

UNIVERSITY OF CAPE TOWN

School for Advanced Legal Studies

**THE THREAT TO SOUTH AFRICAN WATER SECURITY
POSED BY WASTEWATER-DRIVEN EUTROPHICATION: A
PROPOSAL FOR A NEW REGULATORY APPROACH.**

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Words: 24790

Research dissertation presented for the approval of Senate in fulfillment of part of the requirements for the M (Phil) (Environmental Law) in approved courses and a minor dissertation.

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ACKNOWLEDGEMENTS

My sincere thanks to Professor Feris and the staff of the Institute of Marine and Environmental Law (IMEL) for their guidance and inspiration during my two years of association with the Kramer Law School. It has been an edifying and inspirational experience. Professor Feris is especially thanked for her interest in my efforts to translate science into law and her patient mentoring of this process. I was indeed fortunate to have been a student at the IMEL prior to her transition to the position of Deputy Vice-Chancellor (Transformation).

For Heathcliff

ABSTRACT

The quality of South Africa's raw potable water resources is severely impacted by eutrophication (nutrient enrichment). As much as two-thirds of the reservoir impounded resource may be affected. Wastewater effluents and/or the integration of wastewater return flows as part of the water balances of many reservoirs constitute the primary source of this nutrient pollution.

South Africa's historical awareness and understanding of the eutrophication threat to surface waters is comparable with that of other, similarly-afflicted, countries. In particular, the need to manage phosphorus was recognised as early as 1962 when South Africa promulgated one of the first (global) regulations for phosphorus in wastewater effluents. More recently, eutrophication has been ranked as a high priority by the the National Water Resource Strategy.

Despite this background, phosphorus removal from wastewater effluents in South Africa remains virtually unregulated. Additionally, there is no resource-directed protocol for the accounting of all sources of phosphorus (or other pollutants) at a catchment level, rendering problematic, if not impossible, the fair and equitable allocation of levies on wastewater discharges.

This dissertation examines how wastewater-originating eutrophication is regulated in the USA and Europe, with phosphorus as a central focus. A comparative assessment of the equivalent situation in South Africa is provided and the shortcomings of the latter highlighted. As a solution, I suggest an equitable and transparent scheme of pollutant accounting by individual source, ideally suited to the allocation of waste discharge levies. Applied against a specific resource requirement, for example an identified need to reduce phosphorus in a particular reservoir, this approach also provides a legally sound scheme for pollutant load regulation and permitting.

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CHAPTER 1: INTRODUCTION

1. FOCAL RESEARCH AREA

The socio-economic existence of South Africa is largely dependent on water stored in reservoirs. South Africa has a comprehensive set of constitutionally-empowered framework, with ancillary legislation addressing issues of water pollution.¹ At a fine-scale, however, the law remains to be developed to address specific water pollution issues such as the eutrophication² of reservoirs, fuelled by nutrients contained in inadequately-treated sewage effluents.³ In this dissertation I examine the long-standing shortcomings and impacts of the existing policy and legislation, in particular the absence of statutorily-required attention to the water quality conditions pertaining in many South African reservoirs. I also argue that it is not rational to attempt to manage riverine ecosystems in the absence of a parallel and comprehensive understanding of the physico-chemistry of the reservoirs that punctuate them. Furthermore, that the continued eutrophication of South African reservoirs presages a formidable socio-economic and environmental risk that was evident five decades ago, yet remains unaddressed to this day. I propose an immediately-available, integral regulatory solution that dovetails with extant policy and legislation.

2. INTRODUCTION AND BACKGROUND

Eutrophication, seen here as the enrichment of surface waters⁴ and, in particular, reservoirs, by nutrients (nitrogen and phosphorus) contained in sewage (wastewater) effluents, is arguably the greatest water pollution threat that this country faces. The South African National Water Resource Strategy (NWRS) lists eutrophication at the very top of a list water quality issues of concern.⁵

¹ South African Constitution 1996; National Environmental Management Act 107 of 1998; National Water Act 36 of 1998; Water Services Act 108 of 1997, *inter alia*.

² 'Eutrophication' means the enrichment of waterbodies by nutrients, especially compounds of nitrogen and/or phosphorus. This causes an accelerated growth of algae and higher forms of plant life, producing an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.

³ National Water Resources Strategy (2nd Edition, June 2013) at 26 & 39.. The 2013 NWRS lists wastewater treatment works, intensive agriculture, fertilizer use, dense urban sprawl and un-serviced sewage as sources of eutrophication in South Africa.

⁴ Although the problem extends into the riverine, estuarine, wetland and marine environments, my research will focus on wastewater-originating eutrophication in the freshwater environment, with a particular focus on reservoirs.

⁵ NWRS (n3) Table 7 at 40.

Eutrophication from sewage effluents currently impacts between fifty and seventy per cent of the raw potable water stored in South Africa's reservoirs.⁶ While regional issues of acid mine drainage (AMD), sulphate pollution (acidification) and salinization pose additional major water quality challenges, eutrophication eclipses the other three in sheer scale and pan-national occurrence.

Eutrophication impacts negatively on water resources both directly, *inter alia* increased treatment costs, threat to human and/or animal health, loss of recreational potential and property values, irrigation and stock watering, and indirectly in the form of aquatic ecosystem degradation. The problem is exacerbated in instances such as where primary and/or inefficient treatment processes are in use, or where new housing has been connected to an existing sewerage reticulation system unable to process the additional load.⁷

In economic terms: a recent assessment concluded that a one per cent decrease in water quality in South Africa, leading to a loss of use, could translate into 200 000 job losses, a decline of 5.7 per cent in per capita disposable income and a related compensatory increase of R18.1 billion in government spending. Further negative impacts would affect Gross Domestic Product, household spending and fixed investment, all exacerbated by concomitant declines in water supply.⁸ These economic costs can further be divided into Damage Costs (social and ecological damage) and Response Costs (compliance and control, as well as agency-incurred costs for monitoring and enforcing solutions).⁹

⁶ Harding WR 'Living with eutrophication' (2015) 70.*Trans.Roy.Soc.SA* 1-17; See also MW Matthews and S Bernard 'Eutrophication and cyanobacteria in South Africa's standing water bodies: A view from space' (2015) 111 *SA.J.Sci.* 1.

⁷ Morrison G, Fatoki OS, Persson L and A Ekberg (2001) 'Assessment of the impact of point source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma River - pH, electrical conductivity, oxygen-demanding substance (COD) and nutrients'. 27 *Water SA* at 475.

⁸ Plus Economics (Pty) Ltd (2010) 'The South African Water Crisis: An Economic Impact Study'. Draft Report prepared for UASA. www.polity.org.za. Accessed on 19 April 2016.

⁹ Graham M, Blignaut J and L de Villiers et al (2012) 'Development of a Generic Model to Assess the Costs Associated with Eutrophication'. Water Research Commission Report 1568/1/12. Figure 2 at iii.

(a) *Long-standing awareness of the eutrophication problem*

Five decades ago, South African scientists warned about the risks to surface waters posed by wastewater effluents (emphasis added):¹⁰

‘The devastating effects of industrial effluents and domestic wastewater on rivers in particular and water resources generally have aroused world-wide awareness of the need for water pollution abatement.

Forecasts based on reports from many countries show that in spite of accelerated programs for secondary waste treatment facilities, *the pollution problem by the year 2000 will be no different from what it is today.*

Countries not so richly endowed with large and perennial rivers [to provide sufficient dilution to blanket deleterious effects, *such as the Republic of South Africa*, are already moving along this critical path [to where increasing volumes of secondary effluents will reach threshold limits]’.

In 1975, an economic assessment identified the risks associated with wastewater effluents forming a significant part of the water balance of some reservoirs (emphasis added):¹¹

‘The problem of wastewater control is closely related with that of potable water supplies. Surface water is limited, so that the integration of fresh and wastewater resources is merely a matter of mode and timing’... ‘[h]owever, the reliable supply of surface water in South Africa depends on long-term storage conditions [that are] favourable to eutrophication’.

The clear implication was that the risks associated with the sustained discharge of inadequately-treated wastewater effluents to the aquatic environment were clear and evident. Also implicit was that to not heed the warnings would result in the degradation of the water resources into which the effluents were mixed, thus creating additional treatment costs to ensure potable water quality and offset ecosystem deterioration. While the need to enhance wastewater treatment was obvious, so too was the need to ensure that the treatment applied was aligned with the ability of the natural environment to assimilate the pollution load. Where it was not, the pollution load would need to be attenuated prior to discharge. As noted elsewhere, the question to be asked was not ‘how much exposure [to pollution] we can stand but rather how much waste reduction [at source] can we achieve’.¹²

¹⁰ Stander GJ and LRJ Van Vuuren (1969) ‘The reclamation of potable water from wastewater’. 41 *Journal Water Pollution Control Federation*. At 355.

¹¹ Bolitho VN (1975) ‘Economic aspects of wastewater treatment in South Africa’. 1 *Water SA* at 118.

¹² Weale A (1991) *The New Politics of Pollution*. At 112

In light of the foregoing, it is both surprising and worrying that a water-scarce South Africa has yet to formulate an ecosystem-based reservoir management policy,¹³ or devote any considered attention to attenuating the loads of wastewater-borne nutrients discharged daily into South African rivers and thence to its reservoirs. This paper presents a regulatory tool that underpins both of these aspects.

(b) A global problem

The eutrophication problem is not unique to South Africa.¹⁴ Anthropogenically-altered biogeochemical flows of nitrogen and phosphorus, the principle eutrophication ‘nutrients of concern’, now exceed ‘planetary boundaries’.¹⁵ Pollution threats to the ecosystem provisioning services provided by freshwater resources are increasingly impacting on human well-being at a global scale.¹⁶ The United States Environmental Protection Agency (USEPA) considers eutrophication to be ‘one of America’s most widespread, costly and challenging environmental problems...’.¹⁷

The most obvious symptom of eutrophication in both the freshwater and marine environments, namely Harmful Algal Blooms (HABs), have been increasing in frequency, severity and duration in recent times.¹⁸ Although deaths of wild animals, stock deaths and domestic animal poisonings are common in South Africa and elsewhere in the world, chronic exposure of both animals and humans to cyanobacterial toxins, via water supplies, is an unknown and unquantified impact.¹⁹

While the genesis of eutrophication awareness stems from the 1960s, pollution caused by wastewater effluents has, for more than a century, been globally recognised

¹³ In written response to a 2010 parliamentary query concerning whether an aquatic ecosystem health monitoring programme existed for [South African] [reservoirs], the Minister responded in the negative. National Assembly Question No 2082 (6 August 2010).

¹⁴ eg. Wastewater management in Zimbabwe (2002) Nhapi I and H Gijzen. 28th WEDC Conference, Kolkata (Copy on file with author).

¹⁵ Steffen W, Richardson K and J Rockström et al. (2015). ‘Planetary boundaries: Guiding human development on a changing planet’. 347 *Science* at 737.

¹⁶ Constituents of well-being viewed as security, basic materials for an adequate livelihood, health and social relations. *Water Security and Ecosystem Services: The Critical Connection*. United Nations Environment Programme (2009). At 10.

¹⁷ Onsite Wastewater Nutrient Regulation Report (2012). State Onsite Regulators Alliance and the National Environmental Services Center. At 1.

¹⁸ Codd GA, Azevedo SMFO and SN Bagchi et al (2005). CYANONET: A global network for cyanobacterial bloom and toxin risk management. Initial Situation Assessment and Recommendations. UNESCO Working Series SC-2005/WS/55. At 4.

¹⁹ Harding WR (2006) ‘A research strategy for the detection and management of algal toxins in water sources’. Water Research Commission Report TT277/06; Harding WR and BR Paxton (2001) ‘Cyanobacteria in South Africa: A Review’. Water Research Commission Report TT153/01.

as a major, if not *the* major, pollution threat to surface waters. Not long after the advent of flush sanitation, it became apparent that the disposal of sewage effluents to surface waters embodied a threat to riparian water users and municipalities downstream of the discharge point. A direct and negative consequence of the benefits of sanitation was the pollution of watercourses.²⁰ Streams acted as ‘natural sewers’ until the size of the city became so large that the waste disposal impact was felt downstream, resulting in the advent of legislation for sewage effluent disposal.²¹ This awareness soon spread from rivers to include tidal waters²² and transboundary issues.²³ The dual issues of recreation and public health became prominent, although generally absent of any consideration of the health of the aquatic environment.²⁴

(d) The need for load-based vs concentration-based standards

The trophic state arising from nutrient enrichment in lakes and reservoirs is a function of the load (‘load’ being *flow x concentration*) of nutrient entering the system, less the amount that is assimilated within the reservoir or removed from it via abstraction or overflow. This concept is dealt with in more detail in Chapters 2 and 5.

Against the aforementioned global context, the equivalent situation in South Africa may now be summarized:

South Africa is a country utterly dependent on reservoirs for storage of its bulk water resources. As is the case in other semi-arid regions such as parts of North America and Argentina, reservoirs are the main type of standing waters.²⁵ It has long been recognized that these man-made storages would become prone to eutrophication—which would be presumably be offset by standards-driven legislation that limits nutrient discharge in relation to the assimilative capacity of the

²⁰ Frost WH ‘The sewage pollution of streams: its relation to public health’ (1916) 31 *Public Health Reports* 2486.

²¹ Lapp JA ‘Stream pollution’ (1909) 3 *American Political Science Review* 230; Bailey EHS ‘Recent sanitary legislation in Kansas’ (1909) 29 *Am.Assoc.Adv.Sci.* 729.

²² Cumming HS ‘The pollution of tidal waters: its bearing on health and the importance to the state of its control’ (1914) 29 *Public Health Reports* 877.

²³ Phelps EB ‘Control of pollution of streams: the International Joint Commission and the Pollution of Boundary Waters’ (1917) 32 *Public Health Reports* 167.

²⁴ Hoskins JK ‘Some phases of the stream pollution problem’ (1922) 9 *JAWWA* 570.

²⁵ Reynolds CS (2004) Chapter 1 Lakes, Limnology and Limnetic Ecology: Towards a New Synthesis. In: *The Lakes Handbook* (Volume 1) Limnology and Limnetic Ecology (PE O’Sullivan and CS Reynolds, Eds). Blackwell Publishing. At 16.

ecosystem.²⁶ This implies the need for a load-based approach, as opposed to concentration based. South Africa, however, continues to apply concentration-based standards, although the state agency acknowledged two decades ago that they are inappropriate to the application of the RWQO principles.²⁷ At that time (1991) it was also acknowledged that (emphasis added):

*‘Salination of surface water resources and eutrophication present the most serious current water quality problems’.*²⁸

and that:

*‘...the Receiving Water Quality Approach, as defined, will inevitably lead to the deterioration of water resources to the point where they will be marginally fit for the recognized uses.’*²⁹

What these statements are saying is that by simply monitoring concentrations it is virtually impossible to address eutrophication as a water resource threat.

The state agency’s recognition of the fact that a uniform standards approach would not work other than in a ‘temporary minimum standards role’, was acknowledged 24 years ago (emphasis added):³⁰

‘If the application of minimum effluent standards is not sufficient to maintain the fitness for use of the receiving waterbody, then standards stricter than the minimum standards will be enforced. Such stricter standards will be site-specific and will be based on the results of a wasteload allocation investigation in accordance with the RWQO approach’.

and:

*‘...the allowable level of pollution, based on the assimilative capacity of the receiving environment, is established and allotted in the form of permits to individual polluters’.*³¹

The foregoing statements highlight the need for a risk-averse approach to be invoked. Simply put, any management objective that is put in place in the absence of an integrated understanding of all sources and pathways contributing thereto, as well

²⁶ Bolitho VN (1975) (n11) 118 et seq.

²⁷ Van Der Merwe W (1991) A Review of Water Quality Management in South Africa. Department of Water Affairs and Forestry (unpublished report) at 555. Copy on file with author.

²⁸ DWAF (1991) Water quality management policies and strategies in the Republic of South Africa. Department of Water Affairs and Forestry (unpublished report). Copy on file with author.

²⁹ DWAF (1991) (n28) at ii.

³⁰ DWAF (1991) (n28) at ii.

³¹ DWAF (1991) (n28) at 25.

as the projected change in source patterns linked to population growth, is likely to fail a legal challenge.

The most recent National Water Resources Strategy (NWRS)³² acknowledges that ‘*Untreated or poorly treated wastewater is severely affecting the quality of water in many areas*’. Furthermore, while water quality is not a central theme in the NWRS, that:

‘South Africa’s water ecosystems are not in a healthy state. Of the 223 river ecosystem types 60% are threatened, with 25% critically endangered. Of 792 wetland ecosystems 65% have been identified as threatened and 48% are critically endangered’.³³

The NWRS does mention urban and industrial effluents as main sources of pollution impacting on water quality and that they ‘*should be solved at source*’.³⁴ The main source of the urban pollution is the flush toilet, rendering (in the absence of an alternative form of sanitation) the wastewater treatment works as the logical point of pollution control.

South Africa’s sanitation policy is based on the progressive roll-out of flush sanitation. The population of South Africa in 2011 was 51.8 million.³⁵ Of this number, approximately 30 million had access to flush sanitation or bucket toilets, either at home or at their place of work.³⁶ No data were available for towns with serviced conservancy tanks which, as with buckets, are collected and discharged at the nearest treatment works. With the inclusion of large worker compounds such as mines, railway and bus stations, it is estimated here that 32 million people (62% of population) made daily use of flush sanitation. This equates to 70 400 kg of phosphorus entering the wastewater treatment system each day.³⁷

This paper argues that eutrophication constitutes a ‘probable and significant environmental harm’ that poses a substantial and burgeoning threat to water security

³² NWRS (2013) (n3).

³³ NWRS (2013) (n3) Table 3.

³⁴ NWRS (2013) s4.1.1.4 at19 (n3).

³⁵ Census 2011 Statistical Release – P0301.4/Statistics South Africa, Pretoria. Table 3.1. (copy on file with author).

³⁶ User Information Services (Statistics South Africa) spreadsheet data provided by email response to query, received on 27 June 2016. (copy on file with author).

