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THE BASIC RESOURCE EQUATIONS (BRE & BR2RE) – A NEW APPROACH TO THE DEFINITION AND RECONCILIATION OF MINERAL RESOURCES AND RESERVES AT ANGLO AMERICAN PLATINUM LTD

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Abstract

Definition of mineral resources and reserves forms the basis for effective mine planning and reliable public reporting of mineral assets. Historically the mineral resource and reserves declaration process has been the domain of the geology and surveying disciplines, with the declaration of the reserves by the surveyor being based on the application of modifying factors to the declared resources available for mining. As part of an ongoing process to improve efficiency, reliability, and reproducibility of results, this approach has been revised and enhanced through the introduction of a revised process and reconciliation tools.

The revised approach to reserve definition is based on the definition of scheduled resources, at an appropriate confidence estimate in the context of an approved business plan, over the anticipated life of the mineral asset being applied to define reserves. This planning and scheduling is developed, during the annual business planning process, by the mine planning department using tools such as CADSMine™. The scheduled area together with the application of revised modifying factors is tabulated in the BME (basic mine equation) and reflects the mine production plan over time.

Simplification of the modifying factors to dilution and losses underpins the simple yet robust approach to improved definition of reserves in this process and in the basic resource to reserve equation (BR2RE). Dilution intrinsically affects grade but not metal content, whereas the losses reflect both the efficiency of mining and planning and are reflected in metal losses, area losses, or both. Reconciliation of the derived 'resource converted to reserve' area, (which is based on the business plan from CADSMine™), versus the 'resource available for mining', (which is derived from Datamine™), underpins the robustness and auditability of the reserves declaration. This R&R accounting and reconciliation approach is transparent and facilitates interrogation of the logic and rationale of long-term business planning and project strategy.

These numbers are processed and reported in the logic of the basic resource equation (BRE), which also addresses aspects such as white areas (future and historic), tail management, and partial extraction (non-scheduled pillars, etc.) in compliance with SAMREC definitions. Areas that do not have the necessary confidence and data support to be declared as resources find their space as pre-resource (outside the domain of public reporting), outlining existing potential for future extraction and reporting. Use of the BRE leads ultimately to a complete, refined accounting and reconciliation-oriented approach for all production entities.

The revised resource and reserve process includes the discipline of mine planning as intrinsic to the definition and declaration of resources and reserves. Subsequent to the change in process, the resources and reserves have truly become the domain of the mineral resource management discipline.

This paper defines the logic of the basic resource equations and outlines their application in the definition and reconciliation of mineral resources and reserves at Anglo American Platinum Limited.

Introduction

Anglo American Platinum first implemented an integrated business planning approach in 2003 under the direction of the then Strategic Long Term Planning department. The business planning process (BP) starts with the establishment of the mine extraction strategy (MES), followed by the short-term planning phase over a three year budget period. The production scheduling from the short-term planning is then extended from year four of the plan to end of life to create the life–of-mine (LOM) plan. Reserve declaration is an outcome of the business plan towards the end of the business planning (BP) cycle. The BP process has continued to evolve with advances in technology and an improved appreciation of the business value chain with full implementation of the mineral resource management (MRM) philosophy at Anglo American Platinum in 2009.

As part of an ongoing process to improve efficiency, reliability, and reproducibility of reserve declarations, a full review of the Resource and Reserve (R&R) process was initiated during 2010, with the prime objective of implementing a reconciliation process that meets or even establishes global best practice in R&R reporting.

This review lead to the development and implementation of the BRE (basic resource equation) and the BR2RE (basic resource to reserve equation) as part of an integrated, cross-functional business planning process.

Integrated business planning

The business planning process, as part of strategic long-term planning of the mineral asset portfolio, is conducted on an annual cycle comprising the following sequence of events:

- Development and review of a mine extraction strategy for the mining right area
- Development and review of a production profile for a three-year budget period
- Development and review of an operation labour plan for a three year budget period
- Development and review of operating cost and capital estimates for the budget period
- Development and review of the production profile for the life-of-mine plan (year four onwards)
- Development and review of a life–of-mine labour plan
- Development and review of operating cost and capital estimates for the life–of-mine
- Reconciliation and declaration of mineral resources and reserves associated with the business plan.

This process is inclusive of current projects in execution and anticipated projects (expansion and replacement) that support the planned production profile developed through the mine extraction strategy. Throughout the business planning process, multidisciplinary reviews (MDRs) are conducted at the conclusion of each phase to ensure quality of outputs. The review team comprises technical discipline heads from within MRM coupled with the mining engineer and discipline head specific to the review e.g. planning, human resources, and finance.

The mine extraction strategy is a physical depletion plan that covers the area over which mining rights have been granted. As such it is not time-limited and has a life, which is a result of the optimal scale of operations, technology selection, mining layouts, existing asset base, and constraints. The multi-discipline review conducted on the MES reviews all extraction options for the mining right, with selection of a final option based on value accretion and integration into the company portfolio. The operation then implements the approved MES option into the short-term (three-year budget period) and long-term (life-of-mine) plans.

The long-term plan (life-of-mine) extends from year four of the optimized extraction option through to exhaustion of the mineral resource contained in the mining right. The life-of-mine plan thus comprises investment centres at different levels of confidence estimate and mineral resource classification.

These levels of confidence estimate for the various investment centres that make up the plan are:

- Level 1: existing operations not requiring project capital (only stay-in-business capital)
- Level 1e: approved capital project in execution (expansion or replacement projects)
- Level 2a: feasibility study with capital estimates within ± 10 per cent.

The minimum proportion of mineral resources and confidence level required in the payback period footprint, at the end of a feasibility study, is:

- more than 60 per cent in the measured category
- less than 30 per cent in the indicated category
- less than 10 per cent in the inferred category
- Level 2b: pre-feasibility study with capital estimates within ± 15 per cent.

The minimum proportion of mineral resources and confidence level required in the payback period footprint, at the end of a feasibility study, is:

- more than 70 per cent in the indicated category
- less than 30 per cent in the inferred category

- Level 2c: conceptual study with capital estimates within ± 25 per cent.

