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Mining in Morobe, Papua New Guinea – Impacts, Assurance and Self-determination

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ABSTRACT

The Morobe Province of central Papua New Guinea (PNG) has been mined for gold for nearly a century, although it is only in the past decade that large-scale modern mining commenced. The Hidden Valley gold-silver project began construction in mid-2006 and production by August 2009, and is located in the mountains above Wau in the headwaters of the Watut River. The mine is owned and operated by the Morobe Mining Joint Venture (MMJV), which also owns the Wafi-Golpu project, comprising the Wafi gold deposit and Golpu copper-gold deposit, situated in the Watut River Valley. Together they represent a potential mine of the scale of Ok Tedi or Bougainville or bigger. The MMJV is owned in equal shares by Newcrest Mining from Australia and Harmony Gold from South Africa. Although Hidden Valley was the first large-scale mine in PNG to engineer and build a tailings storage facility, poor environmental management during construction and early operations led to significant erosion of waste rock and sedimentation impacts throughout the ~200 km length of the Watut River. Since then, substantial efforts have been made to improve environmental management, especially waste rock placement and storage and water quality management. While the impacts from the Hidden Valley project appear to be reducing, the saga has heightened concerns by many along the Watut River and across PNG about ongoing impacts from mining.

This paper presents the results of an ongoing project in the Morobe Province conducted by the Mineral Policy Institute examining the historical, current and future impacts of mining, including community views, social and environmental impacts and the monitoring and regulation of mining. Overall, there is a clear need to more fully integrate social and environmental issues into life-of-mine planning and go above and beyond regulatory requirements. In this way, some of the lessons learnt – by the community, MMJV and government – can be incorporated before, during and long after mining.

INTRODUCTION

The reality of mining in Papua New Guinea (PNG) lies not just in the recent impacts from mining along the Watut River, but in the history of mining in PNG. A history that spans the Bulolo goldfields in the Morobe Province, the crisis that started at Panguna leaving 16 000–20 000 dead, the destruction of the Fly River by Ok Tedi and the disposal of mine waste into the river at Porgera and the ocean at Lihir, Misima and Basamuk Bay (Ramu Nickel). The history of mining is marked by conflict between economic systems, beliefs and customs where mining profits are expatriated or leave little lasting community benefit to compensate for significant environmental impacts and ongoing social and cultural dislocation. All too often, mineral exploitation is pushed and promoted by those with the most to gain; multinational companies, government and corporate and local elites. For these select few, the benefits from mining outweigh the impacts. For others, their experience is often a loss of

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self-determination and transitory benefits complicated by external processes and scales of operation that overwhelm culturally specific, often localised, knowledge and experience.

The fundamental question is whether mining along the Watut River will follow the historical and destructive pattern of large-scale industrial mining development in PNG or whether it can set a new, more modern standard. The aim of this paper is to contribute to the understanding of mining impacts along the Watut River, particularly in relation to monitoring, reporting, decision-making and transparency. The paper is a shortened version of a wider-ranging report and accompanying documentary (Roche and Mudd, 2014; MPi, 2013) and provides an insight into the links between mining, communities, development and the environment – critical in considering the life-of-mine for any major mining project.

MINING IN PAPUA NEW GUINEA

Brief mining history

Mining has been occurring in PNG for about a century in specific goldfields such as Misima Island, Wau-Bulolo, Woodlark Island and Mt Kare. Large-scale modern mining includes the 1972 development of the Panguna Cu-Au-Ag mine on Bougainville Island, the mid-1980s development of the Ok Tedi Cu-Au-Ag mine in Western Province, the Porgera Au mine in the Central Highlands in the mid-1990s, the Lihir Au mine in New Ireland in the late 1990s and more recently the Hidden Valley Au-Ag mine in the late 2000s. Smaller mines include Tolukuma, Kainantu, Simberi and Sinivit, as well as major deposits being explored and considered for development at Frieda River, Wafi-Golpu and Yandera. The Ramu Ni-Co-Cr project (near Madang) was built in the late 2000s and began production in late 2012. A basic mining map of Papua New Guinea is shown in Figure 1.

At the Panguna and Ok Tedi mines, tailings were directly discharged into the adjacent river systems, while waste rock was either directly dumped into the river or placed on easily erodible dumps. The substantive scale of social and environmental impacts from the Panguna mine led to a civil war breaking out in May 1989 that lasted for more than a decade (Havini and John, 2001), before peace was finally negotiated in 2002. Riverine mine waste disposal is still being used at Ok

FIG 1 – Location of major gold, copper–gold and nickel mining projects in Papua New Guinea.

Tedi, Porgera and Tolukuma, which are all associated with severe environmental and social impacts along their respective river systems (especially the Fly River downstream from Ok Tedi; see Bolton, 2008; Tingay, 2007).

Alternatively, at the former Misima Au-Ag mine on Misima Island, as well as at the operating Au mines of Simberi and Lihir, tailings are discharged into the sea at depths of ~100 m or more. The Ramu Ni-Co-Cr project also now uses marine tailings disposal and began production in late 2012 after a lengthy court case failed to stop the use of marine tailings disposal at Basamuk Bay. Major concerns with marine disposal include the unknown but potentially significant impacts on deep marine biodiversity and ecosystem processes, the lack of transparency, the difficulties of independent monitoring and enforcement and flaws in predicting potential impacts in the approvals process. Ongoing concerns about marine disposal impacts at Basamuk Bay are regularly reported in PNG's formal and social media (see Papua New Guinea Mine Watch, 2014).

By the start of the new millennium, there was yet to be a major PNG mine that used conventional engineered mine waste management, such as a tailings storage facility (or dam) and careful waste rock dump designs to minimise erosion and environmental impacts. These approaches are required by law in countries such as Australia or Canada and are considered standard mining practice.

The cumulative production from major mines across PNG is shown in Table 1, along with reported mineral resources in Table 2. As can be observed, some projects, such as Lihir and Ok Tedi, are very large producers, while deposits such as Wafi-Golpu and Frieda River could be substantial new mines if they are successful in the assessment and approvals process and proceed to commercial production.

Mining in the Morobe Province

This section is summarised from Lowenstein (1982) and Enesar (2004) unless otherwise noted.

Gold was discovered in the Morobe Province in 1910 by Arthur Darling in the Bulolo River near Koranga Creek, although significant activity did not start until the site was re-located in 1922 by William Park and Jack Nettleton. The region was proclaimed a goldfield in February 1923, with work focused on alluvial gold in Koranga Creek and the Bulolo River. Interest continued to grow as rich deposits of alluvial gravels were discovered through the 1920s, and in 1927 the first hard rock or lode gold deposit was discovered at Edie Creek. By 1930, both alluvial dredging and hard rock

TABLE 1

Cumulative production statistics for major Papua New Guinea mines.

Mine	Period	Ore (Mt)	Gold (g/t)	Silver (g/t)	Copper (% Cu)	Gold (kg)	Silver (kg)	Copper (t)	Waste Rock (Mt)	Companies(%shareholding)
Ok Tedi	1984–2012[#]	~668	~0.9	-	~0.8	~416 514	~836 000	~4 343 500	~998	Ok Ted Mining Joint Venture
Panguna	1972–1989	675.37	0.63	-	0.52	305 604	784 041	2 988 058	570	Rio Tinto[53.83%], PNG Government[19.06%], Public[27.11%]
Porgera	1990–2013[#]	107.67	6.17	-	-	572 668	-	-	~879	Barrick Gold[95%], PNG Government[5%]
Lihir	1997–2013[#]	75.440	5.07	-	-	334 139	-	-	525.0	Newcrest Mining[100%]
Misima	1989–2004	87.471	1.45	~13	-	115 896	~570 000	-	347.8	Placer Dome[100%, a]
Tolukuma[b]	1996–2012[#,b]	~2.4	~13	»30	-	~29 500	»38 700	-	~2.79	PNG Government[100%, b]
Hidden Valley	2009–2013[#]	15.310	1.91	~25	-	23 955	»196 900	-	»127.6	Harmony Gold[50%], Newcrest Mining[50%]
Simberi	2008–2013[#]	10.309	1.26	-	-	12 230	-	-	»5.2	Allied Gold[100%]
Kainantu[c]	2006–2008	~0.35[c]	~7.3[c]	-	-	~2200[c]	-	-	no data	PNG Government[100%, c]
Sinivit[c]	2008–2012[#,c]	~0.52[c]	~3.9[c]	-	-	~1130[c]	>129[c]	-	>0.2	New Guinea Gold Corp[100%, c]
Mt Victor	1987–1990	0.199	~3.2	~1.8	-	636	360	-	0.19	Niugini Mining[100%, c]

Note: Mt – million tonnes, g/t – grams per tonne.

[#] Still operating in 2013. [a] Placer Dome was taken over by Barrick Gold in early 2006. [b] Tolukuma was bought by the PNG Government in February 2008 (through state company Petromin PNG) but does not report production statistics; data shown is approximate only. [c] Some production statistics not reported, approximate values assumed.

TABLE 2

Reported mineral resources for Papua New Guinea mines and projects (2012 or most recent data).

