



Vista Gold Australia  
Mt Todd Gold Mine  
WDL 178 Licence Report

October 2014



# Executive Summary

Vista Gold operate the care and maintenance phase of the Mount Todd Gold Mine, situated to the north of Katherine, NT. The site is managed through an approved Mine Management Plan (MMP) under the *Mining Management Act* and administered by the Department of Mines and Energy. The management of water onsite is undertaken through the Water Management Plan (WMP) which is appended to the MMP. The WMP operates in accordance with Vista Gold's Waste Discharge Licence 178-3 (WDL 178-3).

This Licence Report fulfils WDL 178-3 Section 33, WDL 178-3 is provided in Appendix A and detailed below:

*"The Licence requirement dictates Vista Gold are required to:*

33. *The Licensee must provide to the NT EPA not later than 20 Business days prior to the Expiry Date of this Licence the Licence Report.*

*The Licence Report must include:*

*33.1. outcomes associated with ongoing studies including:*

*33.1.1. results of the mixing zone modelling, mixing zone validation and mixing zone confirmation;*

*33.1.2. results of the metal speciation modelling;*

*33.1.3. results of the ecotoxicology testing conducted prior to the commissioning of the water treatment plant (if applicable); and*

*33.2. be made available on the Licensee's Australian website within 10 Business days of being*

*33.2 [3]. be made available on the Licensee's Australian website within 10 Business days of being provided to the NT EPA."*

## **Mixing Zone**

The results of the mixing zone study indicate the size of the mixing zone stabilises at higher flow rates, reaching a plateau around the median flow rate.

Mixing characteristics of this reach of the Edith River are unknown. In the absence of site specific mixing data, a realistic range of transverse mixing rate parameters were modelled. The following mixing zones distances were calculated in order to meet 5% above average criteria:

- Meandering channel ~3,500m
- Curved channel ~1,000m

The mixing zone does not extend to sample site SW10 which is 8.7km from SW4 and site SW4 is within the mixing zone. However, the mixing zone model is considered to be conservative due to the curved characteristics and variable channel cross sections of the Edith River at the discharge (increases the Transverse Mixing Coefficient).

Vista Gold will conduct a mixing zone validation during the 2014/15 Wet Season, providing the mine is discharging to the Edith River, and produce a localised rating curve for site SW4.

### ***Metal Speciation***

Geochemical speciation modelling was used to calculate the distributions, or physico-chemical forms, of dissolved (0.45 µm filtered) cadmium (Cd), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and zinc (Zn) in main wet season Edith River surface water (at control site SW2) receiving treated wastewater (RP3) from the Mount Todd mine site.

The metal speciation results for indicate that the 'bioavailable fraction' of cadmium, copper, manganese and nickel is less than their respective 80% protection trigger value. The 'bioavailable fraction' of zinc exceeds the corrected 80% trigger value by a factor of 1.7. There is no reliable trigger value for cobalt.

No further metal speciation testing has been undertaken since 2012.

### ***Ecotoxicology***

The most recent ecotoxicology test undertaken on RP3 (November 2013) indicated a conservative dilution factor of 1:132 would provide 80% species protection level at the downstream monitoring point SW4 on the Edith River. In addition, all metal concentrations will be below the 95% species protection default trigger values at SW4 at this dilution with the exception of cadmium and zinc.

Treatment of RP3 is changing the water quality throughout the pit. Even though treatment has ceased, the water quality below 30m is still improving with elevated pH and reduced metal concentrations. Detailed ecotoxicology reports are provided in Appendix D and the Discharge Plan 2014/15 details the discharge further.

Additional ecotoxicology tests will be undertaken on RP3 water samples and to validate the mixing zone in November 2014.

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# 1. Introduction

## 1.1 Background

Vista Gold Australia Pty Ltd (Vista Gold) operate the care and maintenance phase of the Mount Todd Gold Mine, situated to the north of Katherine, NT. The site is managed through an approved Mine Management Plan (MMP) under the *Mining Management Act* and administered by the Department of Mines and Energy. The management of water onsite is undertaken through the Water Management Plan (WMP) which is appended to the MMP. The WMP operates in accordance with Vista Gold's Waste Discharge Licence 178-3 (WDL 178-3).

