Chapter 10
Current Water Quality Risk Areas for Vaal, Pongola-Mtamvuna and Orange WMAs

The focus is placed on the WMAs located in the central region of the country, namely the Vaal, Pongola-Mtamvuna and Orange WMAs. These WMAs are predominantly of low to no risk, however, numerous significant risk areas were established for all of the WMAs and directly correlate with the extent of modification of water sources or areas.

Significant risk areas were predominantly established downstream or within close proximity of urban centres, cultivated areas, mining developments as well as WWTWs. Anthropogenic activities play a major role in the degradation of water resources. WWTWs are especially of great concern for all of the WMAs as it is dominated by unacceptable to tolerable levels of most or all selected water quality parameters especially in terms of *Faecal coliform*. Most of the WWTWs facilities within these WMAs do not comply with set standards and can be attributed to these facilities being mismanaged, inadequate or in need of proper maintenance or upgrading. Proper sewage facilities are also needed to be developed for rural settlements. The WMAs could invest in the reuse of wastewater after it has invested in the upgrading or maintenance of current WWTWs as the reuse of wastewater could be seen as an untapped water source which could lessen pressure on catchments which are already experiencing a water deficit. Issues need to be addressed to avoid future significant environmental human health problems and risks especially within the Vaal and Pongola-Mtamvuna WMAs and the Upper Orange catchment due to the high concentration of the country's population and economic activities.

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10.1 Vaal WMA

10.1.1 WMA Overview

The Vaal WMA includes the Upper, Middle and Lower Vaal catchments and its water resources are of great significance for the country and its population as it supports major economic activities and a population of approximately 12 million people. The Vaal River system stretches from Ermelo in the north-east to Vryburg in the North West to Douglas in the south-west to Harrismith in the east (Fig. 10.1).

The Vaal River is the primary water resource in the Vaal system with numerous significant tributaries. The Vaal River flows 1,415 km originating at the Sterkfontein beacon flowing southwest to the Orange River confluence. It is deemed to be the country's and southern African region's most developed and regulated river with 90 major man-made impoundments located on the main stem and tributaries. The Vaal River system is characterised by extensive water resource infrastructure and is linked to substantial water transfer systems to other water resource systems such as Thukela, Usuthu and Lesotho. Significant transfers are also made out of the Upper Vaal catchment through the Rand Water distribution system to the Crocodile West and Marico catchments. The system's supply reaches most of the Gauteng Province, Eskom's power stations as well as Sasol's plants, the North West and Free State goldfields, the North West platinum and chrome mines, the Northern Cape iron and

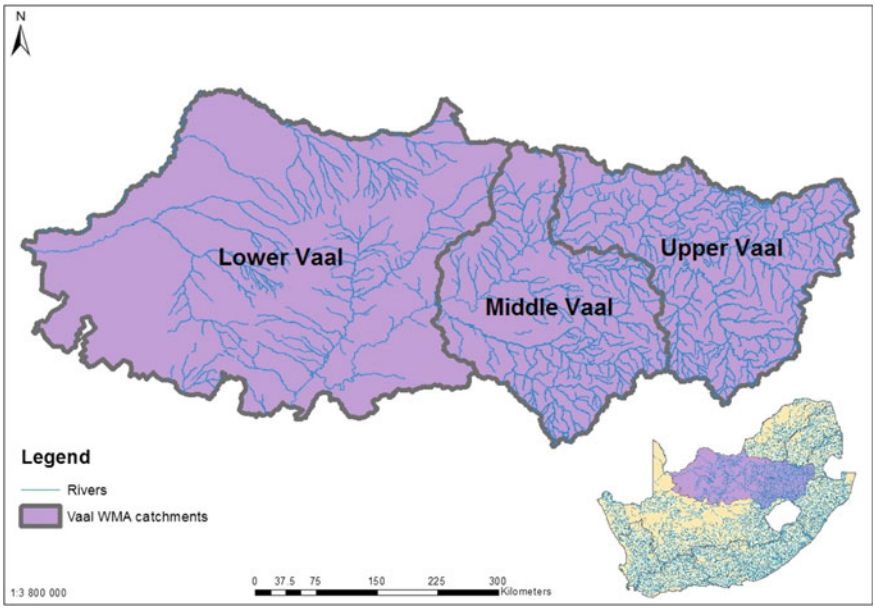

Fig. 10.1 Main catchments of the Vaal WMA

manganese mines, Kimberley, and several other small towns along the course of the river as well as numerous large irrigation schemes.

The Upper Vaal catchment's water resources within the catchment is therefore largely developed and highly altered by developments. The Middle Vaal has few major development centres with agriculture and mining being the primary activities. The Lower Vaal is also less developed with agriculture being the predominant land use. Significant types of development in the system include both formal and informal urbanisation, industrial growth, agricultural activities and widespread mining activities. The development of the system has led to the widespread deterioration of water quality which has required management interventions to ensure that water is of an acceptable quality for all users in the system especially as activities have continued to grow and intensify. The salinization and eutrophication are the two major water quality problems which the WMA has been experiencing.

The Upper Vaal catchment is characterised by extensive urban, mining and industrial areas in the northern and western parts. The urbanised area is primarily located in the Gauteng Province and extends beyond the WMAs boundary. Other developments in the catchment are related to dryland agriculture. The catchment also includes numerous large towns situated around mining, industrial and agricultural development areas and mining plays a significant role in the area's economy.

The Middle Vaal catchment has been shaped by the discovery of diamonds in the North West area which is now dominated by gold mining. The central parts of the catchment are dominated by extensive dryland cultivation. The primary urban areas include Welkom, Klerksdorp and Kroonstad. Irrigation is practiced mainly downstream of dams located along the main tributaries and locations along the Vaal River.

The Lower Vaal catchment is characterised by widespread livestock farming as the main activity and large-scale dryland cultivation in the north and east due to the arid climate. Intensive irrigation occurs at Vaalharts as well as other locations along the Vaal River and the most significant urban area is Kimberley in the south of the catchment. The catchment is also characterised by several towns and scattered rural settlements which are primarily found in the central and eastern parts.

The water quality monitoring of surface water resources is very limited within the Middle and Lower Vaal (Fig. 10.2). This might be attributed to these catchments being less developed and primary focus being placed on the Upper Vaal catchment due to its significance to various water sectors and the country. A total of 382 sampling stations qualified and were used for the analysis. Of these 382 sampling stations, 39 are dams/barrages, 221 rivers, 7 springs/eyes, 1 wetland and 114 WWTWs sampling points. All of these sampling points primarily occur within the Upper Vaal WMA.

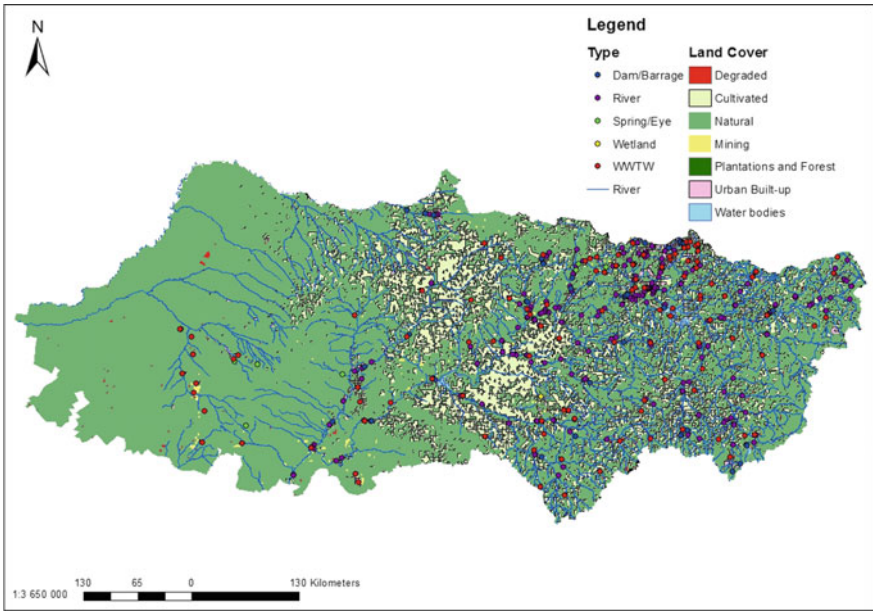

Fig. 10.2 Water quality sampling sites used and land cover of the Vaal WMA

10.1.2 Risk Areas for Domestic Use

The Vaal WMA is predominantly of no to low risk in terms of domestic use water quality standards. Most sampling stations measured acceptable water quality standards in terms of the selected physical and chemical water quality parameters (Fig. 10.3). Of the 382 sampling stations, 206 (54%) sampling stations are categorised as no risk, 96 (25%) as low risk, 39 (13%) as medium risk and 29 (8%) as high risk.

Significant risk areas (risk level 2 and 3), are in close proximity or directly downstream from urban built-up, mining, as well as cultivated land cover and, are spread across the WMA. Medium-risk areas include 4 rivers and 18 WWTWs in the Middle Vaal catchment, 17 WWTWs in the Upper Vaal catchment and 2 rivers and 10 WWTWs in the Lower Vaal catchment. Medium-risk areas are therefore predominantly within close proximity or directly downstream of WWTWs.

High-risk areas constitute of 2 rivers and 13 WWTWs in the Middle Vaal catchment, 1 river and WWTWs in the Upper Vaal catchment and 12 WWTWs in the Lower Vaal catchment.

WWTWs are therefore not up to standard in terms of domestic use water quality as most of these are either of medium to high risk. It should be noted that none of the WWTWs in the Middle Vaal catchment measured acceptable levels and are all either of medium to high risk. This should be of great concern to the whole WMA as these wastewaters can have widespread effects for all water users.

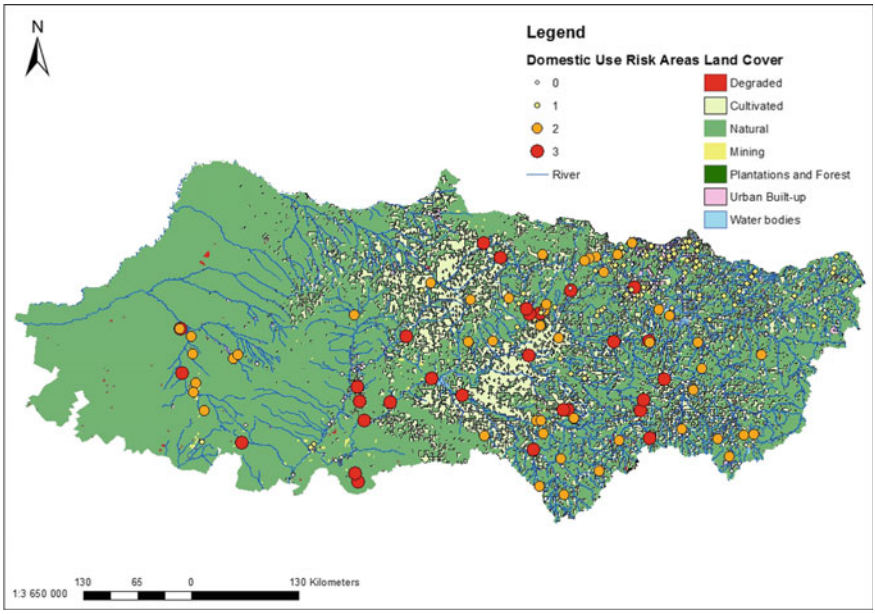

Fig. 10.3 Overall risk profile and significant risk areas for the Vaal WMA (domestic use standards)

10.1.3 Risk Areas for Aquatic Ecosystems

The current aquatic ecosystem water quality is predominantly of low to high risk. Most sampling points measured acceptable standards, however, a large amount also recorded tolerable to unacceptable standards. A total of 242 (63%) sampling stations were classified as low-risk areas, 65 (17%) as medium risk, 61 (16%) as high risk and the remaining 14 sampling stations as no risk (Fig. 10.4).

Significant risk areas are once again spread across the WMA. Medium-risk areas include 3 rivers and 18 WWTWs in the Middle Vaal catchment, 1 dam, 11 rivers and 20 WWTWs in the Upper Vaal catchment and 2 rivers and 10 WWTWs in the Lower Vaal catchment.

