APPENDIX 4

Surface Water Assessment

Inspired people | Dedicated team
Quality outcomes

ULAN WEST MODIFICATION

Surface Water Assessment

February 2015

ULAN WEST MODIFICATION

Surface Water Assessment

February 2015

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Ulan Coal Mines Limited

Project Director:	**Barbara Crossley**
Project Manager:	**Kirsty Davies**
Technical Project Director:	**Susan Shield**
Report No.	**3363/R05/Final**
Date:	**February 2015**

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 Introduction

The Ulan Coal Complex is operated by Ulan Coal Mines Limited (UCML) and located approximately 1.5 kilometres north-east of the village of Ulan, within the Mid Western Regional Council Local Government Area (LGA). The Ulan Coal Complex is located approximately 38 kilometres north-north-east of Mudgee and approximately 19 kilometres north-east of Gulgong in New South Wales (refer to **Figure 1.1**). The UCML landholdings comprise a total of approximately 17,960 hectares, located at the headwaters of the Goulburn River and Talbragar River catchments.

Mining at the Ulan Coal Complex has been undertaken since the early 1920s, with the current open cut and underground mining operations commencing in 1982 and 1986 respectively.

UCML was granted Project Approval (PA) 08_0184 under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 15 November 2010 for the Ulan Coal – Continued Operations Project (UCCO Project). PA 08_0184 allows for continued mining for 21 years from approval with a production rate of up to 20 million tonnes per annum (Mtpa). Since November 2010 a number of modifications and a first working approval to the PA 08_0184 have been granted (refer to **Section 1.2**).

UCML is seeking to modify the approved Ulan West underground operations to provide access to additional coal resources within existing mining titles and allow for a realignment of approved longwall panels as a result of previous modifications (refer to **Figure 1.2**).

UCML has an existing exploration licence (EL 7542) which covers an area south-west and an area to the north of the currently approved Ulan West mine plan (refer to **Figure 1.3**). Since the granting of PA 08_0184 in 2010, exploration activities have been undertaken within existing mining leases and the southern portion of EL 7542. This exploration process has further characterised the coal resource as well as provided additional detailed information on other geological features within this area. At Ulan West a fault had previously been interpreted close to the western boundary of the existing mining lease. The location of this east-west trending fault was previously interpreted to limit the ability to mine south of the currently approved main headings of Ulan West. The further exploration activities completed in the southern portion of EL7542 have more accurately mapped the location of the fault and determined that the feature lies further south than previously interpreted.

UCML has determined that there is a valuable mineable resource within MLA475 and seek to modify the current project approval to enable access to this coal resource by extending the longwall panels in this area. A mining lease application (MLA475) has been lodged for the southern portion of the EL 7542 with the NSW Trade and Investment – Division of Resources and Energy (DRE) (hereafter referred to as MLA475) (refer to **Figure 1.2**).

An Environmental Assessment (EA) has been prepared for the proposed modification to the currently approved mining operation (PA 08_0184). This Surface Water Assessment forms a component of the EA. The Surface Water Assessment also considers cumulative impacts of the Project with the currently approved development, including the previous modifications to the Ulan West mine plan since the November 2010 Project Approval (refer to **Section 1.2**).

FIGURE 1.1

Locality Map

umwelt

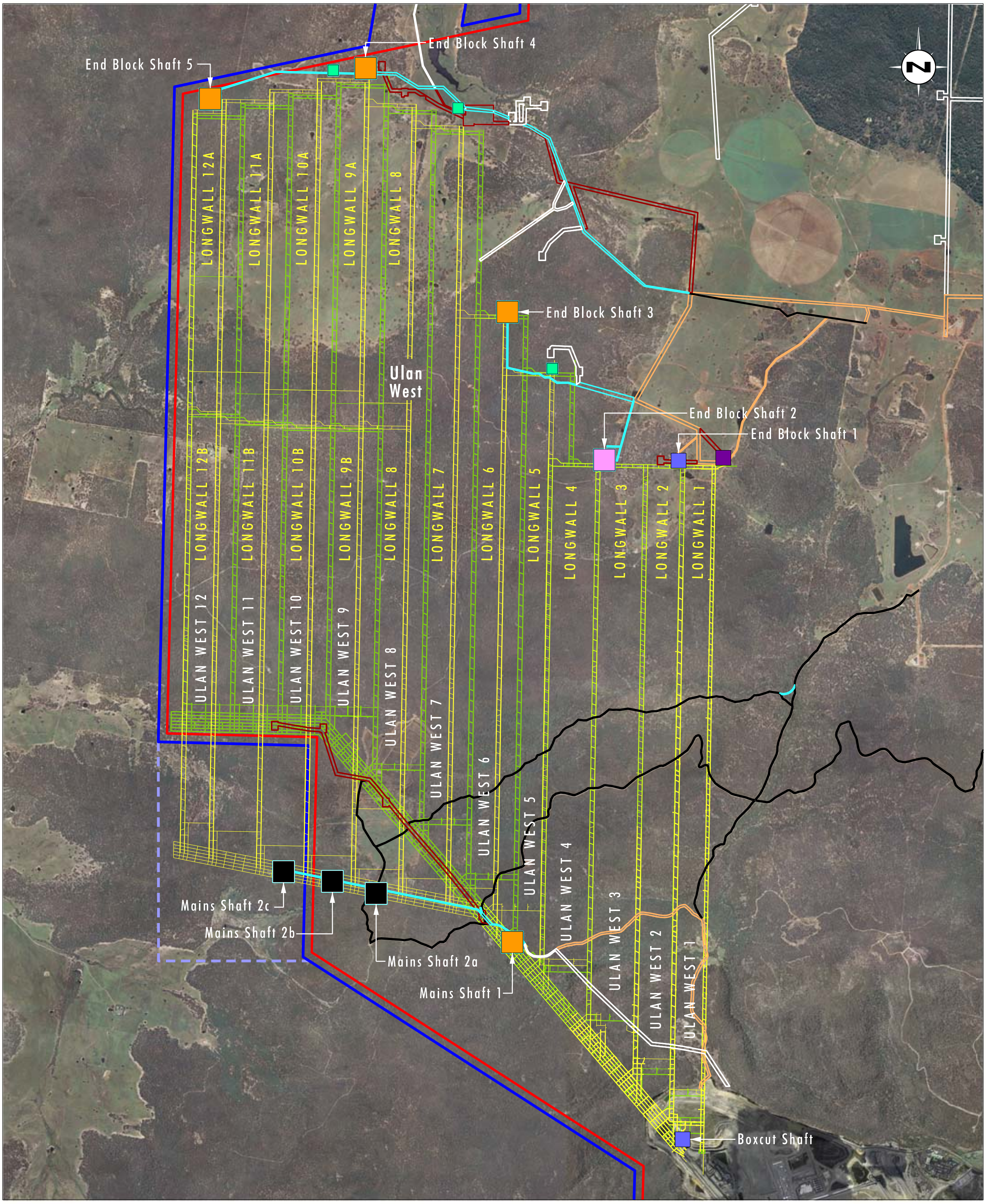


Image Source: Ulan Coal (2008, 2010, 2014)
Data Source: Ulan Coal (2014)

0 1.0 2.0 2.5km
1:50 000

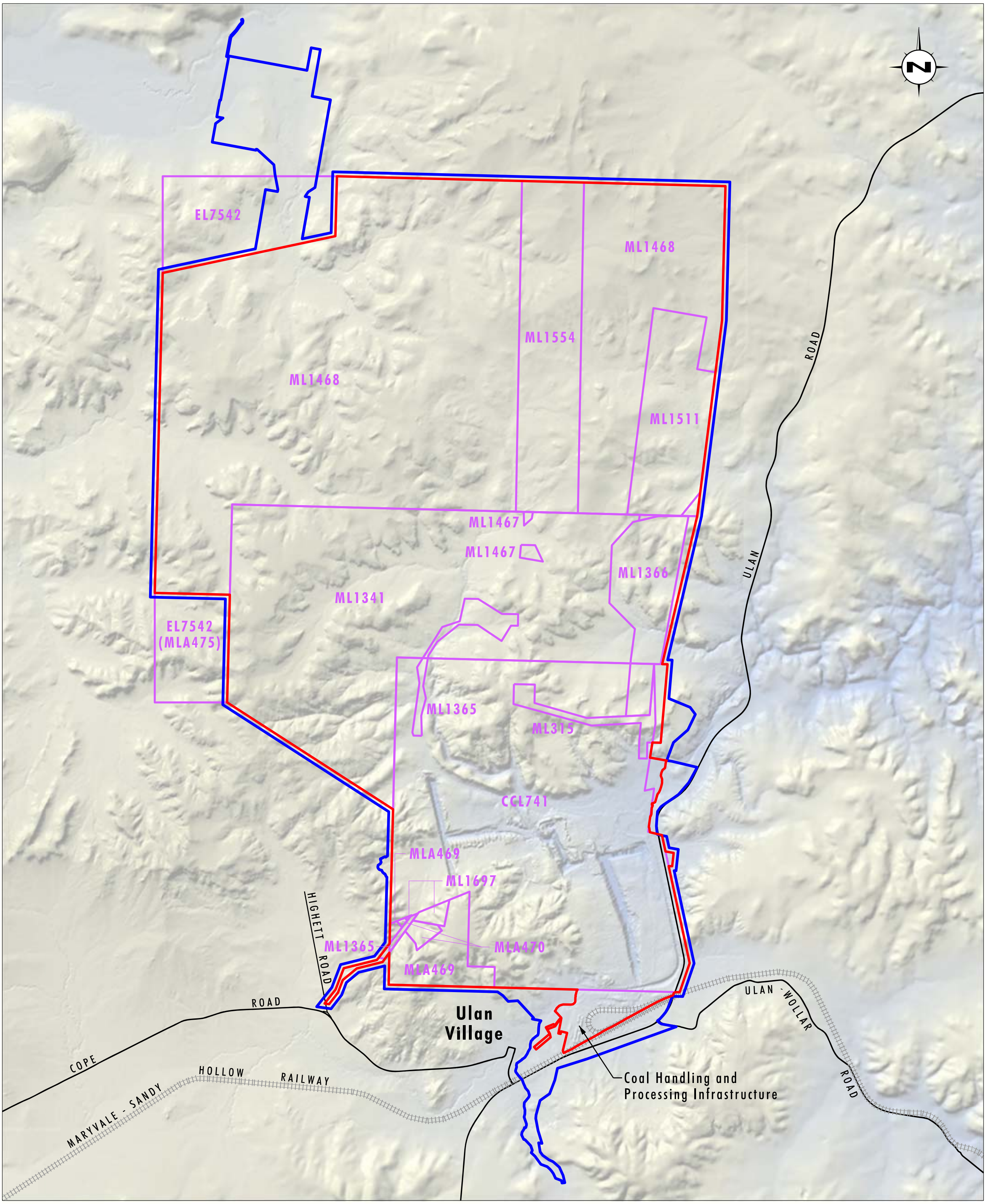
Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Approved Infrastructure Corridor
- Approved Infrastructure Corridor Not to be Constructed
- Proposed Infrastructure Corridor
- Constructed Infrastructure Corridor
- Existing Access Road
- Existing Vent Shaft Compound
- Existing Dewatering Bore Compound
- Proposed Realigned Dewatering Bore Compound
- Proposed New Ventilation Shaft Compound
- Proposed Realigned Ventilation Shaft Compound
- Potential Location of Realigned Ventilation Shaft Compound

FIGURE 1.2

Proposed Ulan West Modification

File Name (A4): R05/3363_035.dgn
20141210 15.30



Data Source: Ulan Coal (2014)

0 1.0 2.5 5.0km
1:100 000

Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- Mine Lease Boundary

FIGURE 1.3

Existing Mining and Exploration Lease Titles

1.1 Proposed Modification

As described in **Section 1.0**, UCML has an existing exploration lease (EL 7542) over an area south west and an area to the north of the currently approved Ulan West mine plan (refer to **Figure 1.3**). Since the approval of PA 08_0184 in 2010, exploration activities have been undertaken within existing mining leases and the southern portion of EL 7542. Further exploration activities have more accurately mapped the location of a geological fault that was previously interpreted as a constraint to mining in the southern portion of EL 7542. This exploration has determined that the feature lies further south than previously interpreted. UCML has determined that there is a viable resource within this area that can be efficiently accessed through a change to the existing Ulan West mine plan.

UCML is proposing to modify PA 08_0184 to allow for changes to the Ulan West mine plan to ensure efficient and optimised extraction of the coal resource. More specifically these changes include re-orientating the main headings further to the south and the southern extension of longwalls LW 6 to LW 12 by between 900 metres and 1300 metres within existing mining titles and MLA 475 to the Ulan West longwall layout, the main headings need to be turned after longwall LW 5 (refer to **Figure 1.2**).

During 2013, UCML was granted approval by the NSW Department of Planning & Environment (DP&E) under the provisions of Condition 25 of PA 08_0184 and by the DRE to undertake first workings to widen longwall panels LW 3 and LW 4 from 300 metres to 400 metres wide. The proposed modification includes the repositioning of longwall panels LW 5 to LW12 which is required as a result of the previous changes to LW 3 and LW 4 (refer to **Figure 1.2**). Some minor changes to the northern extent of the Ulan West longwall panels are also required through this realignment process. The proposed repositioning to the west of LW 5 to LW 12 will generally be within the existing mining footprint and present minimal change to approved environmental impacts.

The proposed modification will produce approximately 13 million tonnes of additional coal and extend the life of the Ulan Coal Complex by approximately 2 years. The currently approved Ulan West mining area covers approximately 3060 hectares. The proposed modification will extend this by approximately 275 hectares.

The key components of the proposed modification are outlined in **Table 1.1**.

Table 1.1 – Proposed Ulan West Modification

Aspect	Currently Approved	Proposed Modification
Mine Life	21 year life until 30 August 2031	Additional 2 years until 30 August 2033
Limits on Extraction	20 million tonnes of coal per annum (including maximum of 4.1 Mtpa ROM from Open Cut)	No change
Operating Hours	24 hours per day, 7 days per week	No change
Workforce Numbers	Approximately 931 people (Complex)	No change
Mine Plan	As shown in **Figure 1.2**	Realignment of LW 5 to LW 12 including a reduction of LW 5 by approximately 170 metres and an extension of LW 6 to LW 12 between 900 metres and 1300 metres as shown in **Figure 1.2**
Mining Method	Ulan West – retreat longwall method	No change

Table 1.1 – Proposed Ulan West Modification (cont)

Aspect	Currently Approved	Proposed Modification
Surface Infrastructure	As per Continued Operations Project EA	Changes to Ulan West infrastructure including repositioning of approved dewatering bores and ventilation shafts, and additional shafts and associated infrastructure for Ulan West mine plan
Ulan Complex Coal Handling and Preparation Plant	As per Continued Operations Project EA	No change
Coal Transportation	All coal transported from the site by rail. No more than 10 laden trains leave the site each day.	No change

1.2 Previously Approved Modifications

Following granting of PA 08_0184, there have been number of approved modifications to the UCML project approval, details of these modifications are outlined in **Table 1.2**.

Table 1.2 – Approved Modifications to Project Approval 08_0184

Modification	Description of Modification
Modification 1	Longwall extraction in the North 1 mining area. Modification of the Approved Ulan No.3 and Ulan West mine plans. Construction and operation of a Concrete Batch Plant.
Modification 2	Modify Ulan West Longwall 1 to Longwall 5. Remove restrictions on construction blasts. Minor amendments to European and natural heritage sites where blasting performance measures are applicable.
First Workings Approvals	Removal of barrier pillar from Ulan No.3 mine plan. Change to the first workings to increase the width of Ulan West Longwall 3 and Longwall 4. Change to extend Ulan No.3 Longwall 28 and Longwall 29. Change to width of development panels at Ulan No.3.

The modifications principally included minor modifications to the early stages of the Ulan West mine plan. The subsidence and surface water assessments undertaken for the modifications considered the localised impacts of the modifications.

The proposed modification to the Ulan West mine plan includes changes to the longwall locality and geometry throughout the Ulan West underground mining area. As a result, the approved (November 2010) subsidence predictions (Strata Control Technologies (SCT), 2009) for the whole of the Ulan West underground mining area have been updated to include both the previously approved modifications and the proposed modification (SCT, 2014).

The Surface Water Assessment also considers cumulative impacts of the Project with the currently approved development, including the previous modifications to the Ulan West mine plan since the November 2010 Project Approval (refer to **Section 1.0**).

1.3 Water Planning Context

The proposed modification has been assessed against the relevant requirements of the following water planning policies/plans and legislation:

- *Water Management Act 2000;*
- *Water Act 1912;*
- *Protection of the Environment Operations Act 1997;*
- State Water Management Outcomes Plan (SWMOP) (Department of Natural Resources (DNR, undated);
- Hunter-Central Rivers Catchment Action Plan (CAP);
- Water Reporting Requirements for Mines (NSW Office of Water (NOW), 2009);
- Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region (Department of Water and Energy (DWE), undated); and
- River Hydrology and Energy Relationships - Design Notes for the Mining Industry (DWE, 2007).

The details of the assessment against the SWMOP and CAP are included in **Section 6.4.1** of this document. The details of the assessment against the *Water Management Act 2000* and the *Water Act 1912* are included in **Section 6.4.2**.

1.4 Potential Surface Water Impacts

The following are the key aspects of the proposed modification that have the potential to impact on surface water resources:

- changes in subsidence resulting from the modification to the Ulan West mine plan;
- potential remediation works required within the predicted subsidence affectation area;
- potential surface water impacts associated with realigned surface infrastructure associated with the modified mine plan; and
- changes to the Ulan Coal Complex water balance associated with the changes to the Ulan West mine plan.

The potential impacts of the proposed modification are discussed in **Sections 4.0** and **5.0** and summarised in **Section 6.0**.

1.5 Predicted Subsidence Impacts

Subsidence predictions for the proposed modification to the approved Ulan West underground mining area and the potential range of impacts resulting from the predicted subsidence have been documented by Strata Control Technologies (SCT, 2014) (refer to Appendix 2 of the EA). The predicted subsidence affectation area, defined by the

20 millimetre subsidence line, is shown on **Figure 1.4**. The subsidence predictions (SCT, 2014) for the proposed modification to the approved Ulan West mine plan are typically consistent with the predicted subsidence for the approved Ulan West mine plan, with maximum predicted vertical subsidence of up to approximately 2.0 metres. The proposed modification includes additional subsidence impacts due to the proposed southern extension of Longwalls LW 7, LW 8, LW 9B, LW 10B, LW 11B and LW 12B.

Two predicted subsidence sets were considered in this surface water assessment:

- predicted subsidence associated with the approved mine plan (SCT, 2009); and
- predicted subsidence associated with the proposed modification to the UIan West mine plan (SCT, 2014).

This Surface Water Assessment includes an assessment of the potential surface water impacts associated with the proposed modification to the Ulan West mine plan relative to the approved Ulan Coal Complex mine plan November 2010).

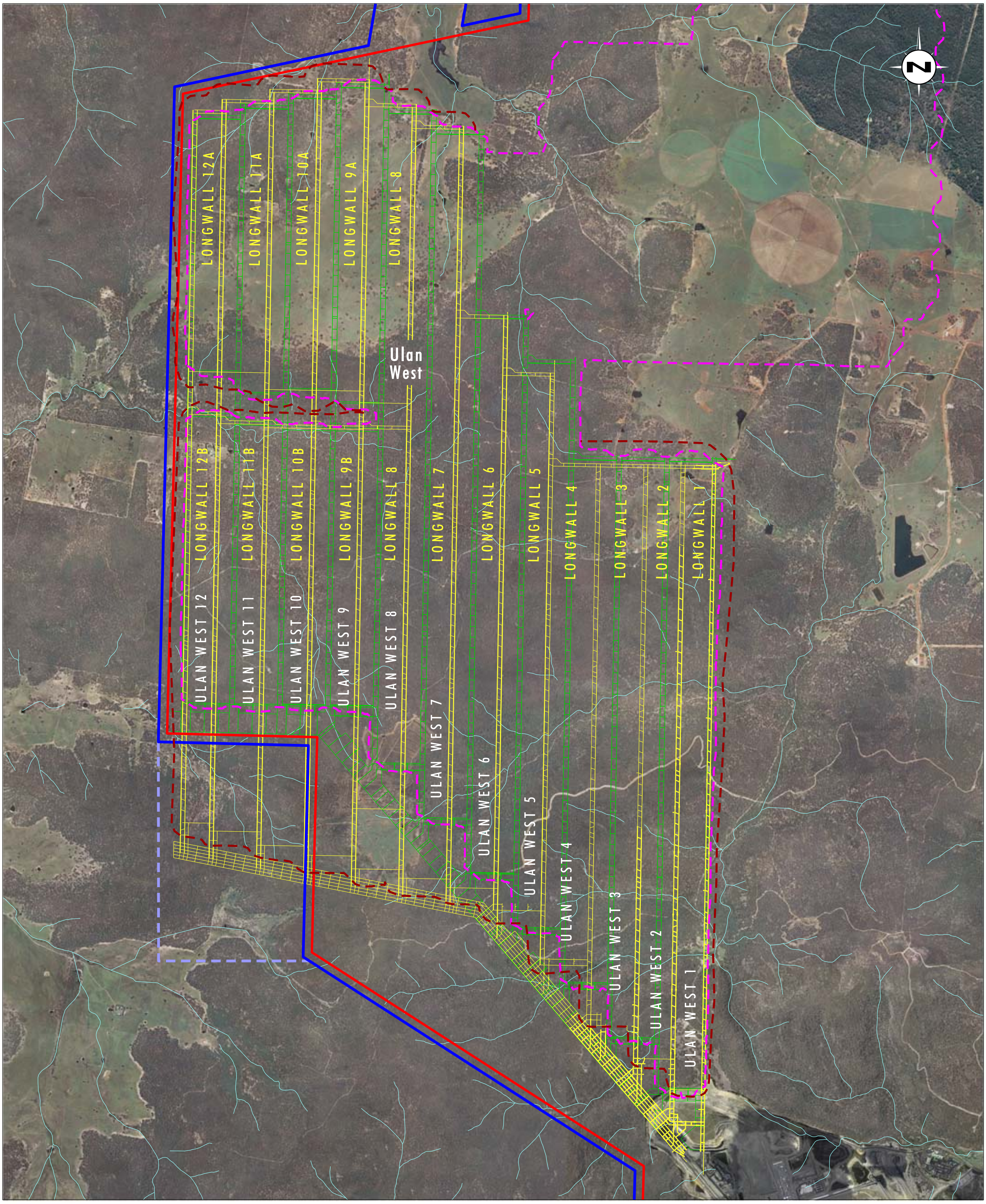


Image Source: Ulan Coal (2008, 2010, 2014)
Data Source: Ulan Coal (2014)

0 1.0 2.0 2.5km
1:50 000

Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved (November 2010) Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Predicted 20 mm Subsidence Contour (Approved November 2010)
- Predicted 20 mm Subsidence Contour (Proposed)

FIGURE 1.4

Predicted Subsidence Affectation Areas Predicted 20 mm Subsidence Contour

File Name (A4): R05/3363_014.dgn
20141112 10.12

2.0 Surface Water Context

Both the approved and proposed Ulan West underground mining areas are located within the Mona Creek, Cockabutta Creek and Ulan Creek catchments (refer to **Figure 2.1**). The Ulan Creek catchment is part of the Goulburn River system while the Mona Creek and Cockabutta Creek catchments are part of the Talbragar River system. The Great Dividing Range separates the Goulburn River and Talbragar River systems, with the Goulburn River system draining east to the Hunter River Catchment and the Talbragar River system draining west to the Macquarie River Catchment and eventually the Murray River. All of the tributaries within the approved and proposed Ulan West underground mining areas are ephemeral by nature.

A number of unnamed tributaries of Mona Creek, Cockabutta Creek and Ulan Creek lie within the predicted subsidence affectation area of the approved Ulan West underground mining area (refer to **Figure 2.1**), however the main channels of each of these watercourses are all outside of the predicted subsidence affectation area. The tributaries of Mona Creek, Cockabutta Creek and Ulan Creek within the approved and proposed Ulan West underground mining areas typically have small catchment areas and are ephemeral with flows only occurring during storm events or after periods of prolonged rainfall. Many of the watercourses within the predicted subsidence affectation area do not have well defined channels. DTMs based on LiDAR data have been used to identify the detailed alignment of watercourses provided by LPI within the Ulan West underground mining area (refer to **Section 3.0**).

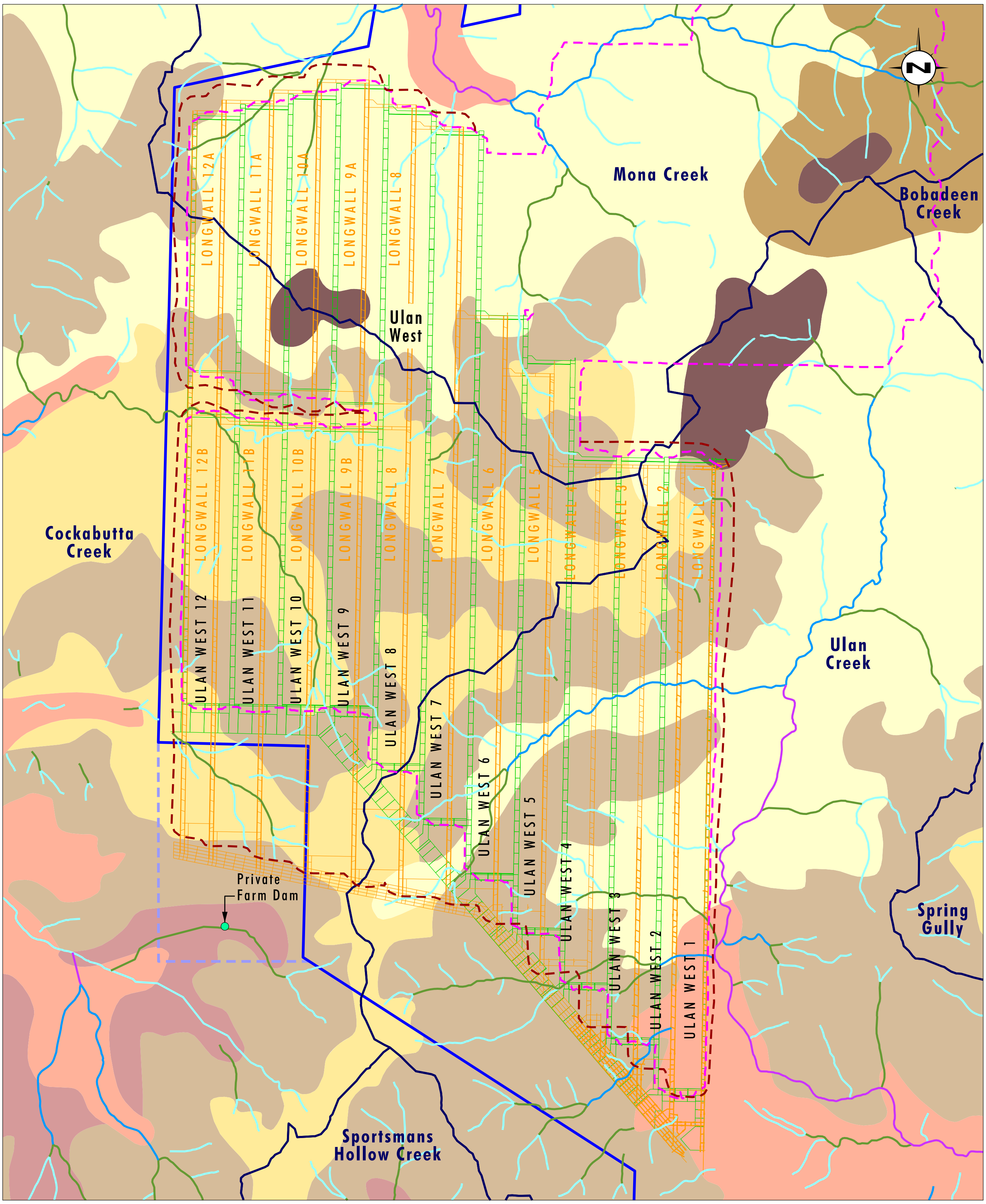
Within the proposed Ulan West underground mining area, the soil landscapes within the Mona Creek, Ulan Creek and Cockabutta Creek catchments include Munghorn Plateau, Lees Pinch, Turill, Ulan, Rouse and Bald Hill soil landscapes (refer to **Figure 2.1**). Each of these soil types is associated with a high erosion hazard. Based on previous site inspections and aerial photograph interpretation, the watercourses within the approved and proposed Ulan West underground mining areas are considered to be in generally good condition. Within the Ulan West underground mining area there are isolated areas of erosion within the bed and banks of some watercourses, including an active head cut within an unnamed tributary of Cockabutta Creek. UCML has previously undertaken works to stabilise sections of the main channel of Ulan Creek, downstream of the approved discharge facility.

The proposed modification to the Ulan West mine plan will undermine approximately 275 hectares of additional land within the eastern portion of the Cockabutta Creek catchment and approximately 8.5 hectares of additional land within the Mona Creek catchment.

Subsidence impacts associated with changes to the location, width and length of the longwalls within the Ulan West mine plan also have the potential to impact catchment boundaries and remnant ponding, as well as longitudinal gradients and stability of watercourses (refer to **Section 4.0**).

A summary of the catchment areas and watercourses within the predicted subsidence affectation area are included in **Table 2.1** and discussed in **Sections 2.1** to **2.3**.

umwelt



Data Source: Ulan Coal (2014), LPI (2012)

0 1.0 2.0 2.5km
1:50 000

Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved (November 2010) Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Catchment Area
- Predicted 20 mm Subsidence Contour (Approved November 2010)
- Predicted 20 mm Subsidence Contour (Proposed)

Soil Landscapes:
- Bald Hill
- Goonoo
- Lees Pinch
- Munghorn Plateau
- Rouse
- Turill
- Ulan

Stream Order:
- 1st Order
- 2nd Order
- 3rd Order
- 4th Order

FIGURE 2.1

Catchments, Watercourses and Soils Landscapes

File Name (A4): R05/3363_011.dgn
20141112 11.17

Table 2.1 - Catchment Areas and Watercourses

Catchment	Catchment Area (hectares)	Catchment Area within Predicted Subsidence Affectation Area (hectares)		Maximum Stream Order [2]	
		Approved	**Proposed**	**Approved**	**Proposed**
Mona Creek	4,720	1,799 [1]	1,862 [1]	Second	Second
Cockabutta Creek	10,330	1,192	1,518	Second	Second
Ulan Creek	3,900	1,205 [1]	1,390 [1]	Third	Third

Notes: 1. Mona Creek and Ulan Creek catchments include the approved subsidence affectation area for the approved Ulan No. 3 underground mining area.
2. Based on Strahler stream ordering of LPI 1:25,000 topographical map series.

2.1 Mona Creek

Numerous first order and two second order unnamed tributaries of Mona Creek lie within the predicted subsidence affectation area of the Ulan West underground mining area (refer to **Figure 2.1**). No additional tributaries of Mona Creek are expected to be impacted as a result of the proposed modification. The proposed modification does however increase the portion of the Mona Creek catchment within the predicted subsidence affectation area by approximately 63 hectares (refer to **Table 2.1**) as a result of the lengthening of LW7, LW8, LW9A, LW10A, LW11A and LW12A.

2.2 Cockabutta Creek

Numerous first order and two second order unnamed tributaries of Cockabutta Creek lie within the predicted subsidence affectation area of the approved Ulan West underground mining area (refer to **Figure 2.1**). The proposed modification includes an additional second order unnamed tributary of Cockabutta Creek within the predicted subsidence affectation area. The proposed modification increases the portion of the Cockabutta Creek catchment within the predicted subsidence affectation area by approximately 326 hectares (refer to **Table 2.1**) as a result of the proposed southern extension of LW 8, LW 9B, LW 10B, LW 11B and LW 12B.

2.3 Ulan Creek

Numerous first order, three second order and two third order unnamed tributaries of Ulan Creek lie within the predicted subsidence affectation area of the approved Ulan West underground mining area (refer to **Figure 2.1**). No additional tributaries of Ulan Creek are expected to be impacted as a result of the proposed modification. The proposed modification increases the portion of the Ulan Creek catchment predicted to be impacted by approximately 185 hectares (refer to **Table 2.1**) as a result of the proposed southern extension of LW 7.

2.4 Downstream Water Users

As discussed in the UCCO Project EA (Umwelt, 2009), the regions downstream of the UCCO Project Approval area are primarily forested within the Goulburn River catchment but also include irrigated pasture/fodder crops within the Talbragar River catchment. Irrigation water along the Talbragar River is primarily sourced from the river, when flowing, and alluvial systems.

A single farm dam is located on a second order tributary of Cockabutta Creek (refer to **Figure 2.1**). The farm dam is located on a private property within the proposed Ulan West modification area but outside of the proposed Ulan West underground mining area. No other privately owned farm dams were identified within the proposed modification area that may be impacted by the proposed modification.

3.0 Assessment Approach

The Surface Water Assessment considers potential impacts of the proposed modification on water flows and water quality by assessing the potential impacts to:

- catchment boundaries;
- remnant ponding; and
- watercourse stability.

Key components of the assessment approach for the Surface Water Assessment are outlined in **Sections 3.1** and **3.2**.

3.1 Digital Terrain Models

Three Digital Terrain Models (DTMs) (pre mining (2006) as used in the UCCO Project EA, approved mine plan (November 2010) and proposed modification) were used to estimate potential changes to catchment boundaries, identify potential changes to remnant ponding within watercourses, and assist in the assessment of watercourse stability. For approved and proposed mining, the DTMs were based on predicted subsidence data provided by SCT (2009 and 2014). DTMs based on LiDAR data provide a means of identifying the detailed alignment of watercourses mapped by LPI within the Ulan West underground mining area.

3.2 Watercourse Stability

The potential changes to watercourse stability were assessed by reviewing the longitudinal grade changes, as well as by hydraulic modelling of watercourses within the predicted subsidence affectation area (refer to **Figure 2.1**).

3.2.1 Longsections

The two DTMs (refer to **Section 3.1**) were used to extract longsections for the watercourses within the Ulan West underground mining area for the approved mine plan and proposed modification. The longsections were extracted for watercourses of first order and above as mapped by NSW LPI with detailed alignments identified using DTMs of the Ulan West underground mining area.

The longsections assisted in the identification of watercourse reaches where the proposed modifications may result in changes to the longitudinal grade of the watercourse which may impact on watercourse stability (refer to **Section 3.2.1.2**) when compared to the approved mine plan impacts.

Charts showing the longsections for the approved mine plan DTM and the proposed modification DTM are included in **Appendix A**.

3.2.2 Hydrodynamic Modelling

Detailed one dimensional (1D) hydrodynamic modelling was used to model the hydraulic response of watercourses within the predicted subsidence affectation area to a range of design storm events. The outputs from the 1D hydrodynamic modelling were used to assess the potential impacts to flow depths, velocities, and tractive stresses within the watercourses predicted to be affected by the proposed modification.

The hydrodynamic modelling undertaken included the development of 1D hydrodynamic models of the unnamed tributaries of Mona Creek, Cockabutta Creek and Ulan Creek within the Ulan West underground mining area. The 1D hydrodynamic models were developed to suit the requirements of the approved mine plan and proposed modifications to the Ulan West mine plan.

Umwelt has previously undertaken 1D hydrodynamic modelling of the main channel and some tributaries of Mona Creek (Umwelt, 2013) and of Ulan Creek (Umwelt, 2012). These existing models were expanded to include all of the tributaries impacted by the proposed Ulan West mine plan and a suitable level of detail to capture predicted subsidence impacts.

The 1D hydrodynamic models were used to estimate the hydraulic response of 13 watercourses within the Ulan West predicted subsidence affectation area (refer to **Section 4.0**). The watercourses modelled were identified as second order watercourses and higher, as mapped by NSW LPI, with topographical details extracted from the two DTMs of the Ulan West underground mining area (refer to **Section 3.1**).

Two landform scenarios were modelled:

- predicted subsided landform for the approved mine plan (November 2010); and
- predicted subsided landform from the proposed modification.

For each of the two DTMs, the hydraulic response for four design storm events was modelled, specifically the 1.5 year, 2 year, 10 year and 20 year Average Recurrence Interval (ARI) critical duration design storm events. This approach is consistent with that used to assess watercourse stability for the North 1 modification (Umwelt, 2011). These events are considered to approximate the bank full and potential overbank flows within the watercourses of the Ulan West underground mining area.

This analysis assisted in the identification of the potential impacts to watercourse stability with the proposed modification using published velocity and tractive stress stability thresholds for bed and bank materials typical of the modelled watercourses (Fischenich, 2001).

Potential changes to watercourse stability may occur in those reaches of the watercourse where the hydraulic modelling indicates a change in the stability threshold for either the velocity or tractive stress. This method identifies potential changes to watercourse stability using both the magnitude of the modelled changes to velocity and tractive stress as well as the bed and bank materials.

A summary of the three bed and bank materials and the corresponding reference velocity and tractive stress thresholds selected is included in **Table 3.1**. These three categories were selected as they provide a reasonable representation of the range of materials observed within the modelled watercourses.

Table 3.1 - Selected Hydraulic Stability Thresholds

Bed and Bank Material	Velocity Threshold (m/s)	Tractive Stress Threshold (N/m^2)
Fine Gravel	0.8	3.6
25 millimetre Cobble	1.5	15.8
Hardpan	1.8	32.1

Source: Adapted from Fischenich (2001)

Charts showing the modelling results for depths are included in **Appendix B**, velocities in **Appendix C** and tractive tresses in **Appendix D**.

4.0 Catchment and Watercourse Impact Assessment

4.1 Subsidence Impacts

The predicted subsidence has the potential to impact surface cracking within watercourses, on remnant ponding, as well as changing catchment boundaries and watercourse longsections.

The soils within the predicted subsidence affectation area along the drainage lines are typically shallow sandy soils. It is considered that there is the potential for cracking, caused by mining subsidence, to connect through the sandy soil layers to the surface. However if cracking does occur through the surface soil layers this cracking may potentially be self healing or require remediation.

The predicted subsidence has limited potential to result in increased remnant ponding, both in or and out of the drainage lines. Historical and recent site inspections indicate that in the majority of areas where the topographical survey indicates existing remnant ponding, water does not pond in these areas as the soils are sandy and relatively free draining. As such, it is considered unlikely, based on the analysis of the predicted subsidence that any additional remnant ponding will occur within the predicted subsidence affectation area. This is due to both the steepness of the existing landform and sandy soils.

The predicted subsidence will result in local changes to the longitudinal slope of watercourses within the subsidence affectation zone. Whilst the magnitude of these changes is consistent with the previously approved subsidence, such changes have the potential to result in local changes to watercourse stability.

The potential changes to catchment boundaries, remnant ponding and watercourse stability within the Mona Creek, Cockabutta Creek and Ulan Creek catchments is discussed in further detail in the sections below.

