REPORT

LEIGH CREEK MINE: SEEPAGE ASSESSMENT SURVEY

Prepared for Flinders Power

13/01/2017

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Flinders Power

Leigh Creek Mine: Seepage Assessment Survey

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1 Introduction

The Leigh Creek Lobe B mine site is located in a low rainfall, high evaporation environment. During the life of the operations it is known that surface runoff occurs from the waste dumps during high intensity rainfall events and potentially bypass flow. However it is unknown if there is any seepage that may emanate from the toe of the dumps. Seepage through the waste dump would move laterally at hydraulic discontinuities whereby there is a significant reduction in hydraulic conductivity. This is expected to occur at the base of the waste dump and would report at the toe through surface or subsurface flow. If no significant hydraulic discontinuities exist seepage would move downwards and report to groundwater. For this study seepage is defined as water that percolates into the waste dump, then migrates through the dump and reports at the toe of the dump.

1.1 Scope

1. To identify, record and sample the presence of seepage at the toe of the waste dumps at Leigh Creek Lobe B operations,
2. To identify and record observations of runoff, preferential water flow and infiltration conditions, and
3. To determine the pathway of seepage, if any, through the waste dumps at Leigh Creek Lobe B operations.

2 Method

2.1 Seepage Survey

In order to assess whether any seepage at the toe of the waste dumps has occurred, the following seepage assessment was undertaken:

- The toe of the waste dumps was inspected by foot to identify any seepage or signs of possible seepage. The inspection of waste dumps occurred at the intersection of the waste dumps with the natural topography and creek lines.
- The seepage assessment was undertaken no earlier than two weeks following significant rainfall, or when pooling of water in local creek beds and depressions had diminished. This criteria was used to avoid confusion with surface water flow. The intent here is to detect the presence of water migrating laterally through the waste dumps, hence if this is occurring, there will continue to be evidence of this well after major rainfall events.
- The key objective was to identify any areas of water pooling or seeping from a dump. Tell-tale signs of an “occasional” seepage (i.e. ephemeral) are:
    - Build-up of salts
    - Localised patches of dead vegetation (where seepage water is poor quality); and
    - Localised patches of vigorous vegetation (where seepage quality is good).
- Where water is present and all evidence is that it is due to seepage, a water sample was taken and chemically analysed. The suite of analytes to be tested will be the same as for the standard surface water analysis suite (see Appendix A). Interpretation of analytes will be based on comparison to waste dump chemical characteristics and evidence of acid and metalliferous drainage.
- Where water is not present and all evidence is that seepage has occurred, soil samples of the impacted area was taken at the soil surface (0-10cm) and just above the subsoil hydraulic interface (or 40-50cm, whichever is shallower). This was repeated along a transect perpendicular to the dump at 10, 25, and 50 metres, where possible, to provide adequate background sampling and indication of extent. A 1:3 soil:water extract was taken from all soil samples collected and chemically analysed. Interpretation of analytes will be based on comparison to waste dump

chemical characteristics and evidence of acid and metalliferous drainage and between sites where no seepage is evident.

- Inspection of the crest of the waste dump will also be undertaken to identify areas of ponding and to characterise likely infiltration properties. Observations of runoff and preferential flow will also be recorded during the survey.

2.2 Trigger Event

The larger than average winter rainfall at the mine site provided ideal conditions that would promote the occurrence of seepage. The 2016 winter rainfall was significantly higher than average with 145 mm falling in August and September and 260 mm from May to October 2016. These rainfalls are significantly higher to the average of 35.8 mm in August and September and 105 mm from May to October[1]. The last rainfall greater than 5mm preceding the survey occurred on 29th September 2016 of 7.2 mm.

The seepage survey was undertaken between 21st and 24th of November, 2016. Only 1.8 mm of rainfall had fallen since 29th September 2016. During the seepage survey overnight rain occurred on the 21st and 22nd of November 2016. It is estimated that up to 5mm of rainfall fell on both occasions around the mine site whereas Leigh creek airport recorded 0.2 and 3.0mm, respectively.

3 Seepage Survey Outcomes

No free water due to seepage was observed at the toe of the waste dumps for all inspection areas around the Lobe B waste dumps. Only one area around the dump was suspected to be seepage with some surface wetness and salt crusting which was sampled and compared to areas with no seepage at both the toe and approximately 100 metres away from the toe in the same landscape system. Comparison of soil chemical properties between locations and depth showed no substantial difference suggesting that this was not due to seepage at the toe. However, the higher saline conditions in the surface soil determined in all sampled locations suggests that the surface moisture evident is due to capillary rise of saline waters from a perched groundwater system on the Telford gavels. The patchy nature of these moist areas suggests variable soil profile characteristics with natural lenses promoting greater capillary rise of the perched groundwater. What is unclear is whether the degree of soil saline conditions are a natural feature of the surrounding landscape or whether the surface saline condition are generated by the existence of a more saline perched water table than what would exist in the surrounding landscape. A broader survey of soil profile saline conditions surrounding Lobe B would provide greater background evidence along with the review of data collected through the groundwater monitoring plan to identify variable hydraulic and water quality conditions. The following outlines the observations of water movement for different sections of the Lobe B waste dumps.

An overview of the path trekked and each observation point is presented in Appendix A. Descriptions and outcomes from each observation point are listed in Appendix B.

3.1 Western bund (Observations sites 1-14)

No seepage at the toe of the western bund was identified along its entire length with observation points shown in Figure 1. Surface crusting was evident on top of the western bund that promoted surface runoff and reduced the amount of infiltration (Figure 2). There was evidence of significant surface erosion and tunnelling. Surface erosion varied in intensity as shown in Figure 3. Most of the significant erosion reported easterly to the interior of Lobe B mine site area. Similarly, all tunnelling reported to the interior of Lobe B mine site area such as that found at site 5.

