A Water Accounting Framework for the Minerals Industry

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Overview
The minerals industry water accounting framework is founded in a concept model that relates an operational facility’s water interactions with the surrounding environment and community (Figure 1). The concept model at this level is comprised of four functional elements:

1. Input, representing the receipt of water to the operational facility;
2. Divert, moving water around or through the operational facility;
3. Task-treat-store cycle, representing the operational tasks associated with minimising losses, managing climate variability and implementing efficient technologies and processes; and
4. Output, representing the removal of water from the operational facility.

![Water system concept model for accounting purposes (DRET 2008)](image)

For water accounting purposes, there are three key areas requiring attention:

1. The intersection of the facility with the surrounding environment, community and other stakeholders; this addresses common questions such as ‘where does the water come from’, ‘how much water comes from where’, and ‘where does the water go’? This area has been labelled the Input-Output Model and it constitutes the fundamental component of the water accounting framework.
2. Activities and uses of water internal to the operation, which describe the typical actions that water is subjected to whilst in control of the minerals operation. This includes activities such as operational tasks (e.g. dewatering ore bodies, processing ore), water quality treatment (e.g. cyanide destruction, physical settling), and storing of water. It addresses common questions such as ‘how much water do you recycle’, ‘how much water do you reuse’, ‘how efficiently do you use water’ and ‘do you use water as efficiently as other nearby users’? This area has been labelled the Operational Model.
3. The quality of the inputs and outputs; this addresses common questions such as ‘what quality of water enters or leaves the site’ and ‘how did an operation transform water quality’? This area has been labelled Water Quality Description.
The combination of these three areas is the Minerals Industry Water Accounting Framework. The areas have been separated to provide guidance for companies at several levels; the Input-Output Model provides the basis for a water accounting framework, and the Operational Model and the Water Quality Reporting provide guidance for companies that see greater value in applying these two approaches. The standard accounting period is one year but the framework can be applied at shorter or longer intervals if required.

Each area is discussed in detail with examples for each component in Appendix 1. The framework has been designed to be as flexible as possible, enabling individual companies or operations to determine their accounting needs based on their requirements. The Input-Output Model is a fundamental component of the Minerals Industry Water Accounting Framework, with other elements being incorporated based on specific risks and drivers.

### Consider Materiality, Context and Accuracy Across all Accounting Efforts

Regardless of the level of detail to be included in specific water accounts, and the nature of those accounts (e.g. including water quality or the Operational Model), the concepts of materiality and context should apply to all accounting efforts.

When deriving the quantitative values of any water flows, the concept of **materiality** is applied. Information is material if its omission from the model can influence decisions related to the interpretation of the water account. For example, environmental water flows may be relatively small in volume, but may be critical for maintaining ecosystem health, and therefore information about such water flows is relevant to decision makers and should be included in the input-output model.

A **contextual statement** is an essential part of the water accounting framework as it ensures accounts are not divorced from the context in which a facility is operating. A contextual statement provides background information about the water resources of the operational facility as well as any conditions that have an impact on the management of those water resources. As a guide they should contain a description of the geographical location of the operational facility, details of the catchment, climatic conditions during the reporting period, information on water policy and rules applicable to the operational facility, and any administrative change such as changes to a water-sharing plan.

The accuracy of accounts is communicated through an **accuracy statement**, which shows the proportions of flows (by volume and / or number), which are measured, estimated or simulated. The level of confidence associated with each flow (low, medium or high) should be provided in the accuracy statement.

Finally, **notes** provide information about major assumptions, how each element in the account was calculated and about which account elements are affected by information gaps. Issues dealing with contractual and legal arrangements (e.g. discharge license), third-party arrangements should also be listed in the notes.