4.2 Mona Creek Catchment

The proposed modification will result in predicted subsidence within the Mona Creek watercourses (refer to **Figures 4.1**, **4.2** and **4.3**) that is of a comparable magnitude and scale to the predicted subsidence associated with the approved mine plan (SCT, 2014).

4.2.1 Catchment Boundaries

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West mine plan will have negligible impact on the catchment boundaries compared to the approved Ulan West mine plan (refer to **Figure 4.1**) for the Mona Creek catchment area. The analysis indicates that the total catchment area of Mona Creek will increase by approximately 0.4 hectares (from Cockabutta Creek catchment area) (i.e. an increase of approximately 0.01 per cent).

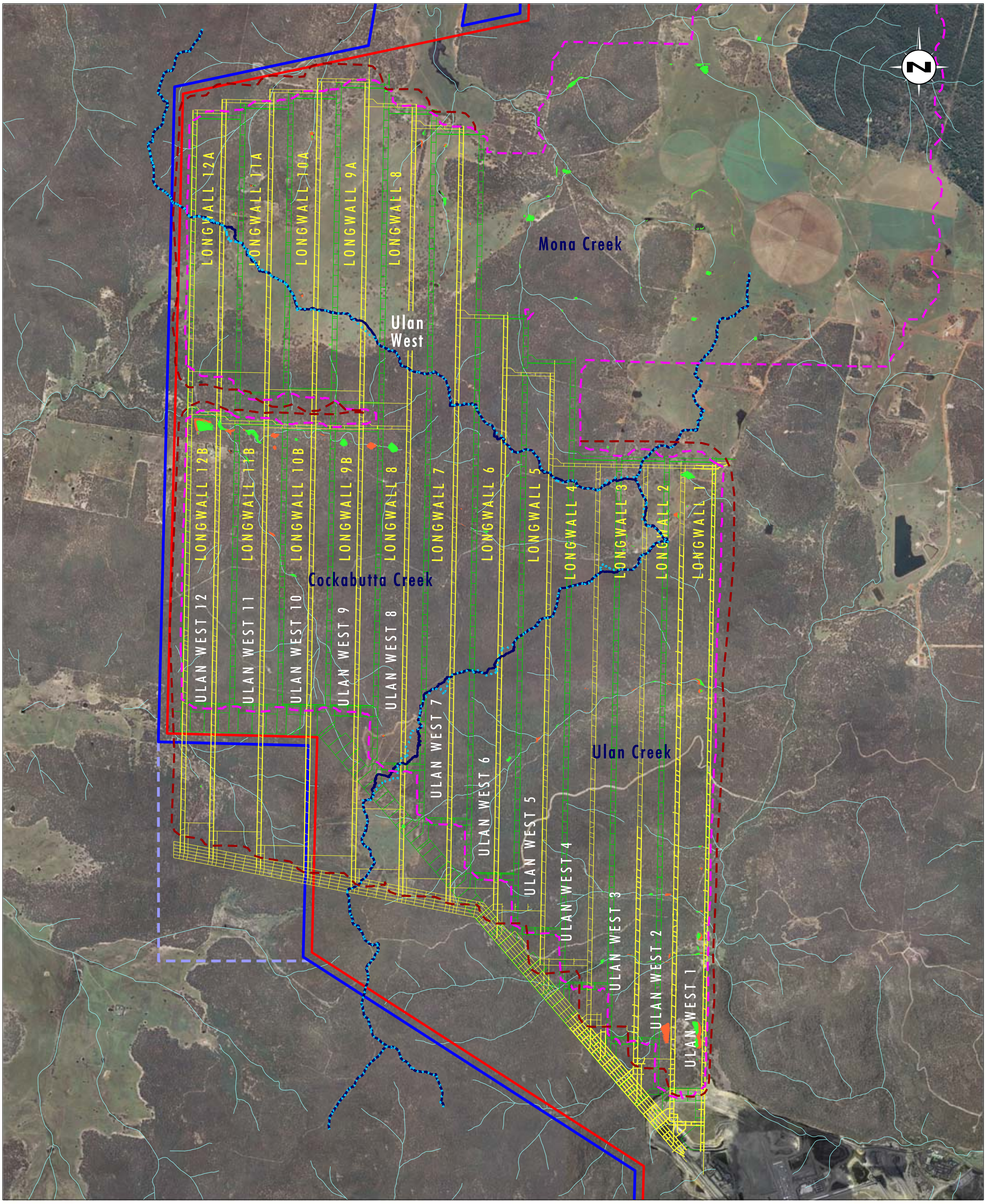


Image Source: Ulan Coal (2008, 2010, 2014)
Data Source: Ulan Coal (2014), LPI (2012)

0 1.0 2.0 2.5km
1:50 000

Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved (November 2010) Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Approved Major Catchment Boundary
- Proposed Major Catchment Boundary
- Approved Remnant Ponding
- Proposed Predicted Remnant Ponding
- Predicted 20 mm Subsidence Contour (Approved November 2010)
- Predicted 20 mm Subsidence Contour (Proposed)

FIGURE 4.1

Catchment Boundaries and Remnant Ponding Impacts

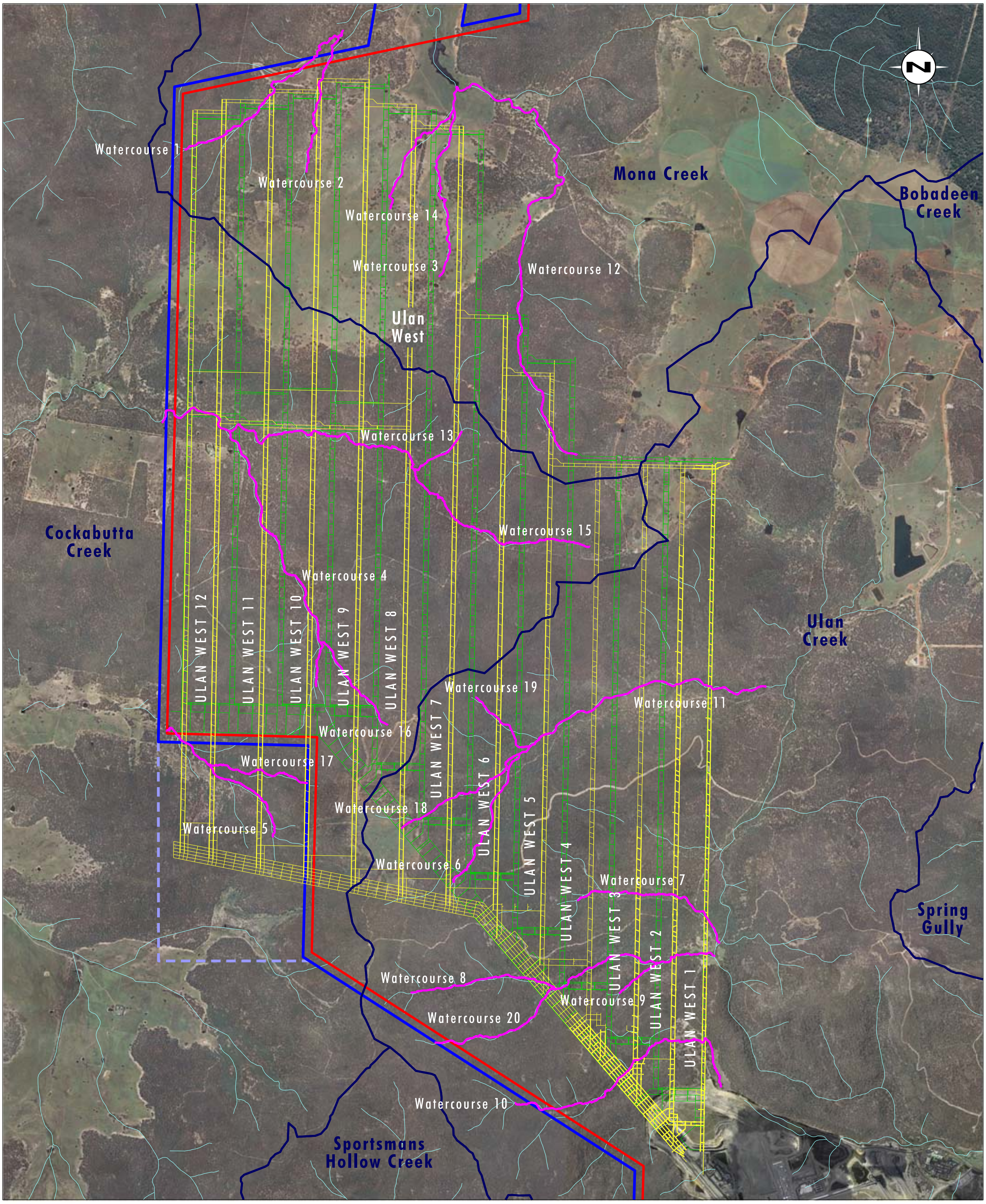


Image Source: Ulan Coal (2008, 2010, 2014)
Data Source: Ulan Coal (2014), LPI (2012)

0 1.0 2.0 2.5km
1:50 000

Legend
- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved (November (2010) Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Catchment Area
- Watercourse Longsection

FIGURE 4.2

Watercourse Longsections Location and Extent

File Name (A4): R05/3363_012.dgn
20141112 11.24

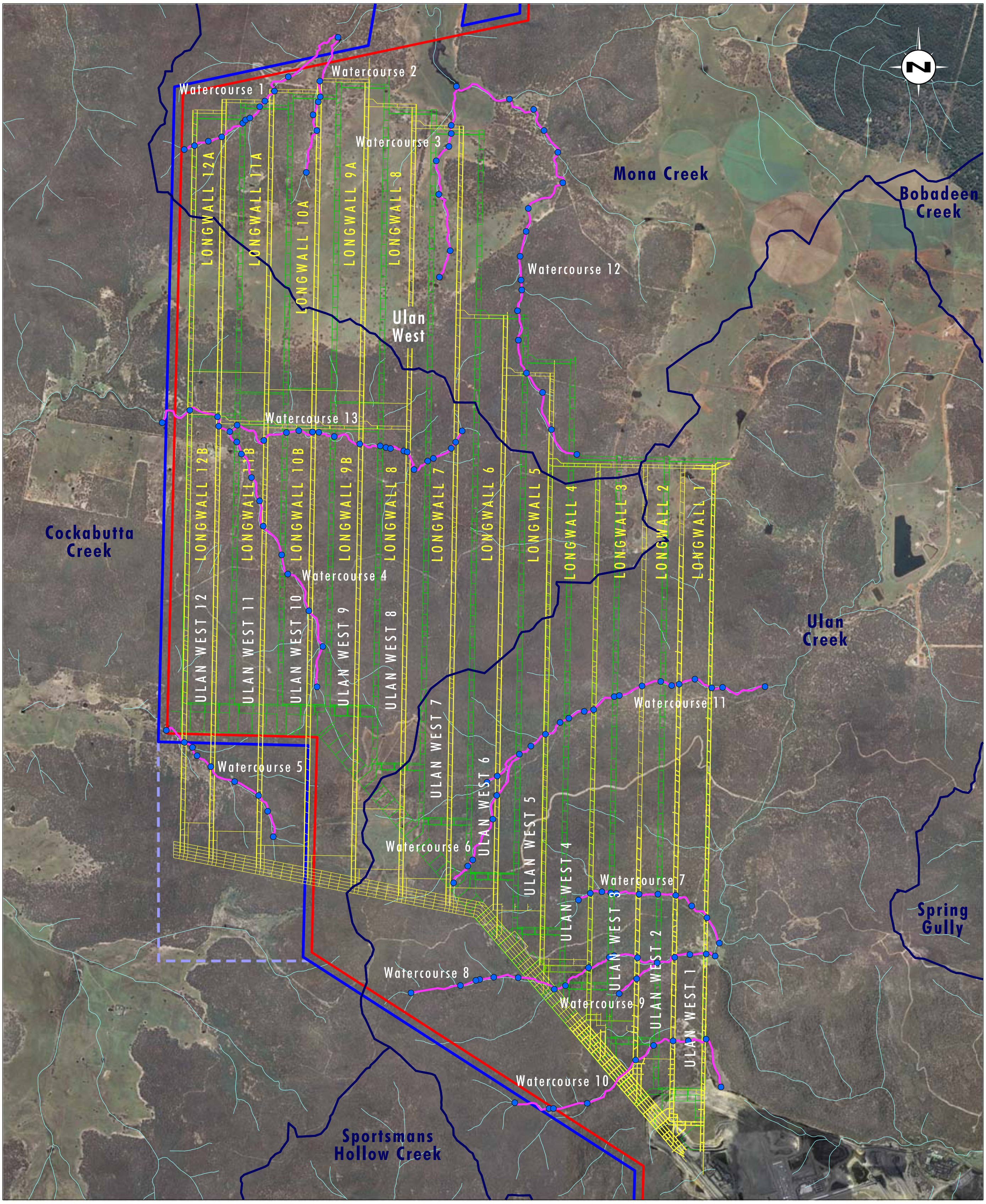


Image Source: Ulan Coal (2008, 2010, 2014)
Data Source: Ulan Coal (2014), LPI (2012)

0 1.0 2.0 2.5km
1:50 000

Legend

- Existing Colliery Holding Boundary
- UCML Continued Operations Project Approval Area
- MLA 475
- Approved (November (2010) Ulan West Mine Plan
- Proposed Conceptual Ulan West Mine Plan
- Catchment Area
- XP-Storm Link
- XP-Storm Node

FIGURE 4.3

XP-Storm Model Layout

File Name (A4): R05/3363_013.dgn
20141112 11.28

4.2.2 Remnant Ponding

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West mine plan results in minor changes to the pattern of remnant ponding compared to the approved Ulan West mine plan (refer to **Figure 4.1**) within the catchment area of Mona Creek. The analysis indicates that the remnant ponding will remain within channels of the watercourses within the Mona Creek catchment area. No areas of remnant ponding are predicted to occur outside of the existing watercourse channels.

4.2.3 Watercourse Stability

4.2.3.1 Longsection Analysis

A summary of the changes to the maximum predicted subsidence of watercourses within the Mona Creek catchment are included in **Table 4.1**. From **Table 4.1** it can be seen that the proposed modification results in decreases to the maximum predicted subsidence of watercourses with the Mona Creek catchment from approximately 0.08 metres to 0.32 metres.

Table 4.1 - Maximum Predicted Subsidence - Mona Creek Catchment Watercourse

Watercourse ID	Approved (metres)	Proposed (metres)	Change (metres)
1	1.60	1.52	-0.08
2	1.60	1.28	-0.32
3	1.60	1.52	-0.08
12	1.60	1.60	0.00
14	1.60	1.50	-0.10

A summary of the minimum and maximum longitudinal gradients of the watercourses within Mona Creek catchment for the pre mining, approved and proposed landforms are included in **Table 4.2**. The analysis indicates that the predicted subsidence associated with the proposed modification results in changes to the longitudinal gradients of watercourses within the Mona Creek catchment that are typically within the range of the longitudinal gradients for both the approved mine plan and pre mining conditions (refer to **Appendix A**).

Table 4.2 - Watercourse Longitudinal Gradients - Mona Creek

Watercourse ID	Pre Mining		Approved		Proposed	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1	-3.33%	0.00%	-3.68%	0.00%	-3.64%	0.00%
2	-3.39%	-0.68%	-3.41%	-0.66%	-3.37%	-0.68%
3	-3.14%	-1.10%	-3.56%	-0.86%	-3.14%	-1.10%
12	-6.09%	0.11%	-6.91%	0.11%	-6.10%	0.11%
14	-3.33%	0.00%	-3.68%	0.00%	-3.64%	0.00%

(refer to **Appendix A** for charts)

Notes:
1. Longitudinal gradients of watercourses were smoothed using a 200 metre moving average.
2. Negative gradients indicate a downhill slope; positive gradients indicate an uphill slope (i.e. a potential ponding area).

The analysis indicates that the proposed modification results in predicted changes to predicted subsidence and longitudinal gradients of watercourses within the Mona Creek catchment area that are comparable to the approved impacts. However, localised changes to longitudinal gradients have the potential to alter the location and extent of erosion and scouring within the watercourses of the Mona Creek catchment. The potential for changes to erosion and scouring within these watercourses was assessed further using hydrodynamic modelling to estimate flow velocities and tractive stresses within the second order watercourses as a result of the approved and proposed Ulan West mine plans (refer to **Section 4.1.3.2**).

4.2.3.2 Hydrodynamic Modelling

The maximum modelled depths, velocities and tractive stresses within the four modelled second order watercourses within the Mona Creek catchment are summarised in **Tables 4.3**, **4.4** and **4.5** respectively, with the results outlined below.

Table 4.3 - Maximum Changes to Modelled Flow Depths - Mona Creek

Watercourse ID	1.5 Year ARI (metres)		2 Year ARI (metres)		10 Year ARI (metres)		20 Year ARI (metres)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
1	0.03	-0.01	0.02	-0.01	0.03	-0.02	0.03	-0.02
2	0.01	-0.02	0.02	-0.02	0.02	-0.03	0.03	-0.03
3	0.01	-0.01	0.01	-0.01	0.02	-0.01	0.02	-0.02
12	0.01	-0.01	0.01	-0.01	0.02	-0.01	0.02	-0.01

(refer to **Charts A2.1** to **A2.4** in **Appendix B**)

Table 4.4 - Maximum Changes to Modelled Flow Velocities - Mona Creek

Watercourse ID	1.5 Year ARI (m/s)		2 Year ARI (m/s)		10 Year ARI (m/s)		20 Year ARI (m/s)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
1	0.04	-0.22	0.03	-0.15	0.06	-0.12	0.06	-0.13
2	0.05	-0.05	0.06	-0.06	0.07	-0.07	0.07	-0.08
3	0.05	-0.11	0.05	-0.11	0.06	-0.11	0.07	-0.11
12	0.03	-0.05	0.03	-0.05	0.03	-0.02	0.04	-0.03

(refer to **Charts A3.1** to **A3.4** in **Appendix C**)

Table 4.5 - Maximum Changes to Modelled Tractive Stresses - Mona Creek

Watercourse ID	1.5 Year ARI (N/m^2)		2 Year ARI (N/m^2)		10 Year ARI (N/m^2)		20 Year ARI (N/m^2)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
1	7.0	-9.0	7.9	-6.8	9.8	-8.3	12.6	-6.8
2	4.9	-2.0	6.6	-4.3	6.2	-5.5	6.9	-4.2
3	6.3	-6.1	6.9	-8.7	8.5	-10.5	9.5	-9.5
12	3.6	-1.8	5.8	-1.9	4.8	-2.4	5.0	-2.7

(refer to **Charts A4.1** to **A4.4** in **Appendix D**)

The magnitude of the maximum modelled velocities and tractive stresses within the modelled watercourses remain relatively unchanged between the approved and proposed Ulan West mine plans.

Whilst the changes to the velocity and tractive stress stability categories have the potential to result in local changes to erosion and scouring (based on changes to stability thresholds for velocities and tractive stresses: refer to **Section 3.2.1.2**), it should be noted that it is considered that the proposed modification to the Ulan West mine plan is unlikely to result in an overall increase in erosion and scouring of the modelled watercourses. UCML proposes to continue to monitor second order watercourses for potential subsidence impacts and associated watercourse stability as per the existing monitoring programs (refer to **Section 7.1**).

4.3 Cockabutta Creek Catchment

The proposed modification will result in predicted subsidence within the Cockabutta Creek watercourses (refer to **Figures 4.1**, **4.2** and **4.3**) that is of a comparable magnitude and scale to the predicted subsidence associated with the approved mine plan (SCT, 2014).

4.3.1 Catchment Boundaries

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West underground mining area will have negligible impact on the catchment boundaries compared to the approved Ulan West mine plan (refer to **Figure 4.1**). The analysis indicates that the total catchment area of Cockabutta Creek will be reduced by approximately 0.6 hectares (0.4 hectares to Mona Creek catchment area and 0.2 hectares to Ulan Creek catchment area) (i.e. a decrease of less than 0.01 per cent).

4.3.2 Remnant Ponding

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West underground mining area results in minor changes to the pattern of remnant ponding compared to the approved Ulan West mine plan (refer to **Figure 4.1**) within the catchment area of Cockabutta Creek. The analysis indicates that the remnant ponding will remain within channels of the watercourses within the Cockabutta Creek catchment area. No areas of remnant ponding are predicted to occur outside of the existing watercourse channels.

4.3.3 Watercourse Stability

4.3.3.1 Longsection Analysis

A summary of the changes to the maximum predicted subsidence of watercourses within the Cockabutta Creek catchment are included in **Table 4.6**. From **Table 4.6** it can be seen that the proposed modification results in decreases to the maximum predicted subsidence of watercourses with the Cockabutta Creek catchment of up to approximately 0.1 metres. Two watercourses (Watercourse 5 and Watercourse 17: refer to **Figure 4.1**) are located outside of the approved Ulan West underground mining area. The proposed modification is predicted to result in up to approximately 2.29 metres and 2.12 metres of subsidence within Watercourse 5 and Watercourse 17 respectively (refer to **Table 4.6**).

Table 4.6 - Maximum Predicted Subsidence – Cockabutta Creek Catchment Watercourses

Watercourse ID	Approved (metres)	Proposed (metres)	Change (metres)
4	1.60	1.50	-0.10
5	0.00 [1]	2.29	2.29
13	1.60	1.51	-0.09
15	1.60	1.50	-0.10
16	1.60	1.50	-0.10
17	0.00 [1]	2.12	2.12

Notes: 1. Watercourse 5 and Watercourse 17 are located outside of the approved (November 2010) Ulan West underground mining area and within the proposed Ulan West underground mining area.

A summary of the minimum and maximum longitudinal gradients of the watercourses within Cockabutta Creek catchment for the pre mining, approved and proposed landforms are included in **Table 4.7**. The analysis indicates that the predicted subsidence associated with the proposed modification results in changes to the longitudinal gradients of watercourses within the Cockabutta Creek catchment that are typically within the range of the longitudinal gradients for both the approved mine plan and pre mining conditions (refer to **Appendix A**).

Table 4.7 - Watercourse Longitudinal Gradients - Cockabutta Creek

Watercourse ID	Pre Mining		Approved		Proposed	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
4	-2.18%	-0.63%	-2.19%	-0.31%	-2.30%	-0.17%
5	-4.13%	-0.94%	-4.13%	-0.94%	-4.19%	-0.88%
13	-5.75%	-0.25%	-5.82%	0.32%	-5.65%	0.36%
15	-2.50%	-0.53%	-2.89%	-0.03%	-2.82%	-0.44%
16	-11.67%	-1.84%	-10.47%	-1.27%	-11.67%	-1.84%
17	-5.30%	-2.24%	-5.30%	-2.24%	-5.93%	-1.53%

(refer to **Charts A1.6** to **A1.11** in **Appendix A**)

Notes:
1. Longitudinal gradients of watercourses were smoothed using a 200 metre moving average.
2. Negative gradients indicate a downhill slope; positive gradients indicate an uphill slope (i.e. a potential ponding area).

The analysis indicates that the proposed modification results in predicted changes to predicted subsidence and longitudinal gradients of watercourses within the Cockabutta Creek catchment area that are comparable to the approved impacts. However, localised changes to longitudinal gradients have the potential to alter the location and extent of erosion and scouring within the watercourses of the Cockabutta Creek catchment. The potential for changes to erosion and scouring within these watercourses was assessed further using hydrodynamic modelling to estimate flow velocities and tractive stresses within the watercourses (second order and above) as a result of the approved and proposed Ulan West mine plans (refer to **Section 4.2.3.2**).

4.3.3.2 Hydrodynamic Modelling

The maximum modelled depths, velocities and tractive stresses within the three modelled second order watercourses within the Cockabutta Creek catchment are summarised in **Tables 4.8**, **4.9** and **4.10** respectively with the results outlined below.

Table 4.8 - Maximum Changes to Modelled Flow Depths - Cockabutta Creek

Watercourse ID	1.5 Year ARI (metres)		2 Year ARI (metres)		10 Year ARI (metres)		20 Year ARI (metres)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
4	0.67	-0.06	0.71	-0.07	0.78	-0.10	0.79	-0.10
5	0.11	-0.07	0.12	-0.07	0.15	-0.09	0.17	-0.10
13	0.67	-0.88	0.71	-0.88	0.77	-0.88	0.78	-0.88

(refer to **Charts A2.5** to **A2.7** in **Appendix B**)

Table 4.9 - Maximum Changes to Modelled Flow Velocities - Cockabutta Creek

Watercourse ID	1.5 Year ARI (m/s)		2 Year ARI (m/s)		10 Year ARI (m/s)		20 Year ARI (m/s)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
4	0.24	-0.58	0.18	-0.58	0.26	-0.60	0.26	-0.59
5	0.28	-0.37	0.28	-0.38	0.34	-0.44	0.35	-0.46
13	0.65	-0.65	0.64	-0.68	0.60	-0.69	0.63	-0.70

(refer to **Charts A3.5** to **A3.7** in **Appendix C**)

Table 4.10 - Maximum Changes to Modelled Tractive Stresses - Cockabutta Creek

Watercourse ID	1.5 Year ARI (N/m^2)		2 Year ARI (N/m^2)		10 Year ARI (N/m^2)		20 Year ARI (N/m^2)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
4	14.6	-12.8	15.5	-14.2	18.1	-18.7	18.1	-19.9
5	21.6	-22.2	23.6	-25.3	29.8	-34.1	31.6	-35.7
13	18.7	-23.5	18.0	-24.6	20.5	-29.4	22.6	-31.8

(refer to **Charts A4.5** to **A4.7** in **Appendix D**)

The modelling indicates that the proposed modification results in both increases and decreases to the maximum modelled flow depths, velocities and tractive stresses within the modelled second order watercourses within the Cockabutta Creek catchment, compared to the predicted subsidence with the approved mine plan. However, the magnitude of the maximum modelled velocities and tractive stresses within the modelled second order watercourses remain relatively unchanged between the approved and proposed Ulan West mine plans.

Whilst the modelled changes to the velocity and tractive stress stability categories have the potential to result in local changes to erosion and scouring (based on changes to stability thresholds for velocities and tractive stresses: refer to **Section 3.2.1.2**), it should be noted that it is considered that the proposed modification to the Ulan West mine plan is unlikely to result in an overall increase in erosion and scouring of the modelled watercourses.

An active head cut has been observed within an unnamed tributary of Cockabutta Creek (Watercourse 5) (refer to **Section 2.0**). Changes to the longitudinal gradients of watercourses (due to subsidence) have the potential to impact on the occurrence and mobility of head cuts. In accordance with existing monitoring and management plans UCML proposes to continue to monitor areas where potential ponding, bank slumping, head cut erosion or drainage realignment may occur to determine the need for any further erosion control measures at these locations (refer to **Section 7.1**).

4.4 Ulan Creek Catchment

The proposed modification will result in changes to the predicted subsidence within the Ulan Creek watercourses (refer to **Figures 4.1**, **4.2** and **4.3**) that is of a comparable magnitude and scale to the predicted subsidence associated with the approved mine plan.

4.4.1 Catchment Boundaries

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West underground mining area will have negligible impact on the catchment boundaries compared to the approved Ulan West mine plan (refer to **Figure 4.1**). The analysis indicates that the total catchment area of Ulan Creek will be increased by approximately 0.2 hectares (from Cockabutta Creek catchment area) (i.e. an increase of less than 0.01 per cent).

4.4.2 Remnant Ponding

The analysis indicates that the predicted subsidence associated with the proposed modification to the Ulan West underground mining area results in minor changes to the pattern of remnant ponding compared to the approved Ulan West mine plan (refer to **Figure 4.1**) within the catchment area of Ulan Creek. The analysis indicates that the remnant ponding will remain within channels of the watercourses within the Ulan Creek catchment area. No areas of remnant ponding are predicted to occur outside of the existing watercourse channels.

4.4.3 Watercourse Stability

4.4.3.1 Longsection Analysis

A summary of the changes to the maximum vertical subsidence of watercourses within the Ulan Creek catchment are included in **Table 4.11**. From **Table 4.11** it can be seen that the proposed modification results in decreases to the maximum predicted subsidence of watercourses with the Ulan Creek catchment of up to approximately 0.1 metres for three of the nine watercourses. From **Table 4.11** it can also be seen that the predicted subsidence for the proposed modification results in increases to the maximum predicted subsidence of five of the watercourses within the Ulan Creek catchment from approximately 0.66 metres to 0.70 metres (SCT, 2014).

Table 4.11 - Maximum Predicted Subsidence - Ulan Creek Catchment Watercourses

Watercourse ID	Approved (metres)	Proposed (metres)	Change (metres)
6	1.60	1.50	-0.10
7	1.60	2.29	0.69
8	1.60	2.29	0.69
9	1.60	2.30	0.70
10	1.60	2.29	0.69
11	1.60	2.26	0.66

Table 4.11 - Maximum Predicted Subsidence - Ulan Creek Catchment Watercourses (cont)

Watercourse ID	Approved (metres)	Proposed (metres)	Change (metres)
18	1.60	1.50	-0.10
19	1.60	1.50	-0.10
20	0.00 [1]	0.00 [1]	0.00

Notes: 1. Watercourse 20 is located outside of the approved (November 2010) Ulan West underground mining area.

A summary of the minimum and maximum longitudinal gradients of the watercourses within Ulan Creek catchment for the pre mining, approved and proposed landforms are included in **Table 4.12**. The analysis indicates that the predicted subsidence associated with the proposed modification results in changes to the longitudinal gradients of watercourses within the Ulan Creek catchment that are typically within the range of the longitudinal gradients for both the approved mine plan and pre mining conditions (refer to **Appendix A**).

Table 4.12 - Watercourse Longitudinal Gradients - Ulan Creek

Watercourse ID	Pre Mining		Approved		Proposed	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
6	-2.56%	-0.55%	-2.56%	0.11%	-3.31%	-0.55%
7	-3.79%	-1.33%	-4.17%	-0.79%	-4.75%	-0.62%
8	-5.96%	-1.03%	-5.96%	-0.64%	-5.96%	-0.28%
9	-4.52%	-0.47%	-4.41%	-0.49%	-4.83%	0.61%
10	-5.59%	-0.83%	-5.59%	-0.61%	-5.59%	-0.19%
11	-3.91%	-0.33%	-3.91%	0.14%	-4.69%	0.27%
18	-7.72%	-1.65%	-8.22%	-1.07%	-8.24%	-1.71%
19	-7.92%	-1.91%	-8.80%	-1.50%	-7.92%	-1.91%
20	-8.13%	-0.95%	-8.13%	-0.95%	-8.13%	-0.95%

(refer to **Appendix A**)

1. Longitudinal gradients of watercourses were smoothed using a 200 metre moving average.
2. Negative gradients indicate a downhill slope; positive gradients indicate an uphill slope (i.e. a potential ponding area).

The analysis indicates that the proposed modification results in predicted changes to predicted subsidence and longitudinal gradients of watercourses within the Ulan Creek catchment area that are comparable to the approved impacts. However, localised changes to longitudinal gradients have the potential to alter the location and extent of erosion and scouring within the watercourses of the Ulan Creek catchment. The potential for changes to erosion and scouring within these watercourses was assessed further using hydrodynamic modelling to estimate flow velocities and tractive stresses within the second and third order watercourses as a result of the approved and proposed Ulan West mine plans (refer to **Section 4.3.3.2**).

4.4.3.2 Hydrodynamic Modelling

The maximum modelled depths, velocities and tractive stresses within the six modelled watercourses (second order and third order watercourses) within the Ulan Creek catchment are summarised in **Tables 4.13**, **4.14** and **4.15** respectively with the results outlined below.

Table 4.13 - Maximum Changes to Modelled Flow Depths - Ulan Creek

Watercourse ID	1.5 Year ARI (metres)		2 Year ARI (metres)		10 Year ARI (metres)		20 Year ARI (metres)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
6	0.04	-0.03	0.05	-0.03	0.03	-0.06	0.03	-0.03
7	0.06	-0.05	0.07	-0.05	0.10	-0.07	0.12	-0.08
8	0.49	-0.11	0.52	-0.12	0.61	-0.16	0.64	-0.18
9	0.49	-0.08	0.52	-0.08	0.61	-0.10	0.64	-0.11
10	0.07	-0.03	0.07	-0.02	0.09	-0.02	0.10	-0.03
11	0.23	-0.30	0.25	-0.33	0.31	-0.33	0.33	-0.32

(refer to **Charts A2.8** to **A2.13** in **Appendix B**)

Table 4.14 - Maximum Changes to Modelled Flow Velocities - Ulan Creek

Watercourse ID	1.5 Year ARI (m/s)		2 Year ARI (m/s)		10 Year ARI (m/s)		20 Year ARI (m/s)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
6	0.05	-0.03	0.07	-0.04	0.08	-0.05	0.09	-0.06
7	0.12	-0.21	0.13	-0.21	0.16	-0.27	0.22	-0.27
8	0.07	-0.56	0.08	-0.60	0.08	-0.62	0.08	-0.60
9	0.03	-0.85	0.04	-0.91	0.05	-1.04	0.06	-1.08
10	0.01	-0.20	0.00	-0.20	0.00	-0.24	0.00	-0.25
11	0.76	-0.70	0.91	-0.71	1.07	-0.64	1.06	-0.60

(refer to **Charts A3.8** to **A3.13** in **Appendix C**)

Table 4.15 - Maximum Changes to Modelled Tractive Stresses - Ulan Creek

Watercourse ID	1.5 Year ARI (N/m^2)		2 Year ARI (N/m^2)		10 Year ARI (N/m^2)		20 Year ARI (N/m^2)	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
6	14.5	-9.1	15.5	-7.7	18.9	-10.4	17.7	-11.5
7	32.4	-33.1	35.8	-37.9	45.4	-51.5	47.2	-53.0
8	72.9	-48.8	76.9	-52.6	101.2	-68.8	111.4	-74.7
9	97.6	-59.3	105.1	-61.3	130.8	-72.1	138.6	-73.8
10	17.6	-15.0	15.9	-16.7	21.3	-17.7	22.8	-21.7
11	55.2	-47.8	66.2	-50.2	77.9	-60.4	76.3	-60.7

(refer to **Charts A4.8** to **A4.13** in **Appendix D**)

The modelling indicates that the proposed modification results in both increases and decreases to the maximum modelled flow depths, velocities and tractive stresses within the modelled second and third order watercourses in the Ulan Creek catchment, compared to the subsidence predicted with the approved mine plan.

Whilst the changes to the velocity and tractive stress stability categories have the potential to result in local changes to erosion and scouring (based on changes to stability thresholds for flow velocities and tractive stresses: refer to **Section 3.2.1.2**), it should be noted that the magnitude of the maximum modelled velocities and tractive stresses within the modelled watercourses are typically consistent between the approved and proposed Ulan West underground mine plans. Consequently it is considered that the proposed modification to the Ulan West mine plan is unlikely to result in an overall increase in erosion and scouring of the modelled watercourses. UCML proposes to continue to monitor second and third order watercourses for potential subsidence impacts and associated watercourse stability as per the existing monitoring programs (refer to **Section 7.1**).

5.0 Water Balance

5.1 Overview

A predictive water balance model was developed for the Ulan Coal Complex for PA 08_0184. The water balance model was then subsequently modified to include the changes proposed by the North 1 Modification (Umwelt, 2011).

For this assessment the existing predictive water balance model prepared for the North 1 Modification (Umwelt, 2011) was updated to include the predicted changes to groundwater inflows as a result of the proposed modification. The groundwater inflow information was provided by MER (2014). As part of the groundwater assessment (MER, 2014) the Ulan West groundwater model was recalibrated using available groundwater monitoring data and estimated historical inflow information (refer to Appendix 3 of the EA).

The proposed modification includes the extension of the life of the Ulan West underground mining area by approximately 2 years (refer to **Section 1.0**). UCML proposes to maintain existing predicted water usage rates for the additional 2 years proposed as part of the proposed modification.

5.2 Mine Water Management System

The Ulan Coal Complex has an extensive mine water management system, which includes mine dewatering systems, water storages, the Bobadeen Irrigation Scheme, water treatment facilities, sedimentation and retention basins, settlings and tailings ponds, drains, levee banks and earth bunding around the main stockpile, laydown hardstand areas and fuelling areas.

All groundwater inflows to the Ulan West underground mining area will be managed within the existing mine water management system.

The proposed modification will extend the life of the mine water management system by 2 years. Otherwise, no other changes to the approved mine water management system are proposed.

5.3 Site Water Balance

The site water balance model comprises a series of modules that represent the catchments and major components of the mine water management system. Each module is balanced individually and then brought together to represent the total water balance for the Ulan Coal Complex. The predicted water balance provides information on the demand and supply peaks for the operation and identifies the storage and discharge requirements for the mine water management system over the life of the mine.

The recalibrated Ulan West groundwater model indicates that the approved Ulan West mine plan will result in peak groundwater inflows of approximately 11.3 ML per day (MER, 2014). The groundwater modelling of the proposed modification of the Ulan West mining area indicates that the peak groundwater inflows are likely to increase to approximately 12.5 ML per day (MER, 2014).

Total groundwater reporting to the Ulan West underground mining area over the life of the mine is estimated to increase from approximately 51.2 GL for the approved mine plan to approximately 52.3 GL for the proposed modification (MER, 2014). The additional 1.2 GL of water reporting to the Ulan West mining area represents an increase of approximately 2.1 per cent.

The site water balance has been updated to incorporate the predicted changes to groundwater inflows resulting from the proposed modification to the Ulan West underground mining area. A summary of the predicted site water balance for selected years of mining is presented in **Chart 5.1**. After Year 20, the water balance modelling results indicated little change to the Year 20 water balance. The Year 20 site water balance is considered to be representative of the predicted site for water for years 21, 22 and 23.