Copper-Gold/Gold	Mt Ore	g/t Au	g/t Ag	%Cu	Other	Gold (kg)	Copper (t)	$million[@]	Companies[(%shareholding)]
Frieda River Group[a]	2585	0.23	0.59	0.47	-	589 900	12 192 000	125 568	Xstrata[81.82%], Highlands Pacific[18.18%]
Golpu	1000	0.63	1.08	0.90	0.0095% Mo	634 300	8 972 000	104 461	Harmony Gold[50%], Newcrest Mining[50%]
Lihir[(mine)]	1020	1.95	-	-	-	1 993 000	-	103 207	Newcrest Mining[100%]
Panguna	1838	0.34	-	0.30	-	627 500	5 514 000	74 800	Rio Tinto[53.83%], PNG Government[19.06%], Public[27.11%]
Ok Tedi[(mine)]	755.2	0.70	-	0.59	-	526 200	4 420 000	61 154	Ok Ted Mining Joint Venture[#]
Yandera	833	0.05	~1.5	0.34	0.0076% Mo	34 300	2 871 000	26 872	Marengo Mining
Porgera[(mine)]	120.4	3.37	-	-	-	406 200	-	21 035	Barrick Gold[95%], PNG Government[5%]
Hidden Valley[(mine)]	117.9	1.48	26.9	-	-	174 400	-	12 123	Harmony Gold[50%], Newcrest Mining[50%]
Wafi	133	1.63	-	-	-	216 900	-	11 232	Harmony Gold[50%], Newcrest Mining[50%]
Kodu[e]	276[e]	0.30[e]	1.7[e]	0.27[e]	0.0077% Mo[e]	82 800[e]	745 000[e]	11 083	Frontier Resources[100%, e]
Simberi[(mine)]	189.3	1.03	-	-	-	194 200	-	10 057	Allied Gold[100%]
Simiku	200	0.06	2	0.36	0.0061% Mo	12 000	720 000	6891	Coppermoly[100%]
Arie[f]	164[f]	0.1[f]	1.7[f]	0.32[f]	-	16 400[f]	525 000[f]	5147	Triple Plate Junction[75.98%], Pacrim Energy[13.43%], Golden Success[10.59%]
Woodlark Island	42.4	1.5	-	-	-	63 600	-	3296	Kula Gold[100%]
Mt Kare	24.6	2.13	15.49	-	-	52 400	-	3083	Indochine Mining[100%]
Nakru	38.4	0.28	1.80	0.61	0.0013% Mo	10 800	234 000	2487	Coppermoly[100%]
Solwara 1	2.57	5.84	30	7.74	0.70% Zn	15 000	199 000	2413	Nautilus Minerals[70%], PNG Government[5%]
Nambonga[d]	40	0.79	-	0.22	-	31 600	88 000	2312	Harmony Gold[50%], Newcrest Mining[50%]
Crater Mountain	24	1	-	-	-	24 000	-	1243	Gold Anomaly[90%]
Imwauna-Normanby	1.8	12.2	20	-	-	22 000	-	1172	New Guinea Gold Corp[50%], NMC Mining Corp[50%]
Laloki[f]	0.9[f]	21.9[f]		-	-	19 700[f]	-	1021	Unknown
Tolukuma[g, (mine)]	0.58[g]	30.6[g]	-	-	-	17 700[g]	-	919	PNG Government[100%]
Gameta	5.1	1.8	-	-	-	9200	-	475	Gold Anomaly[100%]
Mt Kren-Puan[f]	20	-	-	0.3[f]	-	-	60 000[f]	460	Triple Plate Junction[75.98%], Pacrim Energy[13.43%], Golden Success[10.59%]
Sinivit[(mine)]	2.05	3.5	-	0.26	-	7100	5000	369	New Guinea Gold Corp[100%]
Solwara 12	0.23	3.6	56	7.3	3.6% Zn	800	17 000	201	Nautilus Minerals[70%], PNG Government[5%]
Sehulea-Weioko[f, h]	1.71[f, h]	1.36[f, h]	12.3[f, h]	-	-	2300[f, h]	-	141	New Guinea Gold Corp[100%]
Nickel-Cobalt	**Mt Ore**	**%Ni**	**%Co**			**Nickel (t)**	**Cobalt (t)**	**$million[@]**	**Companies[(%shareholding)]**
Mambare	162.5	0.94	0.09			1 528 000	146 000	30 006	Direct Nickel[50%], Regency Mines[50%]
Ramu	143	1.01	0.1			1 444 000	143 000	28 843	MCC[85%], Highlands Pacific[8.56%], PNG Government[3.94%], Landowners[2.5%]
Wowo Gap	125	1.06	0.07			1325 000	88 000	24 899	Resource Mining Corp[100%]

Note: Mt – million tonnes, Mo – molybdenum, Zn – zinc.

[#] Still operating in 2012. [@] Australian dollar values estimated based on 2012 prices from BREE (2012). [a] Frieda River consists of several deposits – the dominant H-I-T (or Horse/Ivaal/Trukai), Nena, Koki and Ekwai deposits. [d] Nambonga is part of the Wafi-Golpu project. [e] Kodu is extremely close to the Kokoda Track and has been halted from development. [f] Resource estimate not JORC Code compliant. [g] Tolukuma resource is from 2006, since more recent data not available. [h] Resource estimate historical and not JORC Code compliant.

mining were progressing to modest-scale projects based on rich gold grades and easily mineable ore at or near the surface.

The major operations in the region concentrated on dredging in the Bulolo area and hard rock mining around the Edie Creek area throughout the 1930s. At its peak in 1941, the Bulolo dredge processed about 3 Mt gravels/a and recovered ~5200 kg Au and ~2250 kg Ag – a yield of 0.220 g/t Au (Ag yield was 0.098 g/t Ag). The Koranga sluicing operation processed up to ~1 Mt gravels per year at an approximate yield of ~0.09 g/t Au (Ag ~0.05 g/t). The outbreak of World War II and the advance of the Japanese military in the area closed the entire field in January 1942. The Bulldog track from Upper Edie Creek to the Lakekamu goldfield to the south was built by the army from 1942 to 1944 to help supply the war effort in the region. After the re-establishment of infrastructure, especially power supplies, dredging recommenced at Bulolo in February 1947, with hard rock mining re-starting at the Upper Ridges site in 1948. While dredging and hard rock mining returned to their previous production levels for the 1950s, the field had begun to decline by 1960. The Bulolo dredge closed in 1967 and the Golden Peaks mine near Wau closed in 1977. Reported production over time is shown in Figure 2. The alluvial gold resources were considered to be depleted by the mid-1980s, with attention turned to trying to revive the Edie Creek area (Neale, 1994) as well as develop the Hidden Valley/Kaveroi and Hamata deposits discovered in the mid-1980s (see Pascoe, 1991; Denwer and Mowat, 1997). Artisanal mining continues to be important for communities along the Watut and Bulolo Rivers, as shown in Figure 3.

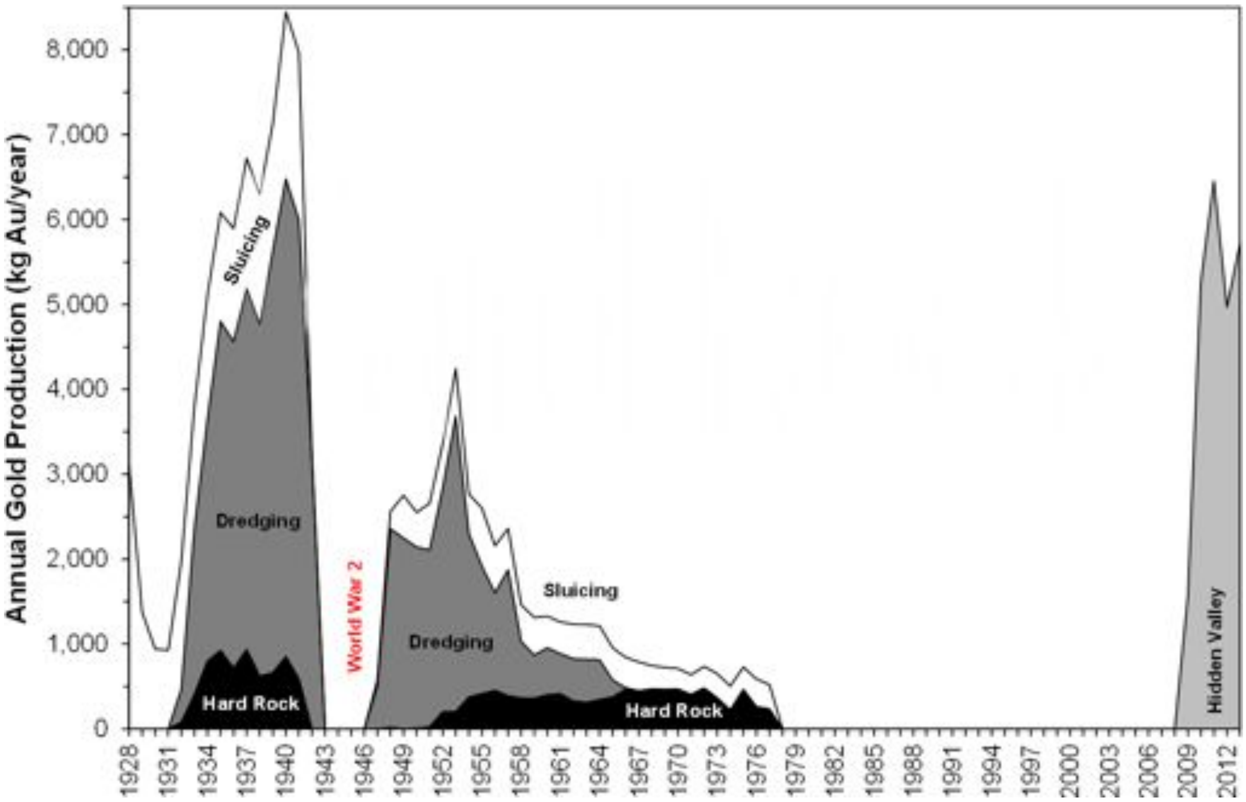

FIG 2 – Reported gold production over time (1928–77) by mining method in the Morobe Province, including inset by mining method (adapted from data in Lowenstein, 1982) plus Hidden Valley (2009–13; from data in this paper; no data is known between 1978 and 2008).

THE HIDDEN VALLEY AU-AG PROJECT

Hidden Valley overview

The Hidden Valley Au-Ag mine is located in the Wau-Bulolo goldfield, ~90 km south-south-west of Lae and some 300 km north-north-west of Port Moresby, with a local map shown in Figure 4. The region forms a major part of the Morobe Province. The Hidden Valley project is located in the headwaters of the Bulolo and Watut Rivers, with the Watut River being a major tributary of the Markham River that reaches the ocean near Lae.