Well vegetated areas found along the toe of the western bund were due to ephemeral creek flows from the western ridge that abut the western bund. Some runoff contribution would occur from the western

[1] Bureau of Meteorology weather station 17110 (Leigh Creek Airport)

bund to the vegetation water regime, although this would be minor. The occurrence of stagnant water with depressions would mostly be derived from the western ridge ephemeral creek flows.

From these observations it is concluded that no seepage from the toe of the western dump occurs and that any flow from the western bund tends to report to the interior of Lobe B mine site area.

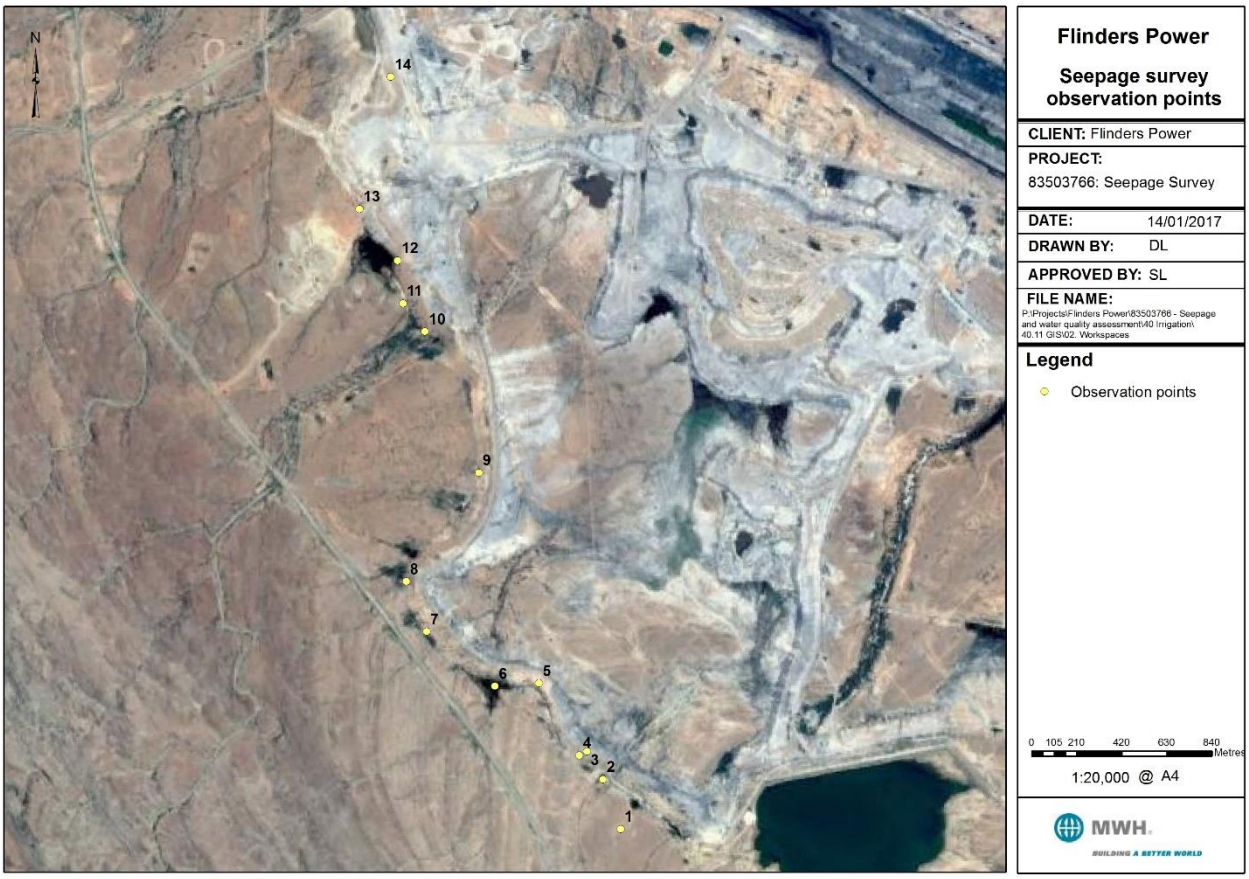


Figure 1: Seepage assessment locations along the Western bund

Figure 2: Thick crust formed on the top of the western bund limiting infiltration and promoting runoff at Site 3 (left) and Site 13(right)

Figure 3: Surface soil crusting promoting runoff resulting in erosion of the western bund at Site 3 (left) and Site 13(right)

3.2 North-Western dumps (Observations sites 15-51)

Observation sites along the north-western waste dumps are shown in Figure 4. The waste dump between sites 15-20 have recently been reshaped but the existing berm at the toe and vegetation remained untouched. No seepage was identified at the toe between these sites and the vegetation remained similar to the surrounding landscape vegetation. Only a small amount of surface erosion was evident most likely due to the recent reshaping.

The waste dump between sites 21-24 have been eroded along the ephemeral creek line that abuts the waste dumps. No seepage along these eroded surfaces was evident and the vegetation remained similar to slightly more vigorous to the surrounding landscape vegetation. There was also significant gully and rill erosion that reported to the ephemeral creek line suggesting low water infiltration due to crusting, although not observed.

The waste dump between sites 25-31 showed no seepage evidence at the toe. However, some of the vegetation located at the base of the waste dump has been impacted by the significant gully and rill erosion that has occurred during large rainfall events. The vegetation and landscape has been partially covered with carbonaceous material and in some instance the vegetation has diminished in density. The shallow surface wetness found at these locations was due to runoff and overnight rainfall.

There was significant soil moisture found at site 32 which was a localised depression that received runoff from the waste dump between sites 31-35. The evident moisture at the toe of the waste dump suggests seepage but the localised nature of the occurrence along with topography suggests the moisture is due to the natural depression and cumulative runoff which has adsorbed into the base of the west dump. Hence, it is concluded that no seepage has occurred at this location.

The waste dump between sites 36-40 showed no seepage evidence at the toe. However, some of the vegetation located within the berm at the base of the waste dump has been impacted by the significant rill erosion that has occurred during rainfall events. This area is small and contained.

