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STAKEHOLDER ACCORD ON WATER CONSERVATION

Guideline for Baseline Water Use Determination and Target Setting in the Mining Sector SAWC G4

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DOCUMENT INDEX

This is the fourth document in the following series of guidelines for the determination of Baseline Water Use and Targets for various economic sectors:

SAWC G1	Irrigated Agriculture Sector
SAWC G2	Commercial Sector
SAWC G3	Manufacturing Sector
SAWC G4	**Mining Sector**

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GLOSSARY

Aquifer	An underground layer of permeable rock or material that is water bearing and from which groundwater can be extracted.
Baseline water use	Water consumption status at the beginning of a water conservation programme. Baseline measurements are used as a reference point to determine a site's water savings as it completes its water conservation plan.
Benchmark	A quantitative measure of performance or qualitative practice against which other levels of performance or other practices may be compared.
Benchmarking	The process of comparing an activity or process to another that is widely accepted as standard.
Beneficiation	Beneficiation is a variety of processes whereby extracted ore from mining is reduced to particles that can be separated into mineral and waste, the former suitable for further processing or direct use.
Blackwater	Wastewater containing faecal matter and urine.
Cooling towers	Structures used to cool water through an evaporative process in which the water is exposed to air in counter-current flow.
Concentrate	The residual valuable material that remains after an ore has been processed to remove most of the waste rock. This fraction of the ore becomes the raw material for the smelting process.
Consumptive water use	Water use that removes water from the immediate environment and does not make it available to other users in the form of a liquid discharge. Consumptive use is generally a term applied to uses that result in evaporation, evapo-transpiration or incorporation into products.
Dense media cyclone	Equipment that utilises fluid pressure energy to create rotational fluid motion, causing relative movement of materials in suspension in the fluid as a result of their relative densities. This allows for separation of these materials.
Drift	Loss of water droplets through the top of a cooling tower as a result of the air draft. Can be reduced by installing drift eliminators.

GLOSSARY

Dust suppression	The process whereby the movement of dust is controlled or prevented, typically through the application of water sprays or equivalent processes.
Effluent	A discharge of liquid waste from an industrial or mining site.
Evapo-transpiration	The evaporation of applied water as well as rainwater from land and plant surfaces, as well as the loss of this water through the stomata of plants.
Flocculation	A chemical process where colloids come out of suspension in the form of flocs or flakes.
Gas scrubbing	The process whereby gases are bought into contact with a fluid with the intent of removing solid, liquid or gaseous components from the gas stream through incorporating them into the fluid. In the context of this guide, the gas scrubbing referred to involves the use of water, though other fluids may be used.
Grey water	Water recycled from showers, sinks and washbasins.
Infiltration or Ingress	The downward movement of surface water through the soil or into mined-out areas.
Internal recycling	The process of recycling water between processes on a mine. Internally recycled water should not be added to site water use, as it was already recorded as a water use when it was used for the first time.
Make-up water	The quantity of water that is required to compensate for losses in a process.
Mining Area	The area for which a mining right or permit has been granted.
Mulching	The practice of covering soil (using natural or synthetic materials) in order to reduce moisture loss, prevent weed growth and prevent soil erosion.
Multi-product mines	Mines that produce a number of minerals or ores, or varying grades of the same ore for different uses.
Open-cast mining	The method of extracting minerals or ores from the earth by their removal from an open pit or burrow.

GLOSSARY

Ore or Ore body	An aggregation of minerals, distinct from the host rock, that contains enough metal, minerals or geological material worthy to be exploited for commercial gain.
Outlier	A statistical observation that is markedly different in value from the other observations of the sample.
Pinch technology	An approach used to minimise water or energy consumption through integrating the various process on a site, and matching water or energy sources to water or energy sinks, reducing the need for “fresh” water or energy sources.
Pit	The hole or cavity in the ground that has been formed as a result of mining.
Potable Water	Water of high enough quality to be used for human consumption without any short or long-term health effects. In the context of this guideline, this is treated water supplied by water service providers.
Precipitation	The quantity of water deposited on the earth in the form of either hail, mist, rain, sleet or snow
Raw water	Untreated water from boreholes or surface water resources or impoundments.
Rain water harvesting	The process of capturing or gathering of rainwater or storage of it for use on site when required.
Rehabilitation	The process of restoring land after some process, for example mining, has altered or damaged it. In mining the overburden is normally removed, the area mined and the pits then re-filled with the overburden. Vegetation is then restored to the mined out area.
Seepage losses	Water that seeps into groundwater from mine-workings, beyond the root zone of plants.
Shaft	A vertical excavation that is sunk adjacent to an ore body to provide access for mining

GLOSSARY

Slurrying	The process of suspending solids in a liquid as a thick mixture.
Stormwater	Rain water diverted into drainage systems for transport to surface water resources.
Sub-metering	The process of metering individual processes or groups of processes in a larger well-defined process area.
Tailings	Tailings are the materials left over after the concentration of an ore.
Underground mining	The method of extracting minerals or ores from the earth by using tunnels or declines, shafts or horizontal excavations into hillsides called adits.
Utility area	The area that houses the materials or services that support the primary mining or manufacturing process. The services or materials are commonly referred to as 'utilities'.
Veld	Wide open rural spaces covered in grass or low scrub.
Water Balance	A calculation or assessment technique in which all water into and out of a site is accounted for, using the principle that the amount of water entering the site (in solid, liquid or gaseous form) should be equal to the amount of water leaving the site. It is also possible to account for water retained on the site, a useful approach should inventories be large or where the balance is conducted over short time intervals.
Water conservation	The process whereby the amount of water used for an activity is reduced without impacting on the outcomes of the activity.
Water efficiency	The accomplishment of a function, task, process, or result with the minimal amount of water feasible. Also called water use efficiency.
Water intensity	Water use per unit of economic activity. In the case of the mining sector, this is expressed as the amount of water used per unit of ore mined or mineral produced.

ABBREVIATIONS

KL	Kilolitre
KPI	Key performance indicator
L	Litres
m	Metre
m^3	Cubic metres
mm	Millimetre
YOY	Year on year
WSP	Water Services Provider

1 INTRODUCTION

1.1 Overview

This is one of a series of guidelines outlining the steps to follow at site-level for the:

i. Determination of baseline water use levels and;
ii. The setting of water use targets, within the context of a water conservation programme.

In particular, this guideline supports the objectives of the Stakeholder Accord on Water Conservation, and the chosen water use performance indicators are aligned to those required for reporting as agreed by Accord stakeholders.

This guideline applies to the MINING sector, which comprises the activities related to the extraction of minerals from the earth, the processing and beneficiation of these minerals, and related secondary activities in support of the primary activity, mining.

1.2 Guideline objectives

The objectives of this guideline are to ensure that participants in the Stakeholder Accord on Water Conservation within the mining sector receive guidance on:

- How to categorise the key water-using processes for their individual sites;
- What the water use and water intensity measures appropriate to the mining sector are in terms of the requirements of the Stakeholder Accord on Water Conservation;
- How to determine baseline water use;
- How to identify opportunities for water conservation and;
- How to translate identified opportunities into short and long-term water use and water intensity targets.

1.3 When to use this guideline

This guideline has been developed specifically to support the Stakeholder Accord on Water Conservation. It is however also of use in the following general circumstances:

- When developing a water conservation management plan and;
- As input to planning and budgeting processes.

1.4 Principles adhered to in this guideline

This guideline is based on the principles governing the Stakeholder Accord on Water Conservation and assumes that baseline determination and target setting would be undertaken at site level on a voluntary basis. The use of this guideline is not mandatory but it is rather a tool aimed at supporting water users in the mining sector in their water conservation efforts. It is assumed that this guideline will be implemented within the regulatory framework governing water use, taking cognisance of all environmental impacts related to the implementation of water conservation projects.

1.5 Structure of this guideline

This guideline is based on the concepts of water auditing. The approach followed in this guideline is comprised of the following steps:

- Determination of the absolute water use and water intensity baselines for the site;
- Identification of potential water conservation initiatives;
- Quantification of water savings expected from implementation of these water conservation initiatives;
- Determination of expected absolute water use targets for future years by subtracting water savings resulting from the implementation of viable conservation initiatives from the baseline. Both water savings and the baseline may also be related to the level of production projected for the mining entity;
- Repetition of this process annually for a rolling five-year period.

The guideline briefly discusses the nature of water use in the mining sector and then defines a generic water balance for the mining site. Thereafter the guideline describes key performance indicators (KPI's) relevant to the sector, to be used as a basis for determining absolute water use and water intensity baselines. Once the process to be used for determination of these baselines has been described, a methodology for the incorporation of water savings into the target setting process is described.

2 WATER USE IN THE MINING SECTOR

2.1 Overview

For the purposes of this document, the mining water-use sector is defined as comprising all enterprises that extract valuable minerals/geological materials from the earth, usually from an ore body, vein or seam. Materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, oil shale, rock salt, potash and extraction of non-renewable resources such as oil and natural gas.

The type of water used, the quantity of water used and the patterns of water use (volume and seasonality) in the mining sector can vary between users based on the mineral ore mined, the nature of mining operations i.e. underground or opencast and the location of operations, amongst other factors. Hence an underground copper mine can have different water use characteristics to an underground gold or platinum mine, and water use characteristics may even vary markedly between two copper mines. The intent of this guide is to provide mining water users, regardless of their unique circumstances, the ability to baseline their water use and set appropriate targets for their particular site.

The five main types of water used in the mining environment are:

i. Raw water obtained from surface water on the site, or from a nearby surface water resource such a river or dam or water supply scheme;
ii. Potable water, which is water that is fit for human consumption, normally obtained from a water services provider or produced on site by the mine;
iii. Underground water or groundwater obtained either by abstraction from boreholes or during the course of the mining activity and which is assimilated into the water circuits of the mine when aquifers are punctured or damaged;
iv. Process water from on site activities or nearby water service providers’ effluent treatment plants;
v. Usable effluents, either generated on the mining site or on sites outside of the mining site boundary;
vi. Stormwater or rain water, which is collected on site and discharged to a stormwater system which returns this water to rivers, or is collected for reuse, which is called “harvesting”.

A typical mine may be demarcated into the following general areas:

1. Extraction area – this is the area in which the extraction of the ore takes place from the earth. In a surface mining operation, this area is normally visible and is where the overburden has been removed and the mining activity takes place. In underground mining this area extends to the periphery or rock face, where the mining equipment extracts minerals or geological materials. Included in the process areas are workshops and related infrastructure such as dams and water pumping systems.

2. Process or beneficiation areas – these are the areas in which the mineral or geological material of value is separated from the ore, using various processes. The level of beneficiation of the ore can vary depending on the type of mineral processing facilities located at the site i.e. processing can be done to concentrate level, for example, platinum concentrate, or to final product, for example, platinum metal.
3. Utility areas – these are areas in which materials or services are produced which support the primary processes involved in mining and beneficiation. Examples of this on a mine would be the areas used for the production of steam, compressed air, purified water, refrigeration and the like.
4. Tailings or waste management areas – these are areas used to store waste materials. These could comprise dams or dumps that vary with respect to size and the types of materials stored. Depending on the mine, these could either be on the surface or underground.
5. Employee amenity areas – these are the areas used by employees, comprising ablution blocks, canteens and office/administration areas.
6. Rehabilitated areas – these are the areas that have been mined and have been rehabilitated for future use.
7. General site areas – these are the areas within the rest of the site boundary that do not belong to any of the other area types identified above. On a mine these areas would comprise roads and farmland or natural veld.

All mining activities should only take place under the auspices of a mining licence issued in terms of the Mineral and Petroleum Resources Development Act (Act 28 of 2002) and all water uses, as defined in the National Water Act (Act 36 of 1998), should only be undertaken if authorised by the National Water Act.