³⁷ Human adults produce ~2.2 g phosphorus per day (Table .1.1 in Emsley J (2000) *The Shocking History of Phosphorus*. MacMillan, London.

in South Africa. I show that, as opposed to addressing the clearly evident problem, it has been downplayed and avoided. An article published by the South African Institute of Race Relations implicates the State as the main polluter of surface waters (emphasis added):

‘A recent survey by AfriForum, using data obtained under the Promotion of Access to Information Act (PAIA) of 2000, reveals a startling set of facts. Wastewater service delivery is provided by 152 Water Service Authorities via an infrastructure network comprising 824 collector and treatment systems. Collectively, according to the *Green Drop* reports compiled by the department to monitor the effectiveness of wastewater treatment, these 824 plants receive 4 901 million litres per day (Ml/d) of sewage flows. What AfriForum’s analysis now shows is that, of this total daily flow, only 1 259 Ml/d (26%) is treated to satisfactory standards before being discharged back into rivers. The remainder – a staggering 3 642 Ml/d – is returned to the country’s rivers as *partially treated or untreated sewage*. *This makes the State the single largest polluter of water in the country*.³⁸

Centrally, I show that, despite an apparent stated intention to adopt a load-based approach to pollutant management, as opposed to the use of uniform standards, such an approach has yet to be implemented – even at a pilot scale.³⁹

3. RESEARCH QUESTIONS

The purpose of this dissertation is the following: To show that (i) eutrophication as a result of nutrients in wastewater effluents constitutes pollution that is regarded as an environmental harm; (ii) that in all but the simplest cases, the effective regulation of eutrophication requires the catchment level identification of all sources of nutrients, particularly phosphorus, on the basis of volumetric loads; (iii) that a need for a load-based approach has been identified in South Africa but has yet to be implemented and (iv) that there exists a legally-established pollutant load allocation approach that can be readily adapted for use in South Africa.

In order to address the foregoing the following research questions were formulated:

Core question: How can existing South African water resource regulation be augmented to prevent or mitigate the wastewater-driven eutrophication of reservoirs?

³⁸ Turton A (2015) ‘Sitting on the Horns of a Dilemma: Water as a Strategic Resource in South Africa.’ South African Institute of Race Relations. 6 @*Liberty* at 11. This volume would contain approximately 40 000 kg of phosphorus per day.

³⁹ A central aspect of a proposed water quality management strategy focusses on wasteload allocations (ie. a wasteload reduction approach). See Department of Water Affairs and Forestry Guideline to the Water Quality Management Component of a Catchment Management Strategy. Water Quality Management Series (Sub-series MS 8.2) (2003). Edition 1; See also Van Der Merwe (1991) (n27).

I address this by means of examining a subset of questions, as follows:

(i) What is eutrophication and what status does it have as a global risk to society?⁴⁰

(ii) Can eutrophication be defined as an environmental ‘harm’? What examples from exist in foreign legislation/policy/case law to regulate eutrophication?⁴¹

(iii) What is the comparative history and contemporary status of reservoir eutrophication in South Africa?⁴²

(iv) What are the strengths and weaknesses of the application of existing Command and Control mechanisms (*de minimus* standards, Resource Quality Objectives) to govern eutrophication in South Africa?⁴³

(v) Proposed solution: What benefits would a catchment-based, waterbody-specific scheme of wasteload allocations provide to govern eutrophication arising from existing, conventionally-reticulated sanitation in SA?⁴⁴

4. RATIONALE

Despite an equivalent awareness of the genesis of the threats posed by eutrophication on a global scale, exacerbated by being an arid, water-scarce country, this paper shows that South Africa lags significantly in terms of implementing legislation aimed at attenuating the impacts. The seriousness of this situation is aggravated by the roll-out of flush sanitation to communities formerly disadvantaged by the social injustices

⁴⁰ While the focus here will be on reservoirs, I make mention of rivers and the marine environment and address the equivalence of lakes and reservoirs in order to place the ecosystem nature of reservoirs in perspective. The concept of risk is seen as a boundary concept interfacing sustainable development with precaution.

⁴¹ Here I address the issues of contamination, contaminants, pollutants and pollution in consideration of nutrients as non-conventional ‘pollutants’ that may impart a negative impact on water resources.

⁴² Here I highlight the warnings raised at the birth of South African limnology as the post WWII pollution discontinuity became apparent.

⁴³ I address the limitations to effective eutrophication governance posed by the dual limitations of cooperative governance and local-level responsibility for wastewater treatment.

⁴⁴ Herein I set out the multiple benefits that would accrue from the top-down establishment of a catchment-focused wasteload allocation approach. This is not the only option, it is arguably and simply the best option for existing reticulation to wastewater treatment works. Delinking sanitation from water should be a key focus of new developments and progressively for extant conurbations.

of apartheid. While there is a clear and urgent need to provide sanitation, the progressive expansion of sewage reticulation to poorly-performing wastewater treatment plants (WWTPs) simply exacerbates an existing problem. The net outcome of this process is that increasing quantities of inadequately-treated wastewater are discharged to surface waters, in most cases those very waters (reservoirs) which constitute the source of raw potable water for a significant portion of the population.

To place the relevance of the eutrophication problem in context, it is necessary to examine the following aspects: First that eutrophication is a serious, globally-recognised problem; secondly that wastewater-derived nutrients are equivalent to pollutants and can cause environmental harm; third, that the regulation of such nutrients has been embodied from science into law in international policy and statutes and fifth that case law examples reflect the seriousness with which transgressions of wastewater discharge regulations are regarded by the courts. In so doing, the absence of an equivalent regard for eutrophication in South African water resource regulation becomes apparent.

5. METHODOLOGY

South Africa's Constitution affords the country with a quasi-federal system of governance,⁴⁵ comprising three spheres of government (national, provincial and local) with residual powers retained by the central government. This 'triple government system'⁴⁶ encompasses a range of constitutionally-specified concurrent and exclusive powers integrated by co-operative governance.⁴⁷ Accordingly, to place the South African situation in perspective, I examine the approach taken to eutrophication by three, flush-sanitation dependent, federal systems: the United States of America, Switzerland and the European Union (EU) which, while not a federation, is federal in its mode of operation.⁴⁸ Switzerland has the longest experience with eutrophication, while the United States (US) has the longest continuous experience with water quality

⁴⁵ Devenish GE (2006) 'Federalism revisited: The South African paradigm'. 17 *Stellenbosch Law Review* 129.

⁴⁶ Devenish (n45) at 129.

⁴⁷ The South African Constitution (1996) sets out concurrent national and provincial powers in Schedule 4 and exclusive provincial competencies in Schedule 5.

⁴⁸ My comparison with these federal systems is based solely on the manner in which they have addressed the management of wastewater effluents originating from flush sanitation. While I make no comparisons on the basis of the economic differences between the various systems and South Africa, it is my opinion that if South Africa wishes to provide the majority of its citizens with flush sanitation, it should equally ensure that the effluents deriving therefrom do not threaten the environment.

legislation and possesses of a comprehensive and integrated system of federal and state regulatory controls. The latter regimes, as well as that of the EU, demonstrate a high level of the centralization of water quality regulation. All three have shown that increased centralization of policy making renders environmental governance more rigorous.⁴⁹

This dissertation is based on a desktop review of (i) examples from the wastewater-directed policy, legislation and case law from the aforementioned countries; (ii) a description of the equivalent situation in South Africa; (iii) the introduction of an assessment and regulation-supporting tool⁵⁰ that meets previously-identified wastewater regulation needs and (iv) the setting out of recommendations necessary to give effect to the implementation of the recommended approach in South Africa.

Structure of this dissertation

Following this introduction (Chapter 1), this paper sets out in Chapter 2 what eutrophication is and that wastewater-driven eutrophication (nutrient enrichment) is a significant problem of global concern. Through the lens of comparative legislation and case law examples nutrient pollution is considered as an environmental harm that is punitively sanctioned by the courts. In Chapter shows that, while South Africa has an awareness and understanding of the eutrophication threat to water resources that is temporally equivalent or pre-dates that of the developed world, there is no policy that underpins providing legislative effect thereto. Although acknowledged by the NWRS, there are both historical legacy and contemporary skill and capacity issues that place attendance to the problem of eutrophication in problematical abeyance. Chapter 4 deals with the management of eutrophication as a four-stage process. First those water resources exceeding a specific eutrophication threshold are identified and listed. Secondly, all sources of the nutrients fueling this condition are identified in an accounting process. Third, the reduction in aggregate load of nutrients to the specific waterbody is apportioned amongst all the contributors in the watershed. Fourth, each discharge is licensed and monitored. This process treats all polluters fairly, equitably and transparently, underpinning the application of the Polluter Pays principle in the

⁴⁹ Weibust I (2009) *Green leviathan: the case for a federal role in environmental policy*. Ashgate Publishing Limited, London. At 1.

⁵⁰ This tool has already been successfully tested in two catchments in South Africa (see Chapter 5).

allocation of wastewater discharge licenses and allowing for trading of excess discharge capacity between polluters. A tool which provides a rigorous framework incorporating all of the aforementioned stages is recommended. This tool dovetails with extant requirements for the South African Waste Discharge Charge System, mandates a catchment-wide approach, disassembles the dichotomy of point- and non-point source pollution and provides a template against which the requisite skills can be developed. Lastly, conclusions and suggested recommendations for a way forward are posited.

CHAPTER 2: EUTROPHICATION IN A GLOBAL CONTEXT

1. INTRODUCTION

The phenomenon of anthropogenic (aka ‘cultural’) eutrophication has been recognised for almost a century, with the impact of nutrients on lakes and reservoirs underpinning a substantial part of the aquatic science investigations of these waters ever since.⁵¹ Part 2 provides an overview of the genesis of the understanding as to how anthropogenic activities have accelerated the eutrophication process, in particular the contribution of sewage (wastewater) effluents thereto and the threats it poses to the ecosystem health of freshwater resources and sustainable socio-economic development. Part 3 considers nutrients as pollutants while Part 4 provides a consideration of eutrophication as an environmental harm. Part 5 examines how eutrophication governance has been statutorily regulated in the United States and the European Union.

2. THE GENESIS OF ANTHROPOGENIC EUTROPHICATION AWARENESS

(a) Population growth and wastewater production

Limnological science has a well-developed and long-standing association with the disposal of wastewater effluents to surface waters.⁵² Wastewater generation is a function of population growth and, in eutrophication terms, a function of how many people are connected to water resources via sewerage reticulation, the latter ultimately discharging its effluent to rivers, lakes or the sea.⁵³ The first widespread indications of the effects of excessive nutrient loading on lakes and reservoirs became apparent in the development years post-WWII,⁵⁴ when a marked upward discontinuity was observed in nutrient levels in wastewater effluents. A generally increasing frequency of nuisance algal blooms was noted circa 1960⁵⁵ — for example in Lake Washington (Seattle USA) — coincident with increased sewerage reticulation and the use of

⁵¹ Reynolds CS (1992) ‘Eutrophication and the management of planktonic algae: what Vollenweider couldn’t tell us’. In: *Eutrophication: Research and Application to Water Supply* (Sutcliffe DW and JG Jones, Eds). Freshwater Biological Association, Ambleside, UK.

⁵² Edmonson WT (1994) ‘What is limnology?’ In: *Limnology Now: A Paradigm of Planetary Problems* (Margalef R, Ed). Elsevier Press. At 547.

⁵³ Vallentyne JR (1994) ‘Not politics, but ecology’. In: *Limnology Now: A Paradigm of Planetary Problems* (Margalef R, Ed). Elsevier Press. At 529.

⁵⁴ Prepas EE and T Charette (2003) ‘Worldwide eutrophication of water bodies: Causes, concerns, controls’. Chapter 9.08 in *Treatise on Geochemistry* Volume 9. Elsevier Publishing. 311-331.

⁵⁵ Ashton PJ and JA Thornton (1988) ‘Long-term data series in reservoir limnology: Problems of scale’. In: *Long-term data series relating to southern Africa’s renewable natural resources* (SANSP Report 157). At 153.

phosphate-based detergents.⁵⁶ Much earlier cases of lake eutrophication were also documented, for example the impacts of sewage on Lake Zurich in 1898⁵⁷, in 1878 at Lake Alexandrina⁵⁸ — the first documented case of animal deaths from algal toxins⁵⁹ — in Australia and Lake Washington (Seattle USA) at the turn of the 20th Century.⁶⁰

Transboundary eutrophication impacts in border lakes (eg. the Laurentian Great Lakes of North America, as well as in lakes Geneva and Constance in Switzerland), prompted the need for international efforts to address the problems.⁶¹ By the mid-1960s the USA already had an established National Eutrophication Research Program.⁶²

With respect to the dry regions of the globe, observations emanating from countries such as Spain and Australia highlighted how:

‘[I]ncreased human pressures on water resources in many semi-arid, if not arid and hyper-arid regions, [have] led to severe, mostly irreparable and certainly deleterious changes to the natural character of a large number of water-bodies in dry areas... [which] will likely be further exacerbated by climatic warming and land degradation.’⁶³

It is nowadays trite to state that the underlying cause of most anthropogenic problems is a function of population growth and technology, yet population growth —

⁵⁶ ‘Eutrophication: the environmental consequences of over-fertilization’. Chapter 11 in Smol JP *Pollution of Lakes and Rivers. A Paleoenvironmental Perspective* (Matthews JA, Bradley RS, Roberts N and MAJ Williams, Eds) (2002) Arnold Publishers.

⁵⁷ Edmonson WT (1994) (n52) at 551; The impacts of wastewater pollution prompted federal involvement to overrule cantonal fragmentation in Switzerland, resulting in significant reversal of eutrophication impacts by the 1990s (Weiburst I, 2009. *Green Leviathan: The Case for a Federal Role in Environmental Policy*. Ashgate Publishing. At 96.

⁵⁸ Francis G (1878) ‘Poisonous Australian lake’. 18 *Nature* 377.

⁵⁹ The most common and well-known symptom of eutrophication is the formation of blooms of Cyanobacteria (=blue-green algae). Cyanobacteria produce a range of potent biological toxins that can be lethal for both humans and animals.

⁶⁰ Lehman JT (1986) Control of Eutrophication in Lake Washington. Chapter 20 in *Ecological Knowledge and Environmental Problem-Solving: Concepts and Case Studies*. National Academies Press, Washington D.C.

⁶¹ Edmonson WT (1994) (n52) at 551. Lake Erie Ecosystem Priority (LEEP) (2013) ‘Recommendations to Reduce Nutrient Loadings and Harmful Algal Blooms’. Draft Summary Report. International Joint Commission (Canada and United States). www.ijc.org accessed on 12 May 2016. At ii. The Commission is an independent binational organization created under the *Boundary Waters Treaty of 1909*. Bartsch AF (1968) ‘Eutrophication is beginning in Lake Michigan’. *Journal of Water and Wastes Engineering*. At 84.

⁶² Bartsch AF (1968) (n61). Dr Bartsch headed the NERP within the Federal Water Pollution Control Administration.

⁶³ Comin FA and WD Williams (1994) ‘Parched continents: Our common future?’ In: *Limnology Now: A Paradigm of Planetary Problems* (Margalef R, Ed). Elsevier Press. At 473.

‘... a forbidden topic’ at the 1992 UNCED, remains a taboo within the realm of sustainable development discussions, especially in the case of developing countries.⁶⁴

If the impacts of population growth on planetary resources are to be mitigated, then human behavior — in this analysis how sewage is treated and the effluents disposed of — will need to change. A lack of will to address eutrophication issues has arguably impacted irreversibly on many water resources.⁶⁵ In recent times the urbanisation of previously rural populations has been a factor underlying the need for more sewage treatment systems, simultaneously the cause of an increased nutrient-rich discharge to surface waters.

(b) Global awareness

A global awareness of the need to attenuate the deleterious impacts of water resource pollution is evident from the many water resource directed control policies developed during the 1960s and 1970s.⁶⁶ Central to this awareness was that sewage effluents imparted a profound and negative impact on rivers and lakes.⁶⁷ In the USA, connections to wastewater treatment plants during the six years following 1928 exceeded that for the antecedent quarter century. By 1970 more than ninety per cent of the population was connected to sewage reticulation.⁶⁸ A comparable realisation took place in Switzerland during the last quarter of the 19th Century, leading to what has become the most comprehensive and federally-directed wastewater management strategy in the world.⁶⁹

Despite the roll-out of flush sanitation, pollution problems continued to worsen in the USA and in Europe throughout the 1970s and 1980s,⁷⁰ initiating the Organisation for Economic Cooperation and Development’s (OECD) multi-year study on eutrophication, a project integrating findings from eighteen countries.⁷¹ These demonstrated the association with nutrients, particularly phosphorus, contained in wastewater effluents. The study concluded:

⁶⁴ Vallentyne JR (1994) (n53) at 540.

⁶⁵ Björk S (1994) Chapter 1 ‘Overview’: In: *Restoration of Lake Ecosystems: a holistic approach*. IWRB Publication 32.

⁶⁶ Weale A (1992) (n12). Table 1.2.

⁶⁷ Weibust I (2009) (n49) At 68.

⁶⁸ Weibust I (2009) (n49) at 65 and Figure 5.2.

⁶⁹ Weibust I (2009) (n49) at 94 & 97.

⁷⁰ Weale A (1992) (n49) at 25.

⁷¹ OECD (1982) *Eutrophication of Waters. Monitoring Assessment and Control*. OECD Paris. 154pp. South Africa has observer status at the OECD and participates in various OECD activities (see South Africa and the OECD at www.oecd.org).

‘Man-made accelerated eutrophication of inland waters in OECD Member countries can generally be viewed as an undesirable degradation of the environment resulting in a deterioration of water quality which interferes with most of the most of the beneficial uses of waters; it is causing, in some cases, significant economic losses...’⁷²

The worldwide degradation of water resources by eutrophication is now an incontestable outcome of man’s activities, with both land-based and atmospheric sources of nutrient loadings to surface waters.⁷³ This has been aptly described as ‘a devastating result of humanity’s often callous indifference towards the environment, coupled with its failure to understand and accurately predict the cumulative impact of individual choices’.⁷⁴

3. ARE NUTRIENTS POLLUTANTS?

Central to a consideration of eutrophication as an environmental harm is the need to consider nutrients as pollutants. Firstly, while nutrients in themselves are not pollutants *sensu strictu*, it has long been established that nutrient loadings in excess of assimilable capacity result in a variety of negative impacts, ranging from loss of beneficial use value to ecosystem degradation. Accordingly, nutrients such as phosphorus need to be regarded as deleterious substances or non-conventional pollutants when present in such excess.