The runoff from the waste dump between sites 41-48 reports directly into a well vegetated ephemeral creek that runs east-west along the toe of the waste dump. The waste dump is partially vegetated with evidence of significant rill and gully erosion. At site 42 there was evidence of moist soil and surface salt suggesting the possible presence of seepage. However, no seepage water flow lines were observed in the location. Surface and subsoil samples were collected at site 42 and further along the creek line where seepage was not evident (site 171) and approximately 100 metres away from the creek line but within the same landscape system (site 175) (Figure 5). The soil chemistry results are presented in Appendix C. Comparison of soil chemical properties between locations 42, 171 and 175 and depth shows copper is

slightly elevated at site 42 and the percentage of sodium as a function of major cations is slightly reduced. Given that there is no substantial difference in soil chemical properties this suggests that site 42 is not seeping at the toe. However, the consistent higher saline conditions (Table 1) in the surface soil determined in all sampled locations suggests that the surface moisture evident is due to capillary rise of saline waters from a perched groundwater system on the Telford gavels. It was also noticed that surface soil moisture occurred in patches throughout the landscape north of the creek line. The patchy nature of these moist areas (Figure 6) suggests variable soil profile characteristics with natural lenses promoting greater capillary rise of the perched groundwater. What is unclear is whether these soil saline conditions are natural and whether the saline condition of the perched water table has contributions from seepage through the waste dumps. It is understood that the waste dump material is highly saline[2] and could be contributing to the potential saline conditions of the perched groundwater system. Nevertheless, the surface saline conditions do not seem to be impacting on the health of the vegetation with dense healthy vegetation present to the northern aspect of this waste dump location (Figure 6).

There are two lagoons at the foot of the waste dump between sites 49-51. No seepage was evident although there was evidence of rill and minor gully erosion that reported to these lagoons. The direction and size of the erosion paths along the waste dumps suggests the majority of the rainfall that falls in the top of the waste dumps sheds to the north into the creek line with a minor amount reporting to these lagoons. There was evidence of seepage through the embankment between the lagoons at site 50 with flow line evident (Figure 7).

From these observations it is concluded that no seepage from the toe of the north-western dumps occurs.

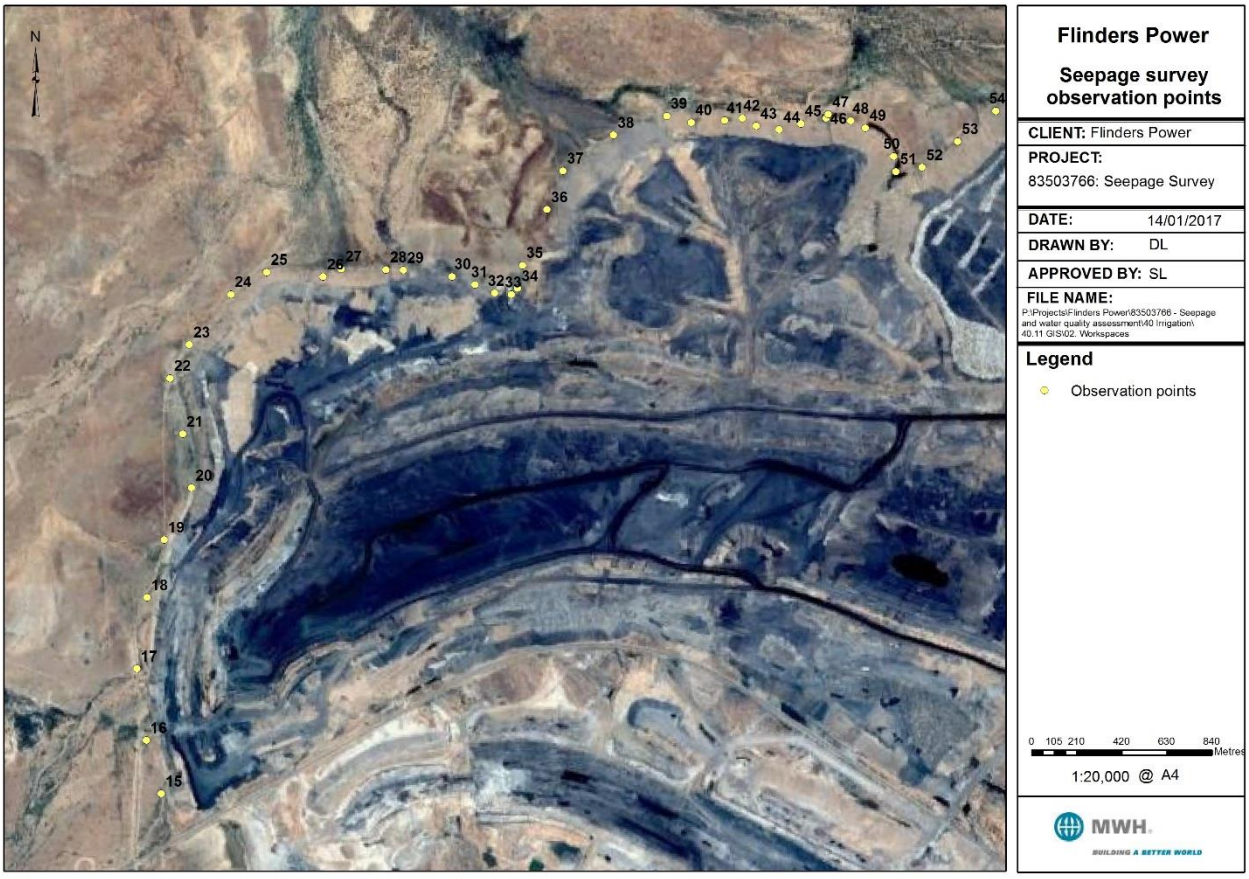


Figure 4: Seepage assessment locations along the North-Western dumps

[2] MWH (2016) Technical Memo: Leigh creek - Preliminary Mine Waste Characterisation Summary, Prepared for Flinders Power

