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Lehating

Lehating Mine Flooding Assessment

710.12015.0002

Report No. 1

October 2011

Lehating Mining (Pty) Ltd

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LEHATING MINE FLOODING ASSESSMENT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACCRONYMS AND ABBREVIATIONS

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	Definition
AMSL	Above Mean Sea Level
DDF	Depth Duration Frequency
DWA	Department of Water Affairs
MAP	Mean Annual Precipitation
RLMA&SI	Regional L-Moment Algorithm and Scale Invariance
RMF	Regional Maximum Flood
RP	Return Period
SANRAL	South African National Road Agency Limited
SAWS	South African Weather Service
SDF	Standard Design Flood
TC	Time of Concentration

LEHATING MINE FLOODING ASSESSMENT

1   INTRODUCTION

1.1   BACKGROUND

Lehating Mining (Pty) Ltd (Lehating) intend to develop an underground manganese mining operation near Hotazel town in the Northern Cape Province. The proposed project will involve the underground mining, crushing and screening of manganese ore and the resultant fines slurry will be disposed of at an on-site tailings storage facility (TSF). Lehating are currently conducting the pre- feasibility study for the proposed project.

In order to comply with applicable guidance, namely DWAF Government Notice 704 (GN704) and as input into an Environmental Impact Assessment (EIA), floodlines are required to be modelled. As such, SLR Consulting (Africa) (Pty) Ltd was appointed to undertake a flooding assessment of the main Kuruman River running adjacent the site. Preferential drainage flowpaths were also assessed so as to provide an indication of areas prone to surface water flooding.

1.2   DWAF GOVERNMENT NOTICE 704

GN 704 was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation which require understanding.

The main principle condition of GN 704 applicable to this study is:

- *Condition 4* which defines the area in which mine workings or associated structures may be located with reference to a watercourse and associated flooding. The 50 year floodline and 100 year flood line are used for defining suitable locations for mine workings (prospecting, underground mining or excavations) and associated structures respectively. Where the floodline is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for both mine workings and associated structures.

1.3   SITE LOCATION

The Lehating project area is centred at -27.048936° latitude and 22.872371° longitude, within the Northern Cape approximately 265km north-west of Kimberley and approximately 95km south east of the Botswana border. See Figure 1.1 for the regional setting of the site.
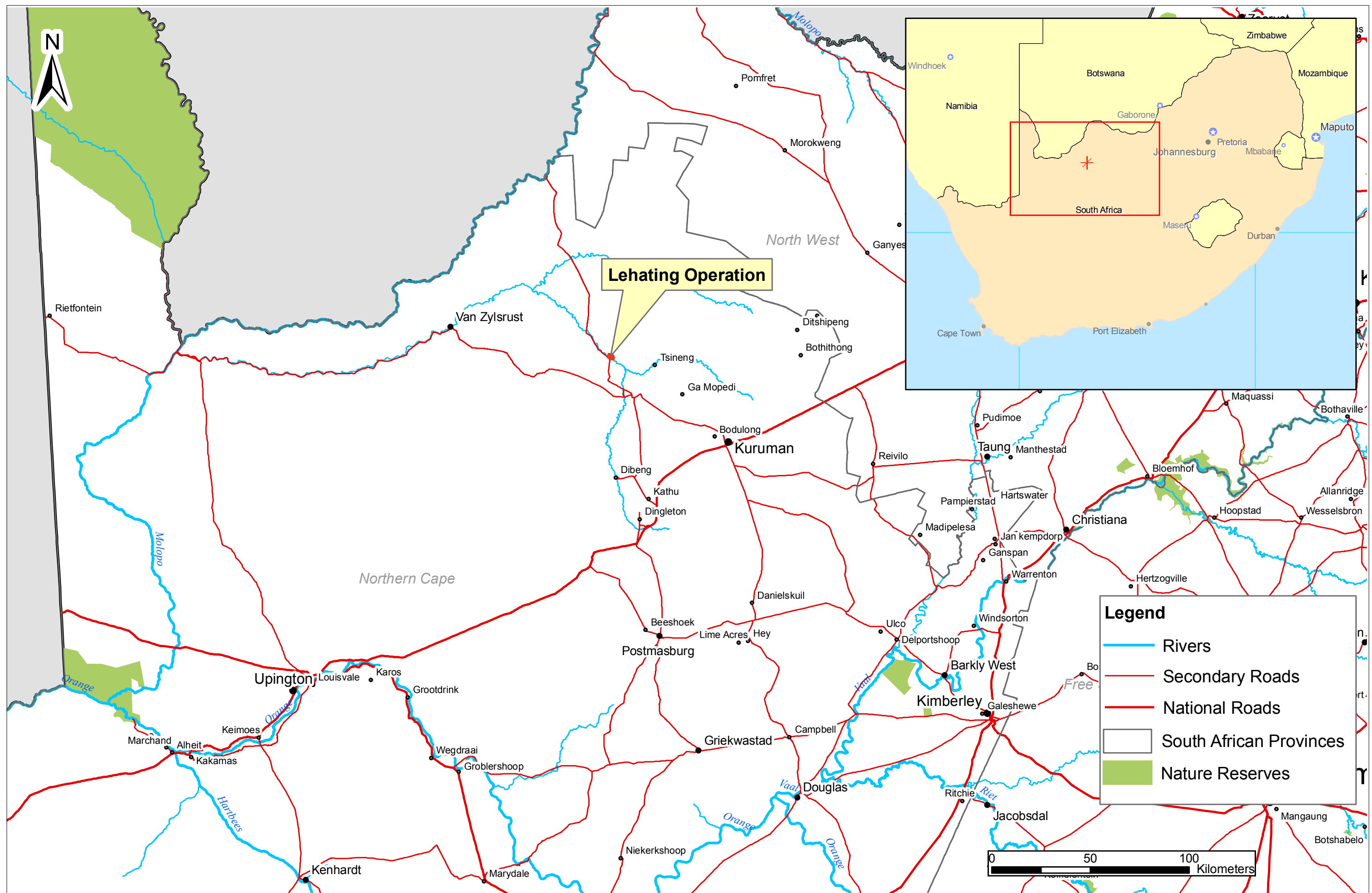
Figure 1.1 Regional Setting of the Proposed Lehating Opertation

2   BASELINE INFORMATION

2.1   REGIONAL CLIMATE

The proposed project site falls within the Northern Steppe climatic zone as defined by the South African Weather Bureau. This is a semi-arid region characterised by erratic rainfall, high evaporation levels, hot temperatures in summer and cold temperatures in winter.   The regional average daily maximum temperature varies between 30°C and 33°C in January and in July it is approximately 17°C. The regional average daily minimum temperature is about 15°C in January and in July it is roughly 0°C. Other details of the regional climate pertaining to the hydrology, flood risk and stormwater management of the site include:

- 5 lightning flashes a year (Adamson TR102, lightning flash density per square kilometre)

- 50 thunder days a year (Alexander 2001, average number of thunder days a year)

2.2   RAINFALL

WR2005 (2009) indicates that the mean annual rainfall (MAP) for the site is approximately 320 mm/annum. There are a number of South African Weather Service (SAWS) weather stations within 50km of the site, while the closest Department of Water Affairs (DWA) station is approximately 55km away.   Table 2.1 presents the monthly totals of rainfall for the two SAWS gauges near the site; namely Winton and Milner located at 40.5km and 17.5km away respectively, and the DWA station, Kuruman (55km away).

