BETTYS CREEK STREAM HEALTH AND STABILITY REPORT

June 2020

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with the Client. Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.12766	3 July 2020	Duncan Barnes	Paul Delaney	Duncan Barnes

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was engaged by Integra Underground to conduct channel stability and stream health monitoring of the Betty's Creek diversion in the areas that have the potential to be impacted by Integra Underground's Longwall 13, Longwall 14 and Longwall 15 in accordance with the Project Approval 08_0101 Schedule 3 Condition 29 requirements. SLR has previously undertaken channel stability monitoring for the Betty's Creek diversion (including the baseline assessment in May 2017, two rounds of monitoring in May and October 2018 as well as the two rounds of monitoring in May and October 2019). This proposed monitoring is required in order to address Section 5.3.3 of the Integra Underground (IUG) Water Management Plan (WMP).

In addition, SLR was also engaged to undertake channel stability and stream health monitoring for monitoring points BC1, BC2 and BC3 in accordance with Table 5.2 of the Bettys Creek Diversion Asset Management Plan.

This round of channel stability and stream health monitoring of the Betty's Creek diversion was undertaken on 2nd and 3rd June 2020.

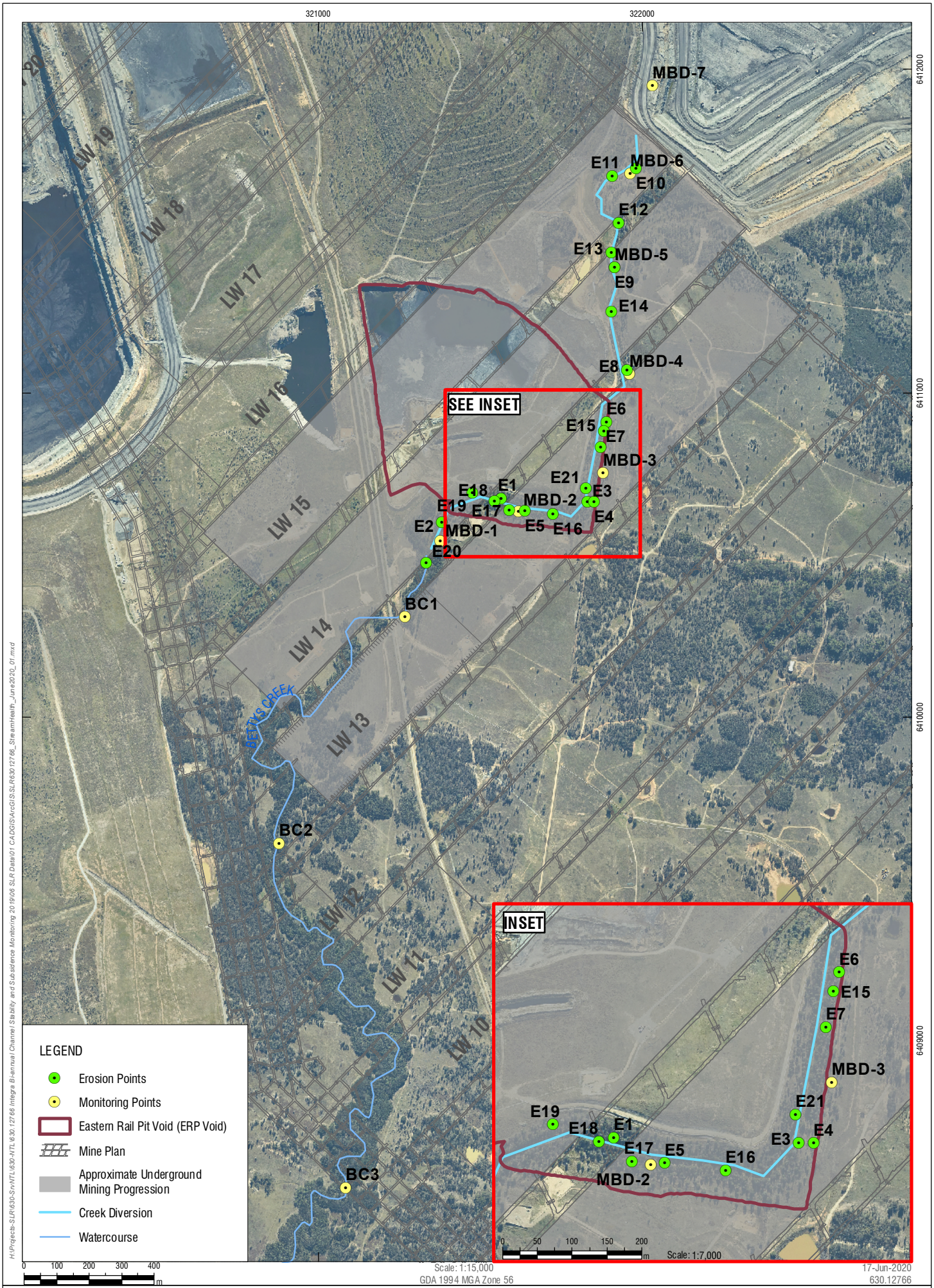
2 Methods

In accordance with the accepted scope of works the following procedure was undertaken at each monitoring site:

- Documenting the locations and dimensions of significant erosive or depositional features;
- Photographs upstream and downstream, at both the left and right banks (looking downstream);
- Rating the site with the Ephemeral Stream Assessment protocol developed by the CSIRO to assess the erosional state of the creek at the monitoring location (a measure of channel stability); and,
- Rating the site with the Rapid Appraisal of Riparian Condition protocol developed by Land & Water Australia. This assesses the ecological condition of riparian habitats using indicators that reflect functional aspects of the physical, community and landscape features of the riparian zone (a measure of stream health).
- A vegetation survey at each of the monitoring points including the following:
    - The age class of the vegetation (e.g. early regen, mature etc);
    - The resilience class (e.g. effect of disturbance at the monitoring point);
    - Vegetation structure (e.g. strata, form, height range and projected foliage cover); and
    - Vegetation composition (e.g. recording the three dominant species present at each strata).

Locations and dimensions of significant erosive or depositional features observed at locations between the designated monitoring points were also documented as part of the channel stability and stream health monitoring.

The locations of the monitoring points are shown in Figure 1.



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Channel Stability and Stream Health Monitoring June 2020

FIGURE 1

2.1 Rapid Appraisal of Riparian Condition

The RARC is an assessment method incorporating indicators of geophysical and biological properties and processes which are likely to provide reliable estimates of ecological condition in riverine ecosystems (Jansen et al., 2005). The RARC index is made up of five sub-indices, each with a number of indicator variables which can be seen in Table 1 below.

Table 1 Summary table of indicators, functions and components assessed in the RARC (Land and Water Australia, 2005)

Functions of the riparian zone at different levels of organisation	Components of the riparian ecosystem that perform those functions	Indicators of the functions used in the RARC
Physical		
Reduction of erosion of banks	Roots, ground cover	Vegetation cover
Sediment trapping	Roots, fallen logs, ground cover	Canopy cover, fallen logs, ground cover vegetation, leaf litter cover
Controlling stream microclimate/discharge/water temperatures	Riparian forest	Canopy cover
Filtering of nutrients from upslope	Vegetation, leaf litter	Ground cover vegetation, leaf litter cover
Community		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover•, leaf litter cover
Retention of plant propagules	Fallen logs, leaf litter	Fallen logs, leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species dominance of natives versus exotics	Native canopy and shrub regeneration, grazing damage to regeneration, reeds, native vegetation cover*
Provision of habitat for aquatic and terrestrial fauna	Fallen logs, leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Fallen logs, leaf litter cover, standing dead trees, hollows, vegetation cover', number of vegetation layers
Landscape		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover*, width of riparian vegetation, longitudinal continuity of riparian vegetation, proximity to other habitat
Provision of refuge in droughts	Riparian forest	Vegetation cover*

* Vegetation cover = canopy, understorey and ground cover

In accordance with previous annual stream health surveys undertaken at the site, classifications have been assigned based on the total score as assessed by the RARC methodology. It is useful to compare this total score over time to see how the biodiversity and functionality of the riparian zone is progressing at each of the monitoring points. Table 2 below outlines these classifications.

Table 2 Summary RARC Classification System

RARC Total Score	Classification
40-50	Excellent
35-39	Good
30-34	Average
25-29	Poor
< 25	Very Poor

2.2 CSIRO Ephemeral Stream Assessment

The CSIRO Ephemeral Stream Assessment procedures (CSIRO, date unknown) were used to assess the channel stability of the Bettys Creek diversion. The assessment uses four main classes of indicators to evaluate the degree of stream-bed condition:

1. The type and condition of the vegetation present, if any;
2. The shape and profile of the drainage line and type of materials on the drainage line floor;
3. The nature of the drainage line wall materials; and
4. The nature of the stream bank bordering flats and/or slopes and regulation of lateral flow into the drainage line.

The indicators produce a rating based on a scoring system, and the combined total of the indicators rank each location from very actively eroding through to very stable as shown in Table 3. This will enable future assessments to be made as to whether the section of creek has changed over time.