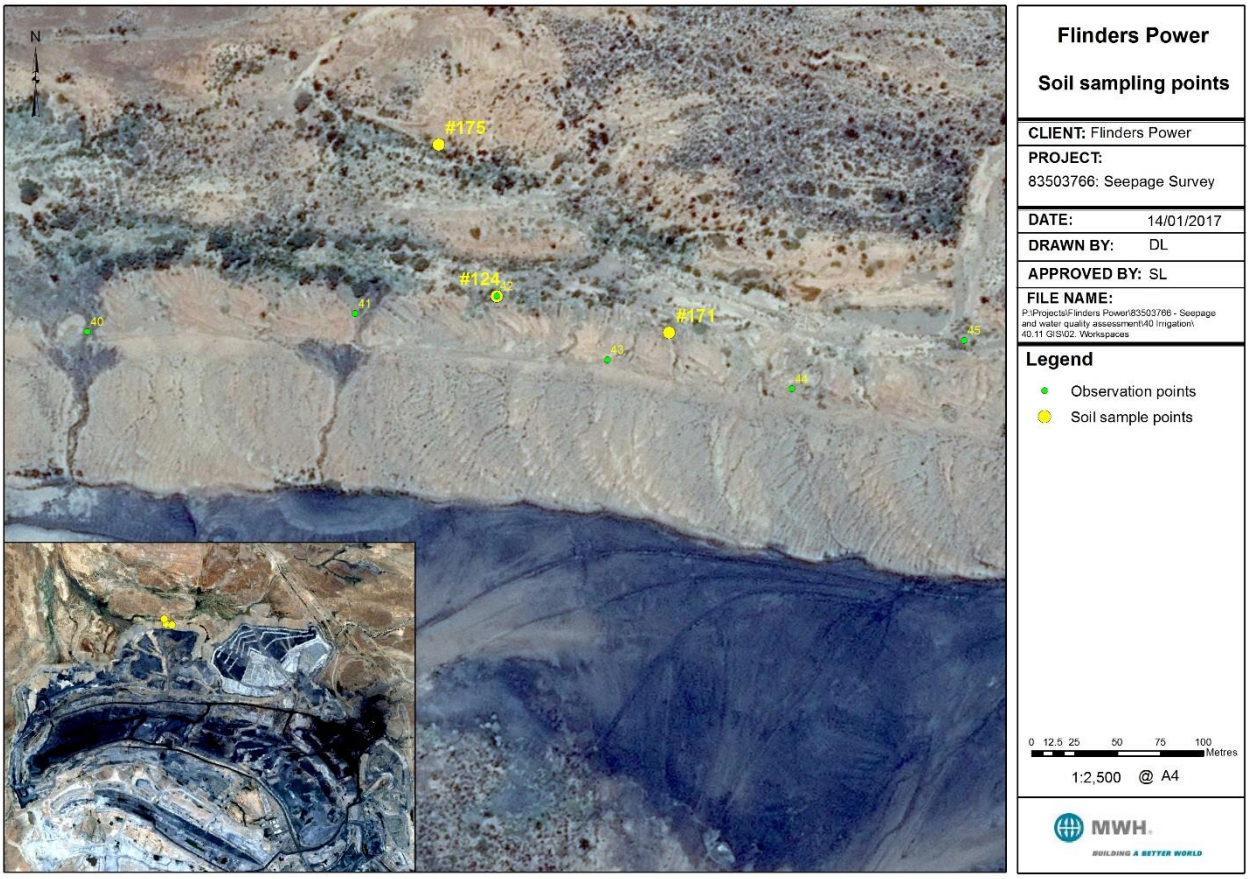


Figure 5: Locations of soil sampling points (refer Appendix C for laboratory results)

Table 1: Soil salinity (ECse), dS/m

Site	124	171	175
Surface soil (0-10cm)	31.6	31.7	56.1
Subsoil (20-30cm)	12.0	13.5	17.7

Figure 6: Capillary rise of soil moisture evident at the soil surface (left) amongst an oasis of healthy vegetation (right)

Figure 7: Evidence of seepage between water storage areas at the toe of the dam wall (Site 50)

3.3 North-Eastern dumps (Observations sites 52-84)

Observations sites along the north-eastern waste dumps are shown in Figure 8. The waste dump between sites 52-56 have a partial berm at the toe of the waste dump with no evidence of seepage at the toe. Vegetation remained similar to the surrounding landscape vegetation with good extensive ground cover. Gully and rill erosion was evident which was contained within the berm at the toe of the waste dump. It is postulated that between sites 54 and 55 is the location of the original pathway for Tobacco Bush Creek that reports to a general floodplain area of strong upper and lower story vegetation. Localised moist soil surface conditions are evident (e.g. site 56) which is presumed to be from capillary rise from a perched water table on the Telford gravels similar to previously described.

The current Tobacco Bush creek joins the old Tobacco bush creek between sites 56 and 57 where it runs close to the toe of the waste dump. There is a localised depression that shows moist soil profiles and salt accumulation around the base of the depression (Figure 9). This type of salt accumulation along the creek lines in localised depressions has been observed upstream from this point along the new Tobacco Bush creek pathway. It is suggested this is natural salt expression from the soil profile rather than seepage from the waste dump.

The waste dump between sites 58-63 showed no evidence of seepage at the toe. The vegetation remained similar to the surrounding landscape vegetation. There was also gully and rill erosion with one large gully erosion near site 61. More pronounced gully and rill erosion was observed between sites 65 and 71 with no seepage evident. Inspection of the mid and upper terraces showed a thick partially cemented crust suggesting that once formed that the crust would persist (Figure 10). These crusts would reduce infiltration and promote runoff causing the large gully erosion whilst runoff from the upper terrace appears to be directed to the lower terrace (Figure 11). The eroded material in this instance reported to Tobacco Bush creek between sites 66-71. The slope of the waste dump had also formed a crust. No seepage was observed to occur within the Tobacco Bush creek line adjacent to the waste dump.

