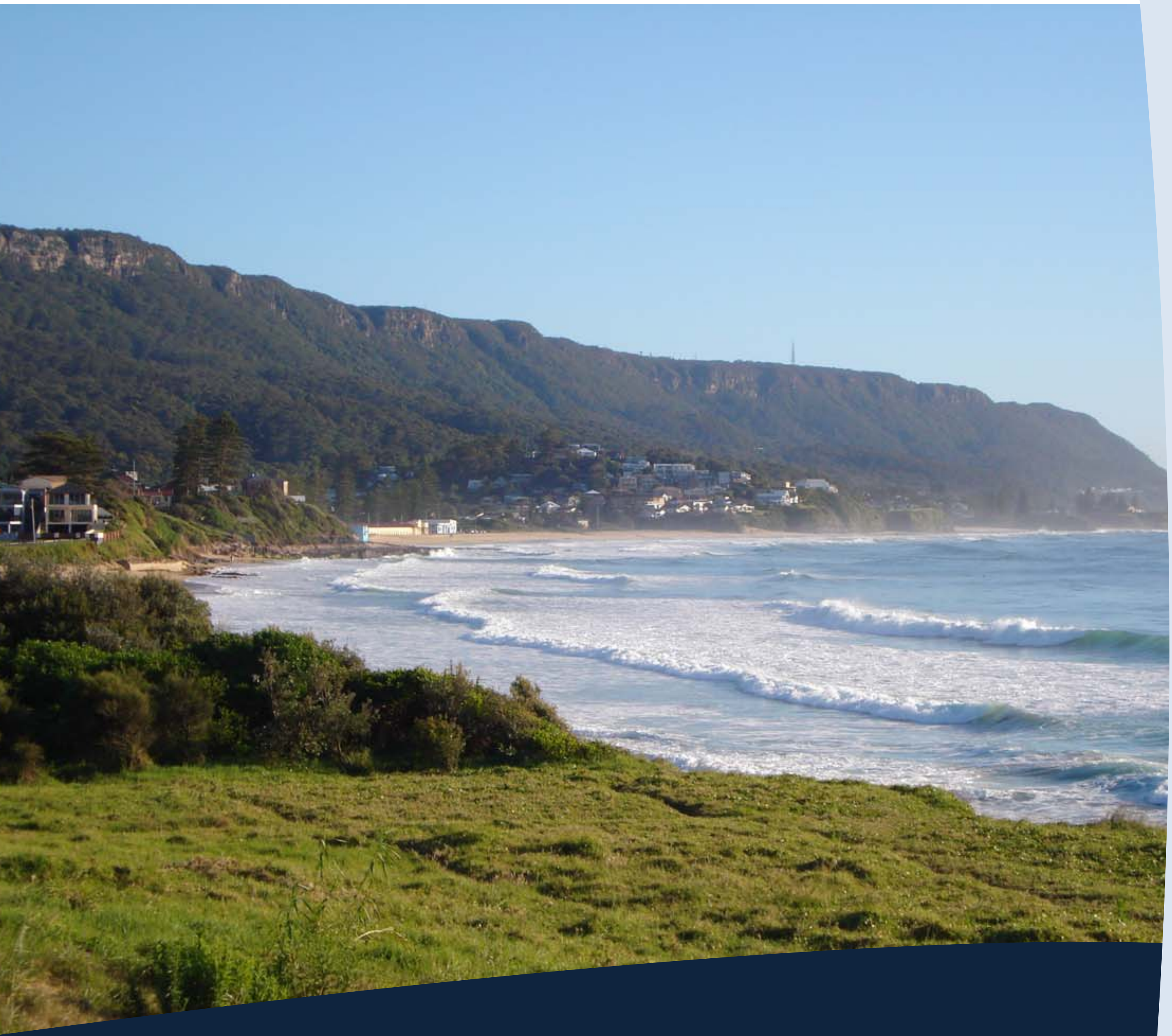

Sandon Point Flood Study

Addendum No. 1

106062-03 Report 002 rev 2

Prepared for Stockland Development Pty Ltd

18 May 2009

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Document Control

Version	Date	Author		Reviewer	
Report 002 Rev 2 Final Rpt	18 May 2009	Mark Favetta	MBF	Anthony Barthelmess	AJB

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1 Introduction

1.1 Background

The NSW Department of Planning engaged Sinclair Knight Merz (SKM) to undertake a peer review assessment of the flood and climate change assessments undertaken for the Sandon Point development (MP07_0032).

