t: +61 08 9228 3060
f: +61 08 9228 3210
a: 45 Gladstone St,
East Perth, WA 6004
e: admin@soilwatergroup.com
w: www.soilwatergroup.com

SOILWATER CONSULTANTS

MEMO

TO:	Justin Robins	COMPANY:	ABM Resources NL	
FROM:	Joe Powers	PROJECT TITLE:	Twin Bonanza Surface & Groundwater EIS	
DATE:	5 December 2013	PROJECT & DOCUMENT NO:	ABM-001-01-03	003
SUBJECT:	Preliminary Surface Flow Analysis for Twin Bonanza Gold			

Justin,

Soilwater Consultants (SWC) has conducted a precursory surface flow analysis and flood risk assessment for the Twin Bonanza Gold Project (Project Area). This work consisted of the following tasks:

- Task 1: Delineate catchment boundaries and surface flows across the Project Area, at a regional and local scale.
- Task 2: Quantify peak flood flow rates at specific infrastructure locations, using rainfall intensity-duration-frequency (IDF) curves for the 1:1, 1:20, 1:100, and 1:1,000 year ARI events, and using both the Rational and Index Flood methods.
- Task 3: Determine potential floodplain characteristics from a regional digital elevation model (DEM) and from the recently flown high-resolution DEM of the Project Area.
- Task 4: Identify flood risk across the site using the information determined in Tasks 1-3.

Regional DEM information was obtained from Geosciences Australia (1 second STRM v1.0 DEM-H) (see Figure 1). Examination of this DEM revealed that the Project Area was located relatively high in the landscape, and is not likely to be affected by regional-scale surface water flows. The National Catchment Boundary (NCB) dataset (Geosciences Australia) confirmed this observation (Figure 1); the site is located on the topographical divide between two NCB Level 1 Divisions (the North Western Plateau Division and the Timor Sea Division), indicating that the site is located in one of the furthermost upstream positions possible. Only local flows are therefore of primary concern at this site.

The recently flown high-resolution DEM of the Project Area (flown by Airvista in June 2013) (Figure 2) provides good, coverage of the Project Area at a minimum resolution of 5 m (horizontal resolution). The majority of the main infrastructure areas are located on topographic highs or diverging slope areas, where the potential for converging surface water flows is minimal. The shape of the landscape indicates that sheet flow will be the dominant surface water flow process, with some accumulation of flows possible in lower-lying areas after large storm events.

Pre-mine catchment boundaries and local-scale flow lines were derived for the main mine site area using a TOPAZ analysis within the Watershed Modelling System (WMS) software (Water Modelling Solutions, 2013) (see Figure 3). As expected, numerous narrow catchments were delineated, reflecting the diverging land surface. Surface water flow is not expected to accumulate in any significant channels within the main infrastructure areas. Flow accumulation lines are presented where surface water flow accumulation is expected to exceed 50 ha.

As outlined in the Erosion and Sediment Control Plan (ESCP) (SWC, 2013a) and the Water Management Plan (WMP) (SWC, 2013b), diversion bunds and drains will be constructed throughout the site to divert the local surface water flows, as identified through the TOPAZ analysis. Peak flood flows were estimated for each of the diversion catchments using the Rational and Index Flood Methods (Pilgrim, 2003). Where possible, input values recommended by the Australian Rainfall & Runoff guide (Pilgrim, 2003) specifically for the Northern Territory were used. Where this was not possible, results were interpolated from values modelled using South Australia (arid zone) and Western Australian (Kimberley) parameters. The results of this modelling are presented in Table 2, and these may be used for preliminary sizing of any required diversion drains.

Table 1: Modelled upstream catchment properties for the main infrastructure areas.