The waste dump between sites 72-84 showed no evidence of seepage at the toe but had considerable gully and rill erosion. Berms were constructed at the base of the waste dump to contain the runoff and

carbonaceous material from sites 72-78 while other sites were uncontained. Inspection of the terrace layer showed crusting of the soil surface and runoff directed to a spillway at site 77 (Figure 12). Some of the vegetation located within the berm has been impacted by the carbonaceous material covering the vegetation and landscape.

From these observations it is concluded that no seepage from the toe of the north-eastern dumps occurs.

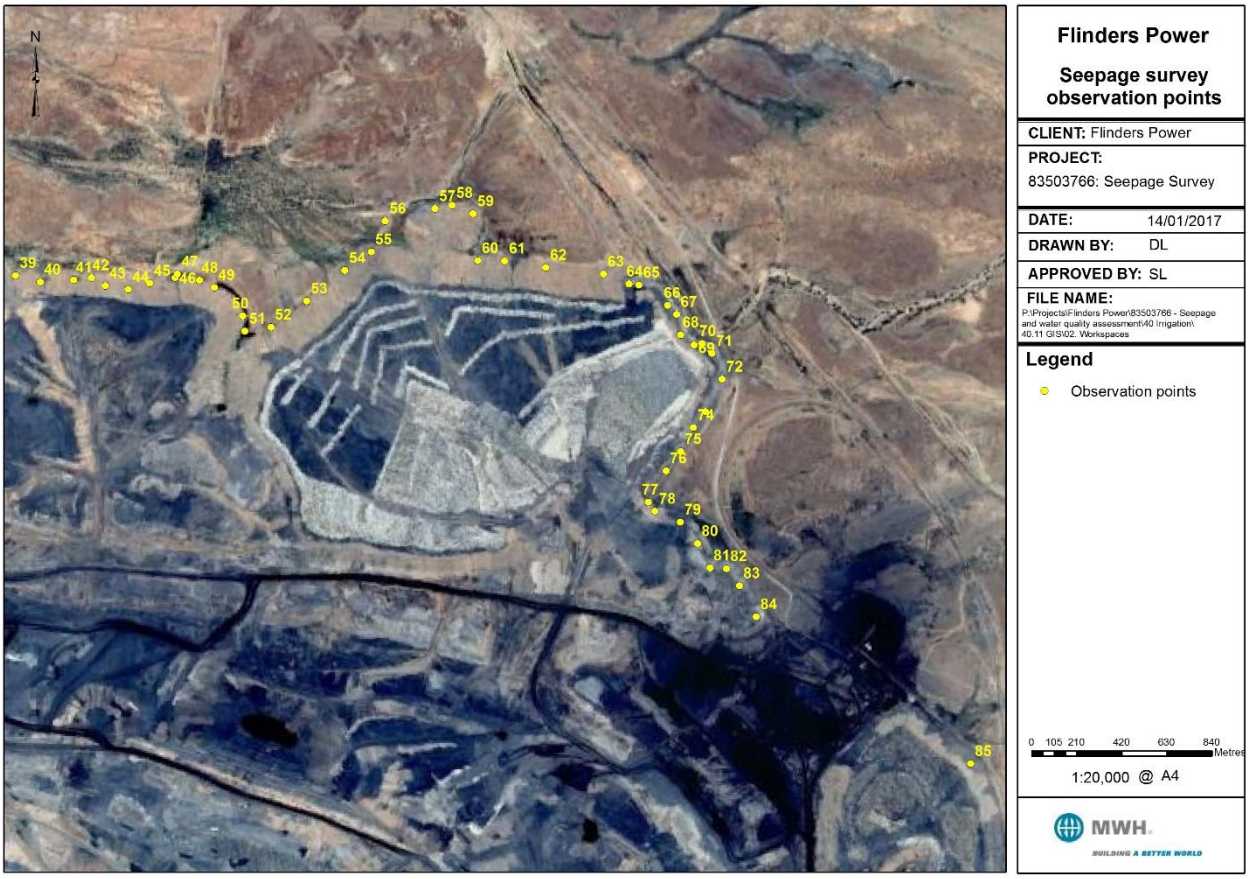


Figure 8: Seepage assessment locations along the North-Eastern dumps

Figure 9: Surface salt evident in a hollow at the edge of the creek line west of site 57

Figure 10: Top of waste dump terrace (left) where runoff reports between sites 65-66 to Tobacco Bush creek. Thick surface crusting of the waste dump promoting runoff (right)

Figure 11: Top of waste dump where runoff is directed to the lower terrace (left) that then reports between sites 65-66 to Tobacco Bush creek. Thick surface crusting of the waste dump promoting runoff (right)

Figure 12: Top of waste dump where runoff is directed to the lower terrace (left) that then reports to site 77. Thick surface crusting of the waste dump promoting runoff (right)

3.4 Eastern dumps (Observations sites 85-96)

No seepage at the toe of the eastern dumps was identified along its entire length with observation points shown in Figure 13. The railway line and roadway essentially act as a berm and direct runoff to a localised depression near sites 87, 89 and 92. The south section of the eastern waste dumps showed large gully erosion. An example of the large gully erosion is shown at site 94 caused by excessive surface runoff during rain storm events (Figure 14). An ephemeral creek reporting to the eastern edge of the railway line where runoff and carbonaceous material from the eastern dumps also accumulates via a culvert under the railway near site 92 (Figure 14). The direction of creek flow and accumulation of water along the south eastern edge of the waste dumps suggests that water flow tends to report to the interior of Lobe B mine site area.

From these observations it is concluded that no seepage from the toe of the eastern waste dumps occurs and that any flow from the eastern waste dumps tends to report to the interior of Lobe B mine site area.