  The minimum proportion of mineral resources and confidence level required in the payback period footprint, at the end of a feasibility study, is:

  - not less than 100 per cent in the inferred category
- Level 3 - Scoping tudy with capital estimates within ± 30 per cent.
- Level 3 plans effectively cover the remaining extent of potentially exploitable resource within the area covered by the current mining authorization and are generally not subjected to a rigorous stage-gate review process. Two sub-categories exist in level 3; 3a and 3b:
  - Level 3a (Scoping study at ± 30 per cent estimate confidence)
  - Level 3b (Scoping study at > 30 per cent estimate confidence based on pre-resource material, ‘blue sky’ opportunities).

Despite the best efforts to plan and find viable means of extraction, an investment centre (project) may not form part of the business plan for two reasons: economics or insufficiency of engineering work. This gives rise to two other categories:

- Not in business plan - NIB (eng) – these are uneconomic investment centres that may have been subject to extensive study work through to pre-feasibility level but are uneconomic for current long-term planning parameters; and
- Not in business plan - NIB (nw) – these are investment centres that have not had any study work done on them to date or where exploitation is planned well in the future (>30 years).

The relationship between the different levels of confidence for a life-of-mine plan is represented schematically, in plan view, in Figure 1.

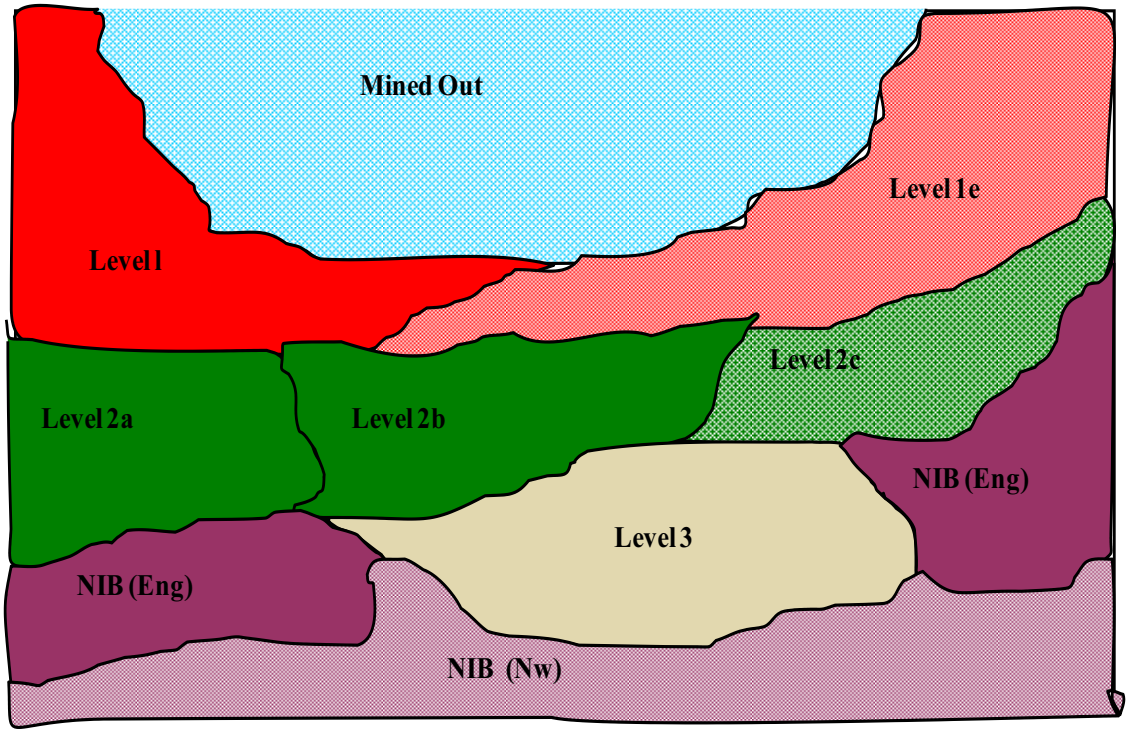

Figure 1-Schematic plan view of LoM investment centres at differing levels of confidence of estimate

However, typically the LoM plan is represented as a production profile (see Figure 2), which represents planned output and indicates the sequencing of anticipated projects. Examination of these profiles can give insight into inherent risk e.g. production ramp-up rates and relative proportions of production from projects at a given time, as well as the confidence aspects of the operations and project pipeline, as indicated in Figure 2.

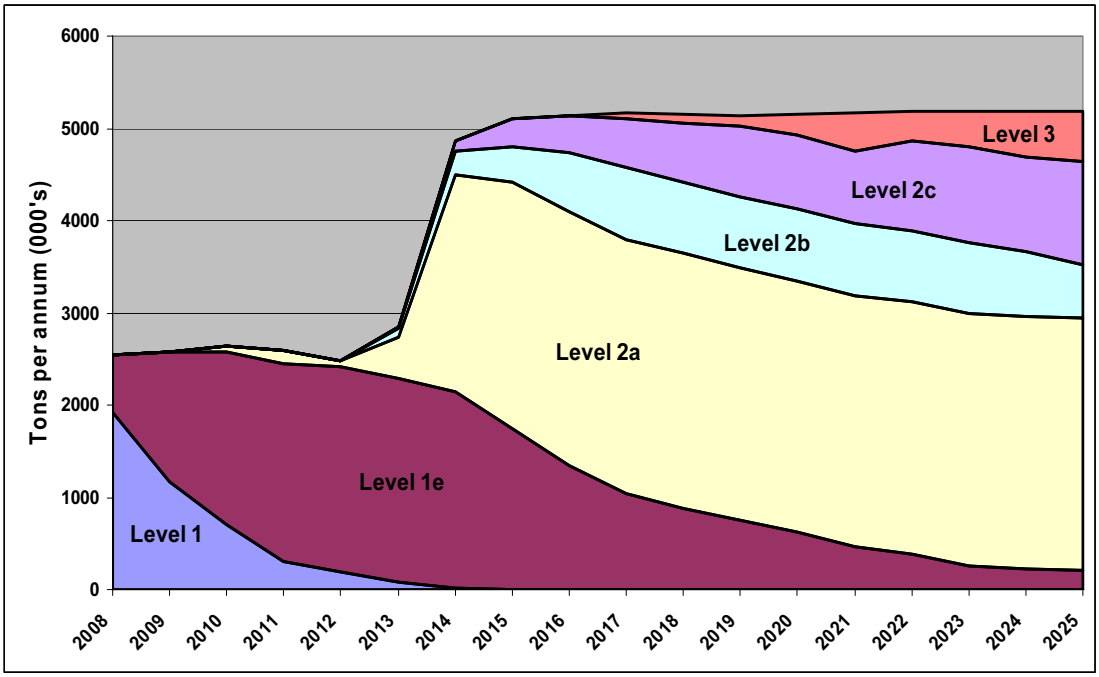

Figure 2-Example LoM production profile reflecting project pipeline and investment centre confidence level