The mean annual rainfall measured at the nearby Winton and Milner weather stations ranges between 330mm and 362mm respectively. Rainfall is typically in the form of thunderstorms during the summer months of October to March. The peak rainy period occurs between the months of January to March. Rainfall is erratic and may vary significantly from year to year. The weather stations presented in Table 2.1 have their positions illustrated in Figure 2.2

TABLE 2.1: MONTHLY RAINFALL FOR WEATHER STATIONS NEAR THE SITE

	STATIONS		
Station name	**Winton**	**Milner**	**Kuruman**
Station No.	392148 W	393083 W	D4E004
Latitude	27°29' S	27°22' S	27°28' S
Longitude	22°37' E	23°02' E	23°26' E
Distance to site (km)	55	40	75
Altitude (m)	1180	1118	1320
Years of Record	72	67	54
	RAINFALL (mm)		
January	62.1	66.1	85.6
February	61.2	61.4	82.9
March	58.0	66.4	86.5
April	31.8	35.5	45.1
May	13.9	16.1	21.5
June	4.2	6.0	7.4
July	2.5	1.9	2.8
August	4.9	4.2	9.8
September	6.2	6.2	7.8
October	16.2	19.0	26.3
November	25.7	32.0	45
December	43.3	46.8	44.9
Annual	330.1	361.6	465.7

2.2.1   RAINFALL DEPTHS

Design rainfall depths for various return periods (RP) and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm in conjunction with a Scale Invariance (RLMA&SI) approach to provide site specific estimates of depth-duration-frequency (DDF) rainfall, based on surrounding observed records. This method of DDF rainfall estimation is considered more robust than previous single site methods. The Water Research Commission (WRC) Report No. K5/1060 provides further detail on the verification and validation of the method.

For comparative purposes, HRU (1978) was considered. This method resulted in slightly lower estimates, thereby placing greater confidence in the RLMA&SI estimates with regard to their use in design. Table 2.2 presents the results of the RLMA&SI and HRU estimates for the site.

TABLE 2.2: RAINFALL DEPTH FOR VARIOUS METHODOLOGIES AND RETURN PERIODS FOR THE 1-HOUR AND 24-HOUR STORM

Methodology	Rainfall Depth (mm) for associated Return Periods in relation to a 1-hour rainfall duration						
	2	**5**	**10**	**20**	**50**	**100**	**200**
RLMA&SI (standard)	26.2	37.3	45.1	52.9	63.6	72.1	80.9
HRU 1978	18.86	24.8	30.6	37.6	49.5	61.0	75.1
	Rainfall Depth (mm) for associated Return Periods in relation to a 24-hour rainfall duration						
	2	**5**	**10**	**20**	**50**	**100**	**200**
RLMA&SI (standard)	58.3	82.8	100.3	117.6	141.4	160.3	179.8
HRU 1978	32.2	42.2	52.08	64.1	84.2	103.9	127.9

2.3 EVAPORATION

WR2005 (2009) shows a range in annual evaporation for the site of greater than 2600mm (A-Pan estimate). A correction factor of approximately 0.65(based upon the annual average for monthly correction factors) allows for the translation of the A-Pan estimate to the evaporation estimate for a very shallow body of water (Lake), equivalent to 1695mm.

Table 2.3 presents evaporation data sourced from the DWA station (Kuruman) closest to the site.

**TABLE 2.3: MONTHLY EVAPORATION FOR KURUMAN WEATHER STATION**

Month	Mean Monthly A-Pan Evaporation (mm)	Mean Monthly Lake Evaporation (mm)
Jan	259.0	169.7
Feb	208.4	144.9
Mar	161.3	112.1
Apr	122.3	83.9
May	113.2	76.8
Jun	82.5	56.1
Jul	99.1	63.3
Aug	131.2	81.8
Sep	188.5	109.9
Oct	236.3	135.9
Nov	243.6	157.8
Dec	272.7	183.3
Total	**2118.1**	**1375.7**

2.4 TOPOGRAPHY AND LAND COVER

The topography of the mine and surrounding area is illustrated in Figure 2.1**Error! Reference source not found.**. The proposed site is located at approximately 1005m AMSL, with a variation in elevation of approximately 5m. The site and its surroundings are characterised by flat sandy plains with slopes under 10%. As presented in Figure 2.1, survey elevation data was only available for the site. Consequently, the elevation about the site was sourced from the ASTER GDEM with a cell size of 30m (ASTER is a product of METI and NASA). The ASTER GDEM estimates seem to approximate those of the survey, although a -10m vertical variation was evident.

The site is characterised by natural land cover consisting of semi-arid scrub. The vegetation of the site is defined as Gordonia Duneveld, which is a component of Kalahari Duneveld Bioregion.

Both the topography and land cover of the sites are regarded as important considerations in the determination of runoff generated during flood events.

