Guide to creating a mine site reconciliation code of practice

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ABSTRACT

The author's intent with this paper is to provide a guide that will assist the reader in collecting the information required to document and establish a reconciliation code of practice for a mine site or for a company with a portfolio of mines. The paper draws from a number of key publications and the author's own experience to emphasise the importance of reconciliation, the role that it can play as a continuous improvement tool and the information that is necessary to document reconciliation practices so that they can be understood and embedded into a mine or organisation.

The use of the mining value chain and ore flow/material movement mapping to facilitate the process of collecting relevant information across a mine site is outlined along with practical suggestions that will assist the reader in applying these concepts in their mine or company.

The elements that should be incorporated into a mine's reconciliation code of practice include:

- key reconciliation relationships
- data collection and validation definitions
- methodologies and calculations
- description of reporting and outputs
- accountabilities.

The objective of creating a code of practice is that it ultimately provides a guide to reconciliation that allows anyone to understand the practices used at that mine site or within a particular company, along with providing information on who is accountable for the reconciliations. In the author's opinion, where documentation such as suggested in this paper is created and associated accountabilities are clear, there will be more chance of the reconciliation practices providing benefits year after year and delivering ongoing continuous improvement benefits that ultimately result in increased accuracy of models, increased recovery of resource and increased profitability of the mine.

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INTRODUCTION

There have been many papers written on reconciliation and its ongoing use in order to continuously monitor and improve a mining operation (for example Parker, 2011; Pitard, 2001; Schofield, 2001; Morley, 2003). The role of reconciliation is a critical one, but too often manually collected data is cut and pasted into a set of spreadsheets created by enthusiastic professionals who have a particular agenda in mind, rather than a continuous improvement objective. As Blucher (2002) points out, poor reconciliation processes and reporting are often fostered in environments where:

- The system exists as a number of poorly integrated spreadsheets or similar computer programs (evolved over time to suit their author's specific requirements), which are not understood by others and can often only be operated by their developers. These spreadsheets can grow to be cumbersome and may be subject to continuous fine-tuning, often without other recipients of the information being aware that changes have been made.
- No single person has overall responsibility for implementing or delivering results from the system and just as importantly, the department heads involved in generating results for the system do not see themselves as joint owners of the process or the outcomes.

These spreadsheets typically contain no documentation and often pay little attention to fundamental principles that are critical to effective reconciliation – such as ensuring the appropriate source and collection of the data are noted, quality control around the data, standard use of terminology and provision of documentation that details accountability and also allows any new user to understand how the reconciliation results are derived.

To assist in addressing these issues the author's intent in this paper is to provide a guide to collecting the information required to document and establish a reconciliation code of practice for a mine site or a company with a portfolio of mines. The objective is to provide the reader with information that will allow them to:

- define the importance of reconciliation as a business improvement process
- identify and document sources of data required for reconciliation
- clearly define the systems and activities involved in manipulating the data
- ensure that the critical aspects of deriving the results are documented in a concise manner

- ultimately produce a guide to reconciliation that allows others to understand the practices used at a particular mine site or within a particular company and that details who is accountable for the reconciliation system.

THE IMPORTANCE OF RECONCILIATION – RECONCILIATION AS A CONTINUOUS IMPROVEMENT TOOL

Why reconcile? As a general principle, the results obtained from a reconciliation process should be used to tune the overall Resource, Ore Reserve, grade control, mine production and processing systems over time. Reconciliation is a reference 'hub' on which the performance of all of the systems in a mining operation can be judged (after Blucher, 2002). Mining is a business that includes the estimation or the creation of models (geological, mine designs and schedules) that accurately predict reality to an acceptable degree. As Box and Draper (1987, 74 p) point out we should remember that all models are wrong; the practical question is how wrong do they have to be to not be useful?

Vann and Stewart (2011) state:

> *… the value of scientific models lies entirely in their use to generate predictions. Historically the usefulness of a scientific model depended on its success in predicting the outcomes of experiments or new observations. The evolution and refinement of a scientific model proceeds by making predictions, based on a model or set of hypotheses and then comparing the outcomes of experiments or observations to those predicted by the model. A model is therefore always interim: it will be refined or even abandoned if it fails to predict existing or new observations.*

These statements by Box and Draper (1987) and Vann and Stewart (2011) highlight what should be the core principle for all reconciliation – we reconcile so that we can calibrate our estimates and models against actual results so that we can continuously improve the quality of our predictions. It is the role of reconciliation to point out how wrong a model is and it is then the role of a mining professional to determine what, if any, action is required as a result. It is therefore critical to use appropriate and sound data and methodologies in order to calibrate predictions via ongoing reconciliation activities. Failure in these early stages of the process will lead to incorrect reactions and inappropriately calibrated models.

Arnesen and van der Westhuizen (2002) in their paper on 'Addressing the root causes of deviations in reconciliation and value tracking' state that:

> *… the process of reconciliation, value tracking and predicting the final product is driven by assumptions, factors and average standards, which are applied to planning and management and control. The assumptions, factors and average standards are normally invalid and do not reflect the impact of variability of the resource on final product, production rate, processing effectiveness, etc. To expose invalid assumptions and dispose of the factors and average standards we have grown accustomed to using, we need to truly understand our mining processes. We must map out the production process from resource to point of sale. This must be done in a step by step manner in terms of a holistic throughput-driven approach and not the typical functional approach. The outcome of this is a detailed cause-and-effect map that indicates the sources of variability in the different processes as well as the interdependency between them and the impact they have on the business' performance.*

It is the author's experience that this can be achieved by using a multidisciplinary approach that combines the mining value chain and ore flow / material mapping to greatly enhance reconciliation results and deliver continuous improvement on a mine site. It is this same process that provides the foundation of any reconciliation code of practice and so this will be now examined in more detail.