**Remember, the creation of perfect accounts is not the overarching goal. The key goals relate to transparency, continuous improvement in water resource management, communication and stakeholder engagement.**

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1 The framework is simply an approach for consistent communication, it does not provide tools to generate accounts. Such tools are external to the framework, and many operations have existing tools that can be used to populate an account.
The Input-Output Model

The Input-Output Model enables the consistent presentation of accounts and it includes the following key terms:

- **The Operational Facility** is defined locally by the operation (or reporting / accounting entity) based on consultation with stakeholders, and alignment with other reporting requirements as necessary. It can include the total mining lease, or a smaller defined operational area. It must be spatially explicit, readily communicated, and sensible.

- **An Input** is a volume of water, which is received by the operational facility, or has become available from within the operational facility [in the case of groundwater which was present before operations began, and has been subsequently accessed].

- **Inputs** can be summarised / aggregated by their sources or reported as a diversion.

- **Sources** are the primary accounting description for inputs, they are described by the point of water extraction, and include surface water, groundwater, sea water and third party supply.

- **Surface Water**: all water naturally open to the atmosphere, except for water from oceans, seas and estuaries. Examples of surface water include:
  - water extracted from natural water bodies such as rivers, lakes, reservoirs, ponds, streams, which is unregulated and un-supplemented;
  - rainfall and runoff collected from within the operational facility, which is regulated or supplemented;
  - precipitation which is captured directly by water storage facilities; and
  - runoff collected from outside the operational facility, which is regulated or supplemented.

- **Groundwater**: water beneath the earth's surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers. For accounting purposes, water that is entrained in the ore can be considered as groundwater.

- **Sea Water**: water from oceans, seas and estuaries.

- **Third-party Supply**: water supplied by an entity external to the operational facility, usually through a commercial arrangement with specific infrastructure for water delivery. Third-party water contains water from the other three sources and in some cases, the distribution of surface water, groundwater and sea water is known. However, minerals operations cannot be accountable for reporting the sourcing of water by third parties. If an operation facility has a commercial arrangement to receive water from a third-party entity, this water should be reported as third-party water. If a third-party is acting as a facilitator to access water (e.g. an operational facility is being granted access to a groundwater bore by the government or a neighbouring farm), the water should be reported as surface water, groundwater or sea water. When there is doubt, the physical source (surface water, groundwater, sea water) should prevail.

- **Diversions** include water that is diverted away from the operational facility, and is not involved in any of the tasks within the operational facility. It is water which is actively managed by the minerals operation, but is not used in a traditional ‘consumptive’ sense. Some handling losses can be incurred before the water is transferred to areas external to the operational facility. Examples of diversions include:
  - creek diversions,
  - runoff diversions; and
  - aquifer dewatering with either subsequent groundwater reinjection or transferral to surface water external to the operational facility.

- **An Output** is a volume of water, which is removed from the operational facility.
Destinations are the primary accounting description for outputs, they are generally described by the point of water receipt outside the operational facility, and include:

- **Surface Water**: all water naturally open to the atmosphere, except for water from oceans, sea and estuaries. Examples of outputs to the surface water destination include traditional discharges to surface waters; and environmental flows specifically provided by the operations.

- **Groundwater**: water beneath the earth’s surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers. It includes seepage from the water stores and from the tailings storage facility. Examples of outputs to the groundwater destination include: aquifer reinjection; and filling closed extractive operations outside of the operational facility.

- **Sea Water**: water from oceans, seas and estuaries.

- **Third-party Supply**: water supplied to an entity external to the operational facility, usually through a commercial arrangement.

- **Evaporation**: water released to the atmosphere during storage, handling or application.

- **Entrainment**: water removed from the operational facility contained within product or waste streams. The water within the tailings that cannot be recovered, is entrained water.

- **Other**: represents a combination of destinations and is used when we cannot identify a clear destination pathway. It also includes losses that cannot readily be accounted for or measured (e.g. losses from a processing plant).

The Input – Output Model is used to derive a statement of inputs and outputs, supported by information that adds context to the numbers that are presented.

That is the end of the description of the framework elements of the Input-Output Model. Such a model will provide most stakeholders with all the water information they require regarding the minerals operation, and its intersection with the environment and community.