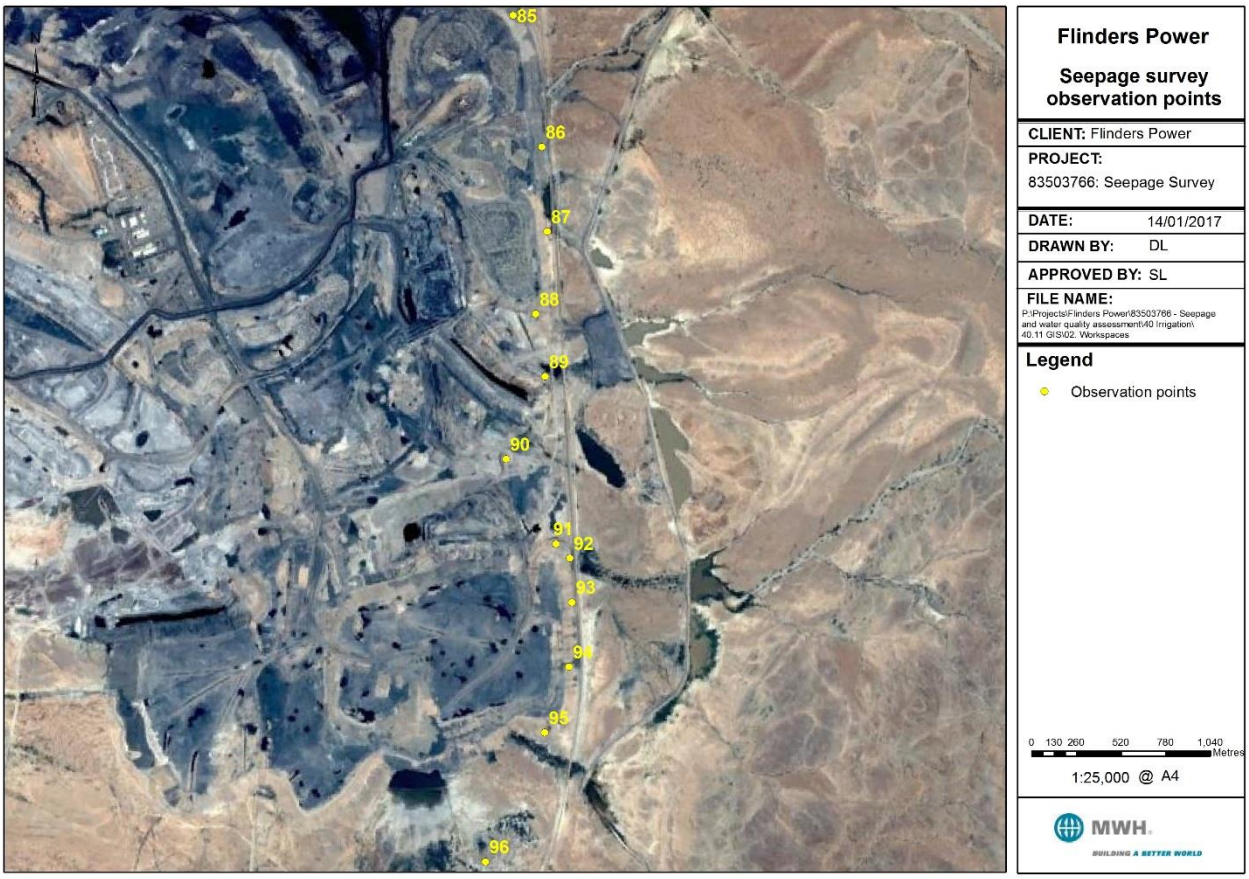


Figure 13: Seepage assessment locations along the Eastern dump

Figure 14: Large erosion gully through waste dump at site 94 (left). An ephemeral creek reporting to the eastern edge of the railway line and culvert (right)