Key:
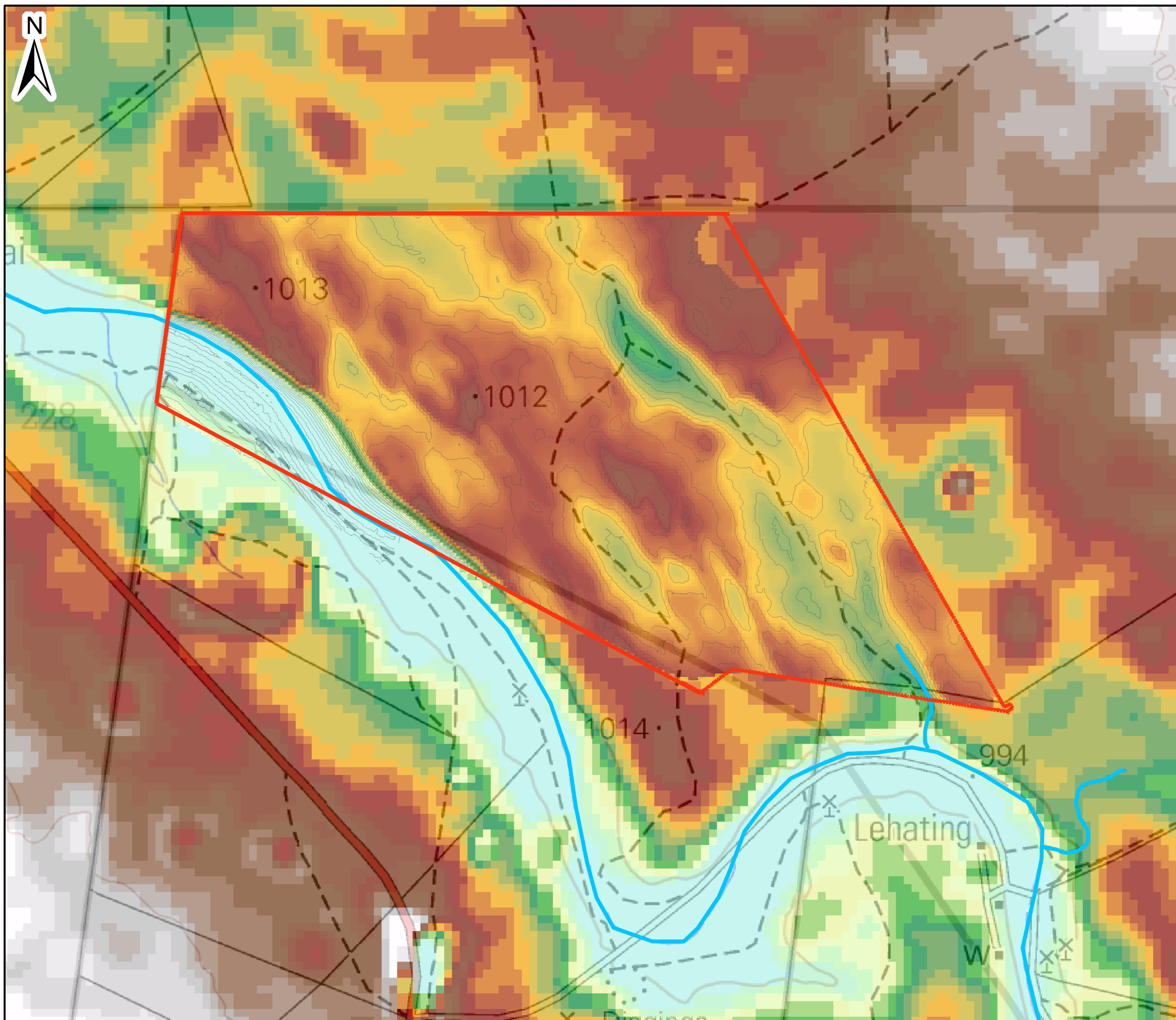
- Site Boundary
- 1m Contour
- Non-Perennial Rivers (50K Dataset)

Elevation (m AMSL)

High : 1020

Low : 995

This map makes use of ASTER GDEM Data.
ASTER is a product of METI and NASA.

0   200   400   600
Meters
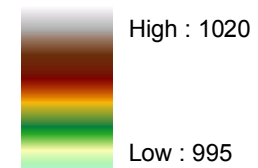
Scale: 1:12,700 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

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Figure 2.1

Site Topography and Hydrology

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2.5 GEOLOGY AND SOILS

The site is underlain by predominantly Kalahari geology which is a combination of Sand and Limestone lithology.

Soils in the region of the proposed project site are typically Kalahari sediments of gravels, clays, calcrete and aeolian sand. The project area is made up largely of deep Hutton and Clovelly soils (± 90%) with a small percentage of rock outcrops and shallow Mispah soils. The soils are well drained and have a low clay content.

2.6 RIVER SYSTEMS

The site is located in the Orange River Basin, in quaternary catchment D41M. With reference to Figure 2.2**Error! Reference source not found.**, the ephemeral Kuruman River runs to the south of the site from east to west. A large catchment of approximately 13,780km^2 feeds the Kuruman River, and consequently when the river is in flood, flows can become considerable. The Kuruman River is, however, considered ephemeral as the river only exists during periods of heavy precipitation.
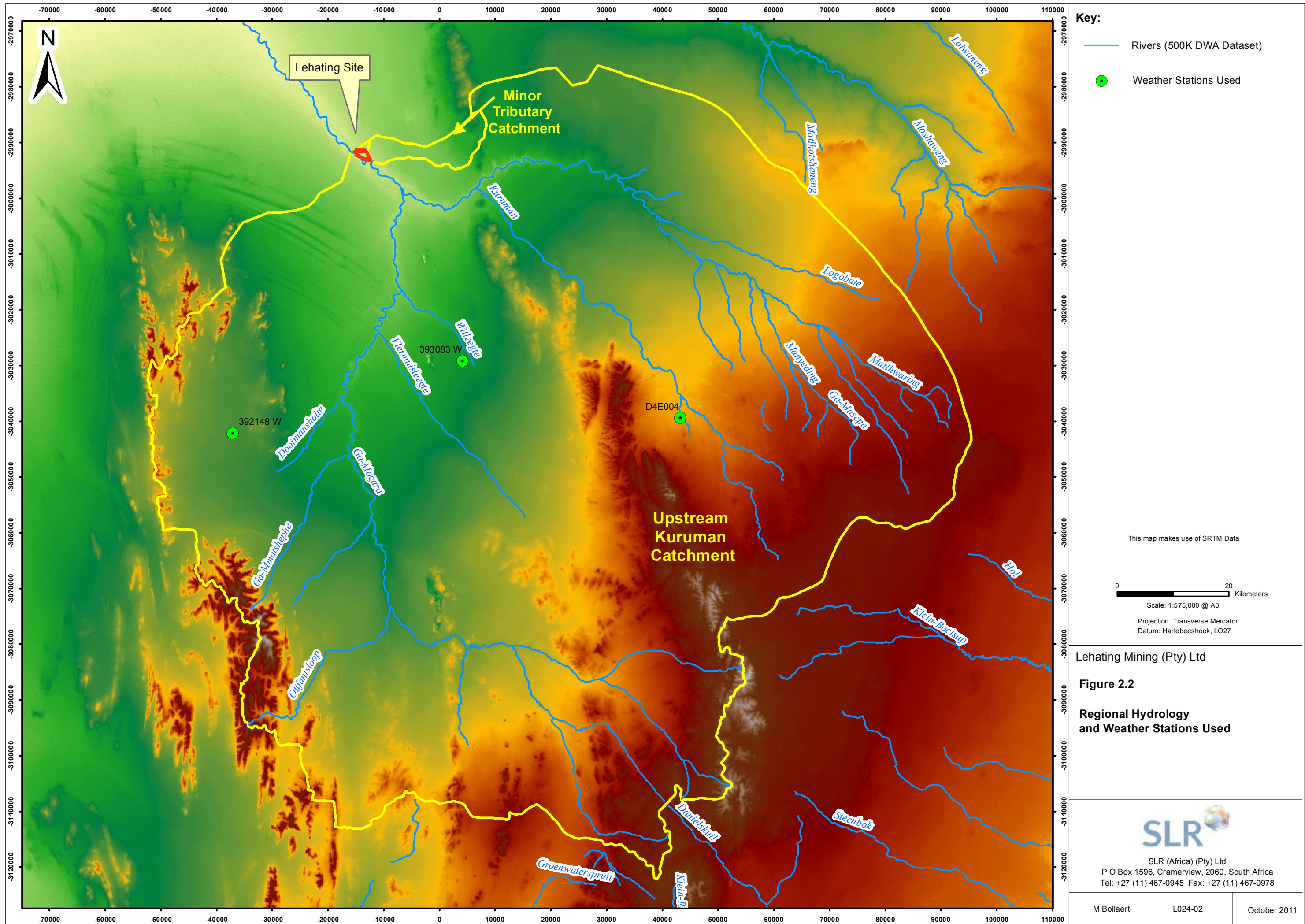
A minor tributary joins the Kuruman River to the south of the site. This river is only defined as having a length of 400m according to the 1:50,000 topographical map for the site. The ASTER data indicates that a catchment area of approximately 58km^2 drains to this tributary during heavy rainfall events. A secondary elevation SRTM dataset (Shuttle Radar Topography Mission) indicates that this catchment is only 20km^2. This disparity is due to the coarse topographic data from which the drainage pathways are being derived as well as the flat slopes of the area (which add error into the calculation of drainage pathways). The presence of a second minor tributary 500m upstream of site tributary is the alternate drainage pathway to which a part the 58km^2 of catchment may flow. To maintain a conservative approach, a 58km^2 catchment area is assumed. Section 5 provides further detail on the noted SRTM and ASTER difference.