High-risk areas include 9 rivers and 13 WWTWs in the Middle Vaal catchment, 2 rivers and 25 WWTWs in the Upper and 12 WWTWs in the Lower. WWTWs once again pose a significant risk, especially in the Middle Vaal catchment where all WWTWs were found to have tolerable to unacceptable water quality standards in terms of the selected physical and chemical water quality parameters. Other risk areas occur downstream or within close proximity of urban built-up as well as mining developments. Cultivated areas were found to also be a contributing factor. Most of these sampling stations measured unacceptable to tolerable levels of ammonia, nitrate and phosphate levels.

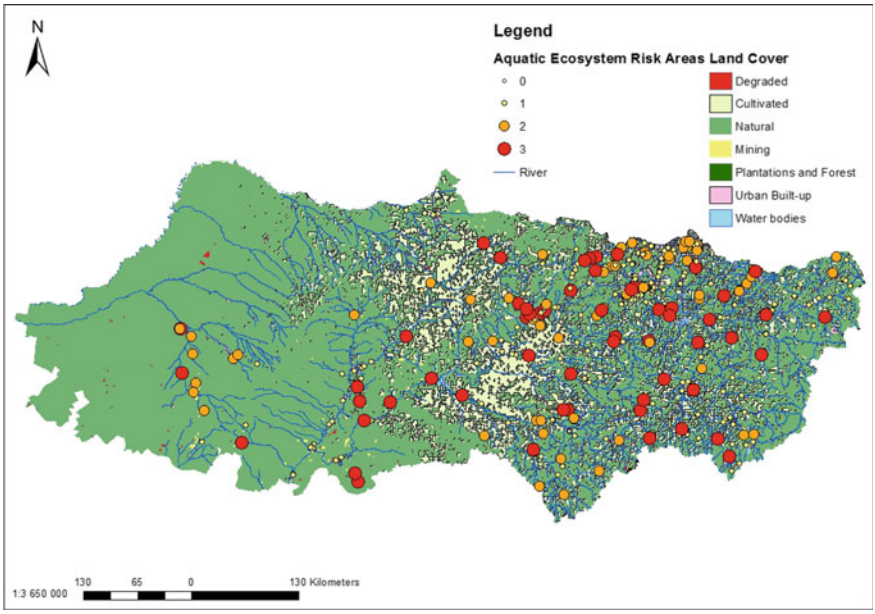

Fig. 10.4 Overall risk profile and significant risk areas for the Vaal WMA (aquatic ecosystem standards)

10.1.4 Risk Areas for Irrigation Use

The irrigation water quality of the Vaal WMA is mostly of no to low risk (Fig. 10.5). Of the 382 sampling stations, 213 (56%) sampling stations were classified as no-risk areas as most of the measured water quality parameters were of acceptable standard. A total of 92 (24%) sample stations are of low-risk, 49 (13%) medium-risk areas and 28 (7%) high-risk areas.

In terms of medium-risk areas, these areas are spread across all three catchments. Medium-risk areas were established to be 5 rivers and 16 WWTWs in the Middle Vaal catchment, 18 WWTWs in the Upper- and 4 rivers, 1 dam and 5 WWTWs in the Lower. High-risk areas include 2 rivers and 13 WWTWs in the Middle Vaal catchment, 1 river and WWTW in the Upper- and 11 WWTWs in the Lower. Therefore, once again, WWTWs have been identified as the primary cause of risk within the Vaal WMA. Most of these sampling stations once again primarily recorded unacceptable to tolerable concentrations of EC, sodium, ammonia, nitrate and in some cases tolerable to unacceptable pH levels over the time period. Cultivated areas which use water for irrigation purposes, located within close proximity or downstream of these facilities should, therefore, use caution especially in the Middle Vaal catchment where all WWTWs have been classified as medium to high risk.

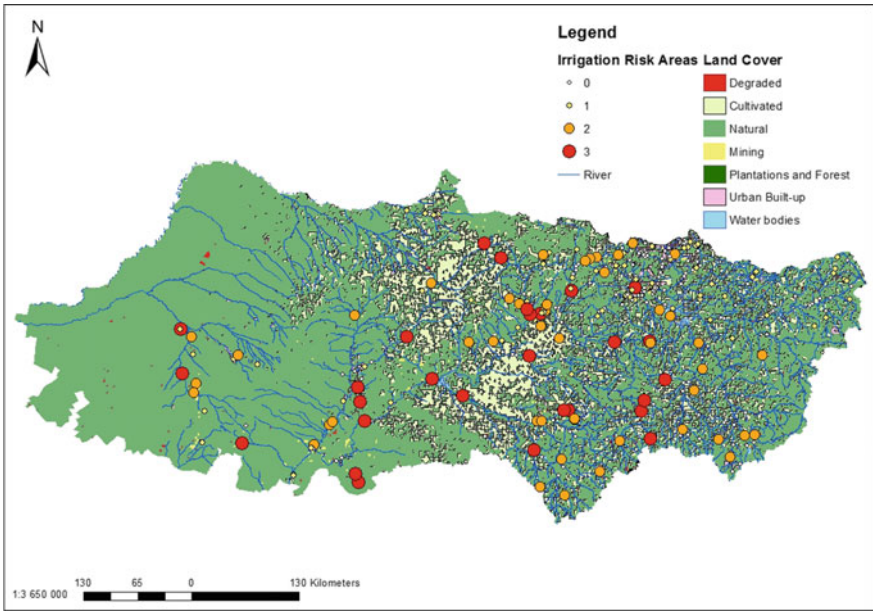

Fig. 10.5 Overall risk profile and significant risk areas for the Vaal WMA (irrigation standards)

10.1.5 Risk Areas for Industrial Use

The Vaal WMA is predominantly of low to medium risk in terms of industrial water quality. A total of 166 (43%) sampling stations have been classified as low risk followed by 109 (29%) medium risk, 67 (18%) high risk and 40 (10%) posing no risk (Fig. 10.6).

Medium-risk areas are predominantly located in the Upper Vaal catchment where 30 river sampling points, 4 dams, 1 spring/eye and 25 WWTWs were classified as being of medium risk for industrial water use. In the Middle Vaal catchment, 3 dams, 15 rivers and 12 WWTWs were classified as medium risk followed by the Lower Vaal catchment where 1 river, 1 dam and 17 WWTWs are of medium risk. Multiple high-risk areas were also identified in the WMA. These include 13 rivers and 7 WWTWs in the Middle Vaal catchment, 21 rivers, 3 dams and 1 WWTWs in the Upper and lastly 15 rivers, 3 dams and 4 WWTWs in the Lower. High-risk areas are therefore predominantly located in the Upper and Middle Vaal catchments, close to or downstream of WWTWs as well as urban built-up or mining developments. High and unacceptable concentrations of pH, EC, chloride and sulphate were measured over the time period.

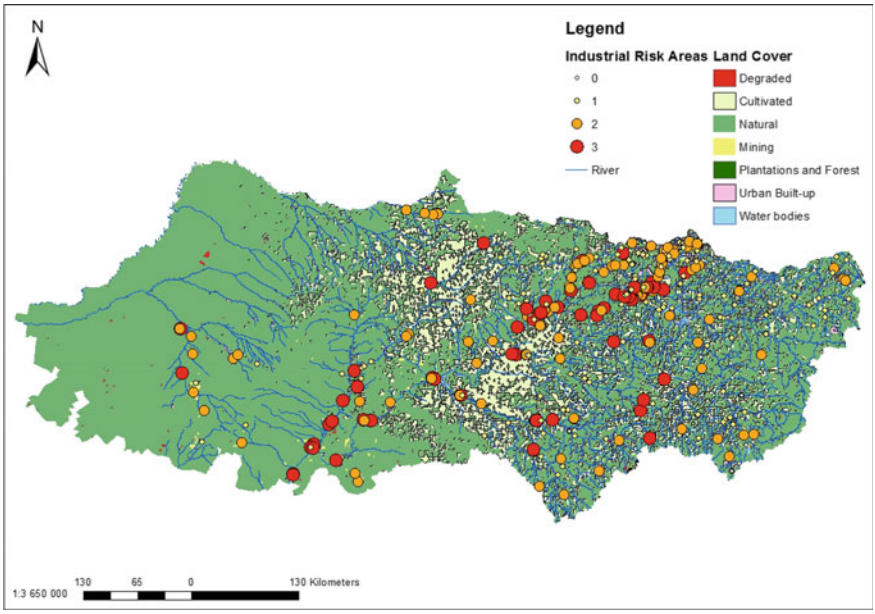

Fig. 10.6 Overall risk profile and significant risk areas for the Vaal WMA (industrial standards)

10.1.6 Risk Areas for Chlorophyll a *and* Faecal Coliform

The Vaal WMA only had 37 sampling stations which measured *Chlorophyll a* during the time period. This should be of concern as eutrophication has been identified as a significant water quality problem in the WMA which should receive increased monitoring in order to establish the extent of it accurately. *Chlorophyll a* water quality standards for domestic use is predominantly of a high risk as 30 of the 37 sampling stations were classified as high risk due to recording unacceptable concentrations of *Chlorophyll a*. The other seven sampling stations recorded tolerable concentrations and were classified as medium risk (Fig. 10.7). Most of the high-risk areas are located downstream or urban built-up areas as well as WWTWs, mining developments and cultivated areas.

In terms of recreational water quality, the Vaal WMA is once again predominantly of high risk (30 sampling stations) followed by some low (3 sampling stations) and medium (4 sampling stations) risk areas following the same trend as in the case of domestic use risk areas (Fig. 10.8).

For the Vaal WMA to improve upon or address its eutrophication water issues, the WMA will have to invest in the expansion of *Chlorophyll a* monitoring points to establish additional risk areas as well as probable causes for the problem. Currently, most of the sample stations have measured unacceptable levels of *Chlorophyll a* in terms of both domestic use and recreational standards which once again emphasises

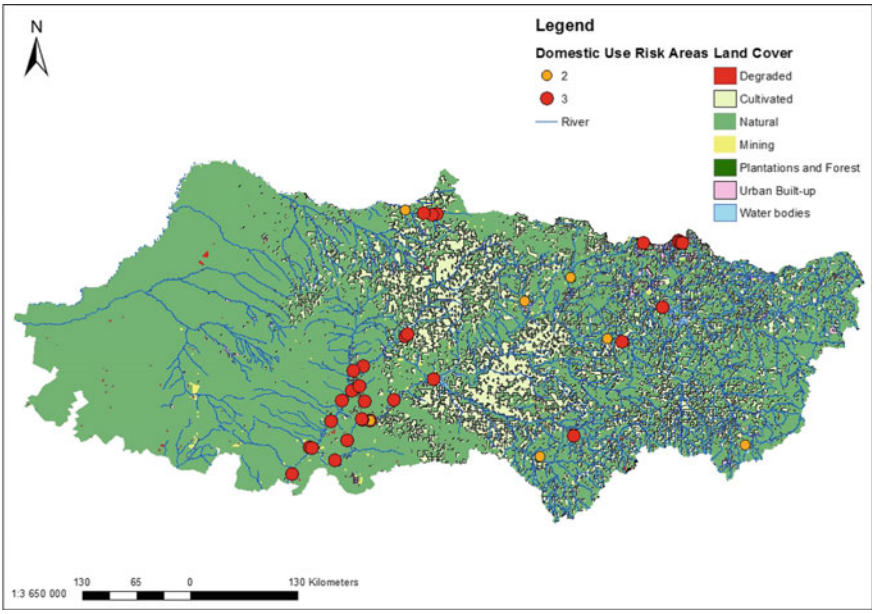

Fig. 10.7 Overall risk profile of *Chlorophyll a* for the Vaal WMA (domestic use standards)

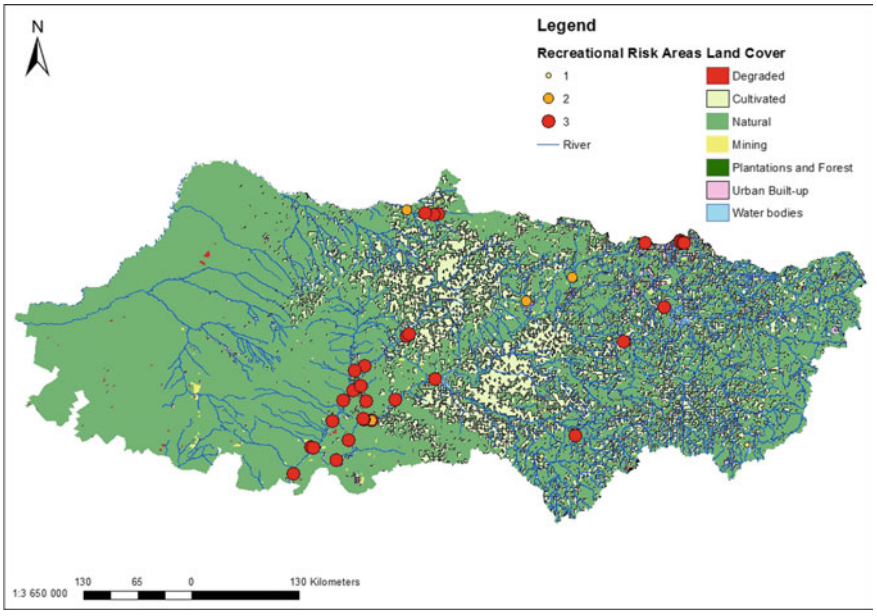

Fig. 10.8 Overall risk profile of *Chlorophyll a* for the Vaal WMA (recreational use standards)

how extensive eutrophication is within the WMA and should receive proper attention to reduce the problem.