No	Site area	Area (ha)	Length (km)	Slope (m/km)
A1	North Pit	11.7	0.8	5
A2	North Pit	15.2	1.2	5.8
B1	South Pit	5.5	0.4	12.5
B2	ROM	10.3	0.7	12.8
B3	WRD 1	16.4	1.4	9.2
C1	South Pit	6.7	0.5	11.4
C2	WRD 2	23.6	1.2	7.5
C3	TD Cell 2B	32.1	1.7	5.8
D1	Plant	5.9	0.35	4
D2	Camp	14.5	1.4	5
E	Workshop	3	0.35	3
F	Landfill	4.5	0.6	6.7

Table 2: Peak flow estimations for a range of event frequencies

No	Site area	Rational Method				Index Flood Method			
		1:1 yr	1:20 yr	1:100-yr	1:1,000-yr	1:1 yr	1:20 yr	1:100-yr	1:1,000-yr
A1	North Pit	0.6	2.1	3.3	5.4	0.9	4.7	6.8	9.8
A2	North Pit	0.6	2.2	3.4	5.6	1.0	5.5	8.0	11.5
B1	South Pit	0.4	1.4	2.2	3.5	0.6	3.0	4.4	6.3
B2	ROM	0.6	2.0	3.1	5.0	0.8	4.4	6.3	9.1
B3	WRD 1	0.6	2.1	3.4	5.6	1.0	5.7	8.3	12.0
C1	South Pit	0.4	1.5	2.4	3.9	0.6	3.4	4.9	7.1
C2	WRD 2	1.0	3.6	5.7	9.4	1.3	7.1	10.3	14.9
C3	TD Cell 2B	1.1	3.9	6.2	10.1	1.5	8.5	12.4	17.8
D1	Plant	0.4	1.3	2.1	3.4	0.6	3.2	4.6	6.6

D2	Camp	0.5	1.8	2.9	4.7	1.0	5.3	7.8	11.1
E	Workshop	0.2	0.7	1.1	1.7	0.4	2.1	3.1	4.4
F	Landfill	0.2	0.9	1.3	2.2	0.5	2.7	3.9	5.6

A risk assessment was conducted to determine the potential for flooding in each of the proposed infrastructure areas. The characteristics of the landscape within each area were rated ("low", "medium", or "high" risk) according to their potential contribution to flood risk in the area. The primary landscape characteristics considered in this assessment included:

- Size of the upstream catchment area
- Land slope
- Land form
- Landscape position
- Soil type

Table 3 summarises the assessed flood risk for each of the main infrastructure areas, and Figure 5 presents a map of the spatial distribution of assessed flood risk. In general, most of the major infrastructure items were given a "low" risk rating because of their location on hill tops and gentle slopes, and because of the predominance of diverging flow conditions. This means that as long as appropriately sized diversion drains are installed, it is not expected that the infrastructure will be affected by significant flooding.

The borefield is located in an extremely flat (slope of 0.5 m/km), low-lying area with a large upstream catchment area, and was thus given a "high" risk rating. Sections of the main access road were also given a "high" flood risk rating because the road crosses several lower-lying areas where flow accumulation is likely during larger storm events. These sections of road should be designed with this in mind (i.e. incorporating floodways or culverts).

Table 3: Flood risk matrix for major infrastructure items

	Catchment Area	Slope	Landform	Landscape Position	Soil Type	Overall
North Pit	Low	Low	Low	Low	Low	Low
Central Pit	Low	Low	Low	Low	Low	Low
South Pit	Low	Low	Low	Low	Low	Low
Plant	Low	Medium	Low	Low	Low	Low
Workshops	Low	Medium	Low	Low	Low	Low
TD Cell 1	Low	Low	Low	Low	Low	Low
TD Cell 2	Low	Low	Low	Low	Low	Low
WRD 1	Low	Low	Low	Medium	Low	Low
WRD 2	Low	Low	Low	Medium	Low	Low
Camp	Low	Low	Low	Low	Low	Low
Airstrip	Low	Low	Low	Low	Low	Low
Borefield	High	High	High	High	Low	High
Borefield road	Low – High	Low – High	Low – High	Low – High	Low	Low – High
Main access road	Low – High	Low – High	Low – High	Low – High	Low	Low - High

Should you have any queries regarding this report, please do not hesitate to contact us.