**Water Quality Description**

Under each Source and Destination category, entries can be reported as being of a stated water quality based on their biophysical characteristics that determine whether they are fit for purpose (defined locally by the operation based on consultation with stakeholders) for alternative uses within the catchment.

The approach to water quality reporting is based on three categories of water:

- **Category 1** is water close to the standards of drinking water, as it only requires minimum treatment (disinfection) to be safe for human consumption. It can be used for all purposes.

- **Category 2** is water that requires treatment to remove total dissolved solids and to adjust other parameters to be safe for human consumption. It can be used for many agricultural and recreational purposes.

- **Category 3** is hyper saline water that cannot be used for any agricultural purposes without removal of total dissolved solids. With regards to the inputs of sea water, if it is desalinated before it is supplied to the operation, it should be reported as Category 1 or 2, depending on the performance of the desalination process. If it is supplied without removal of dissolved solids, it should be reported as Category 3.

The decision tree in Figure 2 can be used to help assign a water quality category to the inputs and outputs.
The Operational Model - Optional

The objective of the Operational Model is to provide a consistent framework for quantifying and documenting water use within an operation, including its efficiency. It is also designed to provide a platform for compiling and comparing minerals industry water use with other sectors. This may support benchmarking activities within regions or companies.

Therefore, to develop the Operational Model, a consistent language is required, for communicating, within operations, how water is managed. In light of the objectives, in some instances it has been easiest to adopt commonly used terms, in other instances, it has been decided that the easiest option is to develop and define a new term.

Activities and uses of water within the operation describe the typical actions that water is subjected to whilst in control of the minerals operation. This includes activities such as operational tasks (e.g. dewatering ore bodies, processing ore), active water quality treatment (e.g. cyanide destruction; see DRET 2008), and storing of water (i.e. usually for operational tasks or influencing water quality). The Operational Model brings together three elements:

1. The Inputs and Outputs;
2. The Task-Treat-Store cycle outlined in the concept model (Figure 1); and
3. The concepts of Reuse and Recycling.

This is not a simple thing to do, and has required the development of several new terms, to communicate the concepts of reuse and recycling sensibly. The concept of water status has been developed for this purpose. The water status is a description of whether or not water has been tasked and/or treated after it has entered the operational facility as an input. We define:

- **Raw water**: water that is received as an input and has not been previously tasked for any purpose by the operational facility;
- **Stores** are the facilities within the operational facility which hold and/or capture water. Water must be stored within so that it is available for another application at the appropriate time;
- **Flows** are the physical movements of water between stores and tasks, these are usually represented in engineering descriptions of water management within operations;

![Figure 2. Selecting a Water Category for a Water Input or Output](image)

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- **Flows** are the physical movements of water between stores and tasks, these are usually represented in engineering descriptions of water management within operations;
Tasks are operational activities that utilise water, typically including ore extraction, ore processing, dust suppression, fire fighting, and amenities uses;

Worked Water: water that has been through a task and is returned to a store for the same or another future task and/or is discharged; and

Treated Water: water that has been treated onsite to provide water of a suitable quality for a particular purpose. It refers to ‘active treatment’ of water (see [DRET 2008]) rather than ‘passive treatment’. It can include raw water treated once received on site, or water used in the process then treated to allow further use, or even release to an output destination.

All water, be it raw, worked or treated water can be tasked, treated or released as an output, thus the water status changes as it moves through the Task-Treat-Store cycle. In the case of raw water which is released as an output, this is known as a diversion.

