.
- *Winter flows in the Wit River would be utilized in the proposed scheme giving an opportunity for the summer flows to be reinstated in this river. The abstraction outlet bottom height must be such that*

summer flows cannot be utilized at any time during the lifespan of the scheme. The offtake should be designed to allow maximum flow variability throughout year with minimum impoundment.

- *Canal modification will effect riparian vegetation (***Figure 14***) and some wetlands en route, including some secondary wetlands, thus subject to Environmental Impact Assessment & DWAF regulations.*
- *Use present excavation (***Figure 18***) without reshaping if possible (i.e the least disturbance route). The summit flats adjacent to present canal supports Hawequas Sandstone Fynbos with composition indicating some water-logging in winter. These summit flats would benefit from alien control (Acacia mearnsii and Leptospermum laevigatum are prominent).*
- *The Kromme River tributary will need evaluation to determine the effect of the raised flow levels.*
- *The changed flow scenario in the Berg River associated with this scheme will need assessing.*
- *The proposed new canal from the Kromme River tributary to the proposed Doolhof or Oaklands Dam on the Kromme River will require an EIA for vegetation as it will probably be constructed through some Endangered Boland Granite Fynbos.*
- *Management of the upper reaches of the Kromme River is required, particularly as the Working-for-Water team has recently partially cleared the aliens immediately below Bainskloof Pass (***Figure 19).** *A realistic prediction is that incision of the channel or lateral erosion will occur should water levels be raised unless the vegetation is stabilised.*
- *Eradication of aliens in the Doolhof or Oaklands Dam catchment as a whole should be part of this scheme to increase runoff into the dam from its catchment. The rainfall here is high, namely 1 700 – 1 800 mm p.a. The following exotic species were recorded along the Kromme River course here: Acacia mearnsii, Arundo donax, Eucalyptus spp., Pennisetum clandestinum, Pinus pinaster, Pinus radiata, Populus canescens, Quercus robur and.Salix babylonica.*
- *Some indigenous riparian vegetation is still present on both Doolhof and Oaklands Farm, despite the latter being rather rundown and the former being modified. This can provide plant material (seed, cuttings) for restoration for dam and downstream of dam. The following indigenous riparian species were recorded along the Kromme River course here: Apodytes dimidiata, Brabejum stellatifolium, Ilex mitis,and Olea europaea subsp africana.*
- *Possibly some rare Shale Fynbos inundated although most of lower valley slopes on both farms appear to be cultivated.*
- *Threatened Red Data Book plant species are possibly present in the effected areas. This will have to be assessed on site beforehand as the literature does not contain adequate site specific information.*
- *Management programme with environmental releases required in the Kromme River downstream of Doolhof or Oaklands Dam.*
- *Increased transference of plant disseminules (e.g. seeds), fauna (e.g. eels) and larvae from Breede Catchment to Berg River. This already happens from Riviersonderend through the Berg River Scheme and there are earlier geomorphological links between the rivers as river capture has taken place upstream.*

2.7.3 Brief review of botanical issues from the literature

No direct on site information is available about the vegetation in the Doolhof / Oaklands Dam area.

The riparian vegetation of the Wit River was examined at the Tweede Tol in the Breede River Basin IFR study.

No detailed study of the vegetation at the extraction weir or along the present canal route is available.

2.7.4 Some non-botanical thoughts

- *Effect of canal modification is over a length of more than 300 m thus any proposed modification would be subject to ratification by the heritage authorities.*

2.7.5 Literature relevant to scheme

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Figure 13. The diversion scheme would comprise a low weir on the Wit River, the off-take for the Gawie-se-Water diversion channel.

Figure 14. Gawie-se-Water diversion canal would require enlarging.

