Journal of Cleaner Production 84 (2014) 727–735

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The robustness of mine water accounting over a range of operating contexts and commodities

A.N. Danoucaras [a,*], A.P. Woodley [a,1], C.J. Moran [b]

[a] Centre for Water in the Minerals Industry, Sustainable Minerals Institute, The University of Queensland, St. Lucia 4067, Australia
[b] Sustainable Minerals Institute, The University of Queensland, St. Lucia 4067, Australia

ARTICLE INFO

Article history:
Received 12 December 2013
Received in revised form
28 July 2014
Accepted 28 July 2014
Available online 7 August 2014

Keywords:
Water accounting
Sustainability reporting
Water reporting
Mining

ABSTRACT

Communicating the mining industry's water use is fundamental to maintaining its social license to operate but the majority of corporate reporting schemes list indicators. The Minerals Council of Australia's Water Accounting Framework was designed to assist the minerals industry obtain consistency in its accounting method and in the definitions of terms used in water reporting. The significance of this paper is that it shows that the framework has been designed to be sufficiently robust to describe any mining/mineral related operation. The Water Accounting Framework was applied across four operations over three countries producing four commodities. The advantages of the framework were then evident through the presentation of the reports. The contextual statement of the framework was able to explain contrasting reuse efficiencies. The Input–Output statements showed that evaporation was a significant loss for most of the operations in the study which highlights a weakness of reporting schemes that focus on discharge volumes. The framework method promotes data reconciliation which proved the presence of flows that two operations in the study had neglected to provide. Whilst there are many advantages of the framework, the major points are that the reporting statements of the framework, when presented together, can better enable the public to understand water interactions at a site-level and allows for valid comparisons between sites, regardless of locale and commodity. With mining being a global industry, these advantages are best realised if there was international adoption of the framework.

1. Introduction

There are many potential water problems associated with mining: acid mine drainage, pollution of groundwater due to seepage of tailings, mine water discharges into surface water and competition for water from other industries and the local community, to name but a few. Additionally, mining has water management strategies that are uncommon in industrial factories. Mine sites may collect rainfall and runoff in large water storages, withdraw water in excess to their needs due to ore body dewatering and recirculate large volumes of used water to meet water demands for ore processing and dust suppression. It is clear that mine sites often 1) interact with water flows to and from the environment and 2) recirculate their internal flows. It is very important to distinguish between internal and external flows in order to properly account and report mine water use. Flows to and from the environment must be delineated from internal flows to facilitate catchment level reporting. An understanding of the recirculation of internal flows is needed to understand the differences between the following volumes: water withdrawn, water consumed and water sent to tasks. Sometimes these different concepts are all termed 'water use' (GEMI, 2010) even though within the mining industry, they may have different volumes due to the presence of water storages and incidental take from ore body dewatering.

It is worthwhile at this point to clarify the terms water accounting, water reporting and lists of indicators since they serve different purposes. Accounting reconciles data, reporting presents the data and indicators are metrics that have been defined for benchmarking purposes. The paper will show that the problem with calculating indicators or reporting water volumes without first creating a fully reconciled water account is that flow volumes may be missed. The subsequent metrics or results that are reported will then be flawed thus they can no longer be considered benchmarks.

* Corresponding author. Tel.: +61 733463418.
E-mail addresses: a.danoucaras@uq.edu.au (A.N. Danoucaras), a.woodley@qut.edu.au (A.P. Woodley), chris.moran@uq.edu.au (C.J. Moran).
[1] Present address: School of Electrical Engineering and Computer Science, Science and Engineering Faculty, Queensland University of Technology, Brisbane 4000, Australia. Tel.: +61 7 3138 0522.

http://dx.doi.org/10.1016/j.jclepro.2014.07.078
0959-6526/

Arguably the Global Reporting Initiative (GRI), which consists of lists of metrics related to sustainability, is the most widely reported initiative in the mining industry (Brown et al., 2009; Fonseca et al., 2013). The GRI has three quantitative indices related to water; EN 8 water withdrawals, EN 22 water discharged and EN 10 water recycled and reused by the organization (GRI, 2013). Some authors have raised problems with the indices. Mudd (2008) attempted to use indicator EN 8, water withdrawals, to establish relationships between water volumes withdrawn and commodity mined. Even plants in similar climates, with similar designs, did not show relationships, which Mudd believed to be a problem with the mines' interpretation of the indicators. Indicator EN10 includes rainwater and whilst rainwater mitigates reliance on other water sources, it cannot be considered to be 'reused water' (Cote, Cummings et al., 2012). Perhaps in deference to the understanding that the GRI does not provide an accounting method (Morrison and Schulte, 2010), the fourth generation of the GRI (2013) guidelines G4 has added the requirement that reporting organisations must specify the standards and methods they use when reporting. Even if the indicators were better defined, researchers are questioning the usefulness of water data that is aggregated from many sites. Leong et al. (2014) argued that because water is context specific, the public needs site-level data to understand a particular mine site's interaction with the environment.