Acceptance of the status definitions enables the consistent development and application of the concepts of reuse and recycling. Reused Water is worked water that is again-tasked without being treated, Recycled Water is worked water that has been treated. We can then define the reuse efficiency and recycling efficiency as a proportion of the total water inputs to the tasks:

\[
\text{Reuse Efficiency} = \frac{\text{Sum of Worked Water Flows to Tasks}}{\text{Sum of All Flows to Tasks}}
\]

\[
\text{Recycling Efficiency} = \frac{\text{Sum of Treated Worked Water Flows to Tasks}}{\text{Sum of All Flows to Tasks}}
\]

In most cases, the sum of inputs (what the operational facility is drawing from the surrounding environment) will be much less than the sum of all flows to the tasks. In the example provided in Appendix 1 the sum of inputs is 9,296 ML and the sum of flows to the tasks is 41,522 ML.

The Operational Model is used to derive a statement of operational efficiencies.

Example

A full example account, based on a pilot operational facility, is provided in Appendix 1. It contains the fundamental component (Input-Output statement with contextual information, statement of operational efficiencies, accuracy statement) and the optional components (water quality reporting, statement of operational efficiencies). Fictional names and locations have been used in the contextual information so that the operational facility cannot be identified.

References & Further Information

Guidelines for developing water accounts based on the minerals industry water accounting framework:
www.wateraccounting.net.au

For water-related information in Australia:

Bibliography


Appendix One
Sample Account
1) Contextual Information

The operational facility is the Mining Company, Henry River site. The water system comprises of: processing and mining facilities, township supply network, Boggy Creek, Henry River-regulated, and Boggy Creek Alluvium.

Third-party water (township supply) accounts for 43.5% of the total water sourcing activities onsite in the 2007/08 financial year, which is closely followed by the 40.3% sourced from surface water rivers and creeks. Groundwater sourced through interception and extraction accounts for approximately 9.7% of the operational facility’s water sourcing activities. Further surface water resources sourced through direct precipitation interception and runoff harvesting reported for approximately 6.4% of the total water inputs to site.

The major outputs from the site were via evaporation, which accounted for 4202ML (46.6%), and entrainment (3895ML, 43.2%). The remainder was lost via seepage, miscellaneous task losses and environmental flows.

The operational facility has two major stores with maximum holding capacities of 4,200ML and 3,700ML respectively.

Water sourcing activities must follow the rules as set out in the water sharing plan for the regulated Henry River as well as those in the macro groundwater sharing plan for the Boggy Creek Alluvium. Moreover, Mining Company Henry River site has its own operational management policies and regulations aimed at maintaining water supply and minimising discharge risk.

The main bodies, besides the operational facility itself, with responsibility for the management of the water resources that constitute the Mining Company Henry River site water system are: State Water, Department of Water and Energy (DWE), the local region Catchment Management Authority, and the local council from which third party water is sourced.

The total rainfall for the reporting period was 710mm compared to the long term average of 817mm. The average temperature was 13°C which was the same as the long term average. (Climate data sourced from BoM SILO).

Entitlement licences are as follows: General security – 4080ML/yr (~0.7% of the total general security access available), High security – 3125ML/yr (11.8% of the total high security access available), Onsite surface water extraction – 4200ML/yr (~0.7% of the total general security access available), Exploration interception – 931ML/yr (14.8% of the total entitlement for the Boggy Creek Alluvium), Bore field extraction – 371ML/yr (5.9% of the total entitlement for the Boggy Creek Alluvium).

Monthly allocations are set by the Water Department and water restrictions are as per the rules set out in the water sharing plan for the regulated river systems. The conditions for extraction from onsite creeks are as follows: water is released from the dam to maintain a flow of 0.4ML/day at the gauging station. When inflows are between 0.4 and 3.4 ML/day, water is released from the dam to achieve a flow rate at the gauging station equal to the inflow into the dam. When inflows are greater than 3.4ML/day, water is released from the dam to maintain a flow of 3.4ML/day at the gauging station. Once per quarter a medium flow event is to be achieved at the gauging station. A medium flow event involves a flow of greater than 10ML/day for at least 3 days.