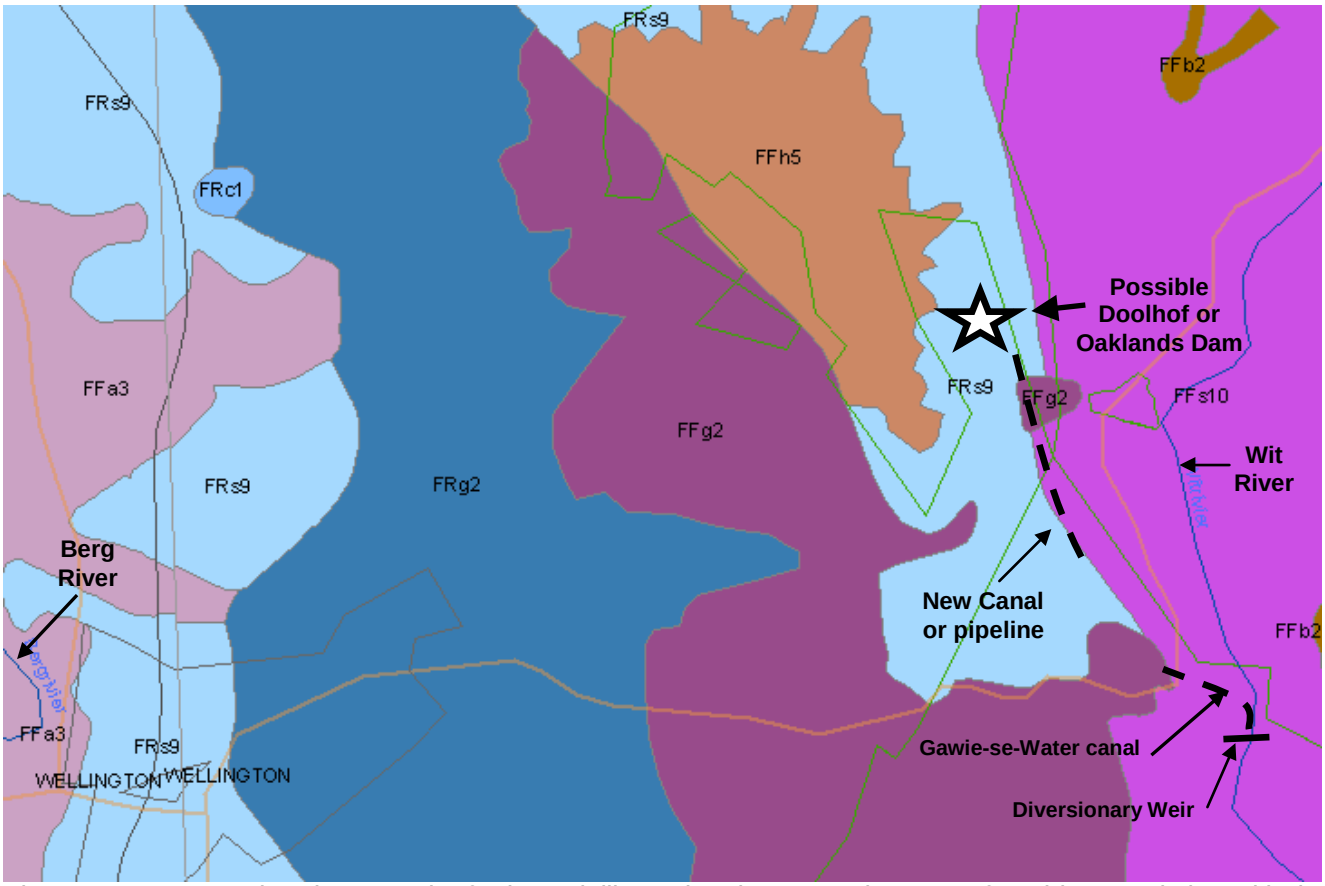

Figure 15. Vegmap (Mucina & Rutherford 2006) illustrating the vegetation types found in association with the Upper Wit River Diversion to the Kromme River at Doolhof.

Figure 16. Vegetation upstream of Gawie-se-Water off-take weir is dense because of the weir pool in the river.

Figure 17. The drought tolerant terrestrial vegetation is invading the river because most of the summer flows are diverted through Gawie-se-Water weir (located on the left side of the river).

Figure 18. Reshaping the Gawie-se-Water canal through the summit flats will disturb the lateral vegetation further. It is environmentally preferable to use present excavation without reshaping if possible (i.e. follow the least disturbance route).

Figure 19. Management of the upper reaches of the Kromme River is required, particularly as the Working-for-Water team has recently partially cleared the dense stands of aliens immediately below Bainskloof Pass. A realistic prediction is that incision of the channel or lateral erosion will occur should water levels be raised unless the vegetation is stabilised.

2.8 Brandvlei Dam

2.8.1 Scheme description

This scheme would increase the use of available capacity (no additional capacity is envisaged) in the Brandvlei Dam by drawing water either directly from the Breede River or from both or one of the nearby tributaries Smalblaar (includes Molenaars) and Holsloot Rivers, to compensate for water taken from other Breede tributaries (Upper Wit, Molenaars or Dwars Rivers). Water would be abstracted by pump during the winter months. Flow would be released back into the Breede River in summer.