The Vaal WMA also has an extensive *Faecal coliform* problem in terms of domestic use and irrigation water quality standards. A total of 339 sampling points recorded levels of *Faecal coliform* for the Vaal WMA. Of these 339, a total of 328 (98%) sampling stations recorded unacceptable levels of *Faecal coliform* for domestic use (Fig. 10.9).

In terms of irrigation water quality standards the WMA is not faring much better as 137 (40%) sample stations measured tolerable and 202 (60%) unacceptable levels of *Faecal coliform* (Fig. 10.10), which can be mainly attributed to poor or inadequate WWTWs.

The overall water quality of the Vaal WMA is concerning in terms of aquatic ecosystems, industrial as well as *Chlorophyll a* and *Faecal coliform* water quality standards. Salinity levels within the WMA are predominantly tolerable to acceptable which also emphasises that its water resources are under stress. The headwaters of the Vaal River are mostly of an acceptable standard. Some tributaries of the Vaal especially those which are located within close proximity or downstream of urban built-up, mining operations, as well as WWTWs, have poor water quality. The Blesbok Spruit tributary is a prime example. The water quality downstream of the Vaal Dam towards the Middle and Lower Vaal catchments are of a tolerable standard and are mainly impacted by flows from tributary catchments. Catchments which are

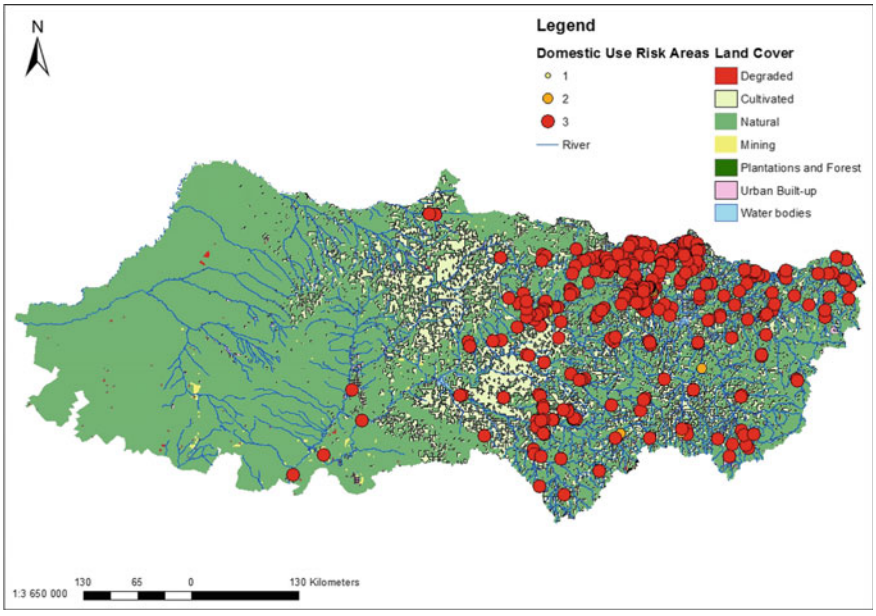

Fig. 10.9 Overall risk profile of *Faecal coliform* for the Vaal WMA (domestic use standards)

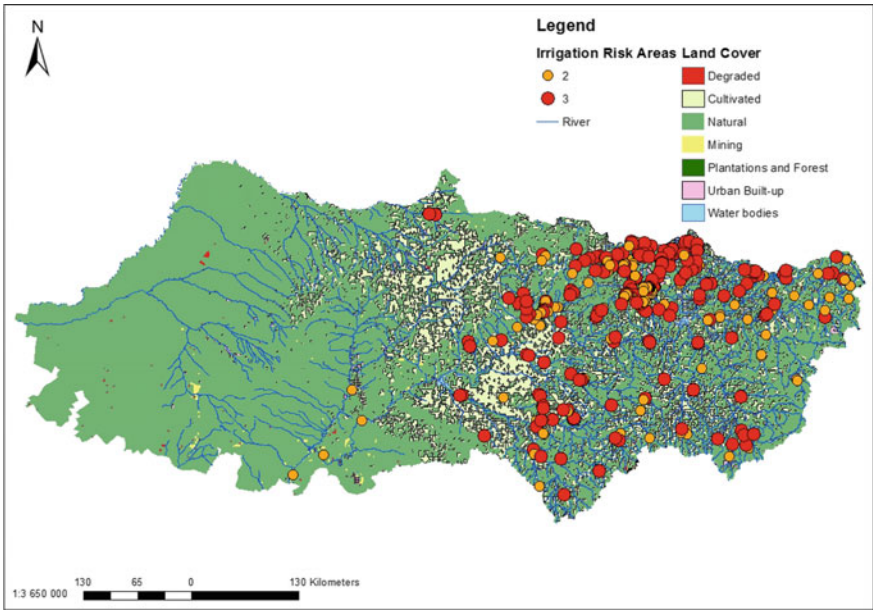

Fig. 10.10 Overall risk profile of *Faecal coliform* for the Vaal WMA (irrigation standards)

characterised by poor water quality and unacceptable ranges of salinity include the Suikerbosrand, Klip River and the Mooi River.

The Middle and Lower Vaal catchment are characterised by mostly tolerable standards. The Koekemoer Spruit and Schoon Spruit located in the Middle Vaal catchment are however of an unacceptable state especially in terms of salinity. Unacceptable levels of salinity are mainly attributed to mining operations in the catchment. The Lower Vaal deteriorates in terms of salinity standards downstream of the Bloemhof Dam. The Harts River's water quality is extremely poor especially in terms of salinity and contributes significantly to salinity problems in the lower Vaal River. Its poor state is largely due to irrigation return flows.

The overall ecological condition of the Vaal WMA ranges from a moderately modified condition to seriously modified state. This is largely due to most of its water resources being developed to capacity. The Upper Vaal catchment is described to be in a moderately modified condition except for the water resources within the Vaal Barrage catchment which are in poor condition and is largely so seriously modified. Other smaller tributaries in the headwater catchments of the Upper Klip and Upper Wilge Rivers are in a good ecological condition and in a largely natural present ecological state due to these areas not being affected by human developments or activities.

The Middle Vaal catchment's water resources range between moderately modified state to largely modified state with the small tributaries located in less developed areas being in a largely natural state. The lower reaches of the catchment's main tributaries

are seriously modified and is indicative of unsustainable systems leading to large losses of biota and ecosystem habitats. The Lower Vaal catchment is classified as being in a largely modified ecological state downwards from the Bloemhof Dam with many of its tributaries being in a moderately modified state.

The WMA has also undergone the water balance reconciliation of the system, and has required the implementation of five core interventions to ensure sufficient water availability to users in the short term. Interventions have included the eradication of extensive unlawful water use, implementation of water conservation and water demand management measures, reuse of water, implementation of an integrated water quality management strategy and lastly the implementation of Phase two of the Lesotho Highlands Project. The surface water resources of the Vaal WMA can, therefore, be described to be stressed and under threat. Precautionary approaches in management should be followed to maintain some good condition.

10.2 Pongola-Mtamvuna WMA

10.2.1 WMA Overview

The Pongola-Mtamvuna WMA contains the Mhlatuze, Pongola, Mkuze, Mfolozi, Thukela, Mngeni, Mvoti, Mkomazi, Mtamvuna and Mzimkulu systems which vary in size from medium-to-large catchments with all rivers flowing towards the ocean apart from the Pongola River which joins the Maputo River in Mozambique. The WMA is characterised by some water transfer across catchments with the most important one being water transfer from the Thukela system to the Vaal system, reserving additional water for long-term requirements. The main catchments of the WMA are the Mhlatuze, Thukela and Mvoti catchments (Fig. 10.11).

The primary challenge facing the WMA is the additional water supply needed to meet growing needs of the Kwazulu-Natal Coastal Metropolitan Area which includes Durban-Pietermaritzburg, KwaDukuza in the North to Amanzimtoti in the South. Water requirements are constantly increasing and catchments are already in deficit. The Thukela pipeline project which entails the raising of Hazelmere Dam and the construction of Spring Grove Dam has been implemented as an intervention to address water shortages. The construction of dams on the Mkomazi and Mvoti Rivers, as well as desalinisation and reuse of wastewater and seawater desalinisation, are other options which are also being considered.

The Mhlathuze, Mfolozi, Mkuze and the Pongola catchment areas are characterised by industrial, agricultural and transportation as their main economic sectors. The land use in these catchment areas, in terms of water use, is predominantly irrigation and afforestation. Large proportions of the area is tribal land which is usually used for stock farming with old mining areas are located close to Vryheid.

The Richards Bay area can be described as a fast-growing industrial hub containing numerous industrial complexes within the Mhlatuze catchment. Majority of the

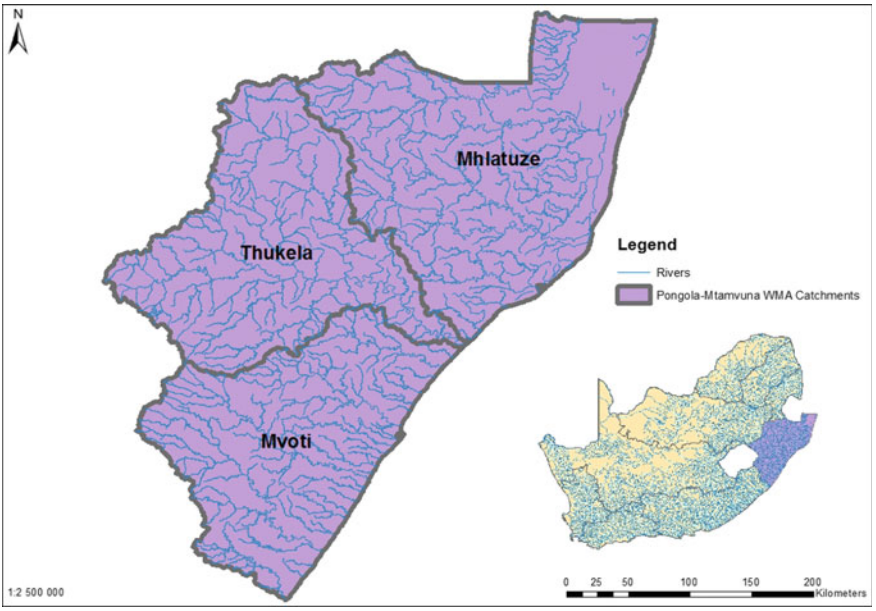

Fig. 10.11 Main catchments of the Pongola-Mtamvuna WMA

population in this catchment still live in rural areas. The Pongola System includes the massive Pongolapoort Dam upstream which serves sugarcane farmers with irrigation water. The Mkuze and Mfolozi sub-catchments are largely unregulated and support mainly forestry and irrigation water users. The world famous heritage site, Lake St Lucia, is located in this catchment. Upstream water use, poor catchment management and widespread erosion have negatively impacted the ecological condition of the St Lucia estuary, and there is still the potential for water resource development in the wider catchment area.

The largest river in the WMA is the Thukela River which includes the Little Thukela, Klip, Bloukrans, Bushmans, Sundays, Mooi and Buffalo rivers as major tributaries and forms the Thukela catchment. The river's water resources are primarily used to support water requirements in other parts of the country in the form of large water transfers to neighbouring catchments. These transfers include water transfers into the Vaal System, to the Mhlatuze catchment in the north and the Mooi-Mgeni system in the South. The catchment also holds eight major dams which include Woodstock, Spioenkop, Zaaihoek, Driel Barrage, Kilburn, Ntshingwayo, Craigie Burn and Wagendrift Dams. Major urban areas include the towns of Newcastle, Dundee, Ladysmith and Escourt. Most of the catchment's population is dependent on agriculture for their livelihoods and subsistence farming is practised on the communal land covering most of the catchment. In terms of industries, the catchment also includes the paper mill at Mandini.