THE FOUNDATIONS FOR A RECONCILIATION CODE OF PRACTICE

Using the mining value chain

At a basic level the mining value chain (as shown in Figure 1) is a linear progression through which each step builds on the prior step to add value and follows the material to be mined through the process of identification, delineation, estimation, design, scheduling, detailed definition, mining, transport, stockpiling and processing. As described above a fundamental aspect of successful reconciliation is to consider the relationships of each estimate to actual relationships across the mining value chain. It is also important to realise that reconciliation can be used to improve or increase the value created at each step through the process, by challenging the assumptions used in the estimates and models early in the value chain through comparison against the actual samples and measurements taken later in the chain. As Arnesen and van der Westhuizen (2002) state:

> *… a throughput driven approach is required to track and manage real value. To achieve this a process view of the business is required in order to be able to align the orebody to processing so that ore utilisation and recovery can be maximised.*

Because reconciliation works across the entire mining value chain it must deal with the temporal, spatial and physical characteristics of data. Reconciliation is not a single process operating in a uniform manner in a single fixed time frame. At any particular point in time, the whole process will consist of a variable number of comparisons and materials-balancing subprocesses. These subprocesses work to different time frames, for example, they may be essentially continuous (larger pits, the mill), periodic (mining of a particular stope), or erratic (delivery of high-grade ore to the run-of-mine (ROM)) (after Blucher, 2002). It is therefore essential when compiling a reconciliation code of practice to document in detail the ore flow and material movement at each stage in the mining value chain as part of understanding what is actually occurring at a mine site, while also providing information

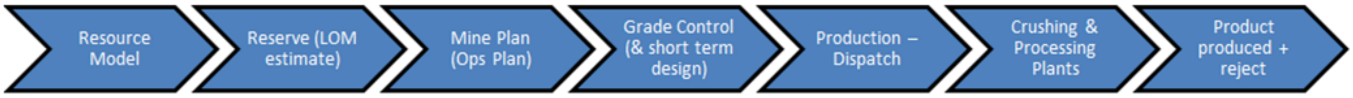

FIG 1 - Mining value chain showing reconciliation relationships. NB: LOM means life-of-mine.

which future mining professionals wanting to understand the reconciliation process can refer.

Ore flow and material movement mapping

In the author's experience the process of following the ore and waste flow along the mining value chain and mapping the processes, activities, systems, inputs and outputs that occur during this journey provides significant insight into the complex array of models, designs, schedules and material movement activities that occur at a mine site. Process mapping is a specialised field in itself that has many techniques and formats. Some companies have adopted standard formats or defined their own methodologies and these can be readily utilised and applied to the task of mapping ore flow and material movement for reconciliation purposes. If the reader is not a specialist in process mapping and/or does not have access to a specified process mapping methodology then the author outlines below a simple methodology that has been successfully applied as part of reconciliation studies to map many different mines globally, including coal, gold, diamond, iron ore, base metals and mineral sands operations in both open pit and underground mining environments.

The mapping consists of two key elements:

1. a matrix that forms a framework in which the processes that occur can be drawn and recorded
2. a checklist that prompts the person carrying out the mapping to ask the right questions to ensure all information is captured on how processes are completed.

Each of these elements is explained further.

The matrix

It is common in process mapping to use 'swimming lanes', which are horizontal rows across a page, and columns that divide the page vertically to create regions on the process map that document specific interactions. The methodology being outlined here assigns professional roles to the horizontal swimming lanes and activities or processes to the vertical columns. This effectively divides the process map into a matrix of who is doing things (in the swimming lanes) and what are they doing (in the vertical columns). For example the swimming lanes may read (depending on the nomenclature of the technical silos at the mine) from the top of the process map to the bottom:

- resource geology
- mine planning
- mine geology
- survey
- mine operations
- processing.

The vertical columns from left to right of the process map may, for example, read:

- geological modelling
- resource modelling and estimation
- long-term mine planning, design and scheduling
- medium- and short-term mine planning and scheduling
- grade control
- drill and blast
- mining
- stockpiling and processing.

In this way the process map now provides a number of boxes in which detail can be recorded that clearly illustrates who is performing what processes and the detail in these boxes shows how. As not all technical silos perform all tasks the process map will tend to 'flow' from the top left-hand corner of the map to the bottom right. Generally, most mines can be summarised onto a single A0 size sheet of paper using this methodology. It is not possible to provide an A0 diagram in this paper; however, Figure 2 gives the reader a 'helicopter' view of what a completed map will look like, while Figure 3 provides a generic example of what one of the intersecting boxes on the matrix can look like.

This brings us to the next element mentioned, which is a checklist that assists in documenting the 'how' in each of the boxes in the matrix.

