

EUTROPHICATION OF IMPOUNDED WATER RESOURCES IN SOUTH AFRICA:

DESCENT INTO CRISIS

**Dr WR Harding
DH Environmental Consulting
(www.dhec.co.za)**

PAPER PRESENTED AT THE WRC-CONVENED
WORKSHOP ON WATER RESOURCES AND WATER
QUALITY

“Water Quality : Are we serious enough? The need
for a CHANGE”,

HELD AT THE 2010 WISA CONFERENCE IN
DURBAN.

21 April 2010

EUTROPHICATION OF IMPOUNDED WATER RESOURCES IN SOUTH AFRICA: DESCENT INTO CRISIS

Dr W R Harding, Professional Limnologist / Certified Lake Manager (USA)
DH Environmental Consulting (DHEC)
info@dhec.co.za

INTRODUCTION

South Africa faces an escalating water crisis, posed by the rapidly-worsening quality of our dams. The problem is by no means new or unknown. The crisis has existed at regional level (Gauteng) for the past decade and in certain dams at local level for 30 years or longer. Despite having been aware of the problem since the 1970s, the Department of Water Affairs (DWA) has made no demonstrable efforts to meaningfully address it. To the contrary, the so-called "controls" that the DWA has in place have allowed the problem to worsen significantly – this despite warnings of three decades ago that the controls were fundamentally flawed (see elsewhere in this document). This situation is untenable in a country that has a significant dependence on raw potable, livestock and irrigation water stored in dams. The development of relevant skills and expertise to both assess and manage the problem has been almost entirely neglected.

While this presentation addresses the issue of eutrophication in reservoir lakes (= dams, impoundments, man-made lakes), there is an equally-problematical situation extant in various major rivers (e.g. Orange, Vaal, Harts, Umgeni, Berg, Buffalo, Breede and Crocodile, to name but a few).

This short presentation cannot address the underlying issues in detail but merely intends to highlight the fundamental shortcomings of an almost non-existent eutrophication management structure. It assumes that the reader of this document has a reasonable understanding of eutrophication, - i.e. that the availability of plant nutrients (nitrogen and – particularly – phosphorus) in excess of an 'assimilable' threshold, result in the overdevelopment of plant biomass, most commonly blue-green algae (cyanobacteria). The process of nutrient enrichment towards problem (elevated) trophic states is slow and insidious, with problems often only becoming apparent a considerable time after onset of pollution. Assuming that the attenuation of loads is effective, the restoration period may be as long as ten to fifteen years.

Eutrophication (the cause) is most commonly characterized by the symptom of algal overgrowth. However this is merely one obvious symptom. Less obvious are ecosystem degradation and other health-related water quality issues that typically exist in concert with increased biomass – this obvious from the common source of the problem – human wastewater effluents, a problem now worsened by failing treatment infrastructure (see **Box**).

It is to be emphasized that the problem is of national import and not simply that of the DWA – i.e. it is a problem that lies directly with Central Government – spanning at responsibility level the Departments of Water Affairs, Health, Agriculture, Trade and Industry and Tourism. South Africa's economy, as well as the ability to ensure human and animal health, is centered on the quality of water available to the nation. The DWA has shown, through its sustained inaction, that it is incapable of recognizing this problem. If it has been recognized – and there is no reason why it should not have been – then the Department is arguably guilty of wilful ignorance and of placing both the nation's resources and its people at considerable and unnecessary risk. This is in conflict with both the Constitutional protections that are in place and the Water Act.

This document incorporates some opinions of the writer but the majority of the statements made can be substantiated. Any opinions are derived from many years of personal contact with water issues in the South African industrial, local government and private sectors. This document serves as the basis for a detailed presentation to be delivered at SIL2010 during August in Cape Town. The content is intended to serve as constructive criticism and it is hoped that it will be received in this light.

Box: Extent of failing wastewater treatment capacity across South Africa.

PROVINCE	% WWTWs with non-compliant effluent	% WWTWs with unknown flows or flows that exceed design capacity
Free State	99	77
Northern Cape	96	87
Eastern Cape	89	95
Gauteng	67	84
Limpopo	95	95
North West	100	95
Western Cape	19	29
Mpumalanga	90	89
KwaZulu Natal	77	50

The author is more than willing to debate any issues contained in this document.