Table 3 Classification of drainage line stability states (CSIRO)

Activity Rating (%)	Classification	Discussion of Classification
80 +	Very Stable	Drainage line is very stable and likely to be in original form. It is able to withstand all flow velocities that have previously occurred in this area and only minimal monitoring is required, predominantly after high flow events, to ensure condition does not deteriorate.
70-80	Stable	Drainage line is stable. It is important to assess this zone in relation to the other classifications and define whether this zone is moving from potentially stabilising to a more stable form, or if it is deteriorating from a very stable form. The nature of this relationship will identify the type of monitoring required.

Activity Rating (%)	Classification	Discussion of Classification
60-69	Potentially Stabilising	Drainage line is potentially stabilising. Ongoing monitoring is required while rehabilitation works are not needed in the immediate future.
50-59	Active	Drainage line is actively eroding and remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.
< 50	Very Active	Drainage line is very actively eroding and immediate remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.

Table Source: CSIRO Ephemeral Stream Assessment (CSIRO, date unknown)

It should be noted that a different channel stability assessor carried out this June 2020 monitoring compared to the October 2019 monitoring. As such, there is some potential for channel stability scoring to change purely as a result of the subjective nature of the CSIRO methodology.

2.3 Visual Assessment of the Bettys Creek Diversion

A visual inspection of the Betty's Creek diversion in the areas that have the potential to be impacted by the Integra Underground longwall panels was undertaken to identify any areas of increased erosion. Where erosion was observed within this reach of the Betty's Creek Diversion the following were recorded:

- Documented locations and dimensions of notable erosive or depositional features;
- Photos so that comparisons can be made in future surveys.

In future inspections any visible changes that occur since the preceding inspection will be documented by comparison to the photos taken during the previous surveys.

3 Results

3.1 Channel Stability / Stream Health Monitoring Site Results

The following section outlines the results of the annual stream health and channel stability assessment undertaken on the 2nd and 3rd June 2020 along a 2.2km reach of the Bettys Creek diversion. Refer to Appendix A for the complete RARC scoring breakdowns for each monitoring site. Refer to Appendix B for the complete CSIRO Ephemeral Stream Assessment scoring breakdown. It is noted that the area was subjected to wet weather conditions prior to this round of monitoring. It is recognised that a long section of the diversion channel between MBD1 and MBD4 is constructed on the fill material of the Eastern Rail Pit (ERP) and has been subjected to settlement of the fill material before being impacted by subsidence from the Integra Underground longwall mining. Any unconsolidated fill material may be more vulnerable to erosion than the areas of natural ground surface.

3.1.1 MBD1 (321375E 6410541N)

As per monitoring undertaken in October 2019, monitoring point MBD1 appears to be stable with good vegetation coverage. This monitoring point does not appear to have changed since the last assessment. Some erosion was again observed immediately upstream and downstream of this point (refer to Erosion Points E1 and E2).

RARC Stream Health Assessment Classification – Poor (see Table 4)

Table 4 RARC condition classification (MBD1) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD1	Very Poor	Very Poor	Very Poor	Poor	Average	Poor

Priority Weed species present - None

CSIRO Ephemeral Stream Assessment Classification – Very Stable

Photos taken at the established photo points for this monitoring point are shown in Plate 1 to Plate 4.

Plate 1 Left Bank

Plate 2 Right Bank

Plate 3 Upstream

Plate 4 Downstream

3.1.2 MBD2 (321616E 6410634N)

As per monitoring undertaken in October 2019, monitoring point MBD2 appears to be have good vegetation cover, however some exposed soil does exist on the left bank with some minor in undercutting of the bank present. The diversion is lined with rip rap immediately upstream from this monitoring point. Unlike the last assessment, ponded water was observed within the channel.

RARC Stream Health Assessment Classification – Poor (see Table 5)

Table 5 RARC condition classification (MBD2) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD2	Very Poor	Very Poor	Very Poor	Very Poor	Poor	Poor

Priority Weed species present;

- Hyparrhenia hirta (Coolatai Grass).

CSIRO Ephemeral Stream Assessment Classification – Potentially Stabilising

The 'Potentially Stabilising' CSIRO channel stability classification is supported by site observations that suggest the existing erosion is stabilising. The change in the classification from the last round of monitoring is likely the result of small subjective differences brought about by a change of assessor for this round of monitoring rather than the result of a significant changes to the creek stability at this location.

Photos taken at the established photo points for this monitoring point are shown in Plate 5 to Plate 8.

Plate 5 Left Bank

Plate 6 Right Bank

Plate 7 Upstream

Plate 8 Downstream

3.1.3 MBD3 (321877E 6410752N)

As per monitoring undertaken in October 2019, monitoring point MBD3 appears to be relatively stable, however water was seen to be ponding in the bed during this round of monitoring. Some historical erosion has occurred on the banks in the vicinity of MBD3 however this erosion appears to be potentially stabilising with the use of coir logs. This is not the case immediately upstream where active erosion is occurring (refer to erosion point E7).

RARC Stream Health Assessment Classification – Poor (see Table 6)

Table 6 RARC condition classification (MBD3) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD3	Very Poor	Very Poor	Poor	Poor	Poor	Poor

Priority Weed species present;

- Hyparrhenia hirta (Coolatai Grass), and

- Opuntia stricta (Common Prickly Pear).

CSIRO Ephemeral Stream Assessment Classification – Potentially Stabilising

The 'Potentially Stabilising' CSIRO channel stability classification is supported by site observations that suggest the existing erosion is stabilising. The change in the classification from the last round of monitoring is likely the result of small subjective differences brought about by a change of assessor for this round of monitoring rather than the result of a significant changes to the creek stability at this location.

Photos taken at the established photo points for this monitoring point are shown in Plate 9 to Plate 12.

Plate 9 Left Bank

Plate 10 Right Bank

Plate 11 Upstream

Plate 12 Downstream

3.1.4 MBD4 (321959E 6411058N)

As per monitoring undertaken in October 2019, the left bank of the diversion and upstream of MBD4 has significant rill/gully erosion due to the exposed dispersive soils on this bank (refer to Erosion Point E8). Although the left bank appears to be actively eroding no significant changes were observed compared to the last assessment. The right bank and bed appear to be generally stable with some vegetation establishment.

RARC Stream Health Assessment Classification – Very Poor (see Table 7).

Table 7 RARC condition classification (MBD4) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD4	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Priority Weed species present;

- Opuntia stricta (Common Prickly Pear).

CSIRO Ephemeral Stream Assessment Classification – Potentially Stabilising

The 'Potentially Stabilising' CSIRO channel stability classification is supported by site observations that suggest the existing erosion is not getting worse and may be stabilising.

Photos taken at the established photo points for this monitoring point are shown in Plate 13 to Plate 16.

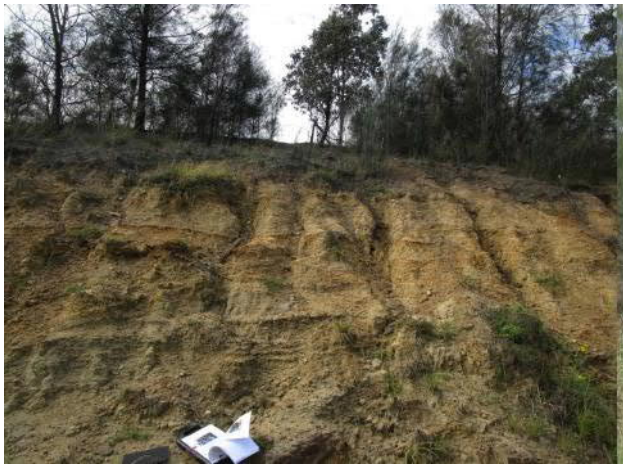

Plate 13 Left Bank

Plate 14 Right Bank

Plate 15 Upstream

Plate 16 Downstream

3.1.5 MBD5 (321914E 6411387N)

As per monitoring undertaken in October 2019, monitoring point MBD5 appears to be stable however the left bank downstream of MBD5 has significant rill/gully erosion due to the exposed dispersive soils on this bank (refer to Erosion Point E9). Generally, the monitoring point appears to be similar to what was observed during the last assessment with increased amounts of water ponding just downstream of MBD5 during this round of monitoring.

RARC Stream Health Assessment Classification – Very Poor (see Table 8).

Table 8 RARC condition classification (MBD5) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD5	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Priority Weed species present;

- Hyparrhenia hirta (Coolatai Grass), and
- Opuntia stricta (Common Prickly Pear).

CSIRO Ephemeral Stream Assessment Classification – Very Stable

Photos taken at the established photo points for this monitoring point are shown in Plate 17 to Plate 20.

Plate 17 Left Bank

Plate 18 Right Bank

Plate 19 Upstream

Plate 20 Downstream

3.1.6 MBD6 (321962E 6411676N)

As per monitoring undertaken in October 2019, monitoring point MBD6 appears to be generally stable. Whilst there is limited vegetation establishment on the left bank no scouring of this bank has occurred. This monitoring point is located immediately to the south of the Mt Owen open cut pit and therefore receives very little upslope runoff. A hay bale check dam has been installed within the diversion at this monitoring point which was observed to be deteriorating. A gas pad has now been installed upstream of the monitoring point, with sediment fence around the pad to control sediment laden runoff. During this monitoring round mud was observed at the base of the diversion. An inlet to the diversion located approximately 20m upstream of the monitoring point is significantly eroded (refer to Erosion Point E10). The right bank appears to be stable with good vegetation establishment.