The Mngeni, Mvoti, Mdloti, Mzimkulu and Mtamvuna systems form the southern portion of the WMA and the Mvoti catchment. The Mzimkulu and Mkomazi comprise the two larger river systems, the Mngeni and Mvoti the two medium-sized and the Mzumbe, Mdloti, Tongaat, Ifafa, Lovu and Mtamvuna as several smaller river systems. The Mvoti, Mdloti and Mngeni catchment areas are highly stressed due to water requirements exceeding available water supply. The catchment is the fourth largest contributor to the country's GDP and predominant land uses include major urban settlements along the Durban-Pietermaritzburg axis with the Durban metropolitan area being one of South Africa's major urban areas. Several small urban settlements in the locality support the surrounding agricultural sector. Large zones of commercial and subsistence agricultural land are located on the outskirts of urban areas. Dominant commercial agriculture includes timber, sugar cane, pastures and cash crops and there is substantial industrial development in main urban areas of Durban, Stanger and Pietermaritzburg. Additionally, it is important to note that the catchment is not facing any significant mining concerns or power stations.

Water quality monitoring of surface water resources are limited in some areas of the WMA (Fig. 10.12). Water quality monitoring is concentrated close to urban settlements and on the coastal area. A total of 375 sampling stations were evaluated. Of these 375 sampling stations, 39 are dams/barrages sampling stations, 208 river-, 89 estuary-, 2 wetland- and 37 WWTWs. The St Lucia estuary is intensely monitored as it is a world heritage site.

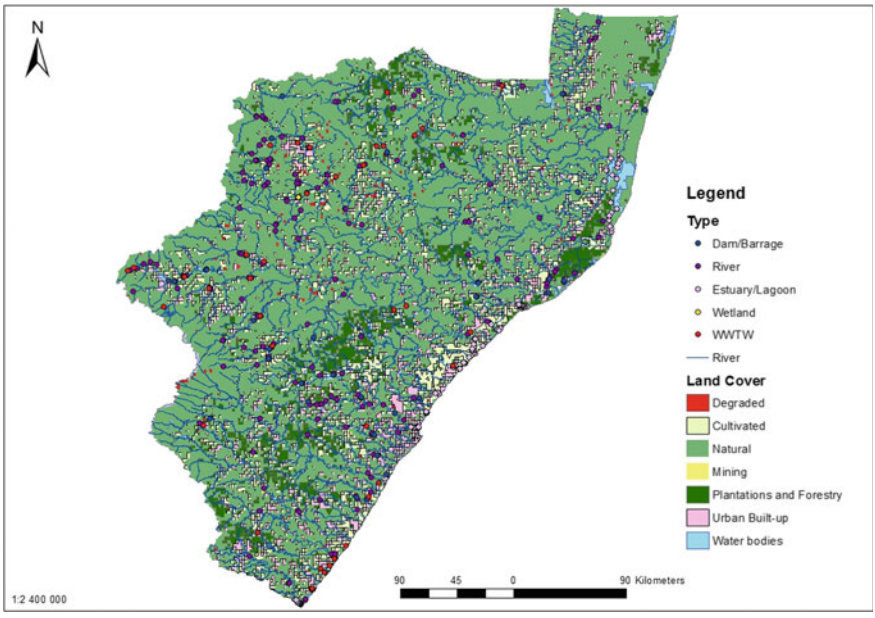

Fig. 10.12 Water quality sampling sites used and land cover of the Pongola-Mtamvuna WMA

10.2.2 Risk Areas for Domestic Use

Pongola-Mtamvuna WMA is mostly of no to low risk in terms of domestic use water quality. Most sampling stations measured acceptable levels for the selected physical and chemical water quality parameters. A total of 217 (58%) sampling stations were classified as no-risk areas, 107 (29%) low risk, 36 (10%) medium risk and 15 (3%) high risk (Fig. 10.13).

Significant risk areas are mostly located in the North West region of the WMA as well as close to coastal areas. Medium-risk areas include 1 river, 6 estuary and 3 WWTWs sampling areas in the Mvoti catchment, 4 rivers and 15 WWTWs in the Thukela catchment and lastly, 1 river, 1 lake and 5 WWTWs in the Mhlatuze catchment.

High-risk areas within the WMA include three estuary- and four WWTWs sampling stations in the Mvoti catchment, three river and two WWTWs in the Thukela- as well as two river and one estuary sampling points in the Mhlatuze catchment. Most of these risk areas are located downstream of urban built-up areas as well as cultivated land use. Tolerable to unacceptable levels of EC, calcium, chloride, sodium, ammonia, nitrate and phosphate were measured by these sampling stations. WWTWs once again play a key role in the degradation of the WMAs water resources as most of these are either of medium to high risk. Water resources which are located

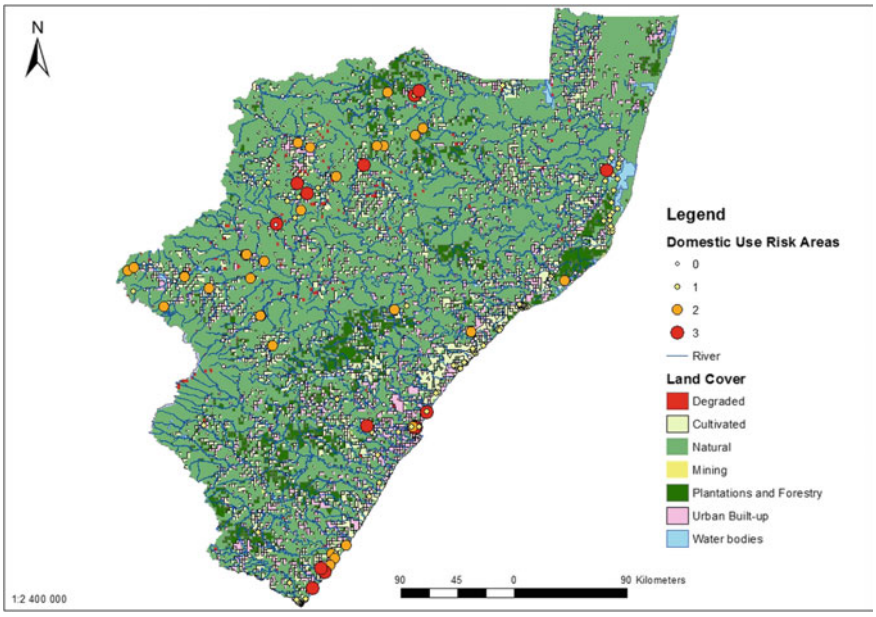

Fig. 10.13 Overall risk profile and significant risk areas for the Pongola-Mtamvuna WMA (domestic use standards)

downstream of these facilities are therefore a risk for domestic use and populations located close to these areas should refrain from using the water.

10.2.3 Risk Areas for Aquatic Ecosystems

The WMA is mostly of low risk in terms of aquatic ecosystem water quality standards (Fig. 10.14). A total of 259 (69%) sampling stations recorded mostly acceptable standards for the selected physical and chemical water quality parameters. No risk sampling stations include 72 (19%), medium-risk 33 (9%) and high-risk 11 (3%) sampling stations. The St Lucia estuary is predominantly of low risk in terms of aquatic ecosystem water quality standards. Risk areas are mostly the same as domestic use water quality.

Significant risk areas include mostly medium-risk areas which can be grouped as the following. Two estuary- and 3 WWTWs sampling stations in the Mvoti catchment, 6 river and 14 WWTWs in the Thukela catchment, 2 rivers and 5 WWTWs in the Mhlatuze catchment. In terms of high-risk areas, 3 estuary- and 4 WWTWs sampling stations in the Mvoti catchment, 3 WWTWs in the Thukela catchment and only 1 river sampling station in the Mhlatuze catchment recorded unacceptable standards. It

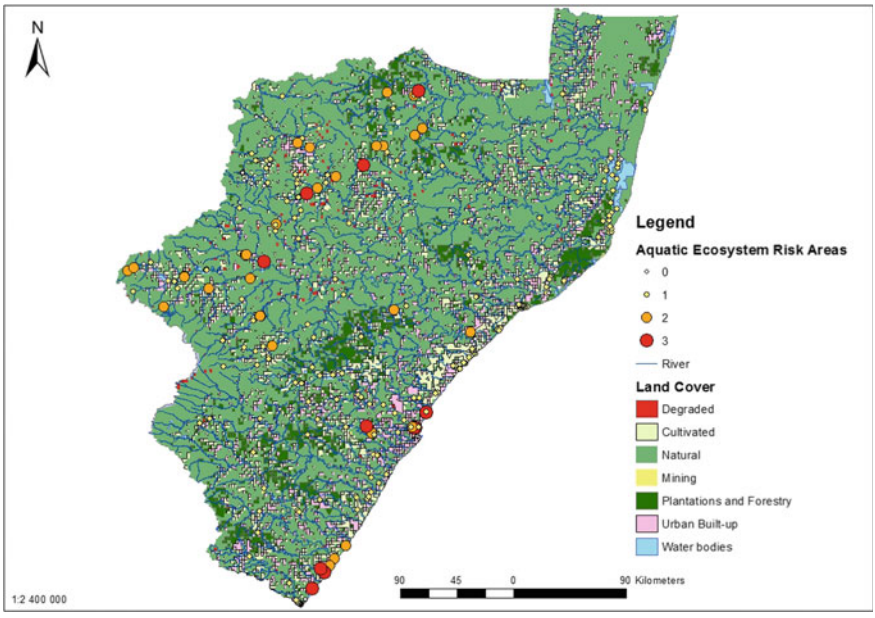

Fig. 10.14 Overall risk profile and significant risk areas for the Pongola-Mtamvuna WMA (aquatic ecosystem standards)

should be highlighted that in terms of the Mhlatuze catchment, all except 1 WWTWs is of medium to high risk.

Runoff from urban areas, especially from the Durban metropolitan area as well as wastewater from WWTWs across the WMA is of high risk. Cultivated areas also play a role in the degradation of the WMAs water resources however to a lesser extent. WWTWs, therefore, need to be investigated to ensure that wastewater is treated and up to standard to avoid further degradation of aquatic ecosystems. Even though the WMA is overall of low risk for aquatic ecosystems, this may become a larger issue if WWTWs are not addressed.

10.2.4 Risk Areas for Irrigation Use

Irrigation water quality is mostly of acceptable standard in the WMA. The WMA has a no-to-low-risk profile as of the 375 sampling stations, 218 (58%) sampling stations were classified as no risk and 121 (32%) as low risk (Fig. 10.15).

Sampling stations which measured mostly tolerable concentrations include 1 river, 5 estuary- and 7 WWTWs sampling stations in the Mvoti catchment, 2 river- and 14 WWTWs sampling stations in the Thukela catchment and 1 river-, 1 dam and 5 WWTWs in the Mhlatuze catchment. High-risk areas which mostly measured

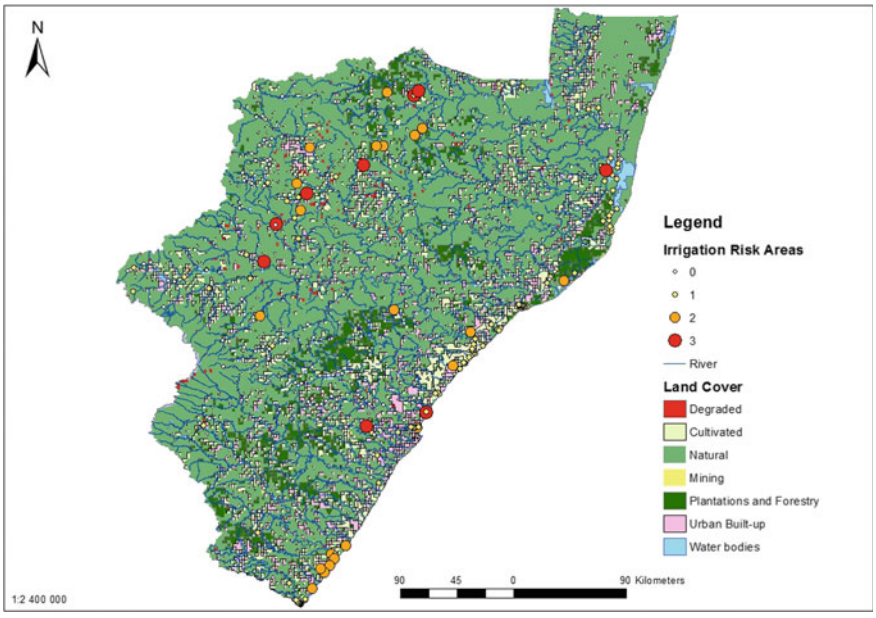

Fig. 10.15 Overall risk profile and significant risk areas for the Pongola-Mtamvuna WMA (irrigation standards)

unacceptable levels especially in terms of EC, calcium, chloride, sodium, ammonia, nitrate and phosphate include 1 estuary- and 1 WWTWs sampling station in the Mvoti catchment, 2 river- and 3 WWTWs sampling stations in the Thukela catchment and 2 rivers and 1 estuary sampling station in the Mhlatuze catchment.