2.2 Typical uses of water in the Mining Sector

2.2.1 Water used for extraction activities

This refers to water used for extraction activities such as drilling, blasting, crushing of the ore and conveyance of the ore to the points where it is processed or beneficiated. Generally water is used for activities such as cooling of equipment, the generation of steam, scrubbing of gases, slurrying of materials, chemical treatment and dust suppression. Based on the specific use of the water it could either be raw, potable or processed water that is used in these activities.

2.2.2 Water used for beneficiation activities

Beneficiation is normally carried out on ores to produce concentrate, or to improve the quality of the ore, as in the case of coal washing. The processes that are used in primary beneficiation are typically flotation and the use of dense media cyclones and spiral chutes for separation of the ore from discard materials. The water used in these processes can either be raw or processed water.

2.2.3 Water used for utility areas

The utility areas house the materials or services that support extraction and beneficiation processes. Water is used in these areas for the production of steam, refrigeration plants for cooling of equipment, in water purification processes (for the disposal of effluents) and the like. The water used in these processes can either be raw, potable or processed water.

2.2.4 Water used for tailings or waste management areas

Water is typically used for the conveyance of waste or discard products and for dust suppression at tailings facilities or waste management areas. The greater part of the water used is captured in dams and re-used. Water that is not recovered is absorbed in the waste materials, kept within the interstitial hold of the dump or dam, evaporated or lost through seepage. Raw water, and in many cases recycled process effluents are used in waste management areas.

2.2.5 Water used for site amenities

Potable water is normally used for site amenities. The uses vary from water use in food preparation in the canteens to basic uses such as for operation of ablutions and cleaning inside buildings. Other uses can include garden irrigation and recreational uses such as water for swimming pools and golf course maintenance.

2.2.6 Water used for rehabilitated areas

Water use at rehabilitated areas is mainly in the form of irrigation of vegetation until the indigenous plants have taken root and are established. The type of water that is used for this purpose is either abstracted raw water or harvested rainfall.

2.2.7 Water used for general site areas

Water that is used in general site areas could either be raw, potable or process water. Where there are farms sited on the property, there are instances where mines provide raw or potable water to the farm. Natural veld is normally not irrigated. Some water may also be used to clean roads.

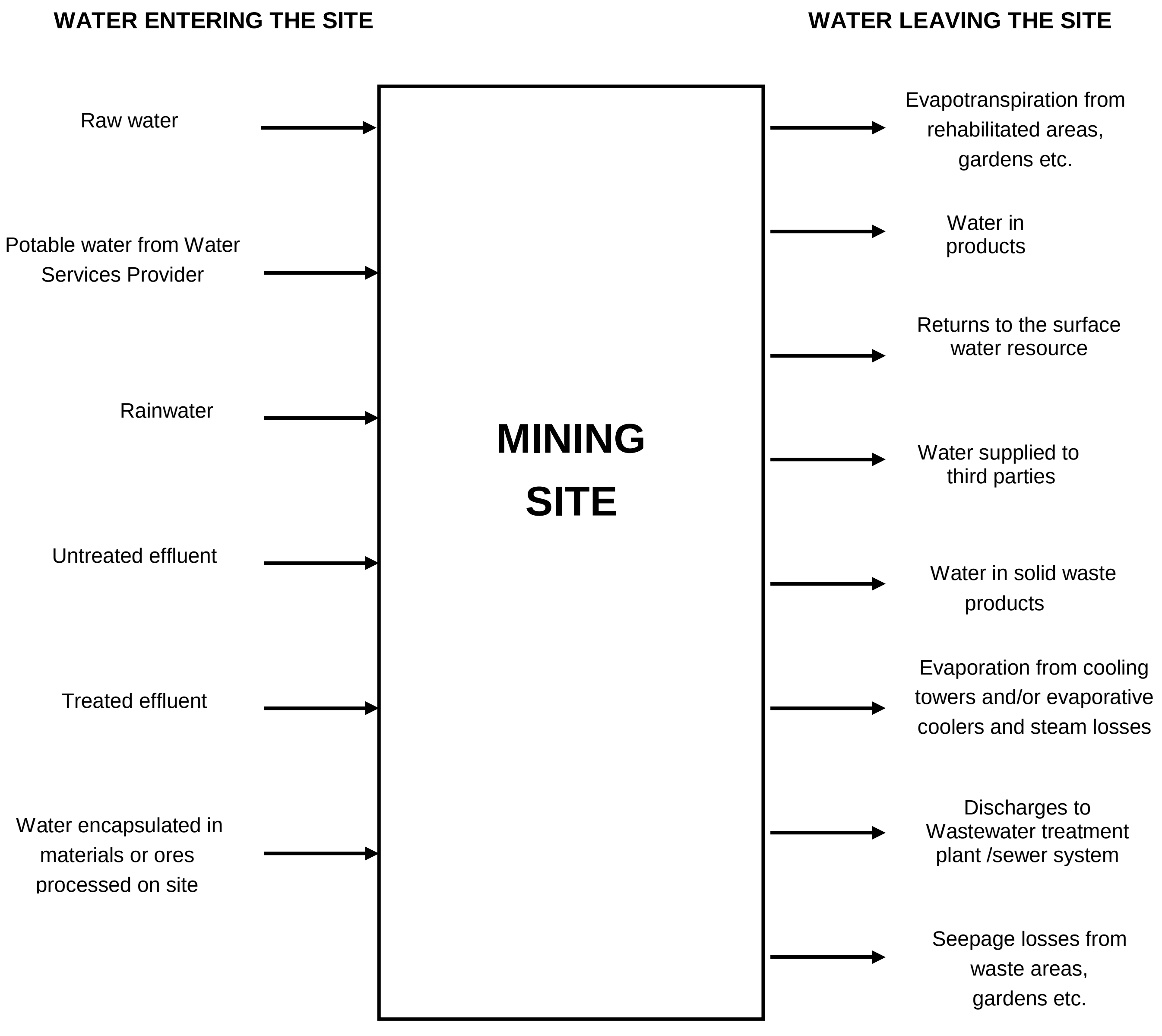
2.2.8 Water supplied to third parties

Due to the remoteness of their locations, mines often supply water to local communities or farmers. This could be raw or potable water, depending on the needs of those receiving the water.

3 DEFINITION OF THE SITE

In order to define the key performance indicators (KPI's) to be used for baseline water use performance determination and the setting of water use targets, it is necessary to define the water management system at a typical mining site. Figure 1 below outlines the key components of this system.

Figure 1: Water Management System on a Mining Site



The following are general notes applicable to Figure 1:

i. Potable water is the treated drinking-quality water supplied by Water Service Providers;

ii. Rainwater may be directed to on-site stormwater drains or impoundments and/or harvested for use on site;

iii. Raw water refers to untreated water from surface water resources such as rivers or impoundments, bulk water supply infrastructure and/or groundwater. Note that groundwater introduced by virtue of the mining process itself is to be included in this figure;

iv. "Untreated effluent" refers to discharges from users outside the site boundary which are of a quality that permits their use on site, either in their current form or after additional treatment;

v. "Treated effluent" refers to discharges from users outside the site boundary that have been treated to a level that permits their use on site without further treatment being required;

vi. "Water encapsulated in materials or ores processed on site" refers to sites that receive wet ore or concentrates for further processing i.e. slurries of these materials. This would involve the use of water as a carrier rather than just an issue of "moisture" i.e. the amount of water involved is considerable and should be taken into account;

vii. Evaporation includes steam losses, losses from refrigeration or cooling equipment, evaporation from on-site impoundments etc. and ***excludes evaporation from waste management areas***;

viii. "Evapotranspiration from rehabilitated areas, gardens etc." refers to evaporation of applied water as well as rainwater from land and plant surfaces, as well as the loss of this water through the stomata of plants;

ix. "Seepage losses" would entail water that seeps into the ground from mine-workings, and, in the case of water applied at surface level, beyond the root zone of plants. It excludes seepage losses from waste management areas, which is included in "water in solid waste products". The fate of this water depends on individual geohydrological considerations for each site. It may well find its way into surface or groundwater resources and be made available to other users;

x. "Discharges to sewer" would entail discharges of any grey water and black water that are not reused on site.

xi. "Returns to the surface water resource" comprise that portion of rainwater that is not harvested for reuse or effluent water that is discharged from the site.

xii. "Water supplied to third parties" is the water, either raw or potable, that is provided to local communities by the mine site.

xiii. "Water in products" refers to the water that is within the product in the form of moisture, as would be the case for a product such as coal.

xiv. "Water in solid waste products" refers to the water associated with waste products, and includes losses from these products through seepage and evaporation.

Figure 1 represents the overall water balance for a mining site. It should be clear that by reducing the amount of water leaving the site boundary through evaporation, evapotranspiration, returns to the surface water resource, seepage losses, water in the product or water in waste materials, the amount of water that has to be transported across the site boundary may be reduced. Rainwater harvesting and the re-use of process water are examples of actions that could be taken to achieve this. The other key way to reduce water use on site is to reduce the amount of water used by water-demanding processes at point-of-use. An example here would be the use of high-consistency cyclone separators to reduce the amount of water associated with tailings stockpiles, and hence reduce the potential for losses.

4 KEY PERFORMANCE INDICATORS (KPI's)

4.1 Why Key Performance Indicators are Necessary

KPI's can be established at a number of levels, for example to measure the performance of an entire site or to measure the performance of an individual process within a site e.g. the water requirements and water use efficiency of a particular shaft or pit.

The use of quantitative measures of water use performance allows individual sites to track performance over time as well as to benchmark performance against that of other sites. This document considers only site-level performance. More detailed KPI's would have to be developed by users at each site based on the structure of water-demanding processes on that site. These lower-level KPI's would permit improved management of water use at the site level.

4.2 Site-level Key Performance Indicators

The two key measures regarding water use at site-level in the mining sector are the following in the context of the Stakeholder Accord on Water Conservation:

i. The absolute volume of water used, which is an indicator of the demand that a site places on freshwater resources and;
ii. Water intensity, which is an indicator of the efficiency with which water is used and hence an indicator of the sustainability of the site's water use.

4.2.1 Absolute Water Use

Absolute water use is simply the total volume of water used by a site over a defined time period. The units of absolute water use in the mining environment are m^3/annum (which is equivalent to kL/annum). For any particular mining area, the calculation of absolute water use, using Figure 1 as a basis would be:

Equation 1: Absolute Water Use

Absolute Water Use / Annum = potable water use / annum + raw water use / annum
+ harvested rainwater / annum
+ treated effluent/annum + untreated effluent / annum
+ water encapsulated in materials or ores processed /annum
- water supplied to third parties / annum

On some sites the water encapsulated in materials or ores processed may be negligible and could be ignored. This may not be the case where:

i. The site is processing concentrate from an adjacent mine,
ii. Where there is significant groundwater ingress due to mining activities in the vicinity of the water table, or where significant amounts of rainwater have accumulated in the mine.

In the latter instance, care must be taken that harvested rainwater is not accounted for twice and a clear distinction must be made between conscious harvesting and the inclusion of rainwater from the mine workings.

Example1:

The water received from the bulk water pipeline that services an iron ore mine is 650,000 m^3 over a 12- month period. In the same period, the mine received 160,000 m^3 of potable water from the water service provider, the local municipality. The calculated net runoff captured on site for re-use in the mining process was estimated to be 150,000 m^3. No water was abstracted from boreholes during the period and rehabilitation of mined-out areas had only commenced in the last month of the period. No water was supplied to third parties and water associated with the ore was minimal. Calculate the annual absolute water use for the mine if the associated seepage losses are negligible.