2.8.2 Key botanical issues

2.8.2.1 Impacted vegetation types

*The National vegetation type impacted by this proposed option (***Figure 10***) is:*

- *Cape Lowland Alluvial Vegetation (AZa 2), with a conservation status of Critically Endangered. This vegetation type is mainly threatened by water abstraction, agriculture and alien plant invasions. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted. Restoration of disturbed areas is imperative.*

2.8.2.2 Other botanical issues

- *The water quality (clarity, turbid through suspended clay material from dam) would deteriorate a bit more because there would be less clear water from either the Molenaars, Wit or Dwars, depending on which was utilized. The effect on the benthos and other instream vegetation needs clarifying.*
- *Would require a permanent structure in river which would change riparian vegetation locally through raised levels in the dammed area upstream. Presently a temporary structure is constructed which is renewed periodically in the river following flood damage.*
- *The current upstream (this also occurs downstream) practice of modifying the stream channel would potentially impact on any formal structure through a heavier than normal sediment load. The practice also encourages an increase in alien vegetation which also has negative effects on flows.*
- *Deepening the Breede River channel must impact on essential flooding of the Papenkuils Wetland. Any diversion of the Upper Wit, Molenaars or Dwars Rivers must take cognisance of potential consequent changes to this important wetland.*

2.8.3 Brief review of botanical issues from the literature

Boucher & Rode (2001) underline the influence of dams in the Breede River:

"Very specific flow regimes are required to maintain vegetation zonation patterns along these rivers. Following damming, emulation of the natural flow regimes are necessary to resettle the rivers at lower flow-levels. Careful management is required during the resettlement period to limit further invasions by exotic woody species. Aliens invade stressed areas following changes to flow levels." "No channel manipulation should be allowed as this leads to alien invasion which blocks channels during flood events and exacerbates the floods. The presence of dense stands of exotic woody plants, particularly of Eucalyptus species, contributes to excessive water loss during low flow periods (Le Maitre et al. 1995). Long periods with low flows result in the invasion of the stream bed by Wetbank Zone vegetation, for example by Prionium serratum and Paspalum distichum, which exacerbates the problem of flooding during high flows."

South African National Biodiversity Institute's (SANBI) Critical Biodiversity Area maps for the Breede River, Breede Valley and Winelands Municipalities, together with the Biodiversity Sector Plans, are regularly updated

on the SANBI website (enter <bgis sanbi> on Google-South Africa and follow markers in the "Projects" and "Map" folders). Downloadable maps and their explanations need to be consulted for the appraisal of this scheme, particularly in respect of infrastructure routes such as proposed pipelines.

2.8.4 Some non-botanical thoughts

Harding (2002) has the following comment to make about the status of the Papenkuils Wetland:

"The Papenkuils is a rare and important example of a wetland that contains a variety of wetland and terrestrial flora that are worthy of conservation. There are no other wetlands within the BRBS that would offset the total or partial loss of wetland services provided by the Papenkuils. The wetland is presently negatively impacted by reduced water availability and retention as a consequence of anthropogenic activities within the catchments of the three influent rivers [Holsloot (Smalblaar), Molenaars and Breede Rivers], and redirection of flows to Brandvlei Dam. The wetland's B/C Ecological Importance and Sensitivity category is offset by a declining C-category Present Ecological Status, and implies the need for rehabilitation to mitigate this disparity. Any further reduction in the availability of water for the wetland, such as would be the result of additional abstraction, will bring about further drying and deterioration, as well as reducing the recharge of groundwater that is currently occurring via the wetland. Impoundment of the wetland would lead to its complete loss."

2.8.5 Literature relevant to scheme

Boucher, C & Rode, E. 2001. Section 6, Botany, part 1, vegetation. In: Southern Waters, Breede River Basin Study: Specialist reports for the ecological reserve (water quantity) determination for key reaches. Volume 1: Introduction, water quality and biology. Unpublished report prepared for the Dept of Water Affairs and Forestry.