2.7 HYDROLOGICAL REGIME

The catchment is large but sparsely vegetated and features freely draining soils which indicates that minor rainfall events would infiltrate to groundwater as opposed to generating significant volumes of runoff. This understanding is supported by the fact that numerous road crossings and houses are situated within or immediately adjacent to the channel which suggests that the watercourse does not flow on a regular basis. Anecdotal evidence suggests that no flow has been observed within the watercourse in this locality for some years.

The Kuruman River in this locality is meandering and features a low longitudinal gradient (approximately 1V:1050H) indicating that any flows are likely to be relatively deep but slow moving. The Kuruman River and the site tributary are ephemeral in nature only flowing during periods of heavy rainfall. In this regard, the site tributary will only require incident rainfall to fall over its catchment area, whereas the Kuruman River could come into flood due to rainfall occurring somewhere else in its catchment.

Key:

Rivers (500K DWA Dataset)

Weather Stations Used

Lehating Site

Minor Tributary Catchment

Kuruman

Lohwaneng

Matlhoishaneng

Moshaveng

Logobate

Manyeding

Matlhwaring

Witlegte

393083 W

Vlermuislegte

Ga-Masepa

D4E004

392148 W

Daaimansholte

Ga-Mogara

Upstream Kuruman Catchment

Ga-Mmadschephe

Hol

Klein-Boetsap

Olifantsloop

Steenbok

Danielskuil

Groenwaterspruit

Klein-R

This map makes use of SRTM Data

0   20   Kilometers
Scale: 1:575,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

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Figure 2.2

Regional Hydrology and Weather Stations Used

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3 PEAK FLOW ESTIMATION

3.1 METHODOLOGY

Flood peaks for the catchment draining up to the site were determined using the Standard Design Flood (SDF) and Regional Maximum Flood (RMF) method as implemented in the UPD software (SANRAL, 2006).   These methods were selected to be the most appropriate since the size of the main catchment precluded other methods (e.g. Rational and Unit Hydrograph).

The SDF method was developed by Alexander to provide a uniform approach to flood calculations. This method is based on a calibrated discharge coefficient for a return period of 2 to 100 years. Discharge parameters are based on historical data and were determined for 29 homogenous basins in South Africa. The RMF method is recognised as a reliable method of estimation for the purposes of design, due to its use of observed floods within homogenous flood regions as defined by Kovacs (SANRAL, 2006).

3.2 MODEL INPUTS

For the purposes of defining flood risk, only the single main reach of the Kuruman was modelled. A total catchment area of 13,789km^2 was delineated using a combination of the quaternary catchments dataset and ASTER GDEM.

The SDF method required the input of catchment characteristics as presented in Table 3.1, in addition to the specification of the site as lying within SDF Basin number 13.

The RMF method is even more simplistic in its data requirements, only requiring the input of a catchment area and the selection of a Kovacs Region. The Kovacs Region was set as K2, while area was set to that as indicated in Table 3.1.

For compative purposes, the site tributary was also included in the hydrological modelling.

TABLE 3.1: CATCHMENT CHARACTERISTICS

Description	Catchment	
	Kuruman	**Site Tributary**
Subcatchment Area (km^2)	13 789	58
River Length (km)	194	25
10-85 height difference (m)	331	70

3.3   PEAK FLOW ESTIMATES

The resulting peak flows are presented in Table 3.2. These results demonstrate that the majority of flow is attributed to the main river channel as would be expected. It is also noted that the SDF method presents a more conservative estimate and consequently the SDF peak flows were applied to the rest of the project.

TABLE 3.2: PEAK FLOW ESTIMATES USED IN THE HYDRAULIC MODELLING

Methodology	Return Period Flows (m^3/s)	
	1:50	**1:100**
Kuruman (SDF)	1 411	1 767
Kuruman (RMF)	1 152	1 457
Site Tributary (SDF)	36[*]	45[*]

* These estimates assume a catchment area of 58km^2 vs. the secondary estimate of 20km^2.

4 HYDRAULIC MODELLING – FLOODING

4.1 METHODOLOGY

The following section details the approach and the methods used in the development of a hydraulic model for the purposes of defining the 1 in 50 year and 1 in 100 year flood extents.

4.1.1 CHOICE OF SOFTWARE

HEC-RAS 4.0 was used for the purposes of modelling the flooding resulting from a 1 in 50 year and 1 in 100 year rainfall event. HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

4.1.2 TOPOGRAPHIC DATA

Modelling was informed by a total of 13 cross-sections surveyed on 3rd October 2011 at regular intervals through the main channel, with another cross-section through the minor tributary from the north. 0.5m contour data was used to supplement some of the the cross-sections.

Figure 4.1 presents the surveyed cross-section locations.

Some post processing of the cross-sections was required in order to establish a more appropriate section for inclusion into the HEC-RAS model.