THE PROBLEM – CAUSES AND CONSEQUENCES

1. Nature and extent of the problem

Conservatively, 35% of South Africa's impounded water resources are seriously impaired (eutrophic to hypertrophic); a further 20-30% are incipiently problematical. All of the major impoundments in the economic heartland of the country, Gauteng, are grossly impaired. The full extent of the problem is unknown as no systematic comprehensive spatial surveys have been conducted. The problem of exposure to eutrophic water will be acute in the vast rural areas where people have no choice but to drink whatever is directly obtainable from the river or waterhole. For a nation where so many people are already compromised by the TB-HIV-AIDs pandemic, there is little hope when the basic water resources present an additional challenge to human health.

In most cases, especially in the inland areas, the pollution problems are point-source discharges of wastewater effluents. Accordingly, the cause has been both obvious and manageable for a long time, yet it has been ignored. Other waters, as a consequence of their background (catchment background) nutrient loadings, are already at the threshold where very small anthropogenic impacts will negatively tip their trophic state. Very few, if any, management practices are available in such cases. Biomanipulation, (adjustment of the food web structure to benefit algal grazers) is not a viable option in reservoirs as it is in some natural lakes systems overseas – but is likely to provide benefit for imbalances in foodweb pressures caused by the overdevelopment of undesirable biota.

The extent to which extant nutrient loadings to the country's major impoundments should be reduced has been provisionally determined (WRC, 2008). This ranges from 25-85% - with reductions in excess of 70% typically required in order to meet desired management targets.

2. The problem is exacerbated by:

- 2.1 The lack of DWA department or directorate of Reservoir Management, staffed or informed by experienced limnologists versed in the specifics of South African reservoirs. What national knowledge was developed during the 1970s and 80s has been allowed to deteriorate to insignificance.
- 2.2 Non-attention to published warnings about the parlous state of South African limnology – for example a confidential report commissioned during the 1990s or the 2000 report by the WRC (the Walmsley report) – or the concern, also during the 1990s, raised via a resolution of the South African Society of Aquatic Scientists (SASAqS).
- 2.3 The inability of the Water Research Commission (WRC) to draw public or official attention to problem issues that their research has identified – this being against their mandate and the obvious cooperative governance relationship with the primary recipient of WRC research – the DWA. This is a non-sensical relationship given that WRC research is funded by public money derived from a levy on the sale of water. The derivation of the wastewater pollution loads to key dams is a case in point. Additionally, there has been total disregard of recommendations made in their (WRC) commissioned review of ‘contemporary reservoir limnology’ as recently as 2006.
- 2.4 Over-attention, since the late 1980’s or early 1990’s, to river ecology – without comparable efforts in the linked fields of impoundments, wetlands or estuaries (the latter only recently being attended to – although the work done for wetlands has simply rehashed excellent methods and approaches previously available from other countries – rather than simply adopting same and moving immediately to local and regional specifics of wetland functional biology. The singular focus on rivers has been in direct conflict with the intentions of the Water Act, namely that an holistic, source-to-sea approach be adopted from the outset. The DWA's RDM Office is largely responsible for this lack of appropriate oversight. The blatant oversight of the fact that many rivers are impounded, and the quality of their downstream flows is influenced correspondingly, is indicative. Notions of water quality improvement during impoundment have never been substantiated (in the medium-term time horizon) under local conditions.
- 2.5 An inability or unwillingness of the remnant SA limnological fraternity to work in concert with each other and to collaborate in pursuit of a greater goal. Furthermore, the disinclination of the country’s professional aquatic sciences body, SASAqS, to associate with the world’s premier international limnology meeting – SIL2010, to be held in Cape Town – perhaps illustrates this – as well as the dominant influence of river biologists in

SA aquatic sciences. Although there are some SIL members in this country, local SIL representatives have for years done absolutely nothing to form a limnological “chapter” (here it must be conceded that as long as the national department continues to ignore the problem it will be impossible to develop South African limnological science to any meaningful degree).