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Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

3. General considerations and comparison between sites

Key botanical issues requiring on site determination in the EIA phase of the project are:

- *The impact of the proposed scheme on rare, endangered or narrowly endemic species. Specific Red Data Book information for each particular scheme is best compiled through on site evaluation of the affected area as experience has shown that data held in the SANBI database is too general to provide the necessary specific information.*
- *The impact on threatened vegetation types would require detailed investigation (e.g. Elgin Shale Fynbos with Campanula Dam; Breede Alluvium Fynbos, Breede Shale Renosterveld & Breede Shale Fynbos with the Michell's Pass scheme; and Boland Shale Renosterveld with the Voëlvlei Augmentation Phases 1-3).*
- *The interruption or disturbance of ecological process, such as the effect of further reduction of Summer flows or an unnatural increase in volumes, on the affected river system(s), particularly in respect of aquatic fauna and riparian flora.*
- *Impact on conservation areas, e.g. on the Voëlvlei Nature Reserve. No Critical Biodiversity Area maps for the Swartland Municipality have been produced yet.*
- *It is recommended that a detailed study of the dam site which is finally accepted should be undertaken, over at least a full year, to ensure that the full impact on the inundated flora is assessed and that the effects of extraction on the down-stream ecology of the system be addressed.*

The following rating of the botanical sensitivity of the different sites given below is so-called "gut-feel" based on information gained during site discussions, evaluation of the literature and personal knowledge about the different options as presented above. The sites, including their perceived degree of disturbance to the natural environment are ordered from the Preferred to the Least Preferred option.

Preferred scheme

Michell's Pass Diversion
Raising of Lower Steenbras Dam
Voëlvlei Dam - Phase 1 Augmentation
Voëlvlei Dam - Further Augmentation of Voëlvlei Dam
Upper Molenaars River Diversion
The Upper Wit River Diversion
Upper Campanula Dam - Alternative 1
Upper Campanula Dam - Alternative 2

Least preferred scheme

4. Comprehensive reference list

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Appendix 1. National vegetation type Conservation status categories *(Mucina & Rutherford 2006)*

The Ecosystem Status of these different vegetation units in South Africa are categorised into four types based on the remaining % of untransformed area, as follows:

- *Least Threatened – Up to 20% of the original extent is irreversibly transformed with more than 80% left.*
- *Vulnerable – 20 to 40% of the original extent is irreversibly transformed with 60 to 80% left.*
- *Endangered – 40 to 75% of the original extent is irreversibly transformed with 25 to 60% left.*
- *Critically Endangered – 75 to 100% of the original extent is irreversibly transformed with less than 25% left. One would expect loss of species to take place in such vegetation types and biodiversity targets cannot be met.*

The above classes draw on the Red List classification scheme developed by the IUCN. Conserving the natural habitats in which species occur will ensure their continued persistence. This classification system is provided for in the new Biodiversity Act No. 10 of 2004 and the National Environmental Management Act No. 107 of 1998.

In general terms the following approaches should be considered in respect of evaluating the presence of vegetation belonging to the above categories in a potential impact area:

- *Least Threatened - Disturbance of natural undisturbed stands should be avoided.*
- *Vulnerable – Disturbance of natural undisturbed stands of vegetation belonging to this category should be avoided unless in instance of unavoidable regional interest and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Endangered - Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Critically Endangered - Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted. Restoration of disturbed areas is imperative.*

Appendix 2. SANBI national Red Data Book threat status categories

The following Threatened Plant Rating categories (Red Data Book categories) are currently used by CapeNature and by the South African National Biodiversity Institute.

- *Extinct - A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.*
- *Critically Endangered - A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and is therefore considered to be facing an extremely high risk of extinction in the wild.*
- *Endangered - A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and is therefore considered to be facing a very high risk of extinction in the wild.*
- *Vulnerable - A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and is therefore considered to be facing a high risk of extinction in the wild.*
- *Near Threatened - A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is very close to qualifying for or is likely to qualify for a threatened category in the near future.*
- *Least Concern - A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.*
- *Data Deficient - A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. DD is therefore not a category of threat. Listing of taxa in this category is only justified after ensuring that maximum use has been made of the available data.*

ADDENDUM

2.5.6 Elandspad Diversion

2.5.6.1 Scheme description

The second option on the Molenaars River system is an alternative and involves the potential construction of a low level weir on the Elandspad River (a tributary of the Molenaars) upstream of the existing DWA flow gauging station. This would negate the need for infrastructure to be developed in the Molenaars River itself. The yields from the alternative option on the Elandspad River would be about 75% of those from the Molenaars diversion, for the same diversion capacities. Water becoming available in winter from the scheme would be stored, via a new pipeline of approximately 26 km, in the Berg River Dam and in this way integrated into the Western Cape Water Supply System.