High-risk areas are predominantly located downstream of WWTWs or urban built-up land cover as well as some cultivated areas. Cultivated areas located downstream of WWTWs or urban built-up areas should reserve some caution when using water for irrigation especially those located at the mentioned high-risk areas.

10.2.5 Risk Areas for Industrial Use

Industrial risk areas are predominantly of a low to no risk in the WMA. A total of 190 (51%) sampling stations were classified as low risk and 130 (35%) as having no risk. Medium-risk areas are spread across the WMA. A total of 45 sampling stations were classified as medium risk and measured mostly tolerable concentrations of the selected physical and chemical water quality parameters (Fig. 10.16).

The Mvoti catchment contains 3 river-, 7 estuary- and 4 WWTWs sampling points of medium risk and only 2 river sampling stations which were classified as high risk. In terms of the Thukela catchment, 8 rivers-, and 9 WWTWs sampling areas were

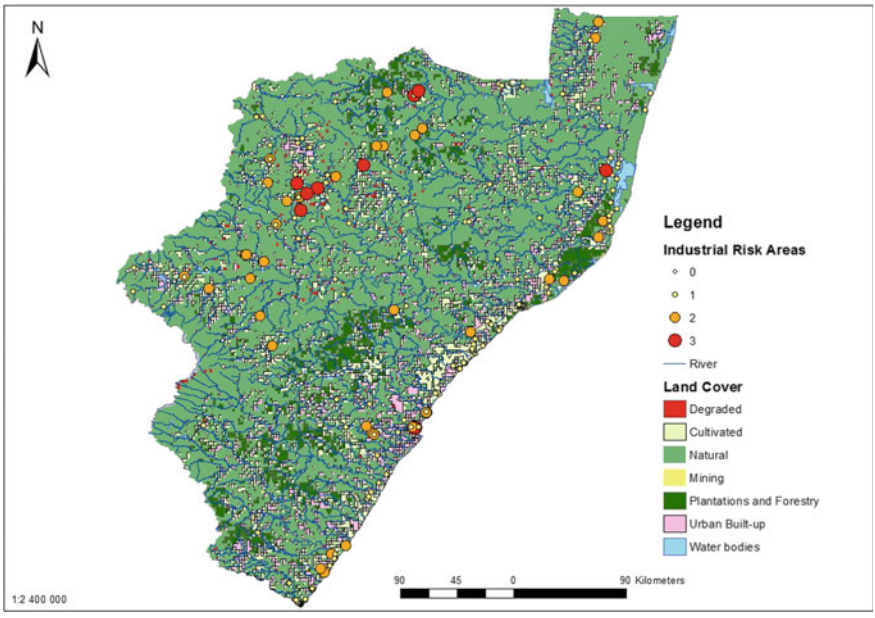

Fig. 10.16 Overall risk profile and significant risk areas for the Pongola-Mtamvuna WMA (industrial standards)

classified as medium risk and 3 river- and 2 WWTWs sampling points are high-risk areas. Lastly, 6 river-, 3 dam/lakes- and 5 WWTWs sampling points are medium-risk areas and only 2 river- and one estuary sampling point was classified as high risk.

The WWTWs within the Mhlatuze catchment are once again of concern as 5 of the 6 sampling points are identified as medium risk. Industrial activities located downstream of these facilities need to serve caution if water resources within these identified risk locations are used within their processes. Water resources downstream of urban built-up land cover may also pose a risk.

10.2.6 Risk Areas for Chlorophyll a and Faecal Coliform

A total of 107 sampling stations recorded *Chlorophyll a* concentrations during the time period. These sampling stations are primarily located close to the coastal area downstream of urban built-up land cover or cultivated areas. The *Chlorophyll a* risk for the WMA is medium risk as most sample stations measured tolerable concentrations. A total of 2 stations measured acceptable-, 92 tolerable- and 13 unacceptable concentrations of *Chlorophyll a* in the WMA in terms of domestic use (Fig. 10.17).

The St Lucia estuary is of concern as all sampling stations within the vicinity measured tolerable concentrations of *Chlorophyll a*. Sampling stations which measured

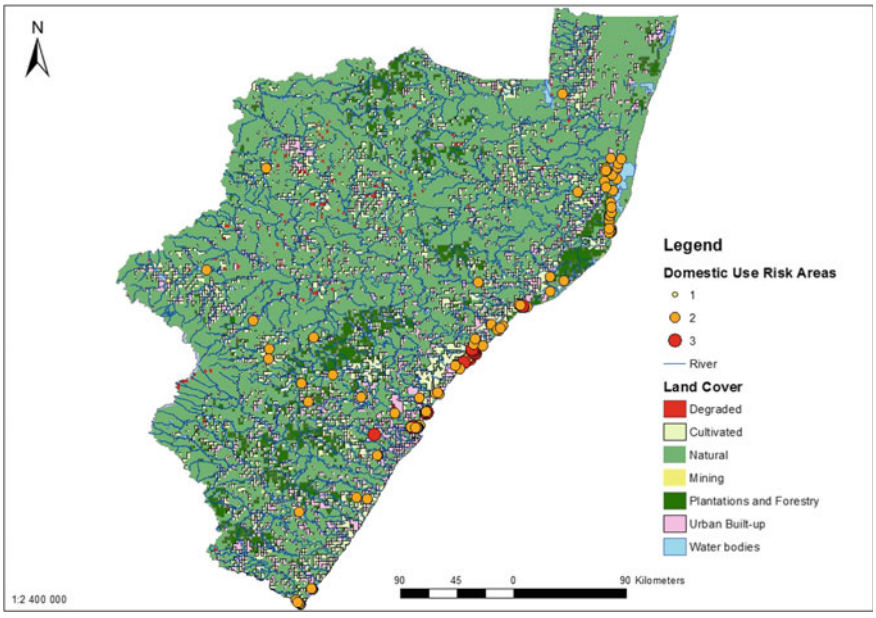

Fig. 10.17 Overall risk profile of *Chlorophyll a* for the Pongola-Mtamvuna WMA (domestic use standards)

unacceptable concentrations are predominantly located downstream of cultivated areas, WWTWs or urban built-up land cover areas. In terms of recreational water quality, the WMA is also mostly of medium to low risk as most sampling stations measured tolerable to acceptable concentrations of *Chlorophyll a*. A total of 66 sample stations measured tolerable, 25 acceptable and 13 unacceptable concentrations (Fig. 10.18).

Same trend exists as in the case of domestic use water quality where most high-risk areas are located downstream of cultivated areas as well as WWTWs and urban built-up. The monitoring network, however, needs to be expanded upon in the WMA as large areas are not being monitored for *Chlorophyll a*. The coastal region of the WMA clearly has significant issues with *Chlorophyll a* which can be mainly attributed to poor or inadequate WWTWs. For the WMA to avoid future eutrophication issues, it will have to invest in the improvement or upgrading of wastewater facilities as these are currently lacking and may exacerbate eutrophication issues in future.

A total of 150 sampling stations measured *Faecal coliform* in the WMA for the time period. In terms of domestic use standards the WMA is of high risk as 114 stations measured unacceptable- and 11 tolerable levels of *Faecal coliform*. Only 25 stations measured acceptable levels of *Faecal coliform* and are mostly located in undeveloped regions downstream of cultivated land cover areas (Fig. 10.19). The whole coastal area, as well as some urban centres located inland of the WMA, are plagued by unacceptable levels. Concerningly, mostly all sampling stations located

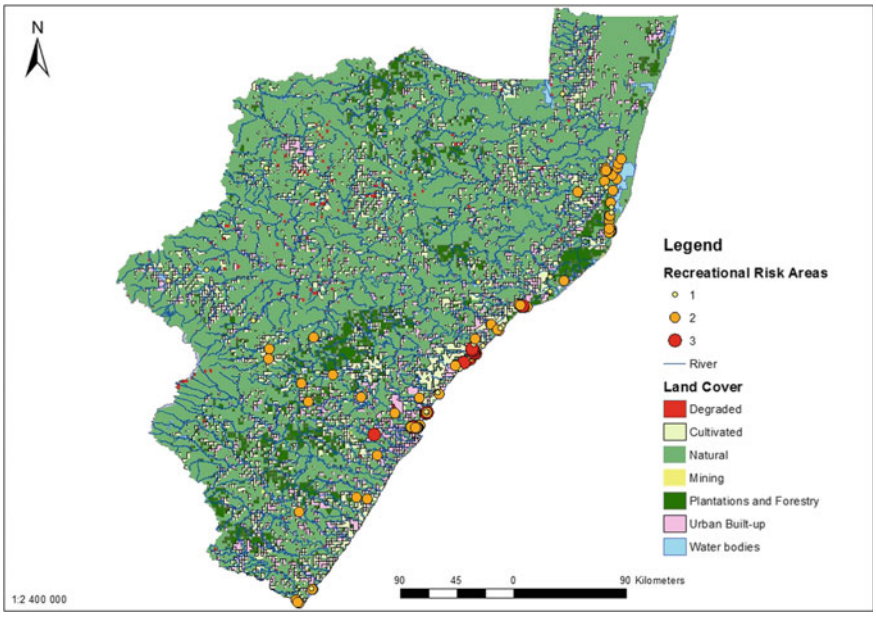

Fig. 10.18 Overall risk profile of *Chlorophyll a* for the Pongola-Mtamvuna WMA (recreational use standards)

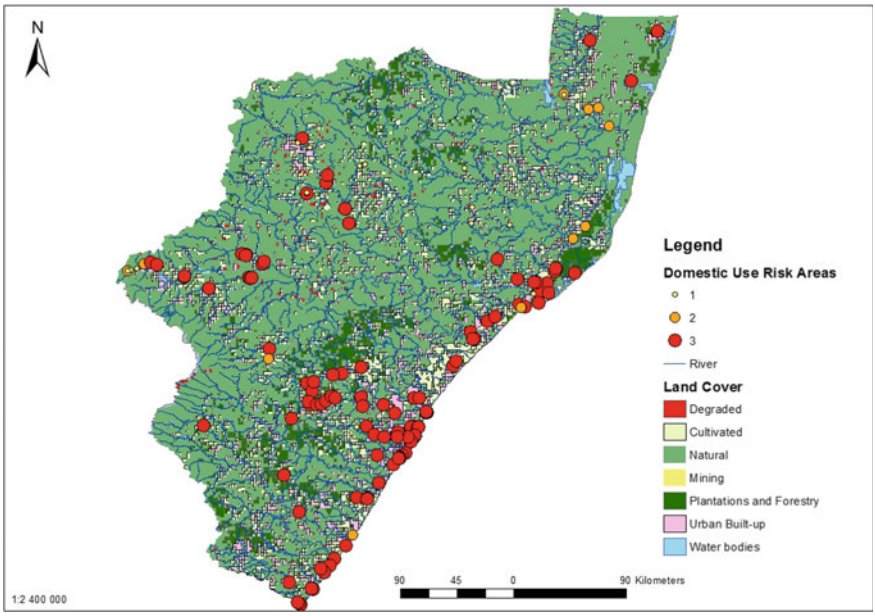

Fig. 10.19 Overall risk profile of *Faecal coliform* for the Pongola-Mtamvuna WMA (domestic use standards)

close to the coastal areas have measured unacceptable levels. Populations living in these areas, therefore, have to be cautious when making use of water from these areas and the development of desalinisation plants needs to take this into account as water obtained from the ocean will be contaminated and will require further treatment to remove *Faecal coliform* to be of an acceptable standard.