SKM issued their preliminary draft report on 9 December 2008, containing a suite of recommendations to the Department of Planning outlining where SKM believed further work was required. The issues related to stream stability, flooding and climate change.

A meeting was held on 27th February 2009 at the Department of Planning, attended by representatives from the Department of Planning, Stockland, Don Fox Planning, Cardno Forbes Rigby and SKM. The purpose of this meeting was to discuss in more detail the issues SKM required addressing prior to the development approval being granted, and to attempt to settle any resolvable issues during the meeting.

CFR tabled two different plans (see **Appendix C** of this report) showing historic geomorphic data through the site, which were at odds with SKM's position that channel failures were possible.

As SKM's geomorphologist had not had the benefit of visiting the site prior to making comments, it was agreed that SKM would attend a joint site inspection. This inspection was undertaken on 9 March 2009 attended by Anthony Barthelmess (CFR), Lih Chong (SKM) and Peter Sandercock (SKM). The historical geomorphic data extracted from the previous Hewitts Creek studies was discussed with SKM showing how the site, and the catchment, had responded geomorphically to various historic flood events.

SKM issued their final Peer Review Report on 6th March 2009 which included specific 'recommended actions' to be undertaken. SKM further issued a letter dated 12 March 2009 outlining their further requirements and modified 'list of issues' after having the benefit of the site inspection.

1.2 Purpose of This Addendum Report

This report responds to:

1. The recommended actions in the SKM 6 March 2009 report
2. The additional issues contained in the SKM letter of 12 March 2009

2 Discussion of SKM Peer Review Comments

The following sections have been structured to align with SKM's comments for ease of review.

2.1 SKM Report Recommended Actions – March 2009

2.1.1 Reduced Roughness Configuration of Creek Channel

SKM state:

> *Undertake sensitivity analysis in the hydraulic modelling, incorporating lower Manning's' n values than the design values of 0.1 – 0.15, to estimate flow velocities and shear stresses for comparison against stability thresholds for the selected channel lining materials*

SKM further advise in their 12 March 2009 letter that they consider this issue to be resolved. SKM states that they *have since received a response from Cardno on this issue, and is satisfied that the adopted channel roughness values relate to an established, vegetated state of the channel.*

2.1.2 Beach Berm Migration

SKM state:

> *Consider the impact of climate change-induced beach berm migration (associated with sea level rise and shoreline recession) on flooding behaviour in Woodlands and Hewitts Creeks*

We have undertaken additional modelling as recommended, and presented this in detail at **Section 3.2** of this report. The modelling conclusively shows that such impacts will have no effect on flood levels through the subject site. We consider this issue to be resolved.

2.1.3 Alternate Bridge Modelling Approaches

SKM state:

> *Undertake further flood modelling, utilizing the appropriate bridge modelling approaches for the proposed bridges on Woodlands and Hewitts Creeks, and subsequently provide the flood modelling results to demonstrate the sensitivity of the design flood levels to the change in bridge modelling approach;*

We have undertaken additional modelling as recommended, and present this in detail at **Section 3.1** of this report. The modelling conclusively shows that such impacts will have minimal effect on flood levels through the subject site. We consider this issue to be resolved.

2.1.4 No Upgrade to Woodlands Creek Culvert

SKM state:

> *Undertake sensitivity analysis of "no culvert upgrade" scenario (Woodlands Creek railway culverts) in the climate change scenario, and assess its impact on flood flows and flood behaviour;*

In an email from SKM's Lih Chong to CFR's Anthony Barthelmess dated 2 March 2009, SKM advise that *SKM is satisfied with CFR's assurance that Council is committed to upgrading the Woodlands Creek railway culvert in the near future. Highly unlikely that the "no culvert upgrade" scenario will occur in the climate change scenario. No further action required on this issue.*

This is further reinforced by the advice on Wollongong Council's website, which advises:

> *Woodlands Creek, Bulli - upgrade of railway culvert. Significant flooding is also known to occur in the area immediately upstream of the Illawarra Railway line embankment (including the Princes Highway) due to the inadequate capacity of the existing culvert beneath the railway line and its potential to block with debris. This project aims to reduce the incidence of flooding along the section of Woodlands Creek immediately upstream of the railway embankment by upgrading the existing culvert system. As a result, the capacity of the upgraded system will be significantly increased, therefore reducing its potential to block, and resulting in lower flood levels upstream of the railway line. The project is currently in the preliminary design phase.* http://www.wollongong.nsw.gov.au/environment/hewittscreek.asp

We understand that SKM have been engaged to undertake this preliminary design work which is noted on the website as being underway. We therefore consider this issue to be resolved.

2.1.5 Design Flow Increase of 20%

SKM state:

> *Undertake sensitivity analysis in the hydraulic modelling, incorporating a 20% increase in the design flows in the 100 year ARI event (existing climate scenario).*

CFR sees little point in undertaking a 20% sensitivity model run for this scenario, when our modelling already provides for a 30% increase in design flows through the site. The modelling for this 30% increase in design flows shows that the proposed development, and the proposed floor levels and compliance with Council's DCP54 are not adversely impacted by a 30% increase in design flow.

Further, the sensitivity analysis already undertaken (and the adopted design flows) are well in excess of DECC's *'Practical Considerations of Climate Change'* guidelines (2007). This guideline suggests only a 7% increase in extreme rainfall for the Illawarra, whereas our design adopts a 30% increase in extreme rainfall. CFR considers it inappropriate to conduct a further sensitivity of a 20% increase in flow, on top of a 30% increase in flow which is already excessive when compared with DECC's best practice guideline.

As such, we consider the assessment of a 20% increase in design flow to be not in accordance with current DECC guidelines, and have not included such an assessment in this addendum. We consider this issue to be resolved.

2.1.6 Woodlands Creek Transitioning

SKM state:

> *Provide clear demonstration of effective transitioning between the Woodlands Creek re-diversion and the area downstream of the site on the design plans. More detailed topographic data required for the downstream area.*

The diversion works are required by Council, under the Hewitts Creek Floodplain Risk Management Study & Plan (2002) and are not required to support the development. SKM accepts that the proposed tail-out works are only an interim stage for the purpose of designing and constructing the proposed Woodlands Creek floodway. SKM also accepts that the tail-out works can be upgraded once Council negotiates permission with the affected landowner.

Stockland is proposing to carry out tail-out works for a length of approximately 15m along Woodlands Creek and approximately 75m along Hewitts Creek. As SKM correctly observe the upgrades (i.e. further works identified in the Hewitts Creek FRMS&P) would be carried out by Council, once Council has obtained permission from the affected landowner.

This is not work that will be undertaken by Stockland and an experienced civil engineering designer would have little difficulty in transitioning into the downstream landscape. If Council had forseen engineering difficulties when preparing the Hewitts Creek FRMS&P, then the Council and community might not have supported or adopted the Hewitts Creek FRMS&P.

We also note that the Woodlands Creek diversion was deemed as having a 'high priority' for upgrade in the Hewitts Creek FRMS&P. Measures that are given a 'high priority' contribute the most to a schemes benefit, and for this reason the Hewitts Creek FRMS&P states that such works should be implemented as soon as funding is made available. It is anticipated that this may occur over a 1-5 year time frame.

As the Hewitts Creek FRMS&P was published in 2002, such works should have been implemented by 2007. We infer that these works are still 'high priority' and as such will likely be implemented in the immediate future. Given the above, it is likely that the Woodlands Creek diversion works may be undertaken by Council prior to the work being undertaken by Stockland, given that the works are overdue for completion.

2.1.7 Alternate Approach to Creek Design

SKM state:

> *Develop an alternative approach for the creek design, in agreement with DoP / peer reviewer;*

This comment was provided by SKM prior to their geomorphologist inspecting the site. A subsequent inspection was undertaken on 9 March 2009 and historic geomorphic information was provided to SKM. Further issues came out of this site inspection and were provided in SKM's 12 March 2009 letter. We have also addressed these additional issues in this report.