The Hidden Valley Au-Ag deposit, including the adjacent Kaveroi zone, was discovered by CRA Exploration Ltd (CRA) in July 1985 (Nelson, Bartram and Christie, 1990; Pascoe, 1991), while the Hamata deposit was discovered in July 1987 (Denwer and Mowat, 1997, 1998) CRA was the majority owner and operator of the former Panguna mine on Bougainville Island. Although CRA lodged a

FIG 3 – Artisanal gold mining, Wau-Bulolo region (photos: Jessie Boylan, Mineral Policy Institute, February 2011).

development application for Hidden Valley in 1988, it later withdrew it (Burton, 2001). Curiously, some of the early CRA environmental studies led to the following prediction by Pascoe (1991, p 75):

> *Sediments derived during construction, prestripping and waste rock dumping would enter the Bulolo and Upper Watut Rivers. While no cultivated river-side areas would be affected, there will be a depressed fish population which would affect subsistence fishing during, and for a short time after, the construction period. Water-borne waste during operations would be confined to the rivers affected by the Upper Watut River catchment area and would have some minor impact. No gardening or riparian land use would be threatened. The main potential for impact comes from the tailings dam decant water so control methods would be incorporated in the plant facilities to ensure compliance.*

The Hidden Valley project was sold by CRA to Australian Goldfields NL in 1997, which completed an 'environmental plan inception report' and began other technical studies in 1997. However, this work was shelved in March 1998 when the company was forced into bankruptcy. The project was bought by Aurora Gold Ltd and CDC Financial Services (Mauritius) Ltd in September 1998, with Abelle Ltd merging with Aurora in January 2003. Abelle, in turn, was 75 per cent owned by Harmony Gold Ltd from South Africa, but became a fully-owned subsidiary of Harmony by mid-2004. An environmental impact statement (EIS) for the project was publicly released in February 2004 (Enesar, 2004), proposing three open cut mines (Hidden Valley, Kaveroi and Hamata), a carbon-in-pulp process plant and an engineered tailings storage facility. Approval of the EIS was given by the PNG Government in March 2005. The original mineral resource in the EIS was 36.173 Mt of ore grading 3.2 g/t Au and containing about 116.8 t Au (~3.6 Moz) (this compares to the current reported resource of 117.9 Mt at 1.5 g/t; see Table 2).

Harmony Gold began development of the Hidden Valley project in September 2006, with Newcrest Mining becoming a joint venture partner in August 2008, initially at 30 per cent but rising to a 50:50 joint venture at the commencement of production in July 2009. The partnership is known as the Morobe Mining Joint Venture (MMJV) and includes three main projects – the Hidden Valley, Wafi-Golpu and the Morobe Exploration Joint Ventures (MMJV, 2013).

During construction of the project between September 2006 and June 2009, major problems arose with respect to managing waste rock and erosion due to side-casting of waste rock down steep slopes. Although it is claimed by the MMJV that these issues are now effectively resolved and current operations minimise all erosion off-site, the downstream communities in the Watut River have been publicly complaining about the ongoing extent of impacts, especially sedimentation, poorer water quality and perceived health issues. During 2010, the PNG Government's Department of Environment and Conservation (DEC) engaged Australian engineering consultants SMEC International to review and formally audit the status of environmental management at Hidden Valley (SMEC, 2010a), as well as a major study of the erosion and additional sedimentation to the Bulolo and Watut Rivers caused by the Hidden Valley project (SMEC, 2010b).

Although the MMJV has numerous internal studies and reports, these are (invariably) not publicly available – nor were many of them available for the SMEC reports (SMEC, 2010b, p 6). The only reports released publicly to date by the MMJV are the 2011 and 2012 Annual Environment Reports (HVJV, 2012, 2013), which contain the results of environmental monitoring and assessment work for

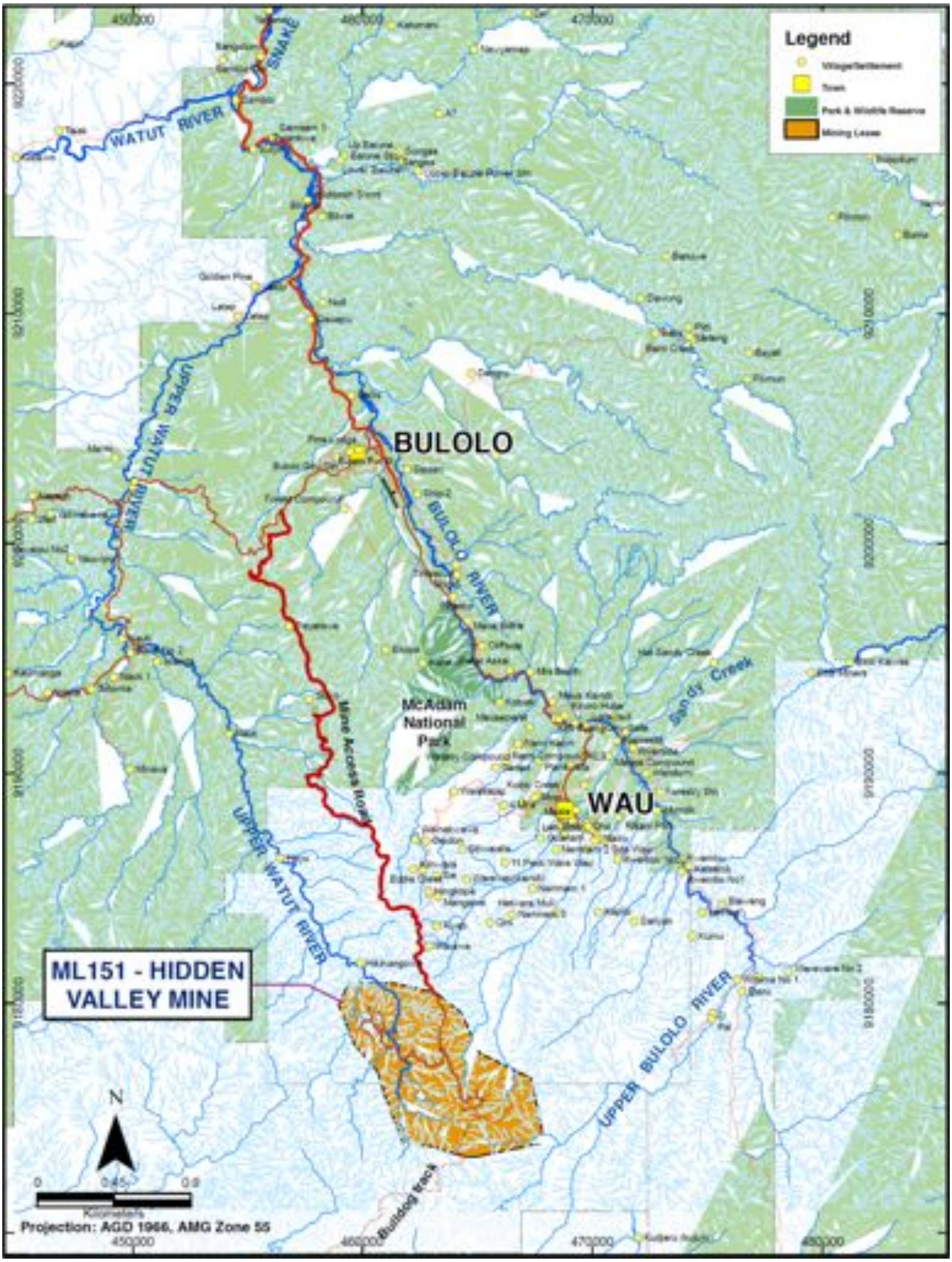

FIG 4 – Regional location map of the Hidden Valley Au-Ag mine, Papua New Guinea (SMEC, 2010a) (note: it appears the scale is incorrect).

2011 and 2012 respectively (these reports are reviewed in detail later). To date, the lack of publicly available information has restricted a complete independent study or review of the environmental impacts and issues associated with the Hidden Valley Au-Ag mine. As such, this paper focuses on the original EIS and relevant conditions of approval; the principal findings of the two SMEC reports, including some of the data presented in the SMEC reports concerning sedimentation impacts on the

Watut River the 2011 and 2012 Annual Environment Reports as well as other technical reports and studies available for the Morobe region.

The total production statistics for the Hidden Valley project, from commissioning in July 2009 and commercial production from October 2010 to December 2013, are 15.31 Mt ore, grading 1.92 g/t Au and ~24 g/t Ag for extraction of 22 413 kg Au, »164 201 kg Ag and »127.5 Mt waste rock. Unfortunately, no data has been published concerning waste rock produced during the construction phase, although it is expected to be more than 30 Mt (see SMEC, 2010a, 2010b). Annual processing capacity is presently ~3.8 Mt of ore, grading ~1.7 g/t Au and ~25 g/t Ag, to produce ~5500 kg Au and ~60 000 kg Ag per year. The MMJV is currently working towards optimising the existing mining and mill infrastructure and increasing the processing rate to ~4.7 Mt ore/a. As of December 2013, reported total mineral resources remaining were 117.9 Mt, grading ~1.5 g/t Au and ~27 g/t Ag (~5.61 Moz Au, 102 Moz Ag) (Newcrest Mining Ltd, 2014). At present processing rates, this gives a mine life of some 31 years.

A detailed site map is shown in Figure 5, outlining all major site features (open cuts, power station, processing plant, tailings storage facility, waste rock dumps and rivers and streams). Recent aerial views of the main part of the project site are shown in Figure 6 (the Hamata open cut mine, processing plant and tailings storage facility) and Figure 7 (looking from the Hidden Valley open cut to Hamata).