In terms of irrigation standards, the situation is a bit better, however, follows the same trend as above (Fig. 10.20). The WMA is predominantly of high to medium risk as most stations recorded unacceptable to tolerable levels of *Faecal coliform* for the period. Only 9 stations recorded acceptable levels and are once again located in undeveloped areas of the WMA.

The water quality of surface water resources is mostly fair except in terms of *Chlorophyll a* and *Faecal coliform*. Additional and more extensive water quality monitoring is however required to be able to fully understand the water quality of the WMA. Large parts of the WMA are in good ecological condition as majority of its rivers are classified as being largely natural to moderately modified. Rivers which are located within the vicinity of urbanised areas are classified as largely to seriously modified and are immensely impacted by urban built-up land use and associated activities. Most of the WMAs water resources are not stressed or under great threat. Water resources of rivers which have been largely or significantly modified are however stressed and under threat and requires precautionary approaches in the management thereof to maintain acceptable conditions. The WMA does, however,

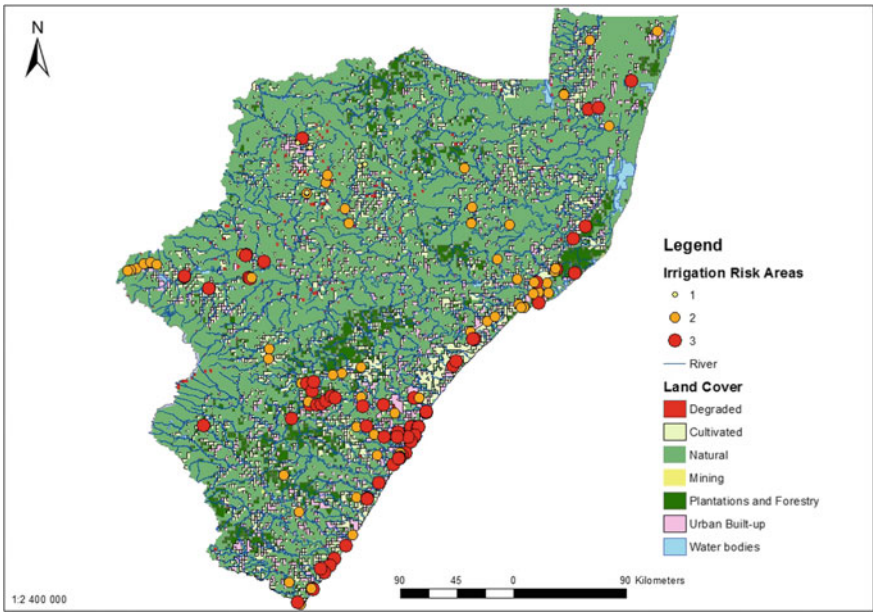

Fig. 10.20 Overall risk profile of *Faecal coliform* for the Pongola-Mtamvuna WMA (irrigation standards)

have to invest in the expansion of the water quality network but more importantly in the improvement or upgrading of current WWTWs as most of these facilities are not up to standard. The water resources of the WMA may become more stressed due to eutrophication problems caused by unacceptable levels of *Chlorophyll a* and may also face human health problems due to unacceptable levels of *Faecal coliform* especially in coastal regions.

10.3 Orange WMA

10.3.1 WMA Overview

The Orange WMA is of critical importance to South Africa and is made up of the Lower and Upper Orange catchments (Fig. 10.21). The Vaal River system is augmented from the Upper Orange (Senqu) by the Lesotho Highlands Water Project which supplies the economic heartland of the country. Thermal power stations located in the Highveld, irrigation schemes along the Vaal, Middle and Lower Orange rivers is also supplied by the river system. The Orange basin supplies approximately 15 million people which are heavily dependent on it.

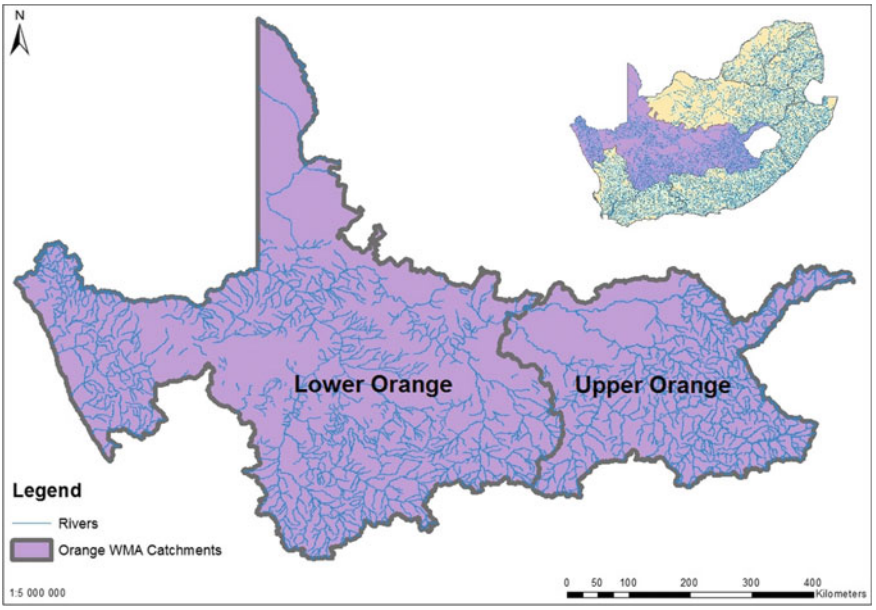

Fig. 10.21 Main catchments of the Orange WMA

The Orange River originates in the Drakensberg Mountains in Lesotho and flows towards the west through South Africa to the Atlantic Ocean at Alexander Bay. It is consequently the longest river in the country (2,200 km) with a total basin area of 973,000 km^2. The major tributaries within the WMA include the Vaal, Modder, Riet, Kraai and Caledon. The main storage dams in the Orange River are Gariep and Vanderkloof, Welbedacht Dam in the Caledon River, Rustfontein, Mockes, and Krugersdrift Dams in the Modder River with the Tierpoort and Kalkfontein Dams in the Riet River.

The Upper River stretches from the origin of the Senqu River to its confluence with the Vaal River. The Upper Orange catchment's land use is dominated by natural vegetation with the main economic activity being livestock farming. Large areas under dryland cultivation focussed mainly on grain production, primarily located in the north-east of the catchment. The Modder Riet sub-catchment is primarily focussed on agricultural activities with limited mining and few urban centres. Ficksburg is primarily known for cherry orchards in the region. Large areas under irrigation are primarily for growing of grain and fodder crops, located along the main rivers downstream of irrigation dams. Mangaung (previously Bloemfontein), Botshabelo and Thaba 'Nchu are the main urban and industrial developments and two large hydropower stations have been developed at the Gariep and Vanderkloof Dam. Mining has declined overall in the catchment and current activities mainly relate to salt works and small diamond mining operations.

The Lower Orange catchment includes the Orange River between the Orange-Vaal confluence and Alexander Bay. The Orange River forms a green strip in an arid region and also forms the border between South Africa and Namibia. Tributaries include the Ongers and Hertebeest rivers from the South and the Molopo River and Namibia Fish River from the North. The catchment is characterised by highly intermittent water courses along the coast which drain into the ocean. The Lower Orange is the largest catchment but is the driest and most sparsely populated catchment in the country. Minerals and water from the Orange River is the key for economic development in the region. Irrigation is the dominant water use sector in the Lower Orange, using 94% of the total water requirements. The importance of agriculture is attributed to the climate which is suitable for the growth of high-value crops, together with water availability along the Orange River.

The Orange River's flow regime and water quality has severely been impacted by extensive upstream developments. Salinity in the river has also increased due to the transfer of good quality water from the Orange River in Lesotho and Upper Orange WMA as well as due to saline irrigation return flows along the Orange River and its main tributaries. The poor quality water from the Vaal River, containing high proportion of irrigation return flows, mining drainage as well as treated urban effluent also periodically enter the Orange River, significantly negatively affecting its water quality. Current water demands on the Orange System is generally in balance with supply but additional demand will have to be met by increasing supply through building more storage or improving management of existing uses through water demand management and conservation strategies.

As indicated previously, the Orange WMA is dominated by natural landcover. The degraded land use cover is mostly bare soil areas (Fig. 10.22). Cultivated areas mostly occur in the north-eastern region of the WMA.

Water quality monitoring of surface water resources is limited especially within the Lower Orange catchment. Low water monitoring sites can be attributed to the catchment being mostly underdeveloped and being characterised by highly intermittent watercourses. A total of 88 sampling stations had suitable data for the period and are mostly located in the Upper Orange catchment. Of these 88 sample stations, 18 are dams/barrages-, 42 rivers-, 2 spring/eyes- and 26 WWTWs sampling stations.

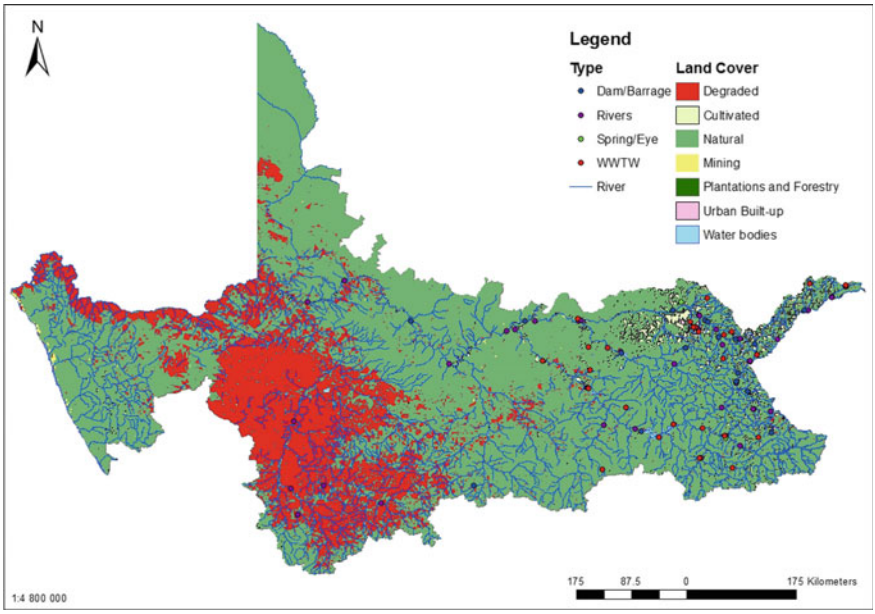

Fig. 10.22 Water quality sampling sites used and land cover of the Orange WMA

10.3.2 Risk Areas for Domestic Use

The Orange WMA is dominated by no-risk areas, followed by medium-risk areas (Fig. 10.23). A total of 50 (57%) sampling stations are classified as no-risk areas and 20 (23%) medium-risk areas. Only seven stations are classified as high risk.

Medium-risk areas are spread over the WMA especially within the Upper Orange catchment and are primarily located downstream of cultivated areas as well as urban built-up and WWTWs. No medium or high-risk areas were recorded in the Lower Orange catchment. Of the 20 medium-risk areas, only 1 is a dam/barrage sampling station and 2 spring/eyes. The other 17 medium-risk areas are all located within close proximity or directly downstream of WWTWs. The 7 high-risk areas which were established are all WWTWs sampling stations located in the Upper Orange catchment. The WWTWs within this catchment should, therefore, receive attention as most are not up to standard. The functioning and standard of effluent from these facilities should, therefore, be investigated to establish which steps need to be taken for these facilities to achieve acceptable standards of the selected water quality parameters.