The checklist

In documenting how things are done on a site it helps to have a simple methodology that guides the process and ensures all elements are captured. Process improvement schools of thought such as Total Quality Management, Six Sigma and Lean Manufacturing have all drawn at different times from a simple model known as 'SIPOC'. Below the author presents a modified explanation of the SIPOC model that the reader can use as a prompt to ensure all relevant information is captured and to draw the 'how' as described previously.

SIPOC is an acronym for 'supplier, input, process, output, customer' and for this purpose the simple SIPOC checklist can be explained as:

- Supplier – where does the information required come from?
- Input – what are the inputs needed to complete the process?
- Process –what is actually done with the data/information and how it is done? Are there decision points or quality control loops?
- Output – what are the results of the process? Is it more data, a model, a report?
- Customer – where does the output go? Who does this process become the supplier to?

By using this matrix of roles and activities and including details on suppliers, inputs, assumptions made, data collection points, outputs and customers it is possible to document the information and ore flow across a mine in such a way that anyone can easily visualise and understand the process. Critical to the documentation of the process map is to meet with those responsible for and those that actually complete the steps being documented. It is the author's experience that a significant amount of value can be derived from holding conversations with all the stakeholders of processes being documented. This process breaks down the technical silos and often clarifies things to site personnel who, due to the demands of production or workloads, have not had time to ask these questions themselves. To paraphrase a proverb, the benefit is in the journey of discovery associated with drawing the process map, rather than in the finished map itself.

Having created the ore flow and material movement process map you will have collected all the data required to document and define the mine site's reconciliation code of practice. The important aspects of what should be included in a code of practice will now be examined in more detail.

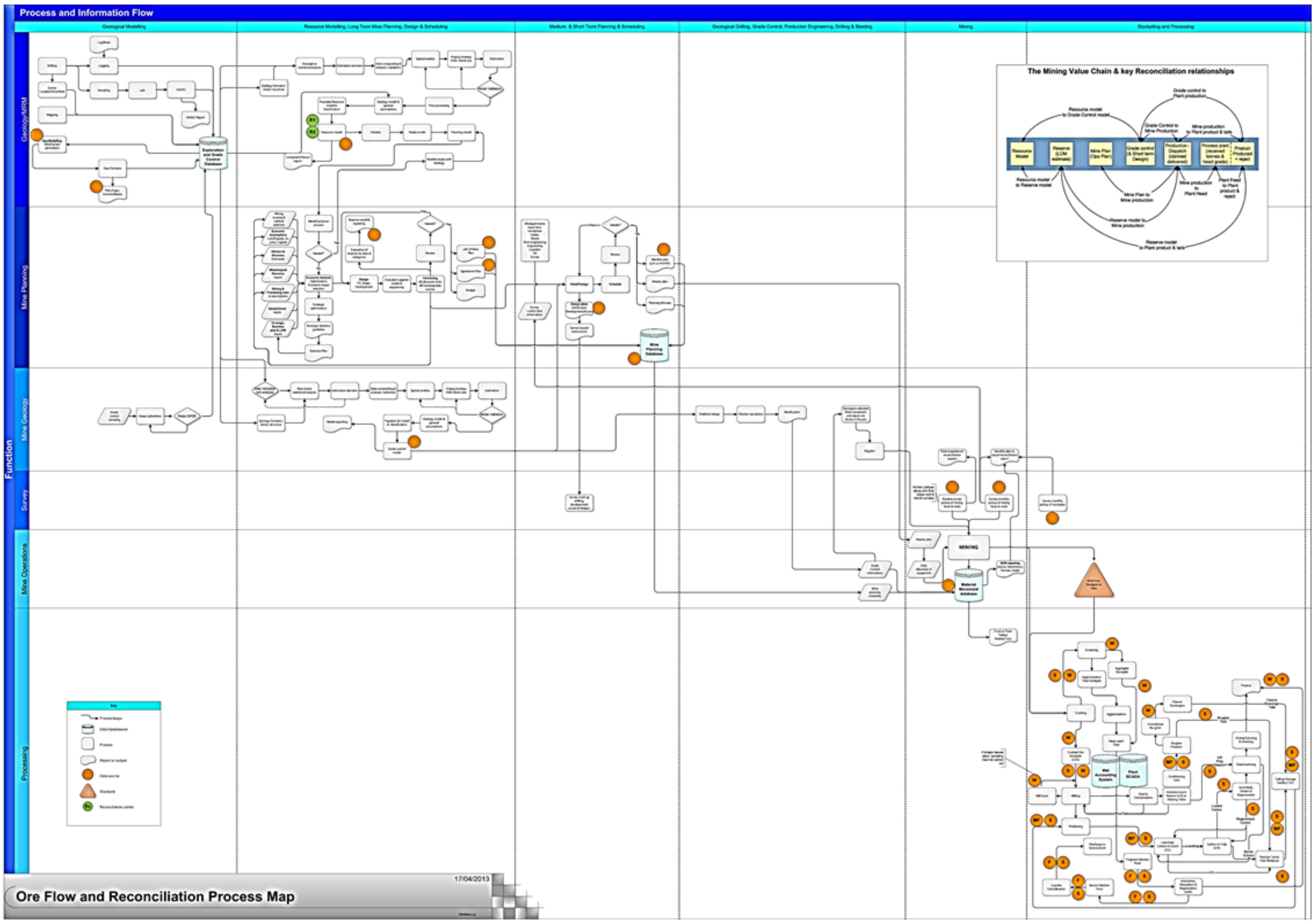

FIG 2 - A general outline or 'helicopter view' example of a completed process map. (Note: the intention is not that the detail should be legible on this diagram. The author's intent is to illustrate the general layout described in the text.)