Resources and reserves

By SAMREC (2007) definition 'a "Mineral Reserve" is the economically mineable material derived from a Measured or Indicated Mineral Resource or both. It includes diluting and contaminating materials and allows for losses that are expected to occur when the material is mined. Appropriate assessments to a minimum of a Pre-Feasibility Study for a project and a Life of Mine Plan for an operation must have been completed, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors (the modifying factors).'

At Anglo American Platinum this definition has been interpreted into the business planning process as being that a reserve is an estimate of the quantum of ounces to be delivered to the mill in a business plan, as derived from the scheduled resource (Measured and Indicated but excluding Inferred) at level 2a (feasibility study) or better estimate of confidence. Scheduled resources at pre-feasibility study level (level 2b) are included in reserves only where there is a high probability that the project will move to feasibility study during the following planning cycle.

Prior to 2010 the conversion from resource to reserve was based on the application of the appropriate modifying factors (considering dilution and content loss) to the resource that covered the five-year mining plan footprint, plus approved projects in execution and projects in feasibility or pre-feasibility study, with the work being conducted primarily by the survey and geology disciplines. In this process no real consideration was given to resources left behind as a result of the extraction rate, or remaining resources inside the reserve footprint that were unlikely to have reasonable prospects of eventual economic extraction (RPEEE). These resources were removed from the resource statement to retain integrity of reporting, but were then difficult to track for planning purposes.

During 2009 a full review of the resource–to-reserve definition process was conducted in order to enhance effectiveness of resource utilization, reporting, and reconciliation. Critical changes to the reserve definition process that were implemented as a result of this review were as follows.

Process:

- Reserves are based on a *scheduled resource*, ensuring that the planning discipline is integral to process
- Appropriate mine design and layouts are applied to the resource areas as dictated by current mining methods and mine design criteria to derive a *mineable resource*
- The *mineable resource* is scheduled according to production requirements to develop a *scheduled resource*
- Only current operations (level 1), approved projects in execution (level 1e,) and projects in feasibility study (level 2a) included in the business plan are defined as reserves (in Proved and Probable categories according to SAMREC)
- The remaining scheduled area of the LOM plan is termed *scheduled exclusive resource* and includes projects from Level 2b, 2c, and Level 3 with the objective of optimally extracting the available resources
- Resource categories have been increased to cater for exclusions and confidence levels (e.g. mineral resources above the geothermal gradient cut-off are moved to *mineral inventory*)
- The introduction of *mining losses* pertaining to resources left in pillars. The *mineable resource* excludes material locked up in mine-design related pillars
- Uneconomic production plan ‘tails’ revert to *mineral resource or mineral inventory* (depending on position in plan) through a ‘tail management’ process
- The application of modifying factors (technical, mining, geotechnical, processing and recovery, legal, market, and social/government factors) is implemented in three distinct phases:

  - Mine design and scheduling: Those modifying factors that impact on dilution of the resource (i.e. stope width *versus* resource width, tertiary development and other waste mining done on the reef horizon etc.) and modifying factors that define mining losses (i.e. non-mineable pillars and RIH/RIF mining inefficiencies etc.) are applied to the criteria included in establishing the mine design and scheduling
  - Processing: Those modifying factors that influence the efficiency of processing and recovery are applied to the *scheduled resource*, and the result is a *mineable reserve*
  - Economic: The subsequent application of modifying factors that influence the economic aspects of the mining operation results in the tail management requirement.
- The scheduled reserves are multi-discipline peer-reviewed and signed off by the competent person(s).

Reporting

- Resources are declared *inclusive* and *exclusive of reserves*.

Reconciliation

- The reserve definition process is readily auditable
- Reconciliation between the level 2a plan and *declared reserves* is possible
- Reconciliation between *declared reserves* and *scheduled resources converted to reserve* is possible.

This reconciliation process is facilitated by the use of the basic mining equation logic (Table I) and a data tabulation known as the 'production ounce to reserve reconciliation' (Table II), both of which integrate with the BRE (Table III) and BR2RE (Table IV) tools.

