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An Analysis of Water Management Practices in Uranium Mines in Namibia

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Abstract: Namibia is a water stressed country with a limited amount of fresh water. Therefore, the use of water is an important topic in the country's development agenda. Water is a shared and finite resource, with high social, cultural, environmental and economic values. However, freshwater resources are under pressure from ore processing, industrialization, urbanization and the demands of a growing population. In Namibia, ore processing, coupled with the anticipated increase in water demand for human consumption and other uses, has created significant stress on its limited water resources. This is critical in mining industry as water remains typically the prime environmental medium (besides air) that is affected by mining activities. This study sought to investigate the strides made in water management in mining, especially in environmentally sensitive areas in Namibia. Most mining companies operate adjacent to or alongside farms, national parks and fishing areas. The overall objective of this research is to highlight the current practices in Namibia's mineral industry operating in environmentally sensitive areas, especially where uranium is being mined and processed. The methodology consists of comprehensive literature review, field visits to the case study areas, and comparative studies with best practices. This study shows that over a ten-year period, freshwater consumption has been reduced by over 55% per tonne of milled ore in uranium mines, resulting in substantive financial savings as well as a delay in water augmentation through desalination. The strategies employed by Namibian companies involve inclusive stakeholders' engagement, recycling and reuse, and the minimization of water losses. The realization that the water challenge cannot be solved by any one party acting alone has been fundamental in ensuring environmental compliance within the mining industry in Namibia. Namibia's industrial leaders have increasingly recognized that reducing the water footprint of mining activities must be one of the key performance indicators for management.

Keywords: cleaner production, environmentally sensitive, freshwater, stakeholder engagement, water stewardship

1 Introduction

Water is an increasingly scarce but valuable resource across the globe. Governments, communities and industries are experiencing unprecedented concerns as a result of the increasing demand from fast growing populations, unsustainable water practices and persistent droughts (Savenije and Van der Zaag 2008). Climate change is expected to place more pressure on available water resources, with some regions predicted to become much drier and other regions wetter. Water is an essential component of most mining and metals operations. However, global water resources are under increasing pressure and it is widely recognized that a holistic approach to water management is required in order to achieve resource sustainability and to secure future access (ICMM 2014). In Namibia, ore processing coupled with anticipated increases in water demand for human consumption and other uses, has created significant stress on the limited water resources of the country. Freshwater resources are under pressure from ore processing, industrialization, urbanization and the demands of a growing population (Musiyarira et al 2017). This is critical in mining industry as water remains typically the prime environmental medium (besides air) that is affected by mining activities. This study sought to investigate the strides made in water management in mining in some environmentally sensitive areas of Namibia. Most of the mining companies operate next or alongside farms, national parks and fishing areas. Therefore the future of mining depends on the sustainability of the Earth's water resources, which are increasingly under pressure. Water supply and quality have emerged as the top risk facing minerals industry. The overall objective of this research is to highlight the current practices in Namibia's mineral industry, which is operating in environmentally sensitive areas, especially in areas where uranium is being mined and processed.

Namibia is one of the countries that could face an especially significant increase in water stress by 2040 (Maddocks et al 2015). This means that businesses, farms, and communities in these countries in particular could be more vulnerable to water scarcity than they are today as shown in Figure 1. Therefore, the use of water is an important topic in the country's development agenda. Freshwater is a precious, shared resource with significant social, environmental and economic values. In Namibia,

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most of the mining activities are found in water stressed areas and they are increasingly in competition with different users, presenting challenges to the security of supply. The future of mining companies and society depends on the availability of freshwater resources, which are increasingly under pressure. Globally, the per capita availability of freshwater is steadily decreasing and the trend will inevitably continue as the world's population grows towards nine billion people. As a result, many regions of the world are reaching a point of "freshwater stress", where freshwater resources can no longer support the demands of human populations (WBCSD 2012). Therefore, the approach to water management cannot remain business as usual as it needs a paradigm shift in the implementation of the best practices which minimize the potential for adverse environmental, social and economic impacts.