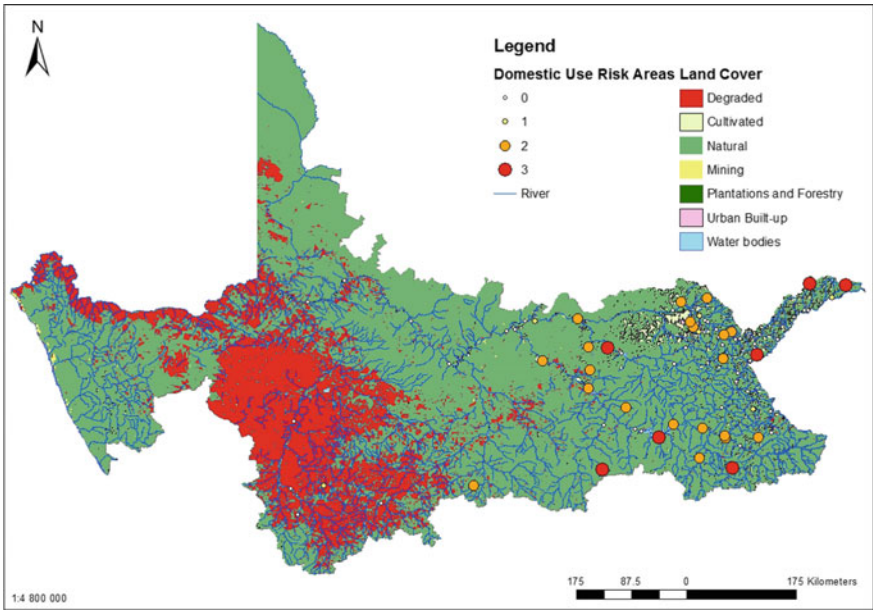

Fig. 10.23 Overall risk profile and significant risk areas for the Orange WMA (domestic use standards)

10.3.3 Risk Areas for Aquatic Ecosystems

The aquatic ecosystem water quality for the WMA is predominantly of low to medium risk. Of the 88 sampling stations, 57 sampling stations are of low risk, 23 of medium risk and 8 of high risk. Once again, these risk areas are located in the Upper Orange catchment especially close to cultivated and urban built-up land cover (Fig. 10.24).

Medium-risk areas are primarily located in the eastern half of the WMA and include 1 dam/barrage-, 4 rivers-, 1 spring/eye and 17 WWTWs sampling stations. High-risk areas are found close to cultivated and urban built-up land cover areas and are all WWTWs sampling stations. To ensure that the WMAs aquatic ecosystems are not degraded further, focus has to be placed on WWTWs as these facilities are clearly functioning below standard and are lacking proper management.

10.3.4 Risk Areas for Irrigation Use

The WMAs water quality for irrigation use is predominantly of no risk (Fig. 10.25). Of the 88 sampling stations, 52 (59%) are of no risk, 11 (12%) low risk, 18 (20%) medium risk and 7 (9%) of high risk all located in the Upper Orange catchment.

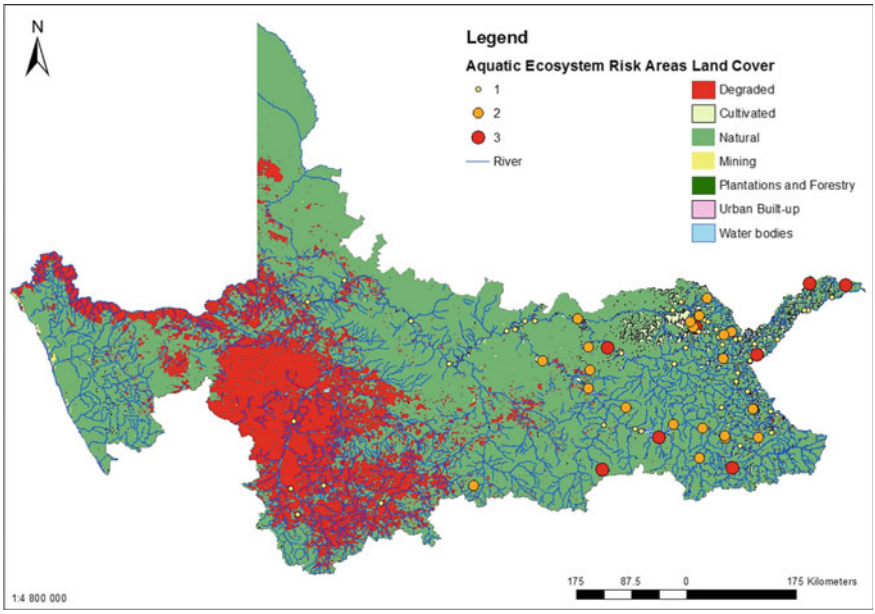

Fig. 10.24 Overall risk profile and significant risk areas for the Orange WMA (aquatic ecosystem standards)

Medium-risk areas to similar to those identified for domestic use and aquatic ecosystem water quality standards. Of the 18 identified medium-risk areas, 1 dam/barrage and 2 spring/eye sampling stations were classified as medium-risk areas. The other 15 stations are all WWTWs. In terms of high-risk areas, all 7 sampling stations are WWTWs. Farmers or irrigation schemes making use of water resources close to these areas or facilities should, therefore, reserve caution as high-risk areas are characterised by tolerable to unacceptable standards of pH, EC, chloride, sodium, ammonia and nitrate concentrations.

10.3.5 Risk Areas for Industrial Use

Industrial water quality for the Orange WMA is predominantly of low to medium risk. A total of 49 (56%) sampling stations were classified as low risk and 29 (33%) as medium-risk areas. Only 2 sampling stations were classified as being of no risk (Fig. 10.26).

Medium and high-risk areas are located in both the Upper and Lower Orange catchments. Medium-risk areas include 2 river sampling stations in the Lower Orange catchment and 1 dam/barrage-, 5 river-, 2 spring/eye- and 19 WWTWs sampling stations located in the Upper Orange catchment. High-risk areas according to industrial

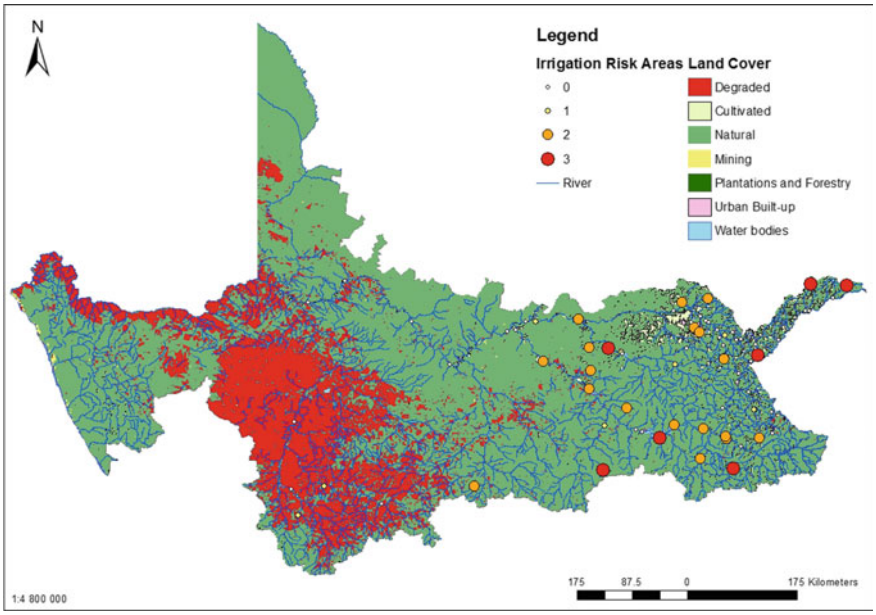

Fig. 10.25 Overall risk profile and significant risk areas for the Orange WMA (irrigation standards)

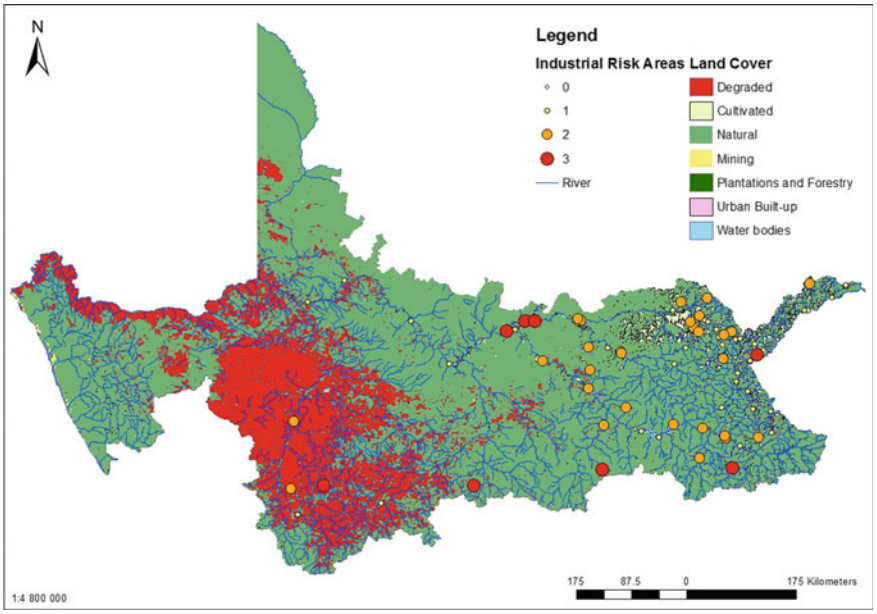

Fig. 10.26 Overall risk profile and significant risk areas for the Orange WMA (industrial standards)

water quality guidelines are primarily found in the Lower Orange catchment with 2 river- and 2 dam/barrage sampling stations recording mostly tolerable to unacceptable standards of pH, EC, chloride and sulphate. High-risk areas for the Upper Orange catchment include 1 river- and 3 WWTWs. All WWTWs sampling stations located in the Orange WMA recorded tolerable to unacceptable water quality standards for industrial water use in terms of the selected water quality parameters. Industries located downstream of these WWTWs facilities need to take note as the use of these water resources may affect the efficiency of operations and lead to unintended financial expenses due to the poor quality of water resources.

10.3.6 Risk Areas for Chlorophyll a *and* Faecal Coliform

The Orange WMA only has a total of 11 sampling stations which measure *Chlorophyll a* concentrations and are located along the course of the Orange River and on some tributaries located in the Upper Orange catchment. In terms of domestic use water quality standards, the WMA is of medium to high risk as nine of the 11 sampling stations measured tolerable standards. Unacceptable standards were recorded by 2 sampling stations either located downstream of urban built-up, specifically WWTWs, or downstream of agricultural activities within the Upper Orange catchment (Fig. 10.27).

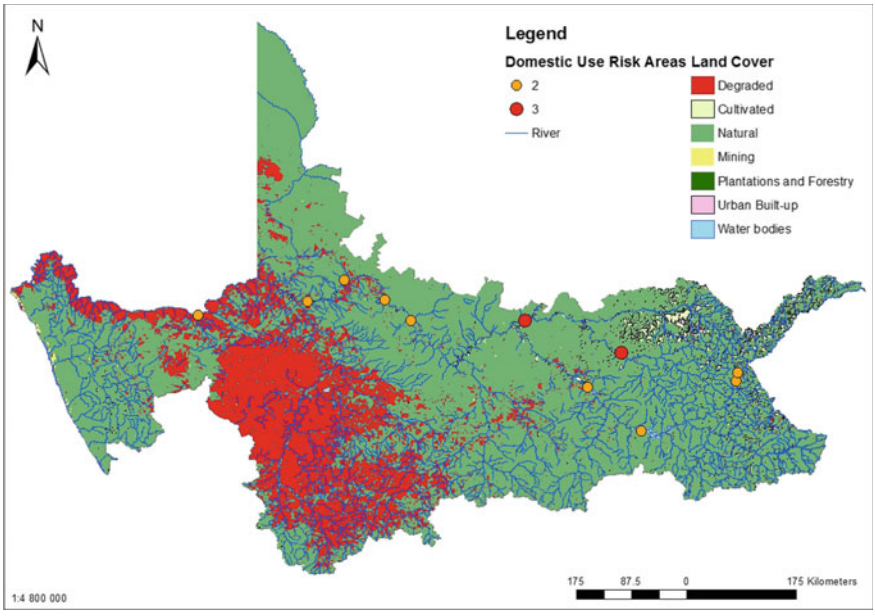

Fig. 10.27 Overall risk profile of *Chlorophyll a* for the Orange WMA (domestic use standards)

In terms of recreational water quality standards, the WMA is predominantly of medium risk as 6 sampling stations measured tolerable concentrations. Only 3 stations measured acceptable concentrations of *Chlorophyll a* and are located in natural land cover areas. High-risk areas are the same as above with 1 high-risk sample station located downstream of a WWTWs and other downstream of cultivated land cover (Fig. 10.28).

A total of 112 sampling stations recorded levels of *Faecal coliform* within the Orange WMA. In terms of domestic use water quality standards, the WMA is of high risk as 111 (99%) sampling stations recorded unacceptable levels of *Faecal coliform* which should be of great concern. Most sampling stations are located throughout the Upper Orange catchment with 3 sampling stations located in the Lower Orange catchment (Fig. 10.29).