We contend that this peer review process constitutes the outcome of an alternate design developed in agreement with DoP's peer reviewer. SKM have made direct comments and contributions to the design and the current design represents their inputs. Revised design plans are included in **Appendix B**, which introduce additional creek bed armouring and rock bed controls in both Hewitts and Woodlands Creeks. We consider this issue to be resolved.

2.1.8 Geomorphic Assessment

SKM state:

> *Undertake appropriate geomorphic assessments to support proposed creek design, with consideration of stability/erodibility of fill material on site;*

Again, we contend that this peer review process constitutes the outcome of an appropriate geomorphic assessment being undertaken. CFR prepared the original design put forward for approval, and through the peer review process SKM's expert geomorphologist has made several comments relating to how the designs could be improved and made more robust. CFR has acknowledged and responded to each and every comment and this direct input from SKM is reflected in the current design (see plans in **Appendix B**). We consider this issue to be resolved.

2.1.9 Post Construction Monitoring

SKM state:

> *Monitor the post-construction creek for any impacts of the Woodlands Creek re-diversion on downstream habitats. The monitoring will identify any necessary adaptive maintenance actions.*

No action is required at this stage. Stockland are implementing a flood mitigation scheme on behalf of Council; in other words these works would have occurred irrespective of the Sandon Point development. Ongoing monitoring of the performance of these works is a general requirement of these works, and if Council were to have implemented these works prior to it being undertaken by Stockland, Council would have been required to undertake such monitoring.

As the works are required by Council, under the Hewitts Creek Floodplain Risk Management Study & Plan (2002), and not required to support the development, we recommend Council undertake inspections after each flood event to monitor the need for any adaptive maintenance requirements.

Further, the Statement of Commitments references a 2 year maintenance period for WSUD features and a 5 year maintenance period for vegetation and open space. This maintenance period is from the release of the final subdivision certificate. The post construction monitoring requested by SKM is already covered under this maintenance plan referenced in the Statement of Commitments.

2.2 SKM Letter – 12 March 2009

2.2.1 Sediment Deposition in Woodlands Creek

SKM state:

> *There is potential for sediment deposition to occur in the reconstructed creeks, particularly Woodlands Creek once the railway culvert is opened up and the proposed vegetation is established. This may reduce the hydraulic capacity of the creeks. The proponent needs to coordinate with Council to ensure that monitoring of sedimentation and adequate maintenance occurs.*

No action is required at this stage. Stockland are implementing a flood mitigation scheme on behalf of Council; in other words these works would have occurred irrespective of the Sandon Point development. Ongoing monitoring of the performance of these works is a general requirement of these works, and if Council were to have implemented these works prior to it being undertaken by Stockland, Council would have been required to undertake such monitoring. As the works are required by Council, under the Hewitts Creek Floodplain Risk Management Study & Plan (2002), and not required to support the development, we recommend Council undertake inspections after each flood event to monitor sediment accumulation (if any).

Further, the Statement of Commitments references a 2 year maintenance period for WSUD features and a 5 year maintenance period for vegetation and open space. This maintenance period is from the release of the final subdivision certificate. The post construction monitoring requested by SKM is already covered under this maintenance plan referenced in the Statement of Commitments.

2.2.2 Erosion Protection Treatment

SKM state:

> *Sizing of rocks in the erosion protection treatments is potentially undersized, considering the estimated shear stresses and velocities, and the shear stress and velocity thresholds presented in Fischenich (2001), on which Cardno's rock armour sizing is based. While the general nature of the treatments are acceptable, the size of the rocks which make up the treatment may need to be increased to provide sufficient stability (given the Director-General's requirements for a 20 year ARI design event). Therefore, it is recommended that Cardno reconsider the required sizing of the rocks in the erosion protection treatments.*

CFR has amended the design plans to show a general increase in the application of rock to the creek bed, to cater for SKM's concerns regarding a potential under sizing of this material. The updated design plans are included in this report as **Appendix B**. CFR will further consider such changes to the rock armouring details at detailed design stage. We consider no further action is required.