WDL 178 licenced activity is:

*“Discharge of waste water from Retention Ponds One (RP1), Three (RP3) and Seven (RP7) on the Mount Todd mine site, which comprises Mining Lease Numbers MLN1070, 1071 and 1027, into the Edith River from the confluence of Stow Creek and Edith River, the confluence of Burrell Creek and Edith River, and the confluence of West Creek and Edith River subject to this Licence.”*

### 1.1.1 Location

The site is situated within the Daly River Catchment, part of one of the largest river systems in the Northern Territory with a catchment area of 52,577km<sup>2</sup>. Several ephemeral streams which are tributaries to the Edith River cross the site including:

- West Creek – receives water from a diversion channel located to the west of the Waste Rock Dump and potentially from the Waste Rock Dump (RP1) spillway during periods of uncontrolled discharge.
- Burrell Creek – predominately covered by the Waste Rock Dump and has the potential to receive water from the RP1 siphons during controlled discharges.
- Batman Creek – fed by a natural catchment area up-stream of the site, but can potentially receive overflows from RP2 and RP5.
- Horseshow Creek – primarily fed by natural catchment flows which include the raw water supply reservoir and a diversion channel around the Tailings Storage Facility (RP7)..
- Stow Creek – situated to the south of the site and is fed by Batman Creek and Horseshoe Creek.

## 1.2 Scope of Work

This Licence Report fulfils WDL 178-3 Section 33,

WDL 178-3 is provided in Appendix A and summarised below:

*“The Licence requirement dictates Vista Gold are required to:*

33. *The Licensee must provide to the NT EPA not later than 20 Business days prior to the Expiry Date of this Licence the Licence Report.*

*The Licence Report must include:*

*33.1. outcomes associated with ongoing studies including:*

*33.1.1. results of the mixing zone modelling, mixing zone validation and mixing zone confirmation;*

*33.1.2. results of the metal speciation modelling;*

33.1.3. results of the ecotoxicology testing conducted prior to the commissioning of the water treatment plant (if applicable); and

33.2. be made available on the Licensee's Australian website within 10 Business days of being

33.2 [3]. be made available on the Licensee's Australian website within 10 Business days of being provided to the NT EPA.”

### 1.3 Limitations

This Vista Gold Australia WDL 178-3 Licence Report (“Report”):

- Has been prepared by GHD Pty Ltd (“GHD”) for Vista Gold Australia Pty Ltd (Vista Gold) and the NT EPA;
- May only be used and relied on by Vista Gold and the NT EPA;
- Must not be copied to, used by, or relied on by any person other than Vista Gold without the prior written consent of GHD; and Vista Gold; and
- May only be used for the purpose of addressing WDL 178-3 requirements (and must not be used for any other purpose).

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Vista Gold arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in section 1.2 of this Report.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report.

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until 6 months, after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

### 1.4 Sources of Information

This report has been compiled based on the following sources of information:

- GHD (2012) *Site Specific Trigger Values Plan*. Report prepared by GHD for Vista Gold, dated May 2012;
- GHD (2014) *Discharge Plan 2014/15*. Report prepared by GHD for Vista Gold, dated October 2014;
- GHD (2013) *Mixing Zone Study: Flow Rate Analysis*. Memo prepared by GHD for Vista Gold (Appendix B);
- Aquatic Solutions International (2012) *Speciation Modelling of Metals in Surface Waters of the Edith River During Wet Season Discharge of Wastewater from the Mount Todd Mine* (Appendix C);



- GHD (2014) *Mt Todd Discharge Surface Water Report*. Report prepared by GHD for Vista Gold, dated March 2014 (Appendix D);
- GHD (2013) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated February 2013 (Appendix D);
- GHD (2013) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated July 2013 (Appendix D); and
- GHD (2014) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated January 2014 (Appendix D).

## 2. Mixing Zone

### 2.1 Introduction

Vista Gold has commissioned documents to assist with its application for Site Specific Trigger Values (SSTVs) and a mixing zone. A summary of the mixing zone modelling, validation and confirmation is provided below. The information is summarised from previously issued reports including:

- GHD (2012a) *Site Specific Trigger Values Plan*. Report prepared by GHD for Vista Gold, dated May 2012;
- GHD (2014) *Discharge Plan 2014/15*. Report prepared by GHD for Vista Gold, dated October 2014; and
- GHD (2013) *Mixing Zone Study: Flow Rate Analysis*. Memo prepared by GHD for Vista Gold (Appendix B).

### 2.2 Mixing Zone Model

A mixing zone model has been used to predict the size and behaviour of a mixing zone downstream from the Mt Todd Gold Mine. The model assesses a range of ambient conditions that may be encountered downstream of the discharge site. The selected model used physical characteristics of the discharge, and the Edith River, to predict the extent of the mixing zone.