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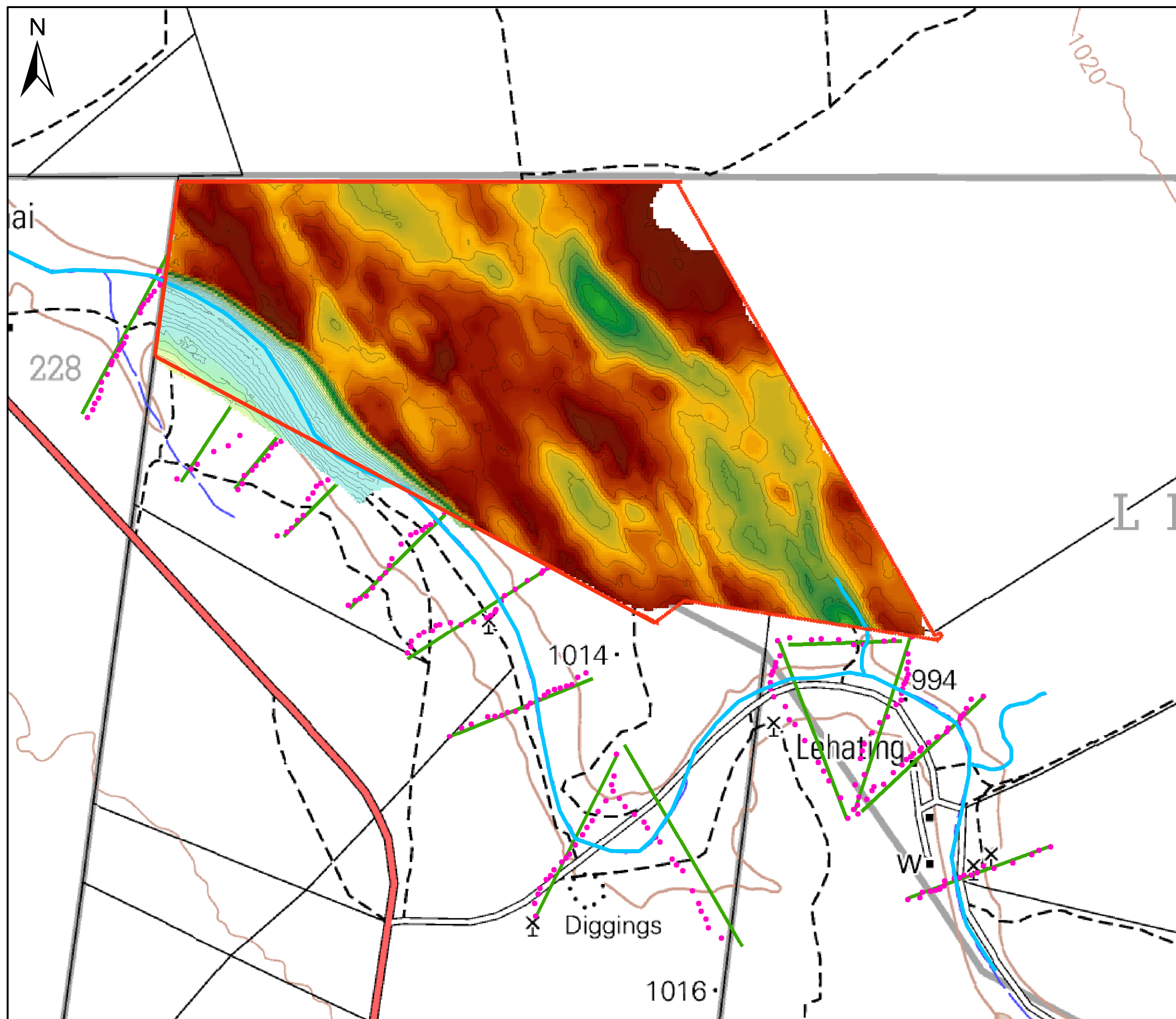
― Site Boundary

― Non-Perennial Rivers (50K Dataset)

― Requested Cross-Section

● Surveyed Points

― 1m Contours (Surveyed)

0 200 400 600 Meters

Scale: 1:13,900 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

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Figure 4.1

Surveyed Sections

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1014 ·

994

Lehating

W ·

1016 ·

Diggings

1020

4.2   DESCRIPTION OF HYDRAULIC MODEL

4.2.1   MODEL EXTENT AND SCHEMATISATION

A 4870m reach of the watercourse was modelled as shown in Figure 4.2 stretching from 900m upstream to 150m downstream of the study area.

4.2.2   FLOOD PROTECTION

No flood protection infrastructure (berms, channels etc.) were identified or modelled, unless this infrastructure was captured by the contour survey.

4.2.3   ROUGHNESS COEFFICIENTS

Based on observations of the channel and floodplain characteristics from aerial topography a Manning's 'n' value of 0.035 was assigned to the floodplain and a value of 0.03 was assigned for the main channel. Visual review of the cross-sections was used to delineate between the steep sided constrained 'channel' and the wider flatter floodplain - in some cross sections raised levees clearly marked the extent of the channel.

### 4.2.4   INFLOWS AND DOWNSTREAM BOUNDARY CONDITIONS

The calculated (SDF peak flows) were used in the hydraulic model as described in Section 3. A summary of the modelling assumptions and input data sources is presented in Table 4.1

TABLE 4.1: MODELLING ASSUMPTIONS

Assumptions	Value	Source
Upstream Boundary Condition	Normal Depth Slope = 0.00095	Topographical survey of channel
Downstream Boundary Condition	Normal Depth Slope = 0.00095	Topographical survey of channel
Flow	1:50 year = 1,411m^3/s 1:100 year = 1,767 m^3/s	SDF Method