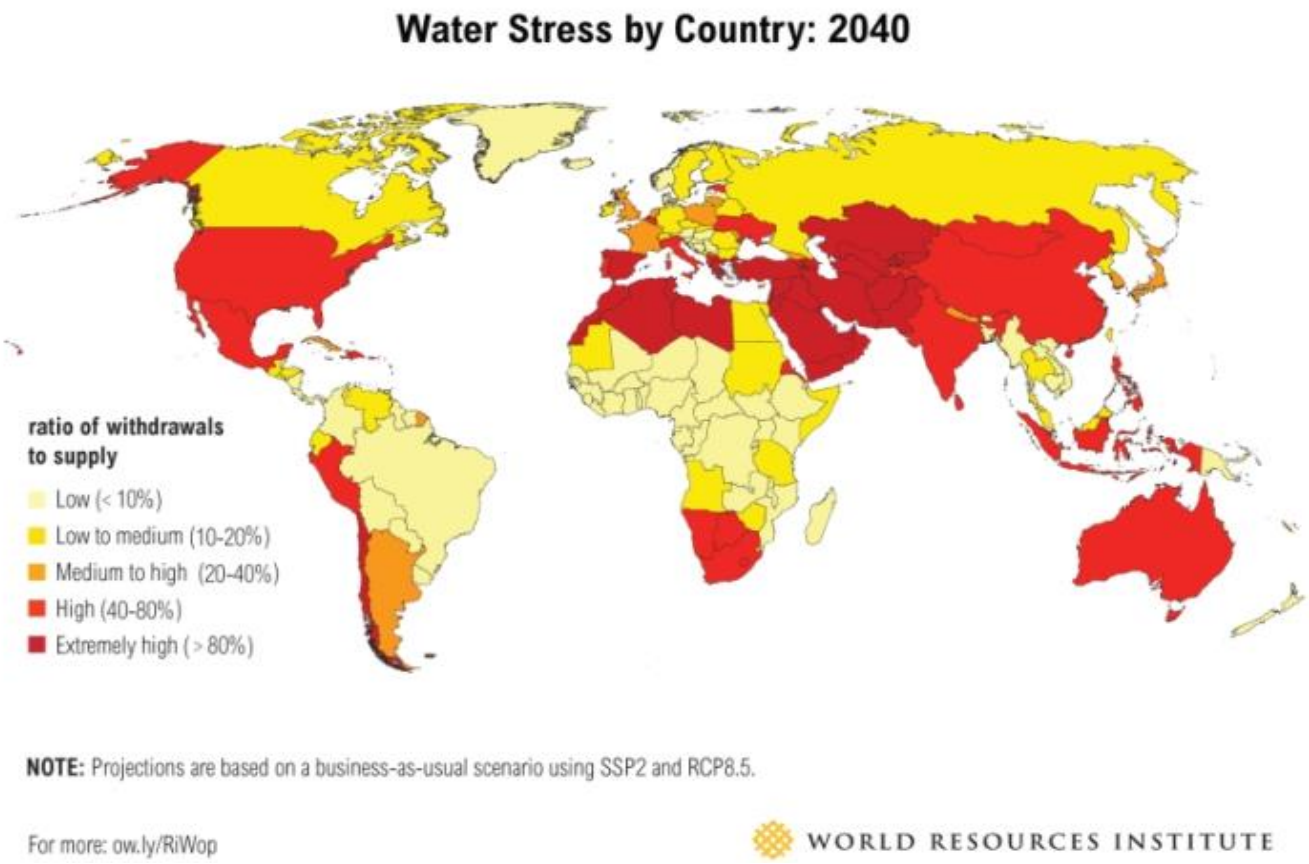

Figure 1. Water stress by country (Maddocks et al 2015)

2 Overview of Mining in Namibia

Namibia is a primary source for gem-quality diamonds mined inland and offshore, and is the fifth-largest producer of uranium in the world. Namibia produces gem quality rough diamonds, uranium oxide, special high-grade zinc and acid-grade fluorspar, as well as gold bullion, blister copper, lead concentrate, salt and dimension stone. Rio Tinto and Vedanta produce and export uranium oxide and special high-grade zinc respectively. Paladin Energy's Langer Heinrich Uranium mine achieved nameplate production in 2013. De Beers works with the Government of the Republic of Namibia through Namdeb Holdings in a 50:50 joint venture, producing some of the world's finest gem diamonds. Namibia's output increasingly comes from the marine environment, reflecting the technical expertise of Debmarine Namibia. Further value addition is boosted by eleven cutting and polishing factories, supplied with rough diamonds from Namibia Diamond Trading Company, worth approximately US$300 million annually (Ralston et al 2015).