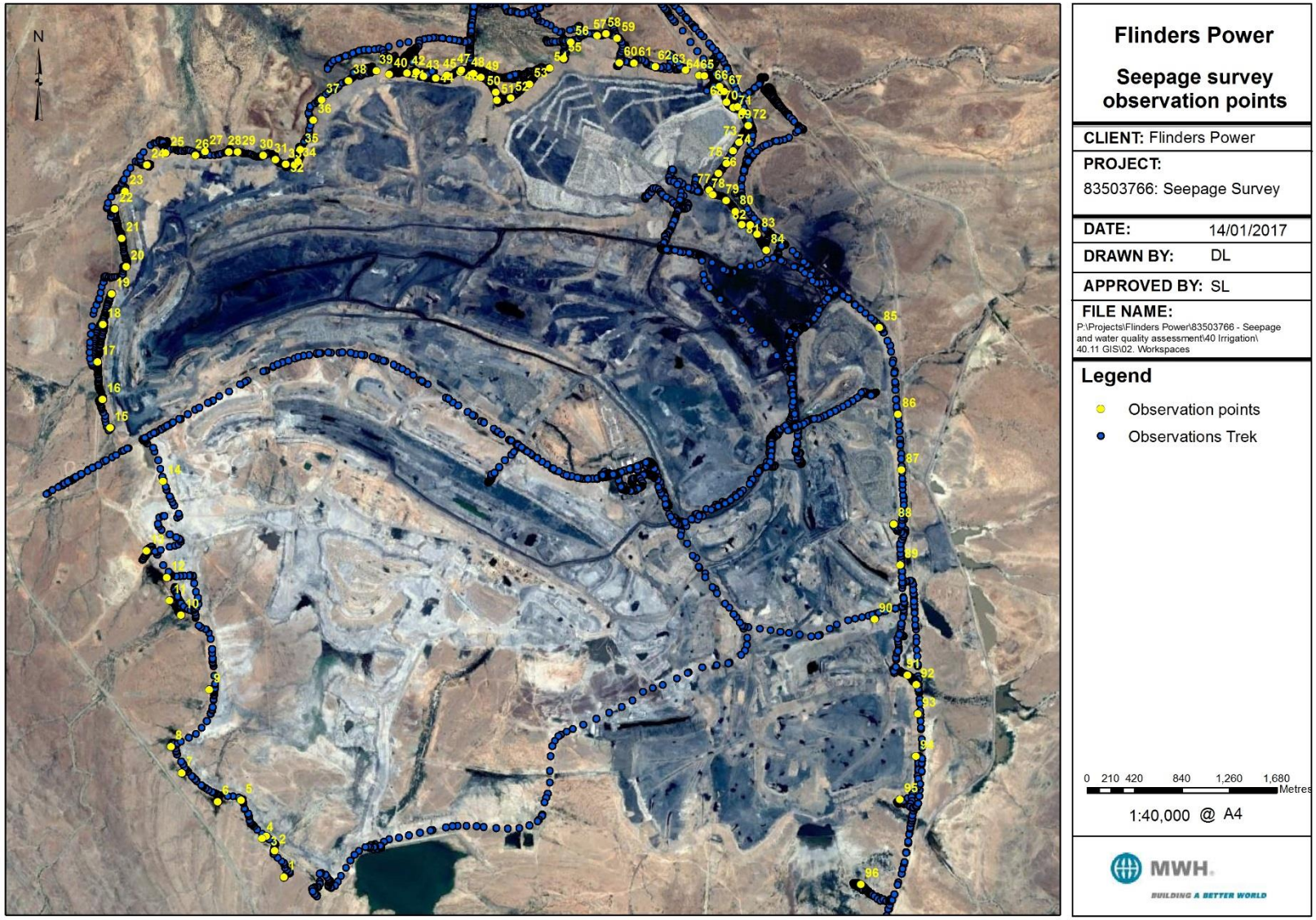
4 Conclusions

As a result of conducting the seepage survey the following conclusions can be made.

- There is no seepage at the toe of the waste dumps either at the surface or through the shallow subsoil as a result of potential water transmission through the waste dump profile.
- Water accumulation at the toe of the western bund and eastern waste dump reports inward to the mine site.
- There is strong evidence that the major flow pathway of rainfall is through surface runoff from the waste dumps.
- The occurrence of surface soil moisture and high saline conditions may be derived from capillary rise from a perched water table on the Telford gravels.
- It is unclear whether seepage through the waste dumps, if any, reports to the perched water table on the Telford gravels.
- A broader landscape survey surrounding Lobe B is required to provide adequate background information about soil saline conditions.
- Review the data collected as part of the groundwater monitoring plan to identify any changes in perched groundwater hydrology and water quality on the Telford gravels north of Lobe B.

Appendices

Appendix A Map of Observation Points



Appendix B Site observations and descriptions

Site: 01 **General Observations:** Natural occurring vegetation at the toe of the bund with runoff from western ranges inducing changes in vegetation growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 02 **General Observations:** Water entry point to interior of Lobe B mine site area. Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 03 **General Observations:** Surface crusting and runoff to interior of Lobe B mine site area. Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred. **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 04 **General Observations:** Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions. Evidence of runoff from western ridges causing increased vegetation growth **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 05 **General Observations:** Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 06 **General Observations:** Creek line from western ridge reports to toe of bund causing increased vegetation growth at the toe of the bund **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	

Site: 07 **General Observations:** Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions. Evidence of runoff from western ridges causing increased vegetation growth **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 08 **General Observations:** Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions. Evidence of runoff from western ridges causing increased vegetation growth **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 09 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 10 **General Observations:** Creek line from western ridge reports to toe of bund causing increased vegetation growth at the toe of the bund **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 11 **General Observations:** Creek line from western ridge reports to toe of bund causing increased vegetation growth at the toe of the bund to depression area **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 12 **General Observations:** Natural depression area with accumulated runoff from bund and western ridge **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	

Site: 13 **General Observations:** Natural occurring vegetation at the toe of the bund with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 14 **General Observations:** Natural occurring vegetation at the toe of the bund with some changes in growth conditions in depression area **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 15 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	

Site: 16 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 17 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 18 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	

Site: 19 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 20 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 21 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	

Site: 22 **General Observations:** Natural occurring vegetation at the toe of the waste dump along creek line with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 23 **General Observations:** Natural occurring vegetation at the toe of the waste dump along creek line with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 24 **General Observations:** Natural occurring vegetation at the toe of the waste dump along creek line with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	

Site: 25 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 26 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 27 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some loss of vegetation due to carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 28 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some loss of vegetation due to carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 29 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some loss of vegetation due to carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 30 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some loss of vegetation due to carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	

Site: 31 **General Observations:** Natural occurring vegetation at the toe of the waste dump with an increase in vegetation in local depression and runoff from iron knoll to the south of waste dump **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 32 **General Observations:** Scant vegetation at the toe of the waste dump with moisture in local depression from runoff from iron knoll to the south and the surrounding waste dump **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 33 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 34 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 35 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 36 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	

Site: 37 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north east	
Site: 38 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north east	
Site: 39 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 40 **General Observations:** Natural occurring vegetation at the toe of the waste dump with increased vegetation along creek line **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north east	
Site: 41 **General Observations:** Vigorous vegetation at the toe of the waste dump along creek line with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 42 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species with a surface salt scold **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** Salt scald and moist conditions suggest potential seepage point **Picture:** Looking south	

Site: 43 **General Observations:** Vigorous vegetation at the toe of the waste dump along creek line with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 44 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 45 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 46 **General Observations:** Vigorous vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 47 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 48 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	

Site: 49 **General Observations:** Closed lagoon at the toe of waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 50 **General Observations:** Closed lagoon at the toe of waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected from waste dump but seepage between lagoons **Picture:** Looking south west	
Site: 51 **General Observations:** Closed lagoon at the toe of waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south west	

Site: 52 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 53 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 54 **General Observations:** Natural occurring vigorous vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	