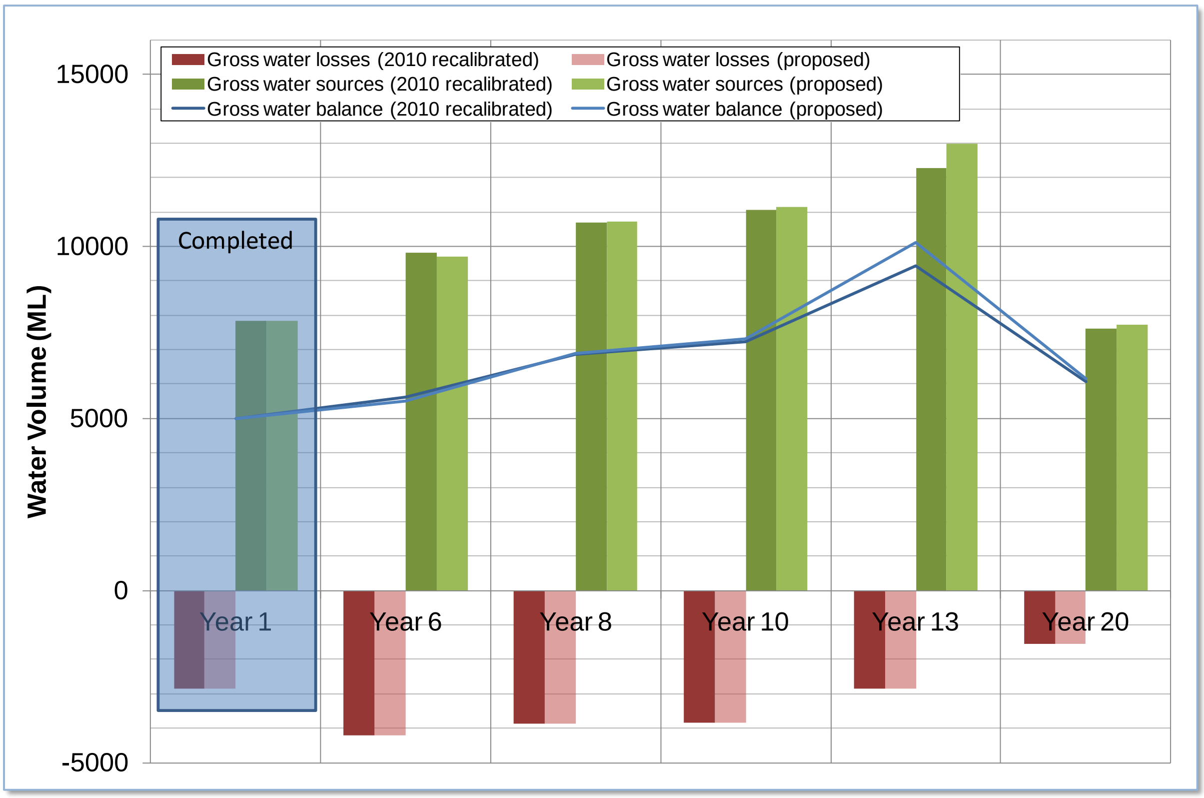


Chart 5.1 - Gross Water Balance (not including discharges)

The maximum water surplus for the Ulan Coal Complex, including the proposed modification, is predicted to occur during Year 13 with a maximum modelled water surplus of approximately 10,106 ML per year (i.e. 27.7 ML per day). This is approximately 684 ML per year (i.e. 1.9 ML per day) higher than the maximum modelled water surplus (occurring in Year 13) for the approved Ulan West mine plan (with the recalibrated groundwater inflows: refer to MER, 2014).

UCML proposes to continue to maintain a neutral site water balance by utilising existing and approved discharge facilities in accordance with the conceptual water discharge management strategy outlined in the UCCO Surface Water Assessment (Umwelt, 2009). The approved discharge strategy provides a maximum discharge capacity of approximately 52 ML per day based on 100 per cent utilisation of the water discharge facilities. All discharges will be undertaken in accordance with the site Environment Protection Licence (EPL).

It is considered that the predicted water surplus can be managed within the site water management system while still retaining significant flexibility and redundancy within the site water management system.

6.0 Project and Cumulative Impact Assessment

6.1 Summary of Catchment and Watercourse Impacts

As described in **Section 4.0**, it is considered that the proposed modification to the Ulan West mine plan will have impacts comparable to those previously assessed as a part of UCCO Project EA (Umwelt, 2009). The modification will be managed in accordance with existing Project Approval conditions and the Water Management Plan required by these conditions.

The predicted subsidence has limited potential to result in increased remnant ponding, both in or and out of the drainage lines. Historical and recent site inspections indicate that in the majority of areas where the topographical survey indicates existing remnant ponding, water does not pond in these areas as the soils are sandy and relatively free draining. As such, it is considered unlikely, based on the analysis of the predicted subsidence that any additional remnant ponding will occur within the predicted subsidence affectation area. This is due to both the steepness of the existing landform and sandy soils.

It is considered that the predicted subsidence impacts will not result in any substantial changes to watercourse stability relative to the current approved impacts. However, UCML proposes to continue to monitor second order watercourses for potential subsidence impacts (refer to **Section 7.1**). If monitoring indicates that remediation works are required, remediation works will need to maintain channel grades and take into consideration channel stabilities and existing channel characteristics.

If remediation works are required, these works have the potential to generate short term impacts in terms of water quality while the remediation works are being undertaken and stable vegetated post mining landforms are being achieved. Potential water quality impacts in terms of downstream users and downstream ecosystems will principally be due to the potential for increased sediment generation and export of sediment off site. To mitigate this potential impact it is proposed to implement a number of erosion and sediment control measures (refer to **Section 7.2**).

6.2 Downstream Water Users

As discussed in the UCCO Project EA (Umwelt, 2009), the regions downstream of the Project Approval area are primarily forested within the Goulburn River catchment but also include irrigated pasture/fodder crops within the Talbragar River catchment. Irrigation water along the Talbragar River is primarily sourced from the river, when flowing, and alluvial systems.

The UCCO Project EA (Umwelt, 2009) predicted potential impacts on baseflows with the Goulburn and Talbragar River systems. UCML has approval to offset the predicted losses to the baseflows of the Goulburn and Talbragar River system by discharge of treated surplus mine water to both river systems. Groundwater modelling (MER, 2014) has indicated that there are no predicted changes to the baseflow impacts as a result of the proposed modification.

There is some potential that during the time between mining and completion of any required surface remediation works some minor stream capture may occur during rainfall events. As such there is potential to influence the volume of runoff available for harvestable rights at downstream properties. However, it is considered that this potential is limited as the catchment areas upstream of the mining areas are small, sequential mining will affect only short sections of creek at any time, runoff rates are relatively low and as such only a relatively low volume of runoff could be captured during storm events due to surface cracking.

As any cracking will appear very rapidly on the surface after longwall mining, regular checking and resealing of in channel cracks will be undertaken. These progressive resealing works will significantly reduce the potential for loss of surface flows due to subsidence cracking.

It is also considered that the proposed modification will not adversely impact on the potential use of water for downstream users on the local creek systems or rivers, including the quantity and quality of flows into the privately owned farm dam located on an unnamed tributary of Cockabutta Creek.

The water balance modelling (refer to **Section 5.0**) indicates that the proposed modification to the Ulan West underground mine plan will result in an increase in the estimated site water surplus. However, UCML proposes to continue to maintain a neutral site water balance by utilising existing and approved discharge facilities in accordance with the Project Approval (PA 08_184) and the site Environment Protection Licence (EPL) No. 394.

6.3 Surface Infrastructure

The proposed modifications to the surface infrastructure are considered to be generally in accordance with the existing approved development and are not expected to result in appreciable changes to the quantity or quality of surface water. Each surface infrastructure component will require erosion and sediment controls to manage sediment laden water generated both during construction and operational phases of the surface infrastructure component. The required management measures are set out in detail in the approved Water Management Plan, as described in **Section 7.2**.

6.4 Water Planning Context

Consistent with the current planning context related to surface water, the proposed modification has been assessed against the following water regulations, planning policies and plans:

- State Water Management Outcomes Plan (SWMOP);
- Hunter-Central Rivers Catchment Action Plan;
- *NSW Water Management Act 2000*; and
- *NSW Water Act 1912*.

6.4.1 State Water Management Outcomes Plan and Catchment Action Plan

The SWMOP and the Hunter-Central Rivers Catchment Management Authority Catchment Action Plan provide guidelines for water management in NSW and the Hunter Valley respectively and are therefore relevant to the proposed modification.

The introduction of the *Water Management Act 2000* led to the development of a statewide policy on water management known as the SWMOP. This plan provides direction for all water management actions in NSW by setting out the overarching policy context, targets and strategic outcomes for NSW water management.

The intent of Catchment Action Plans (CAPs) is to identify the key natural resource features of the catchment that the community and government wish to see protected or improved, and then to determine the best way to achieve these outcomes. The CAPs guide how improvements in natural resources will be achieved in the next ten years and define where effort and funding should be focussed to get the best protection and improvement in natural resources and the most benefits for the community. The CAPs build on planning and activities defined in the catchment blueprints, regional vegetation management and water sharing plans.

The Hunter-Central Rivers Catchment Authority Catchment Action Plan commenced in 2006 and has a term of ten years.

As the proposed modification will result in no changes to the approved site water management system (Umwelt, 2009) (refer to **Section 5.0**) and negligible changes to the existing approved surface water impacts, the proposed modification is considered to be consistent with the SWMOP and the Catchment Action Plan objectives both within the site and with regard to potential downstream interactions.

6.4.2 Water Management Act 2000 and Water Act 1912

The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009, in accordance with the *Water Management Act 2000*, commenced on 1 August 2009 and is considered is a 'macro' water sharing plan. That is, a plan that applies to a number of water sources across catchments or different types of aquifers. The plan is broken into a number of extraction management units (EMU). The sections of the mining operations that lie to the east of the Great Dividing Range fall within the Upper Goulburn River Management Zone of the Goulburn River EMU.

Although works approvals are not required under the *Water Management Act 2000* for approvals being assessed under Part 3A of the EP&A Act the key aspects of the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 are listed below and are commented on in regard to the surface water interactions with the proposed modification:

- The Plan provides for no new growth in water entitlements with the annual extraction limit typically set to the current annual extraction limits.
- The proposed modification does not propose to extract surface water from the surrounding streams or rivers.

Groundwater that flows into the underground mining operations will continue to be extracted from underground mine working under existing groundwater licences (MER, 2014). Further details on groundwater inflows and licensing are included in the Groundwater Assessment (refer to Appendix 3 of the EA).

6.5 Cumulative Impacts

UCML will continue to discharge surplus mine water to the Goulburn River system and, as approved, in the future to the Talbragar River system. Any mine water discharges from the site will continue to be managed under the Ulan Coal Complex EPL.

The modification will result in no changes to the catchment area of the mine water management system and will have no impact on surface water runoff to downstream catchment areas.

The surface water assessment of the predicted subsidence impacts indicates that the catchment boundaries of the creek systems to be undermined will not change significantly. It is also considered unlikely that the proposed modification will significantly alter the approved impacts to watercourse stability and remnant ponding. The watercourses in the predicted subsidence affectation area will be monitored as part of the Ulan Coal Complex Surface Water Monitoring Program and subsequent Subsidence Management Plans as longwall extraction advances.

Erosion and sediment control measures, consistent with those currently utilised by site, are proposed to ensure that there will be no significant impact on downstream water qualities if subsidence remediation works are required.

On this basis it is considered that the proposed development will not result in adverse cumulative impacts on water use, flows or qualities in the surrounding areas.

7.0 Monitoring, Remediation, and Licensing

7.1 Surface Water Monitoring and Reporting

The monitoring and reporting program is outlined within the Water Management Plan (UCML, 2014) and will be amended to include the areas of the proposed modification, as required, if approved.

Monitoring results will, as per the Water Management Plan, be reported in the Ulan Coal Complex Annual Review which is distributed to Department of Planning and Environment (DP&E), Office of Environment and Heritage (OEH), the NSW Office of Water (NOW) and other relevant government agencies and made available to the community through UCML's website. Monitoring data will be retained in an appropriate database.

The results of the water quality monitoring will be used to review the effectiveness of the Ulan Coal Complex mine water management system on an ongoing basis.

As outlined in the Water Management Plan, water usage, rainfall, dam volumes and discharges (including transfers) at the Ulan Coal Complex will continue to be monitored for the entire operation to assist in the management of the mine water management system.

7.1.1 Subsidence Monitoring

In accordance with the existing monitoring program, watercourse stability monitoring of second order and higher watercourses is proposed to continue. Watercourse stability monitoring will assist in ensuring that the subsidence associated with the Ulan West mine plan does not result in increased rates of erosion and scouring within the overlying watercourses. It is recommended that the watercourse stability monitoring specifically includes the active head cut in the unnamed tributary of Cockabutta Creek (refer to **Section 2.2**).

Where monitoring indicates a potential increase in the rates of erosion and scouring within the affected watercourses, stabilisation works maybe required within the affected watercourses.

The requirements for subsidence monitoring within the areas impacted by each longwall panel will be included in the relevant Subsidence Management Plan.

7.2 Subsidence Remediation and Surface Facility Water Quality Controls

UCML proposes to continue to utilise subsidence remediation methods and associated erosion and sediment control measures and monitoring programs to manage potential subsidence impacts on watercourses. These measures are described in the Water Management Plan and outlined below and in **Section 7.1** of this report.

UCML will continue to manage any potential subsidence remediation and surface facility works by utilising erosion and sediment control measures that will be designed and constructed to a standard consistent with:

- Managing Urban Stormwater: Soils and Construction (the Blue Book) Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008); and

- Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields (DIPNR undated).

In addition, water quality and erosion and sediment control measures proposed to be implemented for the proposed modification are consistent with those outlined in the Water Management Plan (UCML, 2014) and include:

- clearly identifying and delineating areas required to be disturbed and ensuring that disturbance is limited only to those areas, clearing vegetation only as required to achieve the works and minimising machinery disturbance outside of these areas;

- construction of erosion and sediment controls prior to the commencement of any substantial construction works;

- construction and regular maintenance of sediment fences downslope of disturbed areas;

- soil amelioration, to minimise potential erosion on disturbed or reshaped areas;

- limiting the number of roads and tracks established;

- regular maintenance of erosion control works and rehabilitated areas; and

- prompt revegetation of areas as soon as earthworks are complete.

7.3 Contingency Measures

7.3.1 Water

With the proposed modification, the site will continue to have water in excess of its operational needs. The proposed modification will not change the site water management strategy (UCML, 2011) and will not require any additional discharge infrastructure to be constructed. With the approved discharge facilities (Umwelt, 2009) there is considerable flexibility in managing the volume of water that is discharged from the site. Management options include cycling the use of the discharge facilities and varying the rate at which water is discharged from the site. Water sharing opportunities may provide additional discharge capacity and additional water storage opportunities may be available within the open cut operations and underground voids if required.

7.3.2 Soil

If surface stabilisation during remediation works is required due to surface rilling, soil amelioration prior to revegetation may be required and additional erosion and sediment controls may need to be implemented (refer to **Section 7.2**).

7.4 Licensing Requirements

7.4.1 Water Act and Water Management Act

Surface waters of the project area are governed by the *Water Management Act 2000* and the groundwater associated with the hardrock aquifers (i.e. coal seams) are governed under the *Water Act 1912* and *Water Management Act 2000*.

The potential implications of the Water Sharing Plan Hunter Unregulated and Alluvial Water Sources 2009 are considered in **Section 6.4.2**. The potential implications for water licences under the *Water Act 1912* and *Water Management Act 2000* are also considered in **Section 6.4.2** and the Groundwater Assessment (refer to Appendix 3 of the EA).

8.0 References

Department of Environment and Climate Change (DECC), 2008. *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries*.

DIPNR, undated. *Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields.*

DWE, undated. *Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region*.

Fischenich, C., 2001, *Stability Thresholds for Stream Restoration Materials*, U.S. Army Engineer and Research Development.

Landcom, 2004. *Managing Urban Stormwater: Soils and Construction – Volume 1*.

Mackie Environmental Research (MER), 2014, *Assessment of Groundwater Related Impacts Arising from Modifications to the Ulan West Mine Plan*, prepared on behalf of Ulan Coal Mine Limited.

Murphy, B.W. and Lawrie, J.W., 1998. *Soil Landscapes of the Dubbo 1:250 000 Map Sheet.* Department of Land & Water Conservation of NSW, Sydney.

NOW, 2009. *Water Reporting Requirements for Mining Operations*.

Strata Control Technologies (SCT), 2009, *Part 3A Subsidence Assessment - Ulan Coal - Continued Operations*, prepared on behalf of Ulan Coal Mines Limited.

Strata Control Technologies (SCT), 2014, *Subsidence Assessment for Proposed Ulan West Mine Plan Modification* prepared on behalf of Ulan Coal Mines Limited.

UCML, 2014. *Ulan Water Management Plan*.

Umwelt, 2007. *Mona Creek Hydraulic Assessment*, prepared on behalf of Ulan Coal Mines Limited.

Umwelt, 2009. *Ulan Coal - Continued Operations Environmental Assessment*, prepared on behalf of Ulan Coal Mines Limited.

Umwelt (Australia) Pty Limited, 2011, *Surface Water Assessment, Modification of Ulan Coal – Continued Operations, North 1 Underground Mining Area, Minor Modifications to Ulan No. 3 and Ulan West Mine Plans and Proposed Concrete Batching Plant*, prepared on behalf of Ulan Coal Mines Limited.

Umwelt, 2012. *Ulan Creek Hydraulic Assessment*, prepared on behalf of Ulan Coal Mines Limited.

Yoo, E K, Tadros, N Z, and Bayly, K W, 2001. *A Compilation of Geology of the Western Coalfield.* Geological Survey of New South Wales, Report GS2001/204 (unpublished).