RARC Stream Health Assessment Classification – Very Poor (see Table 9).

Table 9 RARC condition classification (MBD6) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
MBD6	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Priority Weed species present;

- None

CSIRO Ephemeral Stream Assessment Classification – Potentially Stabilising

The 'Potentially Stabilising' CSIRO channel stability classification is supported by site observations that the exposed left back is still not eroding over time.

Photos taken at the established photo points for this monitoring point are shown in Plate 21 to Plate 24.

Plate 21 Left Bank

Plate 22 Right Bank

Plate 23 Upstream

Plate 24 Downstream

3.1.7 MBD7 (322030E 6411949N)

Monitoring point MBD7 no longer exists due to the Mount Owen mining progression in this area.

3.1.8 BC1 (321310E 6410280N)

Monitoring point BC1 is located immediately upstream from the rail line crossing where gas and water pipeline works have previously been undertaken. A hay bale coffer dam has been installed upslope of these works and is starting to deteriorate. As per monitoring undertaken in October 2019, the site is stable with good tree coverage immediately adjacent to the creek.

RARC Stream Health Assessment Classification – Very Poor (see Table 10).

Table 10 RARC condition classification (BC1) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
BC1	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Priority Weed species present;

- Lycium ferocissimum (African Boxthorn), and
- Hyparrhenia hirta (Coolatai Grass).

CSIRO Ephemeral Stream Assessment Classification – Stable

The 'Stable' CSIRO channel stability classification is supported by site observations that indicate that creek is stable at this location.

Photos taken at the established photo points for this monitoring point are shown in Plate 25 to Plate 28.

Plate 25 Left Bank

Plate 26 Right Bank

Plate 27 Upstream

Plate 28 Downstream

3.1.9 BC2 (320885E 6409646N)

Monitoring point BC2 is located at the water level meter labelled as BC2. This monitoring point is situated in a fairly incised section of Bettys Creek with steep (near vertical) walls on the left bank. As per monitoring undertaken in October 2019, some exposed soil does exist on this left bank however the soil does not appear to be overly dispersive. Indeed, while there is evidence of previous undercutting on the left bank, the rate of erosion appears to be stabilised by vegetation. The creek bed has minimal vegetation present but the right bank is covered with grass. The site is generally stable with good grass and tree coverage immediately adjacent to the creek.

RARC Stream Health Assessment Classification – Average (see Table 11).

Table 11 RARC condition classification (BC2) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
BC2	Very Poor	Poor	Poor	Average	Average	Average

Priority Weed species present;

- Lycium ferocissimum (African Boxthorn), and
- Cestrum parqui (Green Cestrum).

CSIRO Ephemeral Stream Assessment Classification – Stable

Photos taken at the established photo points for this monitoring point are shown in Plate 29 to Plate 32.

Plate 29 Left Bank

Plate 30 Right Bank

Plate 31 Upstream

Plate 32 Downstream

3.1.10 BC3 (321077E 6408513N)

Monitoring point BC3 is located at the water level meter labelled as BC3. This monitoring point is situated downstream of a side arm inlet on the left bank. As per monitoring undertaken in October 2019, monitoring point BC3 is stable with good tree coverage immediately adjacent to the creek. The monitoring point is generally covered with leaf litter with some fallen trees / logs in the area. Some minor undercutting is present at and downstream of the monitoring point on the right bank, however, the right bank does not appear to be actively eroding. Some minor undercutting was also observed on the left bank during this monitoring round. No water was observed to be ponding in this section of the creek during the site inspection.

RARC Stream Health Assessment Classification – Good (see Table 12).

Table 12 RARC condition classification (BC3) 2018-2020

Site	May 2017	May 2018	October 2018	May 2019	October 2019	May 2020
BC3	Very Poor	Poor	Poor	Poor	Average	Good

Priority Weed species present;

- Lycium ferocissimum (African Boxthorn), and
- Cestrum parqui (Green Cestrum).

CSIRO Ephemeral Stream Assessment Classification – Stable

Photos taken at the established photo points for this monitoring point are shown in Plate 33 to Plate 36.

Plate 33 Left Bank

Plate 34 Right Bank

Plate 35 Upstream

Plate 36 Downstream

3.2 Observed Erosion in the Bettys Creek Diversion

Locations and dimensions of significant erosive or depositional features observed at locations between the designated monitoring points were also documented as part of the June 2020 channel stability and stream health monitoring as documented in the sections below. It is recognised that a section of the diversion channel is constructed on the fill material of the Eastern Rail Pit (ERP) and has been subjected to settlement of the fill material before being impacted by subsidence from the Integra Underground longwall mining. The monitoring points on fill material of the ERP include E1, E3, E4, E5, E6, E7, E15, E16, E17, E18, E19 and E21. Any unconsolidated fill material may also be more vulnerable to erosion than the areas of natural ground surface.

3.2.1 E1 (321563E 6410673N)

As per earlier monitoring undertaken in October 2019, erosion observed at E1 included tunnel erosion on the left bank downstream from monitoring point MBD2. This tunnel erosion begins in the upslope contour bank and appears to have gotten significantly worse since previous inspections. The contour bank contains a significant scour hole (4m x 2m x 1.5m) and a tree with exposed roots within this scour hole. It is possible that this tunnel was created by a wombat and has subsequently eroded. There is a high potential for ongoing erosion of this area.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E1 are shown in Plates 37-38.

Plate 37 Tunnel Erosion on Left Bank (entry)

Plate 38 Tunnel Erosion on Left Bank (exit)

3.2.2 E2 (321380E 6410600N)

As per earlier monitoring undertaken in October 2019, an inlet into the left bank of the diversion upstream of MBD1 is significantly eroded. This side arm erosion is approximately 1.5-2.0m deep and has exposed material which appears to be moderately dispersive.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E2 are shown in Plates 39-40.

Plate 39 Gully Erosion on Left Bank (1)

Plate 40 Gully Erosion on Left Bank (2)

3.2.3 E3 (321829E 6410699N)

As per earlier monitoring undertaken in October 2019, a section on the right bank has eroded with vertical, slightly undercut banks. A scour hole previously observed at the toe of the left bank could not be found during this round of monitoring, possibly due to the additional volume of water ponded in the creek. This erosion doesn't appear to have progressed significantly since the last inspection but additional ponded water in the creek bed has made any comparison difficult.

The lateral crack observed near the top of the left bank in the last assessment still exists and is still approximately 10m long, 20cm wide and 20cm deep. This crack could be a result of settlement of the fill material at the interface of the natural ground and fill material following construction of the channel. Similar cracks were observed on the left bank in several sections of the Bettys Creek diversion, and all were identified prior to the recent longwall mining activities.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E3 are shown in Plates 41-42.

Plate 41 Water Ponding in Creek Bed

Plate 42 Vegetation on Right Bank

3.2.4 E4 (321851E 6410664N)

As per earlier monitoring undertaken in October 2019, a lateral crack was observed near the top of the left bank at E4. Similarly to other locations, this crack was approximately 20cm wide, 20cm deep and extended over a length greater than 50m. The crack becomes quite substantial above the top of the left bank. This crack is also located along the interface between natural ground and fill material of the ERP. The initial cracking is not likely to be related to subsidence from underground longwall mining but may have been increased by the mining of Longwalls 13, 14 and 15. Similar cracks were observed on the left bank in several sections of the Bettys Creek diversion and all were identified prior to the recent longwall mining activities.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E4 are shown in Plates 43-45.

Plate 43 Lateral Crack on Left Bank (1)

Plate 44 Lateral Crack on Left Bank (2)

Plate 45 Vegetation on Left Bank

3.2.5 E5 (321636E 6410636N)

As per earlier monitoring undertaken in October 2019, scouring around the rip rap material has occurred on the left bank within the diversion (approximately 1m deep) exposing dispersive soil material which appears as though it would actively scour during significant flow events.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E5 are shown in Plates 46-47.

Plate 46 Scouring of Left Bank (1)

Plate 47 Scouring of Left Bank (2)

3.2.6 E6 (321887E 640911N)

As per earlier monitoring undertaken in October 2019, a lateral crack was observed near the top of the left bank adjacent to a hickory wattle tree. Similarly to other locations, this crack was approximately 10m long, 20cm wide and 20-30cm deep. This crack is located along the interface between natural ground and fill material of the ERP. The initial cracking is not likely to be related to subsidence from underground longwall mining but may have been increased by the mining of Longwalls 13 and 14. Similar cracks were observed on the left bank in several sections of the Bettys Creek diversion and all were identified prior to the recent longwall mining activities.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E6 is shown in Plate 48.

Plate 48 Lateral Crack on Left Bank

3.2.7 E7 (321869E 6410832N)

As per earlier monitoring undertaken in October 2019, a lateral crack (approximately 10m long, 20cm wide and 20cm deep) was observed near the top of the left bank at E7. This crack is located along the interface between natural ground and fill material of the ERP. Similar cracks were observed on the left bank in several sections of the Bettys Creek diversion and all were identified prior to the recent longwall mining activities.