In order to calculate the water use for the year, the relevant water sources need to be aggregated using equation 1. The water harvested has been calculated for the site. Thus the absolute water use is given as:

= potable water use / period + harvested rainwater / period + raw water used / period

= 650,000 m^3 + 160,000 m^3+ 150,000 m^3

= 960,000 m^3 for the period

4.2.2 Water Intensity

An efficient water user may be defined as a user that uses the minimal amount of water feasible to achieve a given outcome or result. The measurement of water use efficiency therefore requires an indication of absolute water use as well as a measure of the level of economic activity associated with that level of water use.

For mining, the measure of water use efficiency generally used is that of “water intensity”, which relates absolute water use over a defined time period to the output of the mine. The output would be measured in different ways depending on the nature of the mining operation. A measure typically used for mines such as copper mines and mineral sands operations would be “tons per annum”, while “ounces per annum” would be used for precious metals, and “carats per annum” in the case of gemstones.

It must be noted that mines are normally multi-product mines and that a number of ancillary minerals or ores can be produced at a particular mine. A mining site may also be involved in producing products at various intermediate stages of processing, and hence the final products from a site could comprise ore, concentrates or purified minerals or metals. Integrated operations would produce finished mineral products.

In the mining sector, water intensity is defined as follows:

Equation 2: Water Intensity

Water Intensity = (Absolute Water Use / Annum) / (Production / Annum)

Example 2:

The procution for the mine in example 1 was 15 million tons for the year. What is the water intensity of the site?

Using equation 2, the water intensity of the mine is given by:

Water intensity = 960,000m^3 per annum /15,000,000 tons per annum
= 0.064 m^3/ton

Water intensity, as an individual measure, is unable to describe the level of water use efficiency on a site completely. A more complete assessment of water use efficiency would require comparison to benchmarks and/or best practice. Water intensity does however provide a measurement that can be used to monitor trends in water use efficiency at a site. Figure 2 below outlines how trends of water intensity may be interpreted as regards water use efficiency at an individual site.

Figure 2 examines the water intensity trend at a mining site over a period of 4 years. The dashed line represents the theoretically derived minimum feasible water intensity at the site. This is the water intensity level the site could achieve if all feasible water conservation initiatives were implemented. The graph shows that an increase in water intensity from years 1 to year 2 resulted from the activities on the site, after which the water intensity decreased. Increases in water intensity indicate a decline in water efficiency whilst a decrease in water intensity indicates an improvement in water efficiency.

Figure 2: Example of a Water Intensity Trend at a Mine

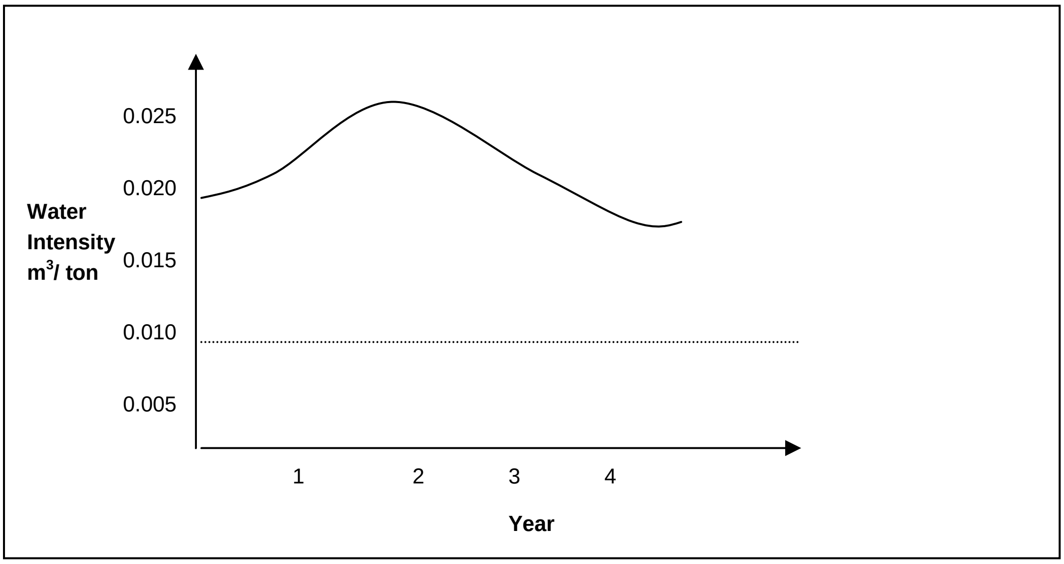


Table 1 below contains the raw data for this site measured for each of the four years in question.

The table also contains the year on year percentage change in water intensity.

For any year, $Year_n$ followed by a year, $Year_{n+1}$, the percentage change year on year is given by the relationship described by equation 3:

Equation 3: % Change Year on Year

% Change YOY = (Water intensity in $Year_{n+1}$ -Water intensity in $Year_n$) x 100 / Water intensity in $Year_n$

To calculate performance in any year, $Year_n$ relative to the base year, $Year_b$:

Equation 4: % Change Relative to Base Year

% Change = (Water intensity in $Year_n$ – Water intensity in $Year_b$) x 100 / Water intensity in $Year_b$

Table 1 shows the changes in the water intensity over the years with a year on year change in years 3 and 4 decreasing by 28%. The relative change from the base year is 0.07 m^3/ton.

Table 1: Water Intensity Example

	YEAR 1	***YEAR 2***	***YEAR 3***	***YEAR 4***
Water Intensity m^3/ton	0.020	0.025	0.018	0.013
% Change YOY	N/A	+25%	-28%	-27.8%
Change Relative to Base Year m^3/ton	N/A	+0.05	- 0.02	-0.07

The percentage change from the base year, Year 1 to Year 4, using equation 4, would be:

% Change = (Water intensity in Year$_n$ – Water intensity in Year$_b$) x 100 / Water intensity in Year$_b$

%Change = (Water intensity in Year$_4$ – water intensity in Year$_1$) x 100/Water intensity in Year$_1$

= (0.013 – 0.020) x 100 / 0.020

= -35%

It is clear that this site has made significant improvements in water efficiency.

5 DETERMINATION OF BASELINE WATER USE

5.1 The Need for Baseline Water Use Determination

Determination of the baseline is the process of establishing the status of absolute water use and water intensity for a mining site at a defined point in time. When this baseline has been established, it serves as a benchmark against which water use performance improvements may be judged.

5.2 Pre-requisites for Baseline Water Use Determination

In order to determine the baseline water use for a mining site, the following are the minimum pre-requisites necessary.

5.2.1 Site Demarcation

For the purposes of this guideline, the mining site would comprise the entire local operations of an organisation. This site could comprise mining and beneficiation operations such as concentration and smelting, all the way through to finished product production. While for water management purposes organisations may wish to separate these operations, this guideline applies to entire sites. Hence if a site contains a number of widely different operations, all of these should still be viewed as part of a single site.

5.2.2 Water Measurement

Determination of baseline water use requires that the volume of all water that enters the site from outside the site boundary be measured. This implies that metering systems be in place to measure the volumes of potable water, untreated effluent, treated effluent, harvested rainwater and raw water on a routine basis. Where harvesting of rainwater or water from the ingress of groundwater to the mine workings cannot be measured, a methodology to calculate the water made available to the mine from this source should be used. This would typically involve a detailed site water balance and the calculation of excess water by difference.

The metering systems must be capable of measuring the cumulative volume of water used for the period of interest. Metering intervals for mining sites should be no longer than a month in terms of routine monitoring. Meters that have a counter that cannot be reset are preferred, since the volume used between measuring periods can then simply be found by subtracting the most current reading from the reading before it. Meters that can be reset can result in lost information, since they could be reset in the middle of the month for example. Water use would in this case be under-stated. Water supplied by Water Services Providers (WSP's) would normally be metered and volumes would appear on water bills.

In the case of rainwater harvesting, the rainwater is either captured directly in the dams or pits on the mine from the surface run-off or through ingress into the underground workings. Mineral processing plants typically would have well developed stormwater infrastructure. Water harvested from rainfall can be calculated using runoff and infiltration factors to estimate surface and sub-surface capture respectively.

This approach should be used when there are no physical flow meters in place or it is difficult to measure the water that is made available from rainfall to the working areas on the mine. The availability of surface runoff and the use thereof can have a significant impact on the abstracted metered water use from other water sources.

Various models and methods are used to estimate the runoff diverted to rainwater harvesting systems. It is important when using these methods that a single method is adopted and used to ensure consistency. If any change in methodology is adopted from any one period to the next, this should be noted and the difference in modelling should be carefully documented and accounted for in the absolute water use determination. Such changes should be appended to any trends used for comparison over different periods.

5.2.3 Mine Production Output

The issue of expressing mining output was discussed briefly earlier, and is explained in more detail here. As highlighted, there are a number of ways of expressing mining production, even for a single site. For example, a site could express production in terms of the tons of ore produced, the tons of concentrate produced or the tons of finished mineral products produced. Some sites may only produce concentrate, while others may only produce ore. Other sites may receive concentrate from elsewhere and use it to produce refined metals. The point here is that there are no hard and fast rules as to the basis to be used for production output, even within a single sub-sector in the mining sector, or indeed even for a single site. The key approach then is to choose the relevant measure and then to be consistent in order to allow ongoing trending of performance over time. As a general rule, two measures may be used for most operations. The first addresses the amount of ore mined, irrespective of the beneficiation carried out. The second addresses the quantity of final product produced by the site. Table 2 outlines these two measures for various different types of mines.

Table 2: Examples of Possible Production Metrics at Individual Mining Sites

MINING SUB-SECTOR	NATURE OF SITE	POTENTIAL PRODUCTION MEASURE (S)
Coal	Opencast coal mine with coal washing plant	Tons coal produced; Tons ore mined.
Copper	Copper mine with concentrator plant	Tons ore mined; Tons concentrate produced.
Heavy minerals	Mineral sands operation with concentrator plant and processing complex	Tons sand mined; Tons concentrate produced; Tons final product produced.
Platinum Group Metals	Platinum mine with concentration and refining complex	Tons ore mined; Tons refined metal produced.
Diamonds	Opencast mine producing rough stones	Tons ore mined; Carats produced.

The relevance of choosing a production basis is that this will be used to calculate the water intensity level of the site, which is explained in more detail below.

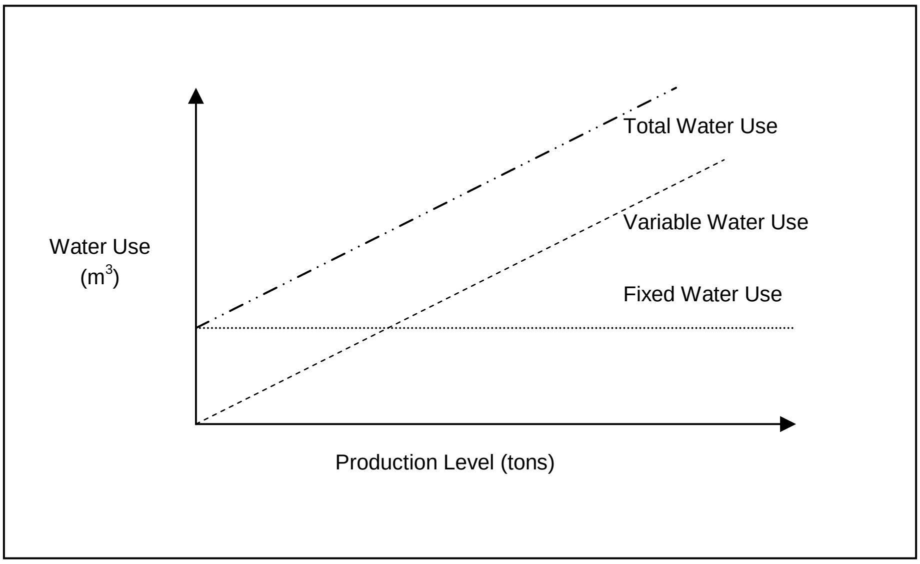
5.3 Determination of Baseline Water Use and Baseline Water Intensity

5.3.1 Constant Production Level

Mines do not operate at the same production levels throughout a year or over a period of years. Furthermore, based on the impact of the water harvesting potential of the site, the amount of metered water that is used may vary. The constant production level however will be considered to illustrate core concepts of baseline determination and target setting. This is then expanded in the next section to include the impact of changes in production.