Documenting the reconciliation code of practice

Objectives of the code of practice

A code of practice is a high-level 'standard setting' document that set out a series of principles that form part of a mine's or company's systems and procedures. In this case the objective is for the code to provide ideas or standards on how certain reconciliation issues may be approached and the code should also set the benchmark of acceptable practices and methodologies. Obviously these will vary from company to company and in many cases the detail will even change from mine site to mine site. The author's objective in this paper is to provide a set of suggestions that the reader can use and adopt as is practical and relevant to their own particular circumstances in order to develop a code that suits their requirements.

Characteristics of the code

In the author's opinion a reconciliation code should:

- identify key reconciliation relationships
- identify the data sources and record the activities involved in collecting, validating and storing the data
- clearly define any post processing that is carried out on the input data
- clearly define the calculations that are carried out using the data to derive reconciliation results
- document the standard reporting frequency, charting and end users of the reconciliation results.

Key reconciliation relationships

In the author's opinion it is important to be able to clearly illustrate and articulate which reconciliation relationships are going to be monitored across the mining value chain. This requires the code to be able to provide a graphical or tabular summary of what reconciliations are being conducted and also to use a nomenclature that is intuitive to anyone who is going to interact with reconciliations from that site or company. Building on the mining value chain presented in Figure 1 the author suggests that graphically illustrating the key relationships to be used in the code, such as is shown in Figure 4, will assist readers of the code to understand exactly what is being compared and reported. A tabular summary, such as that shown in Table 1, presents the reconciliation process by discipline section and the individual reconciliation relationship names will also help readers understand what is included in the code. Based on experience across a number of mines around the world the author suggests that Figure 4 and/or Table 1 will assist in achieving the objective of clearly illustrating or summarising the reconciliations performed on any site. Of course these will need to be modified to suit the reader's exact requirements; the examples presented are designed to provide a starting point.

In terms of nomenclature the reader will see in both Figure 4 and Table 1 that each reconciliation relationship adopts a standard naming convention that is derived from the source of information along the mining value chain, as follows:

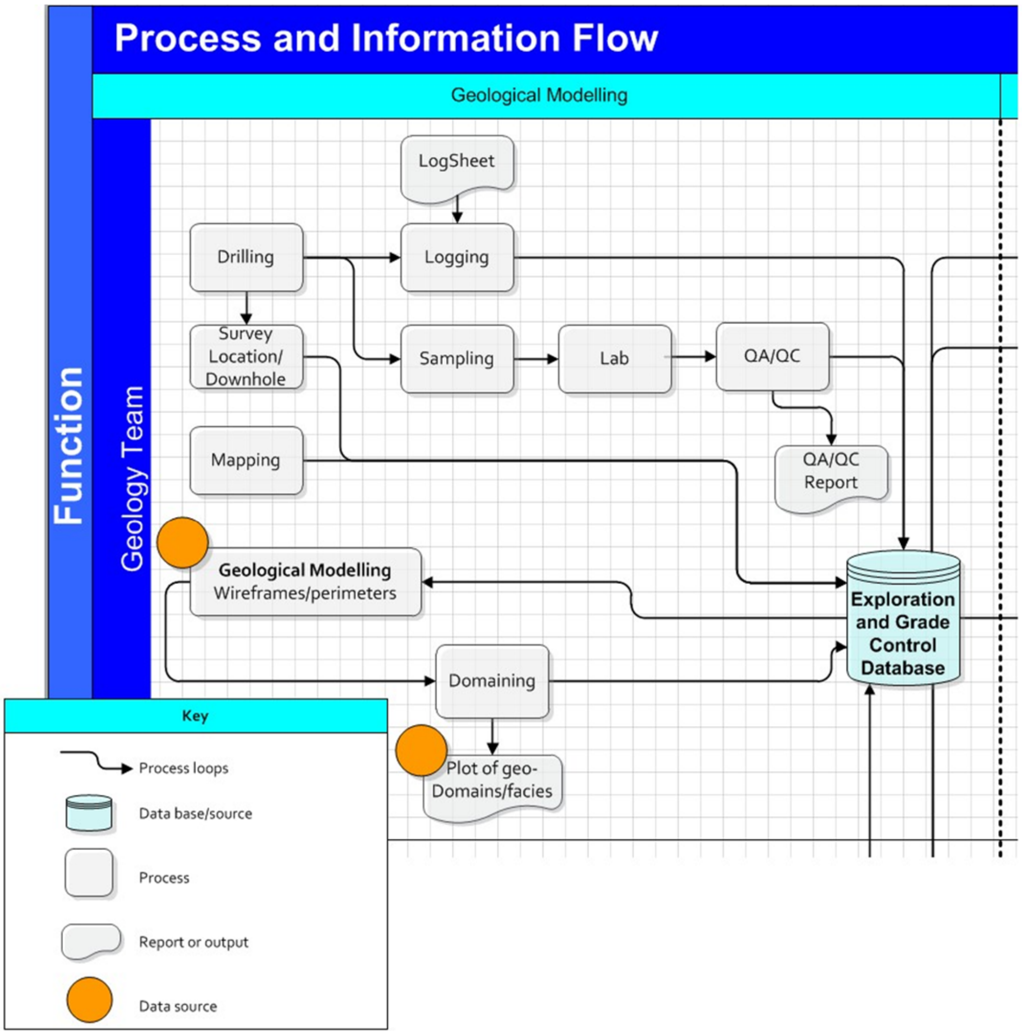

FIG 3 - Detailed example of an intersecting box on the matrix illustrated in Figure 2.