Trading activity for the 2007/08 period: entitlements were purchased from land owners on the Henry River catchment. This transfer accounted for 4.8% of the overall water sourcing activities onsite.
(2) INPUT – OUTPUT STATEMENT

REPORTING PERIOD 1st July 2007 to 30th June 2008

Input sources and output destinations are in bold.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>ML</th>
<th>Quality</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation and runoff</td>
<td>2,535</td>
<td>Category 1</td>
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<tr>
<td>Rivers and Creeks</td>
<td>1,132</td>
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<tr>
<td><strong>Groundwater</strong></td>
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<td></td>
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</tr>
<tr>
<td>Aquifer interception</td>
<td>487</td>
<td>Category 2</td>
<td>2</td>
</tr>
<tr>
<td>Bore fields</td>
<td>354</td>
<td>Category 1</td>
<td>2</td>
</tr>
<tr>
<td>Entrainment</td>
<td>570</td>
<td>Category 2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Sea Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Third party water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Town Effluent</td>
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<td>Category 1</td>
<td>2</td>
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<tr>
<td>Entitlement transfer</td>
<td>418</td>
<td>Category 1</td>
<td>2</td>
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<tr>
<td><strong>Total Inputs</strong></td>
<td>9,296</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Surface Water</strong></td>
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</tr>
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<td>Environmental flows</td>
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<td><strong>Groundwater</strong></td>
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<tr>
<td><strong>Sea Water</strong></td>
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<td></td>
</tr>
<tr>
<td>Supply to Third party</td>
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<td></td>
</tr>
<tr>
<td><strong>Evaporation</strong></td>
<td>4,202</td>
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<tr>
<td><strong>Entrainment</strong></td>
<td>3,895</td>
<td>Category 2</td>
<td>2</td>
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<tr>
<td>Other – Task losses</td>
<td>183</td>
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<td>5</td>
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<tr>
<td><strong>Total Outputs</strong></td>
<td>9,025</td>
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</tbody>
</table>

Water Balance

Inputs – Outputs (ML) 271
Storage at Start (ML) 983
Storage at End (ML) 1,254
Change of storage (ML) 271

Notes
1. This value is from the Water Management Plan. We have recalculated it and found that precipitation interception (particularly from tailings storage facility) is likely to have been omitted from the reported value. We did not have enough data to confidently calculate precipitation interception.
2. From Water Management Plan
3. Low confidence estimate based on processing rate of ore and an entrainment factor of 0.026.
4. Calculated to close the water balance.
5. Task loss includes losses from potable water, underground mining

For ease of reporting, the volumes that make up the four sources and seven destinations are summarised:
## INPUT SUMMARY BY SOURCE & QUALITY (ML/yr)

<table>
<thead>
<tr>
<th>Source</th>
<th>Category 1 Water</th>
<th>Category 2 Water</th>
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<tbody>
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<td>Surface water</td>
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<td>Ground water</td>
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<tr>
<td>Sea water</td>
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<tr>
<td>Third-party water</td>
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## OUTPUT SUMMARY BY DESTINATION (ML/yr)

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<th>Ground water</th>
<th>Sea water</th>
<th>Third-party water</th>
<th>Evaporation</th>
<th>Entrainment</th>
<th>Other</th>
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<td>319</td>
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<td>0</td>
<td>0</td>
<td>4,202</td>
<td>3,895</td>
<td>183</td>
</tr>
</tbody>
</table>

| Change of Storage | 271 |

## (3) STATEMENT OF OPERATIONAL EFFICIENCIES

**Operational Efficiencies**

- Total flows into Tasks (water required to mine; ML): 41,522
- Volume of reused water (ML): 32,520
- Volume of water inputs to the Operation (ML): 9,296
- Reuse efficiency (%): 78%
- Volume of recycled water (ML): 24
- Recycling efficiency (%): 0.06%
### (4) ACCURACY STATEMENT

<table>
<thead>
<tr>
<th>Flows Types</th>
<th>% of all Flows</th>
<th>Level of confidence</th>
<th>% of all Flows</th>
<th>Level of confidence</th>
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