2.1 Mining and the environment in Namibia

Worldwide, the mining industry has always posed a great threat to protected areas. While the environmental consequences may be the most obvious, the indirect social effects may also impact on protected area values (Phillips 2001). Most of the Namibian uranium exploration and mining activities occur in the Central Namib, an ecologically sensitive area containing parts of the Namib-Naukluft and Dorob National Parks, where the climate experiences low and erratic rainfall, soaring temperatures and strong seasonal winds that cause high water evaporation rates. The potential for significant impacts is greater when mining occurs in remote and environmentally or socially sensitive areas (Petts 2009). Mining activities can have both positive and negative environmental, economic and social impacts on communities. Worldwide, the mining industry has always

posed a great threat to protected areas. While the environmental consequences may be the most obvious, the indirect social effects may also impact on protected area values (Phillips 2001).

Namibia is one of the few countries that incorporated environmental sustainability in her constitution. Article 95 (Republic of Namibia 1990) emphasizes the importance of environmental protection by stating that Namibia actively promote and maintain the welfare of her people by adopting policies aimed at the maintenance of ecosystems, essential ecological processes and the biological diversity of Namibia, and the utilization of living natural resources on a sustainable basis for the benefits of all Namibians (Republic of Namibia 1990). Minerals are essential to every sector of the nation's economy and they will play a determining role in the feasibility of the emerging technologies that sustainability requires. Water is increasingly recognized as a critical issue for sustainable development. Although the mining industry's overall "water footprint" is relatively small compared to other sectors, most mining companies have recognized the importance of fresh water and the need to take actions to reduce mining industry's water consumption. Mining is vital for the growth of the Namibian economy, and the country must therefore reconcile development objectives and mineral exploitation with environmental protection for its long-term socio-economic growth and stability.

2.2 Environmental regulations in Namibia

The Ministry of Environment and Tourism (MET) was established in 1990 and is responsible for safeguarding Namibia's environmental resources. Since then, the MET has implemented far-reaching policy and legislative reforms in the environmental sphere in an attempt to alleviate many of the constraints that the environment places upon people and vice versa. Namibia's Policy for Prospecting and Mining in Protected Areas and National Monuments aims to promote sustainable development in Namibia by allowing prospecting and mining in protected areas with strict environmental management. The policy stipulates that any mining developments in a National Park must be balanced against the risk that it could negatively interfere with the potential for long-term sustainable development. The policy states that a full Environmental Assessment is required for any mining in a Protected Area and/or National Monument, as set out in the Environmental Management Act (2007) (Office of the Prime Minister of Namibia 2007). The mission of the MET is to maintain and rehabilitate essential ecological processes and life support systems, to conserve biological diversity, and to ensure that the utilization of natural resources is sustainable for the benefit of all Namibians, both present and future, as well as the international community, as provided for in the Constitution.

2.3 Water related regulations in Namibia

The Water Resources Management Act No. 11 of 2013 was enacted to provide for the management, protection, development, use and conservation of water resources; to provide for the regulation and monitoring of water resources and to provide for incidental matters. The Environmental Management Act (EMA) is in line with modern legislative trends, including; adherence to the polluter pays principle, the inherent need to incorporate adequate provisions to achieve "reduction-at-source" in the areas of pollution control and waste management, and the need to consider alternatives and to avoid or minimize negative impacts wherever possible. Before a mine can commence with its activities, it must obtain a Record of Decision and a Letter of Authorization. However, the Letter of Authorization from the MET is not a blanket permission to implement the project; the applicant is still required to obtain a sectoral license or permit, depending on the nature of the envisaged project. Individual mines are responsible for managing their wastewater and industrial effluents as well as for applying for exemption permits, if required.

The Water Act is the principal legal document according to which the Department of Water Affairs currently operates (Office of the Prime Minister of Namibia 2013). The relevant Sections of the Water Act are 21-24, 26 and 170. Section 21 promotes water conservation. It stipulates that water which has been used for industrial purposes shall, after purification, be returned at the nearest convenient point to the place from which the water was abstracted and it shall not be diminished in quantity more than is justified by its use.

The Minerals Prospecting and Mining Act, 1992 (Office of the President of the Republic of Namibia 1992) stipulates that it shall be a term and condition of any mineral license that the holder of such a mineral license shall prepare in such form as may be determined by the Commissioner for the approval of the Commissioner: an environmental impact assessment indicating the extent of any pollution of the environment before any prospecting operations or mining operations are carried out and an estimate of any pollution, if any, likely to be caused by such prospecting operations or mining operations. If any pollution is likely to be caused, then a detailed environment management plan indicating the proposed steps to be taken to minimize or prevent the risk must be developed. This plan must be carried out to the satisfaction of the commissioner (MME 2008). Thus the above clause is important in preventing the pollution of water resources by the mining industry.