Table I-Example basic mining equation at level 2b

		Anglo Platinum - Own Mines							
		Tumela Mine			**Schedule 4**	**Level 2b**			
		BP 12 **Level 2b**			**Years**				
		BME		**TOTAL BP**	**2012**	**2013**	**2014**	**2015**	**2016**
1		Face Length Worked	m	3,302,221	80,154	75,165	77,869	87,052	80,249
2	x	Face Advance	m	7.8	7.5	8.0	7.8	7.1	7.3
3	=	m² Broken	m²	25,723,575	600,072	601,007	609,980	616,308	587,900
4	x	StopeTramming Width	m	1.60	1.70	1.71	1.71	1.68	1.70
5	x	Density	t/m³	3.96	3.93	3.95	3.95	3.96	3.96
6	=	Tonnes Broken from Stopes	tonnes	162,738,947	4,006,517	4,058,648	4,112,308	4,112,889	3,959,035
7	x	4E Stope Broken Grade	g/t	5.08	4.83	4.78	4.78	4.81	4.78
8	=	4E Ounces Broken from Stopes	oz	26,593,593	621,727	624,385	632,151	635,637	609,051
9	+	4E Oz Broken from Development	oz	224,058	8,774	7,559	6,804	5,325	4,911
10	+	4E Ounces from Historic Sweeping & Vampings	oz	4,103	1,323	1,393	1,387	0	0
11	±	4E Ounces from U/G and Surface Inventory Movement	oz	24,394	8,131	7,823	8,441	0	0
12	+	4E Ounces from Other Surface Sources	oz	830	830	0	0	0	0
13	=	**4E Ounces Delivered to Concentrator (Mining)**	**oz**	26,846,979	640,784	641,160	648,783	640,962	613,962
14	x	MCF	%	98.6%	99.3%	99.7%	99.8%	99.8%	99.9%
15	=	**4E Ounces Received at Concentrator (Process)**	**oz**	26,478,413	636,366	639,041	647,248	639,590	613,177
16	±	4E Ounces from Concentrator Stocks Movement	oz	-10,235	881	-1,785	-9,331	0	0
17	=	**4E Ounces in Mill Feed**	oz	26,468,178	637,246	637,256	637,917	639,590	613,177
18	x	4E Concentrator Recovery	%	86.4%	83.8%	85.7%	86.6%	84.0%	84.7%
19	=	4E Ounces in Concentrates (M&C)	oz	22,879,979	534,276	545,891	552,698	537,222	519,164
20	x	4E Equivalent Refined Recovery	%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%
21	=	Equivalent Refined 4E Ounces	oz	22,529,594	526,262	537,702	544,408	529,164	511,376
		BDE - Development							
22		Working Cost Reef metres	m	172,410	9,742	9,355	8,612	3,387	2,935
23	+	Working Cost Waste metres	m	223,885	9,704	10,563	9,268	7,741	5,502
24	=	Total Working Cost metres	m	396,296	19,446	19,918	17,879	11,127	8,437
25	+	SIBC Capital metres (Infrastructure)	m	1,332	0	0	0	437	432
26	+	SIBC Capital metres (ORD)	m	3,497	2,046	82	314	235	0
27	+	Project Capital metres (incl. Shaft Sinking)	m	31,220	778	776	1,598	3,286	2,152
28	=	Total Development metres	m	432,344	22,271	20,776	19,792	15,085	11,021
29		Drop Raise metres	m	28,992	1,547	1,699	1,519	968	688
		Tonnes							
30		Ore Tonnes Broken from Stopes and Development	tonnes	167,963,545	4,477,066	4,301,722	4,394,969	4,511,847	4,274,262
31		Tonnes Available for Hoisting	tonnes	172,090,106	4,500,258	4,323,547	4,410,585	4,570,050	4,287,275
32		Tonnes from Other Surface Sources	tonnes	30,000	30,000	0	0	0	0
33		Tonnes Delivered to Concentrator (Mining)	tonnes	168,056,625	4,531,340	4,323,993	4,411,505	4,511,847	4,274,262
34		**Tonnes Milled**	tonnes	168,095,569	4,530,816	4,324,731	4,412,933	4,483,656	4,274,262
35		U/G & Surface Inventory Movement	tonnes	167,631	57,678	52,961	56,993	0	0
		Grade							
36		4E Broken Grade (Stopes & Development)	g/t	4.97	4.38	4.57	4.52	4.42	4.47
37		4E Pay Limit @ **Cost 4**	g/t	**1.59**	**1.53**	**1.75**	**1.67**	**1.22**	**1.32**
38		4E Grade in Ore Delivered (Before MCF) (Survey Called)	g/t	4.97	4.40	4.61	4.57	4.42	4.47
39		**4E Mill Head Grade (Built-up)**	g/t	4.90	4.37	4.58	4.50	4.44	4.46
		Pt Information (Ounces)							
40		Pt % (Equivalent Refined)	%	60.54%	60.1%	60.0%	59.8%	59.8%	59.7%
41		Pt Ounces Delivered to Concentrator (Mining)	oz	16,018,231	385,738	382,662	382,191	382,199	366,131
42		**Equivalent Refined Pt Ounces**	**oz**	13,639,314	316,427	322,381	325,704	316,262	305,373

Table II-Example production ounce to reserve reconciliation

Anglo Platinum - Own Mines

Production Oz to Reserve Reconciliation

Mine

BP2012

		BME Equiv. Ref. 4E Oz	BME 4E ounces in mill feed (after MCF)	Proved Reserve (A)	Probable Reserve (B)	Total Reserve (A+B=C)	Future M + I Reserve (D)	Future Inferred Reserve (E)	Pre Resource Reserve (F)	Other (G)	Comments D,E,F and G ie what are these Future Reserves or Non reserves
Level 1	Oz ('000s)	5,487	6,541	6,506	28	6,534		2		5	Future Inferred in 15W and 10W areas.
	% Total	10.4%	100.0%	99.5%	0.4%	99.9%		0.0%		0.1%	Historic,s and Sifted material.
Level 1e Incremental	Oz ('000s)		0			0					
	% Total	0.0%	0.0%	0.0%	0.0%	0.0%				0.0%	
Level 2a Incremental	Oz ('000s)	2,447	2,931	2,551	176	2,726		205			Future Merensky Inferred in the 25W Sub Incline area.
	% Total	4.6%	100.0%	104.2%	7.2%	93.0%		7.0%			
Level 2b Incremental	Oz ('000s)	14,596	16,995	2	14954	14956		2,040			Future Inferred within the areras, which replaced the 4 Shaft investment centres
	% Total	27.6%	100.0%	0.0%	102.5%	88.0%	0.0%	12.0%			
Level 2c Incremental	Oz ('000s)	13,836	16,066				14,352	1,713			
	% Total	26.2%	100.0%				89.3%	10.7%			15W SI and 15W TSI
Level 3a Incremental	Oz ('000s)	15,356	17,950				6,807	11,144			
	% Total	29.1%	0.0%								3 Shaft and 5E Open cast
Level 3b Incremental	Oz ('000s)	1,106	1,326				338	988			
	% Total	2.1%	0.0%								Conceptual Project
Total	Oz ('000s)	52,827	61,810	9059	15157	24216	21,497	16,092	-	5	
	% Total	100.0%	100.0%	14.7%	24.5%	39.2%	34.8%	26.0%	0.0%	0.0%	

	Recovery %	MCF %
Level 1	83.88%	99.6%
Level 1e	0.00%	99.6%
Level 2a	83.46%	99.6%
Level 2b	85.88%	99.6%
Level 2c	86.12%	99.6%
Level 3	83.38%	

Note - D,E are the scheduled exclusive resources converted to reserves.
G - other can be historics, sifted reef, purchases,tailings retreatment etc

Implementation of the enhanced process during 2010 and 2011 occurred largely through the development and introduction of two tools; the basic resource equation (BRE – see Table III) and the basic resource to reserve equation (BR2RE – see Table IV).