(a) *A note on phosphorus and the ‘limiting nutrient’ concept*

The attenuation of eutrophication focuses on the two primary plant nutrients, nitrogen (N) and phosphorus (P). Long-term experiments have conclusively confirmed that phosphorus is the indisputable eutrophication management element.⁷⁵ While nitrogen in wastewaters is relatively easy to attenuate or transform, phosphorus is not, yet technologies enabling removal to parts per billion levels have been in use for decades.⁷⁶ Importantly, effective P removal may also ensure similar attenuation of other potentially health-threatening or ecosystem-degrading noxious compounds and chemicals contained in sewage effluents. As wastewater effluents contain high

⁷² OECD (1982) (n71) At 9.

⁷³ Abell JM, Özkundakci D, Hamilton DP & JR Jones (2012). ‘Latitudinal variation in nutrient stoichiometry and chlorophyll-nutrient relationships in lakes: a global study’. 181 *Fundamentals of Applied Limnology* 1–14.

⁷⁴ Waznik CJ (2015) ‘The perfect storm for algal blooms in Arizona’. 47 *Ariz. St. L.J.* 1445.

⁷⁵ SR Carpenter ‘Phosphorus control is critical to mitigating eutrophication’ (2008) 105 *PNAS* 11039.

⁷⁶ USEPA ‘Advanced wastewater treatment to achieve low concentration of phosphorus’ (2007) EPA 910-R-07-002, USEPA Region 10, Seattle. (copy on file with author).

concentrations of phosphorus in bioavailable form, attenuation of this element therein is crucial to offset eutrophication.

(b) Eutrophication definition

Arising from the OECD work was the definitive description of eutrophication:

‘Eutrophication is the *nutrient enrichment* of waters which results in the stimulation of an array of symptomatic changes, among which increased production of algae and macrophytes, deterioration of water quality and other symptomatic changes, are found to be undesirable and interfere with water uses.’⁷⁷

(c) Definition of pollution

Per the European Communities directive on dangerous substances discharged into the aquatic environment, pollution is defined as

‘pollution’ means the discharge by man, directly or indirectly, of substances or energy into the aquatic environment, the results of which are such as to cause hazards to human health, harm to living resources and to aquatic ecosystems, damage to amenities or interference with other legitimate uses of water’.⁷⁸

Dangerous substances are described further in Lists I and II of Annex 1.⁷⁹

Section II includes substances ‘which have a deleterious effect on the environment’. Section 3 of List II schedules (emphasis added) ‘*substances which have a deleterious effect on the taste and/or smell of the products for human consumption derived from the aquatic environment and compounds liable to give rise to such substances in water*’. Further, per Section 5, ‘*Inorganic compounds of phosphorus and elemental phosphorus*’.⁸⁰

Certain types of noxious algae produce unpleasant taste and odour compounds that manifest in potable water supplies. As such, phosphorus may be regarded as a substance ‘liable to give rise to such substances in water’ and as such impart a ‘deleterious effect on the environment’. *Ipsa facto* phosphorus may be regarded as a pollutant.

⁷⁷ The negative consequences (environmental harm) of eutrophication are dealt with in Section 4.

⁷⁸ Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the community. At L64/53.

⁷⁹ Directive 2006/11/EC at L64/56.

⁸⁰ Directive 2006/11/EC at L64/56

The Irish wastewater discharge regulations⁸¹ define a pollutant as ‘any substance liable to cause pollution’ and appends a schedule of such substances. In the latter, ‘substances which contribute to eutrophication’ specifically lists phosphates⁸².

As a final example, the US National Pollutant Discharge Elimination System (NDPES), which regulates sewage treatment, lists three types of regulated pollutants, conventional (human wastes and grey water), toxic (organics and metals) and nonconventional (nitrogen and phosphorus).⁸³

(d) Lakes and reservoirs

Lakes are natural waterbodies whereas reservoirs are man-made lakes. The responses of both lakes and reservoirs to eutrophication are very similar but reservoirs often tend to be more prone to nutrient enrichment than lakes, for the following reasons: (i) reservoirs generally have larger catchment areas (ie. a greater area for the generation of nutrients) and (ii) they typically have impoverished floral and faunal biota⁸⁴ and (iii) an associated lower assimilable capacity for nutrients.⁸⁵ In arid countries, such as South Africa, wastewater effluent return flows may comprise a substantial portion of the annual inflow to a reservoir. In summary, reservoirs may generally be expected to be more prone to eutrophication than lakes and be more challenging from a management perspective than their natural lake counterparts.

(e) Critical loads and assimilative capacity

The adage ‘the straw that broke the camels’ back’ describes in simplistic terms the assimilative capacity response of aquatic ecosystems to pollutant loading. In simple terms, waterbodies can assimilate some nutrients without exceeding any loading⁸⁶

⁸¹ Waste Water Discharge (Authorisation) Regulations S.I. No 684 of 2007. Government Publications Office, Dublin.

⁸² Schedule 1(11) (n78 at 41).

⁸³ USEPA NDPES Permit Writers Manual EPA-833-K-10-001 (September 2010) at 1-6.

⁸⁴ Whereas natural lakes have a range of biota that have evolved to live in such environments, reservoirs, being interruptions of rivers, are populated by riverine species. Riverine fish, for example, are not adapted to feed on algae and zooplankton, hence no natural biological controls that are present in lakes occur in reservoirs. Additionally, water level drawdowns in reservoirs usually preclude the development of submerged, littoral vegetation communities.

⁸⁵ *The Control of Eutrophication of Lakes and Reservoirs* (Ryding S-O and W Rast, Eds) (1989). Man and the Biosphere Series Volume 1. Parthenon Publishing, Paris.

⁸⁶ Loads for any pollution are the product of concentration and volume (concentration x volume).

thresholds beyond which the biophysical character of the ecosystem is altered and significant environmental alteration may occur.⁸⁷

What the metaphor fails to communicate is that the assimilative capacity response is first waterbody specific and second seldom solely measured in terms of nutrient quantity. The ecosystem response is the outcome of a multiplicity of physicochemical and biological interactions and pathways. To focus solely on a particular nutrient in the absence an understanding of these underlying pathways could bring about no effect or create yet another problem. A simple example could be that by reducing the availability of one nutrient could trigger an advantage for another problem organism to proliferate. This has been aptly encapsulated in:

‘...the ecosystem of interest... has fuzzy boundaries, billions of interacting parts, and constantly changing elements. We understand neither the camel nor the straw fully, yet we must make the most informed decisions we can, given what we do know.’⁸⁸

Insofar as water resource management and eutrophication are concerned, limnological science has clearly established the relationships between excess nutrients and water quality/ecosystem impairment. If specific thresholds are not exceeded, the resource can be maintained in a desired state. The general rule, therefore, is that eutrophication can be managed to a large degree via an appropriate removal of nutrients from wastewater effluents prior to their discharge into the environment.

Beyond a specific threshold, however, ecosystem alteration occurs and, in general terms, a progressively less diverse ‘coarser’ mix of biota tend to predominate.

The critical load approach is utilized for both air and water pollution and fundamentally underpins the sustainable utilization of these media.⁸⁹ Importantly, whereas toxicity is commonly measured in terms of exposure to a particular concentration of a pollutant,⁹⁰ the potential to exceed the assimilable capacity of a nutrient in a particular waterbody cannot be determined solely on the basis of

⁸⁷ eg. Hoesper SH (1998) ‘Stable states, buffers and switches: an ecosystem approach to the restoration and management of shallow lakes in the Netherlands’. 37 *Water Science and Technology*. 151-164.

⁸⁸ Kelly RP, Erickson AL and LA Mease (2014) ‘How not to fall off a cliff, or, using tipping points to improve environmental management’. 41 *Ecology Law Quarterly* 843-884.

⁸⁹ Bodansky D (2010) *The Art and Craft of International Environmental Law*. Harvard University Press, London.

⁹⁰ Exposure to toxicity thresholds encompasses an element of time.

concentration of pollutant, but rather by the mass of that element introduced into the system during a given period (volumetric load).⁹¹

4. EUTROPHICATION AS AN ENVIRONMENTAL HARM

Harm is a necessary precursor to state intervention. Pollution can amount to a breach of law by (a) failure to comply with a statutory regulation or (b) when someone's common law rights are breached.⁹² If we consider eutrophication to be an activity that contributes to environmental degradation, then it needs to be regulated if ecological sustainability is to be achieved.

(a). *Harm and environmental harm*

A typical definition of harm would be:

‘[H]arm . . . is the detriment or loss to a person which occurs by virtue of, or as a result of, some alteration or change in his person, or in physical things, and also the detriment resulting to him from acts or conditions which impair his physical, emotional, or aesthetic well-being, his pecuniary advantage, his intangible rights, his reputation, or his other legally recognized interests’.⁹³

As such, harm to the environment can be accessed either directly via specifically-drafted legislation or, alternatively, via the intersection with human and socio-economic rights.

An objective definition of environmental harm is somewhat elusive. Environmental harm may generally be defined as ‘any impact on the environment as a result of human activity that has the effect of degrading the environment, whether temporarily or permanently’. A more comprehensive definition that has particular relevance for considerations of eutrophication (as discussed hereunder) is contained in the South Australian Environment Protection Act (emphasis added):

Environmental harm⁹⁴

(1) ... "environmental harm" is *any harm*, or potential harm, to the environment (of whatever degree or duration) and includes—

(a) *an environmental nuisance*; and

(b) anything declared by regulation ... or by an environment protection policy to be environmental harm.

(2) ... "potential harm" *includes risk of harm and future harm*.

⁹¹ The hydrological year and/or spring/summer growing season are common denominators related to nutrient loading.

⁹² Lin AC (2006) ‘The unifying role of harm in environmental law’. *Wisconsin Law Review*. At 898.

⁹³ Restatement (Second) of Torts § 7 (1965) cited in Lin (n92) at 928.

⁹⁴ South Australian Environment Protection Act (1993) Section 5.

(3) ... the following provisions are to be applied in determining whether environmental harm is "material environmental harm" or "serious environmental harm":

- (a) environmental harm is to be treated as *material environmental harm* if—
 - (i) it consists of an environmental nuisance of a high impact or on a wide scale; or
 - (ii) *it involves actual or potential harm to the health or safety of human beings that is not trivial*, or other actual or potential environmental harm (not being merely an environmental nuisance) that is not trivial; or
 - (iii)
- (b) environmental harm is to be treated as *serious environmental harm* if—
 - (i) it involves *actual or potential harm to the health or safety of human beings that is of a high impact or on a wide scale*, or other actual or potential environmental harm (not being merely an environmental nuisance) that is of a high impact or on a wide scale; or
 - (ii)

(4)

(5) For the purposes of this Act, *environmental harm is caused by pollution*—

- (a) whether the harm is a *direct or indirect result* of the pollution; and
- (b) whether the harm results from the pollution alone or from the *combined effects of the pollution and other factors*.

An examination of each of the elements of the foregoing definition of environmental harm, in relation to eutrophication, reveals the following: Firstly, if we consider the fact that uncontrolled nutrient enrichment of a particular waterbody will predictably alter the nature of the ecosystem, resulting *inter alia* in reduced water quality, fish kills due to hypoxia and the possibility of toxic algal blooms that threaten human and animal health, then eutrophication as a process clearly equates with harm and/or potential future harm.

(b) Future or potential harm

With respect to future potential harm, it is clear that the understanding of eutrophication is such that the outcome of unmanaged nutrient loading to a specific waterbody may be reliably predicted. In this regard, case law from the USA provides an example where a claim can be predicated on the deemed outcome of a particular

activity. In *Center for Biological Diversity v USEPA*⁹⁵ the court noted that (own emphasis):

‘Rather, “an increased risk of harm can itself by injury in fact for standing.” “ ‘ A plaintiff need not wait until his lake becomes barren and sterile or assumes an unpleasant color and smell before he can invoke the protections of the Clean Water Act.’ ” ‘Therefore, an individual can establish ‘injury in fact’ by “*showing a connection to the area of concern sufficient to make credible the contention that the person’s future life will be less enjoyable — that he or she really has or will suffer in his or her degree of aesthetic or recreational satisfaction— if the area in question remains or becomes environmentally degraded.*”

Secondly, eutrophication spans the full range of material to serious environmental harm. Harmful algal blooms maybe of a sporadic, seasonal nature (material harm) or be a permanent annual feature (serious harm). Thirdly, with respect to the cause, the nature of eutrophication lies with both 5(a) and (b) above in that eutrophication is the direct result of the pollution (5a) and may be aggravated by other factors such as climate or the overall level of degradation of the particular environment—eg. imparting a reduced assimilable capacity (5b).

Finally, anthropogenic disturbances such as the continuous discharge of wastewater effluents, will progressively and predictably overwhelm the natural resilience of the receiving waterbody, bringing about a material change in ecological condition — in this progression to a higher trophic state.⁹⁶

In *City of Owatonna*⁹⁷ the plaintiff argued that the local authority was not ‘removing phosphorus [from wastewater effluents] to the fullest practicable extent’ as required by the Minnesota Phosphorus Rule. The underlying reason for this claim was that ‘[p]hosphorus is an important measure of water quality of a lake or reservoir because excessive phosphorus results in adverse changes in water quality’.⁹⁸ In *City of Tulsa v Tyson Foods*, it was claimed that the City’s water supply was

‘adversely affected by an increase in nutrients—specifically phosphorus, which... resulted in excessive algal growth...causing taste and odor problems...and that the plaintiffs have incurred and will continue to incur substantial treatment costs and other damages... The process by which the water quality is affected through the increase of nutrients is commonly known as “eutrophication” ’.⁹⁹

⁹⁵ 90 F.Supp.3d 1177

⁹⁶ Angelo MJ (2009) ‘Stumbling towards success: A story of adaptive law and ecological resilience’.

⁸⁷ *Neb. L. Rev.* 950. At 8.

⁹⁷ 672 N.W.2d at 923.

⁹⁸ *City of Owatonna* (n97) at 924.

⁹⁹ 258 F.Supp.2s 1263 (N.D.Okla.2003) at 1271.

The *Tyson Foods* case is particularly novel in that the claim was partially made in terms of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA).¹⁰⁰ This claim was founded on the fact that the CERCLA lists phosphorus as a hazardous substance ('toxic pollutant') for which releases of specified reportable quantities are regulated.¹⁰¹ This case attracted analysis by various authors¹⁰², none of whom addressed the fact that while elemental phosphorus is a dangerous, flammable and toxic compound that does not occur freely in nature, it is unlikely that the drafters of CERCLA had sewage effluents in mind when they included phosphorus. Had this been their intention then the USA would have had substantial and positive grounds for controlling eutrophication caused by any form of phosphorus release. The defendants in the case argued along the aforementioned lines. However, the court in *Tyson* found that 'phosphorus contained in poultry litter in the form of a phosphate is a hazardous substance under CERCLA'.¹⁰³ The ruling was, however, vacated in the light of a settlement agreement.¹⁰⁴ The finding does not appear to have been analysed further as to its rather profound implications for eutrophication management.

In *Fertilizer Institute v Browner* ('*Phosphoric Acid*')¹⁰⁵ the USEPA was challenged for its listing of phosphoric acid as a contributor to eutrophication, on the grounds that it was an 'indirect' contributor. In this case the court held that (emphasis added):

'Phosphoric acid is a source of phosphorus, which when combined with sunlight and nitrogen in aquatic systems, causes eutrophication, a process of rapid algae growth that quickly depletes the oxygen content in fresh water sources, *leading to significant harm to aquatic ecosystems*, most dramatically fish kills." While this process generates *significant, adverse environmental effects*, the D.C. district court found that these effects were not due to an "inherent" property of phosphoric acid, since lack of sunlight, lack of nitrogen or even turbid waters could prevent eutrophication'.¹⁰⁶

¹⁰⁰ CERCLA (1980) 42 USC 9601-9675

¹⁰¹ CERCLA List of Lists USEPA 550-B-15-001 (March 2015) at 31.

¹⁰² Warren DM (2003) *City of Tulsa v Tyson Foods: CERCLA Comes to the farm—but did arranger liability come with it?* 59 *Arkansas Law Review*; Jackson WJ and WC Petit (undated) *The authority of co-trustees under CERCLAs natural resource damages regime (another look at Coeur d' Alene and Tyson Foods)*. Jackson Gilmour & Dobbs PC, Houston, Texas. www.jgdpc.com

¹⁰³ 258 F.Supp.2s 1263 (N.D.Okla.2003) at 1285.

¹⁰⁴ Copeland C (2011) *Animal waste and hazardous substances: Current laws and legislative issues*. Congressional Research Service RL33691. www.crs.gov.

¹⁰⁵ *Fertilizer Institute v Browner* 1999 WL 33521297 cited in Desai NR (2006) *American Chemistry Council v Johnson: Community right to know, what about what?: D.C. Circuit takes restrictive view of EPCRA*. 33 *Ecology Law Quarterly* 583-612.

¹⁰⁶ *Fertilizer Institute v Browner* (n105) at 591.

Eutrophication reduces ecosystem resilience. From the perspective of ecological sustainability, research has also shown that eutrophication accelerates the loss of carbon from aquatic ecosystems. Such loss via carbon dioxide release can exceed carbon gains, resulting in a progressive weakening of the ecosystem.¹⁰⁷ This is arguably equivalent to long-term environmental harm, akin to the impacts of withholding essential minerals from a human or animal diet.