The general nature of the relationship between water use and production level is based on the characteristics of the particular mine. Factors such as the technology and equipment used as well as the type of mining method employed have a significant role in determining these plant characteristics. For example, process equipment is generally designed with an optimal water use range, and straying from this range could lead to a change in the efficiency with which water is used. In addition, the various work practices in the different unit operations on the mine will also contribute to water use characteristics. Water use on the mine can be divided into fixed water use, i.e. water use that is independent of production and will not change with a change in production level, and variable water use, which is water use that will change with a change in production level. For example, water used for site amenities could be considered to be fixed if there is no significant change in the number of mining staff on site from one period to next. Similarly, water used directly for mining activities could be considered to be ‘variable’ as the quantum of water used would increase with the level of production according to a particular mathematical relationship. This is depicted in figure 3 below.

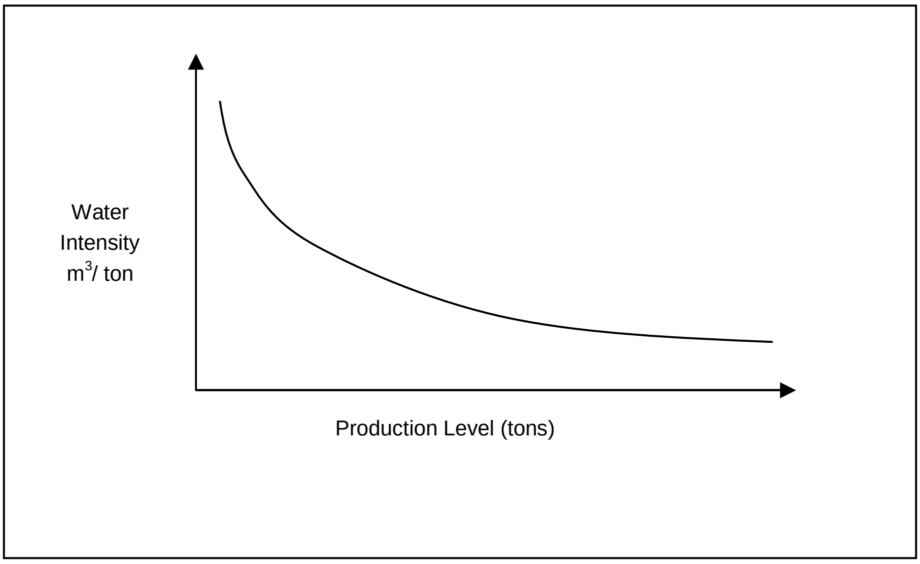
Figure 3: The Relationship of Fixed and Variable Water Use to Production Level on a Mine



The proportions of water use that can be attributed to fixed and variable site water use change with changes in production levels. At low production levels, fixed water use is a larger component of the total water use whilst at higher production levels, the variable portion becomes a larger component of the total water use. The cumulative water use will increase with an increase in production levels and decrease with a decrease in production levels. If the relationship for variable water use and production level is linear, then overall water use will also be linearly related to production levels.

If we consider that water intensity is the ratio of water use to throughput, it is clear that as total production levels increase, water intensity can be expected to decrease. As fixed water use becomes a smaller and smaller portion of total water use i.e. at high throughput levels, the reduction in water intensity with increasing throughput becomes less and less pronounced. This general relationship is described graphically in Figure 4 below.

Figure 4: The Relationship between Water Intensity and Production Level on a Mine



Based on the above, if water intensity is considered for too short a time frame at a mining site at which levels of production fluctuate significantly over time, baseline water intensity could be erroneously determined. As a minimum therefore at least a full year's data must be used to determine the baseline water use for a mining site. The cumulative water volume for the year must be ascertained using equation one:

Equation 1: Absolute Water Use

Absolute Water Use / Annum = potable water use / annum + raw water use / annum
+ harvested rainwater / annum
+ treated effluent/annum + untreated effluent / annum
+ water encapsulated in materials or ores processed /annum
- water supplied to third parties / annum

This volume of water must then be recorded as the baseline absolute water use for the 12 month period selected for baseline determination. Note that water used from internal recycling must NOT be added to the absolute water use, in order to prevent the overstatement of water use.

The baseline water intensity must then be determined using equation 2:

Water Use Intensity = (Absolute Water Use / Annum) / (Production / Annum)

The production output for the period needs to be the same 12 month period used for the determination of absolute water use.

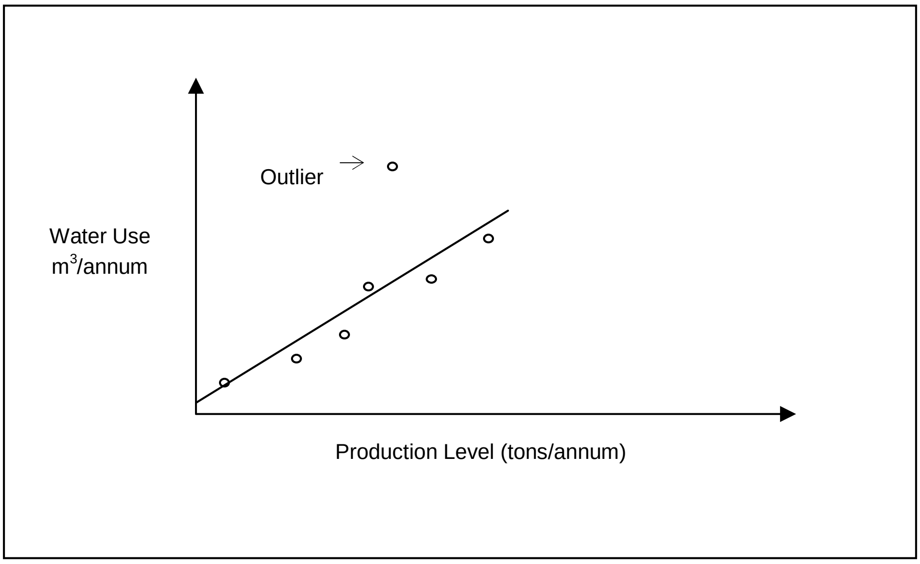
Production output is expressed based on a chosen measure for the site, as outlined in Table 2 above. Some discretion is required in selecting the year to be used for baseline determination. It is preferable to select a baseline year in which no extraordinary business activity occurred on the site. If data for such a year is not available, then as far as possible the collected data should be corrected to accommodate anomalies. It is not necessary to use a calendar year for baseline water use determination where a site has a relatively constant annual production level, since the use of data from any 12- month period during which operations proceeded as normal would address seasonal fluctuations in water demand.

5.3.2 Varying Production Level

As discussed above, water use at mining sites is a function of production levels. Hence if production levels change significantly from year to year, use of a baseline water use value that does not take this impact into account would be of little value. It is therefore necessary to be able to correct the baseline that is determined at the start of a conservation programme for changes in throughput (the terms “throughput” and “production level” are equivalent for the purposes of this discussion).

In order to be able to correct baseline water use for throughput, the relationship between water use and throughput for the mining site has to be established. The time intervals of interest are annual intervals, and for sites that have historical information available, the process would entail plotting a graph of annual water use versus annual production levels and then determining the mathematical relationship that defines that graph. Figure 5 below outlines this process.

Figure 5: Production versus Absolute Water Use at a Mine



The graph in Figure 5 is based on the data from 7 separate years of production. Six of the points are shown to lie roughly on a straight line, while one of the points is an outlier. In that particular year, there may have been unique circumstances that increased water use disproportionately, for example the commissioning of a new shaft. Provided there is evidence of unusual circumstances, such outliers should be ignored and excluded from the data used to determine the relationship between throughput and water use. Note that this process is aimed at understanding how a site behaves before the implementation of water conservation initiatives, or rather, at the time that has been chosen for baseline determination.

The determination of the relationship can be carried out using spreadsheet applications or equivalent statistical packages. Such applications can even be used to define non-linear relationships through fitting a trendline to the data and then using the application to define the relationship mathematically. It is in fact often better to use a polynomial to express the relationship, since polynomials tend to yield relationships with higher R^2 values where the observed relationship is not perfectly linear (a mathematical expression that perfectly described the relationship would have an R^2 value of 1).

Once the relationship is known mathematically, it becomes possible to determine a baseline value of performance for different throughput levels. For sites that do not have historical annual water use and production data, it is possible to use monthly data as an approximation, multiplying both production and water use by 12 to gain a sense of what the relationship could look like annually. This is only an estimation of the water use at these levels. Consider that an individual site could in practice have different water use levels for the same annual throughput level based on how that annual throughput was achieved, that is the cumulative daily throughput levels that led to that annual throughput. By accounting for differences in throughput, a more realistic picture of the performance of the site can be determined against the baseline water use. Example 3 illustrates this concept of varying throughput and its impact on water use baseline.

Example 3

A copper mine had in the past 8 years kept a record of its water use and production level. This is reflected in Table 3 below. Based on this water use pattern, the mine wished to determine the baseline water use for the next 5 years. It was expected that production levels would vary significantly over the period and these are reflected in Table 4 under Years 1 to 5.

Table 3: Water Use and Production Data for Mine

YEAR	B-8	B-7	B-6	B-5	B-4	B-3	B-2	B-1
PRODUCTION (kilotons/annum)	5,000	5,500	6,000	3,900	4,800	6,600	5,300	5,800
WATER USE (m^3/annum)	430,000	630,000	690,000	450,000	600,000	730,000	680,000	620,000

Table 4: Expected Production Levels for Mine

YEAR	BASE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
PRODUCTION (kilotons/annum)	6,600	6,900	7,600	6,100	8,000	8,100
PROJECTED WATER USE (m^3/annum)	To Be Determined					

The absolute water use baseline can be determined using the two methodologies already discussed. Using the constant method, and assuming that the water use in year B-3 was 'normal' i.e. is representative of a year in which no extraordinary activity occurred, then the water use for the base year can then be inferred to be the same as year B-3, that is 730,000 m^3 per annum.

However, the relationship between absolute water use and production can be determined by fitting a polynomial trendline to the raw data for the mine. After plotting the data points, and determining the polynomial trendline, the following relationship was derived:

Annual Absolute Water Use (m^3) = $-3\text{x}10^{-10}$ x (Production (tons))^2 + 0.1106 x (Production (tons)) + 20,724

For the base year the water use can then be estimated to be:

= $-3\text{x}10^{-10}$ x (6600000 (tons))^2 + 0.1106 x (6600000 (tons)) + 20,724

= <u>737,616 m^3</u>

This relationship can also be used to determine the expected absolute water use for the next 5 years, which is effectively the baseline water use. This is given in Table 5 below.

Table 5: Expected Absolute Water Use for Mine based on Production Levels

YEAR	BASE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
PRODUCTION (kilotons/annum)	6,600	6,900	7,600	6,100	8,000	8,100
PROJECTED WATER USE (m^3/annum)	737,616	769,581	843,956	684,221	886,324	896,901

The projected baseline, when corrected for production, is different to the baseline when considering one year's data in isolation as shown above. Thus, this approach is relevant in that it accounts for changes in production level. As shown by the calculation of the baseline using the two methodologies, neglecting to account for changes in production level could lead to use of a baseline that may be meaningless in terms of evaluating the impacts of conservation.

This guideline has dealt with the determination of baseline water use and water intensity at the site level. It is however possible to carry out baseline determination using the principles above for specific areas of the mining operation, provided that the data as regards water measurement and the characteristics of the areas concerned is available. For example, baselines could be determined for particular shafts or pits, tailings/waste areas or amenity areas. The principles of carrying out such a determination are the same as those used at the site level. Individual users may wish to carry out these more focused baseline determinations in the interests of area-specific water management.