2.6 A lack of effective protective controls or instruments.

- The 1 mg/l Phosphate Standard is completely useless and has not been revised or revisited since its promulgation during the 1980s. In addition hereto, the implied allowance for this concentration of nutrient to be conveyed to dams via rivers is orders of magnitude above the phosphorus level (20 µg P per liter) at which riverine ecosystem damage is known to occur. Although the DWA maintains that this standard is being “reviewed”, this writer is not aware of any South African limnologists of any standing being associated therewith.
- The so-called Phosphorus Management Objective for reservoir lakes, PMO, sets a target management level of 130 µg per liter. This has no limnological validity and is more than twice the identified level at which South African reservoirs begin to evidence an increased frequency of eutrophication-related problems. The origin of this number is unclear and if maintained will simply allow all dams to become degraded. The true maximum value to ensure a mesotrophic condition is only 55 µg per liter.
- A sustained tendency by the DWA to grant exemptions for the exceedance of wastewater discharge limits – the fallacy of this heightened by the fact that both the (DWA) General and Special Standards have no foundation in ecosystem functional needs or provide any protection against eutrophication.

2.5 Resort to First World management controls – completely juxtaposed with the burgeoning failure of wastewater and effluent disposal infrastructures and the need to seek Africa-relevant solutions. The DWA’s RDM office continues to develop increasingly sophisticated and expensive (to apply) assessment techniques for rivers. These are well-intended but have no application value given the prevailing worsening water quality and the lack of stringent source controls targeting pollution sources (e.g. wastewater treatment plants).

2.6 A perceived inclination by the DWA to wilfully ignore and marginalize those individuals who highlight problems related to DWA's ambit of responsibility – this perceived as an attack on the Department (multiple personal experiences plus the reports of others support this opinion). Added to this is a reluctance by DWA staffers, who know better, to speak out about identified issues, presumably in fear of their job security. The Hartbeespoort Dam Metsiame Project is a classic example of where this tendency has been exploited to the extreme by petty officialdom.

2.7 Wastewater effluents form a desired volumetric component of the total annual inflows to many inland dams. The obvious threat to the quality of impounded water has been 'informally' countered by water treatment engineers on the premise that “if the water quality gets worse, we will simply increase the treatment process”. Allied to this was the notion created by the DWA that eutrophication would 'never become a problem in South Africa' – a perception created by a paper published by DWA researchers in the 1980s – despite strong professional opinion to the contrary. During 1988 this writer was informed by a senior DWA official that eutrophication would never occur in the Western Cape because of the 'brown [humic-stained] water! Within four years of this statement both the Voelvlei and Theewaterskloof dams exceeded their nutrient tipping-point thresholds and became cyanobacterially-dominated. Additionally, the largest ever loss of cattle occurred in the Kareedouw district, in pH 4 humic water! These arguments

- have no validity and emanate from myths and legends created by ill-informed individuals – sometimes supported by scientists operating outside of their comfort zone.
- 2.8 There is a long-standing perception amongst certain DWA staffers that the cost of attenuating eutrophication loads would be overwhelming to the economy. While cost numbers touted by these officials are entirely spurious, there has been no attempt to accurately quantify the costs – even at Gauteng level where a serious water quality crisis has been in existence for some time. Evidence suggested by a (private) costing for the Roodeplaat Dam's Zeekoegat Sewage Works indicates that upgrading to reduce phosphorus loads to acceptable levels may not be as high as previously thought. It is true, however, that the task will be daunting but the longer the problem is left to fester, the greater the cost will become – and, in all likelihood, eclipse the Eskom saga by an order of magnitude. This would cripple the economy. Alternative energy sources can be used to counter electricity ‘deficits’ – but no such alternatives exist for water – apart from energy-costly desalination – an approach that is totally impractical for water needs in the interior economic heartland..
 - 2.9 An overwhelming tendency to concentrate on symptomatics (e.g. cyanobacteria) and cosmetic alleviations (plant biomass removal), rather than address the root cause (nutrient loading). This farcical approach has been in practice at Hartbeespoort Dam for many years and appears to be founded on little more than public relations exercises to divert attention from the problem.
 - 2.10 The inability of the DWA's Directorate of Resource Quality Services (RQS) to retain and develop and expand in-house limnological skills.
 - 2.11 The absence of a national limnological 'Centre of Excellence & Information' serves to isolate municipalities from informed advice and others and forces them to seek their own solutions, in many cases ill-advised or desperate attempts to utilize “silver bullet” products. Offers to provide a specialized limnological training course for DWA personnel have, since 2005, been ignored by the Department.
 - 2.12 No proper limnological training courses are or have been offered in South Africa. Limnology is not a 'taught' subject at any South African tertiary institution. This despite the dependence of the country on water stored in dams. This coupled with the lack of any related career opportunities has effectively precluded the recruitment of any new skills to the profession. Equally so it has proven near impossible to attract foreign researchers, this exacerbated by the inability to use WRC and NRF or similar funds for this purpose. Thus the opportunity for mentorship and skills transfer has not been created.
 - 2.13 The bulk of the limnological skills built up – at great expense - during the 1970s and 80s has been lost – with those specialists either leaving the country or re-equipping themselves in another field. In this fashion human experience and memory capital has been lost. Additionally, there has been no maintenance of “currency” of skills other than within a handful of specialists mostly in private practice or retired.
 - 2.14 The lack of retention of skills and the loss of national and regionally-specific experience (human capital) has resulted in newcomers to this field of aquatic sciences often utilizing or deferring to outdated or irrelevant understanding or conclusions. This has proved to be a setback as the reinvention of “knowledge wheels” is repeated on a regular basis – without due consideration of functional biology issues (“ego-system management as opposed to ecosystem management).
 - 2.15 There has been no attempt to form a “knowledge colloquium” of retired or otherwise inactive South African limnologists – in an effort to retain and convey skills, knowledge and experience to a new generation of South African reservoir managers – before this resource is completely lost.