The BRE and BR2RE

The BRE (basic resource equation) and the BR2RE (basic resource to reserve equation) provide the means to logically record and track the progression of the mineral asset from pre-resource through to reserve in a logical and systematic manner that could also be related spatially. Critically, the methodology defines numbers but also relates numbers to spatial location to facilitate reconciliation. The approach also facilitates the declaration of an *exclusive resource* (exclusive resource = total resource – resources converted to reserves by application of modifying factors).

Both tools are built using 'equation' logic:

e.g. area (m^2) x stope width (m) x density (t/m^3) = tons (t) x value (g/t) = content (g).

In the tables that comprise the BRE and BR2RE, the equation logic flows from left to right, with mathematical operators indicated in the second column with logic flow running top to bottom.

The ratios in the BRE are applied to allow quick review of the efficiency of critical parameters and to identify areas for additional focus in increasing resource utilization and conversion.

A comprehensive explanation of the line–by-line logic and workings of the BRE and BR2RE is contained in the Appendix.

Table III-Basic resource equation

		Anglo Platinum - Own Mines			
		Mine		Resource Reconciliation	
		BP 12		Reefs	
		BRE		Merensky	UG2	TOTAL
1		**Total Remaining Mineral Deposit** (Excluding Historic Write-offs)	Moz	**45.07**	**64.08**	**109.15**
2	-	Pre-Resource (Not yet in Inferred Category)	Moz	0.00	0.00	0.00
3	-	Historic White Areas (With Potential for Exploitation)	Moz	0.20	0.58	0.79
4	-	Residual Mineral Inventory (No Reasonable Chance)	Moz	6.92	7.27	14.20
5	=	**Published Inclusive Mineral Resource**	Moz	**37.94**	**56.22**	**94.16**
6	-	Scheduled Resource Converted to Reserve (Levels 1, 1e, 2a)	Moz	5.02	18.99	24.01
7	=	**Preliminary Exclusive Mineral Resource**	Moz	**32.92**	**37.23**	**70.15**
8	-	Mining Losses 'A' (Pillars and Future White Areas) (Partial Extraction) - Inside Reserve Footprint	Moz	1.23	3.34	4.56
9	=	**Exclusive Mineral Resource (to be reconciled with Published Exclusive Mineral Resource)**	Moz	**31.70**	**33.89**	**65.59**
10	-	Scheduled Exclusive Resource (Meas & Ind & Inf in Levels 2b, 2c, 3a and Inf in 1, 1e & 2a), includes reser	Moz	7.22	19.11	26.32
11	-	Mining Losses 'B' (Pillars and Future White Areas) (Partial Extraction) - Inside Sched. Exclus. Resource Foo	Moz	1.69	2.30	3.99
12	=	Exclusive Mineral Resource Not in Business Plan	Moz	22.79	12.48	35.28
13	-	Future Projects (Not in Current Business Plan)	Moz	4.49	5.69	10.18
14	-	Unscheduled Tails (At Level 3)	Moz	0.31	0.34	0.64
15	=	**Residual Exclusive Mineral Resource** (Passed 'Reasonableness' Test)	Moz	**17.99**	**6.46**	**24.45**
		INFO				
16		**Published Ore Reserve**	Moz	4.86	19.36	24.22
17		Mining factor	%	96.82	101.93	100.90
		RATIOS				
18		Published Ore Reserve : Scheduled Resouce Converted to Reserve Ratio	:1	0.97	1.02	1.01
19		Published Inclusive Resource : Scheduled Resource Converted to Reserve Ratio	:1	7.56	2.96	3.92
20		Scheduled Resource Converted to Reserve : Published Inclusive Resource Ratio	:1	0.13	0.34	0.25
21		Mining Losses 'A' : Published Inclusive Resource Ratio	:1	0.03	0.06	0.05
22		Published Exclusive Resource : Published Inclusive Resource Ratio	:1	0.84	0.60	0.70
23		Scheduled Exclusive Resource : Published Exclusive Resource Ratio	:1	0.23	0.56	0.40
24		Mining Losses 'B' : Published Exclusive Resource Ratio	:1	0.05	0.07	0.06
25		Future Projects : Published Exclusive Resource Ratio	:1	0.14	0.17	0.16
26		Unscheduled Tails : Published Exclusive Resource Ratio	:1	0.01	0.01	0.01
27		Residual Exclusive Resource : Published Exclusive Resource Ratio	:1	0.57	0.19	0.37
28		Exclusive Resource Not in Bus Plan : Published Exclusive Resource Ratio	:1	0.72	0.37	0.54
29		Mining Losses 'A' -Partial Extraction %	%	19.7%	14.9%	16.0%
30		Mining Losses 'B' -Partial Extraction %	%	18.9%	10.8%	13.2%

Table IV-Basic resource to reserve equation (BR2RE)