APPENDIX A

Watercourse Longsections

Mona Creek Catchment

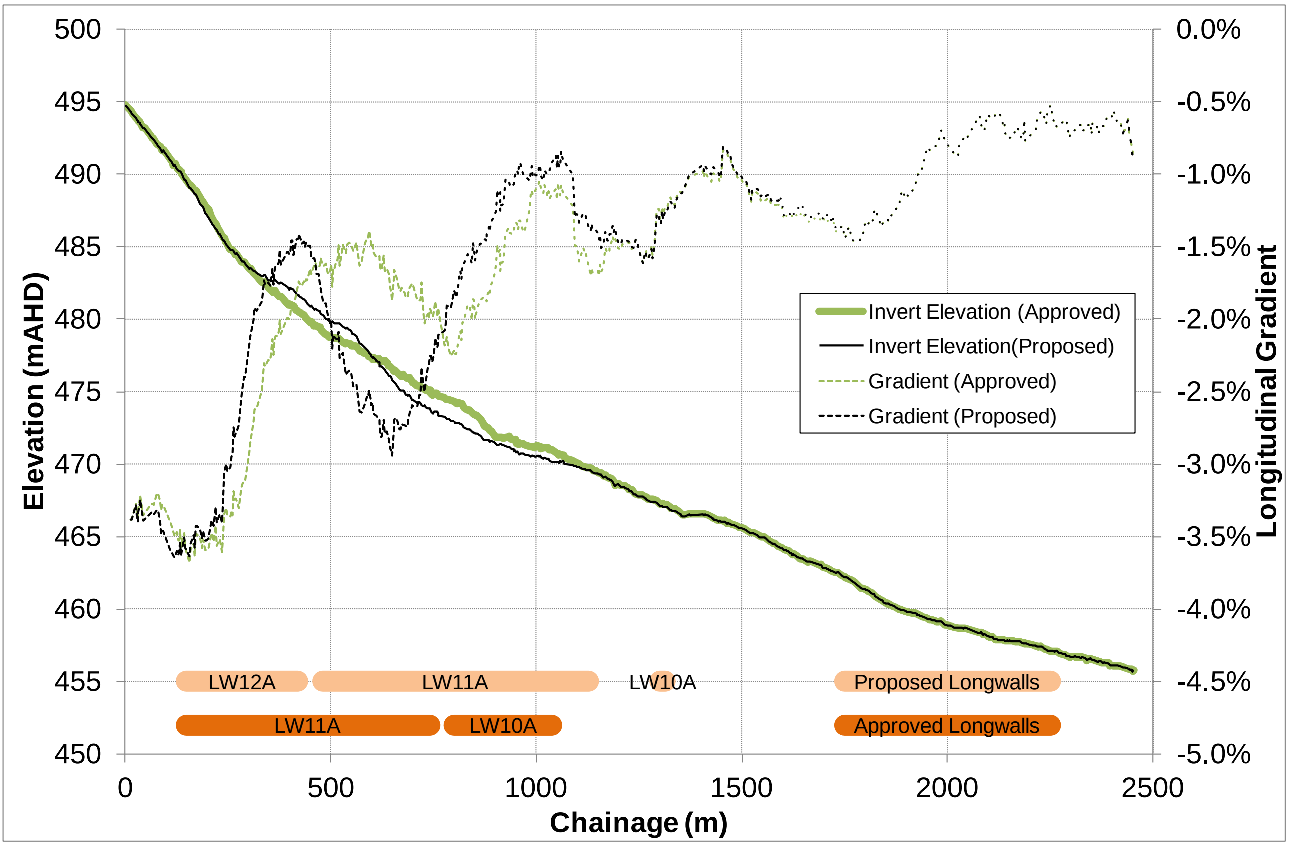


Chart A1.1 - Watercourse Longsection - Watercourse 1

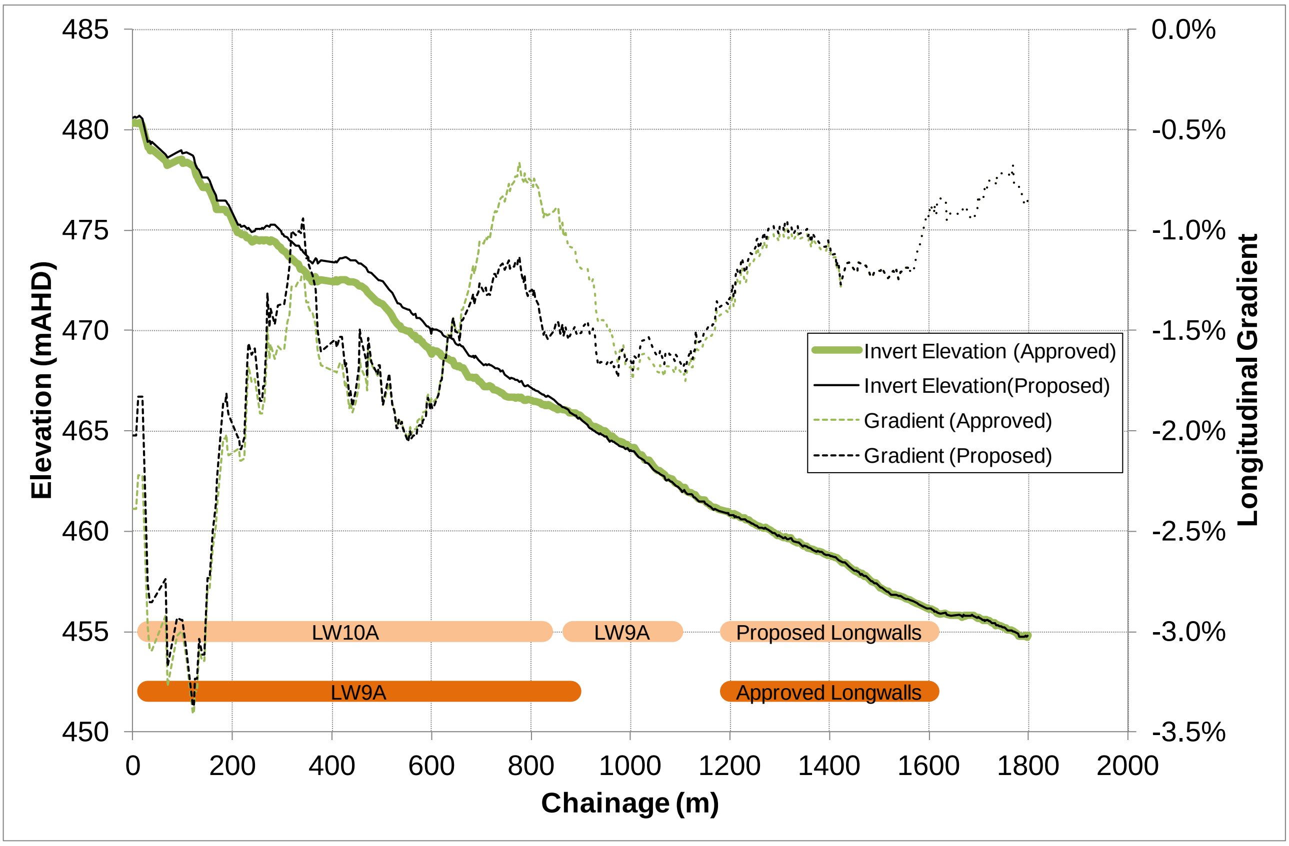


Chart A1.2 - Watercourse Longsection - Watercourse 2

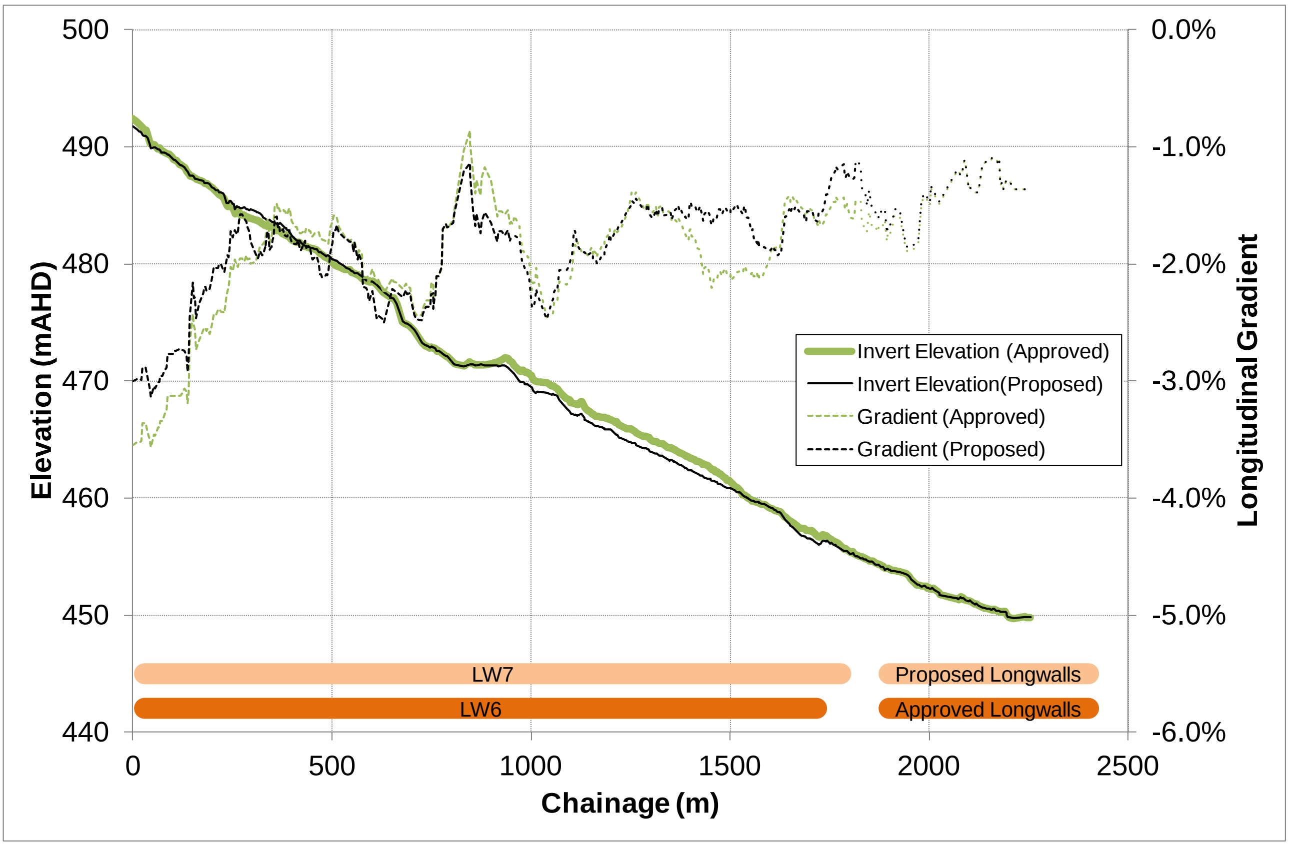


Chart A1.3 - Watercourse Longsection - Watercourse 3

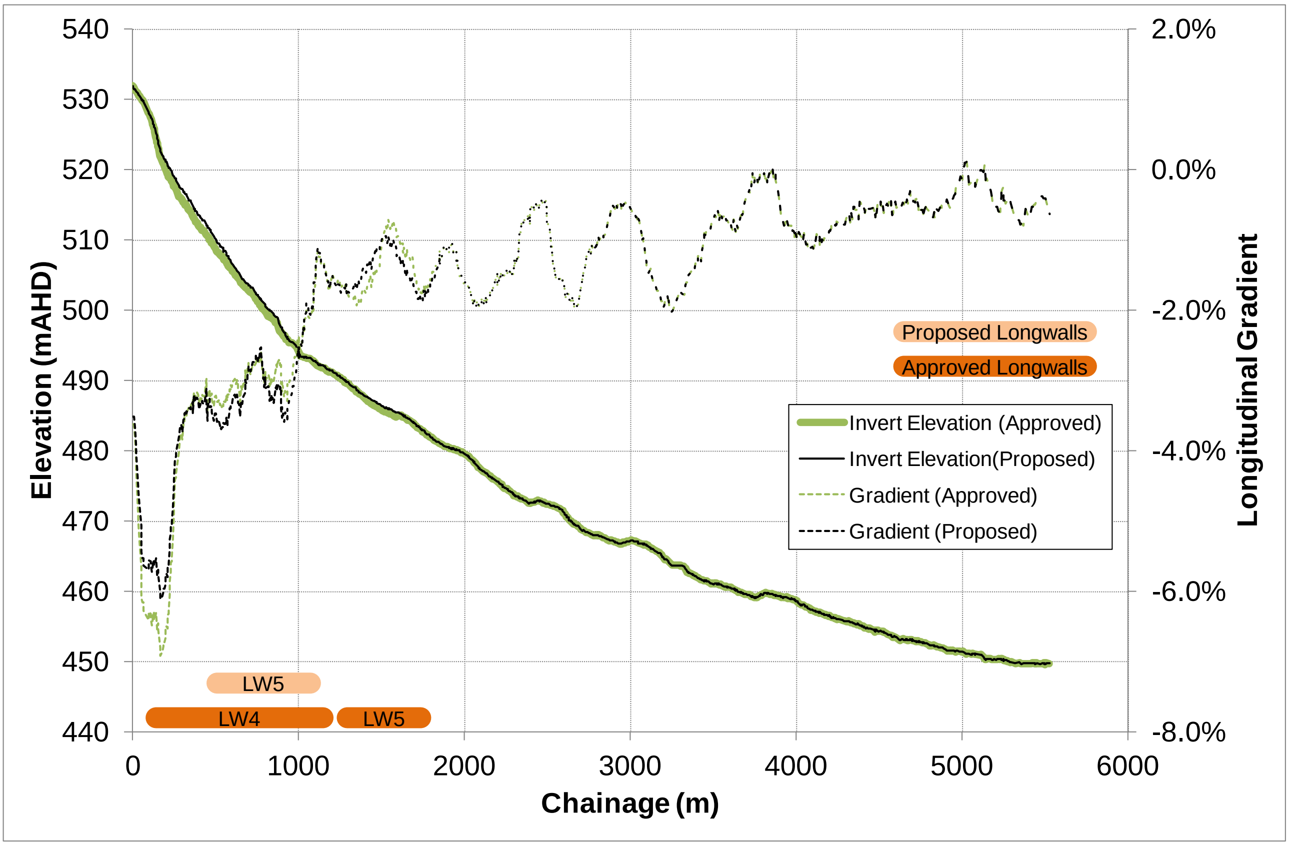


Chart A1.4 - Watercourse Longsection - Watercourse 12

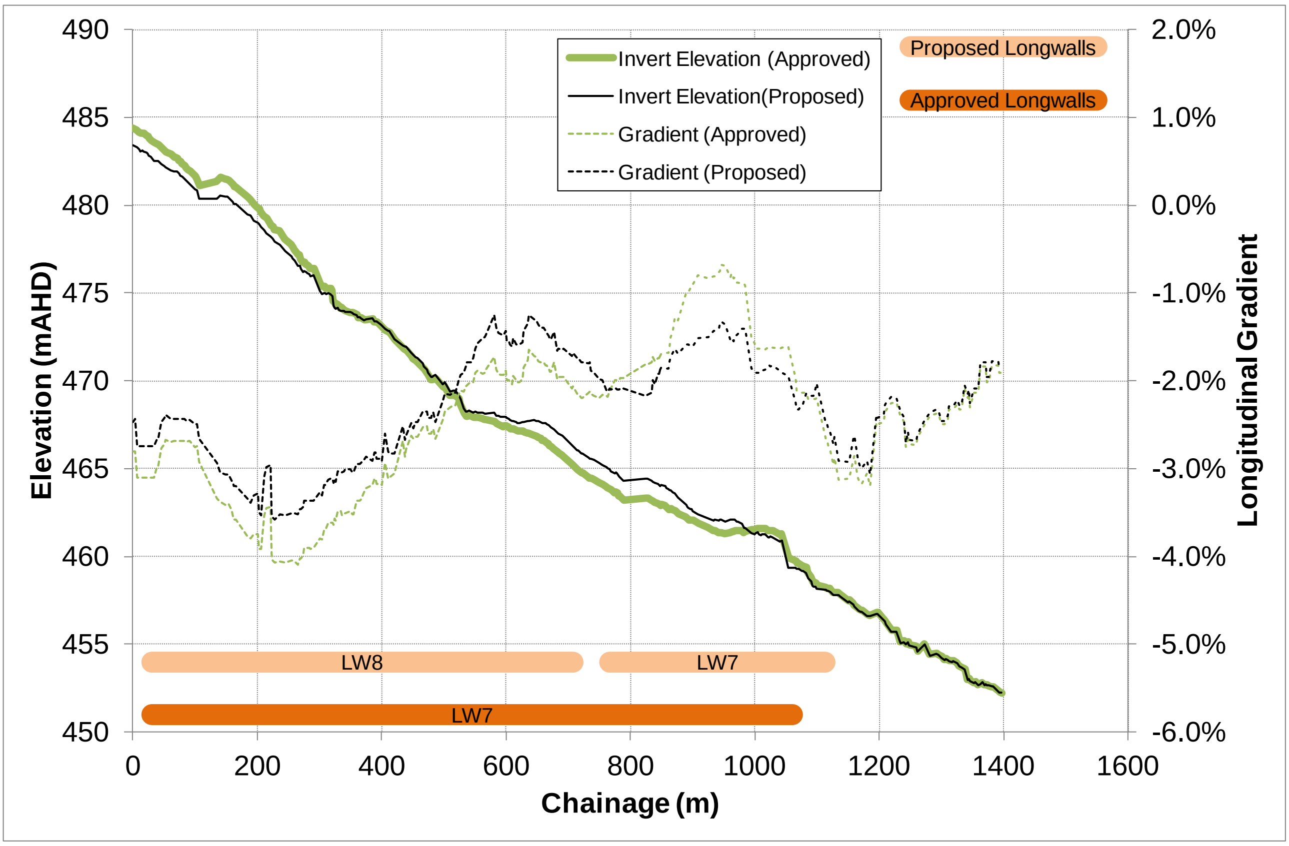


Chart A1.5 - Watercourse Longsection - Watercourse 14

Cockabutta Creek Catchment

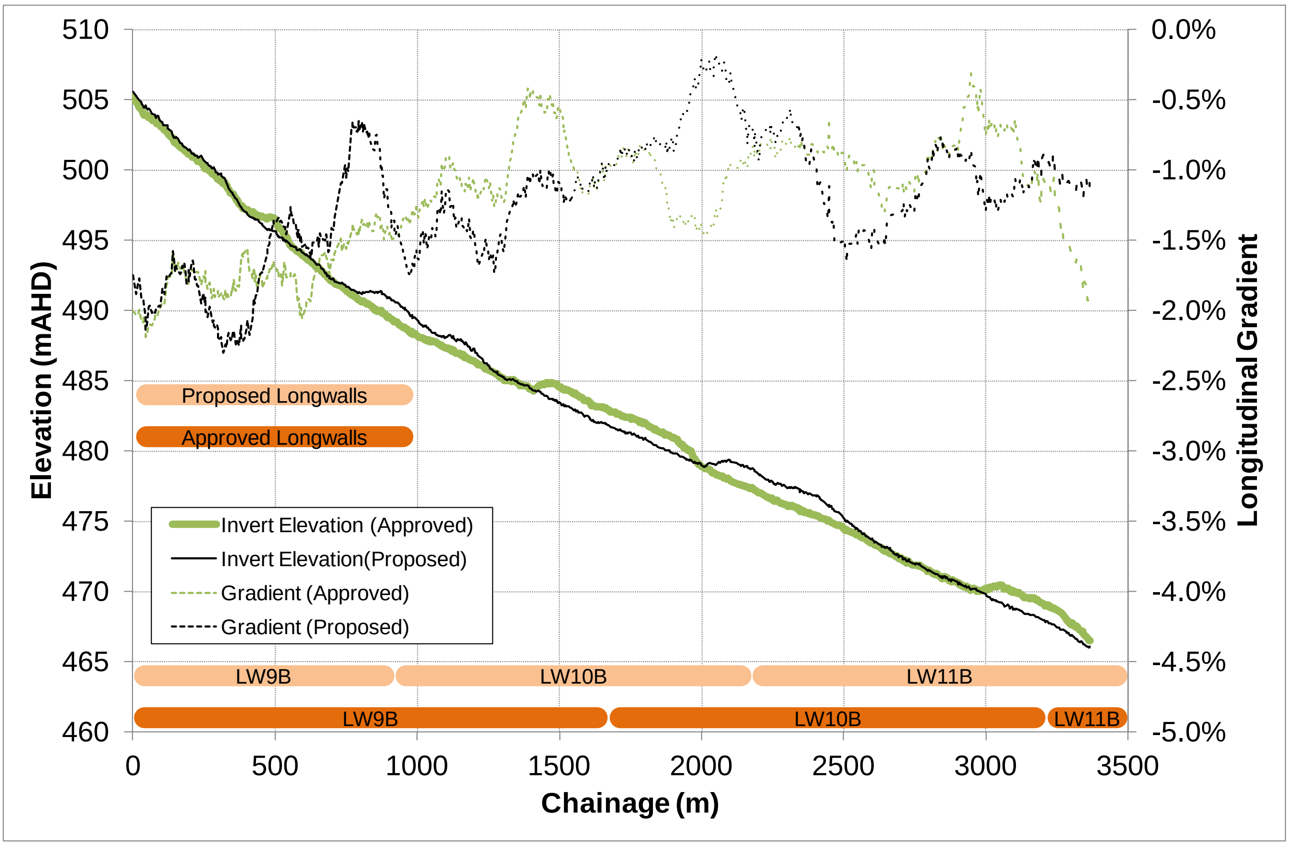


Chart A1.6 - Watercourse Longsection - Watercourse 4

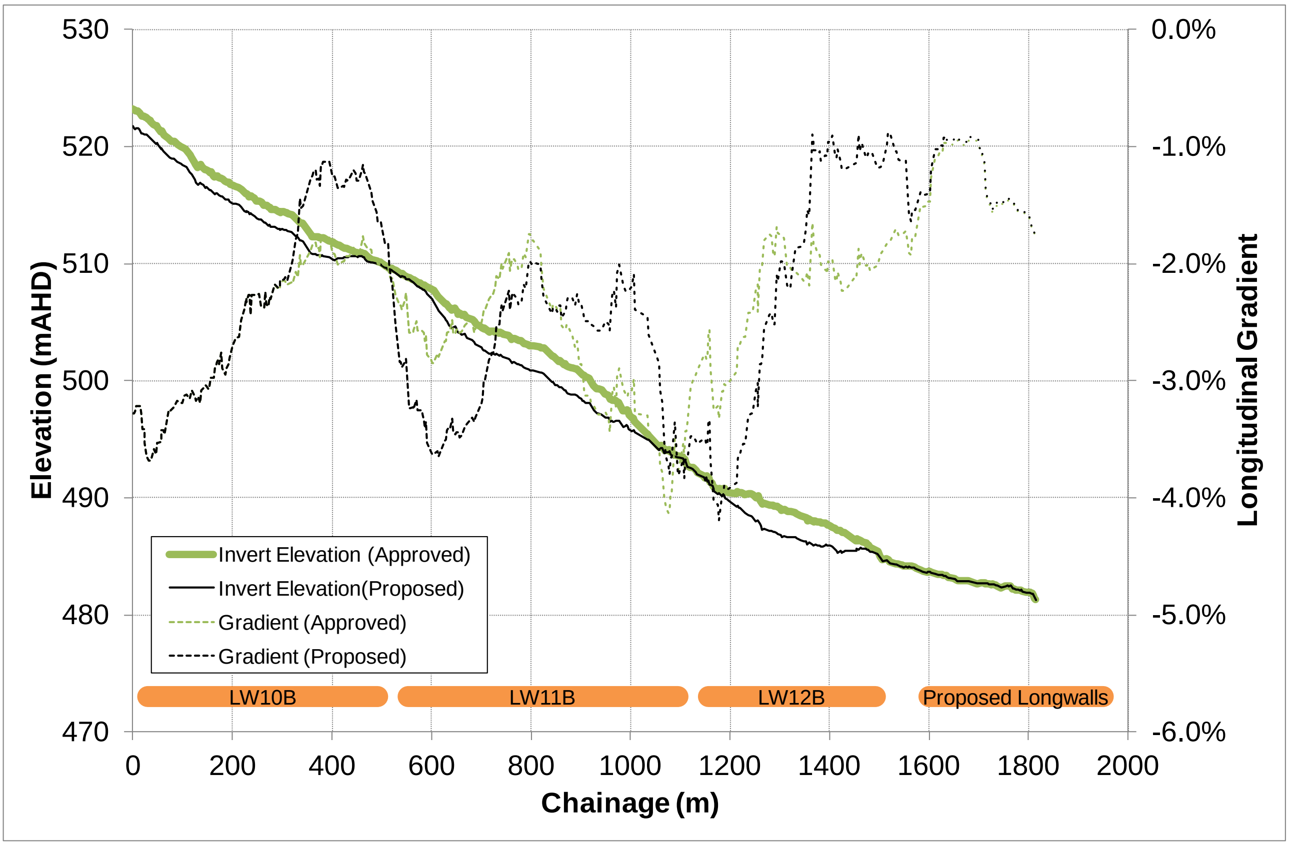


Chart A1.7 - Watercourse Longsection - Watercourse 5

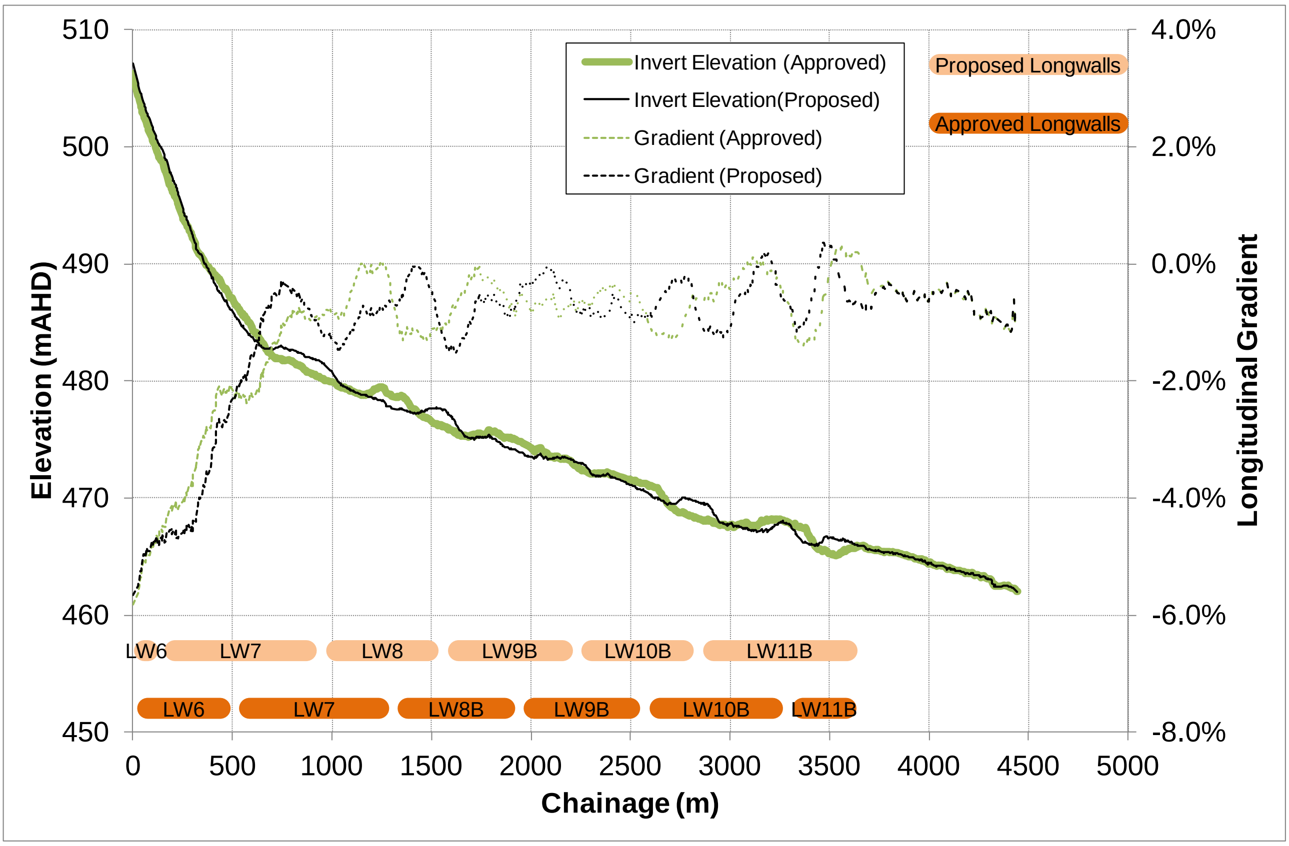


Chart A1.8 - Watercourse Longsection - Watercourse 13

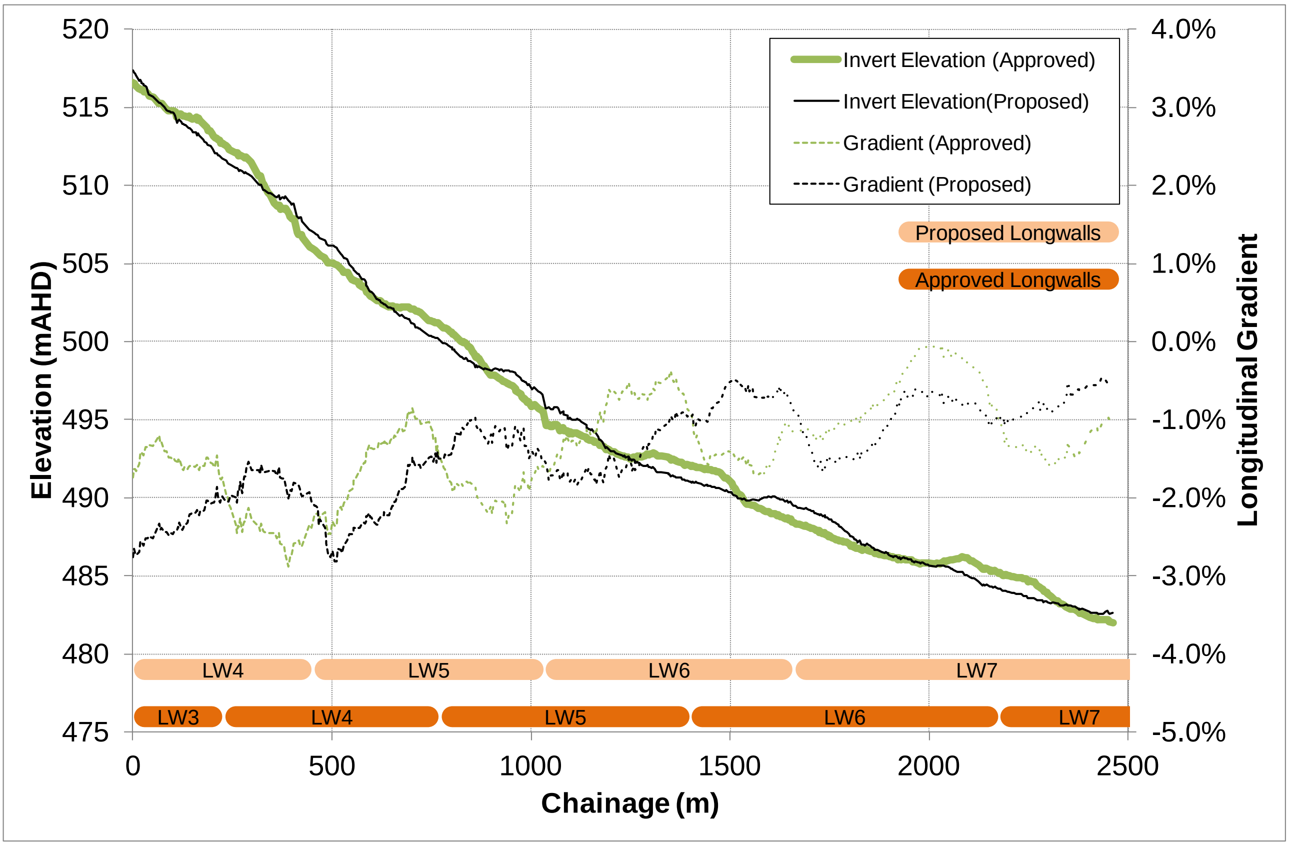


Chart A1.9 - Watercourse Longsection - Watercourse 15

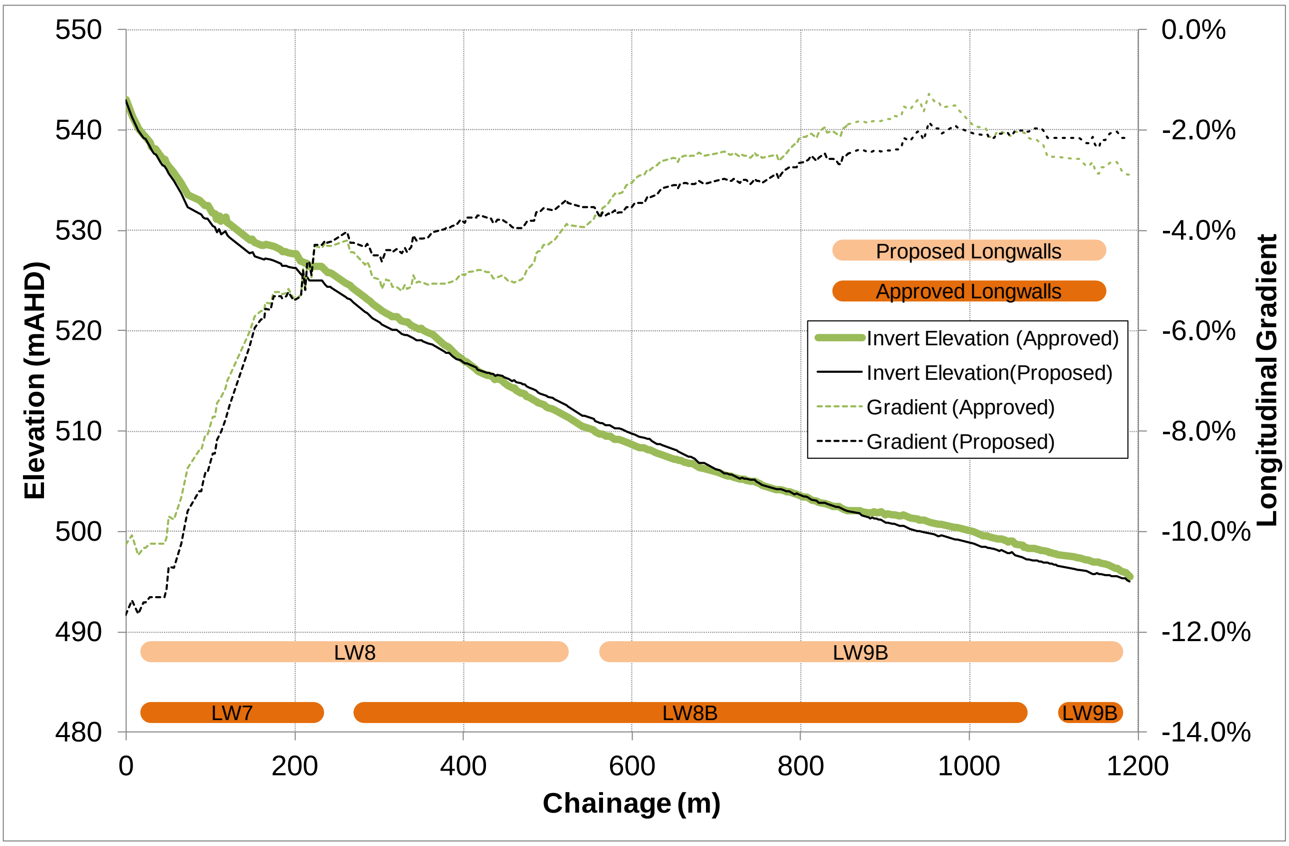


Chart A1.10 - Watercourse Longsection - Watercourse 16

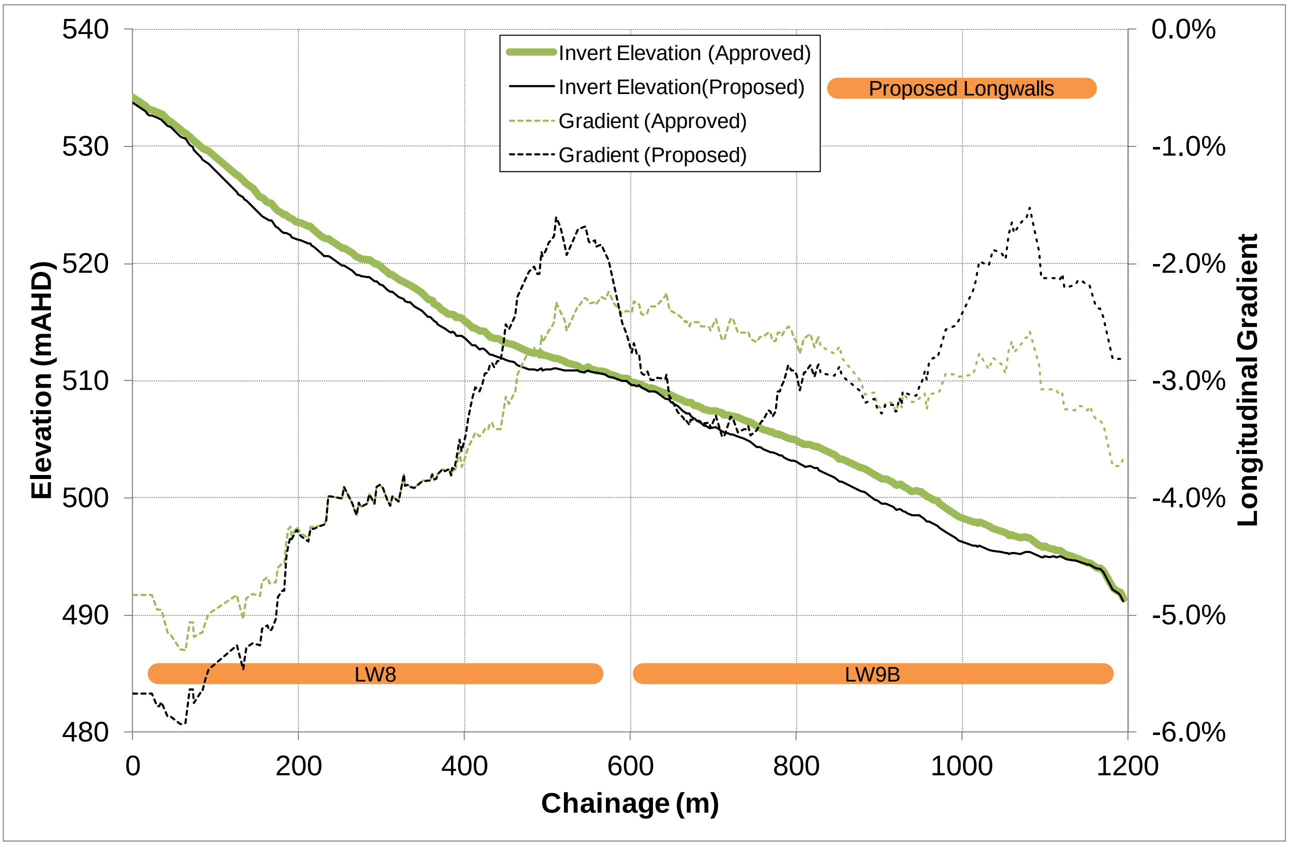


Chart A1.11 - Watercourse Longsection - Watercourse 17

Ulan Creek Catchment

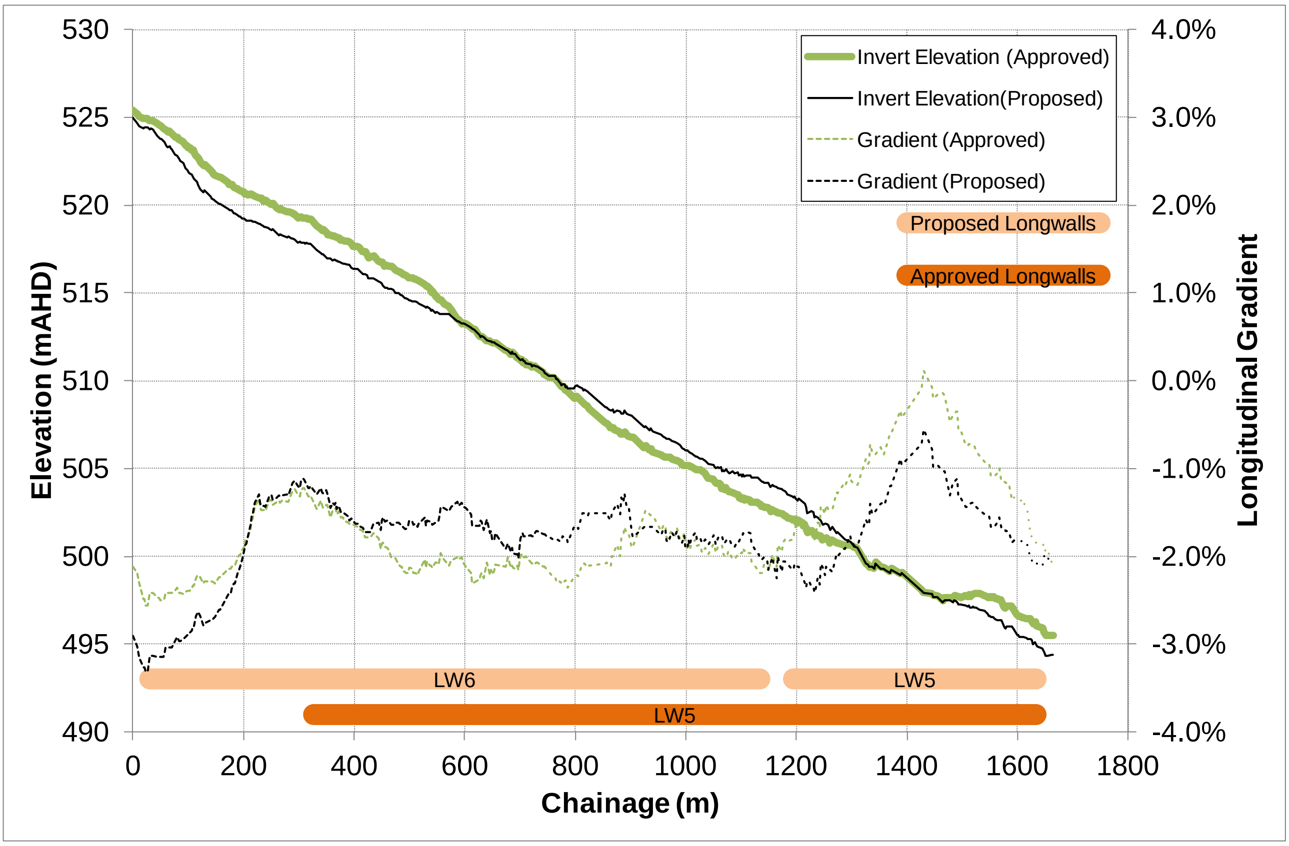


Chart A1.12 - Watercourse Longsection - Watercourse 6

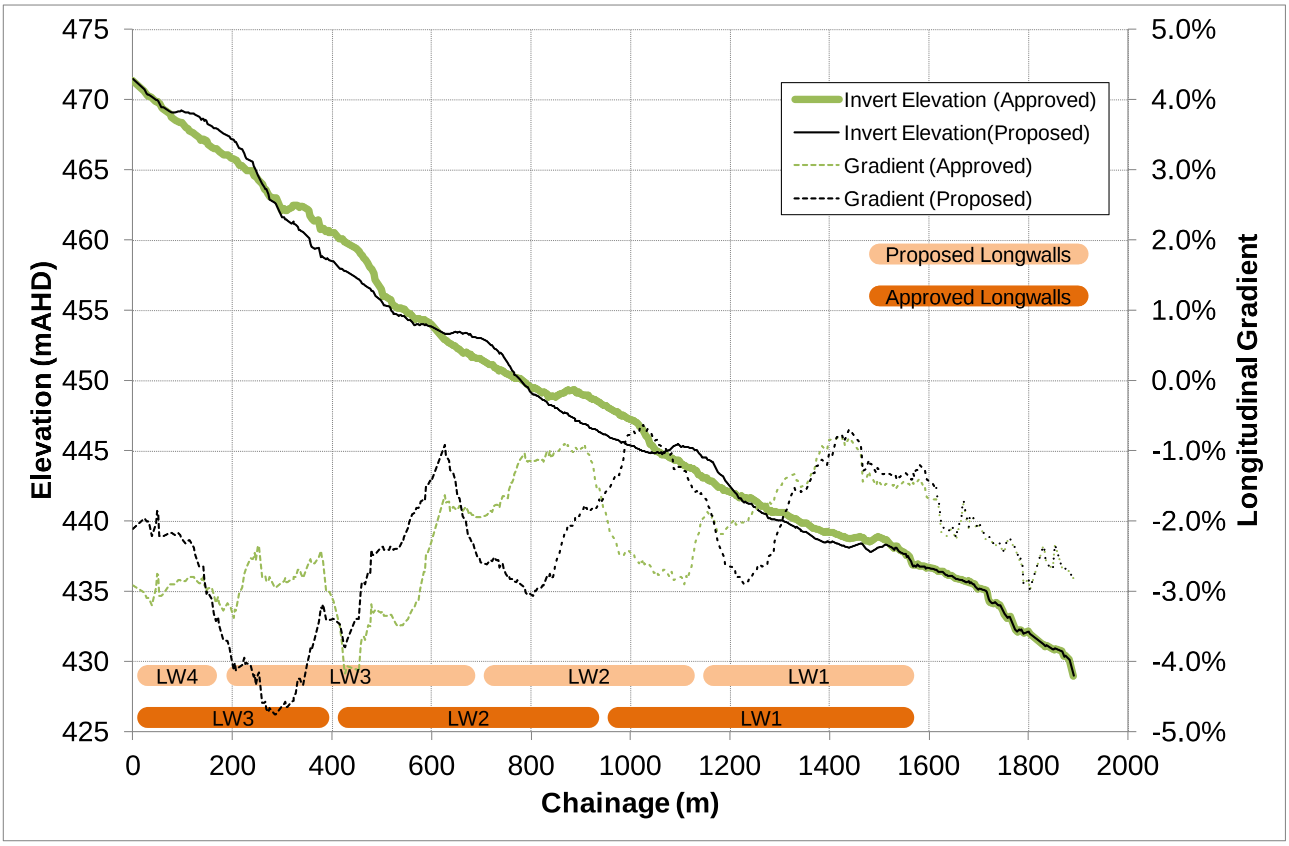


Chart A1.13 - Watercourse Longsection - Watercourse 7

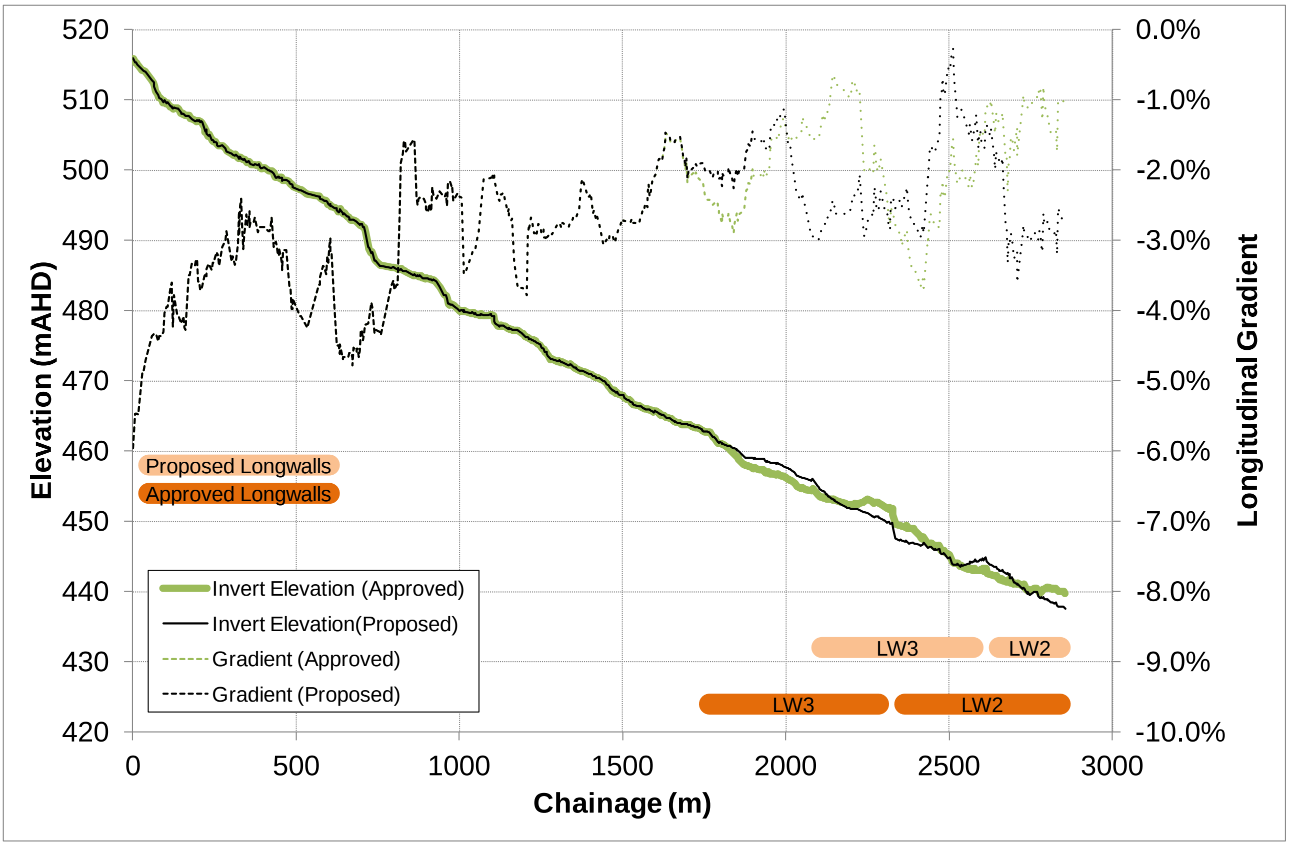


Chart A1.14 - Watercourse Longsection - Watercourse 8

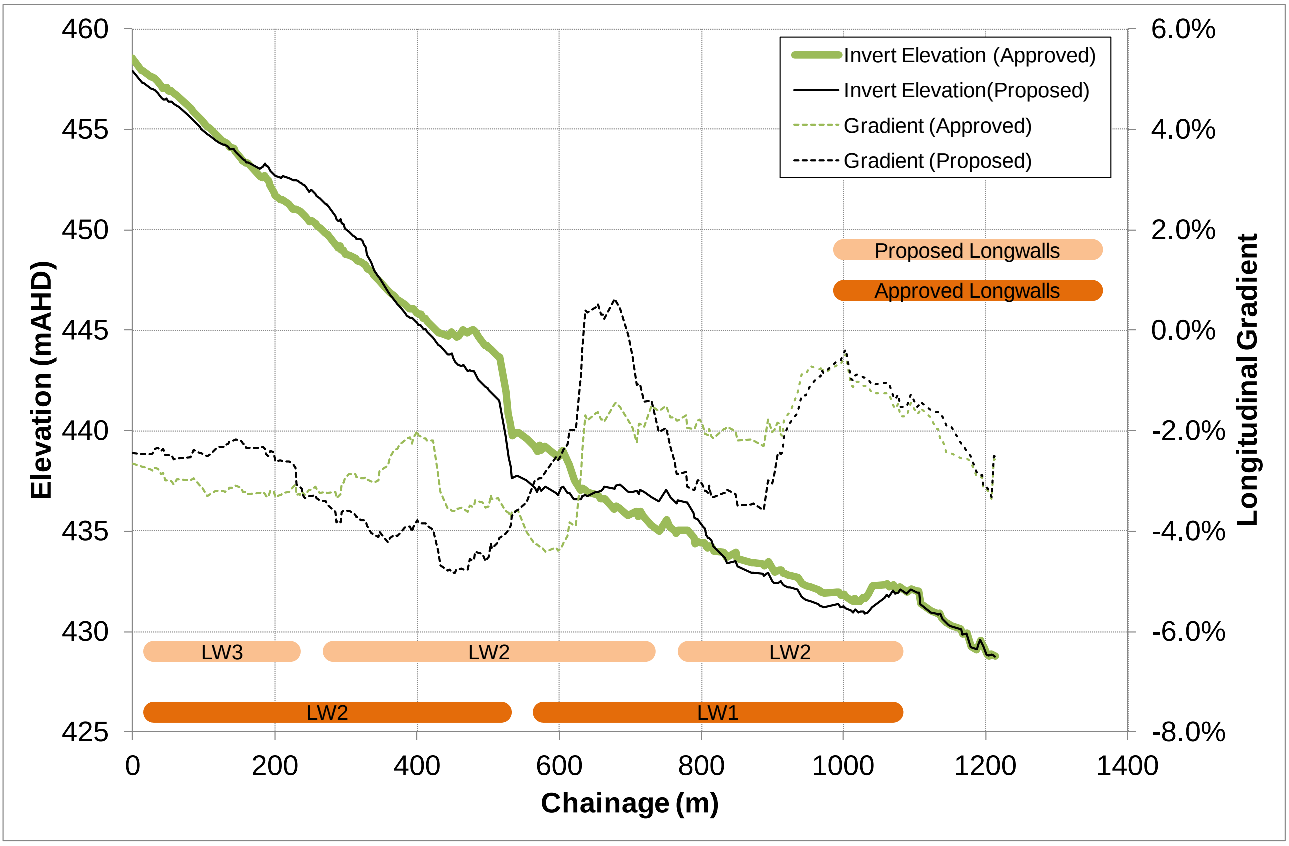


Chart A1.15 - Watercourse Longsection - Watercourse 9

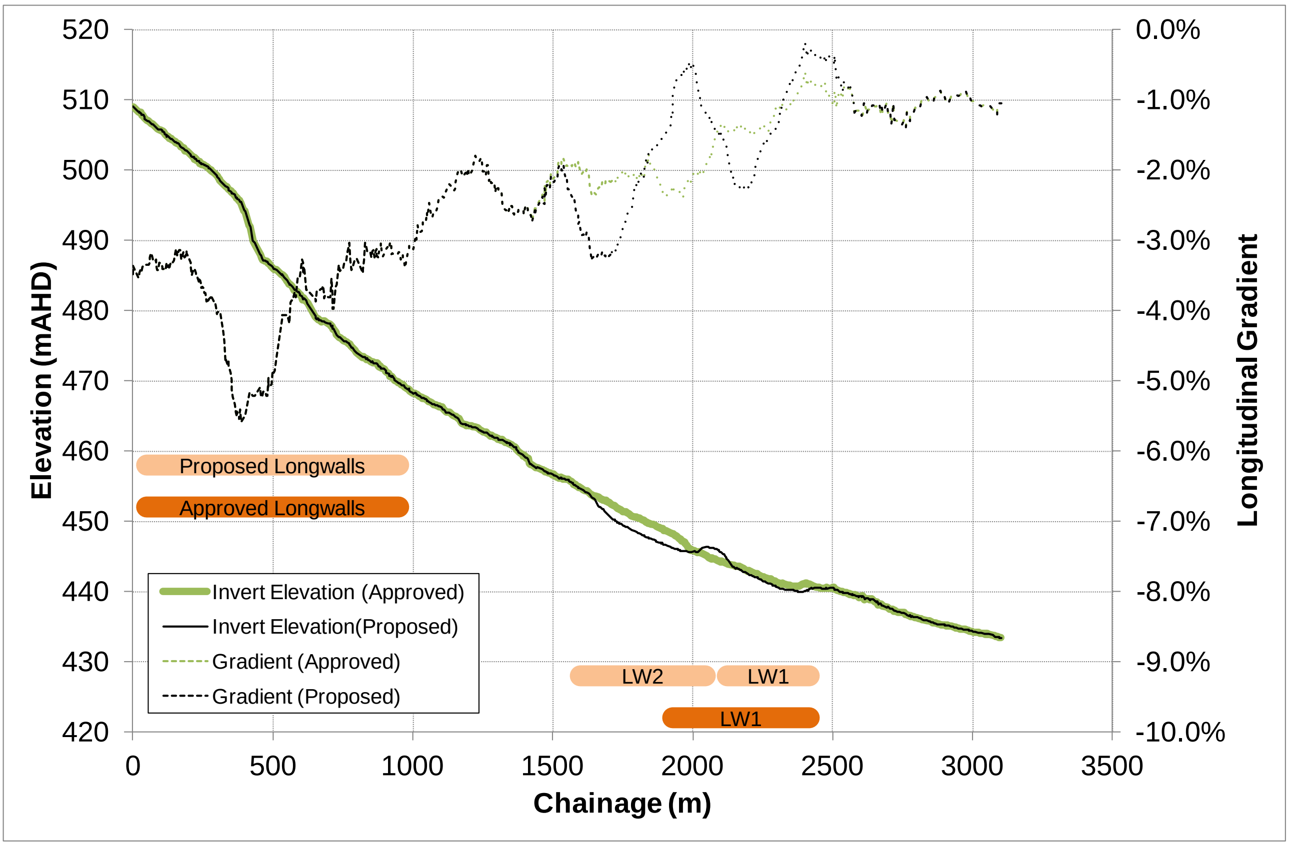


Chart A1.16 - Watercourse Longsection - Watercourse 10

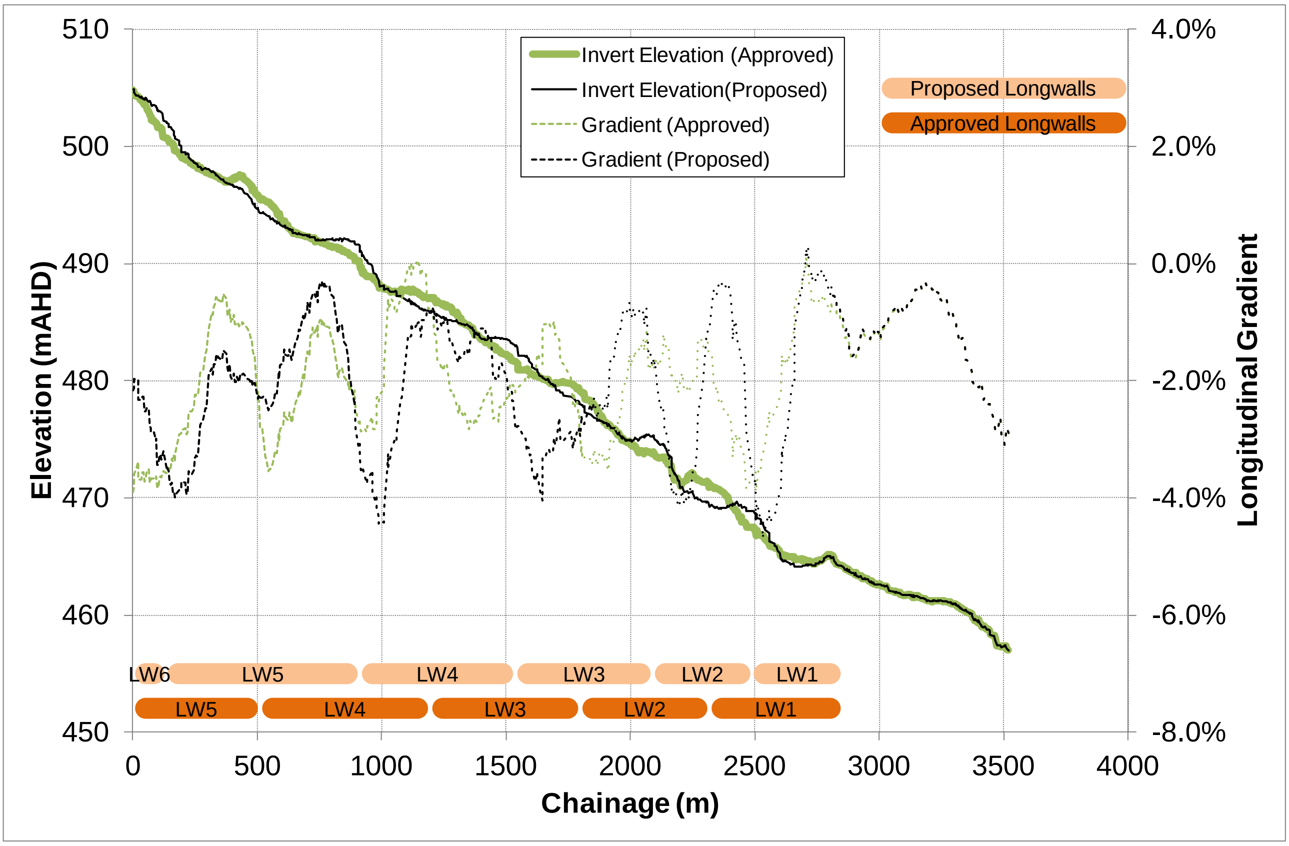


Chart A1.17 - Watercourse Longsection - Watercourse 11

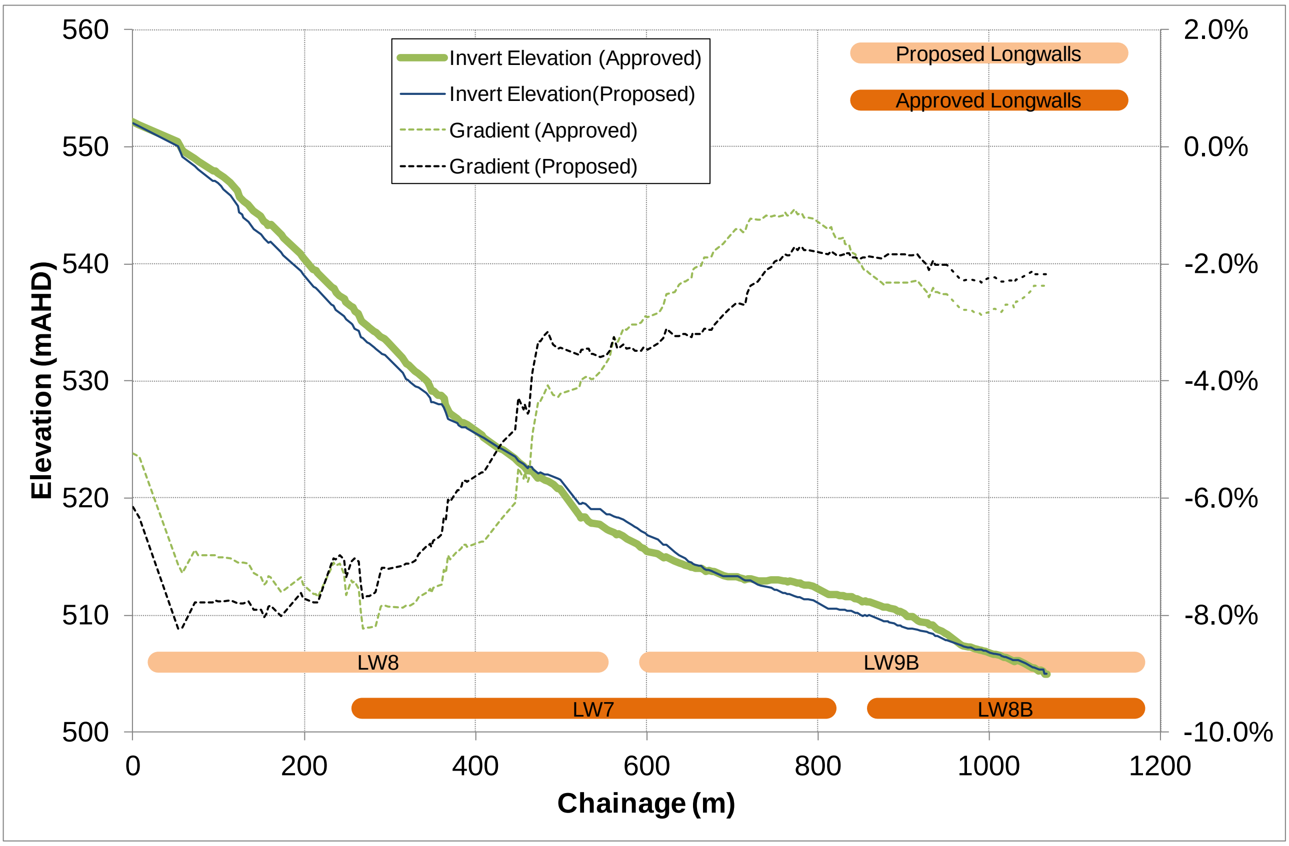


Chart A1.18 - Watercourse Longsection - Watercourse 18

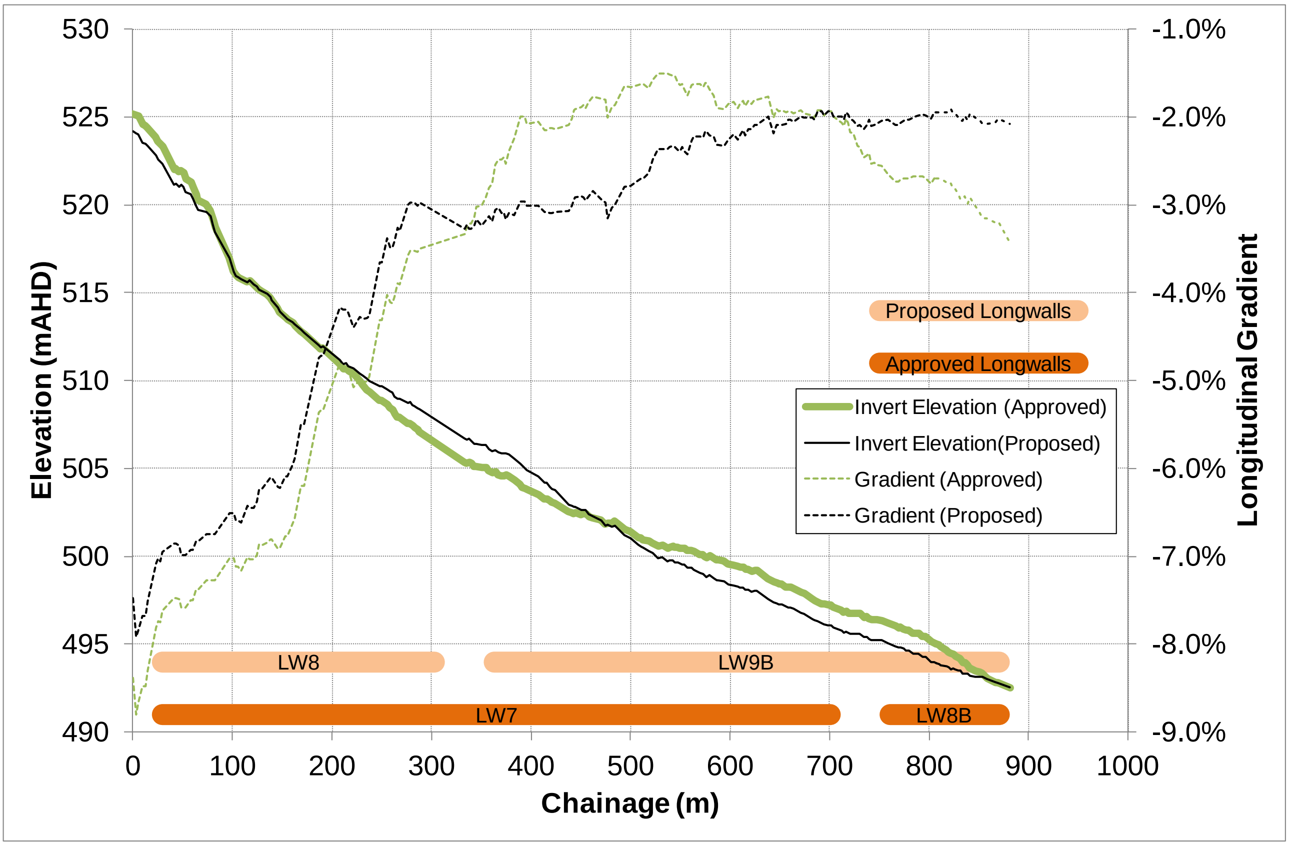


Chart A1.19 - Watercourse Longsection - Watercourse 19

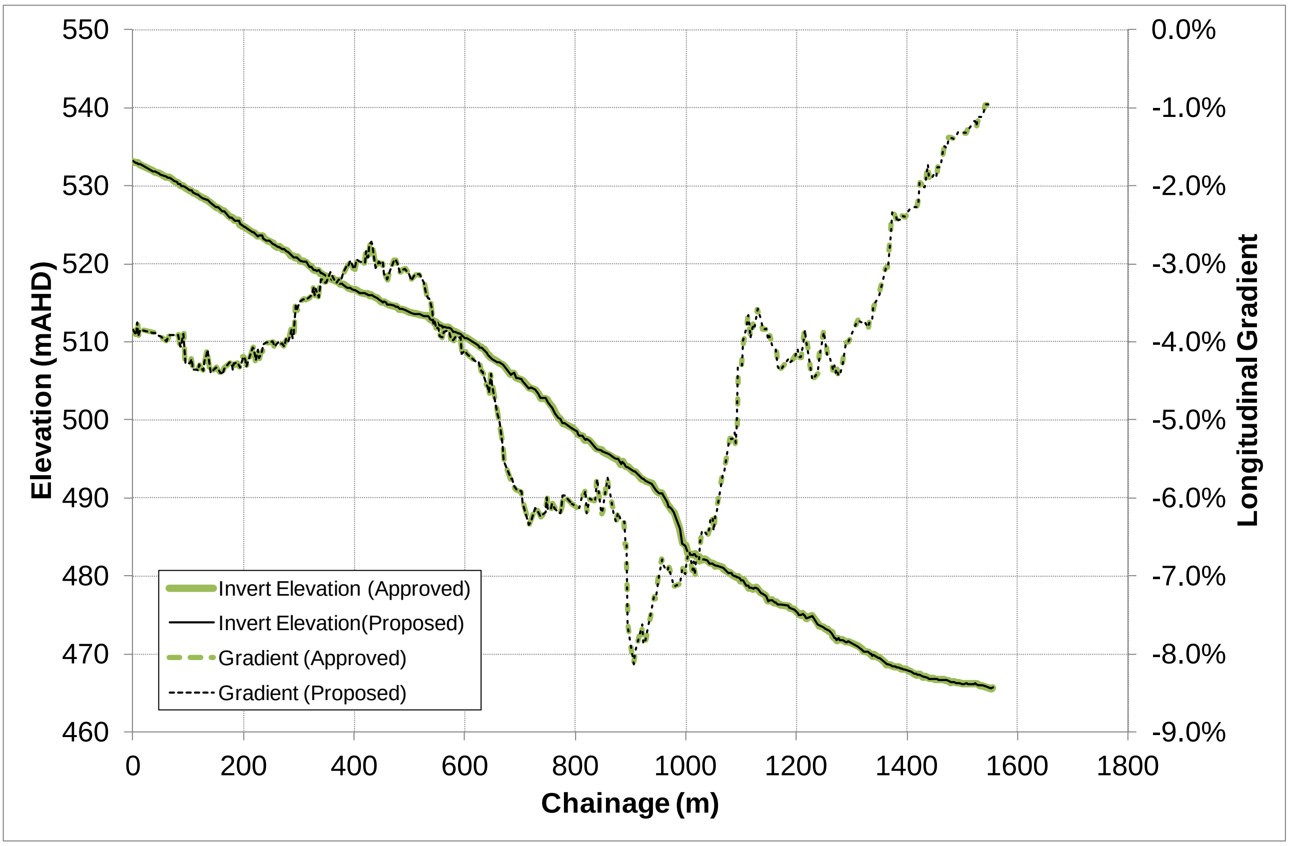


Chart A1.20 - Watercourse Longsection - Watercourse 20

APPENDIX B

Maximum Modelled Flow Depths

Mona Creek Catchment

Watercourse 1

The analysis indicates that the proposed modification results in increases in the maximum modelled flow depths within Watercourse 1 of up to approximately 0.03 metres (refer to **Chart A2.1**). The maximum modelled increase in flow depths occur at the northern end of proposed longwall 11A east (downstream) of the chainpillar that separates approved Longwall 11 and 12 (refer to **Figure 4.2** and **Chart A2.1**). The analysis also indicates that the proposed modification results in decreases in the maximum modelled flow depths within Watercourse 1 of up to approximately 0.02 metres (refer to **Chart A2.1**). The maximum modelled decrease in flow depths occur west (upstream) of the chainpillar that separates approved Longwall 10A and 11A (refer to **Figure 4.2** and **Chart A2.1**).

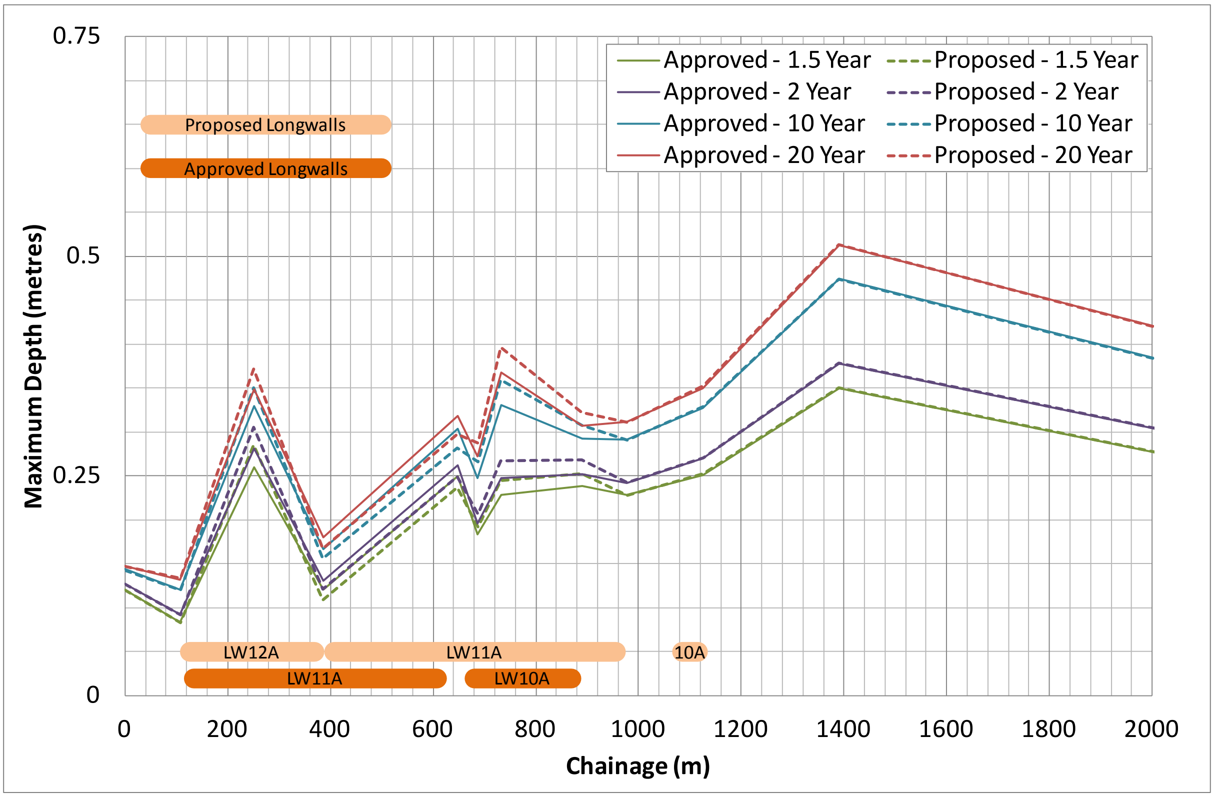


Chart A2.1 - Maximum Modelled Flow Depth
Mona Creek - Watercourse 1

Watercourse 2

The analysis indicates that the proposed modification results in increases in the maximum modelled flow depths within Watercourse 2 of up to approximately 0.03 metres (refer to **Chart A2.2**). The maximum modelled increase in flow depths occur at the upstream end of Watercourse 2 within the centre of proposed longwall 10A (refer to **Figure 4.2** and **Chart A2.2**). The analysis also indicates that the proposed modification results in decreases in the maximum modelled flow depths within Watercourse 2 of up to approximately 0.03 metres (refer to **Chart A2.2**). The maximum modelled decrease in flow depths occur at the upstream of the northern end of approved Longwall 9A (refer to **Figure 4.2** and **Chart A2.2**).

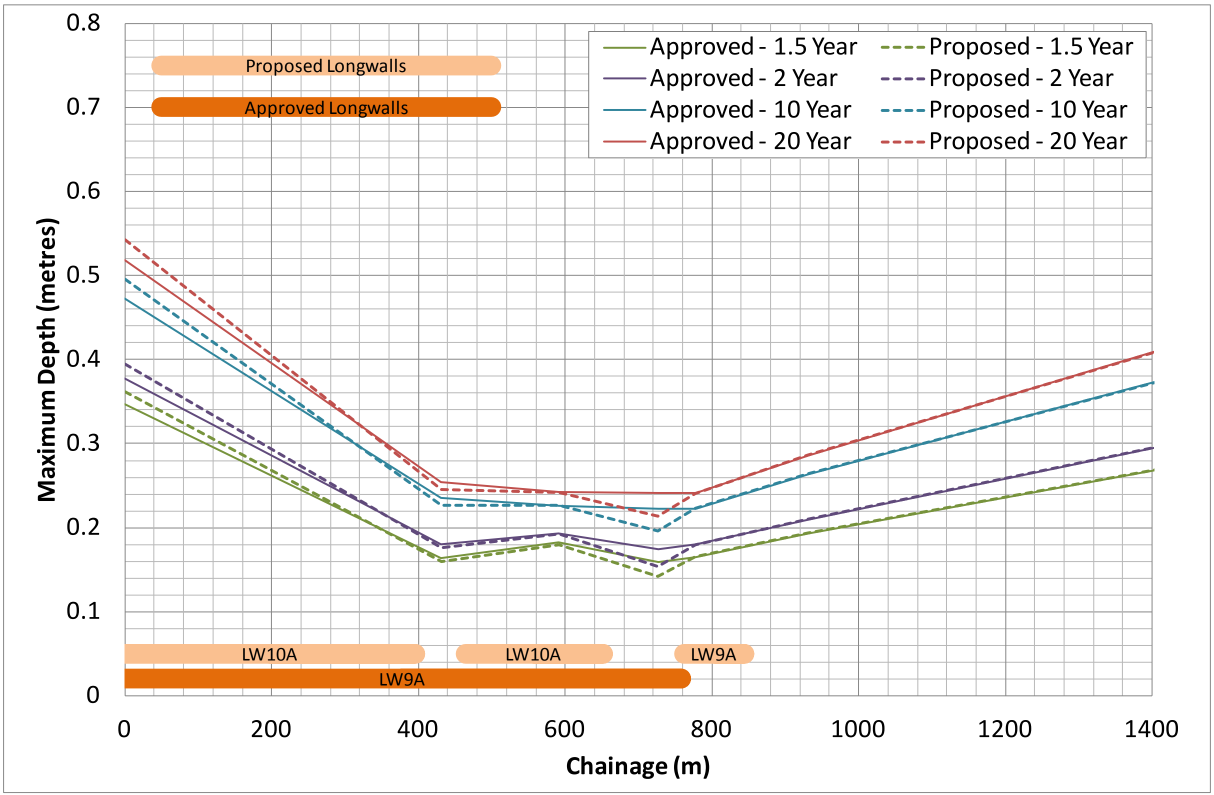


Chart A2.2 - Maximum Modelled Flow Depth
Mona Creek - Watercourse 2

Watercourse 3

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depth within Watercourse 3 of up to approximately 0.02 metres (for the 20 year ARI critical duration design storm event: refer to **Chart A2.3**). The maximum modelled increase in flow depths occurs at the northern end of proposed longwall 7 (refer to **Figure 4.2** and **Chart A2.3**). The modelling also indicates that the proposed modification results in decreases in the maximum modelled flow depth within Watercourse 3 of up to approximately 0.02 metres (refer to **Chart A2.3**). The maximum modelled decrease in flow depths occurs further north towards the northern end of proposed longwall 7 (refer to **Figure 4.2** and **Chart A2.3**).