The model incorporated criteria including the following:

- Reliable and accessible validation record;
- An understanding of the assumptions made in formulating the model and the consequences of those assumptions;
- Appropriate for the available data.
- Publication record in relevant applications.
- Appropriate technical support.

#### 2.2.1 Requirements of Mixing Zone Model

The mixing zone model incorporated site conditions to appropriately establish ambient conditions prior to assessment of the mixing zone. The following items of data were utilised in its development:

- Flow rates of Edith River under different scenarios;
- Flow rates of mine discharge;
- Depth of Edith River;
- Width of Edith River;
- Physical characteristics of Edith River; and
- Water quality of discharge and Edith River.

#### 2.2.2 Mixing Zone Model

##### **HEC-RAS Modelling**

HEC-RAS hydraulic modelling was undertaken to estimate flow conditions at SW4. River cross sections were utilised from LIDAR topographic data and limited observational data for river

bathymetry. Following an assessment of HEC-, a rating curve was established for Station G8140152 and SW4, provided in Figure 1.

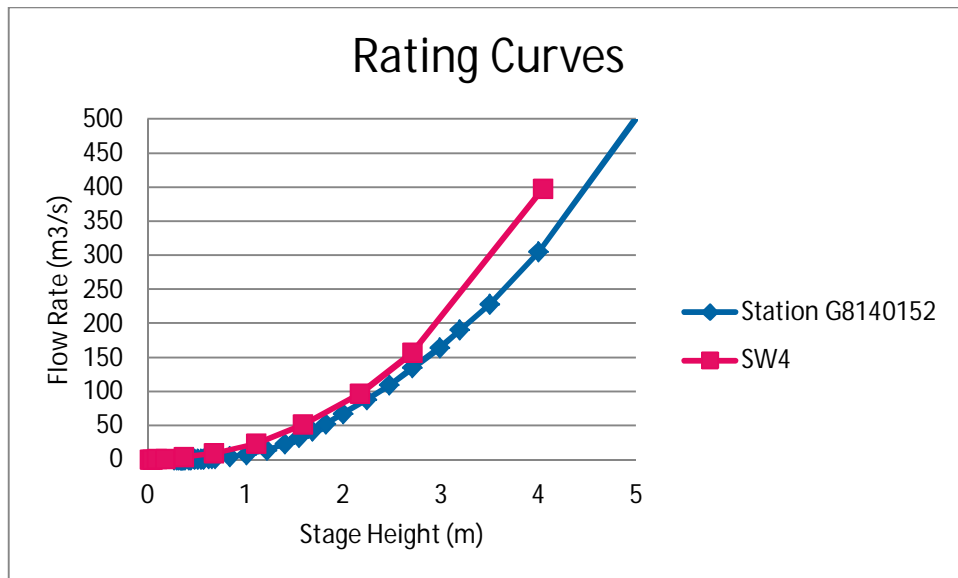


Figure 1 Existing and Modelled Rating Curves

### Mixing Zone Modelling

The longitudinal extent of the mixing zone was calculated using the Gaussian diffusion modelling method described in Fischer et. al. (1979) using parameter values from this reference as well as more recent studies. The mixing zone calculations included:

- Shear Velocity (function of gravity, average depth and river bed slope)
- Transverse Mixing Coefficient (function of mixing coefficient, average depth and shear velocity)

The mixing zone distances were established for two scenarios including the distance where the maximum concentration is:

- 20% above average concentration (qualitatively described as well mixed)
- 5% above average concentration (qualitatively described as effectively fully mixed).

The mixing zone calculations were established for two different mixing coefficient values including:

- $C_T$  0.6 (representative of a meandering channel)
- $C_T$  2 (representative of a curved channel).

A summary of mixing zone distances and associated mixing coefficient is provided in Table 1 below.

Table 1 Mixing Zone Extent Estimates

Percentage Exceedance (%)	Flow Rate (m <sup>3</sup> /s)	Mixing Zone Size for Mixing Coefficient 0.6 (m)		Mixing Zone Size for Mixing Coefficient 2 (m)	
		20% Above Average Criteria	5% Above Average Criteria	20% Above Average Criteria	5% Above Average Criteria
99	0.0051	7	12	2	4
95	0.064	82	134	25	40
90	0.24	291	474	87	142
80	0.99	810	1,321	243	396
65	3.1	1,484	2,419	445	726
50	8.1	1,826	2,977	548	893
35	19	1,913	3,119	574	936
20	44	2,146	3,499	644	1,050
10	82	1,995	3,253	599	976
5	130	2,064	3,366	619	1,010
1	340	2,194	3,578	658	1,073

### 2.2.3 Mixing Zone Validation

Water quality monitoring, macroinvertebrate monitoring and ecotoxicology testing will be conducted across the mixing zone during discharge events. The tests will be utilised to validate the behaviour of the mixing zone and refine the model as required.