4.3   MODEL DEVELOPMENT

The surveyed cross-sections were quality checked for ambiguities and supplementary points were taken from the 0.5m contour data. Following initial modelling runs which resulted in a number of warnings relating to the spacing of cross sections, further cross-sections were interpolated within HEC-RAS to ensure that the cross-sections were spaced no more than 100m apart. The addition of interpolated cross-sections facilitated removal of all results warnings except two due to split channel flow. Given the shape of the channel and adjacent floodplain, split channel flow would be expected through certain cross-sections and this warning is not of concern. No errors were reported within the modelling.
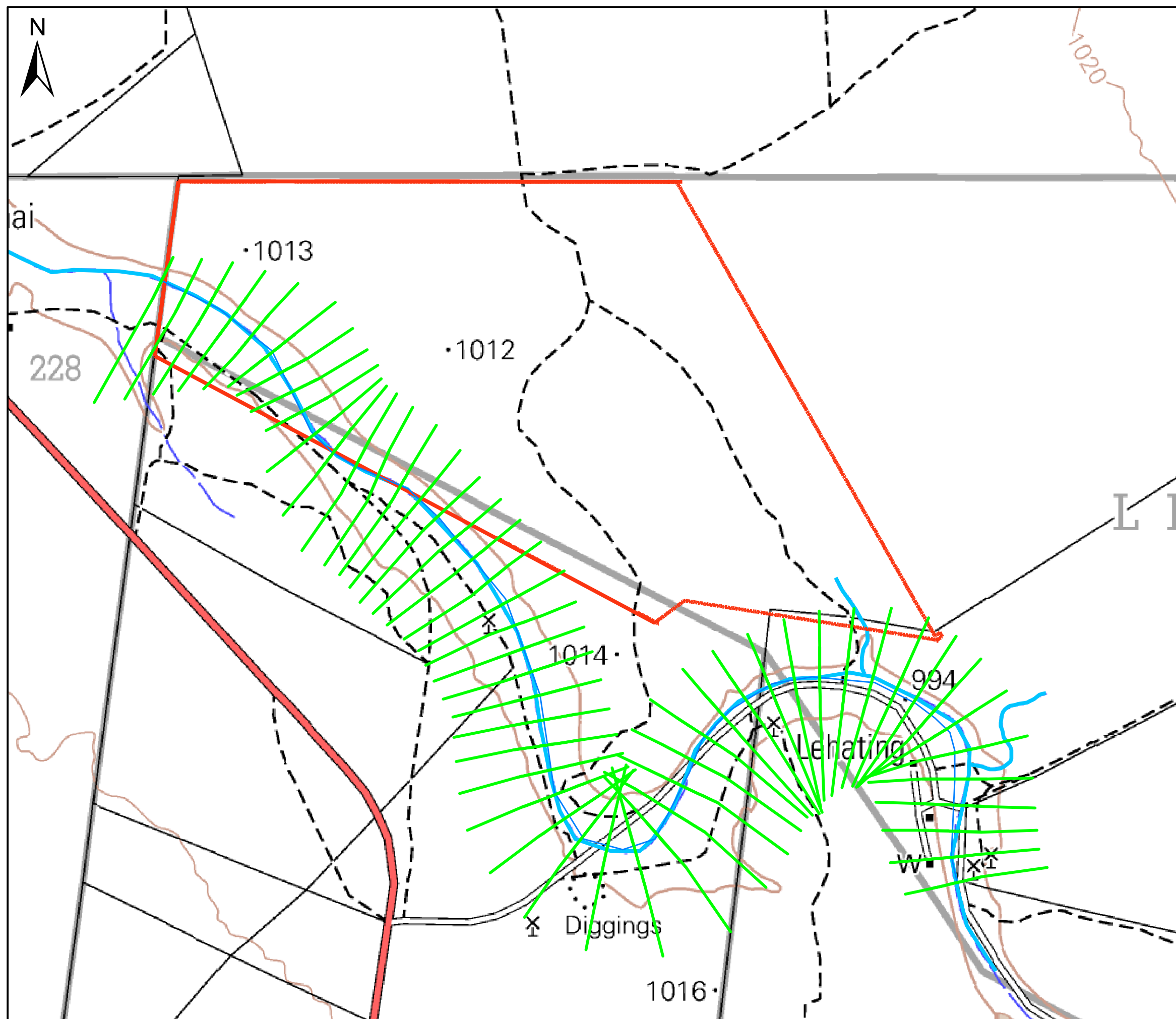
4.4 KEY ASSUMPTIONS IN THE HYDRAULIC MODEL

A number of assumptions have been made in undertaking the hydraulic modelling. These assumptions are in the context of the study and are considered appropriate in view of the level of detail required and the existing site conditions. The key assumptions include:

- That the topographic data provided was of a sufficient accuracy and coverage to enable hydraulic modelling at a suitable level of detail. The approach taken in surveying the river was to restrict survey to the limit at which a sufficiently robust hydraulic model could be derived. Conseqeuntly, the cross-sections were purposely spaced at a distance 300m to 600m. Due to the very flat nature of the watercourse, a large cross-section spacing is deemed appropirate. It is, however, the case that channel or floodplain anomalies present between cross-sections would not be represented in the hydraulic model.

- Hydraulic structures such as bridges and weirs were not modelled as part of this study. This limitation in the model is based on the assumption that only minor structures are likely to be present. The size of the peak flows occuring would easily inundate any minor hydraulic structure present, effectively 'drowing out' their effect.

- The Manning's 'n' values used is considered suitable for use in both the 50 year and 100 year return periods modelled, as well as in representing both the channel and floodplain, for the reasons described in Section 4.2.3.

- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate. This is a conservative approach as is ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur in reality. In addition to pure conveyance, in-channel and floodplain flood storage exhibit a large influence on flood levels and floodplain extents within the low gradient watercourses such as the study catchment. As such, the steady state modelling will result in worse case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease significantly if unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow.

- A subcritical flow regime was selected for running of the steady state model. This flow regime gave a more conservative estimate than when using a mixed flow regime (which is tailored to both subcritical and supercritical flows).

4.5   DISCUSSION OF RESULTS

Figure 4.3 present the results of the hydraulic modelling.   Figure 4.3 also indicates the location of modelled sections. Water surface elevation and velocity at these points is presented in Table 4.2.

TABLE 4.2: RESULTS OF THE HYDRAULIC MODELLING

Station	X-Coord DD	Y-Coord DD	Water Surface Elevation (m AMSL)		Velocity (m/s)	
			50T	100T	50T	100T
1	22.84747	-27.03753	994.22	994.73	2.51	2.73
2	22.85139	-27.03996	994.72	995.26	2.23	2.42
3	22.85258	-27.04185	994.93	995.48	2.13	2.3
4	22.85456	-27.04364	995.16	995.73	1.88	2.03
5	22.85746	-27.04539	995.32	995.88	2.71	2.89
6	22.85990	-27.04818	995.81	996.35	2.74	2.93
7	22.86116	-27.05117	996.33	996.91	2.19	2.33
8	22.86276	-27.05592	996.79	997.37	1.91	2.02
9	22.86560	-27.05574	997.04	997.63	1.34	1.42
10	22.86971	-27.05086	997.39	997.92	2.9	3.09
11	22.87438	-27.05095	998.17	998.72	2.54	2.71
12	22.87654	-27.05209	998.56	999.12	1.78	1.91
13	22.87658	-27.05732	998.87	999.41	3.11	3.32

It should be noted that, for the majority of the watercourse, flood modelling relies on interpolation between discrete surveyed cross-sections which are widely spaced. Given the input data, the flood levels will be more accurate than the horizontal flood-line extents. Therefore, it is recommended that prior to design of any surface infrastructure within the vicinity of the watercourse, further detailed topographical survey be undertaken and cross-referenced against the flood levels presented in Table 4.2 to improve the accuracy of the horizontal delineation of the flood-lines.