The crack appears to be similar to what was observed in the last assessment however, significant tunnel erosion was observed in the crack at several locations which was not present in October 2019. These tunnel erosion entrances are approximately 0.5m x 0.5m but the extent of the tunnel erosion could not be determined.

Significant slumping and tunnel erosion also occurs on the left bank approximately 20m downstream. Coir logs have been used to try to manage this erosion but the area still appears to be actively eroding.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E7 are shown in Plates 49-52.

Plate 49 Lateral Crack on Left Bank (1)

Plate 50 Lateral Crack on Left Bank (2)

Plate 51 Tunnel Erosion on Left Bank (1)

Plate 52 Tunnel Erosion on Left Bank (2)

3.2.8 E8 (321959E 6411058N)

As per earlier monitoring undertaken in October 2019, the left bank of the diversion has exposed dispersive material present along several hundred metres between monitoring points MBD4 and MBD5. Rill erosion has occurred along the bank within this reach of the diversion and appears to be actively eroding due to the lateral inflows, steepness of the bank, and dispersive nature of the soils. Although this bank is actively eroding, no notable change in condition was observed since the last assessment.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E8 are shown in Plate 53-54.

Plate 53 Rill Erosion on Left Bank (1)

Plate 54 Rill Erosion on Left Bank (2)

3.2.9 E9 (321914E 6411387N)

As per earlier monitoring undertaken in October 2019 and similar to E8, the diversion has exposed dispersive material present along the left bank. Rill erosion has occurred along the bank within this reach of the diversion and appears to be slightly worse since the last round of monitoring and actively eroding due to the lateral inflows. The mass wasting of the left-hand bank observed during the last assessment does not appear to have gotten worse.

Muddy vehicle tracks were observed in the diversion at this location which appeared to have occurred relatively recently.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E9 are shown in Plate 55-57.

Plate 55 Ponded Water in Diversion

Plate 56 Rill Erosion on Left Bank

Plate 57 Evidence of Vehicle Movement Through Mud on Left Bank

3.2.10 E10 (321979E 6411691N)

As per earlier monitoring undertaken in October 2019, an inlet to the Bettys Creek diversion located approximately 20m upstream of monitoring point MBD6 is significantly eroded. This concentrated flow path is 1m wide and 1m deep and has exposed dispersive material present. The flow path appears to have actively eroded since the last assessment with evidence of loose sediment below the erosion at the toe and behind the hay bales installed just downstream of the erosion (in line with MBD6 location). These hay bales have deteriorated since the last inspection. Additional water was observed to be ponding in the diversion during this round of monitoring.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E10 are shown in Plates 58-60.

Plate 58 Erosion Left Bank

Plate 59 Water Ponded in Diversion Downstream

Plate 60 Hay Bale Downstream

3.2.11 E11 (321906E 6411669N)

As per earlier monitoring undertaken in October 2019, some minor erosion was observed on the left bank. This erosion appears to have gotten slightly worse and was approximately 1m long, 50cm wide and 30cm deep.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E11 is shown in Plate 61.

Plate 61 Erosion on Left Bank

3.2.12 E12 (321925E 6411525N)

As per earlier monitoring undertaken in October 2019, a number of small holes and cracks exist in the bed of the Bettys Creek Diversion. This site is located between Longwall 14 and Longwall 15. These holes were potentially created by wildlife in the area and not likely to be related to subsidence from underground longwall mining. The holes appear to be stabilising since the last inspection with additional vegetation growth. The rest of the diversion appears to be stable at this location.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E12 is shown in Plates 62.

Plate 62 Cracking in Creek Bed (2)

3.2.13 E13 (321903E 6411434N)

Some minor cracking exists in the creek bed. These cracks are not likely to be subsidence related and were all covered by vegetation at the time of this round of monitoring. The rest of the creek appeared to be stable at this location.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E13 are shown in Plates 63-64.

Plate 63 Cracking in Creek Bed (1)

Plate 64 Cracking in Creek Bed (2)

3.2.14 E14 (321902E 6411250N)

As per earlier monitoring undertaken in October 2019, Mt Owen construction works have completely removed the right bank of the Bettys Creek Diversion at this location. This round of monitoring has shown that grass cover has established well on the right bank. Previously installed sediment controls (hay bale, geo-fabric, etc.) have been removed since the last round of monitoring due to the revegetation success of the Mt Owen spillway rehabilitation works. The left bank is still actively eroding and appears to have gotten slightly worse since the last inspection.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E14 are shown in Plates 65-66.

Plate 65 Rill Erosion on Left Bank

Plate 66 Vegetation on Right Bank

3.2.15 E15 (321879E 6410883N)

The eroded sump observed in October 2019 has gotten significantly worse since this inspection. This sump now has an extra large hole in it (1m x 1m x 1m) which is actively eroding and tunnelling. No exit to the tunnel erosion was observed. Additional tunnel erosion was also observed 10m downstream.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations

Photos taken at E15 are shown in Plates 67-68.

Plate 67 Tunnel Erosion on Left Bank (1)

Plate 68 Tunnel Erosion on Left Bank (2)

3.2.16 E16 (321724E 6410625N)

As per earlier monitoring undertaken in October 2019, slight undercutting of the left bank has occurred above the rip rap which has been placed in the bed of the diversion. This undercutting is approximately 0.2m deep and 0.4m high. Some minor scouring has also occurred downstream of the rip rap material. All other areas of the creek appear to be stable at this location.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E16 are shown in Plates 69.

Plate 69 Undercutting of Left Bank

3.2.17 E17 (321589E 6410638N)

As per earlier monitoring undertaken in October 2019, significant gully and tunnel erosion has occurred down the left bank. It is not clear if this erosion has gotten worse but appears as though it has slightly. This erosion has originated from the upslope contour bank and contains steep (near vertical) side slopes with exposed dispersive soils that are greater than 1.5m high in some locations. The gully erosion appears to be actively eroding.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E17 is shown in Plate 70.

Plate 70 Erosion on Left Bank

3.2.18 E18 (321542E 6410667N)

As per earlier monitoring undertaken in October 2019, erosion was also observed on both the left and right banks at this location. This erosion included near vertical walls (approximately 1m high) with exposed dispersive soils and with some undermining of the eroded batter. This area appears to be actively eroding so it should be monitored regularly for signs of additional erosion.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E18 are shown in Plates 71-72.

Plate 71 Undercutting of Bank (1)

Plate 72 Undercutting of Bank (2)

3.2.19 E19 (321475E 6410691N)

As per earlier monitoring undertaken in October 2019, a scour hole has formed at this location in the right bank. This scour hole has an approximate diameter of 2m and is approximately 1m deep. The scour hole requires remediation works but does not appear to have gotten worse since the last round of monitoring.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E19 is shown in Plate 73.

Plate 73 Scour Hole on the Right Bank

3.2.20 E20 (321332E 6410477N)

As per earlier monitoring undertaken in October 2019, some minor erosion has occurred on the left bank which has exposed the soil (approximately 0.8m high) with some minor undercutting of the creek bank. A tree has fallen in this area and may have contributed to the creation of erosion. The area does not appear to be actively eroding with no apparent changes since the last inspection.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

A photo taken at E20 is shown in Plate 74.

Plate 74 Undercutting of Left Bank

3.2.21 E21 (321825E 6410705N)

As per earlier monitoring undertaken in October 2019, some erosion was observed on the right bank at this location. This erosion included near vertical walls (approximately 0.5m high) with exposed dispersive soils and with some undermining of the eroded batter. Some erosion also exists within an inlet gully on the left bank.

The area appears to have stabilised slightly since the last inspection but there is still some potential for this area to actively erode. As such, it should be monitored regularly for signs of additional erosion.

No evidence was observed to indicate that this erosion is a result of Integra Underground operations.

Photos taken at E21 are shown in Plates 75-79.

Plate 75 Undercutting of Right Bank (1)

Plate 76 Undercutting of Right Bank (2)

Plate 77 Gully Inlet Erosion on Left Bank

4 Vegetation Survey

The vegetation survey recorded the general condition of the vegetation at each monitoring point. Vegetation types were identified at each monitoring site using the OEH Vegetation Information System (VIS Classification 2.1, DPIE 2020). Vegetation communities found on site include the following;

- Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233) (also known as Central Hunter Swamp Oak Forest) – recorded at monitoring sites; MBD04, MBD05, MBD06, BC01, BC02, and BC03.
- Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600) (also known as Central Hunter Ironbark-Spotted Gum-Grey Box Forest) – recorded at monitoring sites; MBD01, MBD02 and MBD03.

The June 2020 site assessment identified minimal change in vegetation condition when compared to previous surveys. The condition of riparian vegetation within the two creek systems are discussed below.