There are also a variety of other Au prospects and deposits in the Morobe region. The Kerimenge-Lemenge deposit, discovered in 1983, was reported to contain 55 Mt at 1.0 g/t gold for 55 000 kg Au (1.78 Moz), but the ore is refractory with low recoveries and remains uneconomic (Hutton *et al*, 1990; Denwer, 1997). The Kerimenge-Lemenge deposit is presently part of the Morobe Exploration Joint Venture. In addition to the activities of the MMJV, there are additional companies conducting mineral exploration in the Morobe Province, although accurate information and maps are difficult to obtain or build.

The Hidden Valley environmental impact statement – principal environmental impacts and issues identified

An EIS was released for public comment in February 2004 (Enesar, 2004), and formed the basis upon which Abelle/Harmony sought approval to develop the Hidden Valley project. This section only briefly touches upon the issues and commitments around the project proposal, tailings, waste rock, water, acid mine drainage, baseline studies, environmental monitoring and management generally – each of which are reviewed in detail in subsequent sections.

- *Project proposal:* Stage 1 was to last 6.5 years, process 3.5 Mt ore per year and produce ~8900 kg Au and ~124 000 kg Ag per year (or ~0.275 Moz Au, ~4 Moz Ag). All three deposits would be mined – including the Hidden Valley, Kaveroi and Hamata deposits – with the mill to be built adjacent to the Hamata pit. In total, 21.5 Mt of ore would be processed and about 107 Mm^3 of waste rock would be mined, or ~300 Mt in total. The identified mineral resource reported was, in contrast, 36.2 Mt ore at 3.2 g/t Au (ie ~113 500 kg or 3.65 Moz Au). Stage 2 development, which would mine and process ore beyond 6.5 years, would require further assessment via a new EIS.
- *Tailings management:* a tailings storage facility (TSF) would be constructed adjacent to the Hamata pit, taking advantage of a relatively flat area in a small valley. The tailings would be deposited using subaerial methods, where the slurry from the processing plant would be discharged via beaches, allowing the tailings to settle and consolidate into a solid mass. Given the high rainfall of about 2.6 to 2.8 m/a and pan evaporation rates of 1.0 to 1.2 m/a, the site has a strongly positive water balance and therefore accumulates water in dams such as the TSF. Tailings water will be treated to reduce cyanide and heavy metal concentrations and excess water from the TSF is to be discharged via Pihema Creek to the Upper Watut River.
- *Waste rock:* all Hidden Valley/Kaveroi waste rock is to be placed in dumps as close as practicable to the pits, generally aiming to fill valleys after accounting for potential acid formation risks (ie acid mine drainage), dump stability and drainage of water from the dump. Hamata waste rock is to be used in the tailings dam walls.
- *Acid mine drainage:* waste rock will be assessed for its potential to form acidic drainage and managed accordingly. Any formation of acidic waters in the pit will be monitored and addressed

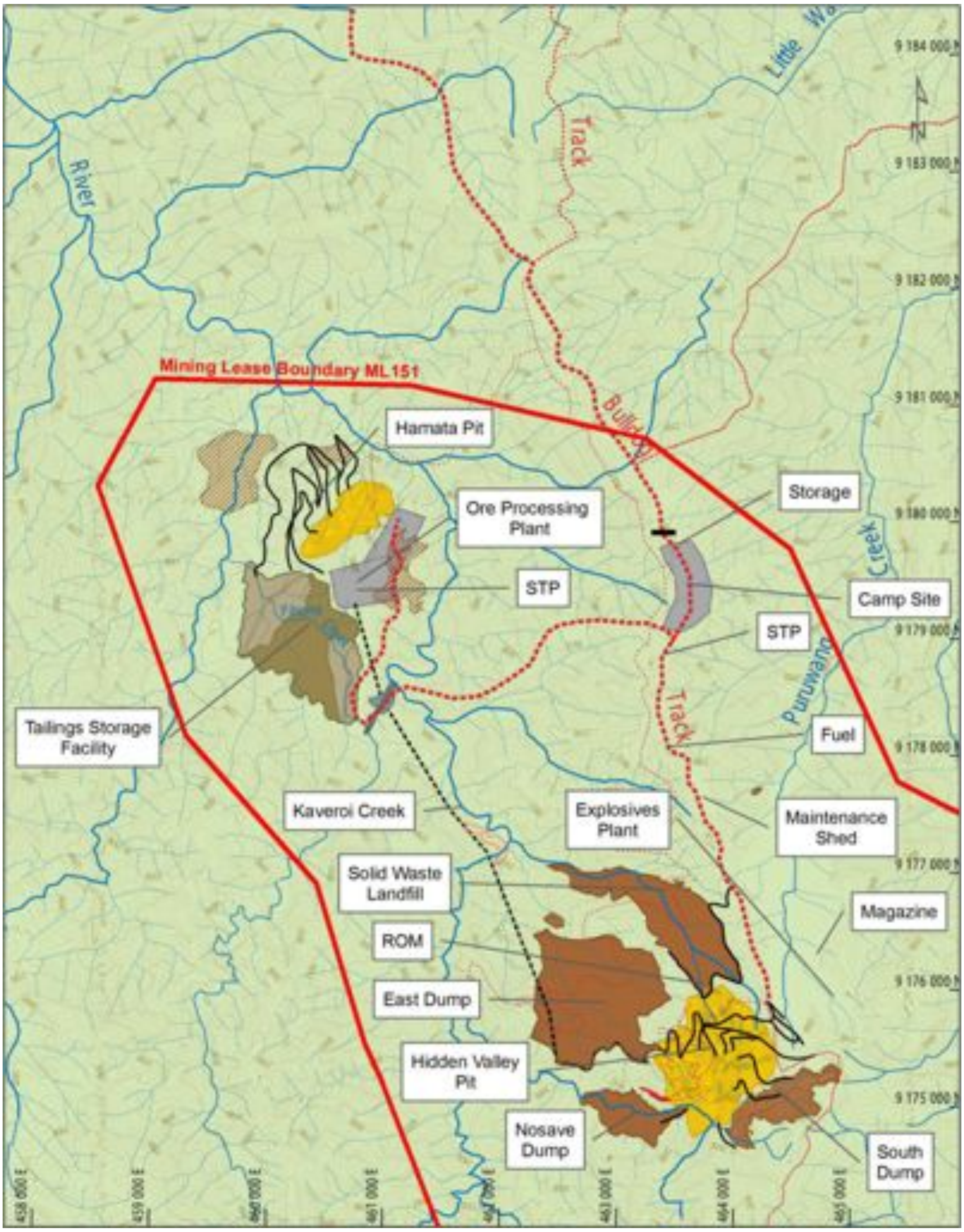

FIG 5 – Detailed site plan of the Hidden Valley Au-Ag mine (SMEC, 2010a).

either through water treatment (eg neutralisation) and discharge to adjacent streams or through sending this water to the process plant.

- *Water:* due to the high rainfall and strongly positive water balance, a vast quantity of water will require capture on-site and be managed according to quality and needs. Fresh water for potable (drinking) purposes will be extracted from the Upper Watut River at a long-term average rate of 110 m^3 per hour.
- *Baseline studies:* no new baseline studies were conducted, with the previous CRA studies and some additional studies by Abelle/Harmony used to characterise the existing environment, such as flora, fauna, climate, land and resource use and water quality, amongst other aspects. Air quality and noise were not assessed. Water quality was generally good, although heavy metals in some samples exceeded PNG guidelines for either environmental or drinking water purposes. Sediment loads in the Bulolo River due to small scale mining were about 0.15 Mt per year, while the Wau Au mine discharged about 0.7 Mt per year from 1984 to 1990. The Middle Watut River,

FIG 6 – Hidden Valley Au-Ag mine, Papua New Guinea, showing the Hamata pit (centre), tailings storage facility (centre left) and processing mill in between (photo: Mineral Policy Institute, February 2011).

FIG 7 – Hidden Valley Au-Ag mine, Papua New Guinea, showing the Hidden Valley pit (front) looking towards the tailings storage facility (centre left) (MMJV, 2011).

downstream of the Upper Watut and Bulolo confluence, was estimated to carry sediment loads of 4.7 Mt/a

- *Environmental monitoring and management:* a detailed environmental management plan (EMP) was developed, which included further baseline studies and validation monitoring as well as plans for operational and post-closure monitoring. In general, monitoring was to include water quality, climate, sewage treatment performance, biodiversity and other aspects. An EMP was prepared and released in November 2005 (see Enesar, 2005).

Tailings dam design

Some small mining projects in PNG have built a conventional tailings dam, although they were short-term projects and very modest in comparison to large mining projects. The Mt Victor gold mine, near Kainantu, built a conventional tailings dam to store ~0.2 Mt during mining from November 1987 to January 1990 (see Samuel and Sie, 1991) The Kainantu gold mine also built a tailings dam, but this was also very modest in scale at ~1.2 Mt (Mudd, 2004). The construction and use of conventional tailings dams to store tailings from large mining projects, however, has been avoided in PNG until Hidden Valley. At Bougainville, Porgera, Ok Tedi and Tolukuma, all mine tailings are discharged to adjacent rivers, causing severe environmental and social impacts matching the scale of each project. The typical case made to justify riverine tailings disposal was the high cost of engineering tailings dams to address risks such as earthquakes and high rainfall rates causing dam failures, as well as sometimes difficult geological conditions and/or rugged topography making suitable sites problematic to find (see Murray, Thompson and Lane, 2003, for an honest and critical review).

In the late 1980s, when CRA was actively assessing the potential development of Hidden Valley, riverine tailings disposal or a conventional tailings dam were both considered, but the '… latter was chosen for financial and environmental reasons' (Pascoe, 1991, p 73). Given that CRA operated Panguna using riverine tailings disposal, largely to avoid the high costs of building and maintaining a conventional tailings dam, this is very curious and perhaps a subtle recognition by the late 1980s of the severe impacts from the Panguna mine on Bougainville.