2.4 Water monitoring and control

The use of water in mining has the potential to affect the quality of surrounding surface water and groundwater. In response to environmental concerns and government regulations, the mining industry worldwide increasingly monitors the water discharged from mine sites, and a number of management strategies have been implemented to prevent water pollution. Water issues and management vary from site to site and they must be addressed locally, but in general, the mining industry seeks to minimize its impacts on water quality and availability. Section 17 of Part V of the EMA empowers the Environmental Commissioner to conduct inspections to monitor compliance with the Act and with conditions stipulated in the Environmental Clearance Certificate. If monitoring and/or inspections reveal that a developer is not abiding by the conditions of the Environmental Clearance Certificate or has contravened the

EMA, the Environmental Commissioner has the power to suspend or cancel the Certificate for a period s/he may determine. The certificate can be reinstated once the Environmental Commissioner is satisfied that the person concerned has rectified the failure that led to the suspension.

3 Water Management

Water is an integral part of all mining operations and no mine can operate without managing water. The business case for leading practice management of water is driven by the need to manage strategic and operational risks and opportunities. Risks and opportunities must be managed at both corporate- and site levels to ensure that shareholder value is maximized, production is secure and the community and environmental values associated with the water are maintained or enhanced (Australian Department of Resources, Energy and Tourism 2008). Top level support and leadership is key to leading practices in water management. The ICMM (2014) report on catchment management strategies reveals that historically mining has approached water as an operational issue, one that is managed inside a fence with a focus on water efficiencies and control of effluent discharges. The same report highlights that its members have come to recognize that even the most water efficient operations that stringently manage water discharges can still be subject to significant water risks manifesting from outside the operation fence line at the catchment level.

Corporate water management is a complex, iterative process that requires companies to assess their water situation, evaluate the impacts of their activities on water, and determine the best course of action on a continual basis (WBCSD 2012, Dragasakis et al 2013). Water risks are different from the water impacts for a company, since one company's risks can depend as much on what happens outside their fence line as what happens within it. In this respect, it is crucial that businesses, communities, and other stakeholder groups work together to manage water resources effectively (WBCSD 2012). Water stewardship is an emerging concept within the industry which supports the sustainable and equitable production and use of water in mining operations. This broader concept involves the care and management of water through its life cycle as shown in Figure 2. One of the central tenets of the ICMM Water stewardship framework is the need for the industry to move from managing water as solely an "inside the operational fence" issue to adopting a catchment-based approach which considers other users. Impacts of sub-standard water management may not only impact at a local level but may escalate rapidly to become national and international issues, consuming large resources.

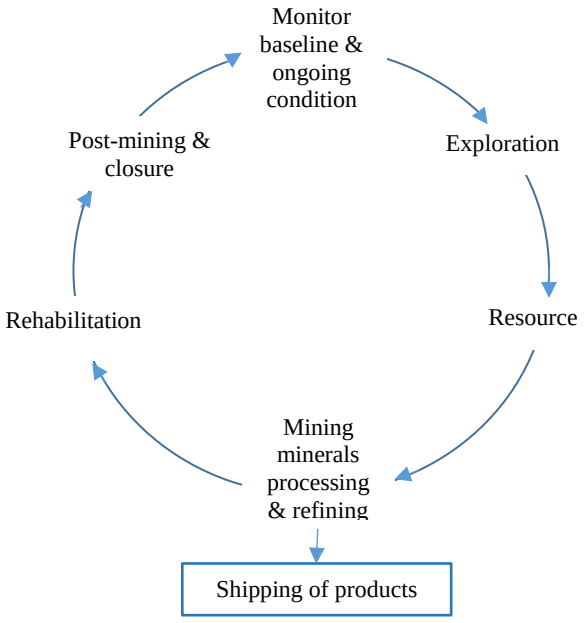

Figure 2. Water life cycle (Source: Australian Department of Resources, Energy and Tourism 2008)

3.1 Best practices in water management

The rate of water reuse and recycling in ore processing is often very high at mine sites, especially in areas with arid climate (Rankin 2011). A number of innovative water conservation practices are being developed and implemented to reduce water use. The recognition and adoption of best practice principles are considered fundamental cornerstones of sustainable development for the uranium industry. Best practices refer to the development of operation specific methodologies that integrates global and local knowledge, which enable planning to produce the best available and most practicable methods to address an operation's site-specific requirements and conditions. Best practices, by nature, are not static but are continuously evolving in response to new technology, increased understanding and awareness of environmental and social impacts, and increasing regulatory requirements and public expectations.