Middle Betty's Diversion

The Riparian vegetation at most Middle Betty's Diversion (MBD) sites is dominated by Casuarina glauca (She-oak), with scattered canopy species including; Eucalyptus tereticornis (Forest Red-Gum), E. crebra (Narrow-leaved Ironbark) and Cormybia maculata (Spotted Gum) becoming more abundant in the upper bank. Mid-storey includes a mix of species including regenerating C. glauca, Acacia parvipinnula (Silver-stemmed Wattle) and A. implexa (Hickory Wattle). Groundcover is patchy and variable between sites but is often sparser on the banks and dominated by a mix of native and non-native species including Cymbopogon refractus (Barbed Wire Grass), Melinis repens (Red-Natal Grass), Eragrostis brownii (Brown's Lovegrass) and Chloris gayana (Rhodes Grass). The channel it is dominated by a mix of grasses (e.g. Chloris gayana) and rushes (e.g. Juncus acutus).

All MBD sites recorded poor to moderate resilience due to the dominance of exotic groundcover species including; Chloris gayana, Melinis repens, Juncus acutus, Megathyrsus maximus (Guinea Grass), and Eragrostis curvula (African Lovegrass). There has been no significant change in canopy cover, composition, habitat values or debris since October 2019. However, many sites have recorded increases in native understorey regeneration, and groundcover (primarily exotics), likely the result of recent rains. The large E. tereticornis hollow-bearing tree recorded 10-15 m from the MBD06 monitoring point remains a key habitat feature for the site.

Betty's Creek

The vegetation at most of the BC sites is dominated by a closed canopy of Casuarina glauca (She-oak)_ trees with a very sparse mid-storey of regenerating She-oaks and occasional scattered Lycium ferocissimum (African Boxthorn). Groundcover is often denser than the MBD sites and constituting a mix of native and non-native grasses and herbs including Aristida vargans and Themeda triandra with scattered Chloris gayana and Microlaena stipoides near the creek banks. As with the MBD sites, there has been no significant change in canopy cover, composition, habitat values, debris since October 2019. However, there has been an increase in groundcover and native mid-storey regeneration, likely due to the recent rains.

Results of the vegetation survey are presented in Table 13.

Table 13 Vegetation Survey Results

Site	Plant Community Type (PCT)	Age Class	Resilience	Projective Foliage Cover (%)	Perennial Native Understory Cover (%)	Site Description
MBD01	Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600)	Uneven	Moderate	90	40	Vegetation in average condition dominated by open canopy of Corymbia maculata with scattered Casuarina glauca and multiple standing dead trees and native species regrowth. Spares mid-storey containing Acacia parvipinnula, Acacia implexa and Bursaria spinosa. Ground cover dominated by Aristida vargans, Chloris gayana and Cynodon dactylon. Good coverage of habitat features including dead trees, fallen logs and leaf litter at the site. No fauna habitats were recorded at the site. Species regeneration evident.
MBD02	Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600)	Uneven	Moderate	80	35	Vegetation in average condition dominated by open canopy of Casuarina glauca and Corymbia maculata with sparse mid-storey of Acacia implexa and Acacia parvipinnula. Sparse ground cover dominated by Aristida vargans and Chloris gayana. Good coverage of habitat features including dead trees and leaf litter at the site. Various burrows and warrens were recorded at the site. Species regeneration evident.
MBD03	Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter (PCT 1600)	Advanced regeneration	Moderate	80	30	Vegetation in average condition dominated by open canopy Corymbia maculata and Casuarina glauca with scattered Eucalyptus crebra and Eucalyptus fibrosa with sparse mid-storey of Acacia parvipinnula, Acacia implexa and scattered Breynia oblogifolia. Sparse ground cover dominated by Aristida vargans, Chloris gayana with scattered C. refractus. Burrows and warrens were recorded at the site. Species regeneration evident.

Site	Plant Community Type (PCT)	Age Class	Resilience	Projective Foliage Cover (%)	Perennial Native Understory Cover (%)	Site Description
MBD04	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Advanced regeneration	Moderate	40	5	Large bare patches along the left bank, while the right bank is highly vegetated and stabilised by regenerating Casuarina. glauca. Vegetation is in average condition dominated by open canopy of Casuarina. glauca with scattered Eucalyptus. tereticornis and Corymbia maculata with sparse mid-storey of Acacia parvipinnula, and Acacia implexa. Ground cover dense, especially within diversion channel. Groundcover is dominated by Chloris gayana, Eragrostis curvula. Melinis repens and Chloris virgata. No fauna habitats were recorded at the site. Species regeneration evident. A number of exotic species were recorded on site, however only one dead priority weed species was recorded Opuntia stricta (Common Prickly Pear).
MBD05	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Advanced regeneration	Poor	25	5	Vegetation in average condition dominated by open canopy of juvenile Casuarina glauca with scattered Eucalyptus tereticornis with sparse mid-storey of Acacia parvipinnula and Acacia implexa. Ground cover dominated by Cymbopogon refractus, Eragrostis brownii and Chloris gayana. A small amount of woody debris was recorded at the site. A number of exotic species were recorded on the site including two priority weeds Hyparrhenia hirta (Coolatai Grass) and Opuntia stricta (Common Prickly Pear).
MBD06	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Early regeneration	Poor	20	5	Site was highly disturbed with large patches of bare soil indicating erosion of topsoil along the lower slope of the diversion banks. Sparse canopy of juvenile Casuarina glauca and planted Eucalyptus species. Mid-storey of regrowth Acacia and Eucalyptus species. Groundcover dominated by Chloris gayana. Species regeneration evident. One large habitat tree was recorded in the upper bank of the diversion. Construction works along left bank complete. Erosion evident from newly installed vehicle crossing north of site with sediment going into creek diversion.

Site	Plant Community Type (PCT)	Age Class	Resilience	Projective Foliage Cover (%)	Perennial Native Understory Cover (%)	Site Description
BC01	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Uneven age	Moderate	90	40	Vegetation in good condition dominated by closed canopy of Casuarina glauca with multiple standing dead trees Midstorey is sparse and includes priority weed Lycium ferocissimum. Sparse ground cover dominated by Aristida vargans, Chloris gayana with scattered Microlaena stipoides near the creek banks. Various fauna habitats were recorded at the site including fallen branches and burrows. Species regeneration evident.
BC02	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Uneven age	Moderate	85	40	Vegetation in good condition dominated by closed canopy of Casuarina glauca with abundance of dead trees, fallen logs and branches. Limited mid-storey of Lycium ferocissimum and Cestrum parqui. Ground cover dominated by Aristida vargans, and Chloris gayana. Noticeable presence of herbs and forbs such Cheilanthes sieberi and Brunoniella australis. Various fauna habitats were recorded at the site. Species regeneration evident.
BC03	Swamp Oak forest of the central Hunter Valley, Sydney Basin Bioregion (PCT 1233)	Uneven age	Moderate	100	40	Vegetation in good condition dominated by closed canopy of Casuarina glauca with abundance of dead trees, fallen logs and branches. Limited mid-storey which includes Lycium ferocissimum and Cestrum parqui. Ground cover dominated by Aristida vargans and Themeda triandra with scattered Chloris gayana and Microlaena stipoides. Various fauna habitats were recorded at the site. Species regeneration evident.

5 Desktop Channel Analysis

In addition to the channel stability and stream health monitoring detailed above, a desktop analysis of aerial photographs as well as recent and historical LIDAR data was undertaken to identify lateral shifts in channel position, potential subsidence impacts and whether geomorphic features (e.g. benches/bars) are forming within the diversion.

A comparison of recent and older aerial photographs is provided in Figure 2. The result of this comparison indicates that no significant lateral shifts of the diversion have occurred in the 6.5 months during the period between when the aerial photographs were taken.

Detailed LIDAR information of the Betty's Creek diversion was available for December 2016 however no detailed survey information was available prior to this date. IUG provided the latest Lidar (December 2019) available for the study area and SLR compared it to the December 2018 and historic contours. Cross-sections at each of the designated monitoring points as well as a longitudinal section across the diversion centreline / thalweg using both of these datasets is provided in Appendix C.

Results from this comparison indicated that the Bettys Creek Diversion levels from the recent December 2019 LIDAR data corresponds fairly well with the December 2018 LIDAR data. Although discrepancies between the datasets suggest that sediment has built up or lost in the diversion over time SLR does not believe this to be the case based on site observations with the majority of minor level differences considered to be a result of the minor inaccuracies of the contour data sets. SLR believes that the July 2018 LIDAR data was significantly more inaccurate than the other LIDAR data sets. The comparison of recent and historic LIDAR / contour is expected to be more beneficial during future rounds of monitoring as more data becomes available over time.

DATE: 28th December 2019

DATE: 10th July 2019

0.0 200 400 600 800

METRE

N

Bettys Creek Diversion
Aerial Photograph Assessment

Figure 2

SLR

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6 Summary of Results

A summary of the RARC Stream Heath and CSIRO Ephemeral Stream assessments is provided below in Table 14.