The CRA plan for Hidden Valley proposed a tailings dam over a small topographically flat area about 5 km from the deposit (ie next to the Hamata deposit), using a downstream dam wall and discharge of excess waters to the Upper Watut River (Pascoe, 1991). It was expected that this water discharge '… would comply with international standards well before any foreseeable requirements of the closest village' (Pascoe, 1991, p 75). CRA failed to proceed with the project, arguing it was uneconomic at the time. The mine was sold several times and it was not until the mid-2000s that the new owner, Abelle Ltd, began steps towards development. Abelle continued the approach by CRA and incorporated a tailings dam in the 2004 EIS. The design of the main dam wall is shown in Figure 8. Murray *et al* (2010) make the following commentary on the Hidden Valley tailings storage facility (pp 15):

> *Building the first on-land tailings containment area sets a precedent for the mining industry in PNG and helps secure a future for the industry by demonstrating the ability to meet modern standards and thereby attract the international investment needed to finance such large ventures.*

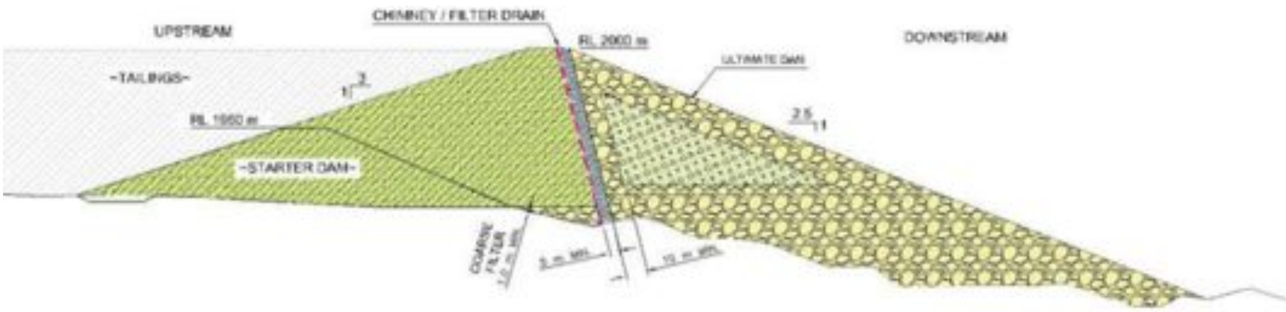

FIG 8 – Engineering design of the main tailings dam wall at Hidden Valley (Murray *et al*, 2010).

Thus the Hidden Valley project has proven that it is possible to engineer a modern, acceptable tailings dam in the rugged mountains of PNG. An additional review of the tailings dam water discharges and associated issues with respect to water quality in the Upper Watut River are presented in a later section.

A note of caution, however, is that the existing tailings dam only has a limited capacity for expansion, and it is likely that a second dam will be required in the future if Hidden Valley continues to operate. That is, the original approvals were for a 6.5 year project and 21.5 Mt of tailings compared to the 2013 mineral resources of 117.9 Mt of ore and production by December 2013 of ~15.3 Mt of tailings. Presumably, approval for a second tailings dam would be part of approvals to operate Hidden Valley beyond the current 6.5 year stage of mining (ie beyond December 2015). The 2004 EIS noted that the Hamata pit could potentially be converted to a second tailings dam after completion of open cut mining (Enesar, 2004, pp 8–10).

The SMEC reports – principal findings

The two reports by SMEC International Pty Ltd (SMEC, 2010a, 2010b) systematically examined the environmental management systems that were in place during the construction phase of the Hidden

Valley project, as well as those in early 2010 after commissioning had started just before commercial production was declared from October 2010.

In summary, the SMEC reports found:

- systematic non-compliance with permit and approval conditions, with ten potential non-compliances and only partial compliance with 30 conditions from a total of 73 conditions, including failure to achieve certification of the environmental management system (based on ISO14001, the relevant international standard)
- a lack of waste rock and erosion controls during construction, including:
  - a weakness in the permit conditions, which set no limit for suspended sediment in waters draining the site during the construction phase
  - an internal study for the MMJV that suggested some 20–30 Mt of waste rock and mine-related sediment had entered the Watut River – or some 5–10 Mt/a, which was higher than the EIS value of 4.7 Mt/a of natural sediment at the Watut-Bulolo confluence
  - a major environmental hazard to aquatic ecosystems and users of the Upper Watut River from the eroded waste rock, of which approximately 30 per cent was potentially acid-forming, ie it contained sulfide minerals, which when exposed to the surface environment would chemically react to form sulfuric acid and leach heavy metals and salts from the waste
  - the EIS prediction of equal but minor impacts on the Bulolo and Watut Rivers was severely deficient because the impacts have been ~90 per cent to the Watut River and resulted in significant environmental and social impacts (especially with respect to waste rock erosion)
- a failure to operate waste management and landfill practices in accordance with the approved plan
- the sewage treatment system was overloaded and causing a major risk of pathogen and nutrient contamination to downstream users of the Watut River
- systematic failure to maintain a thorough environmental monitoring regime for aspects such as ecological, air quality, noise, vibration, hydrometeorology, and water and sediment quality monitoring, and inadequate data management and permit review procedures
- a single grab sample of water from the Watut River showed slightly elevated concentrations of some heavy metals and cyanide compared to environmental baseline studies, and suggested the need for a more thorough study of possible pollutant sources and pathways.

As part of the permit and approval conditions for the Hidden Valley mine, a compliance point is located at Nauti downstream in the Upper Watut River. The total suspended sediment (TSS) in water of the Watut River at the Nauti compliance point is shown in Figure 9. The commencement of road construction in mid-2006 is clearly visible as a major though short-lived spike in TSS levels to ~5000 mg/L, including another short spike in late 2006 to ~10 000 mg/L. As full-scale mine construction began in June 2007, TSS levels gradually rose to a new peak of ~23 000 mg/L in mid-

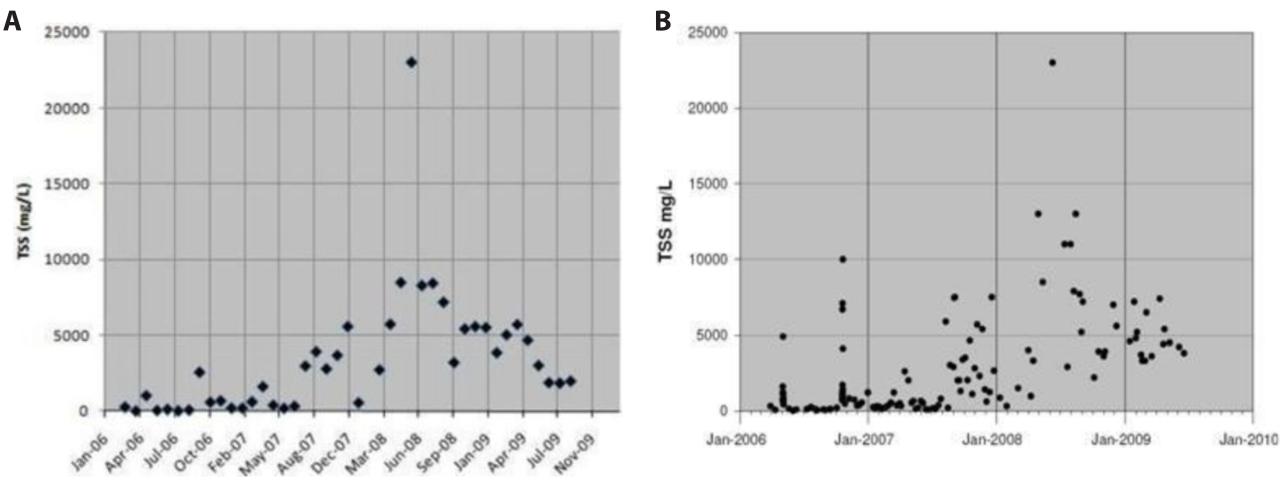

FIG 9 – Total suspended sediment (TSS) at the Nauti compliance point in the Watut River, downstream from Hidden Valley: (A) monthly mean values, (B) individual data points (SMEC, 2010a).

2007, but were declining to ~5000 mg/L by mid-2009. This peak is closely correlated with poor waste rock management practices at the project, which led to excessive erosion into the Watut River. The MMJV did not provide SMEC with any 2010 data to verify if the TSS trend continued to decline. Finally, SMEC noted that a 2010 report by Klohn Crippen Berger for the MMJV, titled *Erosion Sediment Control – Assessment and Mitigation* and detailing the source of sediment into the Watut River, was not made available for the SMEC reports.

Site inspection April 2012

The Mineral Policy Institute (MPi), in conjunction with community representatives, visited the Hidden Valley mine complex in April 2012 and was hosted by the MMJV. This visit allowed a firsthand inspection of the site as well as the various initiatives occurring on-site to improve environmental management outcomes. While the visit was effectively a visual inspection only and not a formal audit, it showed some of the effort involved in addressing risks such as erosion and acid mine drainage from waste rock and the works being conducted to manage these risks. A montage of photographs is collated in Figure 10, showing the primary aspects of the site and some related environmental management aspects. Further photographs and imagery are available in the full report, associated documentary and online media resources.

Annual environment reports 2011 and 2012 – a critical review

This section will focus on the main environmental aspects of the two published annual environment reports for 2011 and 2012 (HVJV, 2012, 2013), which relate to surface water management and monitoring, mine waste management and acid mine drainage.

Surface water management and monitoring

When the Hidden Valley project was approved by the PNG Government, the village of Nauti on the Watut River was designated as the primary downstream compliance point for potential surface water impacts (shown in Figure 4). Nauti is the first village and ~15 km downstream from the Hidden Valley project.