The Orange WMA is of medium to high risk in terms of recreational water quality standards as 62 (55%) of sampling stations recorded tolerable levels and the other 50 (45%) sampling stations unacceptable levels (Fig. 10.30). High-risk areas are mostly located within close proximity or directly downstream of cultivated land cover or urban built-up. The overall tolerable to unacceptable levels of *Faecal coliform* in the WMA can be attributed to animal waste connected to livestock farming activities as well as below average effluent and wastewater from urban built-up areas, specifically WWTWs. The WWTWs facilities in the WMA can, therefore, be described as to be below average to poor as water quality measured downstream of these facilities are

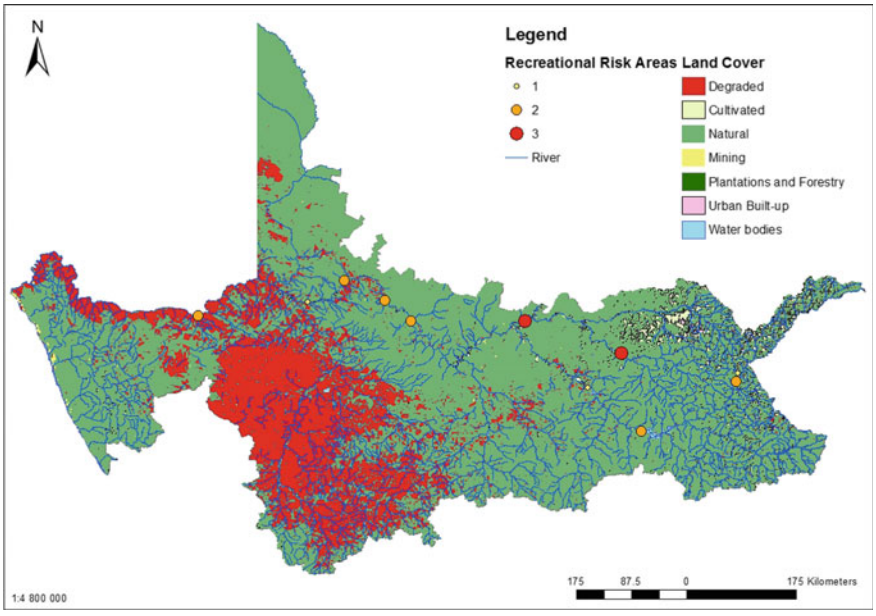

Fig. 10.28 Overall risk profile of *Chlorophyll a* for the Orange WMA (recreational use standards)

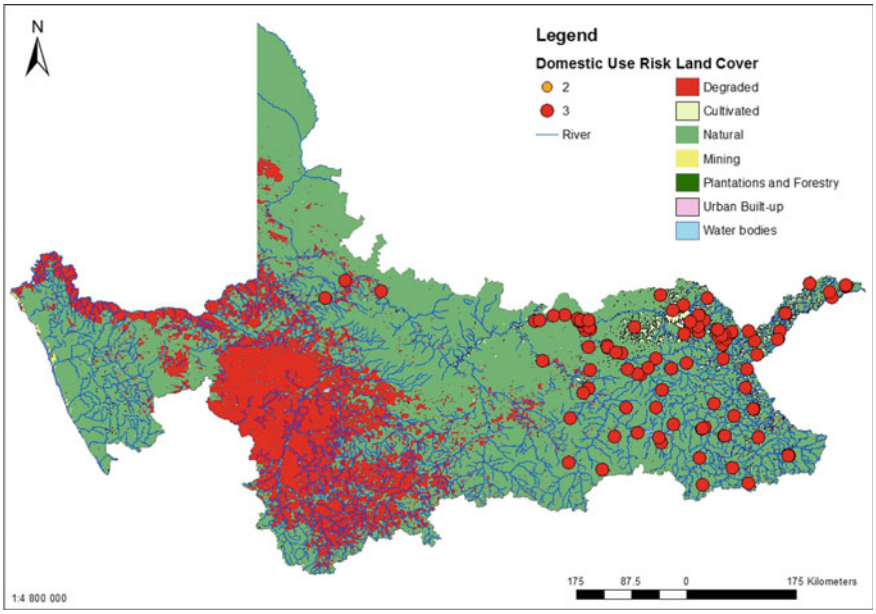

Fig. 10.29 Overall risk profile of *Faecal coliform* for the Orange WMA (domestic use standards)

predominantly of tolerable to unacceptable standards for all of the selected water quality parameters.

The water monitoring network within the WMA is therefore limited to the main stem of the Orange River with monitoring frequency being very intermittent. The Upper Orange is of an acceptable level in terms of salinity due to most of the water flowing from the Highlands of Lesotho into the Senqu River. Salinity however worsens becoming of a tolerable standard in the middle of the Lower Orange River. The Modder and Riet rivers are of a tolerable to unacceptable state primarily due to the impact of irrigation return flows as well as urbanisation and below average wastewater treatment. Salinity is of an unacceptable range at the Douglas Barrage on the Vaal River (just upstream of the confluence with the Orange River). The poor status of the barrage can be attributed to the impact of upstream irrigation activities including those from the Modder Riet catchment.

The ecological state of the WMA varies. The Upper Orange River is moderately to largely modified. Ecological state improves to moderately modified to largely natural state from the Augrabies to the Orange River Mouth. Smaller tributaries are predominantly of a moderately modified state and largely modified state with a very small percentage of tributaries in less developed areas being of a largely natural state.

Half of the WMAs catchments can be described as to be stressed surface water resources which are under threat which will require precautionary approaches to management to maintain good conditions. The WMAs water resources do still have

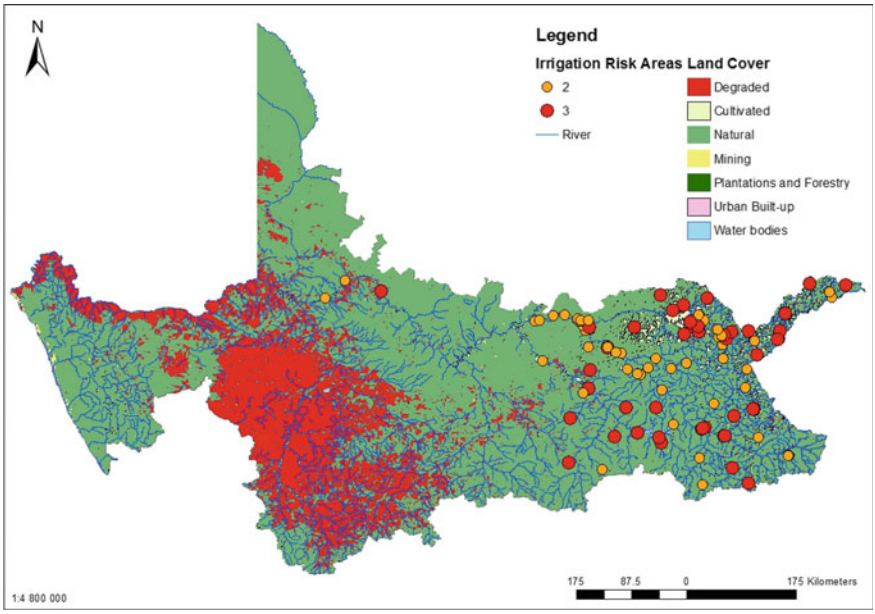

Fig. 10.30 Overall risk profile of *Faecal coliform* for the Orange WMA (irrigation standards)

the capacity to accept degrees of impact, however, this capacity will start to dwindle if medium-risk areas are not addressed.

10.4 Conclusions

The central WMAs vary significantly according to the established risk areas. All three of the WMA are mostly of low risk however significant risks were established which may have widespread environmental effects as well as possibly be accompanied by significant human health risks especially in terms of general unacceptable levels of *Faecal coliform*.

The Vaal WMA is characterised by both formal and informal urbanisation, industrial growth, agricultural activities and widespread mining activities. The Upper Vaal WMA is largely developed and plays a significant role in the country's economy as it serves the Gauteng Province with water. Significant risks were identified for most of the evaluated water quality standards in terms of the selected physical and chemical water quality parameters. The WMA is predominantly of low risk in terms of most of the water quality guidelines for the selected physical and chemical parameters. The Middle Vaal was found to be of highest risk as multiple significant risk areas were established which can be attributed to high concentration of cultivated areas as well as urban built-up and mining operations. WWTWs were found to be the biggest

culprit for tolerable to unacceptable concentrations of EC, sodium, ammonia, nitrate and phosphate throughout the WMA.

The Vaal WMA had very few sampling stations which measured *Chlorophyll a* concentrations and should be addressed. Most sampling stations measured tolerable to unacceptable levels of *Chlorophyll a* which can be attributed to runoff from cultivated areas and urban built-up areas as well as discharge of below standard wastewater from WWTWs. The Vaal WMA, especially in terms of the Upper Vaal catchment has an extensive *Faecal coliform* problem as almost all sampling stations recorded unacceptable levels. Unacceptable levels of *Faecal coliform* can mainly be attributed to runoff of animal wastes from cultivated land cover, inadequate sewage treatment facilities for scattered small towns and rural settlements as well as urban centres. WWTWs needs to be addressed throughout the WMA as this currently poses significant human health risks and will contribute to continued environmental degradation especially in terms of aquatic ecosystems which are already under stress due to anthropogenic activities.

The Pongola-Mtamvuna WMA is facing a major challenge in supplying additional water supply needed to meet the growing needs of the Kwazulu-Natal Coastal Metropolitan Area which includes Durban-Pietermaritzburg, KwaDukuza in the North to Amanzimtoti in the South. Water requirements which are constantly increasing and catchments are already in deficit. The WMA is predominantly of low to no risk for most of the selected water quality parameters in terms of physical and chemical water quality parameters. The *Chlorophyll a* monitoring network is mainly limited to the coastal region of the WMA, downstream of urban centres. *Chlorophyll a* concentrations were found to be mostly of a tolerable standard. Tolerable concentrations can be attributed to runoff of nutrients or wastewaters from cultivated and urban built-up areas. *Faecal coliform* is a major issue as most of the WMA is characterised by unacceptable to tolerable levels. Coastal regions especially those located downstream of urban centres or rural settlements are especially of high risk. The WMAs population, therefore, need to serve caution when making use of water for domestic or recreational use as it poses significant human health risk. The constructed desalinisation plants which will make use of these coastal waters also need to be aware of the major *Faecal coliform* risk as additional treatment will be required to ensure that water is suitable for domestic use.

The Orange WMA is also of critical importance to the country as the Orange River is the key for economic development in the region. The WMA supplies water to 15 million people and is predominantly focused upon agricultural activities in the Upper Orange catchment. The Lower Orange catchment is characterised by bare and dryland cover and is sparsely populated. The WMA is predominantly of low to no risk for most of the selected water quality parameters in terms of physical and chemical water quality parameters. The *Chlorophyll a* monitoring network is very limited as it only had 11 sampling stations which measured the parameter. The limited number of sampling stations measured tolerable to unacceptable levels of *Chlorophyll a* and is mainly attributed to runoff from cultivated areas. In terms of *Faecal coliform*, the WMA showed the same trend as the Vaal and Pongola-Mtamvuna WMAs. The WMA is challenged by unacceptable to tolerable levels of *Faecal coliform* mostly

in the more developed Upper Orange catchment. This is once again mainly due to inadequate or non-functioning WWTWs as well as runoff of animal wastes from cultivated areas as well as the absence of proper sewage treatment facilities for rural settlements.

The central WMAs need to expand their water quality monitoring network especially in terms of the measurement of *Chlorophyll a*, as eutrophication is an identified major water quality problem in the country. Monitoring of *Faecal coliform* should also be expanded as it is a major issue. Significant risk areas once again directly correlate with the highly altered nature of the catchments. Therefore, areas which are characterised by anthropogenic activities need to have more detailed monitoring in terms of all water quality parameters to ensure the proper identification of water quality problems before levels become of a tolerable or unacceptable nature.

All three of the WMAs also need to place a significant focus on the improvement of their WWTWs are these facilities are either inadequate, ill-maintained or not functioning properly due to mismanagement. Proper sewage treatment facilities also need to be constructed for rural settlements. These significant risk areas need to be addressed to minimise or limit future environmental degradation, significant human health risks as well as socio-economic costs.