Table 14 Summary of Stream Health and Stability Results

Monitoring Site	RARC Stream Heath Assessment Classification						CSIRO Ephemeral Stream Assessment Classification					
	May 2017	May 2018	October 2018	May 2019	October 2019	June 2020	May 2017	May 2018	October 2018	May 2019	October 2019	June 2020
MBD1	Very Poor	Very Poor	Very Poor	Poor	Average	Poor	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
MBD2	Very Poor	Very Poor	Very Poor	Very Poor	Poor	Poor	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Stable	Stable	Potentially Stabilising
MBD3	Very Poor	Very Poor	Poor	Poor	Poor	Poor	Stable	Stable	Stable	Stable	Stable	Potentially Stabilising
MBD4	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Active	Active	Active	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising
MBD5	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
MBD6	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising
BC1	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Stable	Stable	Stable	Stable	Stable	Stable
BC2	Poor	Poor	Poor	Average	Average	Average	Stable [1]	Potentially Stabilising [1]	Potentially Stabilising [1]	Potentially Stabilising [1]	Potentially Stabilising [1]	Stable [1]
BC3	Poor	Poor	Poor	Poor	Average	Good	Stable [1]	Stable [1]	Stable [1]	Stable [1]	Stable [1]	Stable [1]

1 – Monitoring points BC2 and BC3 were relocated slightly from the baseline monitoring.

7 Conclusion and Recommendations

The results of the June 2020 Bettys Creek diversion channel stability and stream health monitoring indicates that the majority of monitoring points have experienced no apparent change from what was observed during the October 2019 assessment. A decrease in conditions occurred at two monitoring points (MBD2 and MBD3) with an increase in stabilisation score observed at BC2. These changes are possibly the result of small subjective differences brought about by a change of assessor for this round of monitoring rather than the result of a significant changes to the creek stability at these locations.

The monitoring identified that some sections of the diversion are currently eroding and are vulnerable to further erosion with areas of significant erosion observed. These areas are generally associated with exposed dispersive sub-soils, which hamper vegetation establishment by the development of a hard surface crust when the soil is dry, and the 'melting' nature of the soil when wet. The diversion is generally stable in most areas but some rill/gully erosion is occurring at some locations where the banks are bare (predominately between monitoring points MBD04 and MBD05). No evidence has been observed to indicate that impacts to the diversion have occurred as a result of Integra Underground operations (including subsidence impacts).

No additional erosion points were identified during the June 2020 assessment based on observations made during the site inspection. However, of note, significant tunnel erosion has occurred within the cracks at several locations (refer to erosion sites E7 and E15) which was not observed during the previous monitoring in October 2019. This tunnel erosion has likely occurred as a result of the several large storm events which took place at the diversion area since the previous monitoring. This erosion is not a result of Integra Underground operations.

Evidence of vehicles crossing during wet conditions also occurred at erosion point E9. SLR recommends that measures be put in place to prevent future vehicle access potentially impacting upon the diversion, especially following rain.

The condition of riparian vegetation remained stable amongst the majority of monitoring sites however, most continue to record 'poor' to 'very poor' condition classes. Key to these results are reduced riparian vegetation width, canopy cover and low levels of native species cover in the mid-storey and groundcover. Many sites have a high abundance of exotic species, including a number of priority weed species.

Comparison of recent and historical aerial photographs indicates that no significant lateral shifts of the diversion have occurred in the 6.5 months during the period between when the photographs were taken. A comparison of recent and historic contour data indicated that the Bettys Creek Diversion levels from the recent December 2019 LIDAR data corresponds fairly well with the December 2018 LIDAR data. Although discrepancies between the datasets suggest that sediment has built up or lost in the diversion over time SLR does not believe this to be the case based on site observations with any minor differences considered to be a result of the minor inaccuracies of the contour data sets. The comparison of recent and historic LIDAR / contour is expected to be more beneficial during future rounds of monitoring as more data becomes available over time.

It is recommended that the stream health and channel stability monitoring program be continued annually, or following completion of future longwall panels for which the Bettys Creek Diversions are in the subsidence zones, as required by PA 08_0101. It is noted that the subsidence footprint of the future panels is progressively further and further from Bettys Creek. The current monitoring method is considered appropriate and should be continued as the basis for future monitoring.

8 References

Land & Water Australia (2005), Rapid Appraisal of Riparian Condition – Version Two (River and Riparian Technical Guideline No. 4a)

Commonwealth Scientific and Research Organisation (CSIRO) (date unknown) - Ephemeral Stream Assessment, date accessed 14/09/09. Available at: http://www.cse.csiro.au/research/ras/efa/resources/ephemeraldrainagelineassessment.pdf

ERM (2009) Integra Underground Coal Project. Flora and Fauna Assessment. June 2009. Environmental Resources Management Australia, Thornton.

DPIE (2020) BioNet Vegetation Classification. NSW Department of Planning, Industry and Environment. Available at http://www.environment.nsw.gov.au/research/Visclassification.htm

APPENDIX A

Rapid Appraisal of Riparian Condition Data Sheets

Rapid Appraisal of Riparian Condition

Site Number: MBD01

Site: Betty's Creek
GPS start: S 32.44653°
Date: 02.06.2020
Observer: DM
GPS end: E 151.09594°

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	5	20	3
2	6	10	2
3	5	35	3
4			
Average			2.666666667

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	2	1	1	3
2	1	1	2	2	1	1	3
3	2	2	2	2	3	1	3
4							
Average	1.666666667	1.666666667	2	2	1.666666667	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	3	3	1	0	1
2	1	1	1	0	1
3	2	2	1	0	1
4					
Average	2	2	1	0	1

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	0
2	1	1	0	1
3	1	1	1	0
4				
Average	1	1	0.333333333	0.333333333

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD01

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	2.666666667

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.666666667	1.666666667	2	2	1.666666667	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	2	2	1	0	1

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	1	0.333333333	0.333333333

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)						
	7.666666667	8.333333333	4.666666667	6	2.666666667	29.33333333

Rapid Appraisal of Riparian Condition

Site Number: MBD02

Site: Betty's Creek
GPS start: 313709 E 6388933 N
Date: 02.06.2020
Observer: DM
GPS end:

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	3	15	2
2	3	25	3
3	4	18	2
4			
Average			2.333333333

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	1	1	2	2	1	1	3
2	1	1	2	2	1	1	3
3	1	1	2	2	1	1	3
4							
Average	1	1	2	2	1	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	3	3	0	0	2
2	1	1	1	0	1
3	3	3	0	0	1
4					
Average	2.333333333	2.333333333	0.333333333	0	1.333333333

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	1
2	1	1	1	1
3	1	1	1	1
4				
Average	1	1	0.666666667	1

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD02

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	2.333333333

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1	1	2	2	1	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	2.333333333	2.333333333	0.333333333	0	1.333333333

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	1	0.666666667	1

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	7.333333333	7	4	6.333333333	3.666666667	28.33333333

Rapid Appraisal of Riparian Condition

Site Number: MBD03

Site: Betty's Creek **GPS start:** 317163 E, 6384527 N

Date: 02.06.2020 **Observer:** DM **GPS end:**

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	2	20	3
2	3	15	2
3	4	12	2
4			
Average			2.333333333

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	2	1	1	3
2	1	1	2	2	1	1	3
3	1	1	2	2	2	1	3
4							
Average	1.333333333	1.333333333	2	2	1.333333333	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	0	0	1
2	1	1	0	0	1
3	1	1	1	0	0
4					
Average	1	1	0.333333333	0	0.666666667

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	1
2	1	1	0	1
3	1	1	0	1
4				
Average	1		0	1

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD03

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	2.333333333

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.333333333	1.333333333	2	2	1.333333333	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	0.333333333	0	0

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1		0	0

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	7.333333333	7.666666667	7	2.333333333	1	25.33333333

Rapid Appraisal of Riparian Condition

Site Number:	MBD04

Site:	**Betty's Creek**			**GPS start:**	**322746 E, 6385819 N**
Date:	**02.06.2020**	**Observer:**	**DM**	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	2

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	6	8	1
2	5	15	2
3	5	8	1
4			
Average			1.333333333

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	1	1	2	2	1	1	3
2	1	1	2	2	1	1	3
3	1	1	2	2	1	1	3
4							
Average	1	1	2	2	1	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	0	0	0
2	1	1	1	0	1
3	1	1	1	0	0
4					
Average	1	1	0.666666667	0	0.333333333

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	0
2	1	1	0	0
3	1	1	0	1
4				
Average	1	1	0	0.333333333

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD04

Longitudinal continuity of riparian canopy vegetation

Score
2

Width of riparian canopy vegetation

Average	1.333333333

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1	1	1	1	1	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	0.666666667	0	0

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	0	0	0

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	4.333333333	6	3	2.666666667	1	17

Rapid Appraisal of Riparian Condition

Site Number:	MBD05

Site:	**Betty's Creek**	**GPS start:**	**323779 E, 6388119 N**
Date:	**02.06.2020** **Observer:** **DM**	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	1

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	6	4	0
2	5	6	1
3	6	3	0
4			
Average			0.333333333

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	1	1	1	1	3	1	3
2	2	2	1	1	2	1	3
3	1	1	0	0	2	1	2
4							
Average	1.333333333	1.333333333	0.666666667	0.666666667	2.333333333	1	2.6666667

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	0	0	1
2	3	3	1	0	1
3	1	1	1	0	1
4					
Average	1.666666667	1.666666667	0.666666667	0	1

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	0	1	1	1
2	1	1	0	1
3	0	1	0	0
4				
Average	0.333333333	1	0.333333333	0.666666667