6 IDENTIFICATION AND QUANTIFICATION OF WATER CONSERVATION OPPORTUNITIES

6.1 Overview

This guideline describes a technical approach that can be used in setting water use targets. This technical approach should be complemented by certain strategic considerations, for example business priorities or problems with water scarcity in specific locations. The detail of these considerations is considered outside the scope of this guideline, since they are unique to each organisation. They are however an important input to decisions regarding the viability of each water conservation initiative that is identified, which will ultimately determine whether individual initiatives are implemented or not. The assessment of viability is a matter that is left to the discretion of individual organisations. An important point regarding the viability of conservation initiatives is that financial viability is but one aspect of overall viability.

In order to determine water use targets, it is necessary to identify each of the water-saving opportunities on the site, and to quantify the amount of water that could be saved through the implementation of each one. The first step in doing this is to determine how much water is used in various areas of the site. A generic mining site will be used to illustrate this concept, being mindful that there are significant differences in opencast and underground mining. It needs to be appreciated that in practice, each site is unique, and that similar operations could exhibit very different water use breakdowns. The typical water use areas for a mine have been discussed earlier in section 2.1.

6.2 Quantification of Water Use in Various Site Areas

6.2.1 Determination of a detailed water use breakdown

The extraction, utilities and beneficiation areas are generally the largest water users on a site. Water use is generally metered, while water made available from precipitation is typically estimated or calculated. Water used in the tailings or waste areas, rehabilitated areas, gardens and staff amenity areas may not necessarily be metered, depending on the specifics of each site. The simplest way to ascertain water use in each of these identified areas would be to read the volume of water used from water meters that supply each of these areas. If this is not available, it becomes necessary to calculate or estimate the water use. For example, calculations based on pump running hours can provide a good estimate of the aggregate water use in a particular area.

6.2.2 Quantification of water use in the extraction area

The level of assessment possible in the extraction area is largely dependent on the metering capabilities that have been installed on the site. Typical water circuits and water uses in the extraction area differ between opencast and underground operations. It is important to ensure that metering and sub-metering is extended to a point where different water circuits can be distinguished and uses of water for these can be adequately accounted for in the site water balance.

6.2.2.1 Opencast operations

Water uses (and losses) in opencast operations may comprise of:

i. Water used as service water for cooling of equipment such as rock drills;
ii. Water used for dust suppression;
iii. Evaporation from the pools of water in the pit and;
iv. Seepage or groundwater recharge.

Water use by machinery is a function of:

i. Flow rate of the water use over the duration of the use;
ii. The duration of each use;
iii. The frequency with which each machine is being used.

Where there is no sub-metering to establish the water use of an individual machine or group of machines, an estimate can be made based on the above relationship.

Evaporation from pools in mining pits can estimated using generally accepted principles of thermodynamics. For a more detailed treatment of this, please see, ‘Department of Water Affairs and Forestry, (2006). Best Practice Guideline G2: Water and Salt Balances,’ which provides a step-by-step example for illustration. Seepage or groundwater recharge may be estimated by using geo-hydrological modeling and through verification by the establishment of a series of boreholes in the locality of the extraction area.

Water use for dust suppression can either be metered where a fixed spray system is used or estimated using frequency of use, duration of use and the flow-rate to the system. Where road tankers are used for dust suppression, the filling frequency of each tanker can be recorded over a period of time. As these would have a fixed capacity, the resultant water use would be the filling frequency of each road tanker multiplied by the capacity of each tanker.

6.2.2.2 Underground operations

Water uses in underground operations include that used for dust suppression, chilled and unchilled service water for cooling and other uses and potable water for domestic consumption. Fissure water from groundwater should be accounted for as an additional raw water use over and above that abstracted. There are also water losses associated with the recharge that takes place where compartments are used for storage of water underground, depending on the permeability of the strata or where unlined underground dams are used. Similarly to the opencast operations, water use can be determined from information concerning the flow rates to equipment, the frequency of use of the equipment and the duration of use if the water use is not metered.

6.2.3 Quantification of water use in the beneficiation and utility areas

Water use in the beneficiation and utility areas is similar to water uses on a manufacturing site. Due to the number of pieces of machinery in these areas and their varied nature, metering and sub-metering is an important consideration in quantifying water use. If metering is not in place, an estimate of the water use can be made using flow rates and the duration of the use of the machinery. Normally the equipment manufacturers' specifications can be used to provide this estimate. For additional information please see "The Stakeholder Accord on Water Conservation, 2009. Guideline for Baseline Water Use Determination and Target Setting in the Manufacturing Sector".

6.2.4 Quantification of water use in the tailings or waste management areas

Waste materials in the mining environment can take a number of forms, a few examples being tailings stockpiles and tailings dams. The approaches used to conserve water depend in part on how waste materials are stored and managed. Water uses in waste management areas typically comprise the following:

- Water encapsulated in waste materials;
- Evaporation from waste dams/dumps;
- Seepage from waste dumps/dams;
- Dust suppression to prevent aerial dispersion of fine waste particles.

Water uses such as seepage and evaporation can be estimated using models for these processes. Water may typically be recycled from waste storage areas to upstream processes, or for reuse in waste conveyance or dust suppression. This water can either be metered or estimated using pump running hours and flow rates. It is important to recognise that internal recycling should be excluded when calculating the absolute water use for a waste management area. An example of internally recycled water would be that returned from seepage recovery systems.

6.2.5 Quantification of water use in employee amenities areas

Staff amenity areas in mining facilities use plumbing fixtures and fittings such as taps, showerheads, toilets, mixers and the like. There are three components to water use in these areas:

i. The frequency with which each fitting is used;
ii. The duration for which each fitting is used and;
iii. The flow rate of water over the duration of each use.

These last two of these issues may be grouped into a single item, which would be the average volume of water used with each use.

Amenity areas may not necessarily be individually metered, and may be widely dispersed across mining sites. They may comprise kitchenettes, changing rooms, toilet facilities and the like. At labour intensive sites, staff changing rooms can consume large amounts of water. In order to assess water use due to staff amenities, it is therefore necessary to estimate frequency of use, duration of use and flow rate during use (or volume with each use) for all plumbing fittings. The data on flow rate or volume used could be obtained from manufacturer's specifications. These may not be readily available, and in this instance physical measurements may have to be made. When making these measurements, assess equipment based on typical flow rates during use and not maximum flow rates.

6.2.6 Quantification of water use in gardens

Gardens and other areas of amenities such as golf courses are normally irrigated. The garden areas are typically small in comparison to other uses. Golf courses are however much larger and water for this use can either be drawn from potable or raw water sources. In some cases these facilities are irrigated, under licence, with final treated effluent. The final treated effluent can either be supplied from a third party (in this instance it would be accounted for as part of the site water use) or by the mine water treatment works, in which case it would considered to be part of internal recycling.

6.2.7 Quantification of water use in rehabilitated areas

In rehabilitated areas, water is mainly used for irrigation (during establishment) and dust suppression. This occurs over large areas and could for example be used for pastures. The water uses related to this activity are evaporation, evapotranspiration and infiltration into the ground. Where this is not metered, the water use can be estimated by the frequency of irrigation, its duration and flow rate of water delivered to the irrigation system. This can be estimated using the information from pumps running hours and delivered flow rates. Where effluent is used for irrigation, the water used should only be considered part of site water use where the effluent was supplied by another party. Effluent generated on the site that is subsequently used for irrigation must not be considered part of site water use, as this is an example of internal recycling.

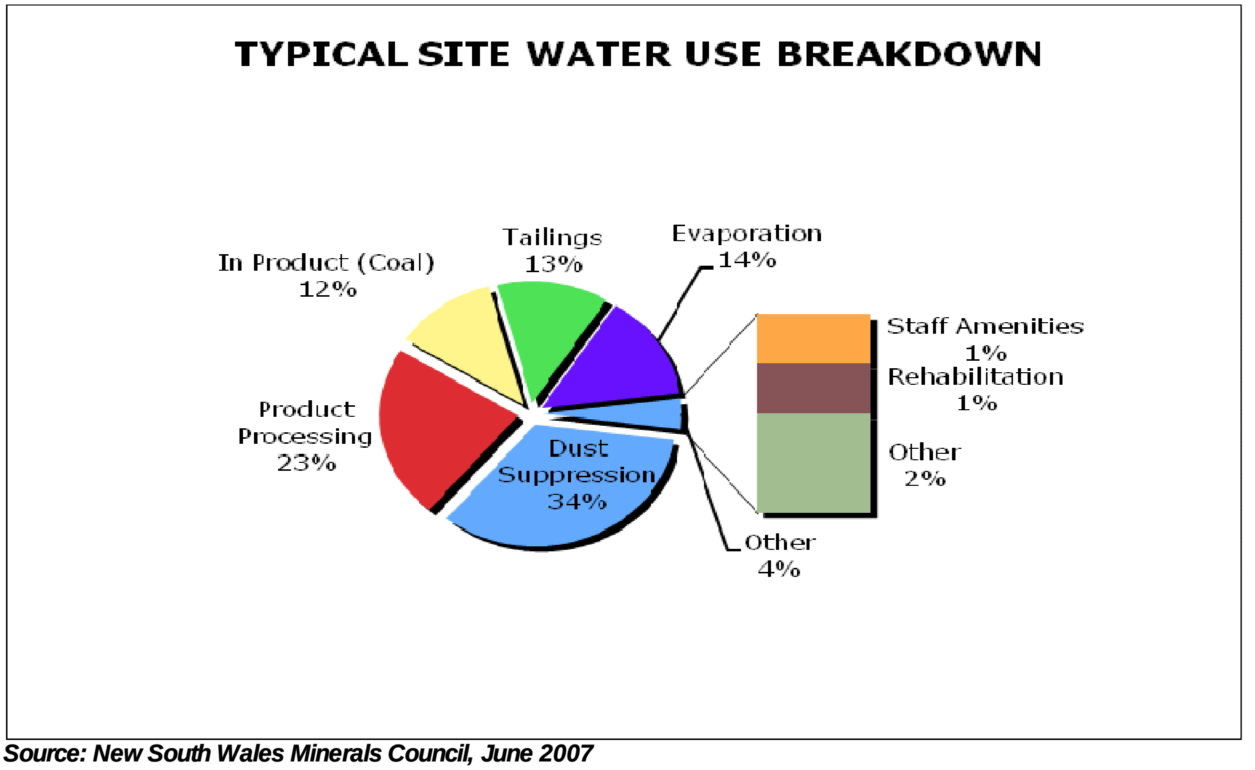
6.2.8 Quantification of water use in general site areas

Water use in general site areas relate to water uses on natural veld and farmland areas. Where this water is used by a third party this water can be netted off the mine water use. The veld and other areas normally rely on the water made available from precipitation or rainfall.

6.2.9 Compilation of the Site Water Use Breakdown

The aim of gathering the information on individual water use areas is to be able to construct a breakdown of water use on the site, which would assist in pointing out where the biggest opportunities are. Figure 3 below outlines an example of such a breakdown.

Figure 6: Typical Breakdown of Water Use on a Coal Mine



Source: New South Wales Minerals Council, June 2007

For a mine site with this profile of water use, the largest water uses on site are related to dust suppression, product processing and evaporation. Notably 25% of water is used or encapsulated in the product (coal) and the tailings or waste products. Amenities and rehabilitation have very low water uses comparatively to other areas. Primary water saving opportunities on these sites would be:

- Improvement in dust suppression systems (optimisation of spray nozzle systems for example). An option for consideration could be the use of chemical treatment to reduce dust suppression water requirements on the mine area;
- The recycling of water and cascading of water between processes based on water quality requirements for each process in the product i.e. beneficiation area and;
- Lining of tailings/waste dams/dumps to reduce seepage losses and minimization of the area of the pools of water contained in dams in order to reduce losses due to evaporation.