(c) Harmful algal blooms

Excessive growth or aggregations of algae in response to nutrient enrichment have become known as Harmful Algal Blooms (HABs). The scientific consensus of cause and effect adopted, *inter alia*, the following statements:¹⁰⁸

- a) Degraded water quality from increased nutrient pollution promotes the development and persistence of many HABs and is one of the reasons for their expansion in the U.S. and other nations;
- b) High biomass blooms must have exogenous nutrients to be sustained;
- c) Both chronic and episodic nutrient delivery promote HAB development;
- d) Management of nutrient inputs to the watershed can lead to significant reduction in HABs.

The realization of the negative environmental impacts of HABs in the USA led the Bush Administration to pass a specific Act¹⁰⁹ to enable research and management of HABs in the marine¹¹⁰ and freshwater environments. HABs were categorized as a ‘high priority national issue’, acknowledging that ‘HABs are one of the most scientifically complex and economically damaging issues challenging our ability to safeguard the health of our Nation’s aquatic and marine ecosystems’¹¹¹.

Research conducted under the auspices of the HAB Act noted, *inter alia*, that human illness and/or death associated with toxic algal blooms had occurred in seven

¹⁰⁷ Rosemond AD, Benstead JP and PM Bumpers et al (2015) Experimental nutrient additions accelerate terrestrial carbon loss from stream ecosystems. 247 *Science* 1142-1145.

¹⁰⁸ Heisler J, Gilbert PM and JM Burkholder et al (2008) ‘Eutrophication and harmful algal blooms: A scientific consensus’. 8 *Harmful Algae* 3-13.

¹⁰⁹ Harmful Algal Blooms and Hypoxia Research and Control Act of 1998. 16 U.S.C. 1451 (Amended in 2004).

¹¹⁰ HABs are as big a problem in the marine environment as in freshwaters. While this dissertation addresses freshwater eutrophication, it should be borne in mind that land-based sources of pollution are substantially responsible for pollution of the coastal zone.

¹¹¹ Lopez CB, Jewett EB, Dortch Q, Walton BT and HK Hudnell (2008). ‘Scientific Assessment of Freshwater Harmful Algal Blooms’. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC. Preamble.

countries, including four incidents in the USA between 1931 and 2004.¹¹² Blooms were regarded as ‘one of the most obvious indicators of nutrient over-enrichment’ and that some 35 US States had documented HABs. A large number of Federal and State HAB programs have arisen following the promulgation of the HAB Act.

In 2013 the International Joint Commission for the USA/Canada Great Lakes Water Quality Agreement noted its concern regarding the human health impacts arising from HABs as a consequence of eutrophication, particularly from phosphorus enrichment, in the Great Lakes:

‘A major consequence of this eutrophication and degradation of the Great Lakes ecosystems is the production of massive concentrations of cyanobacteria termed blooms. In Lake Erie these blooms have been recognized since the 1970s. The “harmful” aspect of these blooms, from an environmental context, begins with a loss of water clarity that suppresses aquatic macrophytes, and negatively affects invertebrate and fish habitats. Bacterial decomposition of dying blooms may lead to oxygen depletion (hypoxia and anoxia), and subsequent fish kills. In addition, many cyanoHABs produce toxic secondary metabolites, the cyanotoxins, which can cause serious, acute intoxication in mammals (including humans) affecting the hepatopancreatic, digestive, endocrine, dermal, and nervous systems.’¹¹³

Most recently, the US National Science and Technology Council Subcommittee on Ocean Science and Technology released an HAB action plan and strategy to the US Congress. This report found that:

‘The prevalence and duration of harmful algal blooms (HABs) and hypoxia (low-oxygen conditions) in the marine waters and freshwaters of the United States, including the Great Lakes, are generating public concern. From extended shellfish closures on the West Coast in 2015, to a larger-than-predicted hypoxic zone in the Gulf of Mexico, these events negatively impact resources across thousands of miles of the Nation’s coastal and inland waters, and represent some of the most scientifically complex and economically damaging aquatic issues. HABs and hypoxia pose a significant challenge to the ability to safeguard the health of the Nation’s coastal and freshwater ecosystems.

HABs and hypoxia have serious effects on a community’s social and public health. They may threaten the safety of seafood and drinking water, as well as air quality. HABs and hypoxia events may also result in disruption of subsistence activities, loss of community identity tied to aquatic-resource use, disruption of social and cultural practices, and lost revenue for lakefront and coastal economies that are dependent on aquatic/seafood harvest or tourism’.¹¹⁴

¹¹² Lopez et al (n111) Box 2.1.

¹¹³ Carmichael WW (2013) ‘Human Health Effects from Harmful Algal Blooms: a Synthesis’. Report by the Health Professions Advisory Board (HPAB) to the International Joint Commission, 22 November 2013. (copy on file with author).

¹¹⁴ Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report (2016). Report to Congress produced by the Interagency Working Group on the

(c) *Examples of eutrophication-directed legislation*

Within the limitations of space allowed, this section provides two examples of how policy and legislation have been developed to counter wastewater-driven eutrophication in jurisdictions that are predominantly serviced by sewage reticulation and treatment systems. As such these would transpose well into South African statutes and regulations, as discussed in Chapter 3.

(i) *European Communities Urban Waste Water Treatment Directive*¹¹⁵

The 1991 EC Urban Waste Water Treatment Directive (UWWTD) has been one of the most influential directives emanating from the 1976 Water Framework Directive (WFD).¹¹⁶ One of the objectives of the UWWTD is to ‘prevent the environment from being adversely affected by the disposal of insufficiently-treated urban waste water’ by mandating the secondary treatment¹¹⁷ of wastewater as the *minimum acceptable norm*, while discharge into sensitive areas requires tertiary treatment. Effluents discharged to ‘sensitive areas subject to eutrophication’, insofar as nutrients are concerned, must conform to the specifications set out in Table 2 of Annex 1, which limit the concentration of phosphorus according to the number of people connected to the treatment works as follows:

$$2 \text{ mg per liter P} < 10\,000\text{--}100\,000 \text{ people} > 1 \text{ mg per liter P}$$

This approach equates to a form of *de minimus* standard based on population.¹¹⁸ The *de minimus* approach provides a method of setting basic effluent criteria below which the law of diminishing returns would apply—further treatment enhancement would not result in cost-effective treatment gains or environmental protection.

The UWWTD is significant in that its ambit is wide. In the European Court of Justice decision in *Commission of the European Communities v Republic of France* the following statements indicate the breadth of the intention behind the directive and

Harmful Algal Bloom and Hypoxia Research and Control Act. Executive Summary. (copy on file with author).

¹¹⁵ 1991 Urban Waste Water Treatment Directive 91/271.

¹¹⁶ 1976 Pollution by Hazardous Substances Directive 76/464.

¹¹⁷ 'secondary treatment' means treatment of urban waste water by a process generally involving biological treatment with a secondary settlement or other process in which the requirements established in Table 1 of Annex I are respected (see n118).

¹¹⁸ By comparison, in Northern Ireland, the minimum allowable phosphorus reduction is eighty per cent.

the importance of protecting the environment against pollution by wastewater effluents:

‘The definition of eutrophication in Article 2(11) of that directive must be interpreted in the light of its objective, which goes beyond the mere protection of aquatic ecosystems and attempts to conserve man, fauna, flora, soil, water, air and landscapes from any significant harmful effects of the accelerated growth of algae and higher forms of plant life resulting from discharges of urban waste water.

For there to be eutrophication within the meaning of the directive, there must be a cause and effect relationship between enrichment by nutrients and the accelerated growth of algae and higher forms of plant life on the one hand and, on the other hand, between the accelerated growth and an undesirable disturbance of the balance of organisms present in the water and to the quality of the water concerned. Species changes involving loss of ecosystem biodiversity, nuisances due to the proliferation of opportunistic macroalgae and severe outbreaks of toxic or harmful phytoplankton constitute an undesirable disturbance of the balance of organisms present in the water. As regards deterioration of water quality, that criterion refers not only to deterioration of the quality of the water which produces harmful effects for ecosystems but also deterioration of the colour, appearance, taste or odour of the water or any other change which prevents or limits water uses.’¹¹⁹

(ii) Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement between the USA and Canada commenced in 1972. The agreement has, as a general objective, that the waters of the Great Lakes System should be ‘[f]ree from nutrients directly or indirectly entering the waters as a result of human activity in amounts that create growths of aquatic life that interfere with beneficial uses’.¹²⁰ Annex 1 contains a specific objective for phosphorus,¹²¹ Annex 2 includes eutrophication as a component of beneficial use impairment¹²² and Annex 3 sets out mandatory phosphorus load reduction targets.¹²³ The requirements are stringent in that they aim to maintain the lowest possible level of eutrophication (oligotrophy) in the lake system.

Canada does not have an admirable record of environmental protection, largely attributed to its policy of decentralization of environmental controls.¹²⁴ As such, efforts to institute water pollution control are of a very recent nature. While the

¹¹⁹ *Commission of the European Communities v Finland*. Celex No 607CJo335 [2009]. Paras 16, 19, 23-25.

¹²⁰ Protocol amending the 1978 agreement between the United States of America and Canada on Great Lakes Water Quality, as amended on October 16, 1983. Art III(e).

¹²¹ Phosphorus - The concentration should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use. (Specific phosphorus control requirements are set out in Annex 3.) Annex 1(C)(3). n77.

¹²² Annex 2(1)(c)(viii). n115.

¹²³ Annex 3 plus supplement. n115.

¹²⁴ Weibust (n49) at 120.

national wastewater regulations do not mention phosphorus,¹²⁵ those in Manitoba, for example, cite regulations for phosphorus discharge that came into effect on 1 January 2016.¹²⁶ Phosphorus discharges are currently limited to 1 mg per liter.

The aforementioned examples provide a basis for both first tier (population-based) standards and also ecosystem-specific objectives.

5. KEY CASE LAW EXAMPLES¹²⁷

What follows are some examples of case law which illustrate the seriousness with which courts in other jurisdictions have regard for non-compliance with wastewater discharge regulations:

(a) European Commission

The European Commission (EC) has demonstrated a marked willingness to enforce the UWWTD in various member countries.¹²⁸ In *EC v Portugal*,¹²⁹ the court held that Portugal had not met obligations under a prior judgment to implement wastewater treatment in terms of the UWWTD. Despite substantial progress having been made in the interim, two out of an original twenty-two agglomerations were not yet serviced. On these grounds the court imposed substantial financial penalties, amounting to a lump sum of €3 000 000, as well as a penalty payment of €8 000 per day, retrospective to the date of the 2009 judgment and until compliance was achieved.

In *Commission of the European Communities v Luxembourg*, Luxembourg was ordered to pay a lump sum of €2 000 000 and a fine of €2800 for each day until compliance was achieved. These are penalties of a substantial magnitude and indicate the seriousness with which the European Court of Justice regards wastewater pollution of the aquatic environment. The original Luxembourg action was brought in

¹²⁵ Canadian Wastewater System Effluent Regulations SOR/2012-139. Office of the Minister of Justice. <http://laws-lois.justice.gc.ca>

¹²⁶ Eg. Manitoba Water Quality Standards, Objectives and Guidelines regulation. The Water Protection Act (C.C.S.M.c. W65) Regulation 196/2011. Art 4(2). https://www.gov.mb.ca/waterstewardship/water_quality/quality/pdf/mb_water_quality_standard_final.pdf

¹²⁷ Space available allows only a limited selection of cases.

¹²⁸ Actions under the UWWTD have been prosecuted against Finland, Greece, Ireland, Luxembourg, Portugal, Spain, United Kingdom and Italy.

¹²⁹ EU Case C-557/14 [2014].

2006. In 2011 the EC brought a second action against six treatment plants that were still non-compliant and the daily penalty was extended.¹³⁰

(b) United Kingdom

Some recent environmental cases in England are particularly insightful. In 2014 the UK promulgated new sentencing guidelines for environmental offences.¹³¹ These assist the courts in identifying appropriate levels of culpability and harm for both organisations and individuals, as well as setting out applicable fines that are related to the size of the company being prosecuted. Very large companies are not covered by the guidelines. In the latter case the court is required to derive a fine that will force directors of large organisations to honour their responsibilities towards the environment and, that in order to do so, *finer must be of such a nature to impact in their finances*.¹³²

Two recent sewage discharge cases against Thames Water illustrate the new guidelines. In *R v Thames Water 1*, the utility was fined £250 000.00 for allowing sewage to discharge into a nature reserve.¹³³ Thames Water took the verdict on appeal and lost, with the appeal court opining that the fine should have been much higher.¹³⁴ In *R v Thames Water 2*, a fine of £1 000 000 was levied for repeated discharges of effluent from a sewage treatment works into the Grand Union Canal in Hertfordshire.¹³⁵

These changes to UK environmental law signal a profound change in attitude towards policing environmental crime, one that links culpability and harm in a clear and transparent manner.

(c) United States

Akin to upstream — downstream issues between sovereign states — such as those governed by the Watercourses Convention, so too do similar issues arise between states in the US. In a landmark case between Oklahoma and Arkansas — which

¹³⁰ EU Case C-452/05 [2006].

¹³¹ Environmental Offences: Definitive Guideline. UK Sentencing Council (2014). (copy on file with author).

¹³² *UKEA v Thames Water Utilities Ltd* (unreported) Case note (2016) 5 *Compliance and Risk* 1-2.

¹³³ (2015) (Crim) 960.

¹³⁴ [2015] 1 W.L.R. 4411.

¹³⁵ *UKEA v Thames Water Utilities Ltd* (n132).

predates the Watercourses Convention — the court held that, despite not being explicitly stated in the CWA, ‘[i]n order to ensure that the EPA-approved water quality standards in all states are ‘met’ or ‘implemented’, it is necessary to require dischargers to meet the applicable requirements of other affected states as well as those of the source state.’¹³⁶ Two important findings emerged from this case. Firstly, that the CWA requires upstream point sources of pollution to comply with the federally approved water quality standards of downstream states.¹³⁷ Secondly, that the issuance of discharge permits was not permitted in cases where the pollutant in question was already responsible for existing violations of standards in a downstream state.¹³⁸ The significance of this decision is that it precludes the issuance of discharge permits based on the immediate receiving waterbody alone, ie. it requires a wider appreciation of the conditions pertaining in the entire downstream reach of river, at least insofar as additional impacts of pollution can be demonstrated.

6. SUMMARY

The foregoing illustrates a long standing global awareness of and the institutional response to eutrophication arising from inadequately-treated sewage effluents. It is clear that the nutrients that fuel eutrophication, in particular phosphorus, are considered to be pollutants and that eutrophication clearly ranks as an environmental harm. This understanding has been embodied in policy and legislation at both federal and state levels. In applying the law, the responsible courts have demonstrated a willingness not only to prosecute non-compliance, but also to set punitive fines and penalties.

¹³⁶ Bushong SJ (1992) ‘Upstream pollution and downstream problems: Oklahoma v EPA makes a splash in interstate water pollution disputes’. 63 *U. Colo. L. Rev.* 233.

¹³⁷ *Arkansas v Oklahoma* 111 S.Ct. 1412 (1991) At 634.

¹³⁸ *Arkansas V Oklahoma* (n137) at 634.

CHAPTER 3: EUTROPHICATION IN SOUTH AFRICA

This chapter deals with some specific aspects of South Africa's past understanding of and response to the problem. Secondly, it addresses the extent of South African legislation insofar as this encompasses the eutrophication aspect of water pollution.

1. HISTORICAL PERSPECTIVE

(a) *The South African context*

One of the most oft-quoted opening lines on water issues in South Africa typically reads '...South Africa is a water scarce (or arid) country with severely limited water resources...'. What is not so often mentioned is that wastewater effluent return flows comprise a major component of the country's water budget and that '[e]ffluents, with their accompanying pollutants, are required to be returned to natural waterbodies to be reused'.¹³⁹ Pertinently, the fact that 'unacceptable' non-compliance with the levels of phosphates in South African rivers is currently as high as *eighty-eight per cent*, goes largely unnoticed.¹⁴⁰

By the 1970s it appeared, to all intents and purposes, that South Africa was serious about addressing the dangers that eutrophication posed to its water supplies. A spatially-extensive study of the trophic status of ninety-eight South African reservoirs clearly showed that urban-industrial effluents were nutrient rich and the major cause of eutrophication. Furthermore, that phosphorus attenuation offered a 'long-term' solution to the observed eutrophication problems.¹⁴¹ A somewhat unique inter-governmental agency study¹⁴² on the toxins produced by blue-green algae — the

¹³⁹ Van Der Merwe, W (1991) (n27).

¹⁴⁰ National Water Resources Strategy (2013) Annexure B Understanding Water Resources. Figure 6. This report notes that 'The quality of our water resources, both in terms of water quality, as well as river habitat and bio-diversity, is a major concern. The situation regarding acid mine drainage and municipal wastewater pollution has reached unacceptable levels. In terms of river health, almost 60% of river ecosystem types are threatened, with 25% of these critically endangered. Wetland ecosystem types are of even more concern with a 65% identified as threatened, including a staggering 48% critically endangered. This situation demands drastic intervention'. At 5.

¹⁴¹ Toerien DF, Hyman KL and MJ Bruwer (1975) A preliminary trophic status classification of some South African impoundments 1 *Water SA* 15-23.

¹⁴² Scott WE (1987) Toxins of blue-green algae: A ten-year report. National Institute for Water Research, Council for Scientific and Industrial Research. Pretoria. Copy on file with the author. At (ii). This study was funded by the Department of National Health and Population Development and the National Institute for Water Research, with support from the National Chemical Research Laboratory, the Botany Department of the University of the Orange Free State and the Research Institute for Nutritional Diseases (Medical Research Council).

common symptom of nutrient enrichment, was underway and continued for a decade. This project stated as its motivation that

‘[h]eavy demands on South Africa’s scarcest natural resource, water, have resulted in a deterioration in the quality of the country’s limited water supplies. Increased eutrophication has resulted in increased occurrence of nuisance blooms of algae in many reservoirs serving as a source of potable water’.