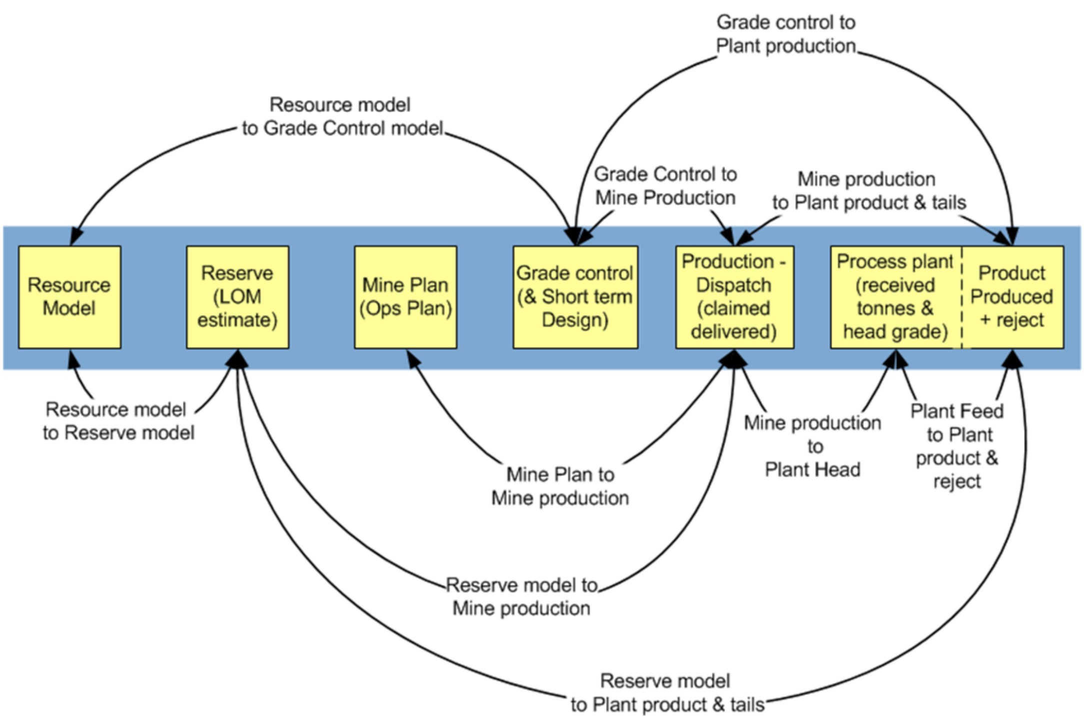

FIG 4 - Reconciliation relationship across the mining value chain (after Morley, 2003, 2008). NB: LOM means life-of-mine.

TABLE 1

Standardised reconciliation nomenclature (modified after Fouet *et al*, 2009).

Section within mining process	Standardised reconciliation relationship name
Geological model reconciliation	Resource model to Reserve model
	Resource model to grade control (mining) model
	Reserve model to grade control (mining) model
Geological model verses actuals reconciliation	Resource model to mining production
	Resource model to plant feed
	Resource model to plant production
	Reserve (LOM plan) to mining production
	Reserve (LOM plan) to plant feed
	Reserve (LOM plan) to plant production
	Reserve (LOM plan) to shipping
Mining reconciliation	Grade control model to mining production
	Grade control model to plant feed
	Grade control model to plant production
	Mine plan to mine production
	Mining production to plant feed
	Mining production to shipping
Plant reconciliation	Plant feed to plant production
Rail and shipping reconciliation	Plant production to shipping

'Name of the earliest source of data' to 'name of the later source it is being compared to'.

Therefore reconciliation of the resource model against grade control information is named 'resource model to grade control'.

In many operations and even across some companies, acronyms have been developed to describe reconciliations such as R1, R2, G1, G2, G3, M1, M2, etc. These codes are meaningless out of context and in the author's experience the relationships they are ascribed to will often vary from site to site, and so while they may be locally understood and form jargon for that site, they quickly become confusing to new staff and anyone external to site. In contrast, if the terminology derived from the suggestion above (eg 'resource model to grade control') is used it is instantly clear exactly what reconciliation relationship is being discussed/reported.

Data collection and validation

As has been discussed above the critical aspects with respect to data are:

- knowing where it is sourced from and at what frequency
- having adequate quality assurance / quality control (QA/QC) processes in place for validation
- knowing any transformations that are carried out in order for it to be used
- understanding the limitations with respect to accuracy of inherent errors.

For each source of data the code should clearly document each of these aspects. Table 2 provides an example format

TABLE 2

Example of a template for summarising key data sources used in mining reconciliation process (after Morley and Thompson, 2006; Morley, 2008).