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD05

Longitudinal continuity of riparian canopy vegetation

Score
3

Width of riparian canopy vegetation

Average	1

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.333333333	1.333333333	0.666666667	0.666666667	2.333333333	1	2.6666667

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1.666666667	1	0.666666667	0	0

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	0.333333333	1	0.333333333	0

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	5	7	3	3.333333333	1.666666667	20

Rapid Appraisal of Riparian Condition

Site Number:	MBD06

Site:	**Betty's Creek**			**GPS start:**	**321984 E, 6411817 N**
Date:	**02.06.2020**	**Observer:**	**DM**	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	0

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	5	4	0
2	5	8	1
3	5	20	3
4			
Average			1.333333333

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	1	1	2	2	1	1	3
2	1	1	2	2	2	1	3
3	1	1	1	1	1	1	3
4							
Average	1	1	1.666666667	1.666666667	1.333333333	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	1	0	1
2	1	1	0	0	1
3	1	1	0	0	1
4					
Average	1	1	0.333333333	0	1

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	1
2	1	1	0	1
3	1	1	0	0
4				
Average	1	1	0	0.666666667

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MBD06

Longitudinal continuity of riparian canopy vegetation

Score
1

Width of riparian canopy vegetation

Average	1

Proximity

Score
2

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1	1	1.666666667	1.666666667	1.333333333	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	0.333333333	0	1

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	1	0	0.666666667

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	4	7	3.666666667	3.333333333	2.666666667	20.66666667

Rapid Appraisal of Riparian Condition

Site Number: BC01

Site: Betty's Creek
GPS start: S 32.44653° E 151.09594°
Date: 02.06.2020
Observer: DM
GPS end:

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	2.5

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	3	30	3
2	3	15	2
3	6	0	0
4			
Average			1.666666667

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
3

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	2	3	1	3
2	2	2	2	2	3	1	3
3	0	0	0	0	3	1	1
4							
Average	1.333333333	1.333333333	1.333333333	1.333333333	3	1	2.333333

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	2	2	1	0	1
2	2	2	0	0	1
3	1	1	0	0	1
4	0				
Average	1.25	1.666666667	0.333333333	0	1

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	0	0	0
2	1	0	0	0
3	0	0	0	0
4				0
Average	0.666666667	0	0	0

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BC01

Longitudinal continuity of riparian canopy vegetation

Score
1

Width of riparian canopy vegetation

Average	2

Proximity

Score
3

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.333333333	1.333333333	1.333333333	1.333333333	3	1	2.333333

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1.25	1.666666667	0.333333333	0	1

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	0.666666667	0	0	0

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	6	8	3.666666667	4.25	0.666666667	22.58333333

Rapid Appraisal of Riparian Condition

Site Number: BC02

Site: Betty's Creek
GPS start: 321966 E, 6385379 N
Date: 03.06.2020
Observer: DM
GPS end:

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	4	40	4
2	3	40	4
3	2	>40	4
4			
Average			4

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m
Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
3

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	1	3	1	3
2	2	2	2	1	3	1	3
3	1	1	2	1	3	1	3
4							
Average	1.666666667	1.666666667	2	1	3	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%
Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	1	0	2
2	1	1	1	0	1
3	1	1	1	0	1
4					
Average	1	1	1	0	1.333333333

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%
Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present
Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	0
2	1	0	0	0
3	1	1	0	1
4				
Average	1	0.666666667	0	0.333333333

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage
Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BC02

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	4

Proximity

Score
3

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.666666667	1.666666667	2	1	3	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	1	0	1.333333333

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	0.666666667	0	0.333333333

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	11	9.666666667	3.666666667	4.333333333	2	30.66666667

Rapid Appraisal of Riparian Condition

Site Number: BC03

Site: Betty's Creek **GPS start:** 321966 E, 6385379 N

Date: 03.06.2020 **Observer:** DM **GPS end:**

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	3	40	4
2	2	40	4
3	3	40	4
4			
Average			4

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
3

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	2	3	1	3
2	1	1	2	2	3	1	3
3	2	2	2	2	3	1	3
4							
Average	1.666666667	1.666666667	2	2	3	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	1	0	2
2	2	2	1	0	2
3	1	1	1	0	1
4					
Average	1.333333333	1.333333333	1	0	1.666666667

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	1	0	0
2	2	1	0	0
3	1	1	0	0
4				
Average	1.333333333	1	0	0

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BC03

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	4

Proximity

Score
3

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	2	2	2	2	2	2	2

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	2	2	2	2	2

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1.333333333	1	0	0

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)						
	A+B+C	D+E+F+G	H+I+J	K+L+M+N+O	P+Q+R+S	
	11	8	6	10	2.333333333	37.33333333

APPENDIX B

Integra CSIRO Ephemeral Stream Assessment Database

Site Number	Distance US/DS from Survey Peg (m)	Date of Monitoring Assessor Channel Characteristic	May-17 SLR Rating	May-18 SLR Rating	Oct-18 SLR Rating	May-19 SLR Rating	Oct-19 SLR Rating	Jun-20 SLR Rating
MBD1	0m (At Survey Peg)	Vegetation on D/L Floor	3	3	3	3	3	3
		Vegetation on D/L Walls	3	3	3	3	3	3
		Shape of D/L Cross-Section	4	4	4	4	4	4
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	4	4	4	4	4
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	4
		Sum of Ratings	26	26	26	26	26	26
		Activity Rating	81	81	81	81	81	81
		Classification	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
MBD2	0m (At Survey Peg)	Vegetation on D/L Floor	1	1	1	2	2	1
		Vegetation on D/L Walls	2	2	2	3	3	3
		Shape of D/L Cross-Section	3	3	3	3	3	3
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	4	4	4	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	4
		Sum of Ratings	22	22	22	24	23	22
		Activity Rating	69	69	69	75	72	69
		Classification	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Stable	Stable	Potentially Stabilising
MBD3	0m (At Survey Peg)	Vegetation on D/L Floor	1	1	1	1	1	1
		Vegetation on D/L Walls	3	3	3	3	3	3
		Shape of D/L Cross-Section	4	4	4	4	4	3
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	4	4	4	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	3
		Sum of Ratings	24	24	24	24	23	21
		Activity Rating	75	75	75	75	72	66
		Classification	Stable	Stable	Stable	Stable	Stable	Potentially Stabilising
MBD4	0m (At Survey Peg)	Vegetation on D/L Floor	3	3	3	3	3	3
		Vegetation on D/L Walls	1	1	1	2	2	2
		Shape of D/L Cross-Section	2	2	2	3	3	3
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	1	1	1	1	1	1
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	4
		Sum of Ratings	19	19	19	21	21	21
		Activity Rating	59	59	59	66	66	66
		Classification	Active	Active	Active	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising
MBD5	0m (At Survey Peg)	Vegetation on D/L Floor	2	2	2	2	2	2
		Vegetation on D/L Walls	3	3	3	3	3	3
		Shape of D/L Cross-Section	4	4	4	4	4	4
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	3	3	3	3	3	3
		Nature of D/L Wall Materials	4	4	4	4	4	4
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	3
		Sum of Ratings	27	27	27	27	27	26
		Activity Rating	84	84	84	84	84	81
		Classification	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
MBD6	0m (At Survey Peg)	Vegetation on D/L Floor	2	2	2	2	2	2
		Vegetation on D/L Walls	1	1	1	1	2	2
		Shape of D/L Cross-Section	3	3	3	3	3	3
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	4	4	4	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	4
		Sum of Ratings	22	22	22	22	22	22
		Activity Rating	69	69	69	69	69	69
		Classification	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising
MBD7	0m (At Survey Peg)	Vegetation on D/L Floor	3					
		Vegetation on D/L Walls	3					
		Shape of D/L Cross-Section	4					
		Longitudinal Morphology	3					
		Particle Size of Materials on Floor	1	NA	NA	NA	NA	NA
		Nature of D/L Wall Materials	4					
		Nature and Shape of Bank Edge	4					
		Nature of Lateral Flow Regulation	4					
		Sum of Ratings	26					
		Activity Rating	81					
		Classification	Very Stable	No Assessment Undertaken	No Assessment Undertaken	No Assessment Undertaken	No Assessment Undertaken	No Assessment Undertaken
BC1	0m (At Survey Peg)	Vegetation on D/L Floor	1	1	1	1	1	1
		Vegetation on D/L Walls	3	3	3	3	3	3
		Shape of D/L Cross-Section	5	5	5	5	5	5
		Longitudinal Morphology	2	2	2	2	2	2
		Particle Size of Materials on Floor	2	2	2	2	2	2
		Nature of D/L Wall Materials	4	4	4	4	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	5
		Sum of Ratings	25	25	25	25	24	25
		Activity Rating	78	78	78	78	75	78
		Classification	Stable	Stable	Stable	Stable	Stable	Stable
BC2	0m (At Survey Peg)	Vegetation on D/L Floor	1	1	1	1	1	1
		Vegetation on D/L Walls	3	1	1	3	3	3
		Shape of D/L Cross-Section	4	3	3	3	3	3
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	3	3	3	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	4	4	4	4	4	5
		Sum of Ratings	24	20	20	22	22	23
		Activity Rating	75	63	63	69	69	72
		Classification	Stable	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Stable
BC3	0m (At Survey Peg)	Vegetation on D/L Floor	1	1	1	1	1	1
		Vegetation on D/L Walls	3	2	2	3	3	2
		Shape of D/L Cross-Section	4	4	4	4	4	4
		Longitudinal Morphology	3	3	3	3	3	3
		Particle Size of Materials on Floor	1	1	1	1	1	1
		Nature of D/L Wall Materials	4	4	4	4	3	3
		Nature and Shape of Bank Edge	4	4	4	4	4	4
		Nature of Lateral Flow Regulation	5	5	5	5	5	5
		Sum of Ratings	25	24	24	25	24	23
		Activity Rating	78	75	75	78	75	72
		Classification	Stable	Stable	Stable	Stable	Stable	Stable