A compilation of annual average water chemistry data from the EIS and recent annual environment reports is given in Tables 3 and 4, using the villages of Hikinangowe, Heyu and Nauti. Hikinangowe is ~4 km downstream of Hidden Valley, while Heyu is ~9 km downstream. These tables show that there is discernible changes in water quality at the Nauti compliance point due to Hidden Valley, primarily in TSS, SO_4 and metals such as Al, As, Cd, Cu, Pb and Mn. The intensity of TSS with respect to rainfall is shown in Figure 11, with detailed As, Cu and Zn concentrations during 2012 shown in Figure 12.

The Nauti permit criteria for TSS in water is stated as no less than a change in 25 turbidity units (or NTU), although the TSS is presented differently in mg/L. In general, a correlation needs to be developed between TSS (in mg/L) and turbidity (in NTU) to demonstrate that the simple measurement of NTU is sufficient to monitor TSS. However, the 2011 and 2012 reports failed to present this correlation, limiting the scientific confidence in the presented TSS information. In addition, although the Hidden Valley permit states <25 NTU change in water quality, this is not referenced to any upstream site or baseline/premining values, making it very difficult to assess compliance. Based on the data in Table 3, TSS appears to have increased ~100-fold in the Watut River at the Nauti compliance point but is decreasing over time, while SO_4 concentrations have increased three to four times and are still increasing.

Finally, in view of the landslides in the broader region and the substantial sediment loads these can deliver to rivers, there is a clear need to distinguish riverine sediment derived from landslides versus those coming from the Hidden Valley project – meaning that the correlation between NTU and TSS is crucial to inform ongoing monitoring and assessment. Perhaps the answer is in the MMJV commissioned report by Klohn Crippen Berger entitled *Erosion and Sediment Control – Assessment and Mitigation*. However, despite repeated requests it has not been made available (SMEC 2010, p 6; MPi, 2014).

Although all metals are below the Nauti permit criteria, all except for iron (Fe) show an increase since the late 1990s studies in the 2010 data but generally declining in 2011 and 2012. In terms of metals of concern, the most critical are Al, Cu and Zn (and to a lesser extent Mn), based on the magnitudes

FIG 10 – The Hidden Valley mine complex, April 2012: (A) view from the mine camp showing the process plant in the centre, Hamata open cut on the right and mountains in the background; (B) Hidden Valley mine showing acid mine drainage on mine wall; (C) waste rock dump encapsulating sulfidic material to reduce acid mine drainage risks; (D) tailings dam panorama (photos: Mineral Policy Institute, April 2012).

TABLE 3

Average water chemistry parameters at the Hikinangowe, Heyu and Nauti monitoring points in the Upper Watut River (compiled from Powell and Powell, 2000; Enesar, 2004; Hidden Valley Joint Venture, 2012, 2013).

	Hikinangowe[a]				Heyu[a]
(mg/L)	Oct 1996	2010	2011	2012	Oct 1996
pH[@]	7.45	7.02	7.4	7.5	7.62
Diss O_2	8.28	6.3	7.08	8.1	8.24
TSS	10	2478	1259	1208	23.7
TDS	42.7	-	-	-	52.7
SO_4	-	54.8	72.4	84	-
NO_3	-	-	-	-	-

	Nauti Compliance Site				
(mg/L)	Oct 1996	2010	2011	2012	Permit
pH[@]	7.67	7.25	7.4	7.7	no change
Diss O_2	8.3	7.3	8.2	8.8	>6
TSS	26	2311	1333	1086	<25 NTU increase[†]
TDS	49.3	-	-	-	-
SO_4	10	29.4	34.8	40.8	-
NO_3	<1	-	-	-	-

Notes: Diss O_2 – dissolved oxygen, TSS – total suspended solids (ie suspended sediment), TDS – total dissolved solids (ie dissolved salts), SO_4 – sulfate, NO_3 – nitrate.

[a] The Powell and Powell (2000) study, as provided in the environmental impact statement, uses names of Ikenenuwe and Aiyu. [@] pH has no formal units.

[†] – NTU is turbidity units, a surrogate for TSS.

of the concentrations relative to Australian and New Zealand Environment and Conservation Council (ANZECC) levels. The higher levels in 2010 are presumably related to discharges of some waters from the mine, such as acidic drainage from some of the waste rock dumps, since significant discharge volumes of treated tailings water did not occur until early 2012 (HVJV, 2013, pp 47–48).

The Cu and Zn concentrations during 2012 show a highly variable behaviour (ranging from ~1 to 220 µg/L), while As is relatively stable at around 4 µg/L. Based on the 2012 annual environment report, it is unclear if the large spikes and variability are due to mine releases or not, but the early 2012 spikes could be related to discharges of treated waters from the tailings dam. Without more detailed site operational information, it is not possible to speculate further, but the magnitudes of the Cu and Zn spikes – reaching some 100 times ANZECC trigger levels to protect 99 per cent of aquatic species – should be of significant concern despite strictly being below the Nauti permit levels.

Importantly, if one compares the Nauti compliance criteria to the relevant Australian standards for freshwater ecosystems (ie ANZECC and ARMCANZ, 2000) using the high conservation value trigger levels (ie 99 per cent protection values), all metals are substantially in excess of these values except for Mn. Although the extent to which the Australian (ANZECC) guidelines may be applicable in PNG can be debated, there is no clear scientific basis for the criteria presented by the HVJV or PNG Government. It seems reasonable, therefore, to speculate that the compliance criteria could be derived from those used for Ok Tedi – especially in the case of Cu and Zn, where the compliance levels are 1000 and 5000 µg/L compared to the ANZECC 99 per cent protection values of 1.0 and 2.4 µg/L respectively (or even the ANZECC 80 per cent protection values of 2.5 and 31 µg/L respectively). Close to the Hidden Valley mine at Hikinangowe, the average heavy metal levels were clearly capable of causing significant biodiversity impacts, such as Zn at 127 µg/L in 2010, with the levels generally reducing by 2012. The average levels at the Nauti compliance point still remain capable of causing biodiversity impacts in the Upper Watut River if the ANZECC values are instead used for assessment. It must also be remembered that there are substantial peaks in heavy metal concentrations that are much higher than the yearly averages, increasing the risk of biodiversity impacts along the Upper Watut River if these were to re-occur.

TABLE 4

Average heavy metals in water at the Nauti compliance point and along the Watut River (compiled from Powell and Powell, 2000; Enesar, 2004; Hidden Valley Joint Venture, 2012, 2013).

	Hikinangowe[a]				Heyu[a]	ANZECC	ANZECC
(μg/L)	Oct 1996	2010	2011	2012	Oct 1996	99% prot	80% prot
Al[#]	44	2740	160	49.9	51	27	150
As[†]	1.1	15	5	3.1	2.1	0.8	140
Cd	<0.1	1	3	0.9	<0.1	0.06	0.8
Cr[‡]	-	<1	<1	0.2	-	-	-
Co	-	16	5	2.7	-	-	-
Cu	0.9	31	24	12.7	0.8	1.0	2.5
Fe	130	4860	190	35.1	110	-	-
Pb	<0.2	28	6	0.3	0.3	1.0	9.4
Mn	14	1970	1380	869.9	10	1200	3600
Hg[§]	<0.2	<0.1	<0.1	<0.1	<0.2	0.06	5.4
Ni	-	7	3	1	1000	8	17
Se[$]	-	<10	<10	<0.2	10	5[$]	34[$]
Ag	-	5	1	0.6	50	0.02	0.2
Zn	-	127	74.5	10.4	5000	2.4	31

	Nauti Compliance Site					ANZECC	ANZECC
(μg/L)	Oct 1996	2010	2011	2012	Permit	99% prot	80% prot
Al[#]	51	200	110	61.9	-	27[#]	150[#]
As[†]	1.4	6	6	4.3	50	0.8[†]	140[†]
Cd	<0.1	0.8	0.7	0.4	10	0.06	0.8
Cr[‡]	-	<1	-	0.6	50	-[‡]	-[‡]
Co	-	2	1	1.8	1	-	-
Cu	0.2	9	6	14.2	1000	1.0	2.5
Fe	170	121	93	53.1	1000	-	-
Pb	<0.2	1	1	1.1	5	1.0	9.4
Mn	12	540	440	337.8	500	1200	3600
Hg[§]	<0.2	<0.1	<0.1	0.5	2	0.06[§]	5.4[§]
Ni	-	1	0.8	1.2	1000	8	17
Se[$]	2.8	<10	<10	0.2	10	5[$]	34[$]
Ag	-	1	0.5	0.2	50	0.02	0.2
Zn	-	16.4	9.6	18.1	5000	2.4	31

Notes: ANZECC values are for 99% protection of biodiversity (ANZECC and ARMCANZ, 2000).

[a] The Powell and Powell (2000) study, as provided in the environmental impact statement, uses names of Ikenenuwe and Aiyu. [#] pH>6.5. [†] As (V) species. [‡] Cr (III) species. [§] Inorganic species. [$] Total Se.

An alternative approach to water quality criteria would be to ensure the Hidden Valley project does not cause unacceptable deviations from background or baseline water quality. This could be done either using an upstream reference site (ie in the Upper Watut River just above the impacted project area) or at the Nauti compliance point as a baseline value plus an allowable but minor statistical variation (as used by the ANZECC guidelines). In any case, there is a clear need to improve the regulation of water quality compliance for the Hidden Valley project and its actual and potential impacts on the Watut River. At present, there appears to be no data published by the Hidden Valley project on the metals concentrations of sediments in the Watut River, and this remains a major weakness of the environmental monitoring regime. Sediment concentrations are crucial to understanding the full picture of environmental risks and impacts.