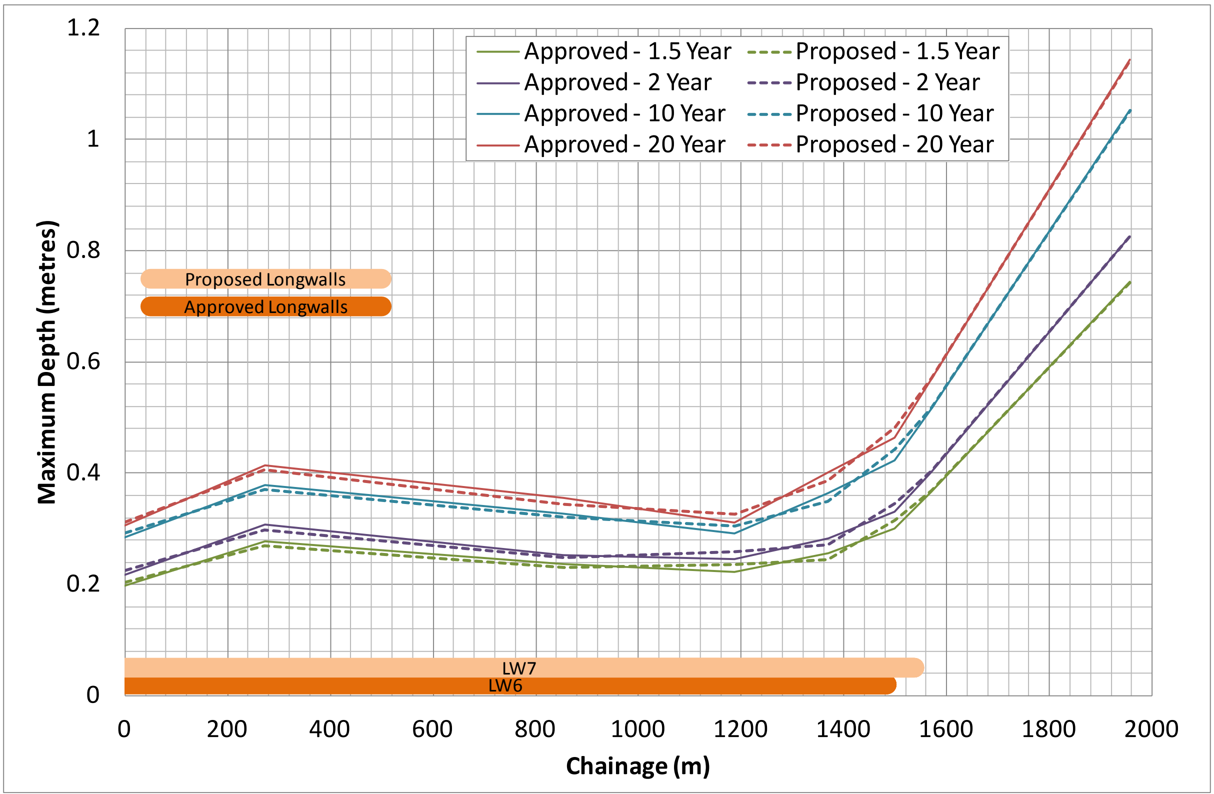


Chart A2.3 - Maximum Modelled Flow Depth
Mona Creek - Watercourse 3

Watercourse 12

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.02 metres (refer to **Chart A2.4**). The maximum modelled increase in flow depths occurs north (downstream) of proposed longwall 5 (refer to **Figure 4.2** and **Chart A2.4**). The modelling indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.01 metres (refer to **Chart A2.4**). The maximum modelled decrease in flow depths occurs within the centre of approved Longwall 5 (refer to **Figure 4.2** and **Chart A2.4**).

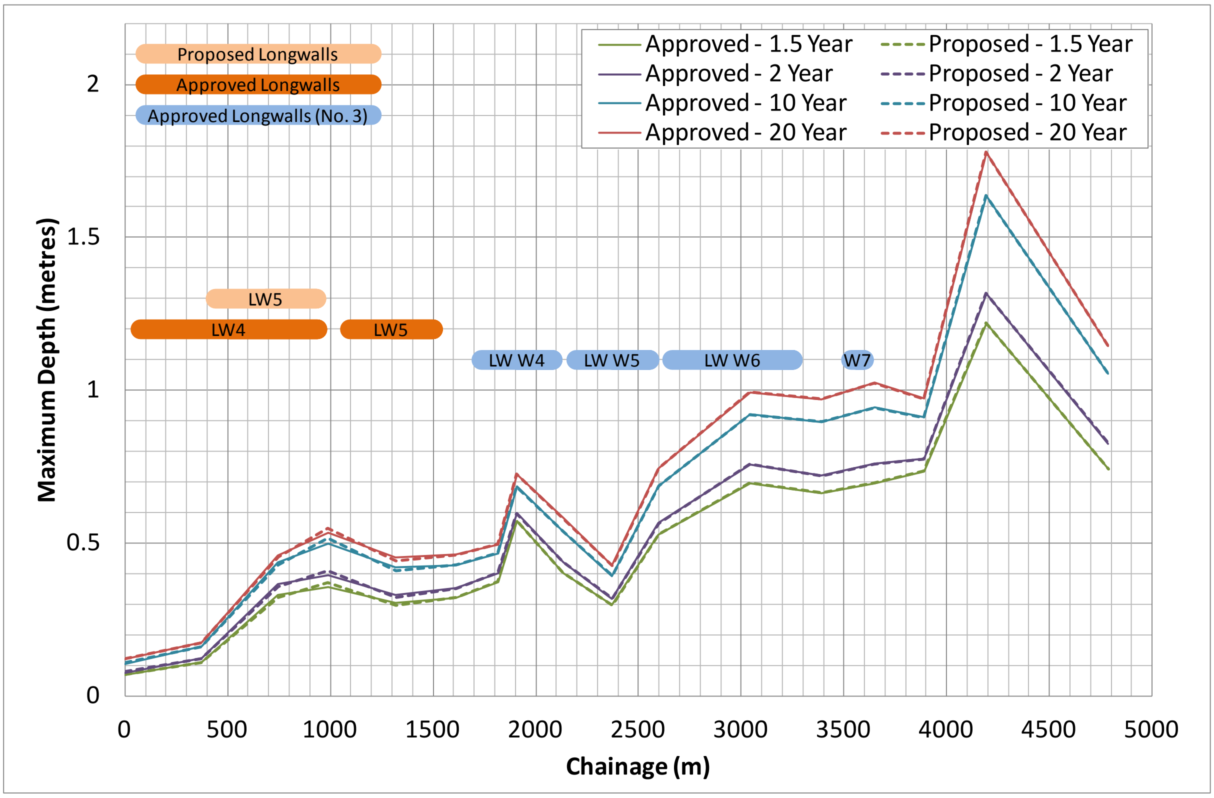


Chart A2.4 - Maximum Modelled Flow Depth
Mona Creek - Watercourse 12

Cockabutta Creek Catchment

Watercourse 4

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.79 metres (refer to **Chart A2.5**). The maximum modelled increase in flow depths occurs at the downstream most end of Watercourse 4 within the centre of proposed longwall 11B above the chainpillar that separates approved longwalls 11 and 12 (refer to **Figure 4.2** and **Chart A2.5**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.10 metres (refer to **Chart A2.5**). The maximum modelled decrease in flow depths occurs within the centre of proposed longwall 11B to the east of the approved chainpillar between approved longwalls 10B and 11B (refer to **Figure 4.2** and **Chart A2.5**).

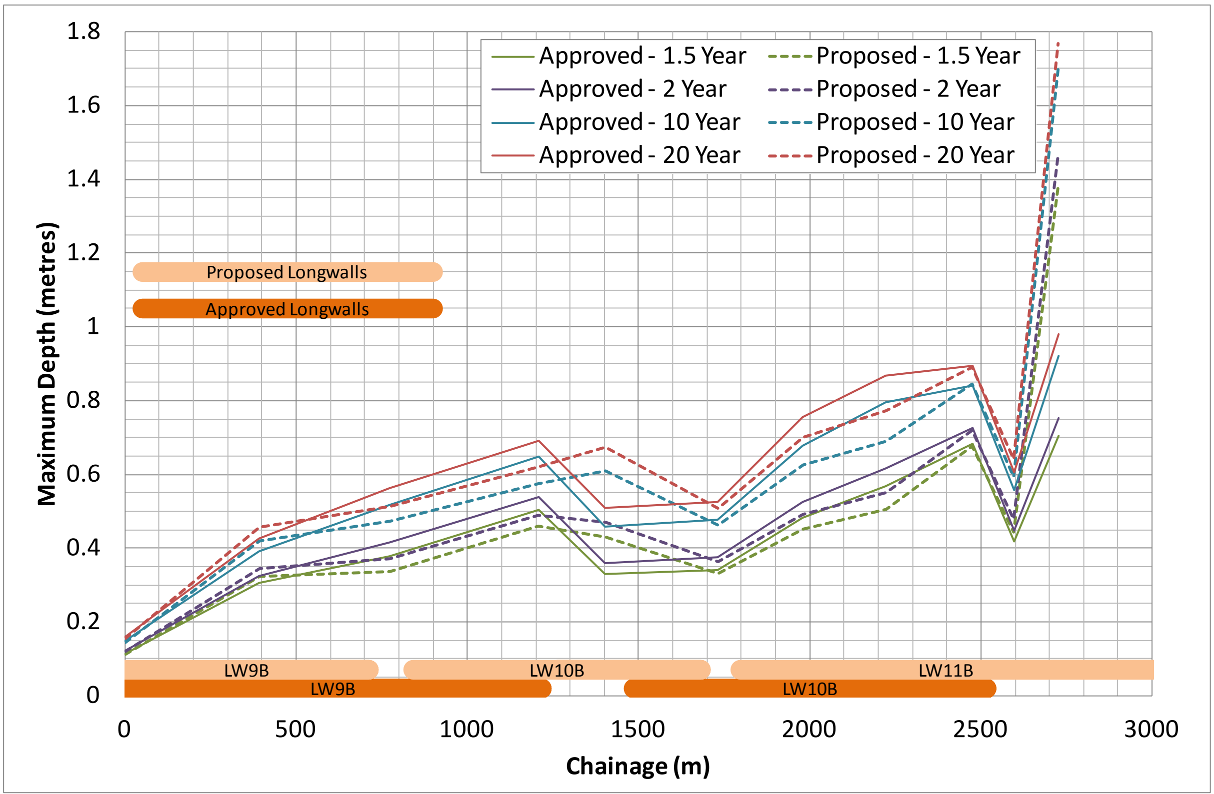


Chart A2.5 - Maximum Modelled Flow Depth
Cockabutta Creek - Watercourse 4

Watercourse 5

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.17 metres (refer to **Chart A2.6**). The maximum modelled increase in flow depths occurs within the centre of proposed longwall 12B (refer to **Figure 4.2** and **Chart A2.6**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.10 metres respectively (refer to **Chart A2.6**). The maximum modelled decrease in flow depths occurs above the chainpillar that separates proposed longwall 11B and 12B (refer to **Figure 4.2** and **Chart A2.6**).

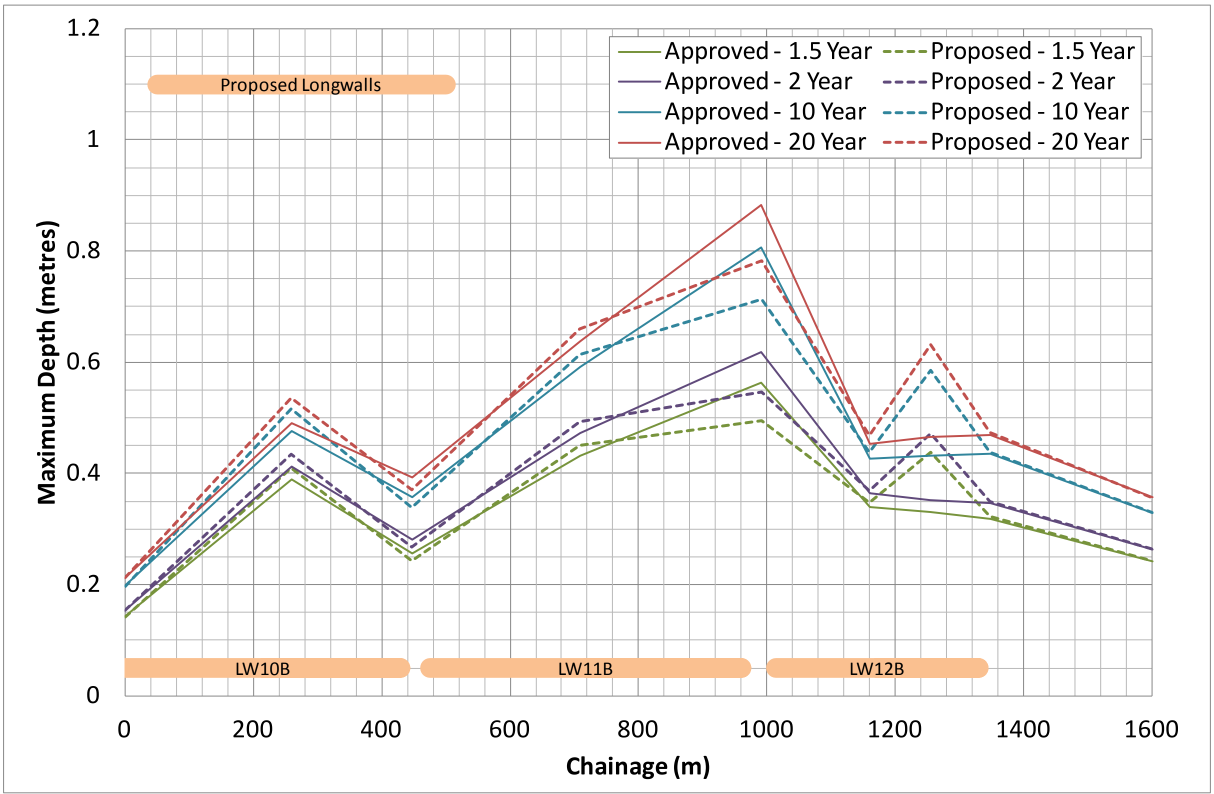


Chart A2.6 - Maximum Modelled Flow Depth
Cockabutta Creek - Watercourse 5

Watercourse 13

The hydraulic modelling indicates that within the Cockabutta Creek catchment, the greatest impacts to the maximum modelled flow depths occurs within Watercourse 13 (refer to **Chart A2.7** and **Figure 4.2**). The largest increase to the maximum modelled depth (approximately 0.30 metres for the 20 year ARI critical duration design storm event) occurs within Watercourse 13 (refer to **Chart A2.7**), at the northern end of proposed longwall 11B (refer to **Figure 4.2** and **Chart A2.7**). Similarly, the largest decrease to the maximum modelled depth (approximately 0.30 metres for all of the modelled critical duration design storm events: refer to **Table 4.10**) occurs within Watercourse 13 (refer to **Chart A2.7**), at the northern end of proposed longwall 12B, adjacent to the chain pillar between proposed longwalls 11B and 12B (refer to **Figure 4.2** and **Chart A2.7**). The hydraulic model results for Watercourse 13 are reasonable given that it flows approximately perpendicular to the orientation of the longwall panels (both approved and proposed: refer to **Figure 4.2**).

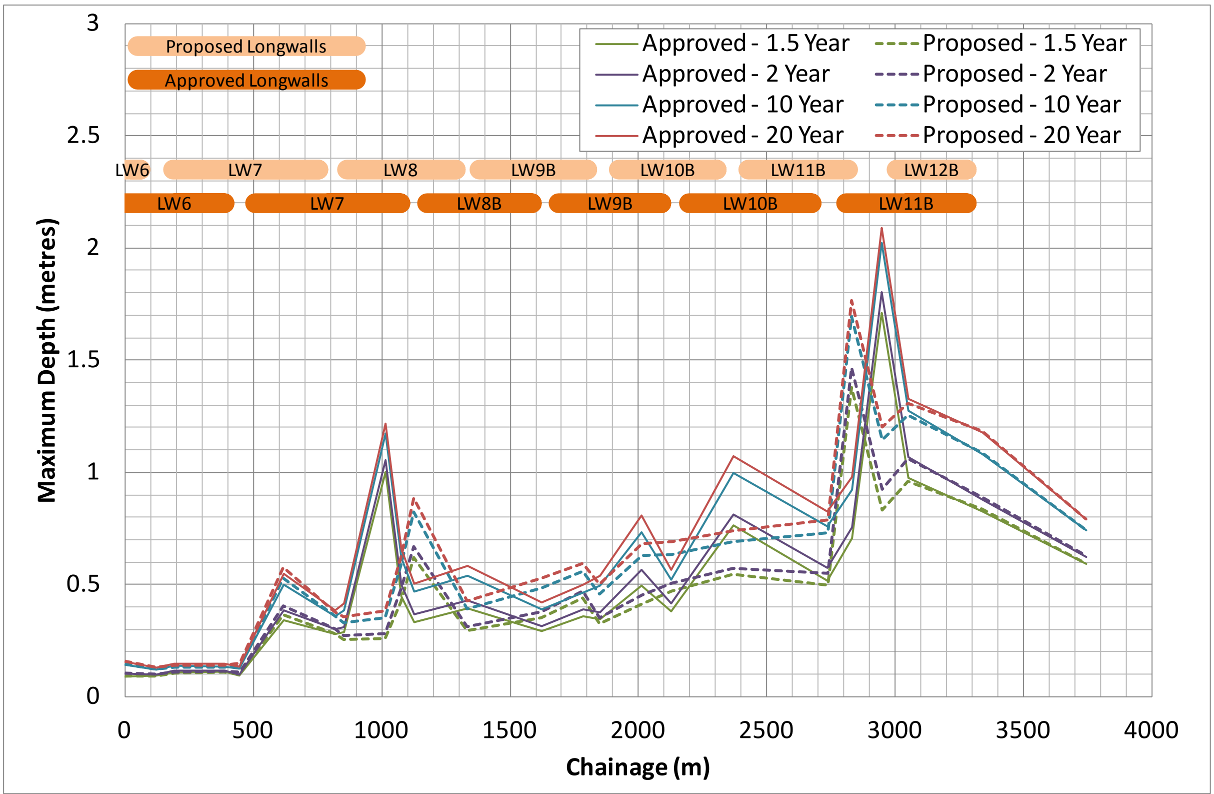


Chart A2.7 - Maximum Modelled Flow Depth
Cockabutta Creek - Watercourse 13

Ulan Creek Catchment

Watercourse 6

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.05 metres (refer to **Chart A2.8**). The maximum modelled increase in flow depths occurs at the downstream end of Watercourse 6, at the confluence with Watercourse 11 (refer to **Figure 4.2** and **Chart A2.8**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.06 metres (refer to **Chart A2.8**). The maximum modelled decrease in flow depths occurs at the chainpillar between proposed longwalls 5 and 6 (refer to **Figure 4.2** and **Chart A2.8**).