There are examples of opportunities in other areas not mentioned that could be exploited in reducing the absolute water use on site. Focusing on these, where the most water is used, is likely to provide the largest conservation opportunities.

6.3 Identification of Individual Water Conservation Opportunities

In order to set meaningful water use targets, the size of individual water conservation opportunities has to be determined. Each opportunity can then be evaluated in terms of its viability, and those found to be viable can then be planned for implementation. Implementation timelines will determine when the savings expected from planned conservation interventions can be built into targets. A water conservation opportunity may be defined as a viable intervention which, when implemented, results in a reduced consumption of water relative to baseline water use.

The viability of individual water conservation interventions should be ascertained using the standard methodologies used by individual organisations when justifying any project. While the details are outside the scope of this guideline, and will depend in part on the approach of individual organisations, the following are important considerations:

i. The capability of the organisation and/or external service providers to sustain the intervention;
ii. The financial viability of the intervention i.e. will savings in water, energy, chemicals etc. justify the capital and operating costs arising from the intervention? It is important in making this assessment to consider not only the cost of the water that would be saved, but all other associated costs;
iii. Risks arising from the intervention – a full risk assessment should be carried out on all modifications to ensure that unintended consequences of implementation are avoided. These risks may include environmental, social and human health aspects;
iv. The risks of not implementing the intervention, which could possibly range from water shortages to sharp increases in water tariffs, for example.

There are two broad categories into which water conservation initiatives in the mining sector may be divided:

i. Operational initiatives and;
ii. Capital projects.

Operational initiatives are those which yield water savings through the modification of work practices and behaviour, or through the use of different materials/consumables. For example, implementation of a preventive maintenance programme could reduce leaks and hence conserve water.

Capital projects are those in which changes to equipment are made. An example here would be the introduction of a water treatment plant to allow increased recycling of treated effluents, thereby reducing fresh water requirements.

What follows are brief examples of how opportunities may be assessed in the various water-use areas of a mine.

6.3.1 Assessing Water Use in the Extraction Area

Mining operations often differ significantly from one site to other. The mining method, the type of material mined and the geology of the area being mined have a significant influence on water use patterns and opportunities for water conservation. Technology and the specific mining processes employed can be important competitive advantages for a mining house, as these factors would impact on the grade of ore that can be exploited, the production capacity realised and the process yields achieved. This implies that local site conditions are important considerations in the determination of the type of changes that can be made to effect water efficiency improvements.

Typically, water conservation opportunities would comprise opportunities for internal recycling and point of use reductions in water use. “Point of use” reductions in water use involve reducing the amount of water required by individual unit operations. An example would be the use of a continuous miner that has a lower water use per ton of ore excavated or the use of a more efficient nozzle system for dust suppression at the ore-face.

Recycling opportunities involve replacing all or part of the water requirements for a process with recycled water. The recycled water could be obtained as an effluent from other processes on site and used in unaltered form if possible, or treated before reuse. Examples of opportunities in the various different mining operations are given in Tables 6 and 7 for opencast and underground operations.

Table 6: Potential Water Use Saving Opportunities for Opencast Operations

WATER CIRCUIT OR USE	POTENTIAL OPPORTUNITIES
Dust Suppression	1. Check whether conveyors are covered to reduce dust blow off from materials or ores transported; 2. Check whether progressive rehabilitation is being undertaken and disturbed areas due to mining are kept to a minimum; 3. Ensure water sprays work optimally on the various equipment used; 4. Consider chemical binders applied as a spray to reduce water used for dust suppression.
Groundwater Recharge	1. Ensure that work practices in mine development reduce run-off into the pit area.
Evaporation and losses through flooding of pit	1. Ensure that pools of water in the pit are minimised through ongoing recovery or the use of berms.
Service water	1. Check piping infrastructure routinely for leaks. Fix these as part of a periodic maintenance schedule. 2. Measure service water use by metering at strategic points in the piping network. Monitor and trend use, and investigate abnormal use.

Source: Adapted from Department of Water Affairs and Forestry, (2008). Best Practice Guideline A5: Water Management for Surface Mines

An important consideration in the use of water in the pit area is the recycling of process water and the limiting or elimination of the use of raw or potable water. Water losses can also be limited in the pit area by lowering evaporation through keeping the surface area of pools to a minimum.

Table 7: Potential Water Use Saving Opportunities on Different Water Circuits for Underground Operations

Water Circuit or Use	Potential Opportunities
Chilled water for cooling circuits	1.Check piping infrastructure routinely for leaks. Fix these as part of a periodic maintenance schedule.
Fissure water and ingress	1. Check that all openings are sealed to the mine or adequately protected with a berm; 2. Intercept water ingress before the water is contaminated through mining spoils or exposed minerals or mixing with mine service water; 3. Check whether boreholes and intersections with perched aquifers are sealed as effectively as possible to prevent groundwater entering the mine.
Service water (chilled and unchilled)	1. Check piping infrastructure routinely for leaks. Fix these as part of a periodic maintenance schedule. 2. Measure service water use by metering at strategic points in the piping network. Monitor and trend use, and investigate abnormal use. 3. Check whether underground re-cycling can be maximised to reduce pumping.

Source: Adapted from Department of Water Affairs and Forestry, (2008). Best Practice Guideline A6: Water Management for Underground Mines.

Within the underground operation, large quantities of water are pumped from the various sections of the mine to ensure that it is kept safe and operable. Other water uses and losses are related to the storage of water in unlined dams or cavities. Where feasible, these cavities and storage facilities should be minimised.

It is generally best to assess these opportunities in an integrated manner. There are techniques and methodologies to implement process integration (such as Pinch Technology) available that may assist in optimising the selection of streams to be recycled and the matching of water-demanding and water-consuming processes on a mining site.

6.3.2 Assessing Water Use in the Beneficiation Area

Beneficiation is normally carried out on ores to produce concentrate or to improve the quality of the ore, as in the case of coal washing. The processes that are used in primary beneficiation are typically flotation, dense media cyclone separation and the use of spiral chutes for the separation of the ore from discard materials. The water used in these processes can either be raw or process water.

Careful consideration should be given to the quality characteristics of the water required by individual processes and the quality of the effluents that each produces. Attempts should be made to re-use water sequentially i.e. opportunities for effluent reuse, with or without some primary treatment, should be investigated.

The general approaches to be followed are to reduce the amount of water used by each individual process as far as possible and limit the water encapsulated in waste materials whilst maximising recycling opportunities.

6.3.3 Assessing Water Use in the Utility Area

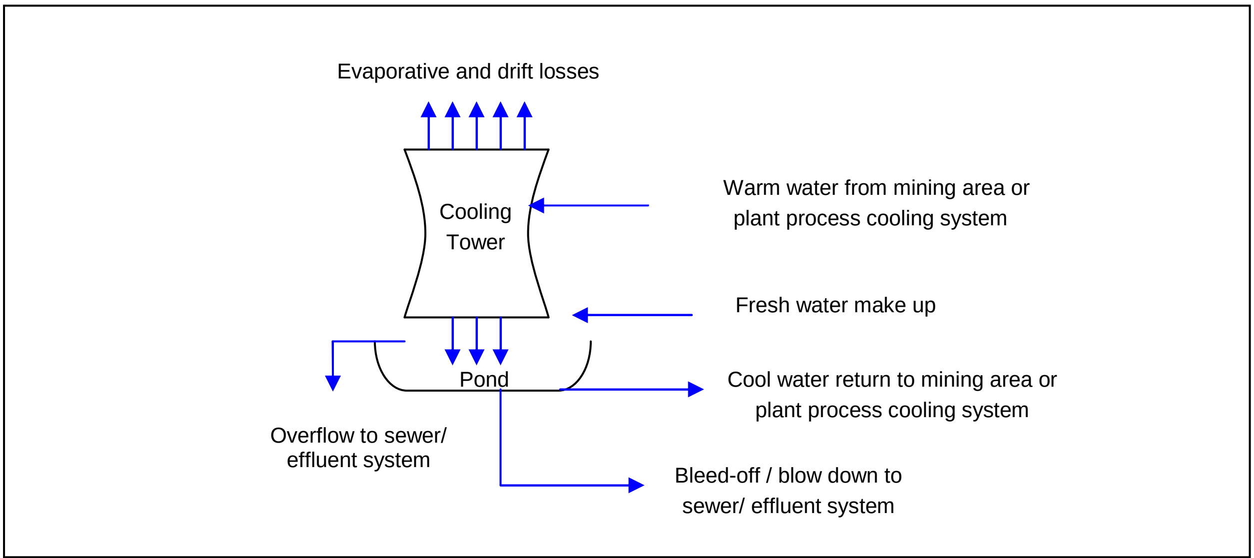
The approach to be followed in the utility area is similar to that followed for the mining and beneficiation areas. Site utilities generally employ generic technologies supplied by a large number of vendors. Special care should be taken to consider how site utilities interface with extraction and beneficiation areas i.e. there are typically a number of links between the performance of site utilities and the performance of mining and beneficiation unit operations. Changes made in water use to further water efficiency goals should not compromise the integrity of the plant, plant performance or employee safety.

As with the beneficiation area, a hierarchy of water use qualities and needs should be established within the various processes that are within this area and a philosophy of treating and reclaiming used water should be implemented wherever possible. For example suspended solids can be removed from waste flows by flocculation or filtration processes, allowing the remaining water to be re-used, or treated further before reuse.

Example 3: Cooling Towers

Figure 7 below outlines the generic water uses associated with cooling towers in a mining utility installation.

Figure 7: Cooling Tower Water Use



The losses from a cooling system which incorporates one or more cooling towers comprise leaks from the reticulation network, evaporation from the cooling tower itself, drift losses, cooling tower overflows and blow down of concentrated cooling water. The sum of these losses is equal to the total volume of make-up water required to maintain the volume in the cooling system. This is represented by the simple mass-balance relationship:

Equation 5: Cooling Tower Make-Up Volume

Make-up Water Volume = Evaporation losses + Bleed-off volume + Leaks + Overflows + Drift Losses

If the freshwater make-up and blow down volume are metered, the difference between the two would be equal to the sum of the evaporation losses, drift losses, overflow losses and the volume lost due to leaks.

The volume used by a cooling tower and its associated reticulation network is simply the volume supplied as freshwater make-up. As a general rule, this volume should always be metered, since it would represent a significant part of the water use in the extraction area or the process area. Should it not be metered, it can be calculated provided that the water pressure is known along with details of the pipe-work and fittings. Where a float valve is used, metering remains the best option since it will be impossible to determine the frequency of opening of the valve and calculation of the make-up volume will be subject to significant error.

The make-up water to a cooling tower is approximately 120 m^3 per hour. A counter-current flow heat flow exchanger is installed on the incoming warm water stream to the cooling tower to extract some of the heat for use in a new process. The total make up to the cooling tower is consequently reduced to approximately 105 m^3 per hour. Assuming all the other parameters of water use remain the same, if the cooling tower operates for 24 hours per day, what are the total savings per annum in water use?

If we ignore the impact of environmental factors such as humidity and air temperature for the sake of simplicity, the savings per hour can be calculated by the difference in make-up water flow rate:

Saving in Make Up = Previous Make Up Water Requirement – New Make Up Water Requirement
= 120 m^3/hour -105 m^3/hour
= 15 m^3/hour

Annual Savings = 15 m^3/hour x 24 hours/day x 365 days/year
= 131,400 m^3/ annum

The above example illustrated how point-of-use water savings of approximately 131,400 m^3/annum (12.5%) in water use were achieved through the addition of the new heat exchanger. Based on the water characteristics defining the blow-down triggers for this particular tower, additional water saving opportunities could possibly be explored by implementing alternative chemical treatment of the water. These would also be point-of-use savings. Should the cooling tower make-up water be augmented with treated effluent from beneficiation processes on the site, this would be an example of the use of internal recycling.