The modelling shows that both the 1 in 50 year and 1 in 100 year floodlines approximate the 100m horizontal distance from the watercourse. For the purpose of mine planning (in accordance with GN704), the greater of the two should be used. It should be noted that a 100m horizontal buffer from the river centreline presents a scenario whereby the required buffer will be underestimated according to the guiding principles of GN704. This is due to the 100m buffer from the centreline of wide rivers (greater than 200m) not exceeding the distance of the river banks. In the case of the ephemeral Kuruman River, no flows are normally evident. Consequently, there is no 'river' present by which to define the point at which a 100m horizontal distance should be taken (i.e. from the right or left bank). As such, the modelled

floodlines are particularly important to the planning process due to the uncertainty in using the 100m buffer from the 'river'.

Consideration was given whether to include the minor tributary in the model. Based on the output from the model it was concluded that flood levels in the main channel were similar to the bed level at the confluence of the tributary and given the steeply sloping nature of this tributary it was concluded that the main channel would not exhibit any backwater effects on the tributary. According to Figure 4.3, the inclusion of a 100m buffer of the tributary (in place of floodlines) is confirmed as conservative. This is due to the results of the modelling of the far larger Kuruman River evidencing a flood extent which approximates the 100m buffer. Consequently, in the case of the site stream, a 100m buffer will exceed the 1 in 50 and 1 in 100 year flood extents due to the smaller flows and steeper channel (both longitudinally and cross-sectionally).

It was noted, however, that the buffered centreline of the site tributary (as defined by the 1:50,000 topographical map, does not correspond with actual channel. As such, the buffered area was extended to include a 100m horizontal distance of the low area which coincides with the site survey.

The results of the modelling show that the Kuruman floodline (either the 1 in 50 or 1 in 100 year) does not exceed the eroded floodplain. The site is therefore not affected, except for the south western perimeter, where the site boundary extends into the floodplain. No works are expected within this area due to the steep topography and proximity to the watercourse.

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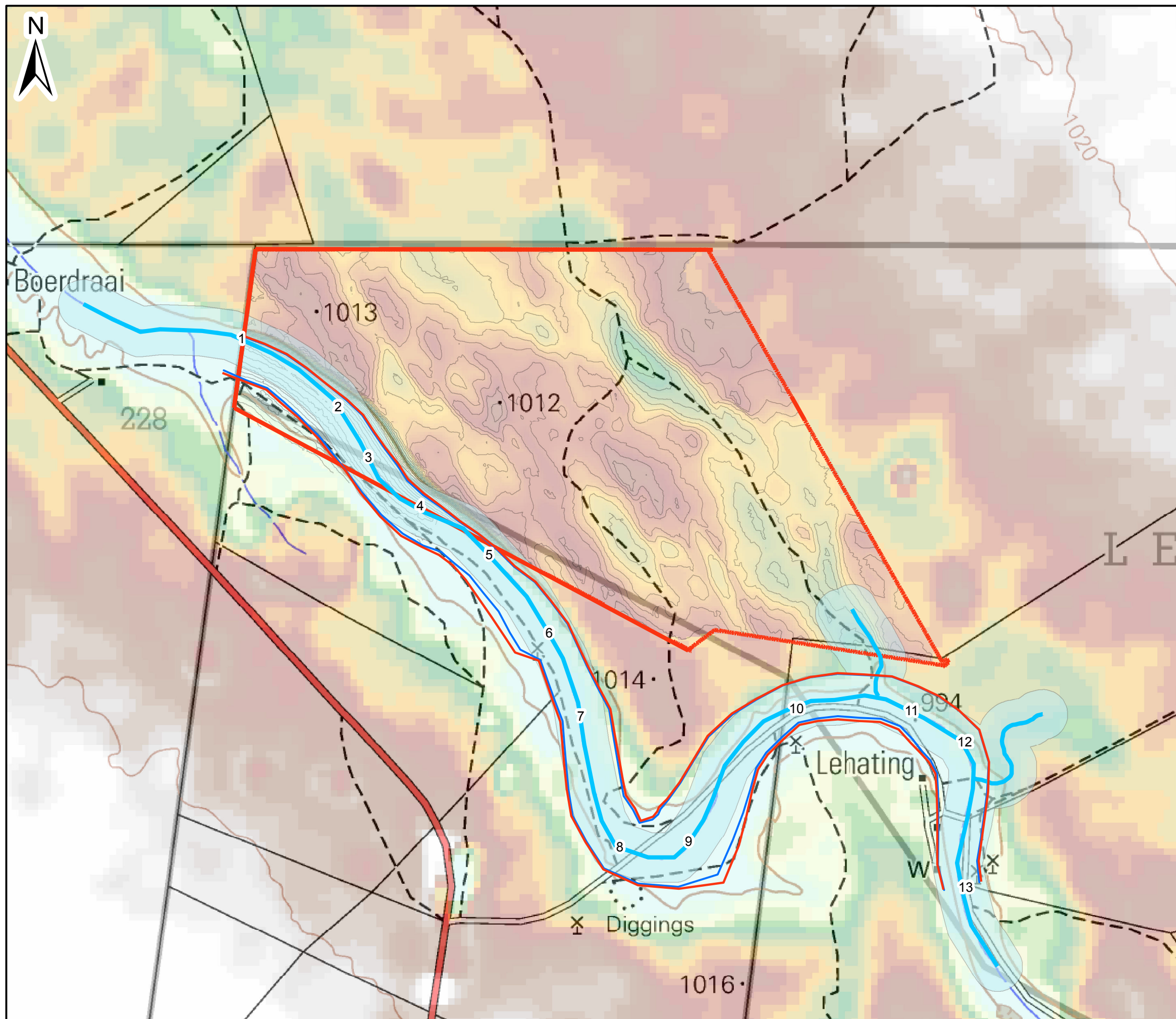
— Site Boundary

— Non-Perennial Rivers (50K Dataset)

— 50-Year Floodline

— 100-Year Floodline

▨ 100m River Buffer

This map makes use of ASTER GDEM Data.
ASTER is a product of METI and NASA.

0   200   400   600
⊢———————————⊣ Meters
Scale: 1:12,600 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