This study was of global significance and provided impetus for an allied investigation, an interdisciplinary assessment of eutrophication in South Africa’s notorious Hartbeespoort Dam.¹⁴³ Together these studies attracted the interest of many overseas researchers via a plethora of scientific papers and symposia.¹⁴⁴

The 1970 South African Commission of Enquiry into Water Matters (‘the Commission’) observed that:¹⁴⁵

‘Pollution of the Republic’s rivers, through the discharging of industrial and domestic sewage effluents...has, already, to a greater or lesser degree, detrimentally affected fresh water sources’.

The Commission further found that ‘...up to 70% and sometimes even more of the water abstracted by cities ...appears as polluted effluent’.^{146,147}

Pertinently, the Commission understood the contributing role played by wastewater effluents and that this aspect was ‘currently receiving critical attention overseas’ (and by implication merited equivalent consideration in South Africa).¹⁴⁸ They noted the existence of a general response to wastewater impacts (emphasis added):¹⁴⁹

‘The result has been that since 1948 strict anti-pollution legislation prohibiting disposal of unpurified effluents in rivers and sub-surface waters *has been precipitated practically throughout the world*’.

Furthermore,

¹⁴³ The Limnology of Hartbeespoort Dam (1985). South African National Scientific Programmes Report 110. National Institute for Water Research, Council for Scientific and Industrial Research. Pretoria. www.researchspace.csir.co.za. Downloaded on 29 June 2016.

¹⁴⁴ Harding WR and BR Paxton (2001) (n19).

¹⁴⁵ Report of the South African Commission of Enquiry into Water Matters (1970). Republic of South Africa. R.P. 34/1970 at pg 6 & 19 (copy on file with author).

¹⁴⁶ Commission of Enquiry into Water Matters. (n145) at 33.

¹⁴⁷ The high percentage of water returning as effluent caused the Commission (at pg 66) to recommend that at least 50% of the Republic’s gross water demand be met by reclamation of effluents.

¹⁴⁸ Commission of Enquiry into Water Matters. (n145) at 113.

¹⁴⁹ Commission of Enquiry into Water Matters. (n145) at 115.

‘...control and prevention of pollution forms an integral part of the conservation, supply and utilisation of water, the implementation of any water legislation must obviously be undertaken with the utmost circumspection, and therefore requires as much foresight, planning, research and financial support as the development of new sources of freshwater’.¹⁵⁰

By 1979 the then Department of Water Affairs (now Water and Sanitation) had envisaged that eutrophication would impart an economic cost if left unattended. This study concluded, *inter alia*, that ‘[s]trong indications were found to suggest that large financial impacts are involved which merit urgent accurate assessment’.¹⁵¹

The onset of South Africa’s eutrophication problem was illustrated in a comprehensive assessment of the status of South Africa’s renewable natural resources.¹⁵² With respect to freshwater ecosystems, anthropogenic impacts were, unsurprisingly, regarded as the major force imparting negative change. An increase in phosphorus concentrations attributed to wastewater effluents, by two orders of magnitude, temporally-equivalent to experiences worldwide,¹⁵³ became apparent during the mid-1950s.¹⁵⁴ By the early 1980s the scientific basis for establishing a South African categorization of reservoir trophic levels had been initiated¹⁵⁵ and the relevance of phosphorus-targeting nutrient load-response models for South African reservoirs had been tested.¹⁵⁶ Finally, the value of a systems approach, integrating politico-legal, economic, social and technological consideration, to eutrophication management, as opposed to ‘traditional engineering approaches’ had been examined.¹⁵⁷ The latter work observed that appropriate reclamation of wastewater

¹⁵⁰ Commission of Enquiry into Water Matters. (n145) at 117.

¹⁵¹ Bruwer CA (1979) The economic impact of eutrophication in South Africa. Department of Water Affairs, Hydrological Research Institute. Technical Report TR94. (copy on file with author).

¹⁵² MacDonald IAW and RJM Crawford (eds) (1988) Long-term data series relating to South Africa’s renewable natural resources. Chapter 4 Southern African Inland Water Ecosystems. South African National Scientific Programmes Report 157. National Institute for Water Research, Council for Scientific and Industrial Research. Pretoria. www.researchspace.csir.co.za. Downloaded on 27 June 2016.

¹⁵³ See Chapter 1

¹⁵⁴ Ashton PJ and JA Thornton (1988) Long-term data series in reservoir limnology: Problems of scale. In MacDonald and Crawford (n183) At 154. Also in Thornton JA, Williams WD and S.-O Ryding (1992). Emigration, economics and environmental pollution in southern Africa. *American Water Resources Association. Managing water resources during global change*. At 613. (Copy on file with author).

¹⁵⁵ Walmsley RD (1984) ‘A chlorophyll-a Trophic Status classification system for South African impoundments’. 13 *J. Environ. Qual.* 97-104.

¹⁵⁶ Thornton JA and RD Walmsley (1982) ‘Applicability of phosphorus budget models to southern African man-made lakes’. 89 *Hydrobiologia* 237-245.

¹⁵⁷ Thornton JA and G Boddington (1989) ‘A new look at the old problem of eutrophication management in southern Africa’. 9 *The Environmentalist* 122-129.

effluents arising from major urban settlements was necessary to protect downstream environments.

In 1991, the then Department of Water Affairs and Forestry (DWAF, now the Department of Water and Sanitation, DWS) acknowledged that, in order to give effect to a precautionary approach to protect the nations' water resources, the need existed to avoid or reduce the threats by:¹⁵⁸

‘...gradually and drastically reducing emission levels of all substances introduced by man into the environment, even when there is no scientific proof that existing levels of emissions are causing harm...’.

Additionally, that:¹⁵⁹

‘One of the most important factors [in applying the precautionary approach] is the vital role that the reuse of effluents has to play in balancing water supply and demand in South Africa’.

Despite the clear and evident danger posed by wastewater effluents, the regulation of eutrophication in South African waters has, historically, not received the attention that it should have.¹⁶⁰ During the 1980s, a continued deterioration in water quality led to the adoption of the Receiving Water Quality Objectives (RWQO) approach,¹⁶¹ in addition to the uniform standards that were already in place. Instead of using the RWQO approach to enforce stricter standards (the common application), it was more often than not been applied to exemptions from compliance with the minimum standards.¹⁶²

¹⁵⁸ Van Der Merwe (n27) at 551.

¹⁵⁹ Van Der Merwe (n27) at 553.

¹⁶⁰ Walmsley RD (2000). ‘Perspectives on Eutrophication of Surface Waters: Policy Research Needs in South Africa’. Water Research Commission Report KV129/00; Harding WR (2015) (n6); DWAF (1991) (n23).

¹⁶¹ Per the NWA “resource quality” means the quality of all the aspects of a water resource including–
 (a) the quantity, pattern, timing, water level and assurance of instream flow;
 (b) the water quality, including the physical, chemical and biological characteristics of the water;
 (c) the character and condition of the instream and riparian habitat; and
 (d) the characteristics, condition and distribution of aquatic biota.

RWQO’s (Resource Water Quality Objectives) ‘reflect the water users’ and other stakeholders’ needs with respect to the in-stream or in-aquifer water quality of the catchment over and above those outlined in the NWRS and by the gazetted RQOs... RWQOs must only focus on the priority water quality concerns in the catchment. (n3).

¹⁶² DWAF (1991) (n23).

More recently, widespread and increasing failure to meet fundamental wastewater treatment requirements, particularly with respect to phosphorus,¹⁶³ has significantly exacerbated the threat posed by effluents discharged to South African rivers, streams and reservoirs¹⁶⁴. It has been demonstrated that massive nutrient load reductions, of sixty percent or greater, are now needed to restore a desirable water quality condition in some of South Africa's most important reservoirs.¹⁶⁵ Comprehensive reservoir management is essential for ensuring the integrity of the raw potable supplies from these man-made lakes, as well as the health of their downstream riverine environments.¹⁶⁶ This paper shows that despite reservoirs falling within the NWA definition of watercourses and requiring of obligatory ecosystem classification, this has not yet been undertaken.¹⁶⁷ Additionally, eutrophication generated in South Africa has transboundary implications for rivers shared with neighbouring states¹⁶⁸ and coastal discharge of wastewaters contributes to marine eutrophication.¹⁶⁹

(b) The South African 'phosphorus standard'

The early 1980s saw the promulgation of a 1 milligram per liter phosphorus (1 mg/l P) standard¹⁷⁰ intended for use in 'sensitive' catchments.¹⁷¹ This was,

¹⁶³ Phosphorus has been proven to be the management element of choice in reducing eutrophication of surface waters.

¹⁶⁴ Kleynhans J (2015). Report on a selection of Wastewater Systems in South Africa that are in a critical state and pose a serious health risk to our population, economy and ecology. Afriforum (copy on file with author).

¹⁶⁵ Thornton JA and WR Harding (2009) Pollution control: The Hartbeespoort Dam Example. In: Water Security and Ecosystem Services: The Critical Connection. World Water Assessment Programme. UNEP Ecosystem Management Programme; Harding WR (2008) The Determination of Annual Phosphorus Loading Limits for South African Dams. Water Research Commission Report 1687/1 /08.

¹⁶⁶ e.g. Rosemond et al. (2015) (n107).

¹⁶⁷ Per the South African National Water Act (36 of 1998) 'dams' [should read 'reservoirs' as the term dam commonly refers only to the barrier or wall forming the dam] are defined as follows:

“water resource” includes a watercourse, surface water, estuary or aquifer” and

“watercourse” means ... (c) a wetland, lake or dam into which, or from which, water flows;...”.

Per Chapter 3 of the Act, Section 12 Part 2, ‘The Minister is required to use the classification system established in Part 1 to determine the class and resource quality objectives of all or part of water resources considered to be significant. The purpose of the resource quality objectives is to establish clear goals relating to the quality of the relevant water resources. In determining resource quality objectives a balance must be sought between the need to protect and sustain water resources on the one hand, and the need to develop and use them on the other.

¹⁶⁸ South Africa shares 5 major rivers with neighbouring states.

¹⁶⁹ Approximately 88 wastewater effluent pipelines discharge into the South African coastal zone.

¹⁷⁰ Grobler DC and MJ Silberbauer (1985) Eutrophication control: a look into the future. 11 *Water SA* 69-78.

¹⁷¹ GNR 1567 in GG7159 dd 1 August 1980. Termed the ‘Special Standard for Phosphorus’.

however, not a new development, as many believed it to have been, rather it was an amendment providing a more stringent version of a standard legislated twenty-two years earlier. In 1962 the then Department of Water Affairs promulgated Regional Standards for Industrial Effluents.¹⁷² This was the first rendition of what are still known as the General and Special Standards for ‘...wastewater or effluent, produced by or resulting from the use of water for industrial purposes...’.¹⁷³ The use of the term ‘...for industrial purposes...’ for limits that include sewage wastewater¹⁷⁴ is curious and is further confounded by somewhat tortuous definitions contained in the previous Water Act¹⁷⁵ — but consideration hereof is beyond the scope of this analysis. Importantly, the Notice included a Special Standard limit for phosphorus of 2 mg/ℓ P.¹⁷⁶ The Special Standard was at that time applicable in seventy-three specific catchment areas listed in a Schedule.¹⁷⁷ The inclusion of this standard indicates that the scientific awareness of the role played by phosphorus in eutrophication had been translated into South African law very soon after the general global awareness of the problem.

The reasons behind the introduction of the more stringent 1 mg/ℓ P standard in 1980 is unclear. The change was probably influenced by what was happening globally at a time when the selection of a 1 mg per liter P standard as a counter to sewage-derived eutrophication was already well developed in the USA and Europe (see Chapter 2).¹⁷⁸ It added seven additional river systems to the 1962 schedule. Curiously, the report announcing the introduction of the 1 mg/ℓ P standard makes no mention of the fact that there was already a gazetted 2 mg/ℓ P phosphorus standard in place, nor does it make mention of it ever having been enforced, or why it could not remain as an additional layer to the P standard.¹⁷⁹

¹⁷² GNR 553 in GG217 dd 5 April 1962.

¹⁷³ GNR 553 (n172) Preamble to Special Standard requirements (at 9).

¹⁷⁴ S1.4 of GNR553 (n172) specifies a limit for faecal coliforms, ie. an indicator of wastewater contamination.

¹⁷⁵ Act 54 of 1956.

¹⁷⁶ GNR 553 (n172) Table 1 at 11.

¹⁷⁷ GNR 553 (n172) at 13.

¹⁷⁸ Taylor R, HJ Best and HNS Wiechers (1984) The effluent phosphate standard in perspective. Part 1: Impact, control and management of eutrophication. 10 *IMIESA* at 55.

¹⁷⁹ Grobler DC and MJ Silberbauer (1984) Impact of eutrophication control measures on the trophic status of South African impoundments. Water Research Commission Report 130/1/84. See also Grobler DC and MJ Silberbauer (1985) (n170).

The implementation of the 1 mg/ℓ P standard was expected to bring about substantial reductions in nutrient loading from wastewater treatment works, of the order of 80-90 per cent of an acknowledged 60-80 per cent phosphorus overload into the environment.¹⁸⁰ Its introduction was qualified by the fact that more stringent standards would be needed in some instances. Despite the incorporation of the standard into law (see hereunder) it met with strong resistance from the engineering fraternity regarding its blanket implementation, rather than on a case-specific basis (see hereunder).

It would be remiss not to mention that it was the understanding of some scientists that even the 1 mg/ℓ P standard was too high (emphasis added):

‘The Department of Water Affairs and Forestry takes a decision in 1978 to limit the allowable maximum concentration of phosphorus in treated effluent to one milligramme [sic] per litre, where the effluent is intended for discharge into a designated "sensitive" catchment. This limit is incorporated into the Special Effluent Standard for sensitive catchments and *is intended to minimize the risks of eutrophication in water storage reservoirs. The decision is taken despite clear and unequivocal evidence that effluent phosphorus concentrations need to be far lower, preferably no higher than 0.1 milligramme per litre.* In addition, the decision to implement the one milligramme per litre effluent phosphorus standard has at least one unintended consequence in that it stalls a large body of research conducted by Dr James Barnard and his NIWR¹⁸¹ team who developed the Bardenpho (BARNard DENitrification and PHOSphorus removal)¹⁸² technology to remove phosphorus (and nitrogen) from domestic effluents. James Barnard eventually moves to North America where his Bardenpho process is received with acclaim. Several variants of the Bardenpho process are now used in *virtually every wastewater treatment works in North America.*¹⁸³ Ironically, South Africa is apparently considering importing this technology for local use. A missed opportunity indeed!’¹⁸⁴

The foregoing broadly outlines the situation in time when South Africa was beginning to transition from a unitary, apartheid state to a quasi-federal constitutional democracy. As such it can be argued that all of the necessary tools and information

¹⁸⁰ Grobler and Silberbauer (1984) (n179) at 2; A recent assessment of nutrient loading into the Berg River (Western Province) revealed that the introduction of the 1 mg per liter P standard at two WWTWs would reduce the loadings by 80%. Harding WR (2013) Berg River Water Quality Intervention Study: Identification of retrofit interventions for the attenuation of pollution reaching the Berg River between Franschoek and Wellington. Report to Lyners Consulting Engineers. DH Environmental Consulting Report 617/2013 (copy on file with author).

¹⁸¹ National Institute of Water Research, an institute of the Council for Scientific and Industrial Research (CSIR) prior to the 1988 change from pure research to ‘contract research’.

¹⁸² The *Bardenpho* process produces very low nitrogen and phosphorus effluent concentrations without the use of chemicals.

¹⁸³ The treatment of wastewater to levels of 0.1 mg/ℓ P or less are now commonplace in the USA (see n76).

¹⁸⁴ Ashton P, Roux D & C Breen et al (2012) The freshwater science landscape in South Africa 1900-2010. Water Research Commission Report K8/852. At 31.

were available to the drafters of the new South African Water Act and for eutrophication management to become a focal point thereof. As will become apparent, this has yet to materialise.

2. CONTEMPORARY WATER POLLUTION LEGISLATION IN SOUTH AFRICA

The foundation for water quality protection in South Africa is provided by the Constitution.¹⁸⁵ Section 24(a) provides fundamental and dual solidarity rights to an environment that is not harmful to one's (i) health or (ii) well-being. To place water within the context of this right one has to examine the definition of 'environment' that is contained within the National Environmental Management Act (NEMA).¹⁸⁶ This framework statute acknowledges this fundamental right in its preamble and defines the environment as:

'environment' means the surroundings within which humans exist and that are made up of –

- (i) the land, water and atmosphere of the earth;
- (ii) micro-organisms, plant and animal life;
- (iii) any part or combination of (i) and (ii) and the interrelationships among and between them; and
- (iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being'.

While water is explicitly mentioned in part (i) of this definition, it is trite that water is an absolute prerequisite for all forms of life, as well as for the natural progression of various water-driven geochemical processes (parts ii - iv). Water is also intricately integrated into many, if not all, cultures and has inarguable intrinsic value insofar as sense of place and well-being are concerned (part iv).

Water pollution may be harmful to both an aquatic ecosystem, as well as to humans and animals. What is lost from considerations of water quality, which focus primarily on the potability of raw waters, is the fact that rivers and streams are often used as the conduit to transport wastewater effluents to the dams, the latter in turn forming a quasi-maturation pond, from which raw waters are sourced. This amounts to a sustained environmental impact on both the lotic and lentic ecosystems.

¹⁸⁵ Constitution of the Republic of South Africa (1996).

¹⁸⁶ Act 107 of 1998.

Section 24(b) of the Constitution adds a directive principle to the right, as follows

‘to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that

- i. prevent pollution and ecological degradation;
- ii. promote conservation; and
- iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development’.

We then need to turn to how the NEMA considers pollution.

“pollution” means any change in the environment caused by -

- (i) substances;
- (ii) radioactive or other waves; or
- (iii) noise, odours, dust or heat,

emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or wellbeing or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future.’

This is a necessarily broad definition, given the multitude of forms that pollution may take. It is clear from Chapter 2 that sewage-containing wastewaters constitute a form of pollution that bring about a negative change in an aquatic environment, with the potential to ‘[have] an adverse effect on human health or wellbeing or on the composition, resilience and productivity of natural or managed ecosystems’.