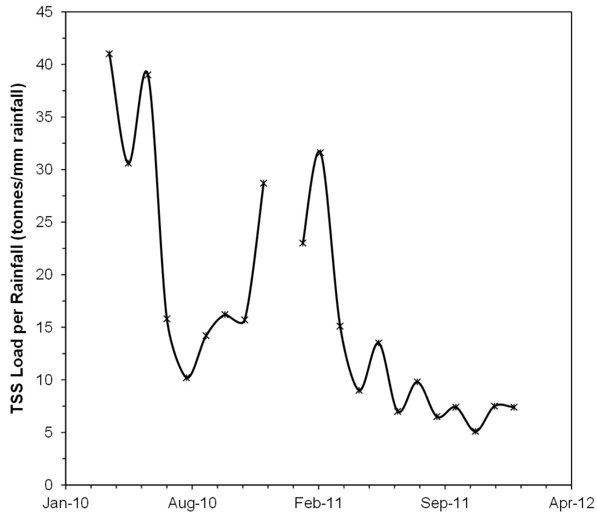

FIG 11 – Suspended sediment load downstream of Hidden Valley (redrawn from Figure 17 in Hidden Valley Joint Venture, 2012).

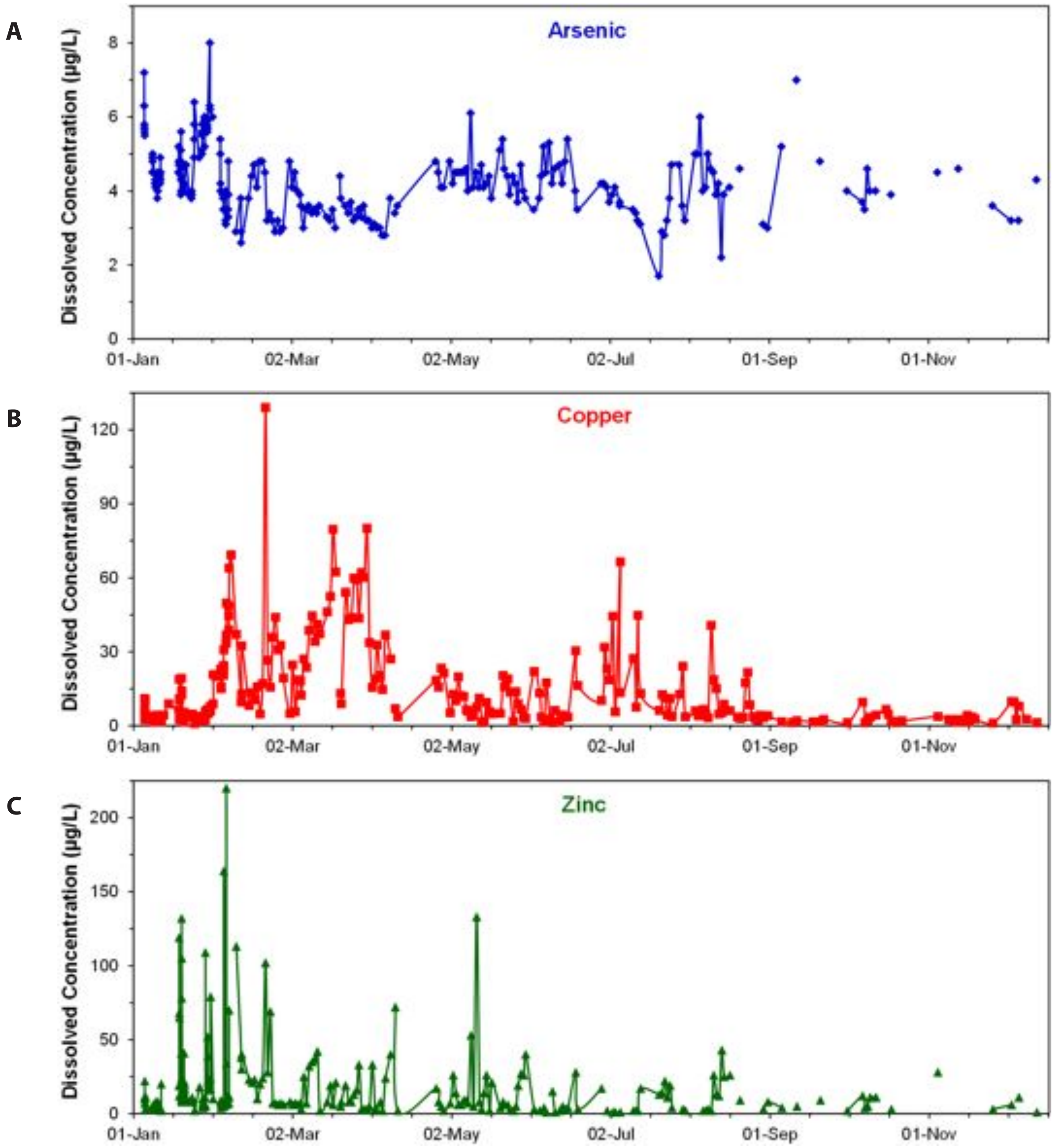

FIG 12 – Concentrations of As (A), Cu (B) and Zn (C) during 2012 at Nauti (adapted from data in Hidden Valley Joint Venture, 2013).

Hidden Valley – summary

There can be no doubt that the Hidden Valley Au-Ag mine has – historically at least – caused environmental impacts in excess of permit and approval conditions, mainly due to poor environmental management practices during construction, especially concerning waste rock. Impacts, however, do seem to be reducing in response to remedial efforts by the MMJV, ideally this would be assessed by a follow-up audit to the SMEC reports. To date, although the MMJV has conducted a wide range of studies on the Watut River, many of its reports and management plans are still not publicly available – and nor were they made available for SMEC to conduct their reviews or to the MPi. Such secrecy and lack of transparency significantly hampers accurate scientific interpretation and only worsens the community perception of the impacts from the project to date.

MANAGING IMPACTS AND ACHIEVING TRANSPARENCY

Understanding and assessing predicted or actual impacts on and contributions to local communities by extractive companies is a complex process that has spawned a whole body of corporate social responsibility (CSR) literature and a host of accountability mechanisms to adhere to or report against. This section presents a rapid rather than exhaustive analysis – evaluating company policies, sustainability reports, the Global Reporting Initiative (GRI) and the International Council on Mining and Metals' (ICMM) principles (for others such as free prior and informed consent (FPIC), social licence to operate (SLO), Organisation for Economic Cooperation and Development guidelines and the Equator Principles, see Roche and Mudd, 2014).

Company policies

Assessing the policies of the MMJV's operations is a difficult and complex procedure. As a wholly owned joint venture by Newcrest and Harmony Gold, there is little information available to the public. For example, while the management team is listed on the MMJV website, there is no mention of a Board (MMJV, 2013). There is also a stark absence of guiding policies, forcing interested parties to turn to the joint venture owners for policy guidance.

Newcrest has a suite of policies (Newcrest Mining Ltd, 2013a) that deal with a range of internal and external issues, including governance, safety, environment, community and a code of conduct. In the main, the policies are high level and hard to assess against performance, as is the norm for much of the globalised mining industry. The following principles from Newcrest's Communities, Environmental and Operations Policy have clearly not been consistently delivered and illustrate how well-meaning policies can be ineffectual at best and, at worst, provide a ready defense for the company while obscuring the real impact on the ground:

> *Be open and transparent in all dealings with communities and in describing and explaining potential social and environmental impacts that might occur.*
>
> *Manage the environmental risks on a site-specific basis to achieve planned environmental outcomes.*
>
> *Exhibit industry leadership in the mitigation of risk and the management of both temporary and permanent change.*

Perhaps this is, in part, explained by the absence of specialised skills in community and environmental impact on the Newcrest Board or at least a failure to monitor the implementation of organisational policies as required by the Board Charter. Interestingly, when questioned about the Board's ability to assess and monitor such impacts at the 2013 annual general meeting, both the Chair and CEO dismissed the need for specialised skills at Board level (MPi, 2014).

Harmony Gold (2013a) does not have a set of similar policies to Newcrest, making policy comparisons difficult and time consuming. For example, rather than having a communities policy, Harmony Gold has a terms of reference for its Social and Ethics Committee. Within that document, the Committee is charged with monitoring company activities in relation to: the United Nations Global Compact, labour and environment and public safety. What the document does not provide is a statement of principles or criteria to guide and assess performance against. Similarly, within the company code of ethics, Harmony stresses the importance of maintaining a SLO and the creation of lasting benefits for communities but again falls short of assessable criteria.

The environment policy (Harmony Gold, 2013b) provides some targeted goals, which have not been consistently delivered since the inception of the project. These include:

> *…we aim to prevent pollution or otherwise minimise, mitigate and remediate harmful effects of our operations on the environment.*
>
> *We will ensure transparent engagement on environmental issues with communities affected by our operations and consider their views and concerns in our decision-making.*

The above goals and policies failed to prevent poor mine practices causing sedimentation of the Watut River. Nor did the initial response, lack of cooperation and absence of publicly available data about the sedimentation of the Watut River assist communities and company to understand and respond to unanticipated impacts. The confusion arising from twin, non-compatible sets of policies diminish their practical effect in informing communities and guiding the practice of mine operators and contractors. The lack of a clear policy structure may have contributed to poor practice or impact response and it also makes it difficult for stakeholders to understand company policies, standards and commitments, thereby further reducing transparency.

Sustainability reporting and assurance

Both joint venture partners reference the ICMM's principles in their respective 2012 sustainability reports, making them relevant standards to assess their activities. Newcrest (2013a) also makes a strong commitment to ICMM via its membership of the Minerals Council of Australia (MCA) and its commitment since 2005 to the MCA's 'Enduring Values Framework' (MCA, 2005), which adopts the ICMM principles, elements and implementation guidance.

Commendably, Newcrest includes a mention of an outstanding lawsuit in relation to the mine-related sedimentation of the Watut River in its 2011 Sustainability Report (Newcrest Mining Ltd, 2012, p 20). Unfortunately, no mention is made in the 2012 report despite the proceedings remaining open. Similarly, references to the SMEC audit, which found numerous non-compliant practices, reported in the 2011 report is not mentioned in the 2012 report (Newcrest Mining Ltd, 2013b) despite ongoing impacts and concerns. By not reporting on either of these matters in the 2012 report, including the GRI section, Newcrest has portrayed a much more positive situation than a site inspection, data analysis and community consultation reveals.