2.5.6.2 Key botanical issues

2.5.6.2.1 Impacted vegetation types

*The National vegetation types (Mucina & Rutherford 2006) impacted by this proposed option (***Figure 20***) are:*

- *Fynbos Riparian Vegetation (AZa 1), formal status not determined as embedded in adjacent types, but is well conserved and is not under any immediate threat except from alien vegetation invasion.*
- *Boland Granite Fynbos (FFg 2), with a conservation status of Endangered. Any impact upon undisturbed stands of this vegetation type must be avoided unless of unavoidable provincial need and any disturbed vegetation must be restored where it is impossible to avoid it.*
- *Hawequas Sandstone Fynbos (FFs 10), with a conservation status of Least Threatened (***Figures 21 & 22***). Disturbance of natural undisturbed stands should be avoided.*
- *Swartland Alluvium Fynbos (FFa 3), with a conservation status of Critically Endangered. Impacting areas supporting this vegetation type, whether in undisturbed or disturbed condition, may only be done in instance of unavoidable national need and after all other avenues of avoidance are exhausted. Restoration of disturbed areas is imperative.*
- *Western Coastal Shale Band Fynbos (FFb 2), with a conservation status of Least Threatened. The presence of this vegetation type is expected but this needs on site geological confirmation. Disturbance of natural undisturbed stands should be avoided.*

2.5.6.2.2 Other botanical issues

- *Abstraction design must allow for current natural flow variability to maintain the riparian vegetation as this is an A-class river. The abstraction inlet bottom height must be such that summer flows cannot be utilized at any time during the lifespan of the scheme.*
- *Downstream impact of abstraction on the Breede River or of floods feeding the Papenkuils Wetland needs evaluation in this scheme.*
- *Plant disseminules (e.g. seeds), fauna (e.g. eels) and larvae from Breede Catchment will be transferred to Berg River. This already happens from Riviersonderend through the Berg River Scheme and to a degree lower down the Berg through Gawie-se-Water.*
- *It would be preferable to keep activities nearest the Huguenot Tunnel eastern exit where the area is already disturbed instead of impacting on this river in its higher reaches. The eastern pipeline route from the abstraction point to the eastern tunnel portal would impact on areas supporting some undisturbed Hawequas Sandstone Fynbos (Least Threatened) and Western Coastal Shale Band Fynbos (Least Threatened) and possibly some Boland Granite Fynbos (Endangered), although the presence of the last*

types is unknown as the proposed route has not been surveyed botanically. Indigenous plants are grown for the cut-flower industry along the pipeline route.

- *The new western pipeline route from the Huguenot Tunnel western portal to the Berg River Dam would have to be aligned to avoid areas of Swartland Alluvium Fynbos (Critically Endangered) and Boland Granite Fynbos (Endangered) supporting colonies of threatened Red Data Book plants. Unavoidable disturbances to this vegetation along the new western pipeline route would have to be restored to a near-natural state.*

2.5.6.2.3 Implications of dam building on the flora and vegetation

- *Impoundments which upset the normal flow regimes undoubtedly influence the riparian vegetation. Sand accumulations following a reduction in flood-scouring action results in the deposition of new bare sandy areas which become colonised preferentially by exotics, particularly Acacia longifolia and Acacia mearnsii. These species form dense stands of trees which impede the growth of the indigenous flora. Fires in the densely infested stands are hotter and the indigenous woodland elements cannot withstand the resulting high temperatures, which then lead to their death. The accumulation of sand leads to changes in the ratios of the different communities present through changing the nature of the river channels.*

2.5.6.2.4 Comments on the wider distribution of communities

- *The Hawequas Sandstone Fynbos and Western Coastal Shale Band Fynbos are still widespread in an undisturbed state. The Boland Granite Fynbos communities in Du Toitskloof and along the western pipeline route are threatened, particularly through agriculture. The communities associated with the Berg River alluvial floodplain are extremely threatened.*
- *The riverine communities do not appear to be unique to Du Toitskloof, but fairly natural riparian wetlands, similar to other wetlands, are no longer extensive anywhere in the south-western Cape and are recognised as a threatened commodity on which attention has been focused, even on a national basis, since 1987.*
- *Appropriate management techniques should be applied after construction is complete to prevent the advance of alien flora within the areas disturbed during building activities and where at all possible these areas should be re-established using plants from the valley.*