Sections 4(a) (o) & (p) of the NEMA, *inter alia*, further address pollution in terms of the principles of sustainable development, public trust and polluter pays:

4 (a) Sustainable development requires the consideration of all relevant factors including the following:

- (i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;
- (ii) that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;
- (iii)...

(iv) that waste is avoided, or where it cannot be altogether avoided, minimised and reused or recycled where possible and otherwise disposed of in a responsible manner;

(v)...

(vi)...

(vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and (viii) that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied.

4 (o) The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage.

4 (p) The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment.

From the foregoing it is clear that the NEMA requires a legislatively-directed, pro-active and risk-averse approach to pollution management.

With respect to defining pollution, the NWA¹⁸⁷ is quite clear:

“pollution” means the direct or indirect alteration of the physical, chemical or biological properties so as to make it—

- (a) less fit for any beneficial purpose for which it may be reasonably be expected to be used; or
- (b) harmful or potentially harmful—
 - (aa) to the welfare, health or safety of human beings;
 - (bb) to any aquatic or non-aquatic organisms;
 - (cc) to the resource quality; or
 - (dd) to property.

In Chapter 2 it was pointed out that the uncontrolled discharge of sewage-derived wastewaters into water resources such as reservoirs will, in terms of nutrients, indirectly alter the biological properties thereof. Direct impairment may arise from the chemicals and/or pharmaceuticals present in wastewater. Insofar as part (b) of the pollution definition is concerned, the aforementioned ‘alterations’ are qualified as harms. The definition does not require that the pollution render the resource unfit for any use, rather that it is rendered ‘less fit’ for such use. Importantly, at (b) pollution does not need to have caused environmental harm, it is may be deemed to have the potential to cause harm. As was noted in Chapter 2, the understanding of

¹⁸⁷ Act 36 of 1998, s1(1).

eutrophication is such that the potential for wastewater effluents to harm water resources can be predicted with a high level of confidence.

Section 2 of the Act describes its purpose:

Purpose of the NWA¹⁸⁸—The purpose of this Act is to ensure that the nation’s water resources are protected, used, developed, conserved, managed and controlled in ways which [sic] take into account amongst other factors—

- (a)...
- (d) promoting the efficient, sustainable and beneficial use of water in the public interest;
- (e) facilitating social and economic development;
- (f) providing for growing demand for water use;
- (g) protecting aquatic and associated ecosystems and their biological diversity;
- (h) reducing and preventing pollution and degradation of water resources;
- (i)...

Degraded water quality, such as that caused by sustained discharges of inadequately treated wastewater effluents, will clearly conflict with achieving sustainable use and socio-economic development, will limit water availability and so reduce the ability to meet demand, constrain the protection of aquatic ecosystems and result in their progressive degradation. It also places rural users who draw their water untreated from rivers at great risk. As such one would assume that wastewater pollution would be a central facet of the pollution prevention strategy that, as shown in Chapter 1, is indeed the case. What is lacking, however, is any form of concerted effort to regulate the very evident threat posed by inadequately-treated wastewater effluents.

Section 3 of the NWA renders the National Government, in the person of the Minister, the public trustee of the nation’s water resources – a responsibility that encompasses the need to protect water quality.¹⁸⁹ This adds an additional layer of state responsibility in addition to that created by the environmental right. The obligation of trust placed on the state has its underpinnings in s24(b) of the

¹⁸⁸ NWA s2.

¹⁸⁹ NWA s3(1).

Constitution in terms of the obligation to protect the environment within the dictates of sustainable development.

Chapter 3 of the NWA deals with the protection of water resources, with s19¹⁹⁰ focusing on pollution prevention ‘in particular where pollution of a water resource occurs or might occur as a result of activities on land. Wastewater treatment is such an activity. The section comprehensively sets out the measures anyone who owns, controls, occupies or otherwise uses the land where the activity occurs, should take. A failure to comply with any directive issued under s19 is deemed to be an offence.¹⁹¹

The DWS is responsible for the discharge of sewage effluent and disposal of sewage waste, both activities regulated by the NWA and effect given thereto by means of Water Use Licenses (WULs) or General Authorisations (GAs). Sewage effluents were previously specifically included under the NEM:WA hazardous waste listings of activities requiring licensing¹⁹². As there are many non-waste related impacts associated with the treatment and disposal of sewage, these were removed and added to the NEMA listing notices.¹⁹³

The General and Special effluent standards for smaller-scale WWTWs are currently set out in a revision of General Authorisations for the discharge of wastewater to water resources, issued in terms of the NWA.¹⁹⁴ There are seventy-nine listed river systems to which the Special Standard applies, plus an additional nine within a specific Water Management Area and fourteen RAMSAR wetlands.¹⁹⁵ In this version of the regulations, the limits for phosphorus are set as 10 mg/ℓ P for the General Standard,¹⁹⁶ and a median of 1 mg/ℓ P, with a maximum of 2.5 mg/ℓ P for the

¹⁹⁰ s19 falls within Part 4 of Chapter 3 of the NWA.

¹⁹¹ NWA s151(d)

¹⁹² NEM:WA GN921 of 29 November 2013. Schedule 19(2) Waste management activities in respect of which a management licence is required in accordance with s20(b) of the NEM:WA (Act 59 of 2008) s3(7), s4(1, 4, 5); See also GG32188 of 30 April 2009, Schedule 19(1) (List of waste management activities that have, or are likely to have, a detrimental effect on the environment).

¹⁹³ National Environmental Management Act (107 of 1998) Listing Notice 1 (GG38282, Regulation 983 of 4 December 2014): List of activities and competent authorities identified in terms of Sections 24(2) and 24D (Activities 10, 25 & 57); Regulation 984, Listing Notice 2: Activities 6, 25 & 28).

¹⁹⁴ GN 665 (GG36820) dd 6 September 2013. Part 2 at 10 et seq. For discharges of 2 megaliters per day or less. Larger works are required to apply for a Water Use License and presumably comply with the 1 mg per liter P standard if located in one of the listed catchments.

¹⁹⁵ GN 665 (n194) Table 2.3 Listed Water Resources.

¹⁹⁶ This is the concentration of phosphorus typically found in raw sewage!

Special Standard.¹⁹⁷ The latter is clearly a relaxation of the standard for wastewater treatment works that is counter to the obvious need for more stringency as set out in Chapter 2. A median value, ie. that concentration occurring at the midpoint of a frequency distribution, also makes little sense as the ‘allowable’ higher values could occur during the season or flow conditions when the receiving water is least able to assimilate same. Lastly, the notice states that the concentration-based limits may be revised based on the outcome of the water resource classification system. As pointed out in Chapter 1, standards based on concentrations alone have very limited value for the regulation of nutrients. While concentrations are applicable to toxic elements such as copper, nutrients impart environmental harm indirectly, serving as a food source for weedy or noxious organisms such as toxic algae.

3. RATIONALISING WASTEWATER POLLUTION WITH WATER RESOURCE PROTECTION.

In the NWA the protection of water resources involves a process of classifying water resources into classes, establishing those resource quality objectives (RQOs)¹⁹⁸ necessary to sustain the deemed category. Specific water quality objectives (RWQOs) form a subset of the RQOs. The assumption is then that if the quality objectives cannot be met, some or other process will be initiated to identify and manage the cause of the infraction. This is a somewhat arbitrary process that is questionable in the South African environment where so many malfunctioning WWTWs discharge to the countries streams, rivers and reservoirs. The pollution of these waters as a result of inadequate wastewater treatment is a clear and evident problem¹⁹⁹ that requires pro-active management, not the setting of objectives that may be far from attainable in practice. It certainly renders all but useless any efforts to set in place legally-based controls as, while the flow from a dam may be possible to control, the water quality in that flow obviously cannot. Implementing the ecological reserve aspect of the NWA has been shown to be extremely problematical on a number of levels and certainly not to an extent to which the process can be translated

¹⁹⁷ GN 665 (n194) Table 2.1.

¹⁹⁸ “resource quality” means the quality of all the aspects of a water resource including—
 (a) the quantity, pattern, timing, water level and assurance of instream flow;
 (b) the water quality, including the physical, chemical and biological characteristics of the water;
 (c) the character and condition of the instream and riparian habitat; and
 (d) the characteristics, condition and distribution of the aquatic biota.

¹⁹⁹ NWRS 2 at 9 (n3).

into a legally-binding license.²⁰⁰ Given that eutrophication is a clear cause of environmental harm, the application of source-directed pollution control regulation would provide substantial ecosystem health benefits and be far simpler to apply than a complex of specifications deemed applicable to a particular ecosystem.

While wastewater treatment is a local authority competency per Schedule 5 of the Constitution, it is trite that the state should lay down the minimum standards applicable to such treatment. With respect to phosphorus this provision has been in place since 1962, yet remains to be enforced.

(a) Ignoring reservoirs – the Achilles Heel of the national water resource strategy.

Chapter 1 illustrated the extent of the wastewater-originating eutrophication problem in South Africa, a problem that is specifically most obvious in seventy per cent of the nations' reservoirs. This is a seemingly implausible oddity, given that the NWA is based on catchment-based, source-to-sea water resource management that should consider all components of a watercourse equally. This is not the case, as reservoirs receive no attention apart from routine monitoring. By contrast, there is a wealth of attention applied to rivers, an area in which a vast skills-base has been developed. Despite the central importance of reservoirs as semi-natural ecosystems storing raw potable water, there has been no skills development for reservoirs. This is directly in conflict with the NWA, as will be illustrated below:

From the definitions of 'water resource'²⁰¹ and 'watercourse'²⁰² in s1 of the NWA, it is clearly evident that 'water resources' include 'watercourses' and that 'watercourses' include in-channel reservoirs²⁰³. This implies both natural and man-made lakes as the Act makes no distinction between the two. The direct implication of this is that wherever the words 'watercourse' or 'water resource' appear in the Act, reservoirs are included. As such the Minister is legally required to consider dams as

²⁰⁰ Schreiner B (2013) 'Why has the South African Water Act been so difficult to implement?' 6 *Water Alternatives* 239-245. At 242.

²⁰¹ "water resource" includes a watercourse, surface water, estuary or aquifer.

²⁰² "watercourse" means—

- (a) a river or spring;
- (b) ...
- (c) a wetland, lake or dam into which, or from which, water flows; and
- (d) ...

²⁰³ The NWA does not define dams and does not include the term 'reservoir'. In common global use, 'dam' refers to the structure that retains the water (the dam wall) and 'reservoir' is the lake or body of water that forms upstream of the dam.

part of the water resource. In a response to a parliamentary question, the Minister admitted that reservoirs have yet to be integrated into the monitoring and resource management system.²⁰⁴

As shown above, Chapter 3 of the NWA, in specific s12, requires a classification system for water resources that, from the foregoing, must include reservoirs. The current classification system is not only poorly written, it does not mention reservoirs, this despite its apparent focus on ‘significant water resources’.²⁰⁵

The implications of inattention to eutrophication at the reservoir level are two-fold: first, there is the issue of degrading water quality and severe impairment of the ecology of these man-made lake ecosystems and, secondly, the sheer scale of eutrophication may render meaningless the establishment of remotely and independently determined quality objectives for river reaches downstream of dams. Many rivers in South Africa experience aseasonal flows, ie. flows that are released for irrigation purposes. The quality of these flows is largely, if not entirely, a function of the water quality in the reservoir.

The management of South African water resources is apparently founded on the principles of Integrated Water Resource Management (IWRM), an old concept that is rarely comprehensively understood or applied. IWRM implies a demanding, holistic management approach at an institutional level but also, vitally, at the ecosystem level. Attempts to manage isolated parts of an integrated system (stream to rivers [via reservoirs] to estuaries) makes no practical or pragmatic sense. Fragmentary approaches and ‘high-handed development decisions made for the benefit of a single user group or faction’ are an anathema to IWRM,²⁰⁶ itself an approach that is challenging to implement even in well-resourced societies. Thus the attention to South African rivers in the absence of a parallel consideration of reservoirs conflicts directly with the need for integrated assessment.

The eutrophication problem is an enormous and burgeoning water pollution liability, a liability that lies squarely at the state’s door. In her analysis of the liability

²⁰⁴ n13.

²⁰⁵ GNR 810 (GG 33541). Regulations for the establishment of a water resource classification system.

²⁰⁶ Giordano M and T Shar (2013) ‘From IWRM back to integrated water resources management’. *International Journal of Water Resources Management* DOI: 10.1080/07900627.2013.851521 accessed on 14 January 2014.

created by inattention to acid mine drainage (AMD), Feris has cogently argued that ‘by way of the public trust doctrine the state as custodian of water resources ultimately bears the responsibility for remediation of water pollution’.²⁰⁷ Arguably there is an entirely equivalent responsibility for eutrophication. Feris implicates a prior lack of both enforcement and a scheme of pollution regulation as key factors for the water quality impairments woes that were inherited by the new regime in 1994.²⁰⁸ The same argument applies to wastewater-originated eutrophication.

The key difference between AMD and eutrophication, however, is that in the latter there are no private actors (mining companies) to share the responsibility and costs. The South African taxpayer is going to have to foot the bill for the intransigence of the DWS in ensuring that wastewater effluents do not pose a threat. Furthermore, eutrophication is a national problem rather than being regionally confined to the Witwatersrand. Despite the plethora of warnings, the state has yet to act on its own admission that wastewater effluents require a significantly greater level of treatment to offset further water quality degradation.²⁰⁹ The crisis is exacerbated by the fact that so many of the nations’ WWTWs cannot meet their basic treatment challenges, let alone the more challenging needs of phosphorus removal. Harding has shown that the DWS has made selective use of water quality data in order to downplay the levels of eutrophication in the nations reservoirs.²¹⁰

(b) The need for a catchment-level approach

As outlined above, the previous South African Water Act²¹¹ was amended such that s21(1)(a) required, as from 1 August 1980, all wastewater effluents comply — in specified catchments — with a concentration of ortho-phosphate phosphorus of 1 mg per liter (the ‘1 mg P standard’).²¹² A five-year extension of this requirement was subsequently allowed so that local authorities could make the necessary changes, rendering the effective implementation date as 1 August 1985.

²⁰⁷ Feris L (2012) ‘The public trust doctrine and liability for historic water pollution in South Africa’. 8 *LEAD* 3-18.

²⁰⁸ Feris (n207) at 12.

²⁰⁹ See Chapter 1.

²¹⁰ Harding WR (2015) (n6)

²¹¹ Act 54 of 1956.

²¹² GN 991 (GG9225) 31 August 1984.

During the extension period a particularly cogent and far-sighted critique of the uniform standard approach was compiled by a South African engineer.²¹³ This acknowledged that wastewater effluents were the major contributing factor resulting in eutrophication in South African impoundments, that phosphorus was the algal growth-limiting nutrient and, moreover, that the necessary levels of wastewater treatment technologies and skills were [then] available in South Africa – able to remove phosphorus ‘to *any* predetermined degree’ (at the time this was considered to be anywhere between thirty and eighty percent).²¹⁴

The blanket application of a concentration-based standard was, however, correctly deemed as extremely unwise for, *inter alia*, the following reasons: Firstly, eutrophication is the outcome of many [abiotic and biotic, physico-chemical and biological] factors, not just nutrients — ‘as each impoundment is only part of its larger catchment area, and each catchment area is unique, there is no simple uniform answer to the question of which phosphorus level one should aim for’.²¹⁵ Furthermore that ‘*unless each [catchment area] is properly surveyed with respect to nutrient load... there would be very little justification for a universally applied fixed limit*’ (emphasis added).²¹⁶

Secondly, background (natural) sources of nutrients can cause eutrophication, even before any anthropogenic sources are added to the equation.²¹⁷ Thirdly, wastewater treatment works differ very widely in terms of the technology they employ and the volume of wastewater they process. Accordingly, while the 1 mg P standard may be relevant to some works it would, especially in the case of smaller works, amount to unnecessary costs — resulting in the small ‘polluters’ being disproportionately disadvantaged, raising the issues of fairness and equity.²¹⁸ Thirdly, there was a need to account for the contributions of diffuse sources of nutrients, more to the point that before a blanket standard could be applied it was necessary to have an understanding of all the sources of nutrients, including atmospheric deposition, contributing to a particular problem. The conclusion reached was that eutrophication

²¹³ Pretorius WA (1983) ‘Should the phosphate concentration in sewage effluents be restricted?’ 8(9) *IMIESA* 23-29.

²¹⁴ Pretorius (n213) at 27.

²¹⁵ Pretorius (n213) at 25.

²¹⁶ Pretorius (n213) at 28.

²¹⁷ Pretorius (n213) at 27; Harding (2008) (n165).

²¹⁸ Pretorius (n213) at 28.

of South African impoundments was ‘inevitable’ unless ‘catchment’ and ‘direct impoundment management’ were applied — a prediction that has been proven to be correct.

4. CONCLUSION

South Africa has a severe water quality problem caused by inadequately-treated wastewater effluents, manifesting as eutrophication in reservoirs that provide raw potable water necessary to sustain basic human rights and socio-economic development. Several problems are apparent from the foregoing analysis:

First, there has been a sustained failure to implement a water quality standard, legislated since 1962, that targets the primary, controllable eutrophication causing nutrient, phosphorus. Insofar as can be determined, no notice or directive has ever been issued in terms of the Special Standard for Phosphate. Allied hereto is an identified prior need to employ a load-based approach, rather than concentration-based, for determining fees for wastewater discharges.

Secondly, of the two levels of phosphorus standard available, the General Standard setting a limit of 10 mg per liter P, provides no practical protection at all. The Special Standard set at 2 mg per liter P in 1962, was made more stringent (1 mg per liter P) in 1984, these changes meaningless in the absence of enforcement. The Special Standard for phosphorus, however, provides a potential ‘first tier’ or *de minimus* uniform standard for wastewater control in South Africa. A second tier of standards is encapsulated in the Resource Water Quality Objectives (RWQOs) that form part of the water resource classification system stipulated in the NWA.

Thirdly, while *de minimus* standards have relevance in low impact situations, eg. as when applied to very small discharges of wastewater, they have no value in cases where the overall load of nutrient exceeds the capacity of the river or reservoir into which the effluent ultimately discharges. As has been shown, the exceedance of load-based nutrient limits is the primary cause of eutrophication in South African reservoirs. This aspect is addressed in more detail in Chapter 4.