Data name	Source and type	Time frame	QA/QC	Transformations	Comment
Grade control	Grade control Model – tonnes Material type Grades	Daily or on an 'as designed' basis	Version tracking, peer review and sign off	Calculation of contained metal	Data is needed on an ore block by ore block basis
Short-term mine plan	Mine planning – volume/tonnes Material type	Daily/weekly/ monthly	Version tracking, peer review and sign off	Application of specific gravity to calculate tonnes from volumes	May also contain grade information
Budget/forecast	Mine planning – volume/tonnes Material type Grade	Monthly	Version tracking, peer review and sign off	Application of specific gravity to calculate tonnes from volumes	
Dispatch	Operations dispatch system – source Destination Material type Truck counts Tonnes	Shift summaries	Valid source and destinations, truck volume validation	Application of truck factor to calculate tonnes from truck counts	Tonnes are collected via truck load cells or truck counts
Stockpile surveys	Survey – volume	Weekly/monthly (end of month process)	Validation against dispatch results, peer review and sign off	Application of specific gravity to calculate tonnes from volumes	Survey may calculate tonnes using volume × density Surveys should include both ROM fingers and medium-grade stockpiles Survey could include waste stockpiles as well
Crusher tonnes	Plant – tonnes	Shift and monthly summaries	Weightometer calibration procedures	Monthly metallurgical balance process may result in changes to previously reported results	Weightometer measurement on crushed material
Head grade	Mill – grades	Shift and monthly summaries	Met balance	Monthly metallurgical balance process may result in changes to previously reported results	

that the reader can consider including within a site's documentation to clearly summarise these aspects associated with some data sources.

Table 3 provides a format that the reader can consider including within a site's documentation to clearly articulate the ranges of error that are associated with some data sources.

Methodologies and calculations

Table 4 presents a format that the author recommends as a template for documenting the methodology and calculations carried out to derive the various reconciliation results for any given reconciliation relationship. This format is a modified version of the table designed by the author and included in the paper by Fouet *et al* (2009), which also included similar tables documenting 17 reconciliation relationships. As mentioned this format is provided as a guide that the reader can modify for their own specific purposes. It is intended that a summary table such as that presented in Table 4 would be included for each of the reconciliation relationships at site.

A series of these tables that are linked to the reconciliation relationships as shown in Figure 4 will allow any reader of the mine's reconciliation code to clearly understand exactly how the information is compiled, calculated and exactly what is being reconciled.

Reporting

The final stage of the code deals with the output of the mine's reconciliation process, which is normally a set of tables, charts or images summarising the reconciliation results. It is beyond the scope of this paper to document all possible reports that can be produced from reconciliation data. As Mascini (2006) points out, when combined, the data described becomes greater than the sum of its parts if collated for a reconciliation report. When the records for every production source are organised, validated and analysed for an entire stope or bench the reconciliation will often contain significant learnings or opportunities for process improvement. Figure 5 presents such a report from Mascini's paper on a reconciliation project at the George Fisher Mine as a general outline or 'helicopter view' example of a final stope reconciliation report.

At a high level the author suggests that a simple summary such as shown in Table 5 will provide sufficient detail to allow a reader to understand what types of output are available.

TABLE 3

Example of a template for summarising the ranges of error that are associated with some data sources (after Morley, 2008).

Source of error	Normal range	Common range	Comments	Strategies to reduce errors
Grade control model estimation methodology accuracy	±10%[b]	±50%[b]	Can vary significantly depending on the understanding of geology and estimation methodology chosen.	Ongoing reconciliation and review of sampling quality, density and estimation methodologies.
Dispatch errors – incorrect source and destination	<5 incorrectly coded results per week[b]	1 to 10 errors per day[b]	Electronic dispatch systems greatly enhance accuracy – but only with constant monitoring and reconciliation.	Shift by shift review by operations and sign off. Errors corrected by dispatchers in the dispatch system.
Truck factors	±15%[b]	Between 15 and 30%[b]	Often empirical numbers that have not been validated for a long period of time.	Monthly compilation of dispatch results against weightometer or survey results.
Truck load cells	±5%[c]	±20%[c]	When truck load cells fail it is not uncommon for that truck to be kept in production – resulting in truck factors being used for tonnage estimates.	Regular maintenance and calibration schedules.
Specific gravity estimations (including *in situ* density estimates)	±5%[a]	±10%[b]	Specific gravity is often an empirical number used by mining, geology, survey and dispatch to convert volumes to tonnes.	Routine charting of survey versus dispatch versus weightometer data. Annual specific gravity laboratory testing.
Swell factors (stockpiles)	±5%[a]	±10%[b]	Includes factors used to convert *in situ* density to a 'stockpiled' density. On large stockpiles this can also include some allowance for compaction of material within the stockpile.	Use of stockpile density measurement devices for example as described by Treasure (2006).
Loader bucket factors	±15%[b]	Between 15 and 30%[b]	Often empirical numbers that have not been validated for a long period of time.	Monthly compilation of dispatch results against weightometer results.
Weightometer measurements	<±5%[c]	±20%[c]	Incorrectly positioned, poorly maintained and infrequently calibrated weightometers will give spurious tonnage measurements.	Regular maintenance and calibration schedules will result in weightometers delivering results within their design error tolerances.
Head grade sampling errors	±10%[b]	±20% up to 200%[b]	Auto-samplers are notoriously difficult to design, install and maintain. Plants with high volume of throughput make it almost impossible to maintain a sampling regime that is statistically appropriate.	Appropriate installation and regular maintenance of an auto-sampler. Reconciliation to metal produced rather than head grade.
Survey volume errors	±10%[b]	±10%[b]	Recent trends to use global positioning systems (GPS) for survey pickup can result in lower precision of the surface volume calculation.	Use of surface pickup by theodolite. Routine areal flyovers to provide calibration for survey surface pick-ups.

a. Treasure (2006); b. empirical industry experience; c. Pan *et al* (2003).