Anglo Platinum - Own Mines												
BR2RE			Mine - UG2 Reef									BP12
		(Basic Resource to Reserve Equation)	BME line	m²	Width	Density	Tonnes	g/t	Value cmg/t	Content	4E Moz	% Dilution
1		Scheduled Resource at Resource Width at 2a		18,689,218	148	3.95	109,265,796	5.44	805	594,237,226	19.105168	
2	-	Inferred Resource at Resource Width		119,000	148	3.75	662,271	5.29	784	3,500,749	0.112552	
3	=	Scheduled Resource converted to Reserve (BRE line 6)		18,570,218	148	4.09	108,603,525	5.44	805	590,736,477	18.992617	
4	-	Development at Resource Width (Equivalent Sq. m)		204,365	148	4.09	1,237,064	5.44	805	6,728,868	0.216338	
5	=	Mined from Stopes at Resource Width		18,365,853	148	4.09	107,366,461	5.44	805	584,007,608	18.776279	
6	+	Additional Volume to Minimum Mining Width		-	0	0.00	0	0.00	0	0	0.000000	
7	+	Additional Volume to Stoping Width		18,365,853	15	3.75	10,328,226	0.96	14	9,888,046	0.317908	
8	-	Content Lost from RIH/RIF (% of total)								1,027,664	0.033040	
9	=	Content Mined from Stopes at Stoping Width		18,365,853	158	4.06	117,694,687	5.04	795	592,867,990	19.061147	8.4%
10	+	Content from Gullies, Roadways,etc.					6,143,769	0.34		2,107,837	0.067769	
11	+	Content from Redevelopment			1	3.39	361,045	0.77		279,517	0.008987	
12	+	Additional Volume from Off Reef		73,815	1	3.33	399,094					
13	=	Content from Stopes at Stope Tramming Width		18,365,853	169	4.03	124,598,595	4.78	808	595,255,344	19.137902	14.7%
14	-	Scalping			0	0.00	-	0.00	0		0.000000	
15	+	Reef Development at Full Development Width		204,365	4	2.94	2,013,622	3.41	13	6,858,736	0.220513	
16	=	Content from Stopes and Development at Reserve Width		18,570,218	173	3.95	126,612,217	4.76	822	602,114,080	19.358415	16.6%
17	x	Mine Call Factor (%)	15							100.0%		
18	=	RESERVE		18,570,218	173	3.95	126,612,217	4.76	822	602,114,080	19.358415	16.6%
19	+	Historics	11			3.99	13,800	9.25		127,618		
20		Waste Trammed to Reef			5	3.22	2,862,876					
21	=	Total Hoisted	33	18,570,218	178	4.03	129,488,893	4.65	826	602,241,697	19.362518	19.2%
22	+	Sifted & Tailings re-treatment	13/34				30,000	0.86		25,816		
23	=	Delivered to Concentrator	16	18,570,218			129,518,893	4.65		602,267,513	19.363348	
24	+	Stockpile Movement	17				-70,000	4.55		-318,344		
25	=	Mill Feed	18	18,570,218			129,448,893	4.65		601,949,169	19.353113	

Other Information			Comments
26	RIH/RIF%	0.17%	8/(5+6+7)
27	Off Reef % (Stoping & Development)	0.32%	
28	Scalping %	0.00%	
29	Dilution %	16.58%	19/3
30	Stope Content Factor (%)	101.93%	17/3
31	Mining Factor (%)	101.93%	19/3

All fields have been used to reflect the comprehensive and logical workings of the calculation

The spatial relationship of each of the line elements of the BRE are represented in plan to facilitate understanding and allow visual reconciliation. For example, line 6 (scheduled resource converted to reserves) is represented in Figure 3.

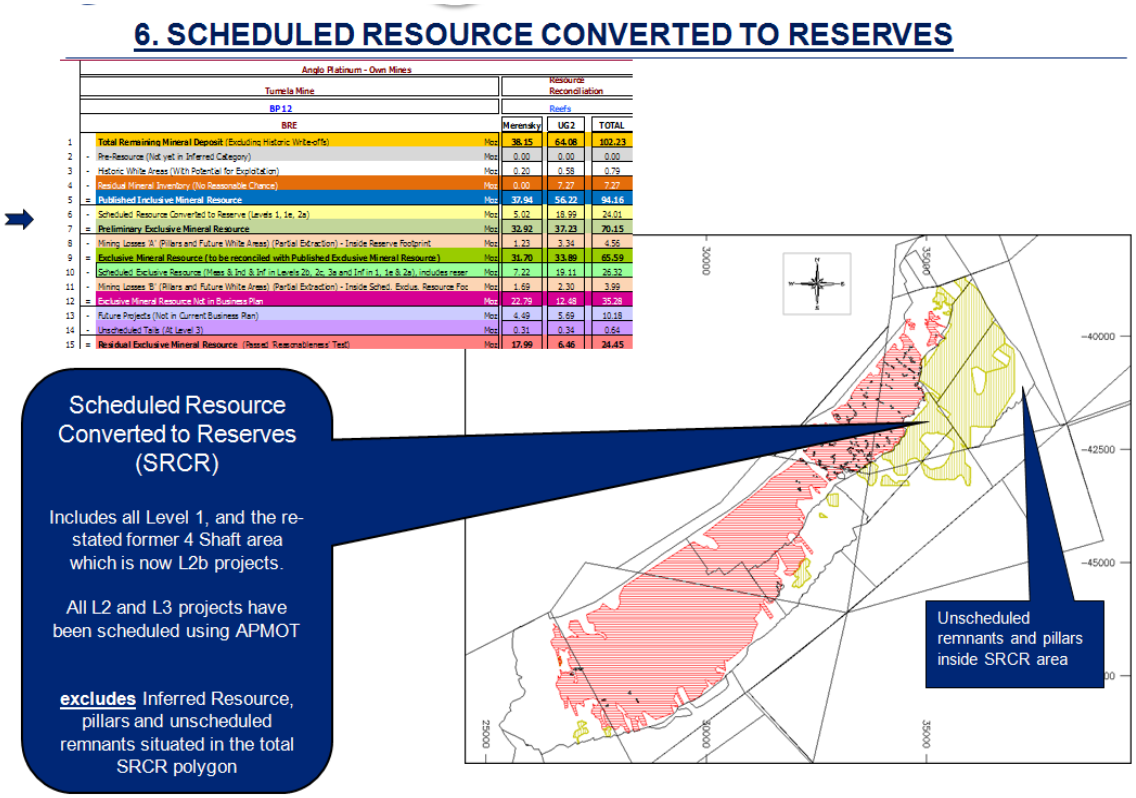

Figure 3- Example of spatial representation of BRE line element.

Reserve to exclusive resource calculation for reconciliation

Although the exclusive resources are calculated through the CADSMine™-based BRE approach, the annual declaration of exclusive resource numbers is still derived from Datamine™. The BRE approach and the back-calculation of exclusive resources from reserves provides a unique reconciliation between Datamine™-generated resources and CADSMine™-generated resources, as indicated in Figure 4.