Fourthly, reservoirs are not yet considered as ecosystems forming part of the riverine continuum, despite a clear statutory obligation to do so. The ability to

comply with RWQO requirements downstream of reservoirs implies that the reservoir forms part of the same water resource classification system applied to the river system as a unitary, longitudinal whole. This is, however, not yet the case. As has been shown, the DWS is failing to meet its statutory obligations by continuing to ignore reservoirs and, by implication, the eutrophication problems in many, including all of the key reservoirs located in the economic heartland of the country.

Finally, South Africa has a unique set of environmental statutes that specifically and clearly pronounce on the need for pollution control. Despite this, the absence of any regulation of eutrophication juxtaposes in stark contrast with the substantial efforts that have been made and continue to be made in countries that have recognised the problem.²¹⁹

The eutrophication problem cannot be embraced for what it is until it is openly acknowledged and accepted. Only then can the governance system adopt the regulatory steering role that is so sorely needed in this case. As encapsulated in Schreiner's introspective review of the cumbersome nature of the NWA leadership challenges, there is a lack of understanding of what catchment level water resource management implies, in all likelihood an outcome of the imbalance caused by the sole attention to rivers. Against this must be weighed the apparent pre-eminence afforded to eutrophication by the NWRS.

The nett outcome is that the public's trust in the state to care for its needs has been and is being abused, resulting in direct and indirect risks to health and well-being and the socio-economic stability of the country. The resultant situation, wherein as much as two-thirds of the bulk water stored in reservoirs is impaired, as with the AMD, energy, rail transport and other crises, adds yet another layer of costs to be borne by the taxpayers as a result of poor governance.

²¹⁹ See Chapter 2.

CHAPTER 4: TOWARDS A TMDL APPROACH

From Chapters 2 and 3 it is apparent that the regulation of nutrient levels in wastewater effluents can be applied using a specified level of treatment or a tiered hierarchy of standards comprising a *de minimus* standard, such as a blanket standard based on concentration, a concentration level to be attained for a particular size of population and/or RWQOs to set a desired in-stream (ambient) concentration. Tension between these approaches will arise when, for example, the attainment of an RWQO downstream of an eutrophic reservoir cannot be attained. Such a scenario might arise because wastewater treatment plants discharging to the reservoir, despite the implementation of the minimum standards, are nonetheless creating an ambient reservoir pollution level in excess of the RWQO requirement. Alternatively, the discharge of wastewater into the river upstream of the RWQO requirement point, from one or more sources, exceeds the instream dilution and assimilable capacity. In order to comply with the RWQO, the pollutant loads to the reservoir or river must be reduced accordingly. In order to achieve this in a fair and equitable manner that lends itself to regulation, all sources of the pollutant in question in the upstream catchment need to be identified and quantified.

This chapter uses the example of the United States Clean Water Act to show how an equivalent understanding has been encapsulated into legislation, and then examines the scope for a TMDL approach in South Africa.

1. THE CLEAN WATER ACT

Water law in the USA is regulated by means of Federal and State-level instruments. The Clean Water Act (CWA) is a reincarnation of the former Federal Water Pollution Control Act (FWPCA).²²⁰ Amendments²²¹ made to the FWPCA in 1972 established national goals, a research program, a substantial grant program for upgrading wastewater treatment works, a standards program – combining both technology and water quality based) and a permitting and license program. The CWA is enabled via a suite of federal regulations.²²² The interaction between federal and state-level control is enabled via process of cooperative federalism, described as a partnership

²²⁰ FWPCA (1948) [As amended through P.L. 107-302, 27 November 2002).

²²¹ 33 U.S.C. §1251 et seq (Chapter 26 Water Pollution Prevention and Control).

²²² Code of Federal Regulations (C.F.R.).

with a shared objective.²²³ This arrangement is thus similar to the cooperative governance policy that links national and provincial functions in South Africa.

The objective of the CWA was to ‘restore and maintain the chemical, physical and biological integrity of the Nation’s waters’. The Act is comprehensive, is of a detailed narrative character and provides both framework and direction, supported by federal regulations and state-level statutes. The Act sets minimum effluent standards²²⁴ for industry and requires a minimum of secondary treatment²²⁵ at all publicly owned (municipal) WWTWs. More stringent limitations on effluent quality are required to meet specific circumstances.²²⁶ Individual states are free to enforce their own water quality laws provided that these are not less stringent than those set out in the CWA and economic factors may only be taken into account in cases where the limitations are more stringent.²²⁷ Standards and implementation plans for designated uses and the criteria necessary to support such designated use are prescribed,²²⁸ inclusive of an anti-degradation policy to protect existing conditions.²²⁹ In determining standards downstream uses must be taken into consideration and there is a presumptive designation that waters will be ‘fishable’ and/or ‘swimmable’ unless specifically stated to the contrary.²³⁰

Under the CWA point source discharges are permitted under the National Pollutant Discharge Elimination System (NDPES).²³¹ Municipalities are required to comply to the ‘maximum extent possible’.²³²

Water quality standards must be reviewed every three years, must be approved by the USEPA and, if the state fails to set standards or they are deemed inadequate for the purpose, the USEPA may set the standards as it sees fit.²³³ The latter is a contentious area of litigation that has seen the USEPA preferring to encourage the states to act in the spirit of cooperative federalism. States are required to list any

²²³ *Arkansas v Oklahoma* (1992) 503 U.S. 91.

²²⁴ 33 U.S.C. §1311.

²²⁵ 40 C.F.R. 133.

²²⁶ 33 U.S.C. §1311(b)(1)(C).

²²⁷ Burbank 35 Cal. 4th 613.

²²⁸ 33 U.S.C. §1313.

²²⁹ 40 C.F.R. §131.12.

²³⁰ 40 C.F.R. §131.10(j).

²³¹ 33 U.S.C. §1342.

²³² 33 U.S.C. §1342 (p)(3)(B)(iii).

²³³ CWA s303(c)(4)(B).

waters that do not meet the set standards and to review the list every two years.²³⁴ Total Maximum Daily Loads (TMDLs, described in Chapter 5) must be established for pollutants *that do not meet the standard – inclusive of both point and diffuse sources*.²³⁵ As with standards, TMDLs must be approved by the USEPA or developed by the USEPA if and when necessary.

(a) Uniform v Ambient Water Quality Standards

The CWA was initially established on a technology-based approach (Best Available Technology, BAT) for effluents (technology based effluent limits, TBELs), abandoning a previously water-quality based approach.²³⁶ While this approach has value for attenuating specific pollutants in industrial effluents, it is of little value for protecting the natural environment as it fails to consider the environmental effects of the pollutants borne by effluents.²³⁷ As alluded to above, uniform regulations create unequal costs of compliance, do not take WWTWs of different ages or sizes into consideration, do not provide a fair and equitable pro-rata allocation of the burden of pollution amongst multiple sources of the same pollutant and they render enforcement extremely difficult.

Furthermore, in a ‘one solution fits all’ approach, there is no limitation on the number of WWTWs, or the size thereof, that discharge to the same river or impoundment, provided they all comply with the uniform standard, and geographic/catchment factors are not taken into account.²³⁸ As illustrated in Chapters 1 and 2, this conflicts with the premise that eutrophication is a load-based and not a concentration-based phenomenon. Essentially uniform standards for nutrients provide little or no protection for the environment. This is not to say that uniform standards have no role to play. As demonstrated for the case of the Berg River in South Africa, the simple implementation of the 1 mg P standard would attenuate eighty per cent of the nutrient loading problem.²³⁹ By contrast, the largest treatment works serving Johannesburg consistently better a concentration of 1 mg per liter P but, because of

²³⁴ CWA s303(d).

²³⁵ CWA s303(d)(1)(A) explicitly requires that waters be listed if they are impaired by a combination of point and non-point sources, confirmed by *Pronsolino v Natri* (291 F. 3d. 1123) (2002).

²³⁶ Pedersen WF (1988) ‘Turning the tide on water quality’. 15 *Ecology L.Q.* at 75. This was ostensibly in response to a knee-jerk need for a system that was simple and easy to implement.

²³⁷ (Anonymous) ‘Technology-based emission and effluent standards and the achievement of ambient environmental objectives’. 91 *Yale L.J.* 792.

²³⁸ Pretorius (n213).

²³⁹ Harding WR (2013) (n180).

the massive volumes of effluent, the loads discharged to the downstream Hartbeespoort Dam have rendered the impoundment permanently hypertrophic.²⁴⁰

By contrast, the use of ambient environmental standards provides a direct measure of ecosystem protection.²⁴¹ Both the CWA and the US Clean Air Act (CAA)²⁴² also include ambient quality standards and South Africa has recently seen its air pollution statute re-worked from a technology basis to using ambient air quality standards. Ambient environmental water quality standards, equivalent to the Resource Water Quality Objectives (RWQOs, see Chapter 3) provided for in the NWA, set a pollutant concentration at a specific point in, for example, a river segment. If this is not met, then the CWA requires that the TMDL protocol be initiated. In South Africa there is, as yet, no guiding mechanism for addressing exceedance of a RWQO standard, in fact there is no system for determining whether the standards set are indeed attainable, as background and atmospheric inputs may be higher than the values set, echoing the warnings made by Pretorius three decades previously.

By 1988 the use of uniform water quality standards in the USA had been found to be ‘inefficient, ineffective and quite predictably results in controls...tighter than they need to be or too lenient to make any real difference’. Insightfully, it was observed that ‘...an ambitious water pollution control program cannot be defended as necessary to preserve the suitability...of water for industrial use or for human consumption. ...efforts must be measured by their ability to protect ecological values’.²⁴³ Along with this admonishment was a caution to the US Congress to require attention to environmental standards and ensure that they were achieved.²⁴⁴ The mix of technology-based tools and water quality standards was problematic as non-point sources were excluded and it proved difficult, if not impossible, to ensure ‘fishable and swimmable waters’.²⁴⁵ The outcome was a system that was inefficient on two grounds: economics and the absence of a regulatory link to water quality

²⁴⁰ Harding WR, Thornton JA and G Steyn et al (2004) Hartbeespoort Dam Remediation Project (Phase 1): Action Plan (Volumes 1 & 11) Final Report. Report to Department of Agriculture, Conservation and Environment, North West Province.

²⁴¹ Such protection assumes that the ambient standard or RWQO is attainable.

²⁴² The US CAA is considered to be the most successful piece of environmental legislation ever drafted. Zygmunt Plater et al, cited in *Upper Blackstone v USEPA* (see n274).

²⁴³ Pedersen (n236) at 71.

²⁴⁴ Pedersen (n236) at 73.

²⁴⁵ Pedersen (n236) at 80.

problems.²⁴⁶ Application of these two approaches also precluded any trading options (Bubble Policy).²⁴⁷

Coupled with the aforementioned limitations of uniform water quality standards, was the pervading realisation that a catchment-level (watershed) approach was the only way to effectively understand and manage water pollution. Since the early 1960s catchment management, as the fundamental underpinning for water resource protection from eutrophication, acid mine drainage (AMD) and thermal pollution, had been called for, yet strongly resisted *by authorities reluctant to pass control to regional authorities* (a similar situation exists today in South Africa with the affording of powers to Catchment Management Agencies).²⁴⁸

An additional complication is that the CWA provides an option for either narrative or numeric standards to be used. The former create substantial problems for permit drafters, as well as confounding legal challenges. Recent years has seen the USEPA becoming insistent on the development of numeric standards.²⁴⁹

The aforementioned limitations of uniform standards and questionably arbitrary setting of RWQOs, combined with the lack of inclusion of non-point pollutant sources and the overall lack of a catchment-wide accounting of all sources of a particular pollutant, place legislatively insurmountable constraints to water quality management. All of these constraining issues, however, are accommodated and addressed within the wasteload allocation approach, as discussed in Chapter 5.

2. TMDLs

The Total Maximum Daily Load (TMDL) approach has been part of the CWA since it was drafted, yet infrequently applied until litigation by concerned citizens and NGOs forced it into the legal spotlight.²⁵⁰ The reasons for it not being applied were many,

²⁴⁶ Pedersen (n236) at 82. Kerr L (2014) Compelling a nutrient pollution solution: How nutrient pollution is redefining cooperative federalism under the Clean Water Act. 44 *Environmental Law* at 1223.

²⁴⁷ Pedersen (n236) at 84.

²⁴⁸ Roberts MJ (1970) River basin authorities: A national solution to water pollution. 83 *Harvard Law Review* 1527-1556.

²⁴⁹ Maker C (2014) Swimming away from the zone of reasonableness: Upper Blackstone and the need for numeric water quality criteria. 41 *B.C. Envtl. Aff. L. Rev* 295.

²⁵⁰ Bell N (2001) 'TMDLs at a crossroads: Driven by litigation, derailed by controversy'. 22 *Public Land and Resources Law Review* 61-81. By 2001 environmental groups had brought TMDL-related litigation in 38 states.

inter alia, a lack of data and catchment understanding and political and industrial resistance to a scheme perceived to bring yet more taxes and fees. It must be said that federal oversight of the implementation of the approach in 52 very different states was guaranteed to be a substantial challenge. South Africa faces a similar challenge, arguably within a much smaller and more homogenous quasi-federal system that enables water resource management at watershed level by means of Catchment Management Agencies.

(a) What are TMDLs?

The TMDL process is, essentially, an accounting of *all sources* of a particular pollutant within the catchment upstream of a particular impoundment, river segment or wetland. As such it can be applied to whole catchments or only a small part thereof, depending on the particular pollution issue. As such it is a water-quality based approach that provides for the allocation of pollutant loadings amongst all the sources thereof, ie. both a quantitative assessment and a planning process.²⁵¹ The inclusion of non-point sources addresses an issue that otherwise bedevils setting compliance for other forms of water quality standards. The approach thus enables a fair and equitable operationalising of the polluter pays principle. As the method requires a Margin of Safety to be included to allow for any uncertainties in the accounting process, the approach also respects the principle of precaution.

The TMDL approach can be applied for any form of pollutant, as well as aspects such as temperature, suspended sediments and pH. Many thousands of TMDLs have been compiled in the USA, with a further 41 000 planned or in progress as of 2012.²⁵² The approach has been successfully tested in South Africa in two catchments.²⁵³

The pollutant load allocation approach can be considered as a four-step process: First, and separate from the allocation, waterbodies (in this case reservoirs) that do not meet specific eutrophication criteria, must be identified and listed. Under the CWA this is known as the s303(d) list. That a listing can be made implies that the

²⁵¹ Copeland C (2012) (n104).

²⁵² Copeland (n104) at Summary.

²⁵³ Harding WR (2015) A feasibility evaluation of the Total Maximum Daily (Pollutant) Load (TMDL) approach for managing eutrophication in South African Dams. Water Research Commission Report 2245/1/15.

necessary scientific skills and understanding are available to (i) assess the waterbody in question and (ii) determine whether a proposed pollutant discharge may impart a negative water quality impact.

Secondly, if the answer to the latter (ii) is ‘yes’ then the TMDL protocol is used to determine Water Quality Based Effluent Limits (WQBELs) for *each source* of the pollutant, including that from non-point sources. A major advantage of this approach is that it *mandates an examination of the entire catchment*, in itself a valuable exercise for any catchment management authority seeking to understand what it is that they ‘manage’.

Thirdly, once all the sources have been individually quantified, TMDLs can be calculated at any temporal resolution from days to months to seasons to annually, the shorter the period the greater the data requirements. The TMDL analysis considers water quality under low-flow conditions, an issue not otherwise dealt with by the CWA. Recent legal challenges have also required that the USEPA include climate change factors into TMDL analyses.

The TMDL is represented by the following equation:

$$TMDL = \sum(WLA) + \sum(LA) + BK + MOS$$

where

WLA = wasteload allocation (point sources)
 LA = load allocation (non-point sources)
 BK = background
 MOS = margin of safety.

The required reduction in the aggregate TMDL, necessary to achieve the desired in-reservoir water quality, is then determined and the reduction applied pro-rata across all sources.

Finally, each individual apportioned discharge load can be licensed or otherwise legally embodied into a permit.

The TMDL regulations have undergone several revisions that have augmented the original structure. Key issues pertaining to TMDLs include additional guidance for addressing non-point sources, stormwater flows, mercury contamination (a major

pollutant in TMDLs in the USA), ocean acidification (TMDLs for carbon dioxide), climate change and multijurisdictional TMDLs.²⁵⁴ An additional and very important consideration is the need to build in allowance for population growth.

Use of TMDLs has been enormously successful. A keystone example is that of dioxin contamination in the Columbia Basin. This particular TMDL was developed with very little available data, yet it underpinned a ninety-five per cent reduction in dioxin discharged from eight pulp and paper mills.²⁵⁵ TMDLs are regarded as ‘having become a core element of overall efforts to protect and restore water quality’.²⁵⁶ However, it is also apparent that a failure by US states to timeously undertake TMDL analyses as from 1972 when the CWA required same, had led by 2001 to forty per cent of US waters having ‘unsafe levels of pollution or habitat damage’.²⁵⁷

As such, the TMDL protocol offers an ‘off-the-shelf’ approach which, augmented by local laws and regulations, can be directly applied in South Africa.

3. WHAT COULD THE TMDL APPROACH MEAN FOR SOUTH AFRICA?

From the foregoing it will be apparent that South Africa has a serious and, as yet, unmanaged water resource problem posed by eutrophication in many reservoirs. While considerable effort has been made to classify various rivers and set RWQOs, these investments are arguably dubious in the absence of a unifying and integrative catchment-level process that demonstrates workable efficacy. Tools to control pollution are limited to a phosphorus standard which is not yet applied and would be arguably impossible to enforce on a permit basis. Reservoirs, the primary receptacles of wastewater effluents, have yet to be included as a component of water resource management in South Africa.

The derivation of TMDLs provides a number of vital benefits, centrally that the process requires that a detailed examination be made of each specific catchment in which an eutrophication (or other water pollution problem for that matter) occurs.²⁵⁸

²⁵⁴ Copeland (n104) at 3-9.