Suggestions for a way forward:

- The DWA must acknowledge that, as is the case in the rest of the world, eutrophication poses probably the single greatest threat to water resources. This is exacerbated in an arid country such as South Africa. Without open and honest recognition of the problem the current scenario of inaction will simply be perpetuated -placing the country at even greater risk.
- Convening of a colloquium of the remnant specialist knowledge and the development of a plan of action. Professor Emeritus (UKZN) Rob Hart has the best experience and credentials to convene and oversee such a grouping. The fundamental approach of this grouping, in collaboration with engineering skills, should be to start addressing the problem and not gathering more information about it. Membership of this colloquium should be based on the ability of an individual to contribute meaningfully and immediately to the problem and not simply on the basis of interest. An initial shortlist of specialists would be Prof RC Hart (Limnologist), Dr WR Harding (Limnologist), Dr G Ekama (Wastewater Treatment Engineering), Dr Carin van Ginkel (Limnologist), Dr SA Mitchell (former WRC Eutrophication Programme Manager, Algologist), Dr G Grobler (DWA, Water Quality), plus senior reservoir hydrology and engineering representatives from the DWA. This core group should be empowered to invite and co-opt additional specialists on a 'need-to' basis.
- The team should be linked to an appropriate executive level of the DWA so as to provide the shortest possible communication chain between recommendations and response. The problem of eutrophication is of such serious proportions that it cannot afford to be constrained by a multiple committee approach. Close liaison between this group and NRF/WRC funding agencies is likely to be required as the planning process unfolds.
- Prioritization of attention to the worst-impacted reservoirs (e.g. in Gauteng), coupled to a substantiated costing of the engineering requirements for nutrient management at source.
- Adoption of a "protect the least impacted reservoirs immediately" approach – this to prevent any further degradation of unimpacted or marginally-impacted water resources, especially 'head-water' reservoirs in reservoir cascades like the Mgeni (Midmar-Albert Falls-Nagle-Inanda).
- Implementation of a catchment-based nutrient-loading approach, based on the load:response characteristics of individual dams, coupled to rapid implementation of controls on the pollutant sources. In the main this will be limited to wastewater treatment works having to adapt their processes within a specified time period. Urgency should be applied to fast-tracking nutrient load attenuation at catchment scale for a subset of impacted waters (= full-scale pilot testing). This approach will serve to highlight the problem areas that may constrain a wider rollout.
- Development of specialized skills and understanding for South African reservoir limnology. This should focus on equipping DWA decision makers, as well as building a new generation of reservoir limnologists having a good understanding of South African conditions. The implementation of such a programme could be put into effect almost immediately before any more skills are lost.