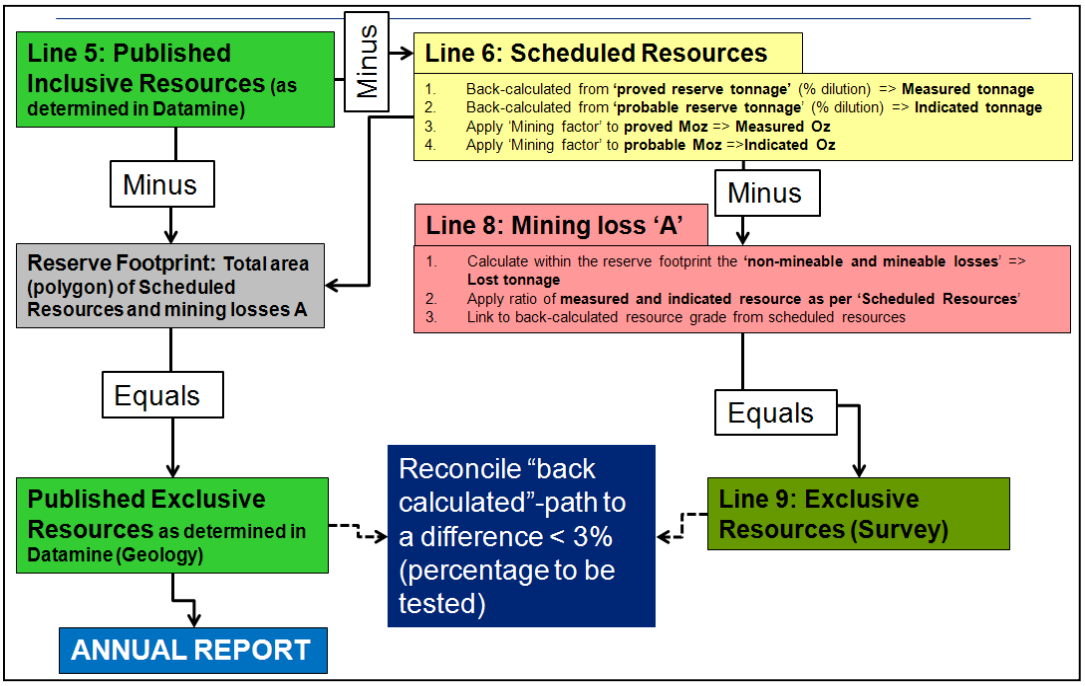

Figure 4-Process flow diagram – reconciliation between Datamine™ and CADSMine™ data for annual reporting

Open-pit operations

The same principles are applied to open-pit mining operations with minor modifications to the BRE categories. However, given that the resources as well as the reserves are derived through the Datamine™ software, direct checking and public reporting through the BRE rather than simply for reconciliation purposes is possible. Similarly to the underground operations, the resources are reported per pit and with the plan view being accompanied by a section view in order to clarify the 3D relationships for review purposes.

Conclusion

The basic resource equation (BRE) and the basic resource to reserve equation (BR2RE) are reconciliation tools that facilitate the understanding of the numerical and spatial relationship of the mineral resource to the resultant mineral reserve after scheduling and the application of modifying factors. Increased understanding of the interrelationship of resources to reserves and planned extraction creates an appreciation of the mineral assets and the overall extraction strategy. The technique and tools facilitate understanding of mineral resource utilization and conversion to reserves, both numerically and spatially, and enables effective review and audit processes.

The benefits of both templates can be summarized as follows:

- The reconciliation of resources and reserves (both spatially and numerically) is facilitated
- The process is simple, transparent, and repeatable
- The extent of resource utilization is evident
- Opportunities for further resource extraction (location and quantum) can be readily identified.

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Appendix

BRE and BR2RE - explanation of the internal workings

Overview of the BRE and BR2RE

The table below reflects the input validation responsibilities of geology, planning, and surveying into the BRE and BR2RE

Input validation responsibilities

Template	Discipline	Lines
BRE	Geology	1, 2, 3, 4
	Survey	8, 11, 16, 17
	Planning	6, 10, 13, 14
BR2RE	Planning (ex BME)	18, 20, 22, 24, 25
	Survey* (ex BME)	6, 7, 8, 10, 11, 12,15, 16

**Based on historic observation from survey measurements*

The BR2RE (see Table IV) is the primary tool used to determine and reconcile the inputs into lines 6, 16, and 17 of the BRE (Table III). The BR2RE also reflects the overall percentage dilution at the various points along the production planning process of the business plan (Levels 1, 1e, and 2a). The stope content factor indicates the difference in content with the conversion from resource to reserve; whilst the mining factor, is the stope content factor multiplied by the MCF. The mining factor indicates the general efficiency of the conversion from resource to reserve.

Reviewing the compilation of the company's long-term planning process requires that each of the 'outcome' milestones along the process fit into one of the classifications reflected in the BRE. For example, the mine extraction strategy (MES) is effectively the published inclusive mineral resource (Line 5 of BRE). In most instances this is the starting point of the BRE and essentially the starting point of the BR2RE too.

The application of the BR2RE

In defining the MES, the mine planner schedules the extraction of the resource around known geological structures and within known resource blocks according to approved mining methods and benchmarked rates of achievement.

Scheduled resource converted to reserve (lines 1 – 3)

The outcomes of the areas with the confidence levels of 1, 1e, and 2a, form the basis of the business plan and also the 'scheduled resource converted to reserve' (line 3 of the BR2RE, and is also subsequently one of the primary inputs into the BRE on line 6 after reconciliation). If any inferred resource (line 2) is included in the business plan, then this is added to line 3 to reverse-calculate the 'scheduled resource at resource width' (line 1).

Mined from stopes at resource width (lines 4-5)

When reducing the 'scheduled resource converted to reserve' figure (line 3) with the expected resource from 'development at resource width' (line 4), the result is 'mined from stopes at resource width'. (Bear in mind the specific focus of the resource evaluator is to evaluate the resource for the best value at an optimized width for declaring the resource.)