²⁵⁵ Bell (n250) at 64.

²⁵⁶ Copeland (n104) at Summary.

²⁵⁷ Bell (n250) at 69.

²⁵⁸ The process of catchment-level pollutant ‘auditing’ would support the identification of a wide range of pollutant types and sources in addition to the target nutrient.

Quite simply, ‘...the correct degree of treatment at any one point cannot be determined without knowing what is being done at all other points...’²⁵⁹ The provision of catchment-level ‘pollution load map’ for phosphorus would allow all phosphorus ‘polluters’ in the particular catchment to view their own contribution arrayed against all other sources. This provides for complete transparency in the application of a permit process.

(a) The benefits arising from the TMDL approach

Multiple benefits accruing from TMDLs allow the science to comprehensively inform the law. These are: (i) a clear vision of the changes they would need to make to their effluent processing, including the aspect of future certainty if population growth and climate change are factored in. This would allow for both tailoring of technology needs and redundancy to be built into a treatment process that can be called on in future as required and offset the need to repeat a works upgrade; (ii) the availability of a catchment level pollution map would provide individual polluters, especially wastewater treatment works, with protection from third-party litigation;²⁶⁰ (iii) the pro-rata allocation of allowable loads would underpin a ‘pollutant load trading scheme’ whereby smaller polluters could enter into Coasian²⁶¹ arrangements with works having spare capacity or where the cost of upgrading per unit of pollutant removed would be more cost effective; (iv) a means for the attainability of RWQOs to be practically assessed i.e. supporting the enforcement of compliance on a quantifiable basis that is clear and evident to all concerned; (v) a precautionary approach that incorporates a reviewable and flexible margin of safety, including that necessary to allow for drought conditions. This would allow for the TMDL to be amended as new information and data become available; (vi) flexibility for revision of the TMDL as new scientific understanding, data and/or information become available and are fed back into the original analysis; (vii) accommodate the progressive implementation of the process according to needs and abilities. This would support both a tiered approach to be implemented that allows for upgrades of capital treatment infrastructure over time, and/or the progressive attainment of targets using a mix of solutions, for example increased treatment coupled with reuse of effluent for

²⁵⁹ Roberts (n248) at 1542.

²⁶⁰ Bell (n250) at 78.

²⁶¹ An example of a Coasian bargain would be for a downstream user of water to pay for the treatment of an upstream polluters effluent.

irrigation;²⁶² (viii) provides a means whereby the loads from agriculture can begin to be understood, ie. the difference between the more precise quantification of point source loads and the total loading where loads from agriculture are imprecisely determined (see hereunder); (ix) allow ratepayers to understand the charges that will necessarily be levied against their domestic water use and (x) promote the option for beneficiation of wastewater effluents and sludges, through phosphorus recovery.²⁶³

With respect to non-point sources, Harding has shown by means of case studies that these can be derived and accommodated using a combined process of forward accounting, based on the aggregate of background and point-source loads, measured against the reverse modeling of the problem total load in a particular reservoir. In this manner, the non-point source load is derived from the difference between the reverse modeled and forward accounted for loads.²⁶⁴ This approach provides a bridge across the information gap of nutrient export data for various landuse types. In the latter regard, Harding has also shown that there are sufficient hydrological and water quality data available in South Africa to analyse nutrient export by landuse type at a catchment level.²⁶⁵

(b) TMDLs as a template for skills development

South Africa currently has a good understanding of which reservoirs are problematical, some of which have been so since the 1970s. Using this information, it would be possible to rank and prioritize these waterbodies in terms of which to concentrate on first. Harding has recommended that such a ranking be seen from both ends of the spectrum, ie. those reservoirs that are already grossly polluted, as well as those which are still unimpacted but on a likely and rapid trajectory towards a problem condition.²⁶⁶

By contrast to the understanding of where the problems are located, is a near-total lack of relevant reservoir limnology skills. So, while it may be known what the

²⁶² s8(3)(a) of the NWA requires that catchment management strategies, of which TMDLs would logically be a component, “be established in a phased and progressive manner and in separate components over time” per s9(d) “take into account the geology, demography, land use, climate, vegetation and waterworks within its water management area”. In this regard waterworks is taken to include wastewater treatment works and not works for the treatment of raw potable water.

²⁶³ Recovery of phosphorus from wastewater is gaining traction in several countries.

²⁶⁴ Harding (n253)

²⁶⁵ Harding (n253)

²⁶⁶ Harding (n253)

trophic state of a reservoir is, an understanding of the waterbody-specific cause and effect pathways and how best to relieve the eutrophication pressure will be lacking. Such understanding is absolutely vital as while nutrient load reduction may bring a measure of relief, in the absence of a reservoir-level ecosystem understanding, the precise degree of such relief will be largely unfathomable.

Ordinarily the lack of skills could be seen as an unbridgeable constraint — that would incur a substantial delay in implementing reservoir management. The implementation of the TMDL approach or a variant thereof, however, provides both an opportunity and a template of needs for immediate upskilling that could become the foundation of future reservoir management in South Africa. Servicing the information and skills needs of the TMDL approach offers a cost-effective ‘learning by doing’ basis on which to re-build South African reservoir limnology. Under this format there would be no need to wait for skills to first be developed, rather they can be developed from the outset mentored by extant residual skills and experience. Given the catchment-level basis for the TMDL approach, this not only dovetails with existing NWRS policy, it allows for regionally-specific variations of reservoir limnology to be incorporated from the outset, ie. aligned with the Catchment Management Agency approach. The necessary theoretical and experiential training lends itself to an academy-based form of instruction. Additionally, excellent guidelines such as the UK Environmental Agency’s guidance on catchment-level eutrophication planning supports the fast-tracking of the development of appropriate procedures, especially for the identification and listing of eutrophication-impaired waterbodies.²⁶⁷

4. CONCLUSIONS

South Africa finds itself much at the same point as did the USA when the latter, during the 1980s, realized that their combination of uniform standards and water quality standards were not providing acceptable protection of water quality—and where the only way forward was to invoke the long-provided for TMDL approach.²⁶⁸ In terms of the NWA, the TMDL process is considered here as fundamentally-valuable in addressing, *inter alia*, the missing category of reservoirs as

²⁶⁷ Leaf S (2014) Guidance note on eutrophication and river basin management planning. Environmental Agency National Office (Bristol) (copy on file with author).

²⁶⁸ Kerr (2014) (n246).

water resources,²⁶⁹ i.e. that TMDLs would arise logically as a governance tool from s12(2)(a),²⁷⁰ s13(1)(a)²⁷¹ and s13(3)(d-h) of the NWA.²⁷² The NWA allows for a preliminary determination of the class of the resource which, given that the trophic state of all the major reservoirs is known, would allow for the listing and according to the trophic state²⁷³ ranking thereof.²⁷⁴ Regulations to give effect to a requirement for TMDLs or implementation of individual TMDLs would be authorized under Chapter 4, s26 of the NWA, in particular s26(d) &(h-j).²⁷⁵ s26 also provides for differentiation between different types and classes of water resources, as well as geographical variations.²⁷⁶

Once the state acknowledges that wastewater-driven eutrophication is a national problem that must to be addressed, the TMDL approach provides an already-developed, cost-efficient, unifying, quantifiable and regulation-compatible basis for pollution management and implementation of the Waste Discharge Charge System for wastewater treatment works. The same approach can also be used for other pollutants and all other types of receiving waters such as rivers, wetlands, estuaries, and the coastal zone. Moreover, it provides a logical foundation for the scientific and technological upskilling of catchment managers. It is trite, however, that without a willingness to implement and enforce, such a scheme it would be rendered worthless

²⁶⁹ Refer to earlier comments on this (eg. N13).

²⁷⁰ s12(2)(a) requires the Minister to, as part of the water resource classification system, establish guidelines and procedures for determining different classes of water resources.

²⁷¹ s(13)(1)(a) requires the Minister to determine a class for all or part of every significant resource, as well as (b) resource quality objectives based thereon.

²⁷² The objectives established in terms of s(13)(1)(b) may relate to:—

- (a)...
- (d) the presence and concentration of particular substances in the water;
- (e) the characteristics and quality of the water resource...
- (f) the characteristics and distribution of aquatic biota;
- (g) the regulation or prohibition of instream or landbased activities which may affect the...the quality of the water resource; and
- (h) any other characteristic.

²⁷³ Trophic state represents the degree of nutrient enrichment in four categories.

²⁷⁴ NWA s14.

²⁷⁵ S26... the Minister may make regulations—

- (a)...
- (d) prescribing the outcome or effect which must be achieved by the installation and operation of any waterwork;
- (e)...
- (h) prescribing waste standards which specify the quantity, quality and temperature of waste which may be discharged or deposited into or allowed to enter a water resource;
- (i) prescribing the outcome or effect which must be achieved through management practices for the treatment of waste...before it is discharged into... a water resource.
- (j) requiring that waster discharged... must be monitored...

²⁷⁶ NWA s26(2)(a & b).

and pollution levels would continue to degrade the nations scarce water resources. The latter would be akin to the situation that currently prevails under the non-enforced 1 mg per liter phosphorus standard.

Wastewater effluents pose and will continue to pose a major and increasing threat to the quality of South African water resources for a very long time to come. There is evidence that countries such as the USA who, for a long time have believed that they had successfully ‘managed’ point sources of pollution such as sewage effluents, are now revisiting this position and population growth increases the overall nutrient loading to surface waters.²⁷⁷ South Africa’s sewage system is founded on flush sanitation, a system that is being rolled out to an increasing percentage of the population on an ongoing basis. So, while there are strong arguments for delinking sanitation and water, replacement of the extant system with an alternative is an improbable scenario, but could apply to new developments going forward. In the meantime, extant treatment levels need to be substantially augmented.

This dissertation has proposed the TMDL approach as a regulatory tool that is directed at the reduction of nutrients in South African reservoirs. It has also shown that this intervention is long overdue and, by comparison with countries that have and are proactively addressing eutrophication, of substantial import for the sustainable use of water resources. The proposed use of TMDLs does not replace existing policy or legislation, rather it provides for a unified and logical application thereof—without TMDL analyses, the efficacy of uniform or *de minimus* standards remains elusory and open to challenge. The central value of the load-based approach is that it requires the entire catchment to be examined and, eventually, managed for the pollutant or pollutants of concern. The proposed use of a load-based tool, such as TMDLs, for water use licensing, accords entirely with the notion that ‘waste discharge will be prevented unless it is proven that... it will not cause pollution’.²⁷⁸ At minimum, implementing the TMDL approach will underpin a detailed understanding of

²⁷⁷ Kerr L (2014) (n246) states ‘Nutrient pollution, which comes primarily from wastewater and stormwater discharges...’; Maker C (n249) notes that despite massive improvements to the Blackstone River ecosystem under the CWA, wastewater effluents prevent the river from reaching its full potential.

²⁷⁸ Bosman C and M Kidd (2009) Figure 10, Chapter 17 in Strydom HA and ND King (eds), *Fuggle and Rabie’s Environmental Management in South Africa* (2nd Edition). Juta & Co, Johannesburg.

catchment-level sources of pollution, along with a much-needed upskilling of water resource management personnel and decision makers.

5. THOUGHTS ON A WAY FORWARD

This dissertation has highlighted the many warnings about, and the urgent need for, attention to the problem of eutrophication in South Africa. Although the National Water Resource Strategy identifies eutrophication as a major threat to water quality, this is at a generic level. There is an absence of any specifics directed at finding a solution. The lack of any focus on the management of reservoirs — as man-made lakes forming integral components of river ecosystems — appears to play a role in this enigmatic inattention. Despite a clear awareness of the role played by phosphorus, as evidenced by regulations formulated as early as the 1960s, enforcement of same remains elusive. In fact, no concerted interest in eutrophication by the responsible South African state agency for water has been evident since the 1990s.²⁷⁹ This is in stark contrast to the eutrophication policy and regulatory advances made in other parts of the world.

The reasons for the sustained inattention to such an acknowledged, evident and urgent problem are unclear. Harding has suggested that perhaps the sustained reluctance of the cohort of South African scientists, who accepted unchallenged the disbandment of reservoir science in the 1980s, to support calls for attention to eutrophication may be a contributing factor. The priority afforded to rivers, as opposed to an integrated examination of rivers and reservoirs, is clearly a factor, coupled with a lack of comparable skills in reservoir aquatic science.²⁸⁰ A recent assessment of the worsening condition of South African rivers between 1999 and 2011 identified eutrophication, arising from failing wastewater treatment infrastructure, to be a primary cause.²⁸¹ From a practical and pragmatic perspective, the legal difficulties in enforcing a concentration-based standard within a catchment-level milieu of different sources and loads, are likely to have been and remain a significant barrier to enforcement. Whilst there could be several sources of a particular pollutant in a catchment, spanning a range of concentrations — each with

²⁷⁹ Walmsley RD (n160).

²⁸⁰ Harding WR (n6 at 10).

²⁸¹ Nel JL and A Driver (2015) National River Ecosystem Accounts for South Africa. South African National Biodiversity Institute. www.sanbi.org.za Downloaded on 20 February 2017. At xiii, xvi & 29.

individual temporal variation — polluters who perform better than the standard, yet produce vast volumes and hence high loads of pollutant, would not be caught by the regulation. This fundamental weakness of a concentration-based regulation is obviated with the TMDL approach.

The reasons behind why South Africa now finds itself in this position pale in insignificance, however, when compared with the contemporary scale of the worsening problem. Of vital importance is the need to acknowledge and address the underlying issues. As set out in Chapter 3, the Constitution, the NEMA and the NWA establish a clear obligation on the state to prevent pollution from occurring and, where prevention is not possible, to mitigate or avoid within the ability to do so. Effectively managing eutrophication in South Africa is not going to happen quickly, and doing so will pose major and costly challenges to the capacity of the responsible authorities. Initiating effective wastewater treatment reforms will take many years to implement in already-underperforming local government structures, where attention to wastewater treatment is typically already under-financed.²⁸² It is most regrettable that the present situation also conflates with mounting allegations of fiscal impropriety, state capture and corruption within the national water agency.²⁸³

Eutrophication is undeniably a national government concern and it is appropriate that direction for eutrophication management emanate therefrom. Here it is insightful to have regard to the direction the NWRS provides and how this may be informed by the TMDL-type accounting of pollutant loads on a catchment basis: In a summary listing²⁸⁴ of seventy-nine individual NWRS strategies are two that are relevant here (emphasis added): ‘33. DWA²⁸⁵ and CMAs²⁸⁶ will establish a ten-year water quality management programme, focusing on *priority interventions such as wastewater treatment works* and acid mine drainage. This includes the restoration of polluted rivers and lakes’; ‘65. DWA will develop a programme which prioritises investment in the refurbishment and upgrading of wastewater treatment plants in

²⁸² Thompson H (2015) Water Law (Juta) at 310-311; NWRS (2013) at 25 & 39, *inter alia*.

²⁸³ Muller M (2016) South Africa’s water sector: a case study in state capture.

www.theconversation.com; Nomvula Mokonyane’s water department is bankrupt. News24 12 February 2017. www.news24.com.

²⁸⁴ Department of Water Affairs (2012) Proposed National Water Resource Strategy (Summary). Copy on file with author. At 49 & 50.

²⁸⁵ Department of Water Affairs.

²⁸⁶ Catchment Management Agencies.

order to prevent the pollution of water resources'. The NWRS (2nd Edition) denotes 'protection of our water resources' as a key focus;²⁸⁷ that 'the DWA, CMAs and WSAs will *develop and implement a targeted discharge regulatory strategy... including the discharges from municipal wastewater treatment works...*';²⁸⁸ and that 'The DWA will *revise the national standards for the provision of water services...*'.²⁸⁹ Furthermore, that the Waste Discharge Charge System (WDCS) would be implemented in *three pilot catchments*.²⁹⁰ With respect to the latter it is most significant that the Raw Water Pricing Strategy stipulates a load-based approach for calculating wasteloads, apparently the only place where discharge on the basis of loads has been specified (emphasis added).²⁹¹

Section 21(f) use – Discharged salt and *phosphorus waste loads calculated as the average discharge concentration times the discharge volume* as reflected on a lawful permit or licence, general authorization and/or verified as existing lawful use.

The NWRS, therefore, clearly acknowledges the wastewater-originating eutrophication problem and encompasses various catchment-level wastewater-directed strategies related thereto. These include an undisclosed revision of the applicable standards and suggests that these will become a component of the WDCS, the latter requiring an accounting by each individual source of the aggregate pollutant load. The TMDL approach outlined in Chapter 4 ticks all of the boxes necessary to achieve these aims. It provides a scientifically- supported means of determining the aggregate pollutant load within a catchment per each individual source; as such it is 'polluter-pays' oriented and 'risk-averse' (precautionary) in that a Margin of Safety factor can be incorporated depending on the level of confidence in the data. Charges levied for the waste (pollutant) discharged can then be directly linked to the loads and these charges possibly levied on a tier-basis according to the load, much along the lines on which potable water tariffs are structured. The process as a whole is infinitely flexible, accommodating changes in pollutant loads from existing polluters or the entry/exit of polluters from the TMDL accounting, and/or the advent of new technology or alternative effluent usage. It can be applied on a prioritised basis, dealing with the most urgent cases first. Of course, once all the sources of a pollutant

²⁸⁷ NWRS (n3) at 13.

²⁸⁸ NWRS (n3) at 73.

²⁸⁹ NWRS (n3) at 73.

²⁹⁰ NWRS (n3) at 90.

²⁹¹ GN 1045 in GG27732 (2005), s6.4.2. The notice states that wasteloads of salinity and phosphorus are the two most widespread water quality problems in South Africa.

have been identified, decisions can be made on the most appropriate means of complying with load reductions, *inter alia* re-use of effluent, enhanced treatment and/or beneficiation of phosphorus from wastewater effluents.

In whole, therefore, the TMDL process is transparent, reasonable, fair and equitable — and provides a legally-tested²⁹² solution to underpin a long sought-after wasteload allocation approach for sewage effluents in South Africa.

²⁹² Thousands of TMDLs have been permitted in the USA.

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