Yours sincerely,

Joe Powers

Water Resource Engineer

t: +61 8 9228 3060

e: Joe.Powers@soilwatergroup.com

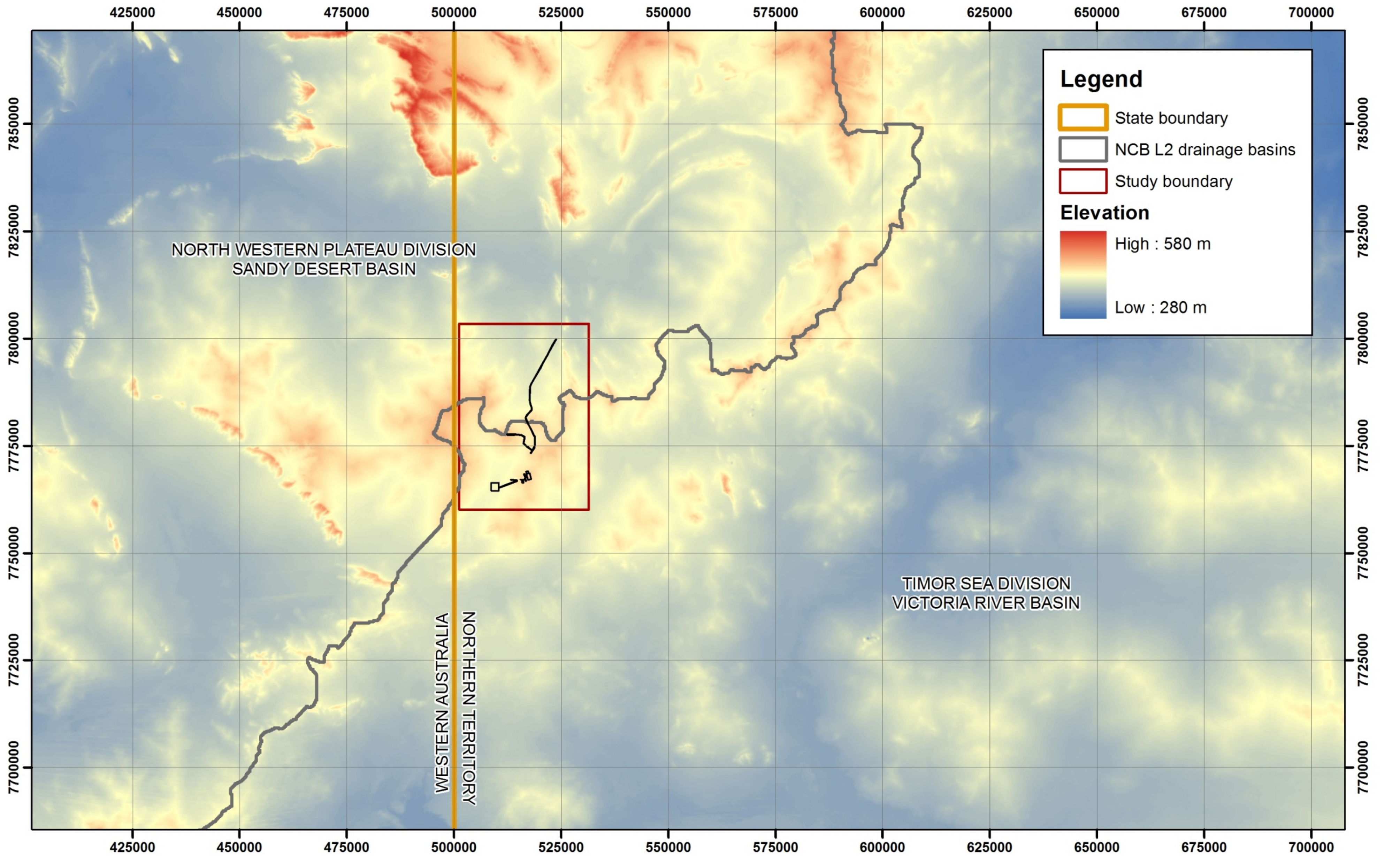
References

Pilgrim, D. H. (ed.) (2003) *Australian Rainfall & Runoff - A Guide to Flood Estimation*. Institution of Engineers Australia. Barton, ACT.

SWC (2013a) *Twin Bonanza Erosion and Sediment Control Program (ESCP)*. Unpublished report ABM-001-01-03 004 prepared by Soilwater Consultants for ABM Resources.

SWC (2013b) *Water Management Plan*. Unpublished report ABM-001-01-03 005 prepared by Soilwater Consultants for ABM Resources.