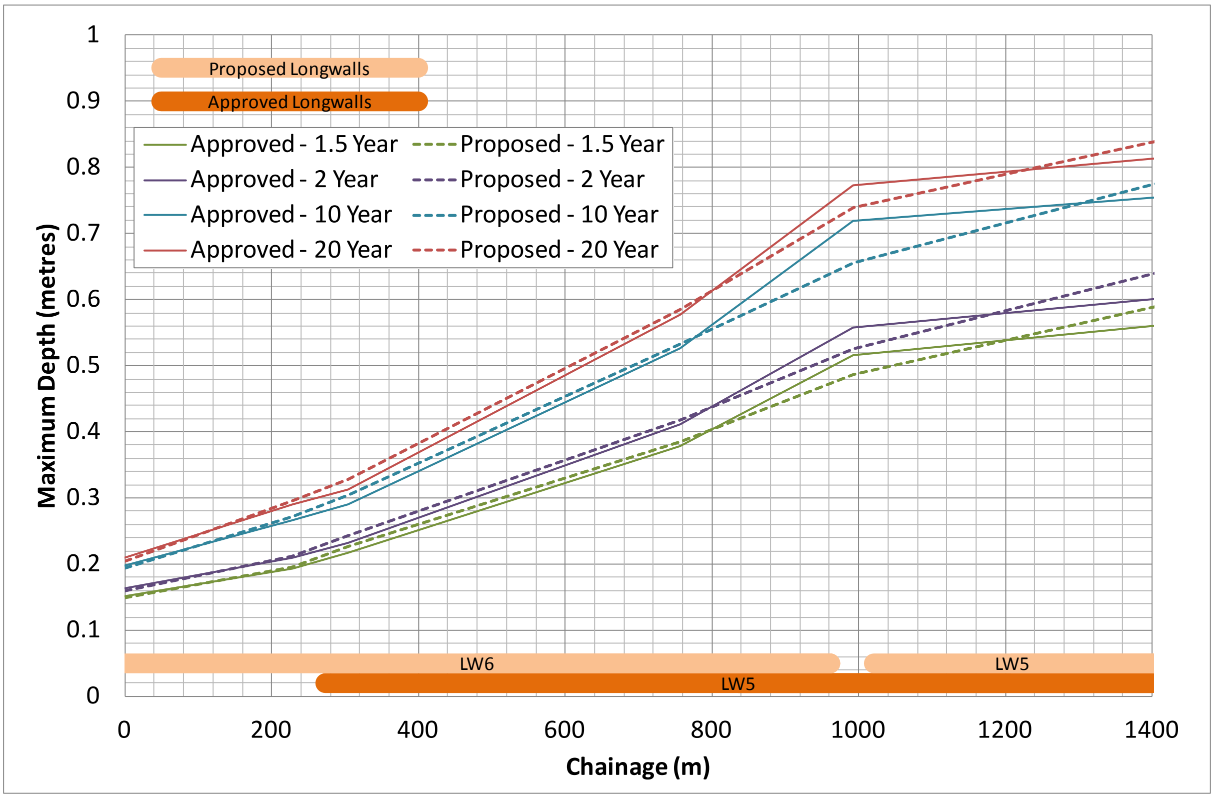


Chart A2.8 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 6

Watercourse 7

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.12 metres (refer to **Chart A2.9**). The maximum modelled increase in flow depths occurs within the centre of proposed longwall 3 (refer to **Figure 4.2** and **Chart A2.9**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.08 metres (refer to **Chart A2.9**). The maximum modelled decrease in flow depths occurs at the chainpillar between longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A2.9**).

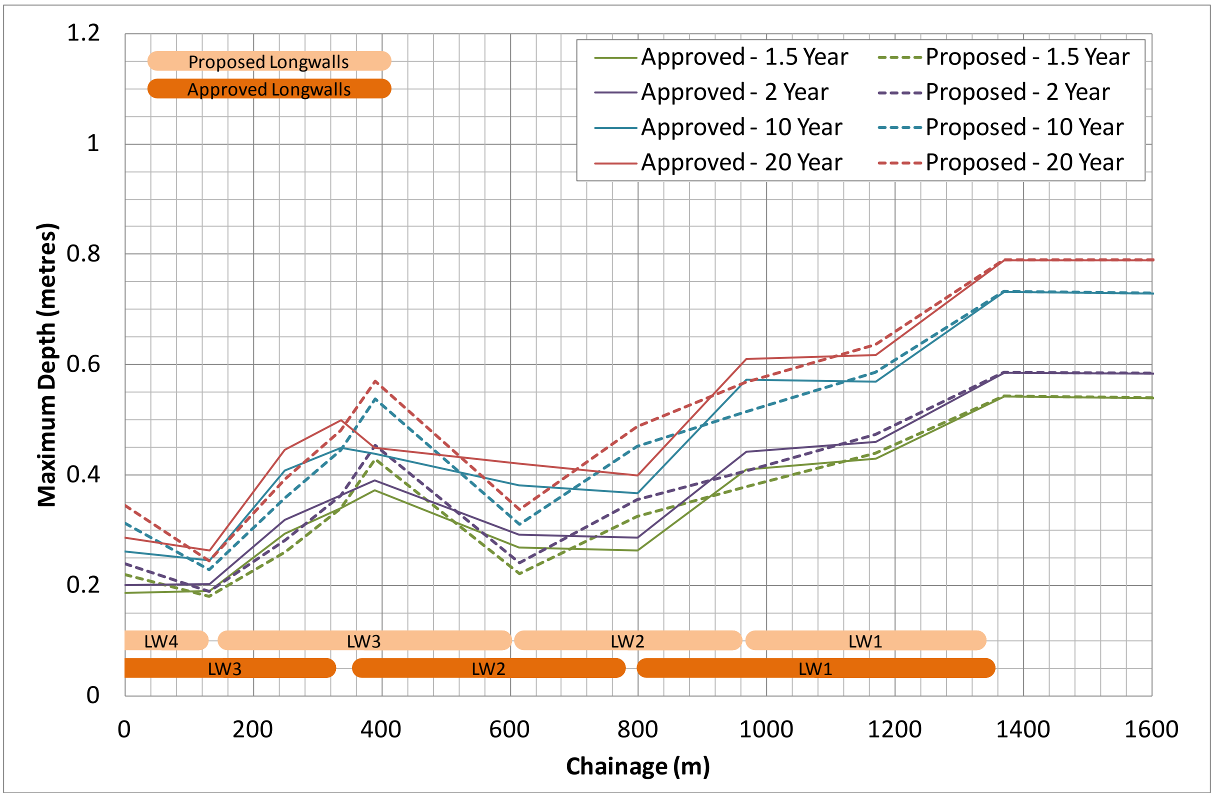


Chart A2.9 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 7

Watercourse 8

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.64 metres (refer to **Chart A2.10**). The maximum modelled increase in flow depths occurs within the centre of proposed longwall 2 at the junction with Watercourse 9 (refer to **Chart A2.10**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.18 metres (refer to **Chart A2.10**). The maximum modelled decrease in flow depths occurs at the chainpillar separating proposed longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A2.10**).

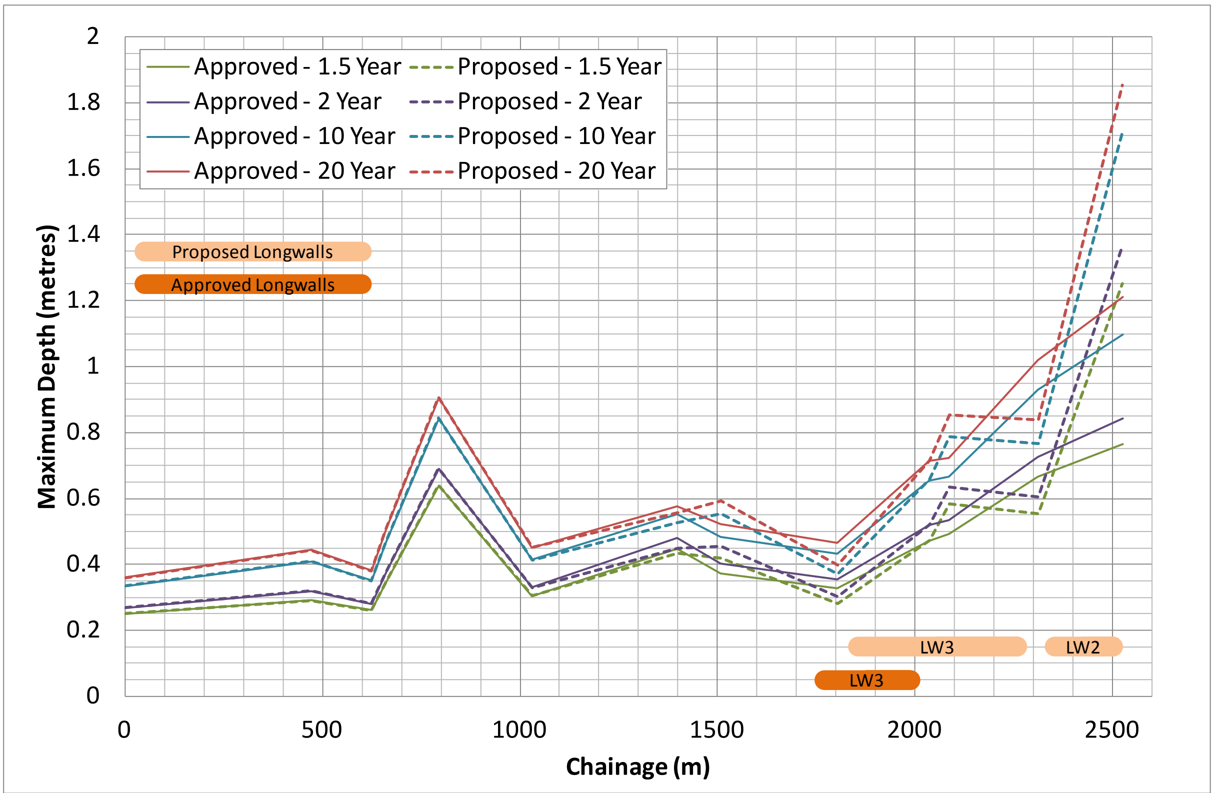


Chart A2.10 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 8

Watercourse 9

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.64 metres (refer to **Chart A2.11**). The maximum modelled increase in flow depths occurs within the centre of proposed longwall 2 above the chainpillar that separates approved longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A2.11**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.11 metres (refer to **Chart A2.11**). The maximum modelled decrease in flow depths occurs at the chainpillar between proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A2.11**).

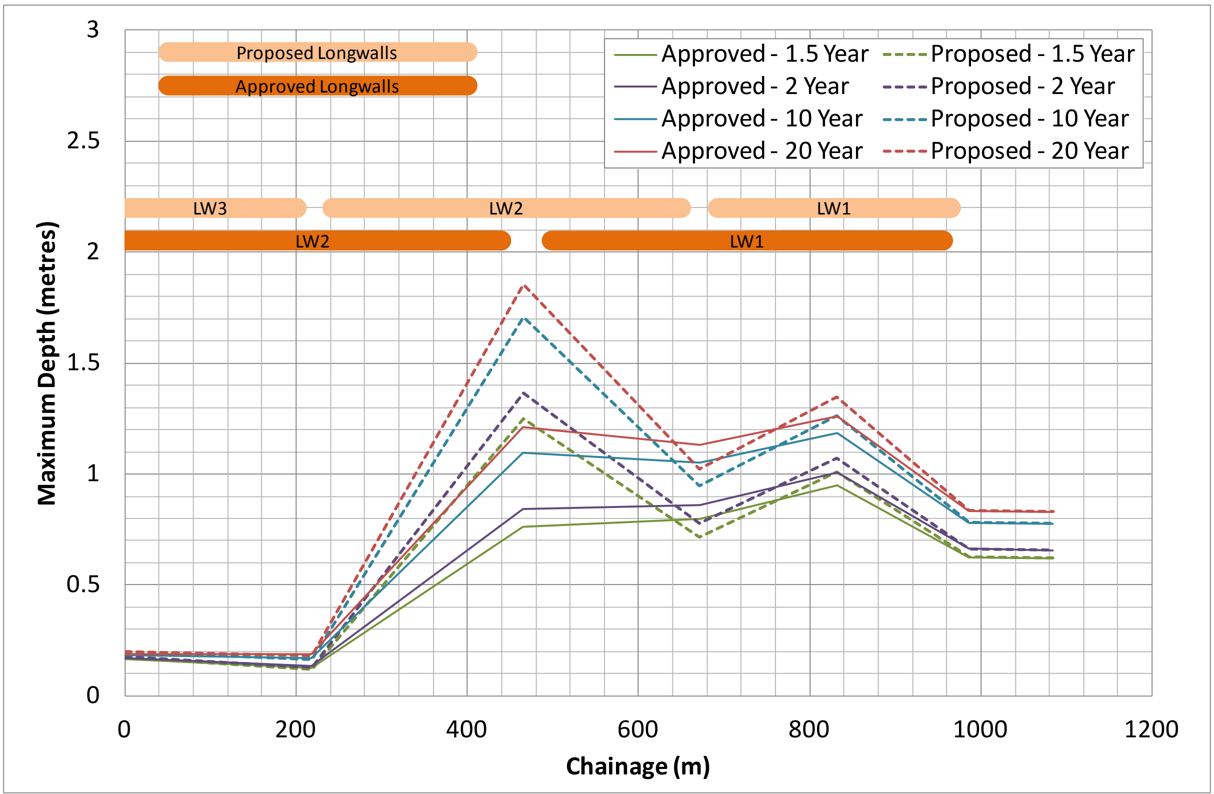


Chart A2.11 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 9

Watercourse 10

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.10 metres (refer to **Chart A2.12**). The maximum modelled increase in flow depths occurs within the centre of proposed longwall 2 (refer to **Figure 4.2** and **Chart A2.12**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.03 metres (refer to **Chart A2.12**). The maximum modelled decrease in flow depths occurs at the chainpillar between proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A2.12**).

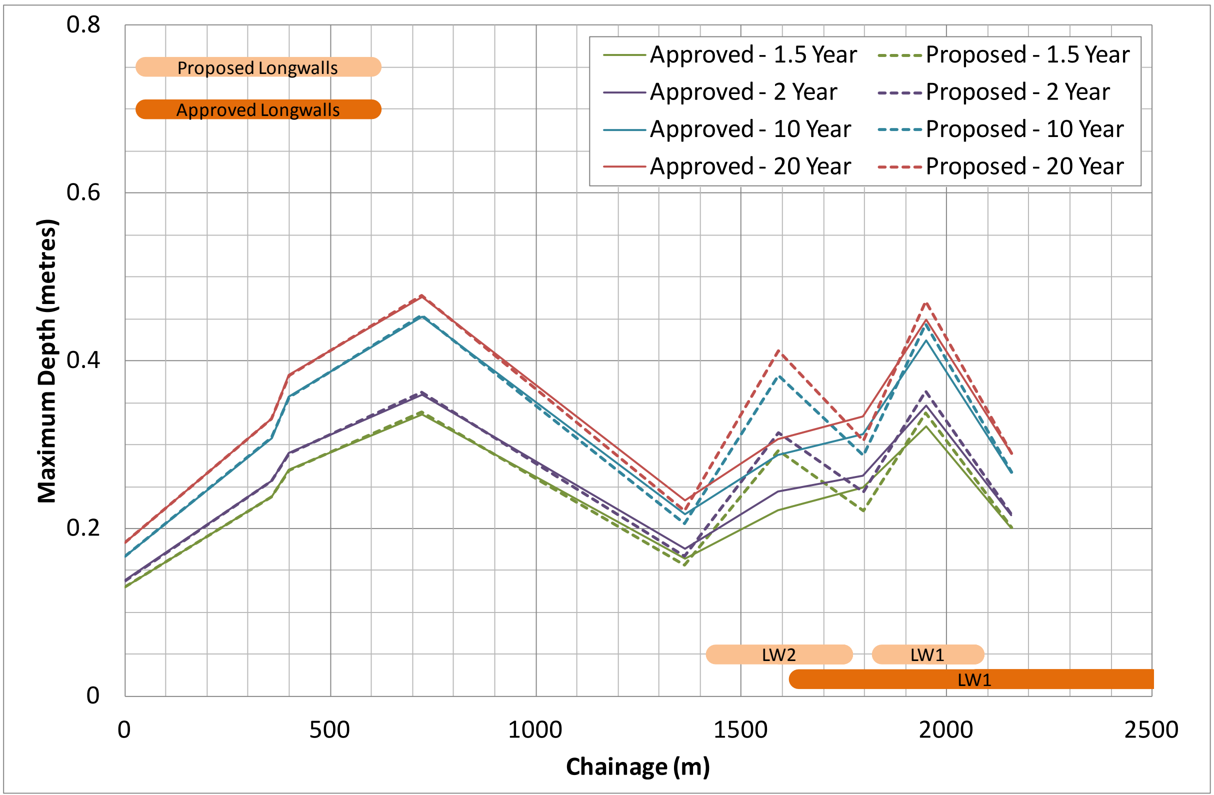


Chart A2.12 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 10

Watercourse 11

The modelling indicates that the proposed modification results in increases to the maximum modelled flow depths of up to approximately 0.33 metres (refer to **Chart A2.13**). The maximum modelled increase in flow depths occurs within the vicinity of proposed longwall 2 west (upstream) of the chainpillar between proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A2.13**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow depths of up to approximately 0.33 metres (refer to **Chart A2.13**). The maximum modelled decrease in flow depths occurs at the chainpillar between proposed longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A2.13**).

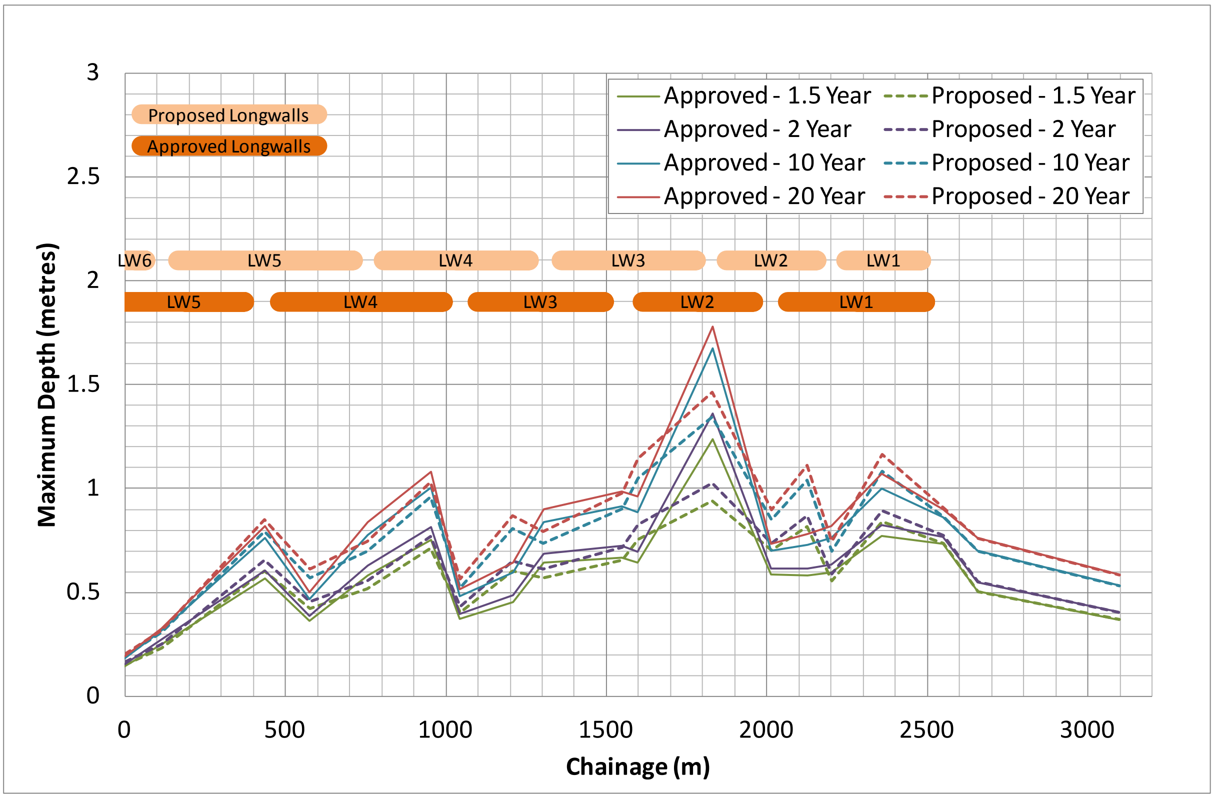


Chart A2.13 - Maximum Modelled Flow Depth
Ulan Creek - Watercourse 11

APPENDIX C

Maximum Modelled Flow Velocities

Mona Creek Catchment

Watercourse 1

The analysis indicates that the proposed modification results in increases in the maximum modelled flow velocities within Watercourse 1 of up to approximately 0.06 m/s (refer to **Chart A3.1**). The maximum modelled increase in flow velocities occur east (downstream) of the chainpillar between proposed longwalls 11A and 12A (refer to **Figure 4.2** and **Chart A3.1**). The analysis also indicates that the proposed modification results in decreases in the maximum modelled flow velocities within Watercourse 1 of up to approximately 0.22 m/s (refer to **Chart A3.1**). The maximum modelled decrease in flow velocities occur west (upstream) of the chainpillar between proposed longwalls 11A and 12A (refer to **Figure 4.2** and **Chart A3.1**).

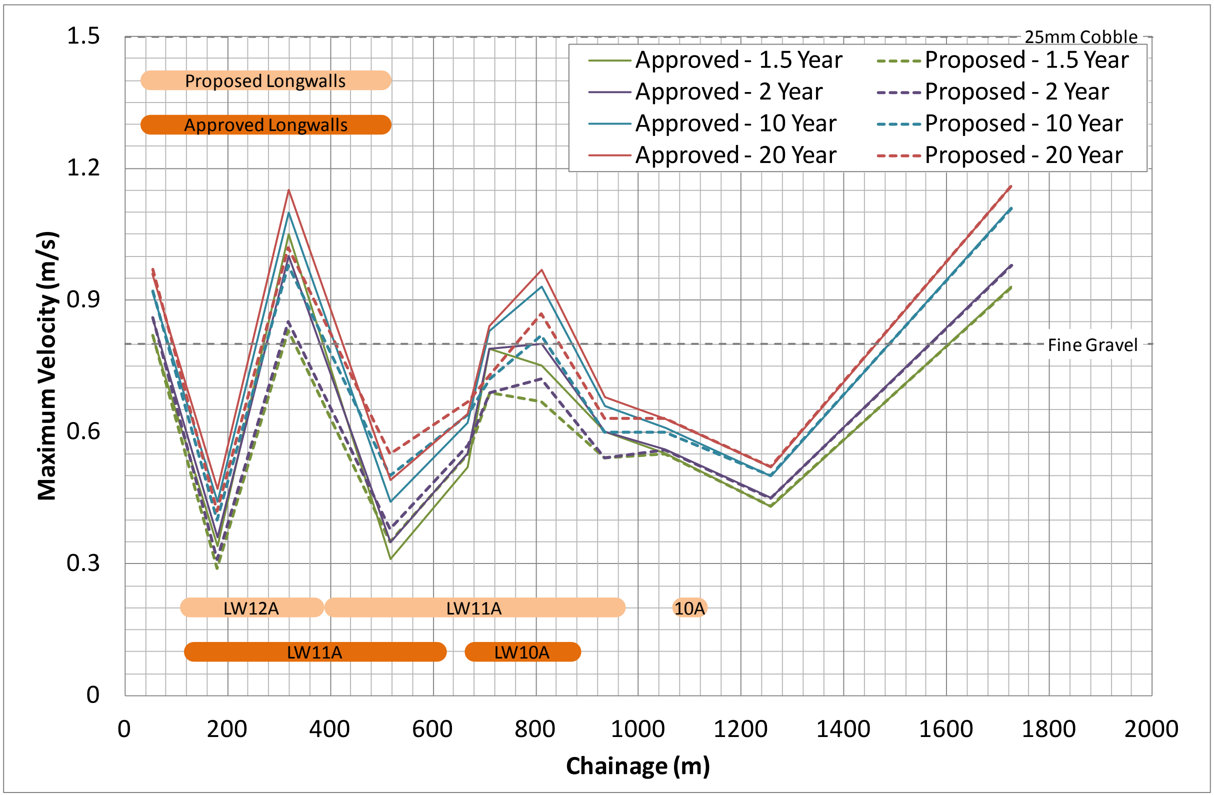


Chart A3.1 - Maximum Modelled Flow Velocity
Mona Creek - Watercourse 1

Watercourse 2

The modelling indicates that the proposed modification results in increases in the maximum modelled flow velocities within Watercourse 2 of up to approximately 0.07 m/s (refer to **Chart A3.2**). The maximum modelled increases in flow velocities occur at the northern (downstream) end of proposed longwalls 9A (the same location where the modelling indicates the maximum modelled reduction to flow depths) (refer to **Figure 4.2** and **Chart A3.2**). The modelling also indicates that the proposed modification results in decreases in the maximum modelled flow velocities within Watercourse 2 of up to approximately 0.08 m/s (refer to **Chart A3.2**). The maximum modelled decrease in flow velocity occur at the southern (upstream) end of Watercourse 2 within the centre of proposed Longwall 10A (refer to **Figure 4.2** and **Chart A3.2**).

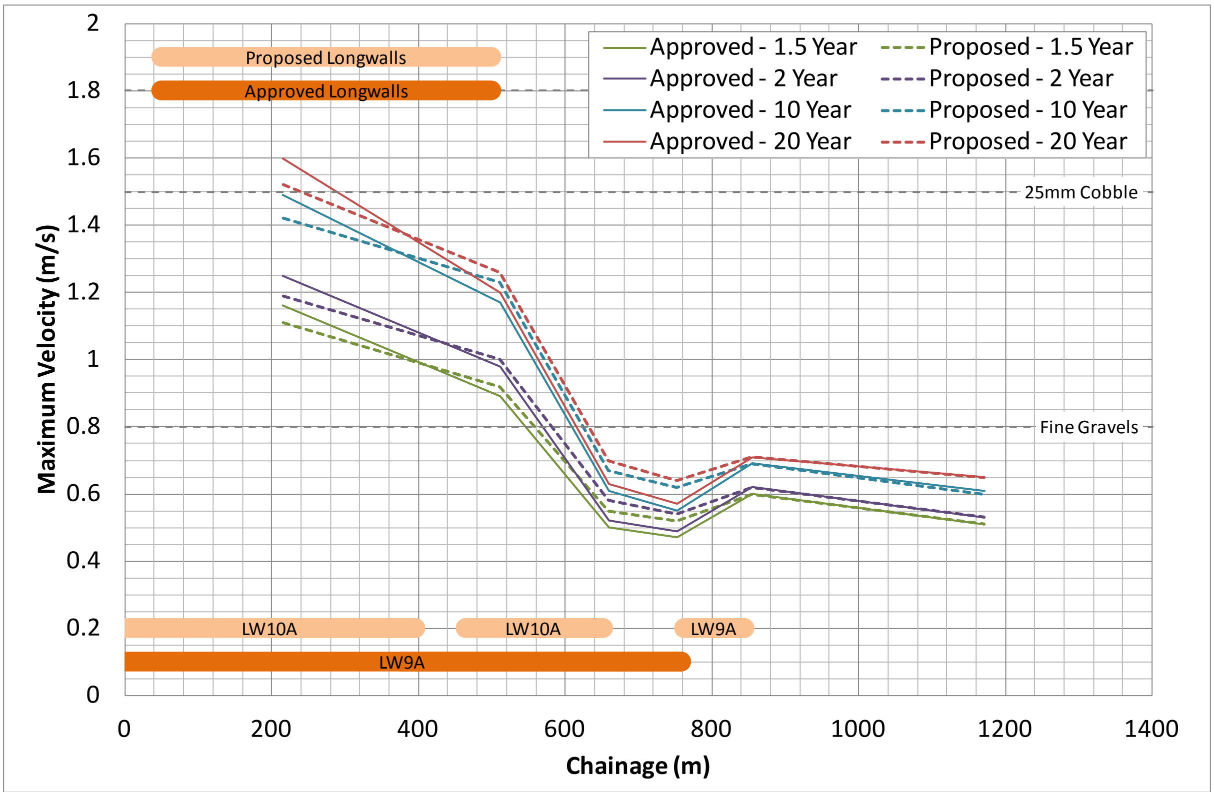


Chart A3.2 - Maximum Modelled Flow Velocity
Mona Creek - Watercourse 2

Watercourse 3

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 3 of up to approximately 0.07 m/s (refer to **Chart A3.3**). The maximum modelled increase in flow velocities occurs towards the southern (upstream) end of Watercourse 3 adjacent to the eastern chainpillar for proposed longwall 7 (the same location where the modelling indicates the maximum modelled reduction to flow depths) (refer to **Figure 4.2** and **Chart A3.3**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 3 of up to approximately 0.11 m/s (refer to **Chart A3.3**). The maximum modelled decrease in flow velocities occurs at the northern (downstream) end of proposed Longwall 7 (refer to **Figure 4.2** and **Chart A3.3**).

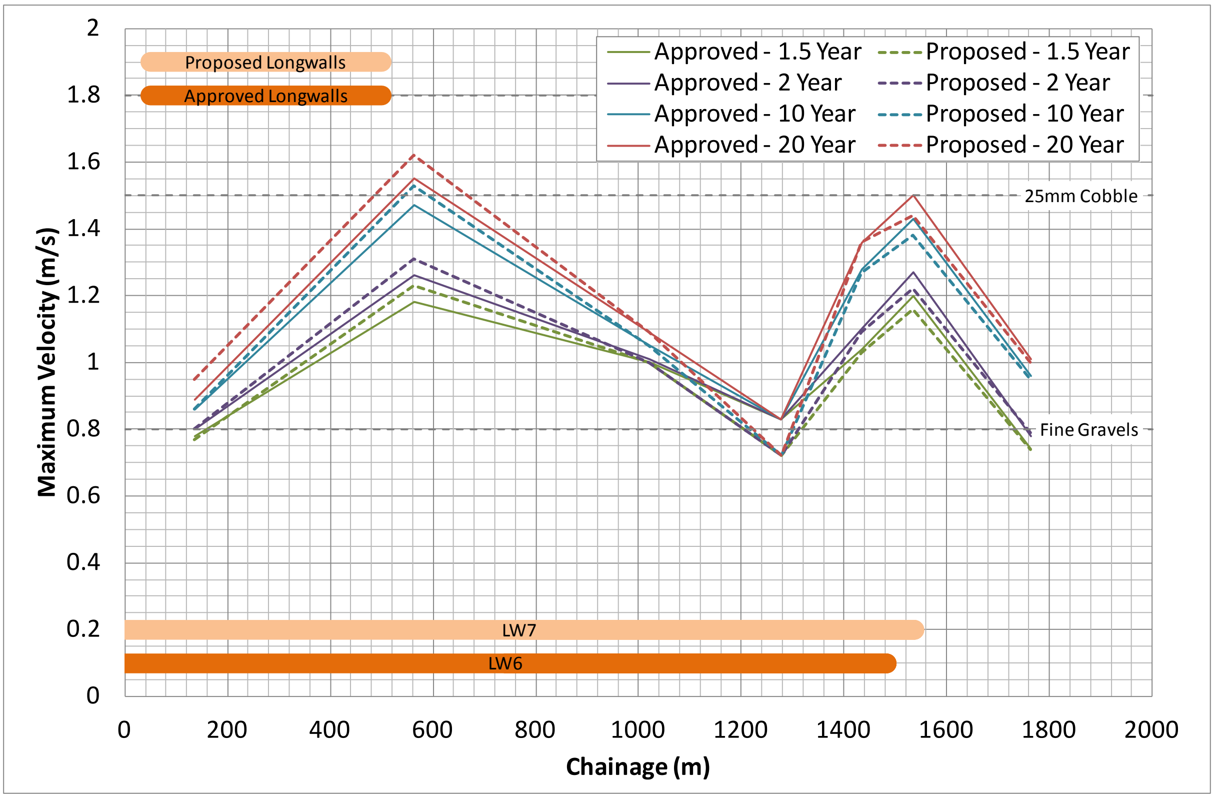


Chart A3.3 - Maximum Modelled Flow Velocity
Mona Creek - Watercourse 3

Watercourse 12

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 12 of up to approximately 0.04 m/s (refer to **Chart A3.4**). The maximum modelled increase in flow velocities occurs immediately south (upstream) of approved Longwall 5 (refer to **Figure 4.2** and **Chart A3.4**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 12 of up to approximately 0.05 m/s (refer to **Chart A3.4**). The maximum modelled decrease in flow velocities occurs in the centre of the previously approved chain pillar for Longwall 5 (refer to **Figure 4.2** and **Chart A3.4**).

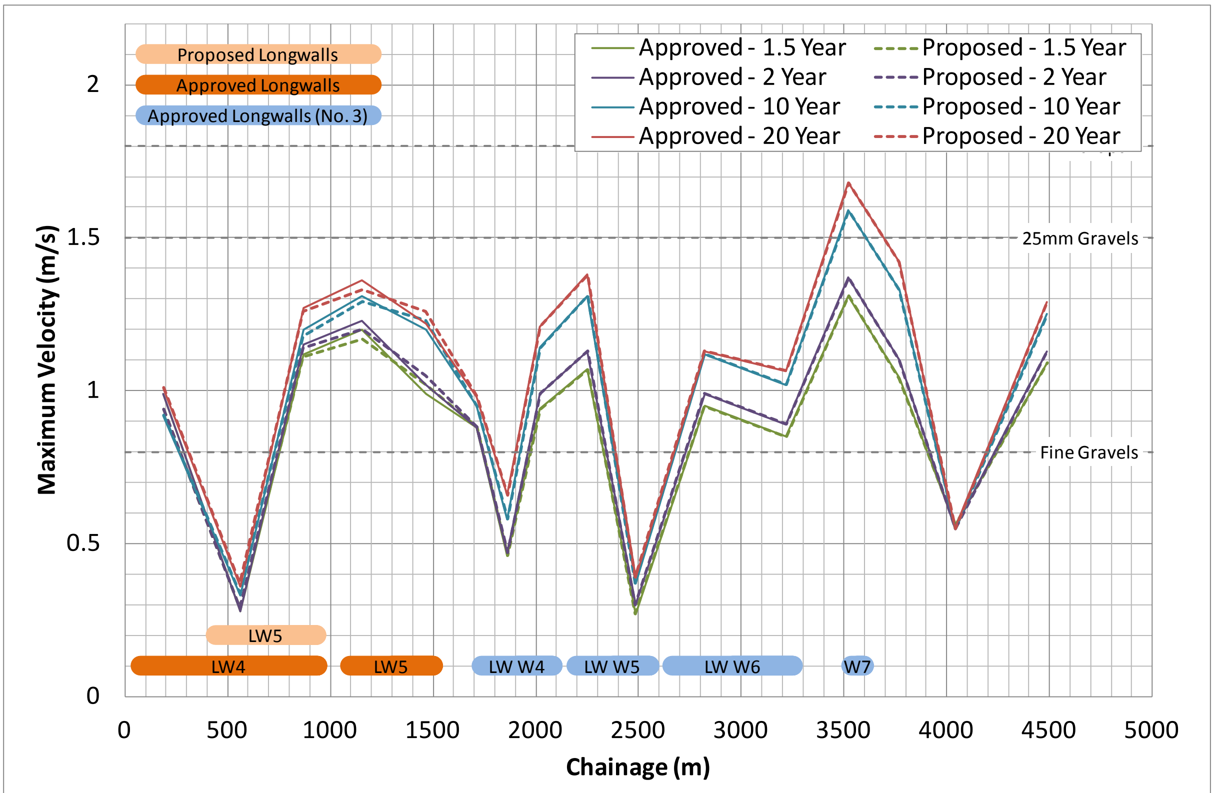


Chart A3.4 - Maximum Modelled Flow Velocity
Mona Creek - Watercourse 12

Cockabutta Creek Catchment

Watercourse 4

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 4 of up to approximately 0.26 m/s (refer to **Chart A3.5**). The maximum modelled increase in flow velocities occurs west (downstream) of the chainpillar between proposed longwalls 10 B and 11B (the same location where the modelling indicates the maximum modelled reduction to flow depths) (refer to **Figure 4.2** and **Chart A3.5**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 4 of up to approximately 0.60 m/s respectively (refer to **Chart A3.5**). The maximum modelled decrease in flow velocities occurs east (upstream) of the chainpillar between proposed longwalls 11 B and 12B (refer to **Figure 4.2** and **Chart A3.5**).

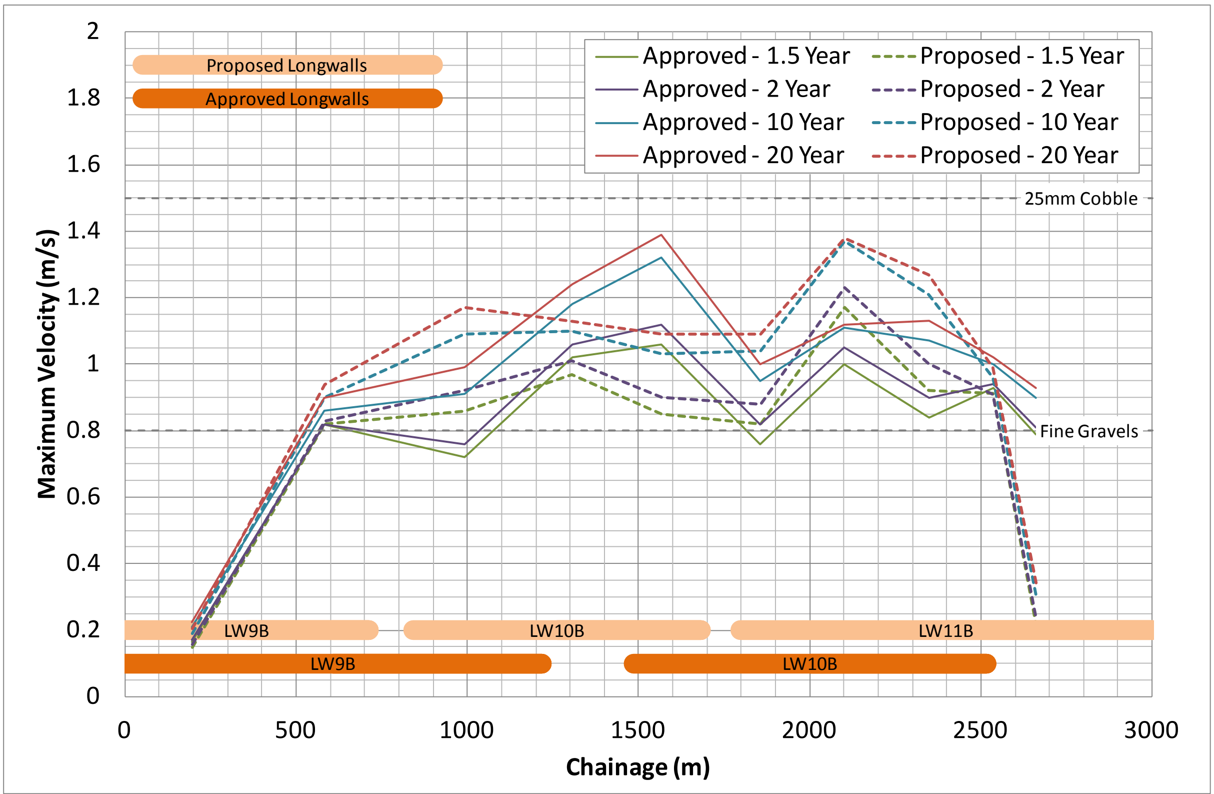


Chart A3.5 - Maximum Modelled Flow Velocity Cockabutta Creek - Watercourse 4

Watercourse 5

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 5 of up to approximately 0.35 m/s (refer to **Chart A3.6**). The maximum modelled increase in flow velocities occurs west (downstream) of the chainpillar between proposed longwalls 11B and 12B (refer to **Figure 4.2** and **Chart A3.6**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 5 of up to approximately 0.46 m/s (refer to **Chart A3.6**). The maximum modelled decrease in flow velocities occurs within the western (downstream) edge of the proposed longwall 12B (refer to **Figure 4.2** and **Chart A3.6**).