Lehating Mining (Pty) Ltd

Figure 4.3

**1in50 Year and 1in100 Year Floodlines
(including 100m River Buffer)**

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5   PREFERENTIAL FLOWPATHS

The site was assessed with regards to preferential flowpaths as illustrated in Figure 5.1. Site survey data shows a clear channel running along the eastern side of the site. This channel is a preferential flowpath since surface water will flow along the channel from upslope regions before flowing into the site tributary and on into the Kuruman River (during heavy rainfall events).
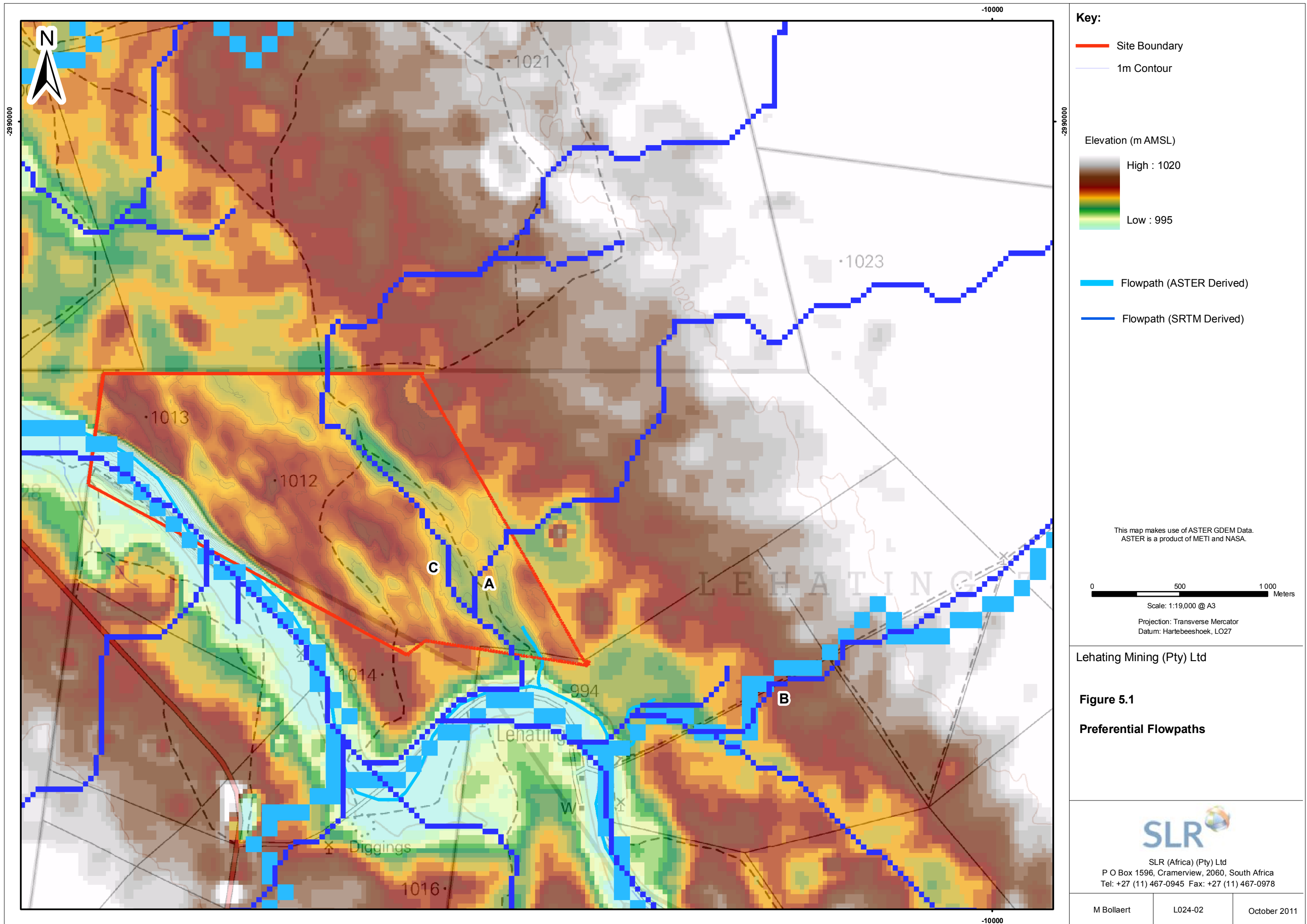
Figure 5.1 presents the results of two elevation datasets (ASTER and SRTM). These datasets were used to calculate the likely preferential flowpaths on and into the site. Since both of these datasets have coarse elevation data, there remains a level of uncertainty as to their accuracy. This is highlighted in the case of points A and B. According to the ASTER dataset, approximately 58km^2 of upstream catchment drains to point A, versus the SRTM which shows this upstream catchment primarily draining to point B.

Given this uncertainty, a conservative approach was previously implemented (see Section 2.6), with a peak flow of approximately 45m^3/s being calculated at point A for the 1 in 100 year design rainfall event (see Section 3.3). The remaining ASTER derived flowpaths on site have smaller catchment areas, with a total contributing area of approximately 12.5km^2 being noted upstream of point C.

A precautionary approach should therefore be adopted on site with regards to the preferential flowpaths, since while these flowpaths are not defined as watercourses, the potential for flooding as a result of concentrated overland flow is still present.

Depression storage may also occur in the aforementioned areas (where depressions exist) as indicated by the site survey data. Cognisance should therefore be taken of the potential for prolonged periods of flooding. This is particularly the case with the depression in the north east of the site, which is also coincident with a preferential flowpath contributing area of approximately 12.5km^2.

Additional depressions are evident on site, however, without significant contributing areas upslope, these depressions are not expected to have much in the way of surface run-on, runoff or storage.

Key:

— **Site Boundary**
— **1m Contour**

Elevation (m AMSL)

High : 1020

Low : 995

— **Flowpath (ASTER Derived)**
— **Flowpath (SRTM Derived)**

This map makes use of ASTER GDEM Data.
ASTER is a product of METI and NASA.

Scale: 1:19,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

Lehating Mining (Pty) Ltd

Figure 5.1

Preferential Flowpaths

SLR

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| M Bollaert | L024-02 | October 2011 |

6   CONCLUSION

The 1 in 50 year and 1 in 100 year flood events were modelled for the main Kuruman River south of the site. In addition to the modelled rivers, two additional minor tributaries were buffered to a horizontal distance of 100m.

The results of the modelling show that the Kuruman floodline (either the 1 in 50 or 1 in 100 year) does not exceed the eroded floodplain. The site is therefore not affected, except for the south western perimeter, where the site boundary extends into the floodplain. No works are expected within this area due to the steep topography and proximity to the watercourse.

The inclusion of a 100m buffer of the site tributary (in place of floodlines) is confirmed as conservative when assessing the results of the modelling, due to the far larger Kuruman River evidencing a flood extent which approximates the 100m buffer. Consequently, in the case of the site stream, a 100m buffer will exceed the 1 in 50 and 1 in 100 year flood extents due to the smaller flows and steeper channel (both longitudinally and cross-sectionally).

Preferential flowpaths on site were assessed, with site survey data showing a drainage channel to the east. This preferential flowpath was confirmed with the use of supplementary ASTER and SRTM datasets. These datasets showed a catchment area of between 20km^2 and 58km^2 draining to point A, while approximately 12.5km^2 of upstream catchment area was noted as draining to point C. A precautionary approach should therefore be adopted on site with regards to the preferential flowpaths, since while these flowpaths are not defined as watercourses, the potential for surface water flooding as a result of concentrated overland flow is still present.   Depressions associated with the preferential flowpaths should also be taken into account since prolonged flooding could occur in the event these became filled by surface water run-on.

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