APPENDIX C

Desktop Diversion Contour Analysis Results

0.0 100 200 300 400 METRE

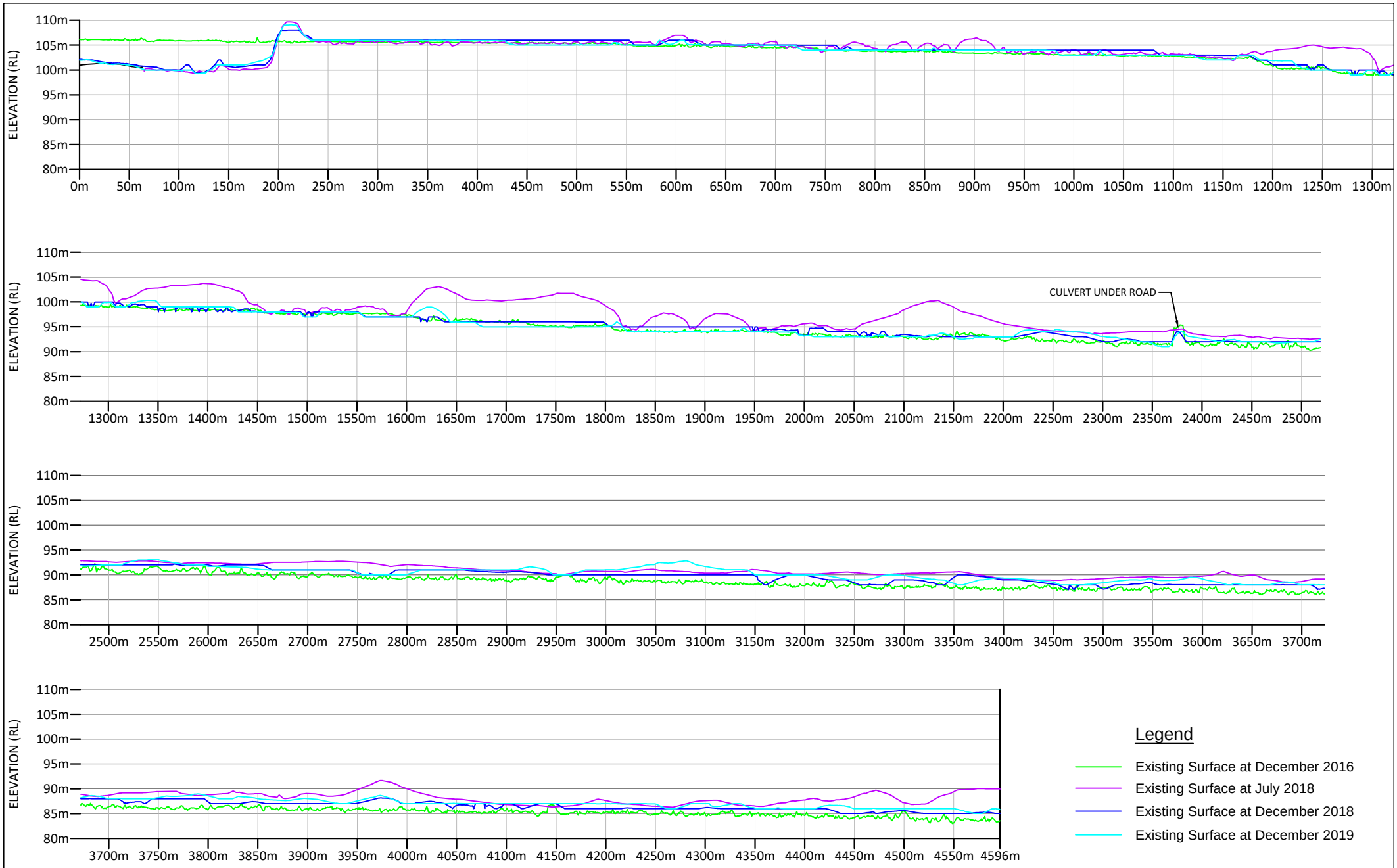
630.12766_BASE_LongSections 20200629.dwg

N

Bettys Creek Diversion Plan

Appendix C

SLR
www.slrconsultingaustralia.com PH: 61 2 4037 3200



630.12766_BASE_LongSections 20200629.dwg

Bettys Creek Longsection

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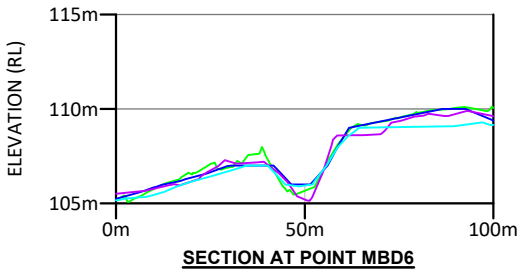
Appendix C



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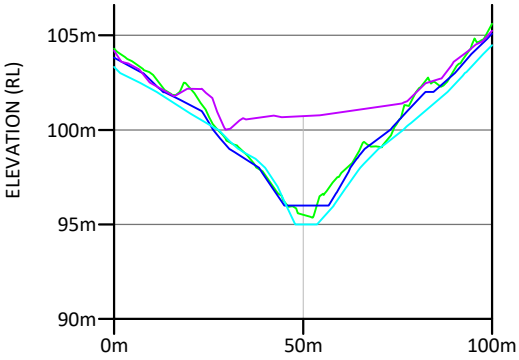

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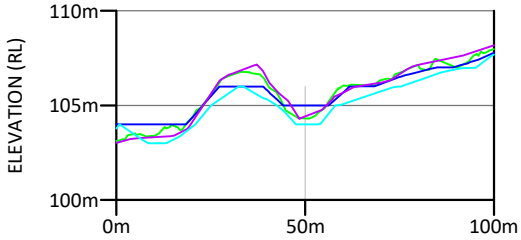

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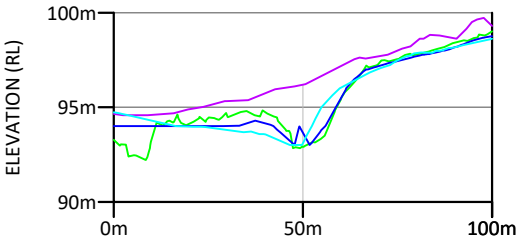

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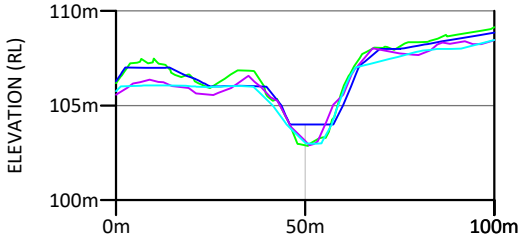
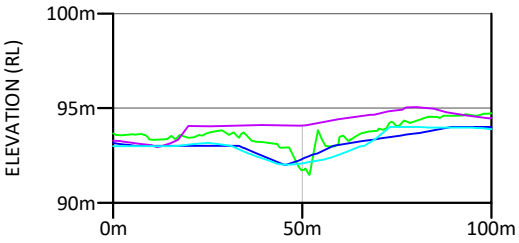
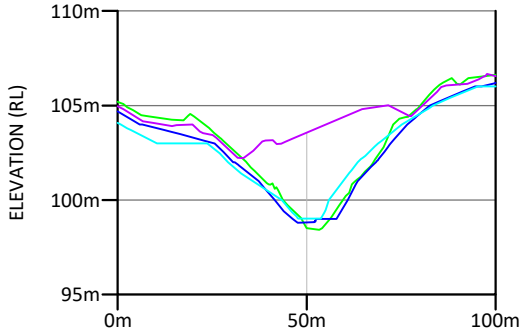


SECTION AT POINT MBD4



SECTION AT POINT BC1



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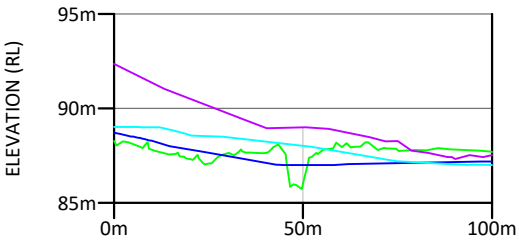

SECTION AT POINT BC2

Legend

- Existing Surface at December 2016
- Existing Surface at July 2018
- Existing Surface at December 2018
- Existing Surface at December 2019

N

Bettys Creek Sections

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Appendix C

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