3.2 Mining practices

Over the years, the mining industry has generated a considerable amount of guidance on how mining practices must evolve for the sector to responsibly fulfill its role in the society's transition to sustainability (Brantes and Olivares 2008). However these practices are not widely embraced, and the degree to which they are implemented varies across political jurisdictions, subsectors of the industry and even with private or public and state owned enterprises. Kogel et al (2014) argue that a large number of mining companies are increasingly recognizing that reducing their water footprint must be a high management priority. The mining industry recognizes that sustainability issues comprise part of a new business reality, in which traditional responses no longer fully satisfy the expectations of investors, communities, employees and other stakeholders. However, while the new business reality is clear to most, the appropriate business response can be elusive and sustainability implementation can be challenging (Ramage 2014). In reality, sustainable development involves managing resources in a way that is conducive to long term wealth creation and the maintenance of capital (natural, human, social, economic and physical). The International Council on Mining and Metals' definition of sustainable development for the mining and metals sector

means that investments should be technically appropriate, environmentally sound, financially profitable and socially responsible. This perspective extends naturally to mineral resources, which are a form of endowed natural capital, and they are an important source of wealth (Shields et al 2012).

3.3 Namibia Uranium Association

Namibia Uranium Association (NUA) seeks to balance environmental protection values with the exploration and mining of uranium. The Uranium industry through the NUA has been spearheading a campaign to encourage the mines to work together in developing water stewardship initiatives in an inclusive and transparent manner that ensures sustainable water management (NUA 2017). Namibian uranium mining companies subscribe to the International Council on Mining and Metals' interpretation of sustainable development for the mining and metals sector, namely that investments should be technically appropriate, environmentally sound, financially profitable and socially responsible. The Water and Air Quality Management working group is one of the four groups that assists the uranium operations in safeguarding their reputation as a safe and responsible industry under the Sustainable Development Committee (SD). The Working Group assists the Namibia Uranium Institute in promoting and sharing leading practices and transferring knowledge with regards to water and quality management. It also provides a uranium industry-wide opportunity to discuss and examine water and air quality related risks and advises the SD Committee on the co-ordination and prioritization of water and air quality risk management issues throughout the industry (NUA 2017). NUA members accept product stewardship as a pillar that supports the overarching concept of Sustainable Development. It ensures that businesses focus on economic development, environmental impact management and social responsibilities through building partnerships throughout the uranium life cycle to ensure that production, use and disposal are consistent with the global sustainable development goals. NUA members do not see uranium stewardship as a compliance issue, it is rather a means to shape their future operational processes, products, services and relationships in a way that ensures that the production, use and disposal of uranium are consistent with global best practices. Cumulative socio-economic and biophysical impacts of mining cannot be successfully addressed by a single company acting in isolation, and unsustainable practices by one company can impact negatively on the entire industry. Proactive cooperation between exploration and mining companies and harmonized positions with reference to health, the environment, radiation safety and security and community issues are therefore a necessity (NUA 2017).

4 Methodology

The methodology used in this study consists of a comprehensive literature review, field visits to the case study areas and interviews. Statistical surveys and comparative studies with mining companies outside Namibia are an integral part of this study. Reports and documents from various stakeholders are also analyzed. Most of the detailed information from the mining companies could not be incorporated in this paper because it is regarded as confidential. However, trends are drawn from the information. This study has identified gaps in the management strategies being employed and pointed out areas for improvement. Moreover, it has identified novel practices that could be shared with other mining companies.

5 Results

Over the last few years, the mines have applied a number of different water management strategies which are aimed at reducing their freshwater intake, reducing the volumes of effluent discharged to the environment, minimizing the deterioration in water quality in the mine circuits and treating the water to the required level for reuse or discharge. Namibia's industrial leaders have increasingly recognized that reducing the water footprint of mining activities must be one of the key performance indicators for management. The realization that the water challenge cannot be solved by any one party acting alone has been fundamental in ensuring environmental compliance within the uranium mining industry in Namibia.