2.5.6.2.5 Comments on general botanical issues

- *Should the Elandspad site be selected, then care will have to be taken to ensure that sufficient volumes of water are released at suitable times to ensure that the integrity of the riparian communities below the impoundment is assured.*
- *It is recommended that a detailed study of the abstraction site and of both pipeline routes which are finally accepted must be undertaken, over at least a full year, to ensure that the full impact on the inundated and disturbed flora is assessed and that the effects of abstraction on the down-stream ecology of the system is addressed.*
- *This scheme is rated among those that are "Least Preferred" from a botanical point of view (see Section Chapter 3 above).*

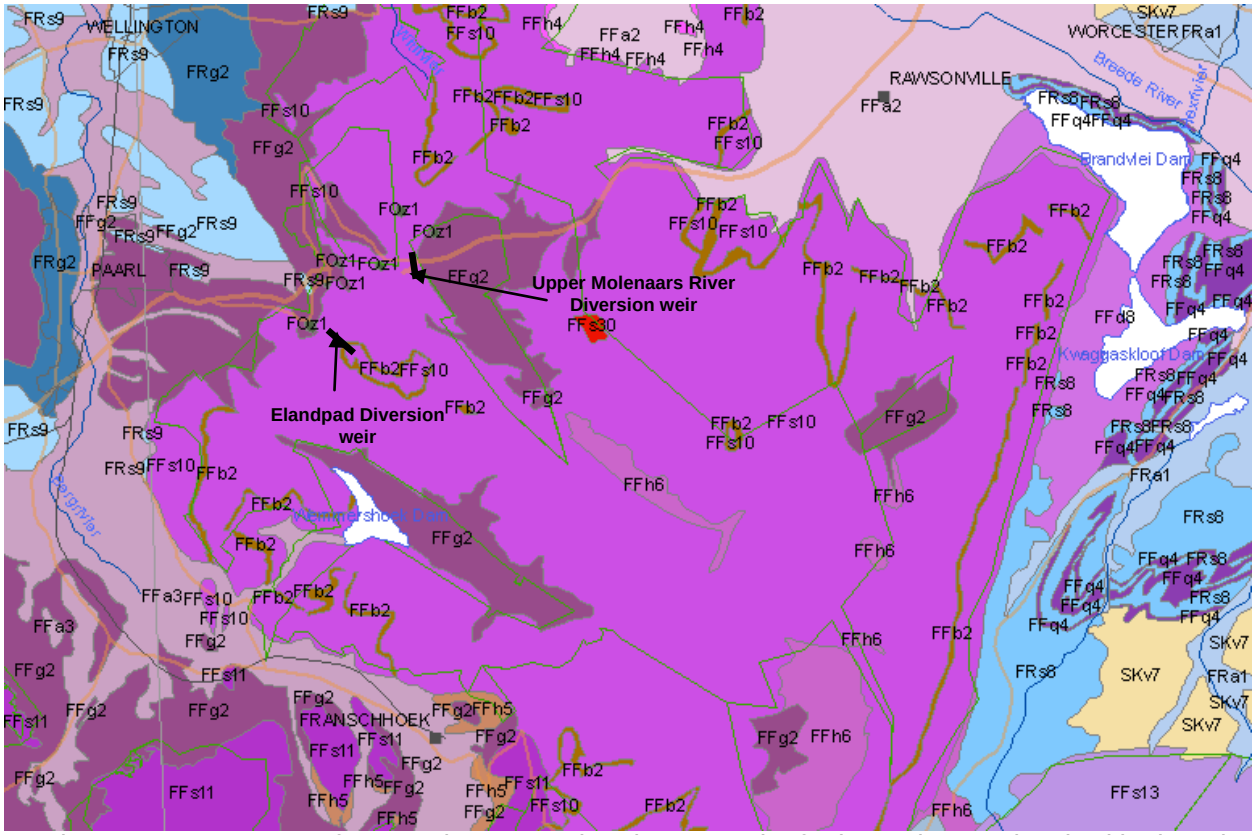

Figure 20. Vegmap of vegetation types (Mucina & Rutherford 2006) associated with the Elandspad Diversion to either Wemmershoek or Berg River Dam. This diversion would influence flows to Brandvlei Dam.

Figure 21. Relatively unspoilt Fynbos Riparian Vegetation and Hawequas Sandstone Fynbos at the Elandspad vlakte near Suzman's house.

Figure 22. Wetland seep in Western Coastal Shale Band Fynbos on Elandspad vlakte.