2.2.3 Construction of Rock Treatments

SKM state:

> *Details on how individual rocks will be keyed in/interlocked with each other, plus how the ends of the rock treatments will be constructed (to prevent outflanking) should be provided. As this may be considered a detailed design issue, it would be satisfactory to provide this information at the detailed design stage.*

No action is required at this stage. As SKM suggest, further details can be readily provided at detailed design stage and an additional Statement of Commitment can be proposed.

2.2.4 Establishment-Stage Vegetation Management

SKM state:

> *In the Final Report, SKM identified the issue that the adopted channel roughness in the hydraulic modelling for the proposed reconstructed creeks was excessively high. SKM has since received a response from Cardno on this issue, and is satisfied that the adopted channel roughness values related to an established, vegetated state of the channel. The proposed vegetation will help to manage erosion and scour when established by reducing flow velocities and physically binding the creek bed material.*
>
> *However, details on establishment-stage erosion control should be provided measures to demonstrate that the un-vegetated channel would not be eroded by the higher flow velocities expected during the establishment stage. As this may be considered a detailed design issue, it would be satisfactory to provide this information at the detailed design stage.*

No action is required at this stage. As SKM suggest, further details can be readily provided at detailed design stage and an additional Statement of Commitment can be proposed.

3 Additional Hydraulic Modelling

This chapter builds upon previous hydraulic modeling undertaken for our March 2008 report titled Sandon Point Flood Study: Concept Plan Application – Climate Change Assessment. The additional hydraulic modeling performed for this report is based on recommendations made in SKM's peer review of the flooding and climate change impacts of the Sandon Point development.

3.1 Alternative Bridge Modelling Approaches

Hydraulic models are constructed to determine flood levels along watercourses and through urban areas where flooding could potentially be an issue. Bridges may be represented in hydraulic models in a number of ways. When modelling clear span bridges which have the soffit (i.e. the underside of the bridge deck) located above flood levels, the choice of bridge modelling approach has a very minor effect on resulting flood levels.

The HECRAS hydraulic model prepared for the March 2008 version of the Sandon Point Flood Study utilised the Energy Equation standard step method bridge modelling approach in HECRAS for both low flow and high flow conditions through proposed bridge structures on Hewitts and Woodlands Creeks.

> Low flow exists when the flow through the bridge opening is open channel flow. This means that water is below the underside of the bridge deck.

HECRAS automatically computes the class of low flow by solving the momentum equation at critical depth inside the bridge at the upstream and downstream ends. It uses the end with the most constricted section as the controlling section in the bridge. The momentum at critical depth of the controlling section is then compared to the momentum of the flow downstream of the bridge when performing a subcritical profile and upstream of the bridge for a supercritical profile.

If the momentum downstream of the bridge is greater than the critical depth momentum inside the bridge, the class of flow is considered to be completely subcritical (i.e. class A low flow). If the momentum downstream is less than the momentum at critical depth in the controlling bridge section, then it is assumed that constriction will cause the flow to pass through the critical depth and a hydraulic jump will occur at some distance downstream (i.e. class B low flow). If the profile is completely supercritical through the bridge, then it is considered class C low flow (USACE, 2004).

> High flow exists when the flow through a bridge opening contact with the underside of the bridge deck.

At the request of SKM we have assessed the effect of using alternative bridge modelling approaches.

The effect of using an alternative energy equation to assess water levels and velocities through a bridge structure is more pronounced when a constricted cross-sectional area is available for flow. We have thus performed all sensitivity analysis to assess the effects using alternative bridge modelling approaches on the 25% bottom-up bridge blockage scenario. It is noted the 25% is blockage scenario was selected as Council requires assessment of this case for water levels in accordance with their conduit blockage policy. We have also performed the sensitivity analysis using the adopted upper bound climate change flows to representative of a thirty percent increase in rainfall intensity.

3.1.1 Original Method: Energy Equation

HECRAS solves the energy equation in the same manner for both low flows and high flows. Computations are based on balancing the energy equation in three steps through the bridge. Energy losses are based on friction and contraction and expansion losses. The energy based method performs all computations as though they are in open channel flow. This is done in the same manner as a natural river cross section would be solved. Where cross-sectional area is obstructed by bridge piers, abutments, and deck, this area is subtracted from the flow area and additional wetted perimeter is added.