6.3.4 Assessing Water Use in the Tailings or Waste Management Area

Water use in tailings or waste areas is largely related to evaporation and seepage as well as the water that is encapsulated with the waste materials, which is generally not recoverable. Where the opportunity exists it is recommended that tailings dams or dumps be lined and be equipped with a proper sub-surface drainage system to collect water that seeps from the waste product. Where there are dams, the surface area of the active pool area should be maintained at a minimum to reduce evaporation. In the case of un –lined dams, trade-offs exist between surface area, which drives evaporation, and static head, which drives seepage losses. In instances where dust suppression needs to be employed on a dump, sprays should be used in preference to flooding the area. Ideally, the design and operation of the dam or dump should be such that the rehabilitation of the dam/dump can take place whilst part it is still in use, to minimise water requirements for dust suppression.

6.3.5 Assessing Water Use in the Employee Amenities Areas

Efficient plumbing devices and fittings are available in South Africa, as are efficient appliances. In order to ascertain potential water saving opportunities, the expected water consumption due to the installation of alternative devices must be compared to the water use due the devices currently installed. The difference is then the magnitude of the saving. Opportunities may also exist to recycle grey water from washbasins and the like. More detail on this topic is available in the guide: “The Stakeholder Accord on Water Conservation, 2009. Guideline for Baseline Water Use Determination and Target Setting in the Commercial Sector”.

6.3.6 Assessing Water Use for Gardens, Lawns and Golf Courses

It is useful to benchmark site water use for irrigation in mm, as this allows horticultural specialists to compare the water use of a site to a projected water use for a given mix of plants, taking the local environment (in terms of rainfall and evaporation) into account. To convert the volume required for irrigation from KL to mm, use the following relationship:

Equation 6: Irrigation Water Use

Irrigation Water use (mm) = Irrigation Water Use (KL) x 1000 / Garden area (m^2)

It is best to use an annual figure for this assessment in order to account for seasonality.

The types of capital investment opportunities that could be pursued in order to reduce irrigation water use include:

- Installation of efficient irrigation systems;
- Rain sensors to shut off irrigation systems;
- Wind sensors to shut off irrigation systems;
- Soil moisture sensors and;
- Use of indigenous plants and plants that use minimal amounts of water e.g. groundcover tends to use less water than lawn does.

From an operational point of view, the types of measures that could be taken include:

- Watering only during cool periods;
- Watering no more than once a week;
- Ensuring that water is directed only at plants and not paved areas;
- Changing watering patterns based on seasonal variations;
- Mulching of flower beds.

The savings associated with each of these initiatives should be documented for possible inclusion in a water conservation plan, dependent on viability.

6.3.7 Assessing Water Use in Rehabilitated Areas

Water used in rehabilitated largely comprises irrigation during the establishment of the area. Rehabilitation would normally require that natural veld or indigenous species of plant is used. It has become accepted practice to use reclaimed water, based on a water use authorisation, for irrigation purposes. The use of automatic irrigation systems assists in the scheduling of irrigation water. Careful consideration needs to be given to the time of day that the irrigation takes place; it is best that this is scheduled either for early mornings or late evenings to reduce evaporation of the water during the warmest parts of the day.

Where the rehabilitated areas have irrigation systems, the water intensity of the process can be measured by metering the water supplied and calculating the water intensity based on the area under irrigation. Precipitation can be factored into the water use by means of a calculation of the run-off and infiltration made available to that specific area.

6.3.8 Assessing Water Use in General Site Areas

Water supply to the general site areas would normally be rain-fed and would not require any further monitoring. For third party supplies from the mine infrastructure, periodic inspection of pipelines to these users and trending of the consumption patterns should provide an indication of any water losses. Where visual inspections are undertaken, the agglomeration of thick plant foliage or growths along the pipeline route is a potential tell-tale sign of some water loss.

6.3.9 The need for an integrated approach to target setting

The preceding sections of this guideline have examined individual water conservation opportunities. However, it is important that once these individual areas have each been examined, the entire site is evaluated as a single integrated system. This ensures that any changes made in one area which could have impacts for other areas are considered with these impacts in mind. This integrated approach can also assist in the prioritisation of the implementation of individual water conservation initiatives. Several iterations would typically be required before the overall plan can be finalised.

For example, consider the implementation of an effluent treatment system that would allow increased recycling. The system's design capacity may be based on a given volume of effluent, which may change significantly should "point of use" conservation initiatives be implemented. It is therefore prudent to consider the entire basket of options and the implications that each option has for the other options before implementing any single option.

7 Setting Water Use Targets

7.1 Timeframes for water use targets

Water use targets should be reviewed at least annually, with a target determined for each year over a five year time horizon. Hence at any one time an organisation should have five targets, one for each of the next five years. The target for the next year may be viewed as a short-term target, and target in five years time as a long-term target. Repeating the process each year allows for current approaches in water conservation well as current business strategy, or in the case of the public sector, stakeholder priorities, to be incorporated into the process.

Continuous improvement is one of the drivers of target setting and performance monitoring, and hence the target for each year should demonstrate a progressive planned reduction in water intensity i.e. a progressive improvement in water use efficiency. These planned improvements should be based on opportunities that have been evaluated as described above. Over time however, it does become more and more difficult to continue to improve without significant capital investment. This is really the law of diminishing returns as applied to water conservation. The focus should then shift to the maintenance of performance.

7.2 The role of water use benchmarks

The use of water intensity trends as a means of reviewing water use efficiency performance has been discussed earlier, and is a means for an individual organisation to determine whether water use efficiency performance is improving or declining over time. An organisation’s absolute water use efficiency performance may in addition be compared to other users in a sector through benchmarking.

It is not recommended that such benchmarks be directly used to set targets, since individual water users each have their own context within which water use has to be managed, particularly mines. Benchmarks may be used as a reference in reviewing targets and performance. Where water use targets derived from site information deviate significantly from a benchmark value, this may indicate that the target should be reviewed, specifically in cases where the water use target is at a far lower level of efficiency than the benchmark value. Since benchmarks are set within a specific environment, it is important that the manner in which these have been derived is understood to ensure that the comparisons are made equitably.

Benchmarks may not be available in some instances, and may need to be developed, particularly for specialised unit operations on the mine.

7.3 Development of a site water conservation plan and associated targets

Once potential opportunities have been identified and the volumes of potential water savings associated with each have been quantified, each of these opportunities now has to be analysed to a level of detail that will permit management within the organisation to be able to make well-considered business decisions regarding implementation. Ideally, the assessment of opportunities on the site should yield a wide suite of potential water saving options. Each of these options would have to be evaluated with respect to specific criteria that determine viability, within each organisation's unique context. Of all the possible options, a number of viable options could then be determined. The viable options could be earmarked for implementation at specific times over the five-year period following the annual iteration of target setting. By subtracting the water savings expected from the baseline water use level, and considering the timing of implementation, targets can then be set. It is recommended that since targets are set annually, initiatives planned for implementation in any one year be used to set the target for the following year. This is illustrated by the following example.

Example 4:

A coal-mine, located in a region that receives on average 650 mm rainfall per annum, has an annual production of approximately 12 million tons of coal. The average moisture content of the coal supplied is required to be a maximum of 8% of volume supplied. The mine abstracts 2,25 million cubic metres per annum of fresh water from a water transfer scheme pipeline that is adjacent to the mine. A further 0,7 million cubic metres per annum of potable water is supplied by the local municipality. The local municipality's effluent treatment plant, situated 3 kilometres from the mine, supplies it with 0,35 million cubic metres per annum of treated effluent. The water use authorisation of the mine only allows the mine to capture the surface run-off from storm-water that is within the mining area for reuse. This has been estimated to be 0,15 million cubic metres per annum based on the average rainfall for the area. The water use at the mine per area is outlined in the table below.

Table 8: Water Use by Area at a Coal Mine

Area	Water Use (Million m^3/annum)	Percentage of Total
Mining	**1.303**	**37.8 %**
Process	0.545	15.8%
Dust Suppression	0.758	22.0%
Beneficiation	**0.727**	**17.3%**
Coal Washing Plant	0.727	21.1%
Utility	**0.399**	**11.5%**
Cooling	0.424	12.3%
Steam	0.061	1.8%
Tailings	**0.324**	**9.4%**
Dust Suppression	0.242	7.0%
Evaporation (Calculated)	0.152	4.4%
Staff Amenities	**0.030**	**0.9%**
Rehabilitation	**0.030**	**0.9%**
Other	**0.060**	**1.8%**
Water in Product	**0.420**	**12.2%**
Total	**3.450**	**100.0%**

Water intensity = volume of water per annum / volume of product per annum

= 3,450,000 m^3 /annum / 12,000,000 tons/annum

= 0.288 m^3/ton

The general manager of the mine noted that the company's two other mines in the vicinity of this mine had an average water intensity of 0.225 m^3/ton. Both of these mines also had coal-washing plants. It was therefore clear that improvements in water use efficiency were possible, and hence a water conservation project was launched.

Based on the breakdown of the water uses at the mine, the focus areas for prioritisation were to be the extraction, beneficiation and utility areas. Water conservation opportunities were identified and estimates of the water savings were quantified for each opportunity. Detailed investigations by engineering staff supported by specialist contractors yielded a number of viable conservation projects.

The interventions identified were to be based on operational improvements followed by capital projects. The operational improvements chosen consisted of a review of work practices and a programme to assess and restore all equipment to function to Original Equipment Manufacturers (OEM) specifications. In addition to these, a water conservation education and awareness programme for all mine staff was planned. This was to be extended to all contractors as part of the induction programme on the mine.

Processes such as dust suppression, coal washing and cooling were then focused on. An increase in the quantity of treated effluent for use in the coal washing process was investigated and a chemical process for assistance with dust suppression in some of the mine areas was piloted. Opportunities were identified in the utility area for chemical treatment of the cooling water in order to reduce blow-downs by approximately 8% per annum.

The suite of options identified was assessed, and those options found to meet the company's investment criteria (in the case of capital projects) were planned for implementation. Table 9 outlines how plans were located within the five-year target-setting period.

Table 9: Projected Annual Savings from Water Conservation Projects

AREA OF SITE	BASELINE WATER USE (m^3)	% OF TOTAL CONSUMPTION	EXPECTED ANNUAL SAVINGS FROM PROJECTS IMPLEMENTED IN YEAR 1	EXPECTED ANNUAL SAVINGS FROM PROJECTS IMPLEMENTED IN YEAR 2	EXPECTED ANNUAL SAVINGS FROM PROJECTS IMPLEMENTED IN YEAR 3	EXPECTED ANNUAL SAVINGS FROM PROJECTS IMPLEMENTED IN YEAR 4	EXPECTED ANNUAL SAVINGS FROM PROJECTS IMPLEMENTED IN YEAR 5
Extraction Area	1,303,000	37.8%	15,000	45,000	25,000	35,000	35,000
Coal Washing	727,000	17.3%	0	45,000	30,000	0	10,000
Utility Area	399,000	11.5%	2,500	0	4,500	20,000	0
Tailings Area	324,000	9.4%	0	30,000	25,000	25,000	25,000
Amenities	30,000	0.9%	2,500	1,500	0	0	1,000
Future annual savings expected from implemented projects			20,000	121,500	84,500	80,000	71,000
Expected Absolute Water Use in following year if no further action is taken (m^3/annum)*			3,430,000	3,308,500	3,224,000	3,144,000	3,073,000
Expected water intensity in following year if no further action is taken (m^3/ton)*			0.285	0. 276	0.269	0. 262	0.256

Table 9 outlines the methodology followed in the target setting process. The methodology includes water savings planned for implementation in a particular year into the target for the ensuing year. Water-saving initiatives planned for implementation within a given year are not built into that year's target. It is possible to include initiatives implemented in any given year into the targets for that year by performing pro-rata calculations of savings and to include these into the target. However this is not recommended since:

- Initiatives may not be implemented as planned leading to penal targets, instead of achievable but challenging targets that are motivators for change;
- Projects generally take a period of time before they yield the optimal results projected due to the need to overcome commissioning problems;

In preparing the water conservation plan, expected savings for each year are subtracted from the baseline to arrive at a new expected baseline. This new baseline would be the amount of water used by the site in the following year if no further action was taken to improve water use efficiency in that year. If further action was taken, the projected new baseline could be higher than the actual amount of water used, since there would be additional savings. The projected absolute water use and water intensity figures in the table are therefore conservative, and could be slightly higher than what could actually be achieved. The approach is however a prudent manner of setting targets, since there are no guarantees that anticipated savings will be fully realised, or that planned projects will be implemented according to expected timelines.