TABLE 4

Example of a template for documenting the methodology and calculations carried out to derive the various reconciliation results for any given reconciliation relationship (modified after Fouet *et al*, 2009).

Name	Mining production to plant feed
Data required	Mine production: dispatch data for material leaving the pit corrected using survey data. Supervisory control and data acquisition (SCADA) systems for the plant production data and laboratory information management system (LIMS) sampling results.
Frequency	Monthly.
Calculation	Tonnes = plant feed / mining production. Grade = plant feed sampled grades / mining production grades (estimated or sampled).
Purpose	Provides a measure of the effectiveness of estimates of actual mining from direct feed ore sources (pit and/or underground) plus stockpiles, to material.
Comments	Temporal reconciliation. This factor will highlight issues with truck factors or weightometer calibrations. Stockpiling effects reconciliation due to the impact on the material that ultimately reaches the mill. Reclaimed material must be included with direct tip material when reconciling material delivered to the mill verses what the mill received.

On a report by report basis the author suggests that within a mine's reconciliation code the capture of 'helicopter views' (such as shown in Figure 5) of all standard reports along with a summary of key information, such as is suggested, will provide clear documentation on what is being produced by whom and for what purpose. Suggested summary information includes:

- purpose of the report
- frequency of reporting
- role and department responsible for generating and issuing the report
- target audience of the report.

Accountability

A critical aspect of any code of practice is the documentation of who is responsible for the processes the code describes. Blucher (2002) points out that:

> *… the practical implementation of a robust reconciliation process must be focused through as few people as practical (preferably one person or a single position) in order for the system to produce information in a timely and consistent fashion. Given this view, it is important that all suppliers of information to the system accept that they are also shareholders in the whole process. Failure by the key stakeholders to accept this premise of ownership eventually leads to a partisan approach to resolving issues and a fragmentation of the whole process. Conversely cooperative ownership of the system will mean that information derived from one part of the process can benefit other parts or may pre-empt issues growing disproportionately in importance.*

The author recommends that any code contains a table or listing that documents the owner's roles on site for each step in the process as well as the management level role that is responsible for the code. The author supports Blucher's