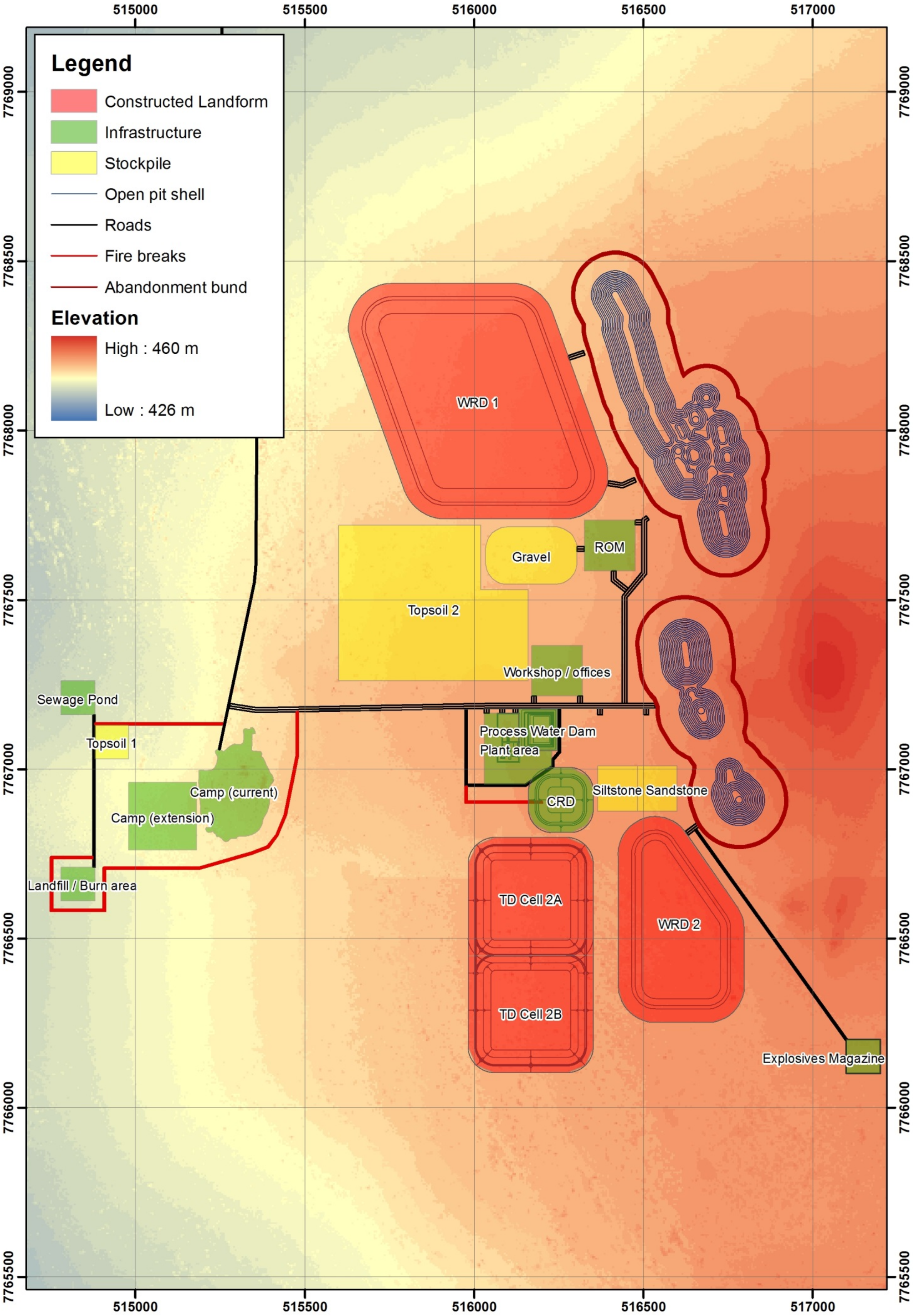
Water Modelling Solutions (2013) *Watershed Management System (WMS) User Manual, Vesion 9.1*
Available at: http://xmswiki.com/xms/WMS:WMS_User_Manual_9.1 (accessed 14 October 2013).