Mined from stopes at stoping width (lines 6-9)

This optimized width is referred to as the 'resource width' and may be less than the prescribed geotechnical width (or minimum mining width). Added to this is the increase in the stoping width through the inaccuracies of mining practice, and this then constitutes the actual stope width at which the resource will be mined. Bear in mind also that not all dilution comes with no content.

The above aspects of 'dilution' are taken into account in lines 6 and 7 of the BR2RE, and when one further considers the vagaries of miners, then the 'losses' of metal accounted for as being left behind as RIH and RIF are also reflected in line 8 of the BR2RE. The result of the equation at this point (line 9) declares the quantities mined from stopes at stoping width.

Mined from stopes at stope tramming width (lines 10-13)

Further 'dilution' in the form of gully excavations, redevelopment, and waste from off-reef mining is considered in lines 10, 11, and 12 respectively. The result at this point (line 13) declares the quantities mined from stopes at the expected tramming width.

Mined from stopes and development at reserve width (lines 14-17)

Line 14 deducts the ore that will be left underground as part of the resource when scalping is practiced, and then the 'reef development at full development width' (line 15) is added back into the equation and 'waste trammed to reef' (line 16) is included. The result at this point reflects 'mined from stopes and development at reserve width' (Line17).

Determination of reserves (lines 18-19)

The application of the MCF (line 18) results in the final RESERVE (line 19) which is to be published.

Reconciliation (lines 20-25)

Reconciliation of these figures is done both between the mine planner and the surveyor with the BME and the BR2RE. Considering lines 25 to 20, this is achieved with the BME's final milled tons and contents following the deduction of any extraneous sources of milled tonnage such as stockpile movement, tailings retreatment, and sifted material and previously called-for material such as historic vampings etc.

Other information (lines 26-31)

An important validation point, as these figures should agree with the inputs provided to the planners. One of the key inputs into the BRE is the mining factor (line 31).

Application of the BRE

Published inclusive mineral resource (lines 1-5)

The published inclusive mineral resource, as previously stated, should equate to the mine extraction strategy, which by definition would exclude any 'pre-resource (line 2), historic white area (line 3), and residual mineral inventory (i.e. that which has no reasonable chance of being economically exploited – line 4). When considering these exclusions in addition to the mine extraction strategy, the 'total remaining mineral deposit' (line 1) is derived.

Note: The pre-resource category accounts for all potential areas or reefs that may be potential economic targets, but are not yet at a confidence level that indicates future potential for extraction or are not yet owned by the company, but a reasonable, non-speculative chance exists. Historic white areas are areas 'left behind' in the past for unknown or economic reasons at the time and which may represent potential future mining targets.

Residual mineral Inventory represents a category that reflects areas/property deemed to have no reasonable chance of ever being exploited. This classification obviously requires adequate geological data/information. However, it also relates to areas within the mining right area that, under the current known technology, cannot be accessed, such as mining below the 75°C isotherm. Should technology and/or economic circumstances change, these assets can be brought back into the public resource domain. These comprise the mineralized inventory not reported in the public domain.

Preliminary exclusive resources (lines 6 -7)

The 'Preliminary exclusive resources' (line 7) is derived by subtracting the reconciled figure of the 'scheduled resource converted to reserve' (line 6) as obtained from line 3 in the BR2RE.

Exclusive mineral resource (lines 8-9)

In order to arrive at the actual exclusive resources (line 9), mining losses, termed ’mining losses A’ (line 8), in form of pillars are deducted from the ‘preliminary exclusive mineral resource’ (line 8).

Note: Mining losses A are either calculated from both mine design polygons or factorized from historic reconciliation work based on the mining method applied and the overall mining extraction percentage. These include pillars such as ventilation pillars, boundary pillars, regional pillars, crush pillars (as per mine design), as well as shaft pillars.

Exclusive mineral resource not in business olan (lines 10-12)

Further excluding the ‘scheduled exclusive resources’ (line 10) in areas with Levels 2b, 2c and Level 3, as well as all inferred resources from the ’Reserve window’ (which are not convertible according to SAMREC), and ‘mining losses B’ (line 11) according to the same principles of ‘mining Losses A’, results in the ‘exclusive mineral resources not in business plan’ (line 12).

Note: There can be numerous reasons as to why these areas have not been included in the business plan of the company for a particular year, but these are typically related to simple economic valuation of these areas as business Investment centres. NPV and IRR hurdle rates, as well the company’s top-down goals in terms of required production from the various operation and JVs, are amongst the main considerations. However, this can be and is generally tested on an annual basis and would typically happen early in the year by means of mine extraction strategy reviews.

Residual exclusive mineral resource (lines 13-15)

Both ‘future projects (not in current business plan)’ (line 13) and ‘unscheduled tails (at Level 3)’ (line 14) are typically not part of the business plan, showing no sign for future project potential, are geologically very complex and/or not well enough understood to interest the company under the current economic environment. Further work or a ’fail’ assessment would warrant their ’transfer’ to the residual inventory (line 4).

Deducting these areas results in the ‘residual exclusive mineral resource (passed the reasonableness test)’ (line 15).

INFO (lines 16-17)

The reserves are reflected as the result of the resource converted to reserves in line 3 multiplied by the mining factor (line 17) as obtained from the BR2RE.

RATIOS (lines 18-30)

Each of the primary constituents of the business planning process reflected above have a relationship with either the scheduled resource converted to reserve, the published inclusive or published exclusive resource. Understanding these relationships and how they compare from one area to another facilitates an appreciation of the drivers and challenges in various aspects of mineral resource management process.

The reasonableness test

The resulting residual exclusive resources at the end of the BRE undergo the reasonableness test for RPEEE. If the requirements for resource reporting are fulfilled and well supported by company economics, the portion of resource remains in the published domain as part of the published exclusive resources. If no reasonable chance exists for future mining, neither on a technical nor on an economic level, a transfer will be initiated to residual mineral inventory. This process of interrogation of economic viability of investment centres as well as resource definition criteria for public reporting, occurs on an annual basis and is deemed an industry best-practice approach to business planning.

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Gordon is a registered Professional Engineer, a Fellow and Office Bearer of the Southern African Institute of Mining and Metallurgy and holds a range of industry technical and managerial qualifications.

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