Vista Gold will conduct a mixing zone validation during the 2014/15 Wet Season, providing the mine is discharging to the Edith River, and produce a localised rating curve for site SW4.

In addition, Vista Gold will undertake additional water quality testing of RP3 and ecotoxicology assessment in November 2014 to validate the Discharge Plan algorithm.

### 2.2.4 Reduction of the Mixing Zone

It is anticipated that the spatial extent of the mixing zone will reduce upon commencement of on-site water treatment. Investigations by Vista Gold indicate water quality of the proposed discharged wastewater will improve when compared with that which could be discharge from RP1.

### 2.2.5 Summary

The results of the mixing zone model study indicate that the size of the mixing zone stabilises at higher flow rates, reaching a plateau around the median flow rate.

Mixing characteristics of this reach of the Edith River are unknown. In the absence of site specific mixing data, a realistic range of transverse mixing rate parameters were modelled. The following mixing zones distances were calculated in order to meet 5% above average criteria:

- Meandering channel ~3,500m
- Curved channel ~1,000m

The mixing zone does not extend to sample site SW10 which is 8.7km from SW4, and site SW4 is within the mixing zone. However, the mixing zone model is considered to be conservative due to the curved characteristics and variable channel cross sections of the Edith River at the discharge (increases the Transverse Mixing Coefficient).

Vista Gold will conduct a mixing zone validation during the 2014/15 Wet Season, providing the mine is discharging to the Edith River, and produce a localised rating curve for site SW4.

A summary of the Mixing Zone Study is provided in Appendix B.

# 3. Metal Speciation

## 3.1 Introduction

A summary of metal speciation modelling is provided below. The information is summarised from previously issued reports including:

- GHD (2012a) *Site Specific Trigger Values Plan*. Report prepared by GHD for Vista Gold, dated May 2012;
- Aquatic Solutions International (2012) *Speciation Modelling of Metals in Surface Waters of the Edith River During Wet Season Discharge of Wastewater from the Mount Todd Mine* (Appendix C); and
- GHD (2014) *Discharge Plan 2014/15*. Report prepared by GHD for Vista Gold, dated October 2014.

## 3.2 Metal Speciation Modelling

Metal speciation modelling was undertaken in 2012 on key metals of concern, including Manganese (Mn), Copper (Cu), Zinc (Zn), Nickel (Ni), Cobalt and Cadmium (Cd). The modelling was undertaken using two models, with metal binding with dissolved organic matter calculated in attached sub-models. The speciation models included:

- WHAM (version 7.0; Tipping et Al., 2012) incorporated with Humic Ion-Binding Model VII; and
- Visual MINTEQ (version 3.0; Gustafsson, 2011) incorporated with Stockholm Humic Model and NICA Donnan Model.

### 3.2.1 Results

The metal speciation study shows that discharge of treated RP3 water may result in the following bioavailability of (0.45 µm filtered) metals at site SW4:

- Cadmium (Cd) 86.6 %
- Cobalt (Co) 92.1 %
- Copper (Cu) 16.8 %
- Manganese (Mn) 94.1 %
- Nickel (Ni) 87.3 %
- Zinc (Zn) 91.9 %

The metal speciation results for RP3 water indicate that the 'bioavailable fraction' of cadmium, copper, manganese and nickel is less than their respective 80% protection trigger value. The 'bioavailable fraction' of zinc exceeds the corrected 80% trigger value by a factor of 1.7. There is no reliable trigger value for cobalt.

No further metal speciation testing has been undertaken since 2012.

Detailed results and discussion of metal speciation is provided in Appendix C.

# 4. Ecotoxicology

## 4.1 Introduction

A summary of ecotoxicology testing is provided below. The information is summarised from previously issued reports including:

- GHD (2014) *Mt Todd Discharge Surface Water Report*. Report prepared by GHD for Vista Gold, dated March 2014 (Appendix D);
- GHD (2013) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated February 2013 (Appendix D);
- GHD (2013) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated July 2013 (Appendix D); and
- GHD (2014) *Mt Todd Discharge Treated Retention Pond 3 Ecotoxicology Report*. Report prepared by GHD for Vista Gold, dated January 2014 (Appendix D).