Site: 55 **General Observations:** Natural occurring vigorous vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 56 **General Observations:** Natural occurring vigorous vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 57 **General Observations:** Natural occurring vigorous vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 58 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 59 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north west	
Site: 60 **General Observations:** Natural occurring vegetation at the toe of the waste dump with increased vegetation around local depression **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking east	

Site: 61 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some changes in vegetation growth conditions due to carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 62 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 63 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	

Site: 64 **General Observations:** Natural occurring vegetation at the toe of the waste dump with increased vegetation around local depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 65 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 66 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	

Site: 67 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	
Site: 68 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing along creek line **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	
Site: 69 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing along creek line **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 70 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing along creek line **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 71 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	
Site: 72 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	

Site: 73 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 74 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 75 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	

Site: 76 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 77 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south	
Site: 78 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	

Site: 79 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 80 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 81 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 82 **General Observations:** Natural occurring vegetation at the toe of the waste dump with some vegetation impacted by carbonaceous material **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	
Site: 83 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	
Site: 84 **General Observations:** Lack of vegetation at the toe of the waste dump with vegetation increasing with distance from toe **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 85 **General Observations:** Lack of vegetation at the toe of the waste dump with highly modified conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking south east	
Site: 86 **General Observations:** Lack of vegetation at the toe of the waste dump with highly modified conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 87 **General Observations:** Natural occurring vegetation at the toe of the waste dump with runoff migrating to local depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	

Site: 88 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** None detected **Evidence of seepage:** None detected **Picture:** Looking north east	
Site: 89 **General Observations:** Lack of vegetation at the toe of the waste dump with carbonaceous material in closed depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking west	
Site: 90 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	

Site: 91 **General Observations: Scant** vegetation at the toe of the waste dump within local closed depression receiving runoff from eastern dumps **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking east	
Site: 92 **General Observations:** Natural occurring vegetation at the toe of the waste dump with runoff reporting to lower closed depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	
Site: 93 **General Observations:** Natural occurring vegetation at the toe of the waste dump with runoff reporting to lower closed depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north	

Site: 94 **General Observations:** Natural occurring vegetation at the toe of the waste dump with runoff reporting to lower closed depression **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north east	
Site: 95 **General Observations:** Natural occurring vegetation at the toe of the waste dump with no evidence of changes in vegetation species or growth conditions **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking south west	
Site: 96 **General Observations:** Natural occurring vegetation surrounding closed depression that reports to the interior of Lobe B mine site **Evidence of runoff:** Yes **Evidence of bypass flow:** Some erosion pathways suggest preferential or bypass flow has occurred **Evidence of seepage:** None detected **Picture:** Looking north west	

Appendix C Soil Chemistry Results from ALS

Analytes	Units	Surface soil (0-10cm)			Subsoil (20-30 cm)		
		124	171	174	124	171	174
1:3 water leachate							
ED093W: Major Cations							
Calcium	mg/L	1080	850	1780	316	296	379
Magnesium	mg/L	358	447	588	93	112	107
Sodium	mg/L	1680	2780	4340	879	1110	1540
Potassium	mg/L	39	25	30	17	10	13
EG020W: Metals by ICP-MS							
Arsenic	mg/L	0.002	0.003	0.003	0.001	0.004	0.002
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	3.93	2.72	2.89	2.32	1.61	2.27
Cadmium	mg/L	0.0020	0.0023	0.0024	0.0016	0.0017	0.0018
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	0.003	0.001
Cobalt	mg/L	0.002	0.002	0.002	<0.001	<0.001	<0.001
Copper	mg/L	0.023	0.018	0.009	0.035	0.009	0.005
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.422	0.425	0.324	0.032	0.020	0.010
Nickel	mg/L	0.004	0.004	0.004	0.002	0.010	0.002
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.02	0.01	0.01	0.01	0.02	0.01
Zinc	mg/L	0.658	0.707	0.982	0.330	0.320	0.477
Boron	mg/L	0.62	2.48	0.69	0.49	3.78	1.93
EG035W: Mercury by FIMS							
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Specific analytes							
EA055: Moisture content (103 °C)	%	20.4	19.4	14.7	12.6	23.4	15.9
EP003TC: Total Carbon	%	1.74	2.40	1.46	1.14	1.59	1.32
EA002: pH 1:5	-	7.6	7.9	7.8	8	8.2	8.1
EA031: pH sat. paste	-	7.5	7.6	7.7	7.8	8.1	8
EA010: EC 1:5	dS/m	8.58	9.42	14.6	3.25	3.84	5.25
EA032: EC sat. paste	dS/m	31.6	31.7	56.1	12.0	13.5	17.7
ED006: Exchangeable Cations							
Exch. Calcium	meq/100g	11.8	17.4	15.6	14.6	10.9	13.6
Exch. Magnesium	meq/100g	2.4	6.3	3.4	3	4.4	3.3
Exch. Potassium	meq/100g	0.5	0.5	0.4	0.4	0.2	0.3
Exch. Sodium	meq/100g	1.2	3.9	4.9	1.4	2.1	2.5
CEC	meq/100g	15.8	28.2	24.3	19.4	17.7	19.7
ESP	%	7.6	13.8	20.2	7.2	11.9	12.7
EA009: Net Acid Prod. Pot.	kg H_2SO_4/t	-94.1	-144	-90.6	-62.7	-106	-93
EA013: Acid Neutralising Capacity							
ANC as H_2SO_4	kg H_2SO_4/t	95.6	148	94	64.5	112	95.8
ANC as $CaCO_3$	% $CaCO_3$	9.8	15	9.6	6.6	11.5	9.8
Fizz rating	Fizz unit	2	3	2	2	3	2

Analytes	Units	Surface soil (0-10cm)			Subsoil (20-30 cm)		
		124	171	174	124	171	174
EA026: Chromium Reducible Sulfur	%	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
ED040: Sulfur as SO_4^{2-}	mg/kg	2700	6790	6500	2080	5370	2020
ED042T: Total Sulfur by LECO	%	1.74	2.4	1.46	1.14	1.59	1.32

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