In contrast to the GRI, the water footprint is based on a sound, well documented method for water accounting and terms are defined. A mining company as a supplier of raw material may have to provide the blue water footprint of its processing step to its customers. The blue water footprint of a process step has been defined as the quantity of water drawn from surface water and groundwater that does not return to the catchment it was taken from in the reporting period (Hoekstra et al., 2011). Even though guidance has been provided in *The Water Footprint Assessment Manual* with respect to the flows to include, the paper shows that it is still possible to under-report to the Water Footprint Network if a reconciled water account is not created first.

The Minerals Council of Australia (MCA) is funded by member companies which represents 85% of Australia's mineral production (MCA, 2013). The MCA along with the Centre for Water in the Minerals Industry developed the Water Accounting Framework (WAF) (Cote et al., 2012). Instead of lists of metrics, the WAF provides a method to ensure that internal flows are accounted for and flows to and from the environment are balanced against the change in water store volumes. In consultation with industry, the framework developers defined a list of water inputs and water outputs. Definitions for raw, worked and treated water were developed which then enabled consistent definitions for reuse and recycling efficiencies to measure internal recirculation of flows. Methods for the calculation of reuse and recycling efficiencies were developed, to ensure that precipitation and runoff, ore body dewatering and other raw water flows were conceptually removed from the reuse and recycling efficiencies thus improving on the GRI description. Thus the drivers behind the development of the WAF were to assist the minerals industry create a reconciled water account, obtain consistency in definitions, and address the problems identified with the definitions of the then G3 GRI indicators, which are unchanged in the current G4 guidelines. Locally there was also the need to help the minerals industry report to the Australian Water Accounting Standard 1 (WASB, 2012).

The MCA board endorsed the WAF's Input–Output model in 2011, thus the uptake of the framework has been good as most mining companies in Australia are required to report the Input–Output Statements. With mining being a global industry, the reasons for creating the framework: for standardisation of terms to improve comparisons across sites and companies; simplifying communication of water accounts to the public and improving the consistency in reporting to other voluntary initiatives, are even more relevant. Attempts to increase the profile of the framework internationally have occasionally raised initial concerns that because the framework has been developed in Australia, it may not apply to a site's operating context, its region or the company's reporting metrics. These concerns are due to a misunderstanding of the role of the framework.

The developers of the framework have designed it such that once the initial water account is created; it enables further reporting to other corporate level water reporting initiatives such as the GRI and the water footprint network (Danoucaras et al., 2013; Osman et al., 2013). Regarding whether the WAF will apply to a particular region, the WAF has been designed so that it is academically rigorous and can be applied to any site, regardless of commodity and location. The developers designed the framework to ensure that the accounts include enough information to enable reporting to academically rigorous regional accounts such as the Molden and Sakthivadivel (1999) Water Accounting Framework. To be compliant with the Molden and Sakthivadivel framework, the reports must contain separate reporting of groundwater and surface water, the change in water storage, other outputs besides discharge such as evaporation, water to the sea, pollution, and incorporation into a product. All this information is contained in the WAF. The global minerals industry itself will benefit from a method to create water accounts with standard definitions although it is acknowledged that reporting to the framework does not replace compliance or legislative reporting.

The paper demonstrates that the framework developed by Cote el al. (2012) can be applied across different commodities in different environments and can therefore, promote consistency in reporting globally. To illustrate the WAF flexibility, the study created water accounts of four different commodities in three countries that operate in different climates to show that a wide range of inputs, outputs and tasks can be described under the definitions of the framework. The different commodities that were compared were: a coal mine in Australia (Site 1), an iron ore mine in Australia (Site 2), a copper mine in South America (Site 3) and a platinum mine in South Africa (Site 4). To avoid the possibility of identification of the sites, the particular region will not be revealed; although the contextual statements of the operational facilities will reveal climate and geographical features that are necessary to understand the results of the water accounts. The discussion will show the aspects of the reporting statements that the public can draw upon to understand the impact of a mine site on the water sources in a region.

2. Methods

A description of the Water Accounting Framework has been published within the book *Water Accounting*: *international approaches to policy and decision-making* (Cote, Cummings et al., 2012). The procedure for creating a water account and for obtaining reuse and recycling efficiencies have been given in greater detail in other literature (MCA, 2014; Woodley et al., 2013) but the salient points of the framework and method are reproduced here to demonstrate how the Water Accounting Framework reporting statements are based on fully reconciled water accounts.

2.1. Identify the boundary

An operational facility is the water reporting entity. Operational facility is the term used as it may be a mine site or/and a processing plant, a port operation – it encompasses any minerals handling facility. The boundary drawn around the operational facility