These examples of a lack of reporting, combined with the lack of available scientific reports, are at odds with general principles of transparency and openness as well as with ICMM principle 10. The over reliance of companies on newsletter and factsheets as effective consultation and information sharing, while simultaneously denying stakeholders access to scientific reports and management plans, reflects poorly on the companies and their reporting mechanisms as well as contributing to ongoing concern and conflict with the community and stakeholders.

In another example of disclosure, Harmony referred to problems with the water quality of the Watut River following mine construction and sedimentation of the river in its 2012 sustainable development report (Harmony Gold, 2012, p 107). Harmony referred to commissioned scientific reports, remedial action and independent advisory committee. Unfortunately, the report does not refer to ongoing problems from sedimentation, the scientific assessments that have not been released to the public or the lack of community representation on the MMJV appointed advisory panel. Nor does the External Stakeholder Advisory Panel (ESAP) transparently 'honour a commitment made in 2010 to continually review sediment and related issues affecting the Watut River' (Harmony Gold, 2012, p 30).

Similarly, Harmony's definition of and reporting on significant environmental incidents (Harmony Gold, 2012, p 23, 124) means that it has nothing to report, despite the ongoing physical and chemical impacts from the sedimentation and pollution of the Watut River. Again, by not recognising the ongoing nature of these impacts and effect on the community, including stress, the report seems to indicate either a lack of awareness or a failure in reporting.

An examination of Harmony's reporting on its grievance mechanisms provides another example where sustainability reporting can both fail to give an accurate description of events or result in an effective mechanism. In the GRI section of the 2012 report, Harmony states that it they now has grievance mechanisms in place, but 'they have not been required to date' (Harmony Gold, 2012, p 143). In another section, there is reference to a grievance mechanism being trialled with primary issues of concern including 'compensation, land, environment, accidents/damage, health, safety/security business development and community projects' (Harmony Gold, 2012, p 99). Given these and other acknowledged mine-related problems in the area, it would appear that the grievance mechanism has not been effective in identifying or hearing concerns/grievances and needs improvement before it would satisfy any reasonable standard, including those in the GRI and ICMM.

To state the obvious, managing environmental impacts, implementing an effective grievance mechanism and achieving genuine, ongoing transparency are all basic elements of a holistic life-of-mine approach by a responsible mining company. There seems to be little benefit to external users of the sustainability reports in reporting to the ICMM's principles or the GRI framework if these standards are easily satisfied by generic policies or general statements.

Both Newcrest and Harmony's sustainability reports have been independently assured, with the companies choosing a moderate and limited assurance respectively. In Harmony's case, it would appear that Price Waterhouse Coopers was either satisfied with the reporting or was unable to ground-truth site reports to detect errors and inconsistencies. It is not clear from the assurance statement which sites were inspected, nor the contract details between assurer and company Board, offering little assurance to the report reader.

In Newcrest's case, the 2012 report used Net Balance, a different assurer than that used in the 2011 report, although both reported to AA1000. Net Balance specifically states that 'nothing came to our attention' (Newcrest Mining Ltd, 2013b, p 50) that would cause them to doubt Newcrest's ICMM alignment statements. That would seem to indicate that either Net Balance approves of the level disclosure by Newcrest or was not able, or not contracted, to undertake a more comprehensive assurance. There is no indication that Morobe data was reviewed under the assurance. It is important to note that the assurer is responsible only to the Board and management of Newcrest, not communities, shareholders or stakeholders, and is guided by confidential terms of reference – again offering little assurance to the report reader.

For both companies, a higher level of assurance, with effective independent on-ground community engagement, is required if the sustainability reports are to be relevant to the company, shareholders and stakeholders alike. Until then, the sustainability reports provide little in terms of real detail and thus relevance to environment and community impacts for communities, investors or regulatory authorities. Alternatively, comprehensive site reporting would provide constructive feedback to the company as well as a more useful assessment of impacts and actions for communities, local, provincial and national governments and other stakeholders.

Community engagement, consent and representation

Rights-based reform is gathering momentum in the international mining industry. The purpose, design and effectiveness of traditional CSR approaches are increasingly challenged (eg negotiations and agreements between community and company that are based on inherent power inequalities are being rejected). More positively, there is a recognition of the importance of self-determination processes that occur alongside of and affect many developments. This is reflected strongly in Morobe Province when talking to communities and captured in the Watut River documentary (MPi, 2013).

Despite making some advances in approach and practice, the Hidden Valley site and its operators, the MMJV, still struggle to meet modern transparency standards. The task for the MMJV has been made harder and more complicated by having to respond at a time of increasing national opposition to the impacts and inequalities of mining in PNG. This opposition has developed from mine sites far worse than Hidden Valley. Indeed, the collective reputation of the PNG mining industry has been almost irreversibly damaged by the human tragedy that arose from Panguna on Bougainville, the environmental devastation from the Ok Tedi mine, the ongoing human rights violations at Porgera, the pollution from Tolukuma and marine mine waste dumping at Mismia, Ramu, Simberi and Lihir.

Alongside these major environmental and human tragedies is an increasing awareness that PNG has yet to fully capture the benefits of the mining industry. With a growing sense that transplanted Western development is not the only option for sustainable livelihoods and economic growth in PNG (MPi, 2013). As indicated by the utility of sustainability reporting earlier in this paper, the industry seems willing to discuss and report to new standards as long as it does not require real change that would alter the balance of power, change practices or result in a more equitable distribution of benefits between company, shareholders, government and communities.

In response, communities and civil society are increasingly advocating for a right to self-determination. A structured approach often uses the concepts of FPIC, SLO and effective community representation to discuss these community rights and aspirations. Communities not familiar with these concepts express themselves differently, but the message is relatively consistent and contains the same central components – community representation, consent and appropriate development.

Despite the FPIC and SLO terms being partially captured as terms in mining industry reporting, they remain effective concepts that can assist in the transformation of the mining industry in PNG. While it may difficult to determine the roles of relevant stakeholders in implementing consent, such as affected communities and government authorities, this should not stop the development and application of the concepts as a method of significantly improving community engagement (Roche and Bice, 2013).

Similarly, the use of citizens advisory councils (CACs) is increasingly seen as a mechanism to ensure the effective representation of all the community and this is particularly important in securing family and female-friendly outcomes from any mining or development. According to Steiner (2013, p 1):

> *…large-scale resource development projects generally receive insufficient oversight by, and engagement with, civil society. And in the absence of effective supervision and public engagement, corporate and government vigilance can weaken, complacency increases, environmental and social standards decline, and risks increase. Such insufficient oversight, lower standards, and complacency can result in acute and catastrophic damage, such as oil spills, chemical explosions, mine disasters, overharvest and stock collapse; long-term, chronic environmental degradation; and social tension, mistrust, litigation, and even violence between local people and industry.*

Steiner's quote effectively reflects and reinforces the previous discussion, demonstrating again that it is vital that local communities and civil society are directly involved in the oversight of extractive industries. If properly funded and structured, CACs can become the 'eyes, ears and voice' for local communities, becoming a fundamental component for the industry and individual operators that need to obtain and maintain a SLO. It is important to note that CACs should complement rather than replace the vital role that government performs in regulating the mining industry.

The difference between a CAC and an expert committee, such as the ESAP appointed by the HVJV/MMJV, is its structure and independence. It is critical for CACs to have a high level of independence, with the necessary human and financial resources to perform their functions properly. While structures may vary, CACs need to include significant representation from the community as well as the ability to appoint their own independent experts as and when required.

SUMMARY AND CONCLUSIONS

There can be no doubt that the Hidden Valley Au-Ag mine has caused environmental impacts in excess of permit and approval conditions, mainly due to poor environmental management practices during construction that resulted in significant and ongoing sedimentation of the Watut River. These impacts from Hidden Valley have added to the historical and ongoing environmental impacts from both the Wau and Bulolo goldfields and more recent workings in the Watut River area. While not the same nature or scale as impacts from mining projects elsewhere in PNG, mining-related problems in Morobe need to be examined as part of a wider discussion about the future of PNG's mining industry, especially in relation to benefits and regulatory oversight.

The scale of problems from the Hidden Valley mine site have been exacerbated by the lack of transparency about the impacts and the response from operators and regulators. This lack of detail leaves communities and stakeholders unsure of the source of, and management response to, sedimentation and other mining impacts. To date, although the MMJV has conducted a range of studies on the Watut River, many of its reports and plans are still not publicly available. This lack of transparency significantly hampers accurate scientific interpretation and only worsens the community perception of the impacts from the project to date. It is clear that by commissioning an independent review, PNG's DEC was able to quantify the level and number of breaches at Hidden Valley, thereby increasing awareness and public scrutiny. Ongoing assessment of impacts and management response by DEC or other agencies would add significantly to our understanding of the project and increase community confidence in both the operation and regulation of the Hidden

Valley mine site and, potentially, the development of Wafi-Golpu. Furthermore, future activities in the Watut River area should be guided by a commitment to maintaining a SLO based upon a free, prior and informed consent process. Similarly, the involvement of the community through CACs or similar structures would capture community concerns, guide operations and inform regulatory agencies.

The future of mining in Morobe is uncertain. In some ways the MMJV's operations are an improvement on existing industry practice as evidenced by the use of a tailings dam rather than riverine or marine disposal. On the other hand, the MMJV is operating under increased scrutiny and community expectation and needs to implement substantial improvements to existing industry practices if it is to obtain and maintain community support as well as contribute to the ongoing reform of the PNG mining industry. Active and well-funded regulators have an essential role in managing the current and potential mining industry in Morobe if it is to contribute to genuine, sustainable development, rather than overwhelm communities, agencies, infrastructure and the environment.

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