ABM Resources NL	Figure 1: Regional DEM (Geosciences Australia, 1 second STRM v1.0 DEM-H)
Preliminary Surface Flow Analysis for Twin Bonanza Gold	

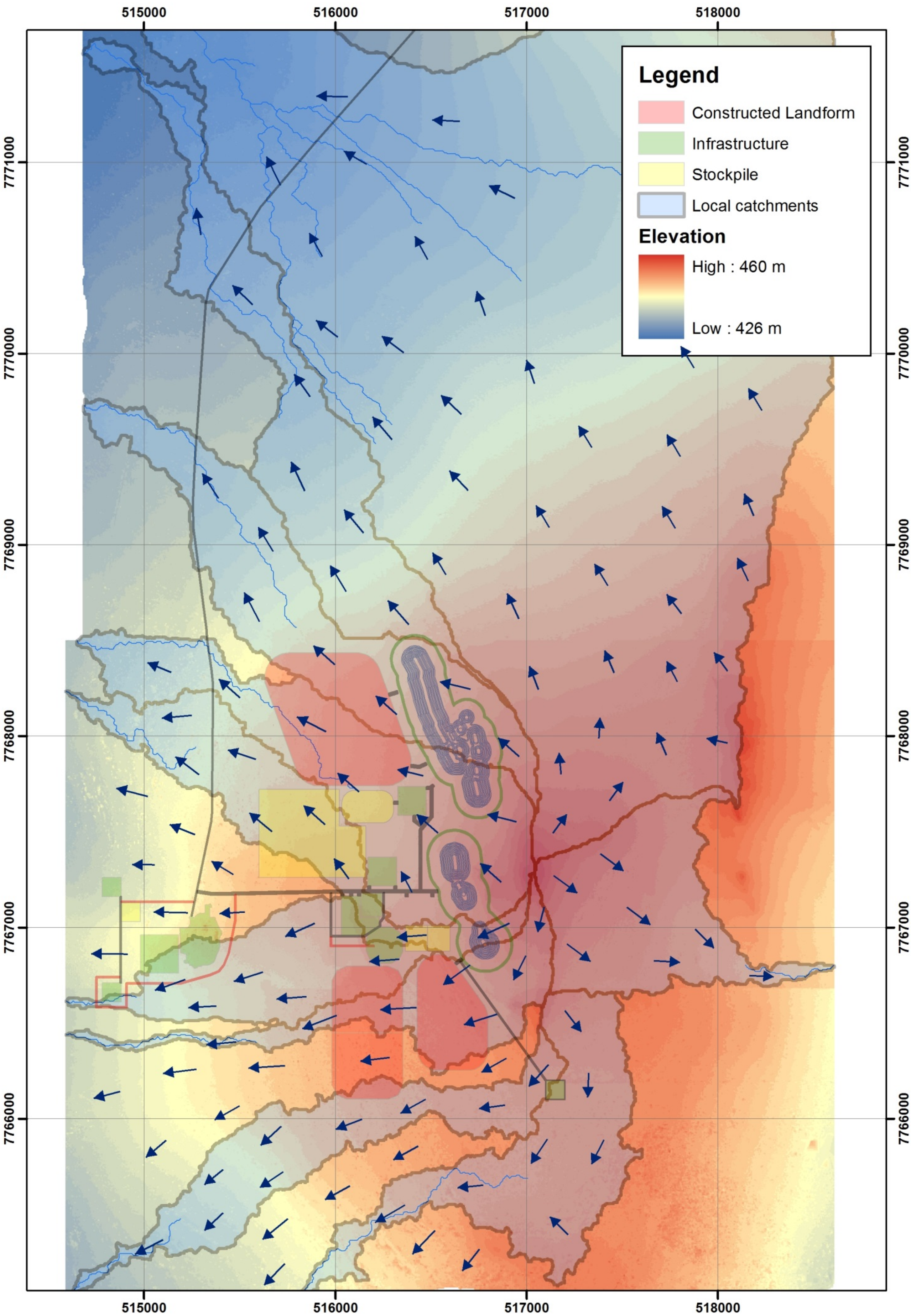
soilwater GROUP

PN: ABM-001-01-03 Prepared by: Date: MM/DD/YY Reviewed by: Date: MM/DD/YY Revision:



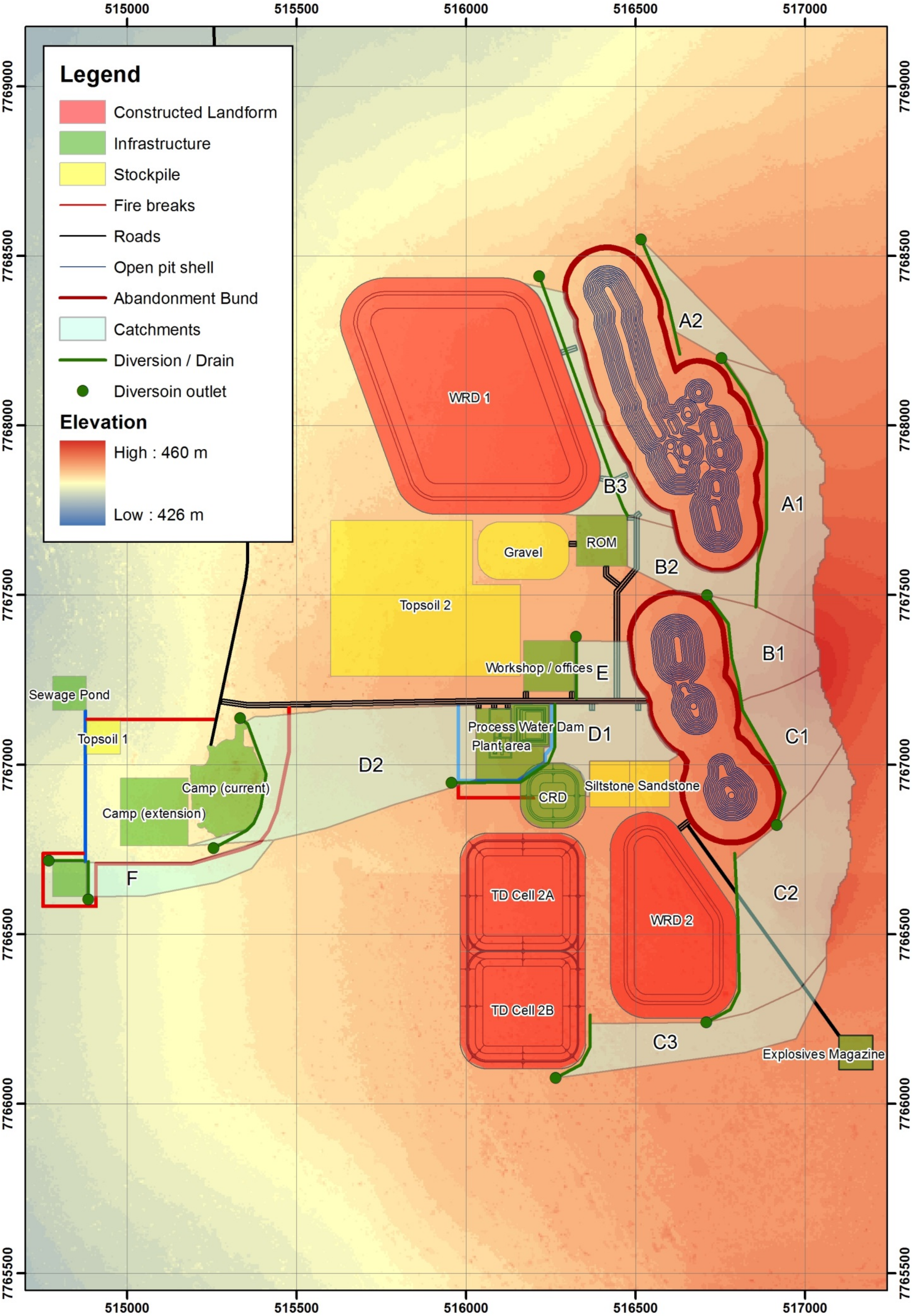
ABM Resources NL	Figure 2: Site layout and local DEM (Airvista, June 2013)	soilwater GROUP
Preliminary Surface Flow Analysis for Twin Bonanza Gold		

PN: ABM-001-01-03 Prepared by: Date: MM/DD/YY Reviewed by: Date: MM/DD/YY Revision:



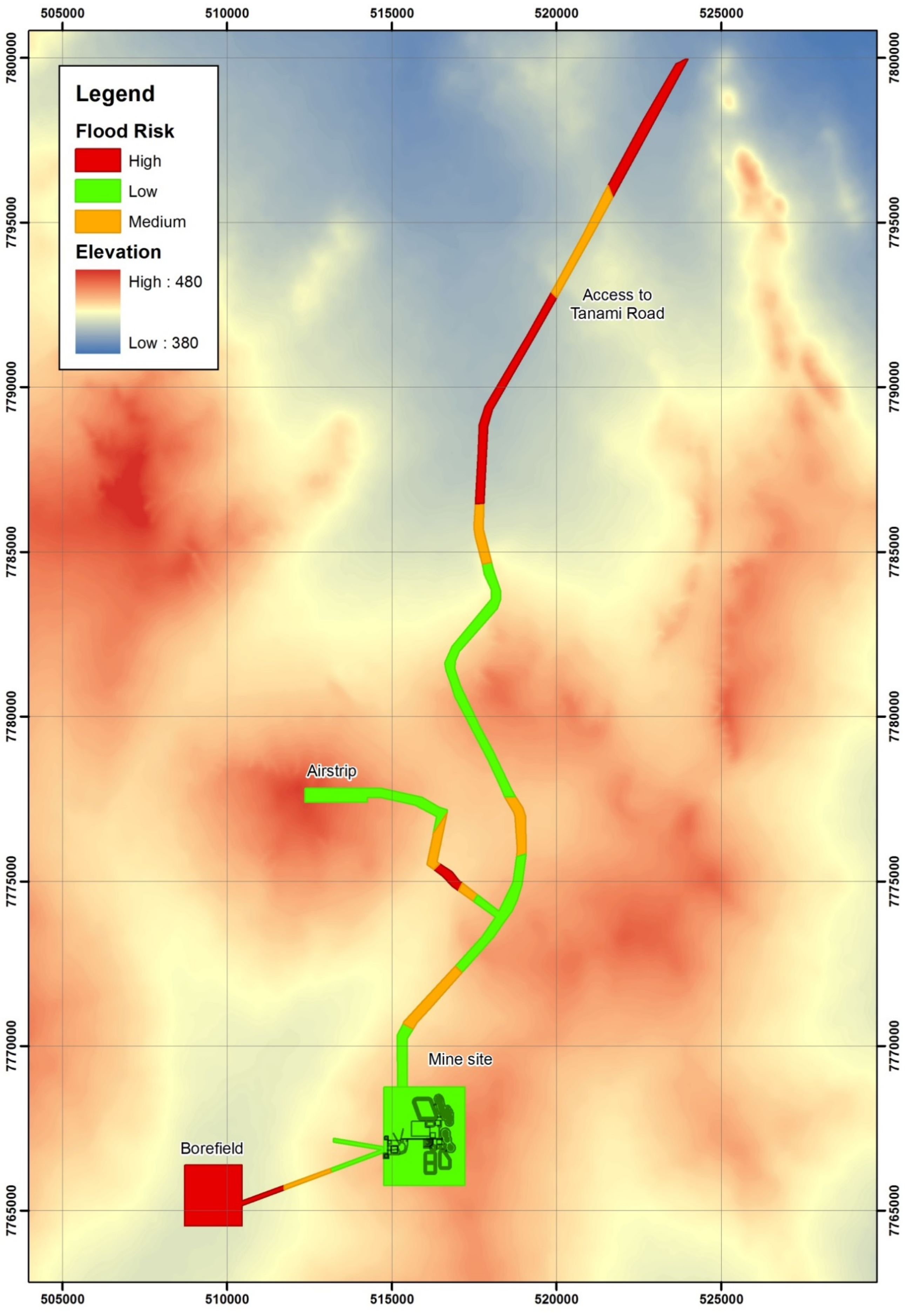
ABM Resources NL	Figure 3: Pre-mine catchment delineation using TOPAZ	soilwater GROUP
Preliminary Surface Flow Analysis for Twin Bonanza Gold		

PN: ABM-001-01-03 Prepared by: Date: MM/DD/YY Reviewed by: Date: MM/DD/YY Revision:



ABM Resources NL	Figure 4: Upstream catchments for primary infrastructure areas	soilwater GROUP
Preliminary Surface Flow Analysis for Twin Bonanza Gold		

PN: ABM-001-01-03 Prepared by: Date: MM/DD/YY Reviewed by: Date: MM/DD/YY Revision:



ABM Resources NL	Figure 5: Assessed flood risk
Preliminary Surface Flow Analysis for Twin Bonanza Gold	