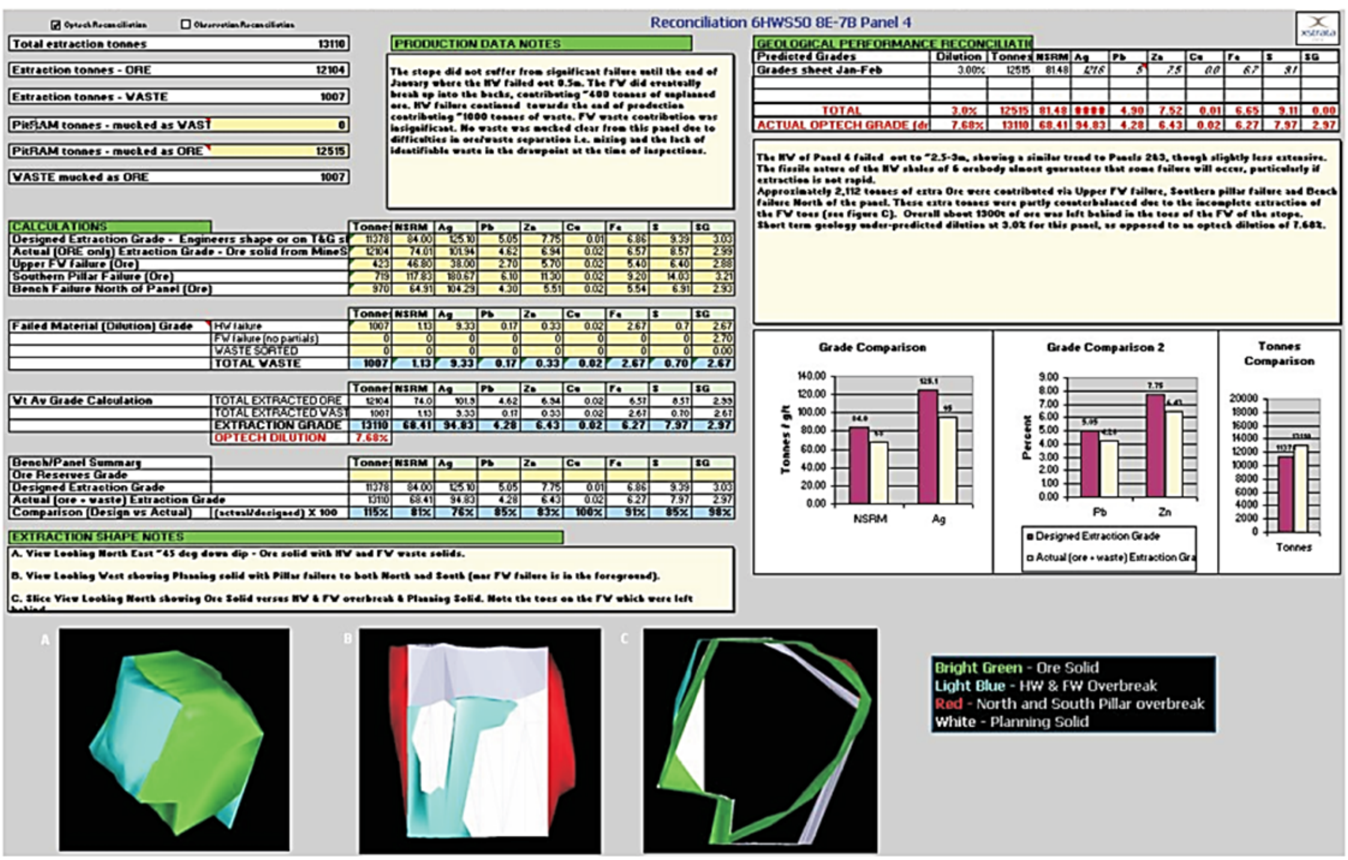

FIG 5 - A general outline or 'helicopter view' example of a final stope reconciliation from the George Fisher Mine (Mascini, 2006).
(Note: the intention is not that the detail should be legible on this diagram. The author's intent is to illustrate the general layout described in the text.)

TABLE 5
Types of reports being produced by the reconciliation system at Telfer (Riske *et al*, 2007).

Report type	Description	
Reconciliation	Reserve (plan)/grade control/mill (actual)	
Material movement	Pit depletion by:	Material type
		Date range
		Destination
	Tonnage comparisons by:	Grade control
		Trucking
		Crushing
	Crusher feed by:	Direct feed
		Rehandle
Stockpile tracking	Tonnes and grade available	
Engineering	Tonnes by equipment	
	Production by stage (performance against plan)	

(2002) conclusion that a single person or owner is critical. On many sites this takes the form of a reconciliation champion, who is often drawn from the geology or mining engineering departments. The reconciliation champion is the keeper of the process – ensuring the code is included in new personnel's induction and also making recommendations on updates so that the code remains relevant to actual practices on site. The reconciliation champion is also often the person that ensures the processes/systems documented by the code run on a day-to-day – month-to-month basis.

It is also recommended that a senior manager be assigned the responsibility and accountability for approval of changes and ensuring adherence to the code. In times of irrational rationalisations the reconciliation champion is often one of the first to be retrenched, resulting in complete collapse of the entire process and failure of the site to benefit from the ongoing continuous improvement that reconciliation can bring. Having a senior site manager (such as a technical service manager, chief geologist, mineral resource manager) own the code can ensure that as people come and go the responsibility is passed from person to person and the practices can survive staff changes and turnover.

CONCLUSIONS

The objective of this paper has been to draw on previously published information and the author's experience to provide a guide to the reader wishing to document the reconciliation processes and produce a code of practice for reconciliation for a mine site or company. By establishing and documenting good mine reconciliation practices, along with the use of quality validated data and sound analysis, it is possible for a mine to establish a continuous improvement process that will add significant value to any mining operation, while at the same time also ensuring large errors don't go undetected for long periods of time and avoiding 'surprise' results (after Mascini, 2006; Ziegelaar and Everett, 2010).

Blucher (2002) summarises the critical characteristics of a reconciliation system as addressing the following components:

- the principal goal of a reconciliation system is to enable the ongoing optimisation of all the key parts of an operation, leading to the best possible utilisation of the resources on which it is based
- all participants (input providers and output recipients) must understand the concepts, the aims, the required inputs, the logic to be implemented and the range of possible outputs of the whole system
- stakeholders in the system must accept that they are part owners of the whole and that the success of the system depends on a unified, cooperative approach to the issues
- the system must be capable of adapting to changing circumstances; however, change to fundamental system design parameters can only occur after consultation and discussion with all stakeholders
- successful implementation of the system relies on all participants being responsible for the quality and timeliness of their particular inputs
- results obtained from the system will be a function of numerous compromises and must be accepted as the best approximation, rather than as absolutes
- feedback to users must be in the form that they can utilise for their own purposes, eg section or departmental manager level
- overall responsibility for the management and operation of the system must be focused through an individual or a single position, which in most cases would be the mineral resources manager (after Blucher, 2002).

In addition this paper has outlined a number of templates and suggestions that the reader can adopt and modify to any site's requirements to ensure that the critical aspects of deriving reconciliation results are documented in a concise manner. This will ultimately provide a guide to reconciliation that allows others to understand the practices used at a particular mine site (or within a particular company) along with who is accountable for them. Pitard (2001) concludes that significant results can be achieved at most operations within one year of putting a reconciliation system in place. However, it is common that after three to five years staff changes and other issues on site result in the system failing, being abandoned or simply lost. In the author's opinion, where documentation as suggested in this paper is created and associated accountabilities are embedded into the key performance criteria for a site, there will be more chance of the reconciliation practices that have been established providing benefits year after year. Operating with an embedded reconciliation code of practice will deliver ongoing continuous improvement benefits that ultimately result in increased accuracy of models, increased recovery of resource and increased profitability of the mine, even more so where a company establishes such a code across all their operations and supports the ongoing reconciliation practices from a senior executive level.

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