5.1 Enforcement of legislation

The ultimate way of ensuring the sustainability of mining in sensitive areas is through developing and strengthening legislation and sound policies coupled with enforcement mechanisms and putting proportionate pressures on the industry to instill good corporate citizenship principles in all their operations. In as much as there has been such enforcement, there are still capacity challenges for the enforcement agencies, which is further complicated by having overlapping roles and responsibilities in administering environmental related acts which are administered under different line ministries. The best way for ensuring that mining in sensitive areas is done sustainably is to ensure that standards and protocols for pollution prevention and monitoring are strictly enforced.

5.2 Water stewardship initiatives

Namibia has water availability challenges and therefore water management remains a critical issue. Uranium mining companies in Namibia have been developing a vision on water stewardship, which includes a broader concept of catchment water management as opposed to the individualistic water management approaches. To achieve this, public meetings, interviews and consultations have been held with the aim to reveal community concerns related to mining activities. This initiative has led to the availability of more fresh water, therefore decreasing the competition for water between mining operations and human consumption. The all-inclusive stakeholder engagement strategy employed by the uranium mines is regarded as a good leading practice which other countries seeking to strike a balance between competing interests including mineral extraction, environmental and wildlife conservation and farming, may learn from.

5.3 Freshwater consumption

This study shows that over the past two decades freshwater consumption has generally decreased by close to 55% per tonne of uranium oxide (U_3O_8) produced. This reduction in freshwater consumption came through water management and sustainable practices. Rössing Uranium's target for freshwater consumption is 0.8 m^3 per tonne of U_3O_8 based on their stakeholder report (RUL 2015) as shown in Figure 3. The water management plan was mainly influenced by the parent company's performance standards and guidelines. The aim of the plan is to ensure sufficient, safe and sustainable use and protection of water resources and ecosystems. It is also important to note that lower tonnages at fixed water usages, combined with lower grades, result in a higher consumption of fresh water per tonne of U_3O_8 produced. Figure 3 also shows that there was an increase in the fresh water rate per tonne of uranium oxide produced in the years 2012 to 2015. This increase in freshwater is explained by lower ore grade, which requires more ore to be milled to achieve the same uranium oxide production output.

5.4 Freshwater consumption / tonne of milled ore

This study shows that over the past three decades freshwater consumption was reduced from an average high of 0.65 m^3 to an average low of 0.27 m^3 per tonne of uranium ore milled. This freshwater reduction resulted in substantial financial savings as well as delaying water augmentation through desalination. The drop in 2010/2011 as shown in Figure 3 was a result of unusual excessive rainfall experienced in Namibia and most of the mines harvested that water and used in their operations, which in itself is commendable as a sustainability measure. The active mines are recycling approximately 50 – 60% of their process water. Water segregation is therefore playing a crucial role in the water management strategies advocated by the mines and this has led to decreased freshwater consumption per tonne of milled ore as shown in Figure 4.

5.5 Water demand

According to a *World Bank* report by Kusek and Rist (2004), water demand is determined by four major driving forces, namely population, technology, trade and environment. The past two decades have seen an increase in the population, building activities, the establishment of numerous industries and new uranium mines in the Erongo region in Namibia. All those resulted in a steep growth of water demand to the extent that almost exceeded the available resources. This has led Areva Namibia Uranium Company to build its own desalination plant with a capacity of 20 million cubic meters per annum. It is difficult to predict when demand will outstrip supply as over the medium term it depends to a large extent on how much water can be obtained and delivered from the additional construction of new desalination plants, and also on how the mining and other industries' demand will develop and work to reduce their water footprint. Over the next 13 years till 2030, mine water demand is expected to increase by nearly 20% as shown in Table 1. While the margin of percentage increment for mine water demand