## 4.2 Method

Ecotoxicology tests have been undertaken using Direct Toxicity Assessment (DTA). The DTA provides an integrated measure of the toxicity of chemicals within a complex mixture, and accounts for interactions between compounds which may be additive, synergistic or ameliorative. DTA provides a better representation of natural environmental conditions than single chemical testing and is recommended by ANZECC & ARMCANZ (2000) for assessing the environmental impact from complex effluents.

The Mt Todd DTA program was designed in line with the recommendations contained in ANZECC & ARMCANZ (2000). ANZECC & ARMCANZ (2000) states that a DTA program should address the following design considerations:

- Test species selection;
- Receiving water selection;
- Nature of contaminant(s);
- Test methods; and
- Statistical considerations.

### 4.2.1 Tests

Mt Todd samples have been tested by ERISS Laboratory (Darwin) and Ecotox Services Australasia (Sydney) because not all test organisms are available from one laboratory. A summary of test organisms utilised, and associated details, is provided in Table 2.

Edith River water sampled from the upstream site SW2 was used as the diluent to assess the toxicity of the treated RP3 mine water, and establish a conservative dilution factor for 80% species protection.

Table 2 Ecotoxicology Test Species

Test Organism	Test Duration	Test Endpoint	Key Reference
<i>Selenastrum capricornutum</i> (green alga)	72 hour (chronic)	Growth inhibition	USEPA Method 1003.0 (2002)
<i>Lemna aequinoctialis</i> (duckweed)	96 hour (chronic)	Growth (frond number)	OECD Method 221 (2006)
<i>Ceriodaphnia dubia</i> (water flea)	3 brood (chronic)	Reproduction	USEPA Method 1002.0 (2002)
<i>Hydra viridissima Pallas</i> (green hydra)	96 hour (chronic)	Population growth	Riethmuller et al. (2003)
<i>Chironomus tepperi</i> (chironomid)	48 hour (acute)	Survival	USEPA (2002), OECD (2011)
<i>Macrobrachium bullatum</i> (shrimp)	96 hour (acute)	Survival	ESA SOP 123 (ESA 2012)
<i>Mealanotaenia splendida</i> (rainbowfish)	10 day (chronic)	Embryonic development and post hatch survival	USEPA (2002)

### 4.3 Summary

The most recent ecotoxicology test undertaken on RP3 (November 2013) indicated a conservative dilution factor of 1:132 would provide 80% species protection level at the downstream monitoring point SW4 on the Edith River. In addition, all metal concentrations will be below the 95% species protection default trigger values at SW4 at this dilution, with the exception of cadmium and zinc.

Treatment of RP3 has been changing the water quality throughout the pond. Even though treatment has ceased, the water quality below 30m is still improving, with elevated pH and reduced metal concentrations. Detailed ecotoxicology reports are provided in Appendix D and the 2014/15 Discharge Plan.

Additional ecotoxicology tests will be undertaken on RP3 water samples and to validate the mixing zone in November 2014.

## 5. References

Aquatic Solutions International (2012) Speciation Modelling of Metals in Surface Waters of the Edith River During Wet Season Discharge of Wastewater from the Mount Todd Mine.

GHD (2012a) Site Specific Trigger Values Plan. Report prepared by GHD for Vista Gold, dated May 2012.

GHD (2014) Discharge Plan 2014/15. Report prepared by GHD for Vista Gold, dated October 2014.

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OECD (2006) Lemna sp. *Growth inhibition test. Method 221. OECD guideline for the testing of chemicals. Organisation for Economic Cooperation and Development. Paris.*

OECD (2011) *OECD guideline for the testing of chemicals. Test Guideline 235: Chironomus sp Acute immobilisation test. Organisation for Economic Cooperation and Development. Paris.*

Riethmuller N., Camilleri C., Franklin N., Hogan A., King A., Markich S.J., Turley C. and van Dam R. (2003) *Green hydra population growth test. In: Ecotoxicological Testing Protocols for Australian Tropical Freshwater Ecosystems. Supervising Scientist Report 173. ERISS, Darwin, NT.*

Tipping, E., Lofts, S., Sonke, J.E. 2011. Humic ion-binding model VII: A revised parameterisation of cation-binding by humic substances. *Environ. Chem.* 8, 225–235.

USEPA (2002) *Short-term methods for measuring the chronic toxicity of effluents and receiving waters to freshwater organisms. 4th Edition. United States Environmental Protection Agency, Office of Water, Washington DC.*