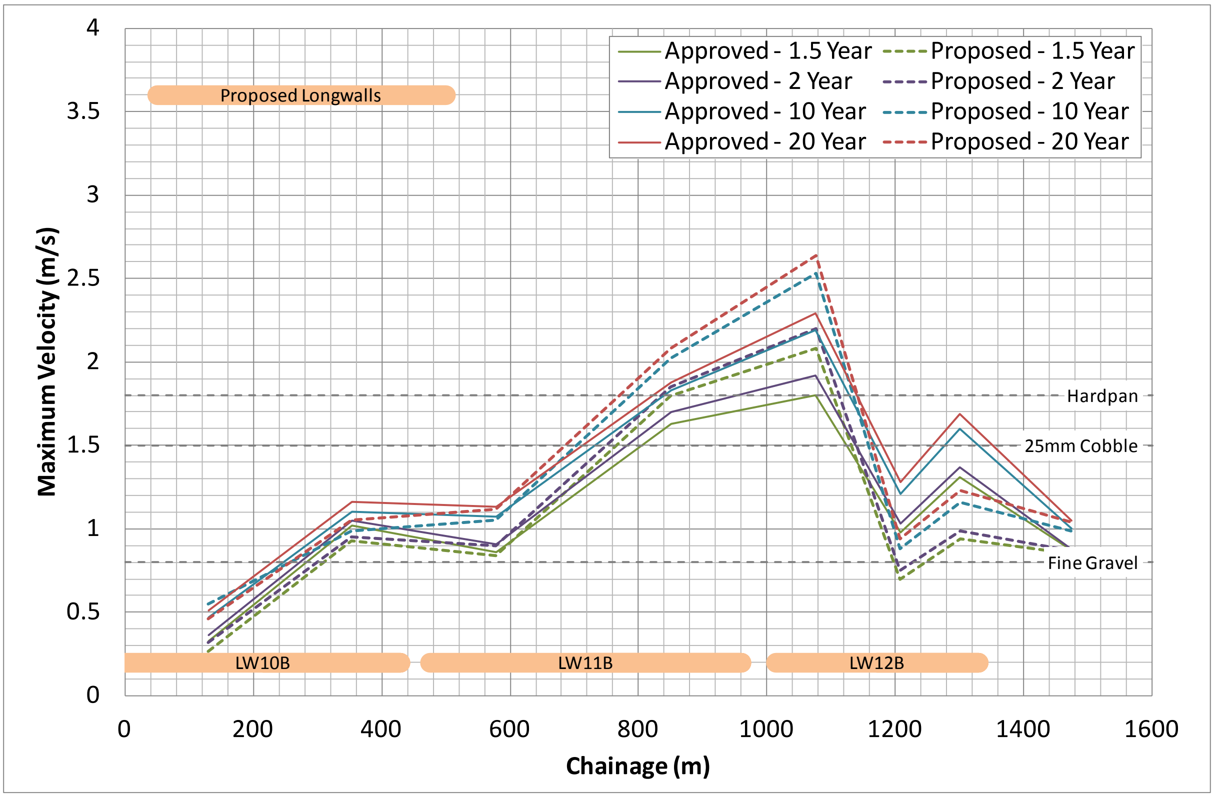


Chart A3.6 - Maximum Modelled Flow Velocity
Cockabutta Creek - Watercourse 5

Watercourse 13

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 13 of up to approximately 0.65 m/s refer to **Chart A3.7**). The maximum modelled increase in flow velocities occurs at the northern end of proposed longwall 12B (refer to **Figure 4.2** and **Chart A3.7**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 13 of up to approximately 0.70 m/s (refer to **Chart A3.7**). The maximum modelled decrease in flow velocities occurs within the centre of proposed longwall 11B (refer to **Figure 4.2** and **Chart A3.7**).

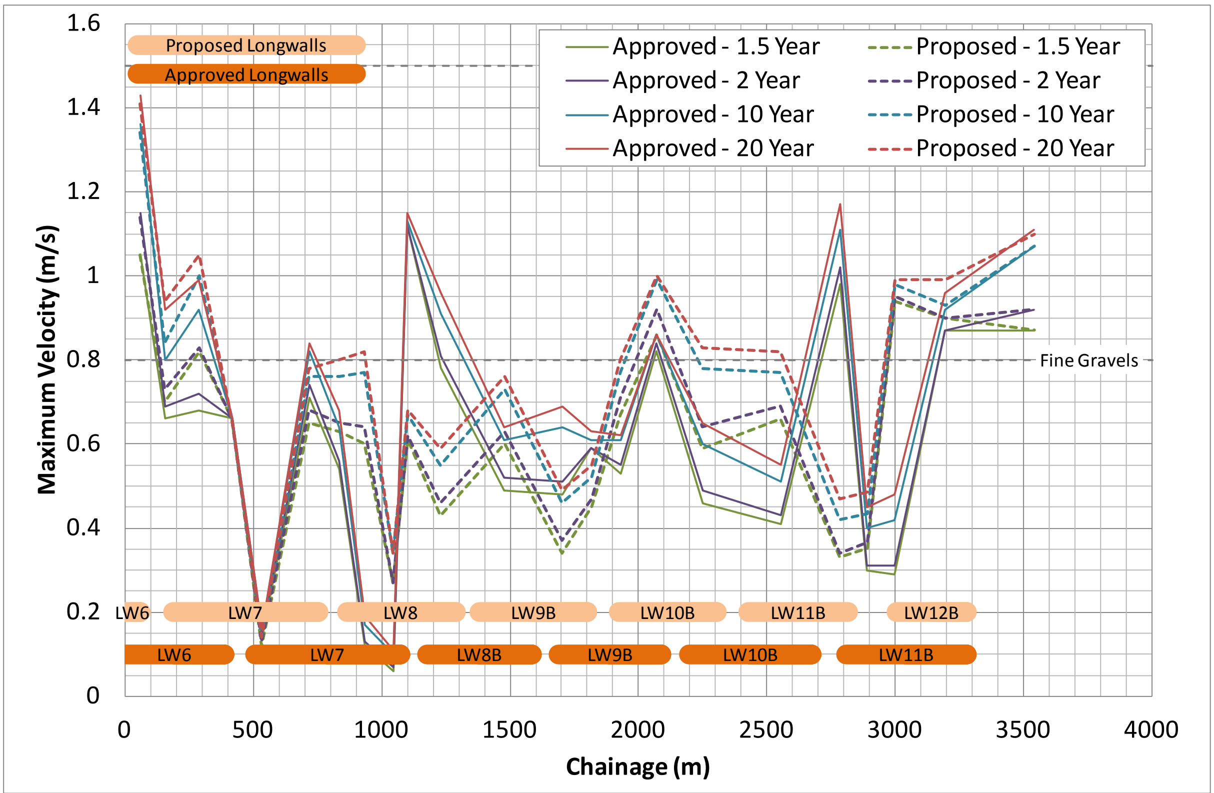


Chart A3.7 - Maximum Modelled Flow Velocity
Cockabutta Creek - Watercourse 13

Ulan Creek Catchment

Watercourse 6

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 6 of up to approximately 0.09 m/s (refer to **Chart A3.8**). The maximum modelled increase in flow velocities occurs west (upstream) of the chainpillar between proposed longwalls 5 and 6 (refer to **Chart A3.8**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 6 of up to approximately 0.06 m/s (refer to **Chart A3.8**). The maximum modelled decrease in flow velocities occurs at the southern (upstream) end of approved longwall 5 (refer to **Figure 4.2** and **Chart A3.8**).

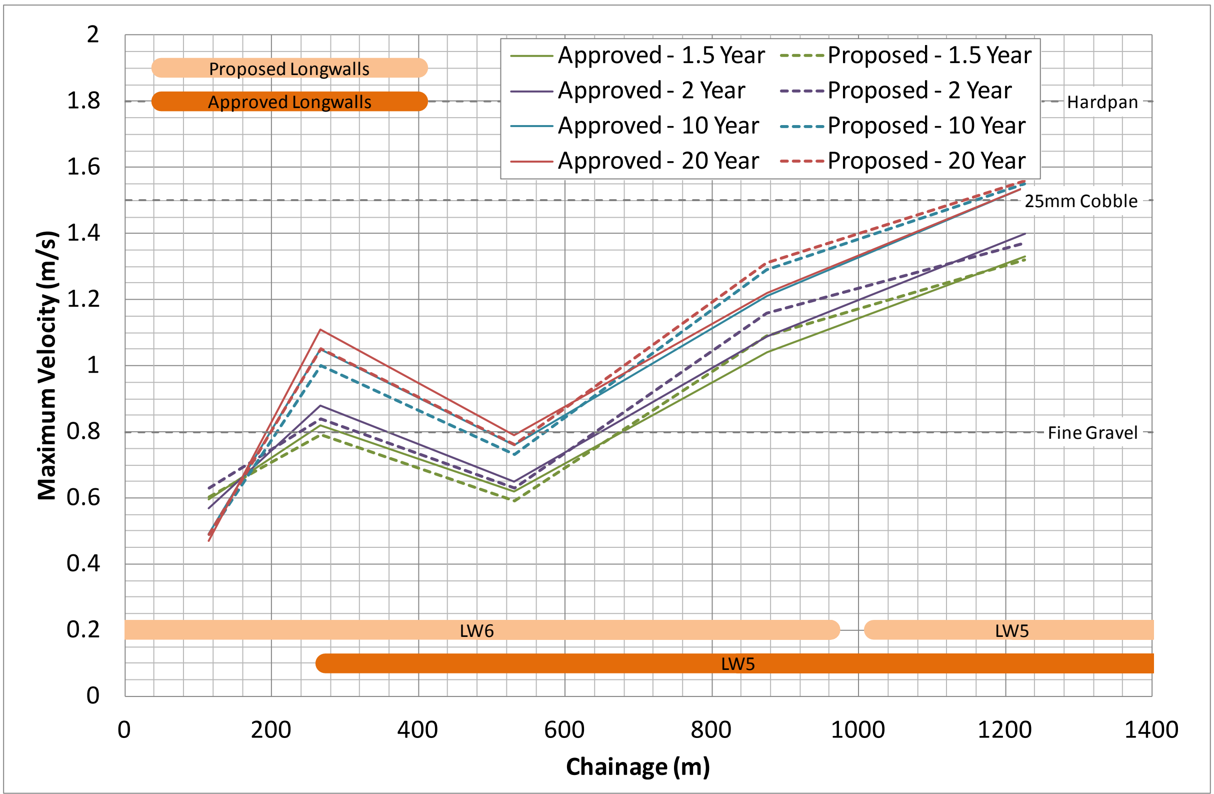


Chart A3.8 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 6

Watercourse 7

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 7 of up to approximately 0.22 m/s (refer to **Chart A3.9**). The maximum modelled increase in flow velocities occurs just upstream (west) of the centre of proposed longwall 3 (refer to **Figure 4.2** and **Chart A3.9**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 7 of up to approximately 0.27 m/s (refer to **Chart A3.9**). The maximum modelled decrease in flow velocities occurs within the centre of proposed longwall 3 (refer to **Figure 4.2** and **Chart A3.9**).

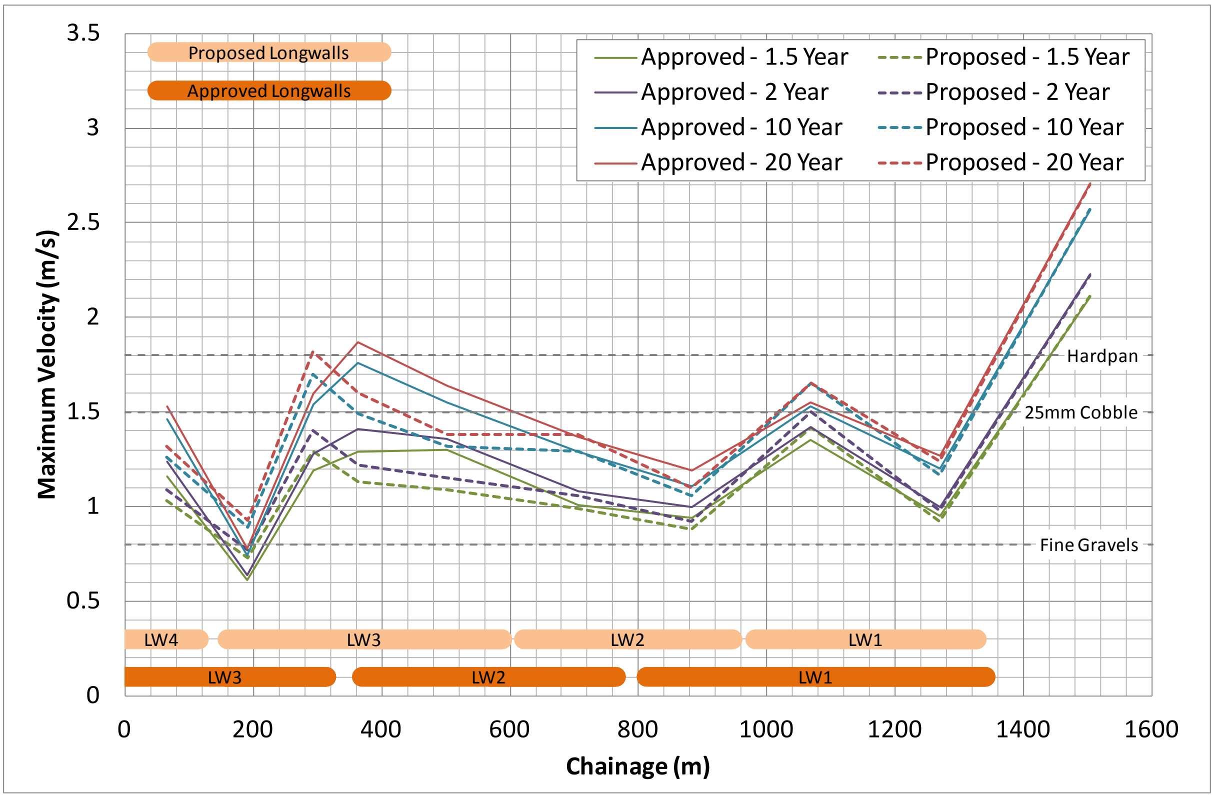


Chart A3.9 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 7

Watercourse 8

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 8 of up to approximately 0.08 m/s (refer to **Chart A3.10**). The maximum modelled increase in flow velocities occurs east (downstream) of the western edge of proposed longwall 3 (refer to **Figure 4.2** and **Chart A3.10**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 8 of up to approximately 0.62 m/s (refer to **Chart A3.10**). The maximum modelled decrease in flow velocities occurs within the centre of proposed longwall 2 at the junction with Watercourse 9 (refer to **Figure 4.2** and **Chart A3.10**).

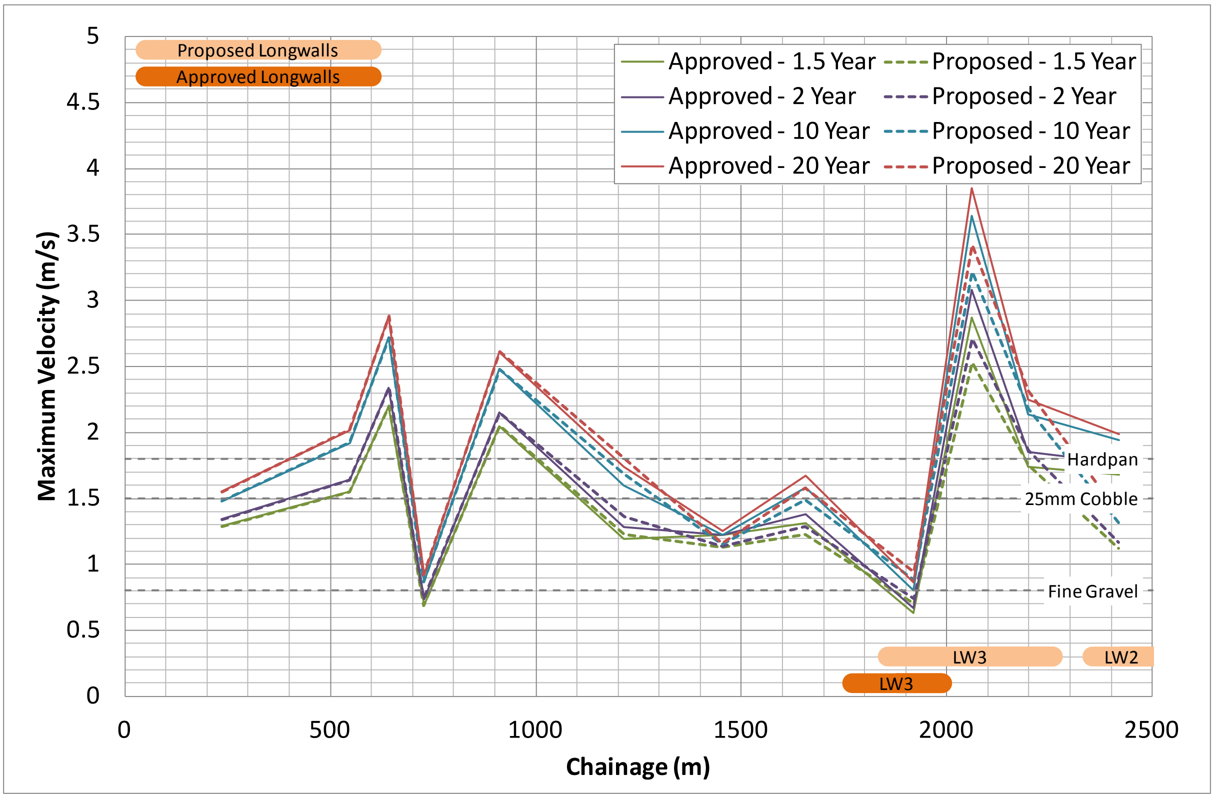


Chart A3.10 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 8

Watercourse 9

The modelling indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 9 of up to 1.08 m/s (refer to **Chart A3.11**). The modelling indicates that within Watercourse 9, increases in the maximum modelled flow velocities of up to approximately 0.06 m/s as a result of the proposed modification (refer to **Chart A3.11**). The modelling also indicates that the maximum modelled decrease in flow velocities occurs west (upstream) of the chainpillar separating proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A3.11**).

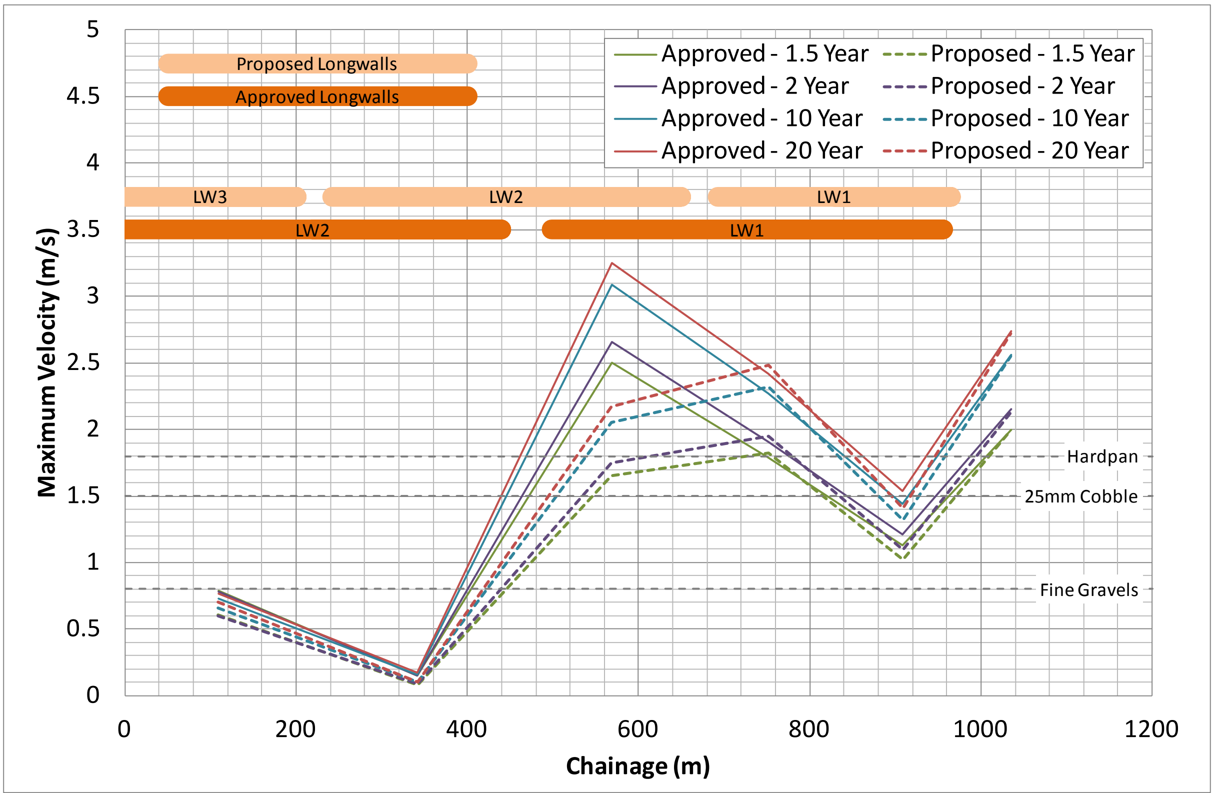


Chart A3.11 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 9

Watercourse 10

The modelling indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 10 of up to approximately 0.25 m/s (refer to **Chart A3.12**). The modelling indicates that within Watercourse 10, only very small increases in the maximum modelled flow velocities are expected (refer to **Chart A3.12**). The modelling also indicates that the maximum modelled decrease in flow velocities occurs west (upstream) of the chainpillar separating proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A3.12**).

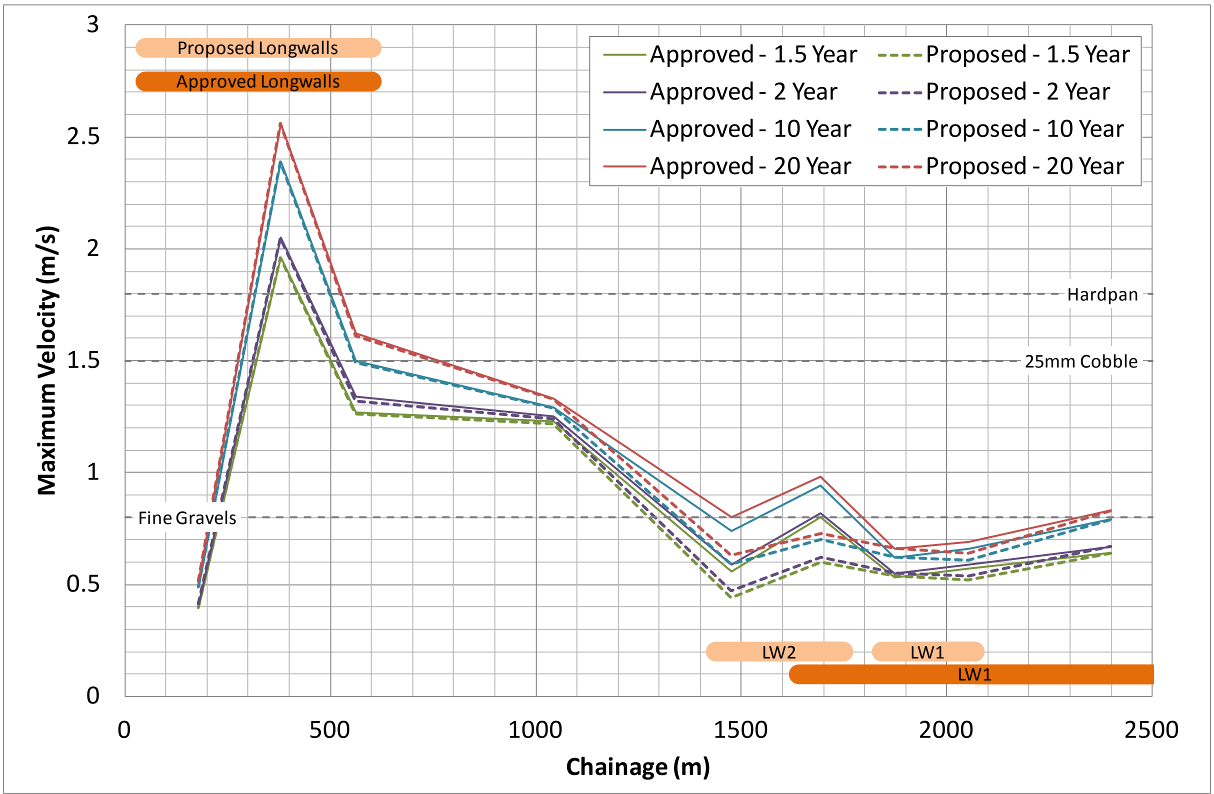


Chart A3.12 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 10

Watercourse 11

The modelling indicates that the proposed modification results in increases to the maximum modelled flow velocities within Watercourse 11 of up to approximately 1.07 m/s (refer to **Chart A3.13**). The maximum modelled increase in flow velocities occurs east (downstream) of the chainpillar between proposed longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A3.13**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled flow velocities within Watercourse 11 of up to approximately 0.71 m/s (refer to **Chart A3.13**). The maximum modelled decrease in flow velocities occurs west (upstream) of the chainpillar that separates proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A3.13**).

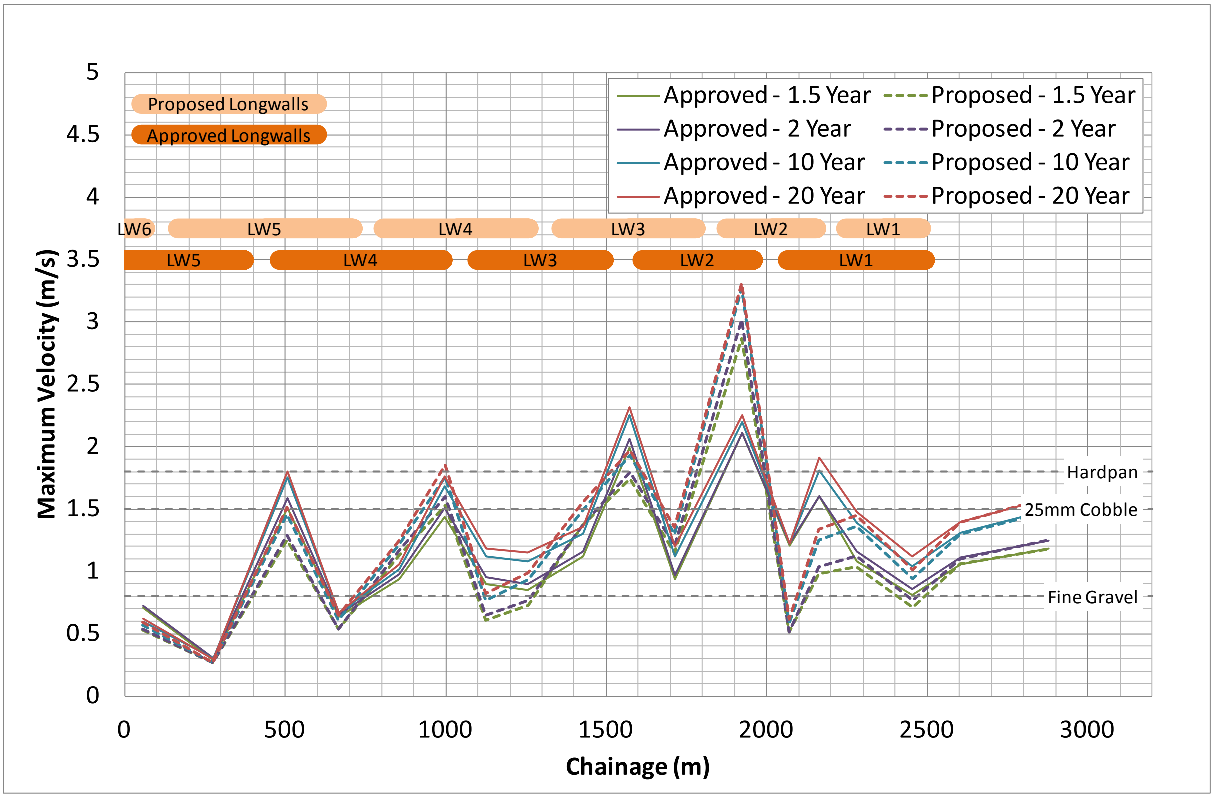


Chart A3.13 - Maximum Modelled Flow Velocity
Ulan Creek - Watercourse 11

APPENDIX D

Maximum Modelled Tractive Stresses

Mona Creek Catchment

Watercourse 1

The analysis indicates that the proposed modification results in increases in the maximum modelled tractive stress within Watercourse 1 of up to approximately 12.6 Nm^{-2} (refer to **Chart 4.1**). The maximum modelled increase in tractive stress occurs east (downstream) of the chainpillar between proposed longwalls 11A and 12A (the same location where the modelling indicates the maximum modelled reduction to flow velocities) (refer to **Figure 4.2** and **Chart A4.1**). The analysis also indicates that the proposed modification results in decreases in the maximum modelled tractive stress within Watercourse 1 of up to approximately 9.0 Nm^{-2} (refer to **Chart 4.1**). The maximum modelled decrease in tractive stresses occurs at the northern (downstream) end of proposed longwall 11A (the same location where the modelling indicates the maximum modelled increase to flow depths) (refer to **Figure 4.2** and **Chart A4.1**).

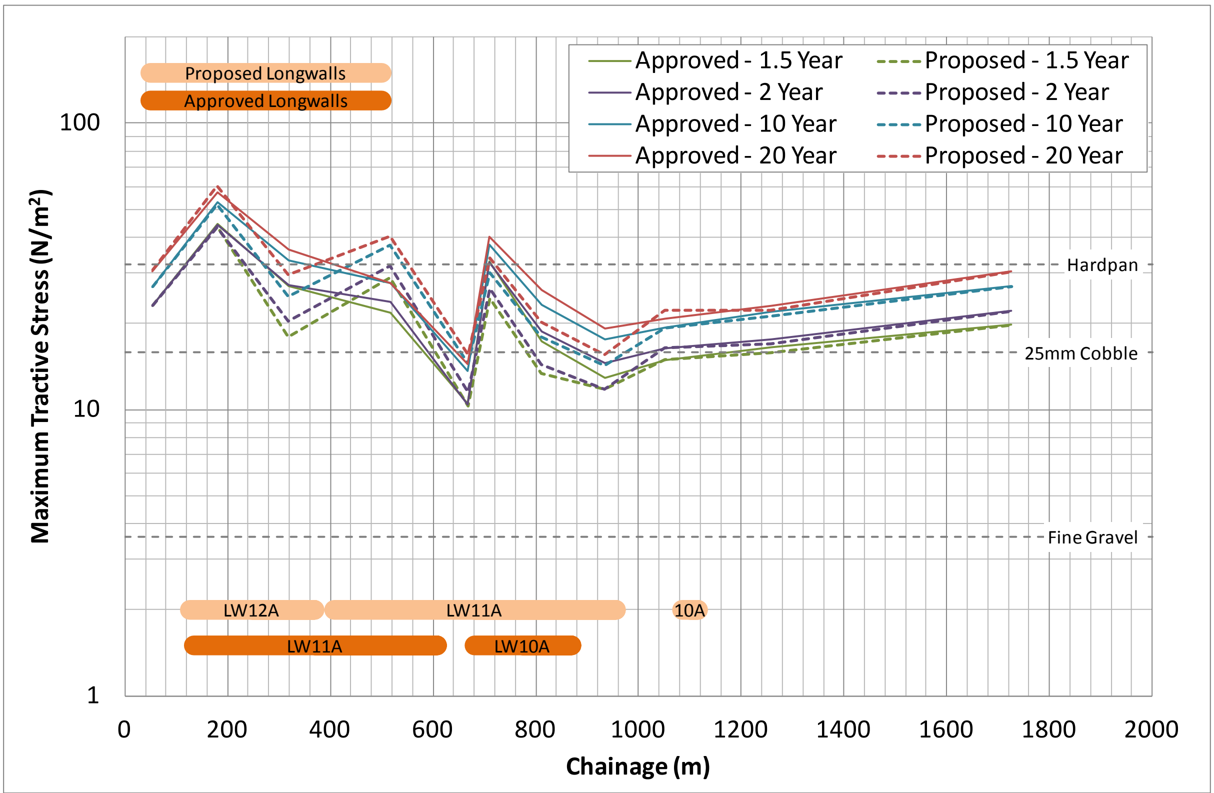


Chart A4.1 - Maximum Modelled Tractive Stress
Mona Creek - Watercourse 1

Watercourse 2

The modelling indicates that the proposed modification results in increases in the maximum modelled tractive stress within Watercourse 2 of up to approximately 6.9 Nm^{-2} (refer to **Chart A4.2**). The maximum modelled increase in tractive stresses occur at the northern end of proposed longwall 9A (the same location where the modelling indicates the maximum modelled reduction to flow depths) (refer to **Figure 4.2** and **Chart A4.2**). The modelling also indicates that the proposed modification results in decreases in the maximum modelled tractive stresses within Watercourse 2 of up to 5.5 Nm^{-2} (refer to **Chart A4.2**). The maximum modelled decrease in flow tractive stresses occur at the upstream end of Watercourse 2 within the centre of proposed Longwall 10A (the same location where the modelling indicates the maximum modelled increase to flow depths) (refer to **Figure 4.2** and **Chart A4.2**).

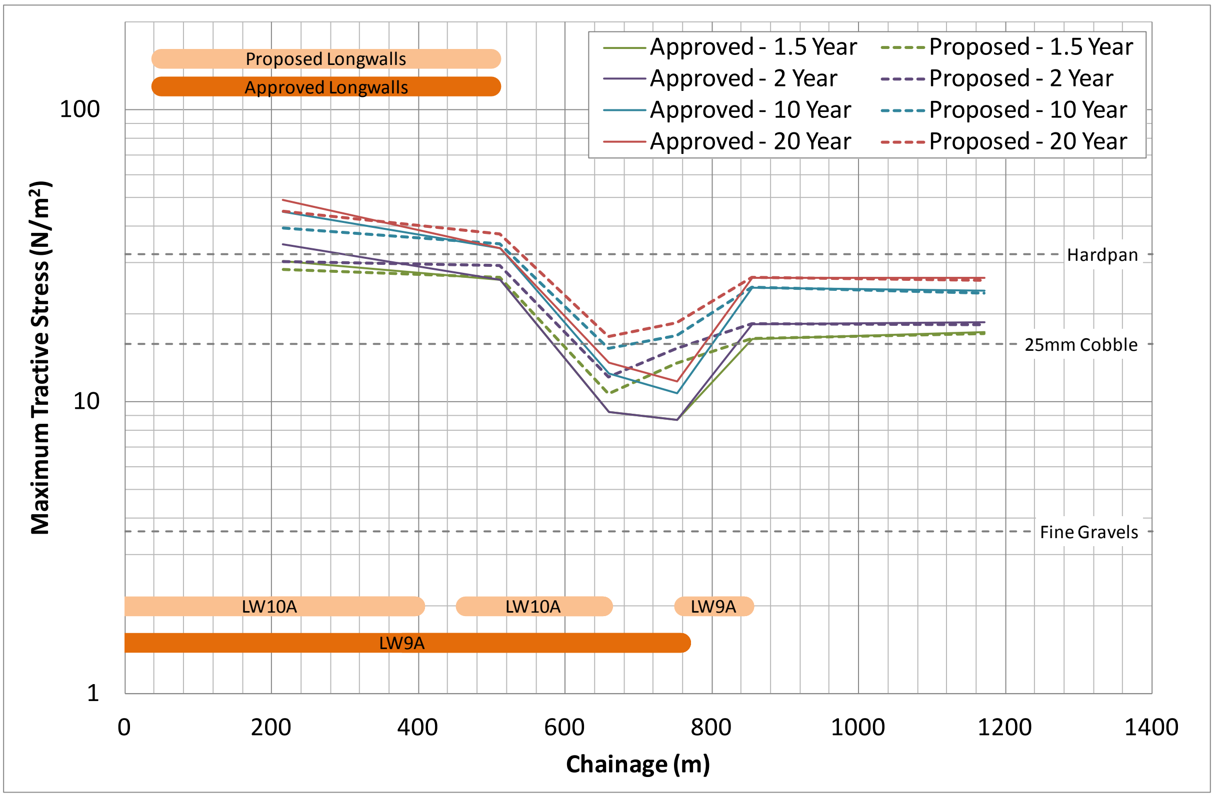


Chart A4.2 - Maximum Modelled Tractive Stress
Mona Creek - Watercourse 2

Watercourse 3

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 3 of up to approximately 9.5 Nm^{-2} (refer to **Chart A4.3**). The maximum modelled increase in tractive stresses occurs at the northern end of proposed longwall 7 (refer to **Figure 4.2** and **Chart A4.3**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 3 of up to approximately 10.5 Nm^{-2} (refer to **Chart A4.3**). The maximum modelled decrease in flow tractive stresses occurs just upstream of the northern end of proposed longwall 7 (refer to **Figure 4.2** and **Chart A4.3**).