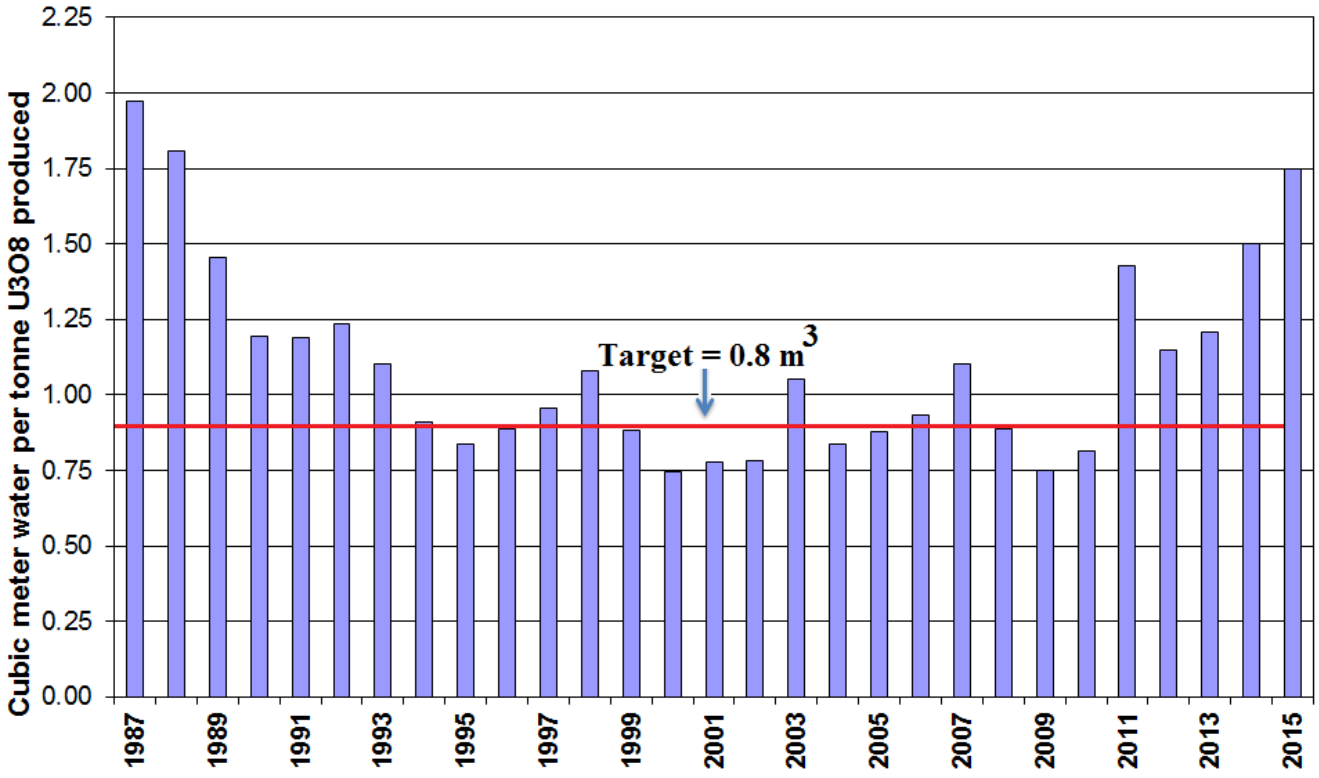

Figure 3. Average freshwater consumption per tonne of U_3O_8 produced

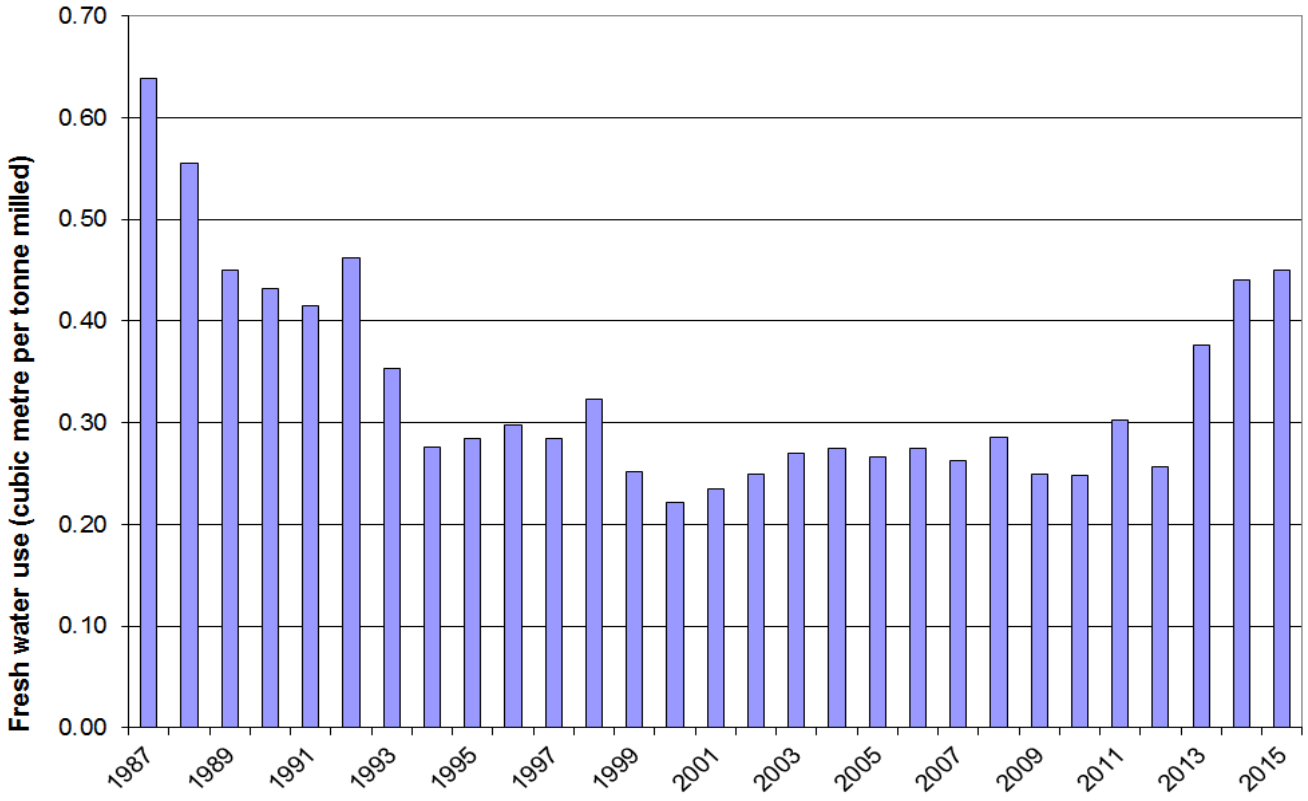

Figure 4. Average freshwater consumption per tonne milled.

appears small as compared to other sectors, the effect of mining activities on water quality and the environment can be quite severe if not managed well. Mines can constitute a serious pollution threat in karst and other secondary aquifers if not properly managed and controlled. It is known that impacts of sub-standard mine water management may not only impact at a local level but they may escalate rapidly to become national and international issues, consuming large amounts of resources. Water has to be managed in a holistic way across its life cycle. Managing water resources and eliminating waste at source is a cleaner production philosophy. This philosophy when drilled into mine workers will bring in the required changes to how freshwater is managed at the mine. Efficient freshwater use starts with minimizing the input and losses associated with it. Basic good housekeeping aspects of replacing worn out hoses,

Table 1. Water demand projections [Mm^3] in Namibia (IWRM 2010)

Consumer group	2008	2015	2020	2025	2030
Urban	66	80	91.1	103.5	117.2
Rural Domestic	10.3	10.6	10.9	11.1	11.4
Livestock	86.8	86.8	86.8	86.8	86.8
Irrigation	135.3	204.6	344.6	379.8	497.2
Mining	16.1	17.2	18.1	19.1	20.3
Tourism	19.1	27.5	31.9	35.2	38.9

sealing leaks and using pressurized water for cleaning equipment coupled with the use of recycled water for dust suppression have allowed Rossing Uranium to save at least 3000 m^3/day of fresh water (RUL 2015).

5.6 Research and development