Table 10 below outlines how this process, which follows from table 9, is used to set targets. Note that the target for each year is the level of water use that the site would like to achieve over the course of that year. The target is set at the beginning of the year and water use would then be monitored over the course of that year. The water use at the end of the year is then compared to the target to assess performance.

Table 10: Annual Water Use Targets Example

YEAR	TARGET (m^3)	TARGET (m^3/ton)	COMMENT
Baseline	3,450,000	0.288	Determined at "Year 0"
Year 1	3,450,000	0.288	Target = baseline
Year 2	3,388,500	0.276	Target = baseline – expected annual savings in year 1.
Year 3	3,224,000	0.269	Target = baseline – (expected annual savings in year 1 + expected annual savings in year 2)
Year 4	3,144,000	0.262	Target = baseline – (expected annual savings in year 1 + expected annual savings in year 2 + expected annual savings in year 3)
Year 5	3,073,000	0.256	Target = baseline – (expected annual savings in year 1 + expected annual savings in year 2 + expected annual savings in year 3 + expected annual savings in year 4)

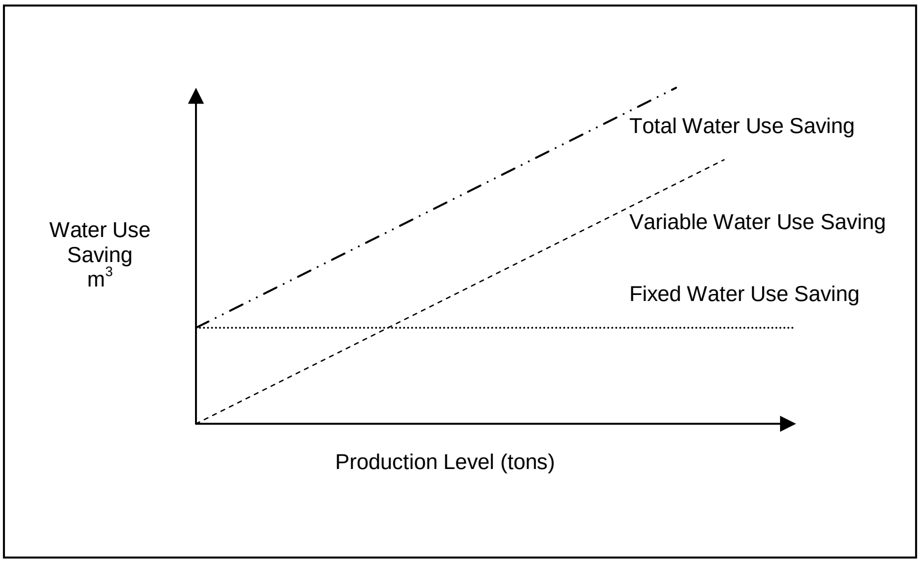
Individual users are however free to decide on whether they would like to incorporate savings into targets more rapidly. For example, if there is confidence as to the implementation timelines and the volumes to be saved, pro-rata savings can be incorporated into annual targets based on precisely when initiatives are to be implemented. Hence the target for a given year could even incorporate projects to be implemented in that same year. The approach outlined in Tables 9 and 10 is however the recommended approach, as it incorporates more certainty into the target setting process.

7.4 Dealing with significant changes in production levels

As discussed earlier in this guideline, water intensity does not remain static with a change in production. The issue of accounting for the impact of changes in production has been handled earlier (refer to section 5.3.2). The assumptions that have been used in the preceding calculations would require further consideration since the level of production typically does change in practice. It is therefore worthwhile to examine the implications of changes in production over a period of time.

An important consideration when there are significant changes in production is that the savings related to variable water use will be effected by the production level, not just for the year the initiative is implemented, but also for ensuing years. This concept follows from concepts introduced earlier regarding fixed and variable water use, shown in Figure 3 of section 5.3.1. Figure 8 graphically illustrates this difference between fixed and variable savings based on their relationship to production level. Fixed savings are a result of water saving initiatives that are independent of production processes or are in within processes that are independent of production output. Variable savings are those that change in relation to production output changes. The total savings will be the sum of the variable and fixed savings and will be a function of production output as outlined in the graph.

Figure 8: Variable and Fixed Water Use Savings



This difference sets the basis for the need to differentiate between an environment in which the production level is constant and in an environment in which the production level changes significantly from year to year. In the former example where the production level was assumed to be constant, the target for the next year was the baseline less the expected volume of water saved in the preceding year as depicted in Table 8. However, in the case of changing production, the variable savings from each initiative will vary with production. The target for any given year can then be determined as the baseline for that year corrected for production less the savings due to initiatives in preceding years corrected for the production level of the year in which the target is being set.

The manner in which changing production level is accounted for and how it impacts on target setting is best illustrated in an example. For the purpose of comparison, data from the previous example, Example 4, is used to show the impact of changes in production.

Example 5

Based on the savings expected as depicted by Table 9 and the same baseline production output and water use, the production varies for years 1 to 5 as given in Table 11. Determine the water use targets for years 1 to 5.

Table 11: Annual Production Output for Years 1 to 5

YEAR	BASE YEAR	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Production (kilotons/annum)	12,000	11,800	10,750	13,200	14,500	15,700

Similarly to the constant production output scenario previously in example 4, the expected water savings for each initiative should be determined. The savings in the year of implementation are assumed to be the same as those in the constant production scenario with the variable savings expected in ensuing years corrected to reflect the impact of production in those years. This is depicted in Table 12 under the corrected baseline water use rows and expected water savings rows.

Targets are then determined using the same methodology for the constant production scenario, which is to incorporate savings made in previous years into any of the ensuing year's targets, however savings within that particular year are not included in that year's water use target. The differences between the variable production case and the constant production scenario are the following:

- The water use baseline is adjusted for the projected production in each year;
- The water use savings are adjusted for projected production in each year;
- Cumulative savings from initiatives implemented in previous years are reflected in the targets of each year ***corrected for the production level of the particular year for which the target is being set.***

Consider example 5, the cumulative savings in year 1 comprises of variable water savings of 15,000 m^3 and fixed savings of 2,500 m^3. According to the principles established these savings are not included in Year 1's target water use. Therefore the targeted water use in Year 1 is the baseline water use corrected for production only.

Table 12: Projected Annual Water Use Savings Based on Production Level

			Baseline Year	Year 1	Year 2	Year 3	Year 4	Year 5
Production Level (kilotons) **(A)**			12,000	11,800	10,750	13,200	14,500	15,700
Corrected Baseline Water Use (m^3) **(B)**			3,456,000	3,398,400	3,278,750	3,498,000	3,770,000	4,066,300
Area of Site	**Baseline Water Use (m^3)**	**% of Total Consumption**		**Expected Water Savings (m^3)**	**Expected Water Savings (m^3)**	**Expected Water Savings (m^3)**	**Expected Water Savings (m^3)**	**Expected Water Savings (m^3)**
Extraction Area	1,303,000	37.8%		15,000	45,000	25,000	35,000	35,000
Coal Washing	727,000	17.3%		0	45,000	30,000	0	10,000
Utility Area	399,000	11.5%		2,500	0	4,500	20,000	0
Tailings Area	324,000	9.4%		0	30,000	25,000	25,000	25,000
Amenities	30,000	0.9%		2,500	1,500	0	0	1,000
Expected Savings Based on Production Level for Ensuing Years	***Fixed Savings for Year***			***2,500***	***1,500***			***1,000***
	Variable Savings for Year			***15,000***	***120,000***	***84,500***	***80,000***	***70,000***
	Savings from Year 1			15,000	13,438	16,500	18,125	19,625
	Savings from Year 2				120,000	132,000	145,000	157,000
	Savings from Year 3					84,500	102,708	111,208
	Savings from Year 4						80,000	104,667
	Savings from Year 5							70,000
	Sub-total of Variable Savings			***15,000***	***134,438***	***233,000***	***345,833***	***462,500***
	Sub-total of Fixed Savings			***2,500***	***4,000***	***4,000***	***4,000***	***5,000***
Total Savings for Year				**17,500**	**138,438**	**237,000**	**349,833**	**467,500**
Expected Water Use Based on Production Level (B)				**3,398,400**	**3,278,750**	**3,498,000**	**3,770,000**	**4,066,300**
Less Savings to Account for From Previous Years (C)				0	15,938	152,500	269,833	396,500
Target Water Use for the Year (D)				**3,398,400**	**3,262,812**	**3,345,500**	**3,500,167**	**3,669,800**
Water Intensity Target for the Year (D/A)				**0.288**	**0.303**	**0.253**	**0.242**	**0.234**

For year 2, a baseline is determined that is corrected for production in year 2, but the savings from Year 1 are now subtracted from the Year 2 baseline, after these savings have been corrected for Year 2's production level. In this instance the variable water use savings for year one are then accounted for as 13,438 m^3 and the fixed water savings are still 2,500 m^3. These savings are subtracted from the corrected water use baseline for the year to yield the target for the year. The target water intensity can then be calculated using equation 2. In summary, for this example the constant production approach predicts a water intensity target of 0.256 m^3 per ton for year 5 whilst when one accounts for production levels, the result is 0.234 m^3 per ton for year 5. This difference is clearly important, and if ignored would lead to inappropriate targets.

Due consideration needs to be given to the saving initiatives that have been implemented and the level of success achieved by these. Where saving initiatives have been implemented, the actual water savings need to be built into future years for target setting, irrespective of their level of success. Where savings have not materialised as planned, this would require investigation to ensure that any problems experienced in realising these are corrected before making any further projections.

8 CONCLUSIONS

Water use baseline determination and target-setting in the mining environment can be complex, particularly when the impacts of changing production levels are incorporated into the process. An additional consideration would be when the site is a multi-product mine and it produces a number of different mining products. Our approach in this guideline has been to ignore the impacts of product mix. In the case of multi-product mines, the absolute water use could be detailed to product level to ascertain individual water use baselines and targets per product, should metering systems be available to achieve this. An alternative would be to express all the products produced at the site in terms of absolute water use and water intensity of the primary product, using defined factors or ratios to relate the water use of each product to that of the primary product. This is a potential future enhancement to the guideline that could be made.

The principles to be employed are however basically the same, regardless of whether production is fixed or whether it changes or if the site is a single or multi product mine. This guideline represents a point of departure for baseline determination and water use target setting in the mining sector. Over time, it is expected that this guideline will be improved, possibly incorporating details on specific sub-sectors within the mining sector. In its current format, it can however be applied to any mining site, provided that the principles illustrated here are adapted to account for any unique site characteristics.

As a final point, this guideline is for the benefit of users, and its ongoing improvement and development is welcome. Comments and suggestions for improvement of this guideline should be communicated to your sector representative.

9 REFERENCES

1. Department of Water Affairs and Forestry, (2008). Best Practice Guideline A6: Water Management for Underground Mines.

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