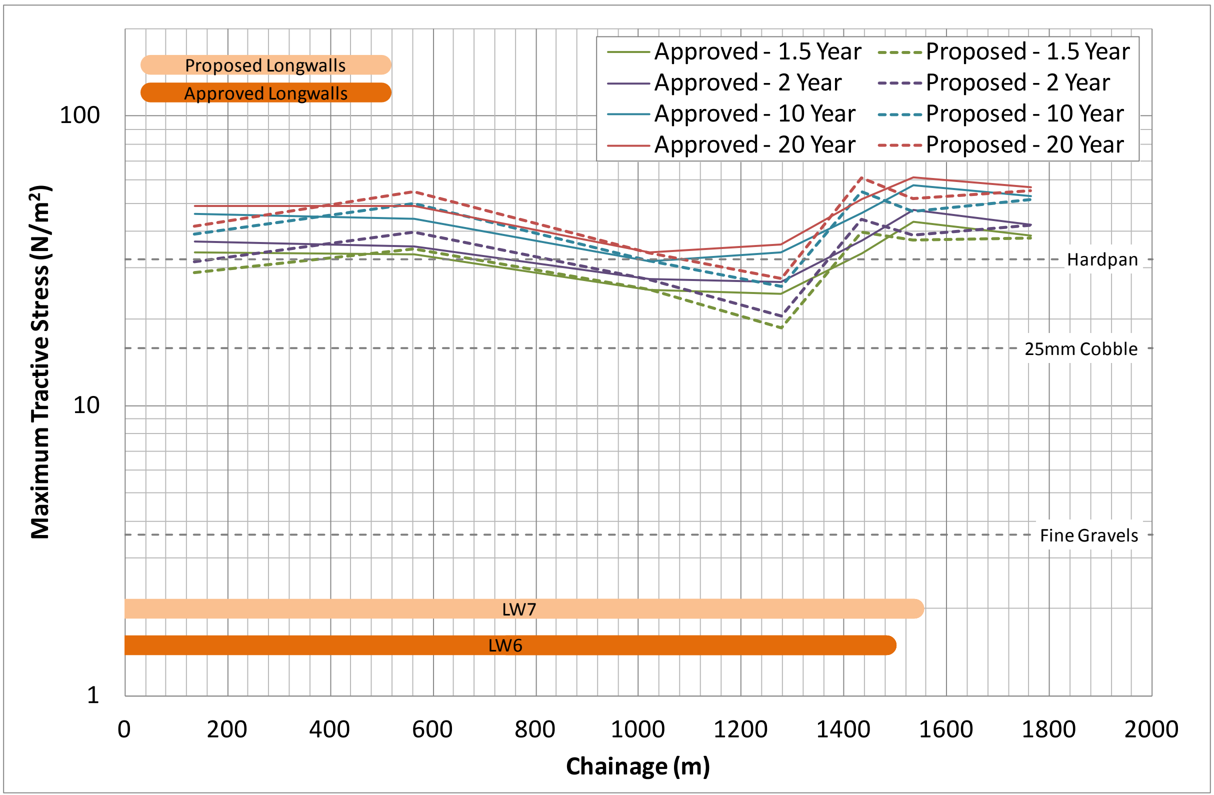


Chart A4.3 - Maximum Modelled Tractive Stress
Mona Creek - Watercourse 3

Watercourse 12

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 12 of up to approximately 5.8 Nm^{-2} (refer to **Chart A4.4**). The maximum modelled increase in tractive stresses occur at the upstream end of Watercourse 12 above proposed Longwall 5 (refer to **Figure 4.2** and **Chart A4.4**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 12 of up to approximately 2.7 Nm^{-2} respectively (refer to **Chart A4.4**). The maximum modelled decrease in flow tractive stresses occurs immediately downstream of proposed Longwall 5 (refer to **Figure 4.2** and **Chart A4.4**).

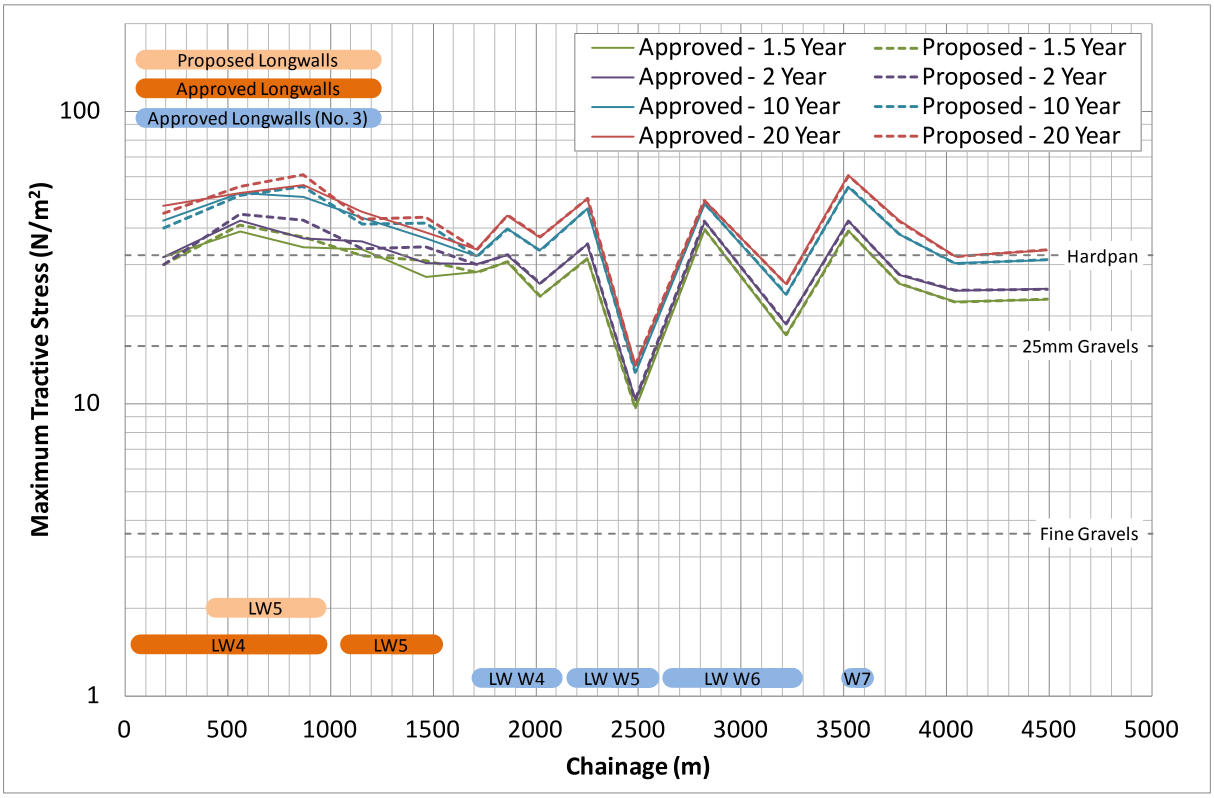


Chart A4.4 - Maximum Modelled Tractive Stress
Mona Creek - Watercourse 12

Cockabutta Creek Catchment

Watercourse 4

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 4 of up to approximately 18.1 Nm^{-2} (refer to **Chart A4.5**). The maximum modelled increase in tractive stresses occurs east (upstream) of the chainpillar between approved longwalls 10B and 11B (refer to **Figure 4.2** and **Chart A4.5**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 4 of up to approximately 19.9 Nm^{-2} (refer to **Chart A4.5**). The maximum modelled decrease in tractive stresses occurs east (upstream) of the chainpillar that separates proposed longwall 10B and 11B (refer to **Figure 4.2** and **Chart A4.5**).

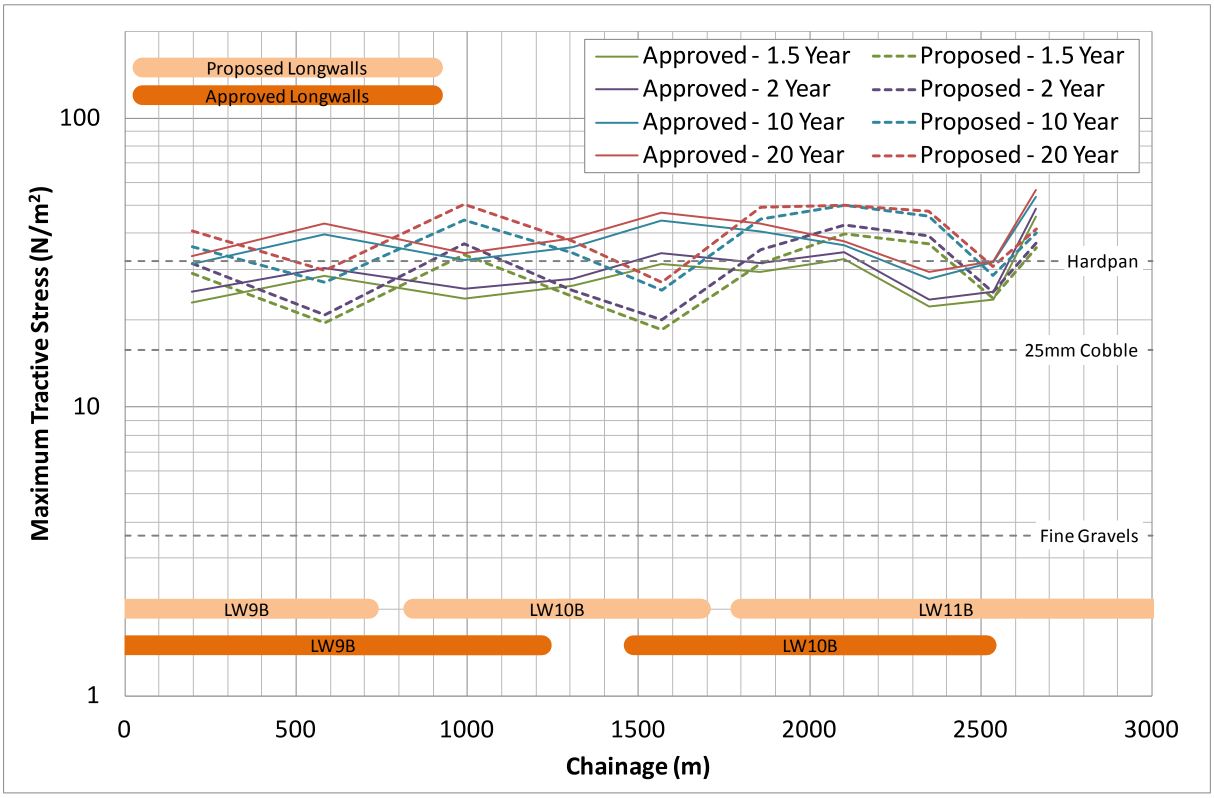


Chart A4.5 - Maximum Modelled Tractive Stress
Cockabutta Creek - Watercourse 4

Watercourse 5

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 5 of up to approximately 31.6 Nm^{-2} (refer to **Chart A4.6**). The maximum modelled increase in tractive stresses occurs west (downstream) of the chainpillar between proposed longwalls 11B and 12B (refer to **Figure 4.2** and **Chart A4.6**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 5 of up to approximately 35.7 Nm^{-2} (refer to **Chart A4.6**). The maximum modelled decrease in tractive stresses occurs within the western (downstream) edge of the proposed longwall 12B (refer to **Figure 4.2** and **Chart A4.6**).

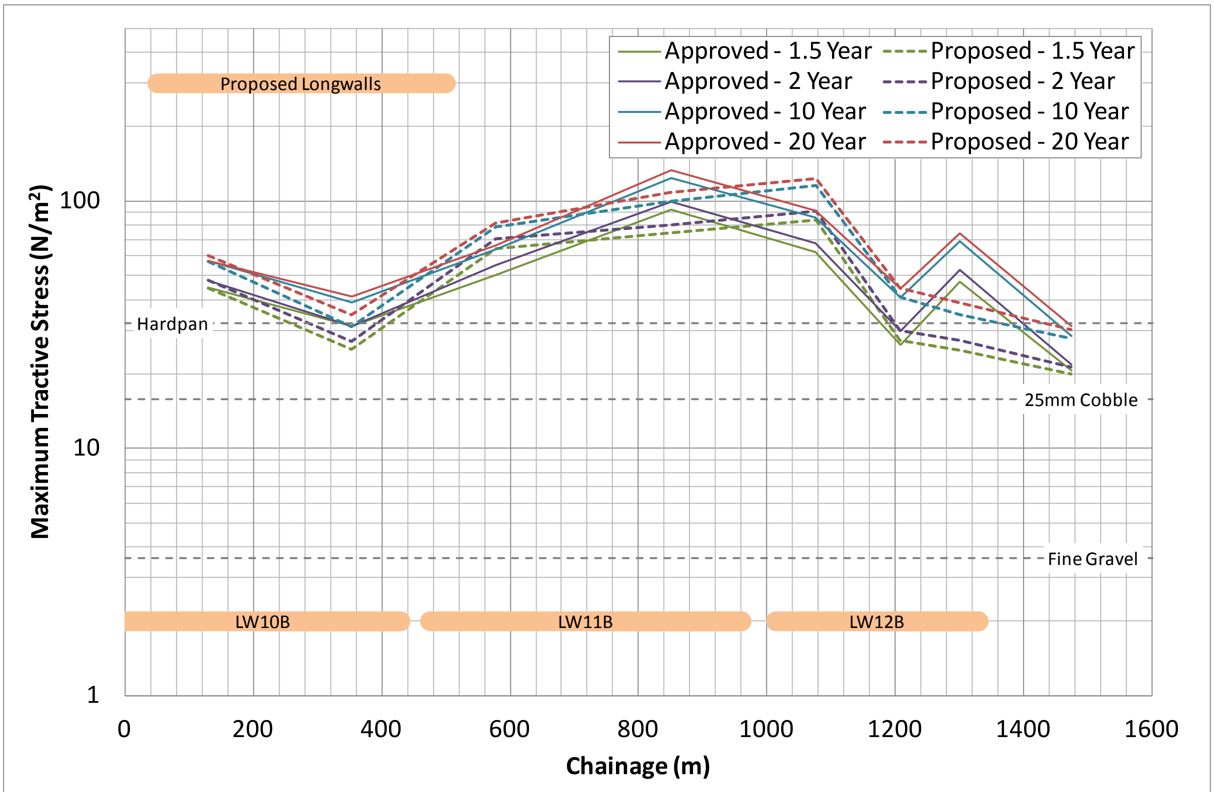


Chart A4.6 - Maximum Modelled Tractive Stress
Cockabutta Creek - Watercourse 5

Watercourse 13

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 13 of up to approximately 22.6 Nm^{-2} (refer to **Chart A4.7**). The maximum modelled increase in tractive stresses occurs in approximately the centre of proposed longwall 8 (refer to **Figure 4.2** and **Chart A4.7**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 13 of up to approximately 31.8 Nm^{-2} (refer to **Chart A4.7**). The maximum modelled decrease in tractive stresses occurs east (upstream) of the chainpillar that separates proposed longwalls 10B and 11B (refer to **Figure 4.2** and **Chart A4.7**).

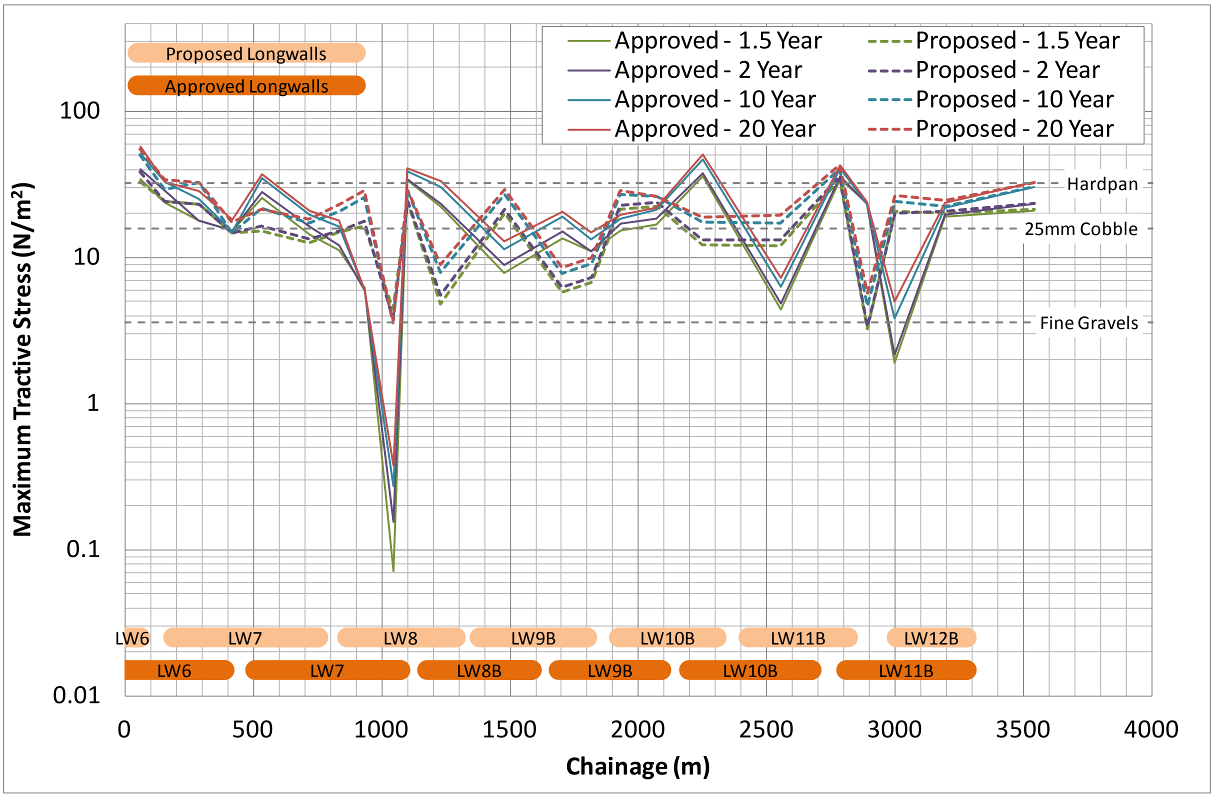


Chart A4.7 - Maximum Modelled Tractive Stress
Cockabutta Creek - Watercourse 13

Ulan Creek Catchment

Watercourse 6

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 6 of up to approximately 18.9 Nm^{-2} (refer to **Chart A4.8**). The maximum modelled increase in tractive stresses occurs at the downstream end of Watercourse 6 at the confluence with Watercourse 11 (refer to **Figure 4.2** and **Chart A4.8**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 6 of up to approximately 11.5 Nm^{-2} (refer to **Chart A4.8**). The maximum modelled decrease in tractive stresses occurs within the centre of proposed longwall 6 (refer to **Figure 4.2** and **Chart A4.8**).

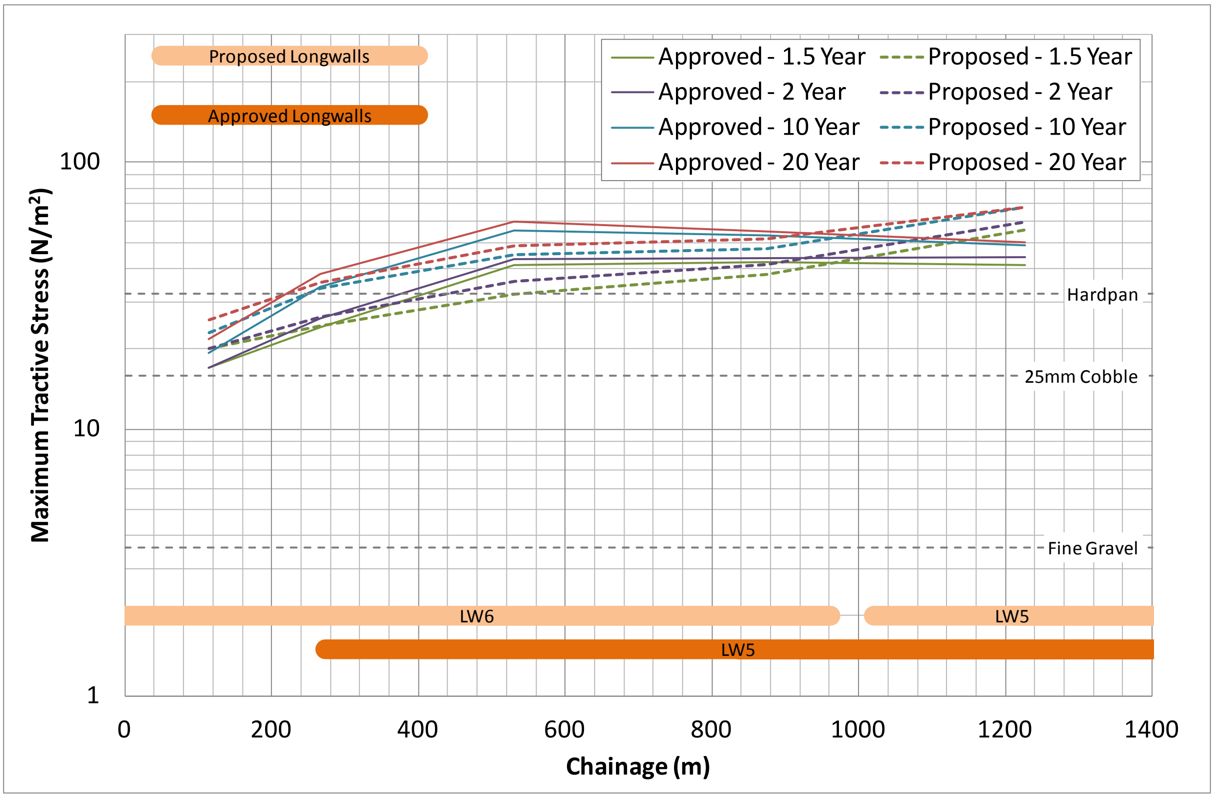


Chart A4.8 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 6

Watercourse 7

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 7 of up to approximately 47.2 Nm^{-2} (refer to **Chart A4.9**). The maximum modelled increase in tractive stresses occurs east (downstream) of the chainpillar between proposed longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A4.9**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 7 of up to approximately 53.0 Nm^{-2} (refer to **Chart A4.9**). The maximum modelled decrease in tractive stresses occurs west (upstream) of the chainpillar that separates proposed longwall 1 and 2 (refer to **Figure 4.2** and **Chart A4.9**).

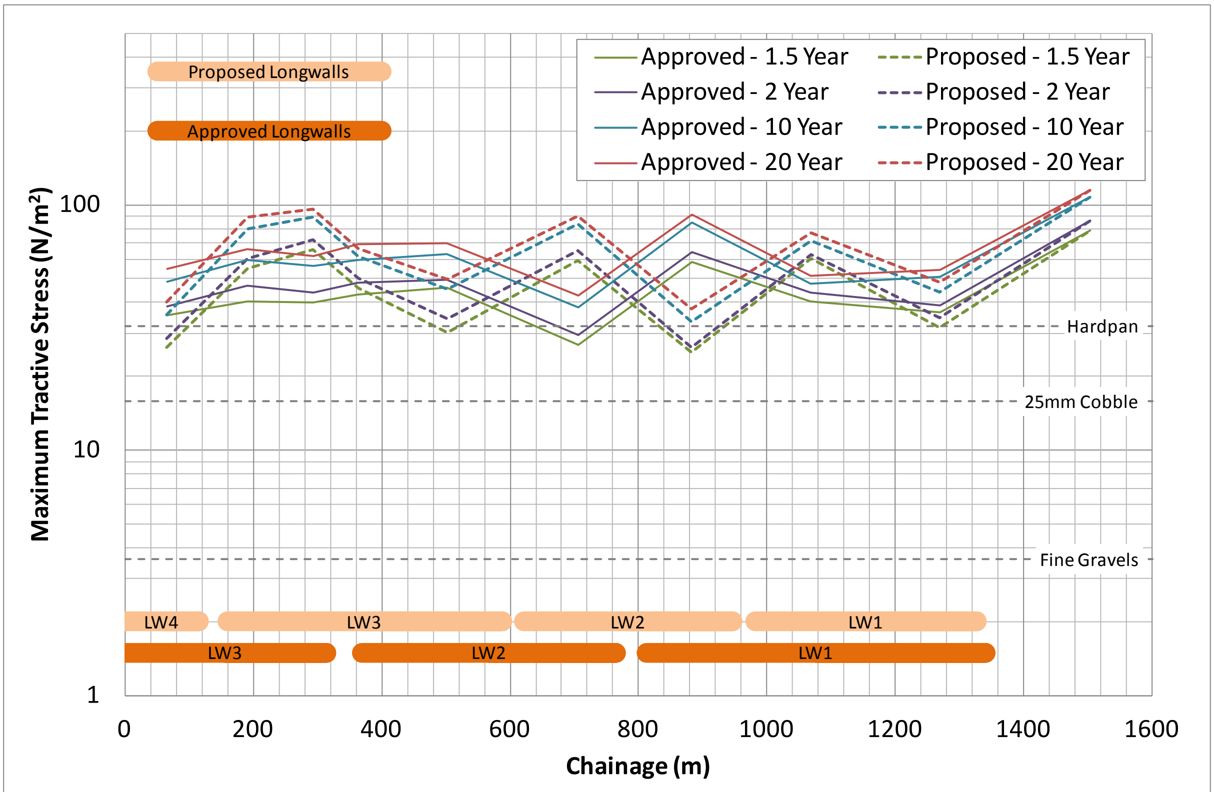


Chart A4.9 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 7

Watercourse 8

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 8 of up to approximately 111.4 Nm^{-2} (refer to **Chart A4.10**). The maximum modelled increase in tractive stresses occurs at the downstream end of Watercourse 8 at the confluence with Watercourse 9 (refer to **Figure 4.2** and **Chart A4.10**). The modelling also indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 8 of up to approximately 74.7 Nm^{-2} (refer to **Chart A4.10**). The maximum modelled decrease in tractive stresses occurs west (upstream) of the chainpillar that separates proposed longwall 2 and 3 (refer to **Figure 4.2** and **Chart A4.10**).

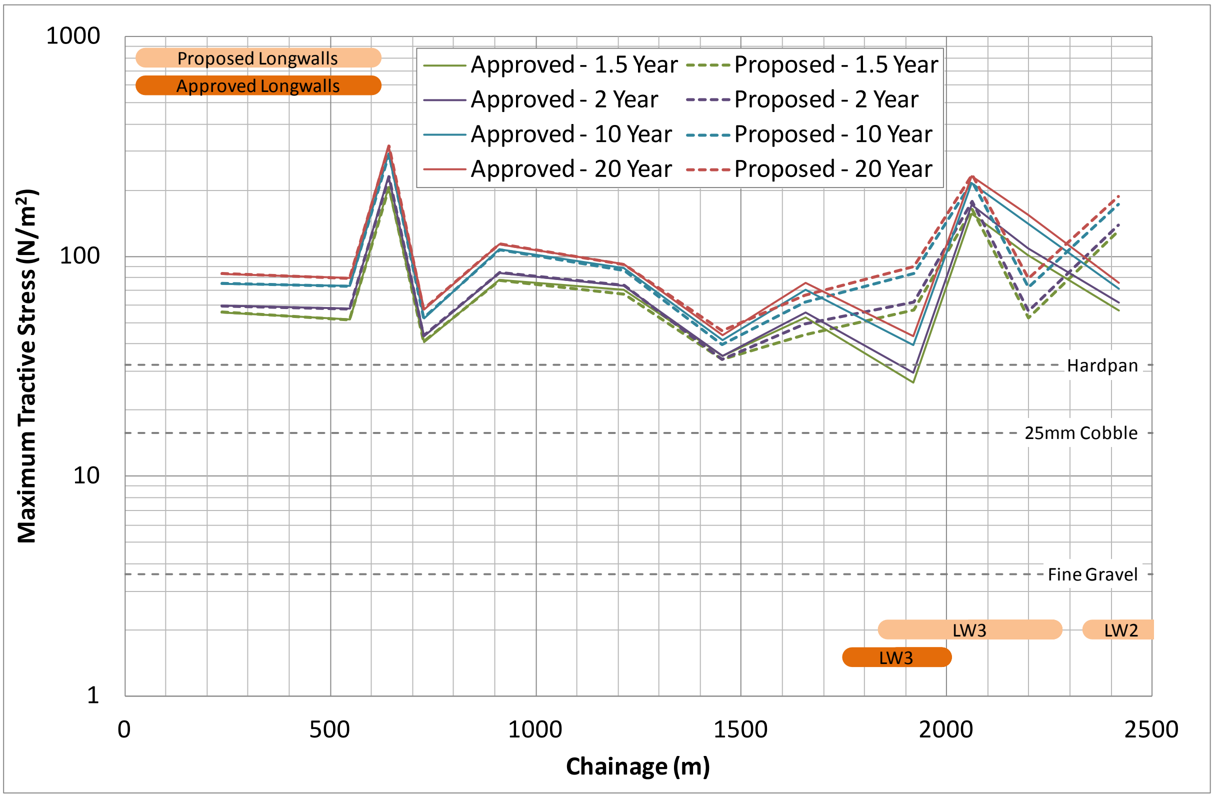


Chart A4.10 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 8

Watercourse 9

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 9 of up to approximately 138.6 Nm^{-2} (refer to **Chart A4.11**). The maximum modelled increase in tractive stresses occurs east (downstream) of the chainpillar between approved longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A4.11**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 9 of up to approximately 73.8 Nm^{-2} (refer to **Chart A4.11**). The maximum modelled decrease in tractive stresses occurs east (upstream) of the chainpillar that separates proposed longwall 1 and 2 (refer to **Figure 4.2** and **Chart A4.11**).

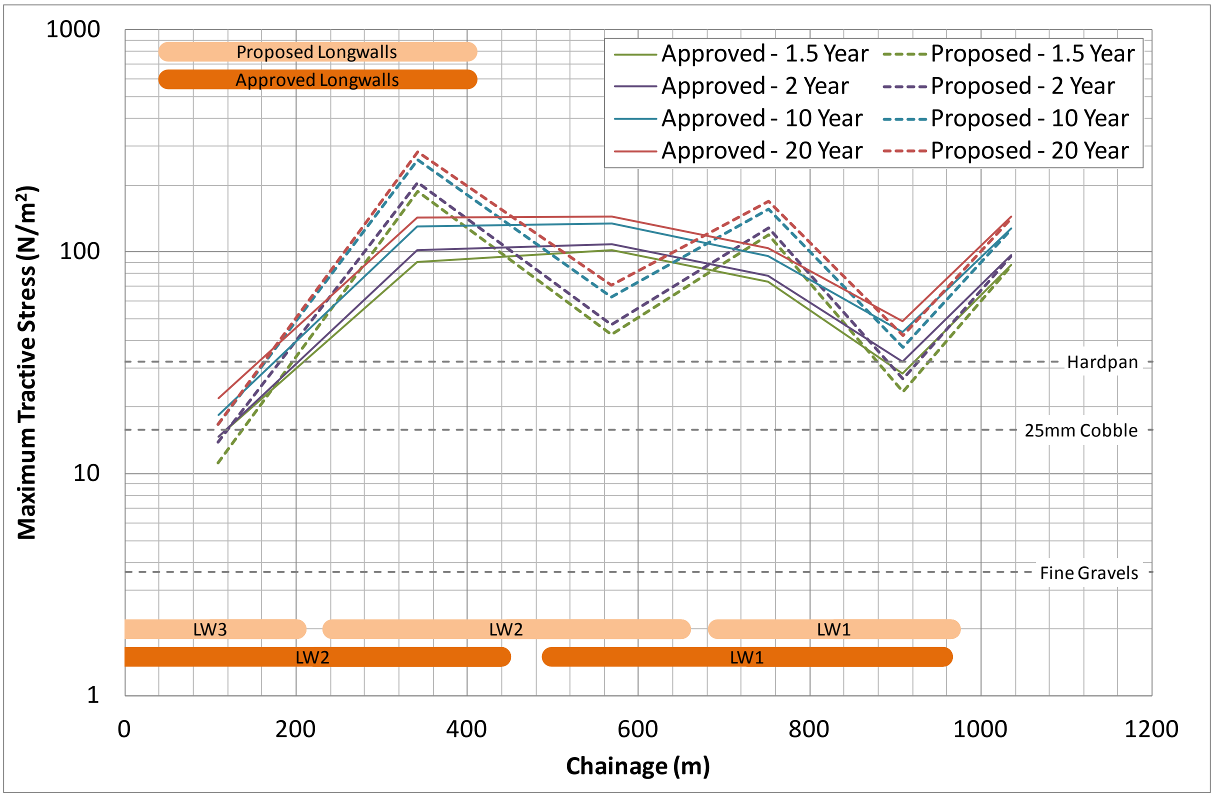


Chart A4.11 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 9

Watercourse 10

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 10 of up to approximately 22.8 Nm^{-2} (refer to **Chart A4.12**). The maximum modelled increase in tractive stresses occurs east (downstream) of the western (upstream) edge of proposed longwall 2 (refer to **Figure 4.2** and **Chart A4.12**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 10 of up to approximately 21.7 Nm^{-2} (refer to **Chart A4.12**). The maximum modelled decrease in tractive stresses occurs west (upstream) of the chainpillar that separates proposed longwalls 1 and 2 (refer to **Figure 4.2** and **Chart A4.12**).

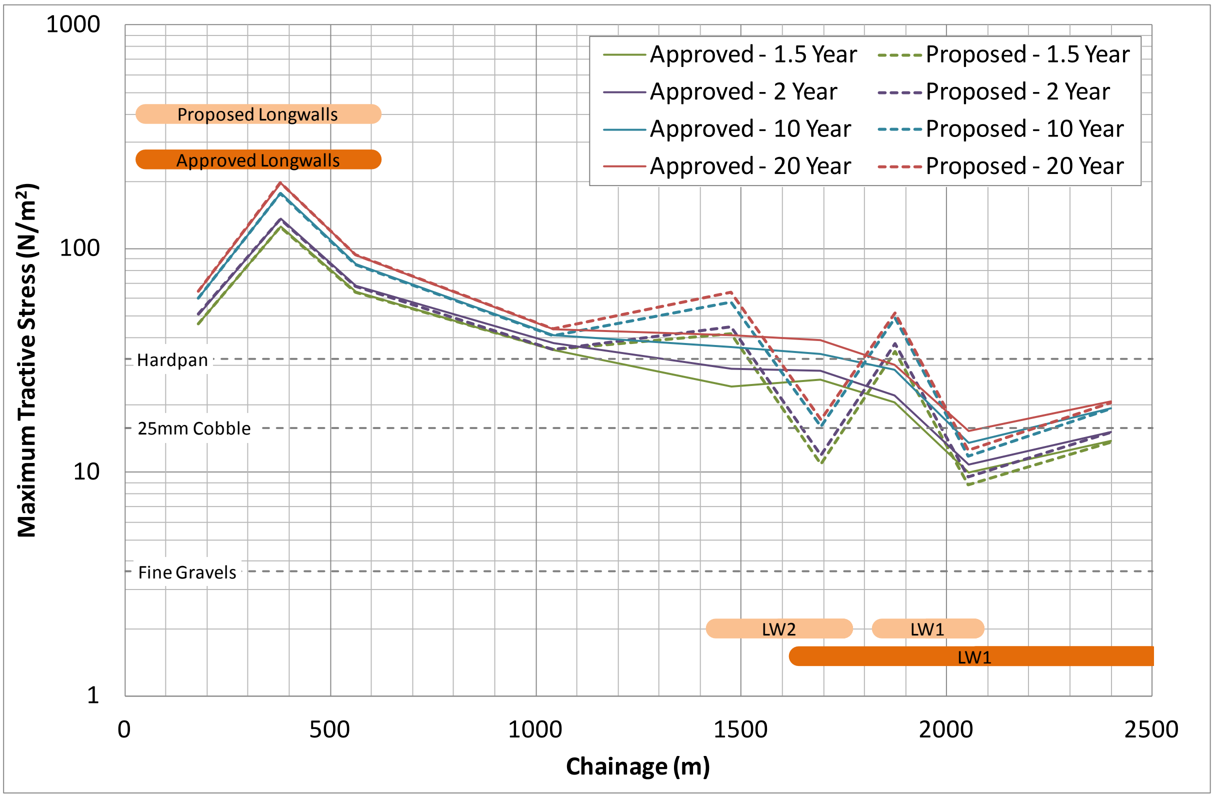


Chart A4.12 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 10

Watercourse 11

The modelling indicates that the proposed modification results in increases to the maximum modelled tractive stresses within Watercourse 11 of up to approximately 77.9 Nm^{-2} refer to **Chart A4.13**). The maximum modelled increase in tractive stresses occurs east (downstream) of the chainpillar between proposed longwalls 2 and 3 (refer to **Figure 4.2** and **Chart A4.13**). The modelling also indicates that the proposed modification results in decreases to the maximum modelled tractive stresses within Watercourse 11 of up to approximately 60.7 Nm^{-2} (refer to **Chart A4.13**). The maximum modelled decrease in tractive stresses occurs west (upstream) of the same chainpillar (refer to **Figure 4.2** and **Chart A4.13**).

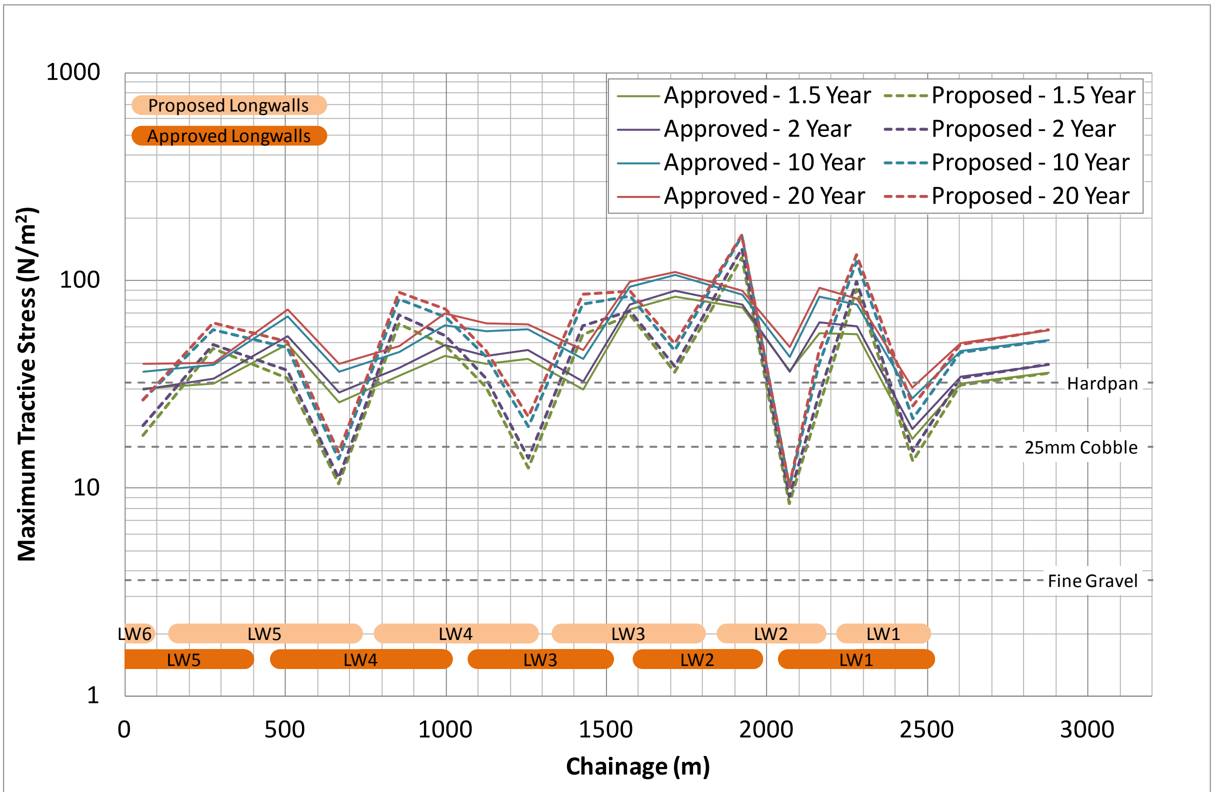


Chart A4.13 - Maximum Modelled Tractive Stress
Ulan Creek - Watercourse 11

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au