The most worrying fact found by this study is that during the past decades, the global mining industry has dedicated only small expenditures to research and development, much less than the 20% to 30% levels in other industries (ICMM, 2012). The same applies in the context of Namibia, where, with the prevailing low commodity prices, most companies have embarked on cost cutting measures including activities related to strategic research for the organizations. Mining companies in Namibia therefore need to undertake water-saving actions and initiatives, and together set targets and develop a vision on water stewardship which must include a broader concept of catchment water management.

6 Conclusions

Namibia is a water stressed country with a limited amount of freshwater. Freshwater resources are under pressure from ore processing, industrialization, urbanization and the demands of a growing population. In Namibia, ore processing, coupled with anticipated increase in water demand for human consumption and other uses, has created significant stress on the limited water resources of the country. This study seeks to investigate the strides made in water management when mining in environmentally sensitive

areas of Namibia. This study reveals that over a 30-year period, freshwater consumption has been reduced by over 55% per tonne of milled ore in uranium mines, resulting in substantial financial savings as well as a delay in water augmentation through desalination. The strategies employed by the Namibian uranium industry involve inclusive stakeholders' engagement and joint water stewardship approaches, recycling and reuse as well as the minimization of losses. The realization that the water challenge cannot be solved by any one party acting alone has been fundamental in ensuring environmental compliance within the uranium industry in Namibia. Namibia's industrial leaders have thus increasingly recognized that reducing the water footprint of mining activities must be one of the key performance indicators for management.

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