The sequence of calculations for solving the energy equation is performed in three standard steps (refer to **Figure 1** for bridge cross-section locations.

1. From just downstream of the bridge (section 2) to just inside the downstream section of bridge (section BD)
2. Inside the bridge from section BD to section BU
3. From just inside the upstream section of the bridge (section BU) to the just upstream of the bridge (section 3)

The energy based method requires input of Manning's n values for friction losses and contraction and expansion coefficients for transition losses.

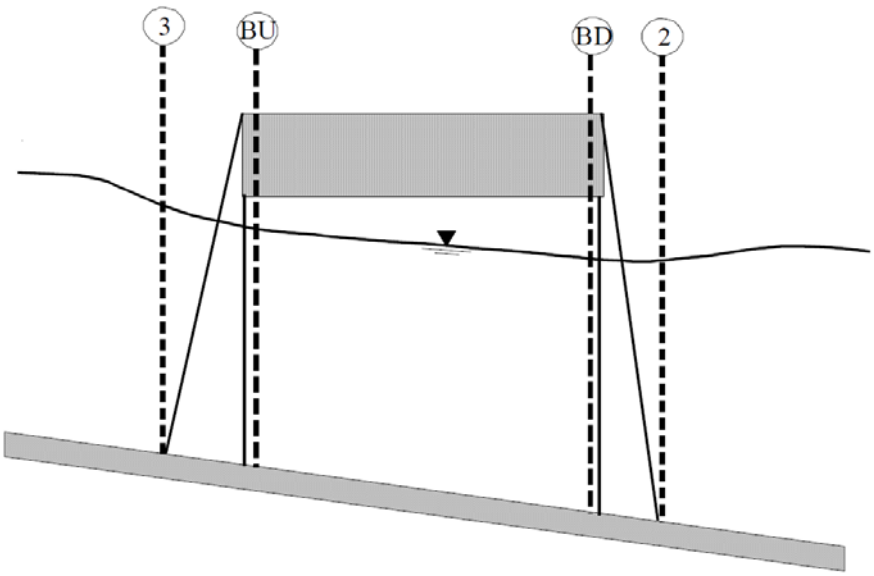


Figure 1: HECRAS Cross-Section Computation Near and Inside a Bridge

3.1.2 Alternative Method #1: Momentum Balance for Low Flow

The momentum balance method is based on performing a momentum balance from cross-section 2 to cross-section 3 (refer to **Figure 1** above for cross-section location). The sequence of calculations is performed in the same order as energy equation standard steps. The momentum balance method requires the use of roughness coefficients for the estimation of friction force and a drag coefficient for the force of drag on piers. Drag coefficients are used to estimate the force due to the water moving around the piers, the separations of the flow, and the resulting wake that occurs downstream (USACE, 2004).

We have selected a circular pier shape with a drag coefficient C_D of 1.20 to represent the piers on the bridges in accordance with the proposed design. It is noted that if water touches the underside of the bridge, the momentum equation is assumed to be invalid.

3.1.3 Alternative Method #2: Weir Plus Pressurised Flow for High Flow

This approach separates the hydraulic equations to compute flow as pressure and/or weir flow. Pressure flow occurs when the flow touches the underside of the bridge. A backwater will occur and orifice flow is established. HECRAS automatically selects the appropriate orifice flow equation depending on the flow situation. The discharge coefficient used in this equation will vary based on the amount the inlet is submerged. HECRAS has been set to automatically calculate this. Flow over the bridge is calculated using the standard weir equation. The approach velocity is included in the calculation by using the energy grade line elevation in lieu of the upstream water surface elevation for computing the head (USACE, 2004). The program performs a series of iterations to calculate the proportion of each type of flow i.e. weir or pressurised flow.

3.1.4 Comparison between Methods

HEWITTS CREEK

Flow through the Hewitts Creek Bridge operates under low flow conditions (i.e. channel flow) for events up to the 100 year ARI and high flow conditions for the PMF. This assessment was performed with the bridge 25% blocked and using the future upper bound climate change scenario flows. During the 100 year ARI, when using the momentum balance equation, flood levels reach a maximum of 0.10 m higher on the upstream side of the bridge. It is noted that there is no change in the 100 year ARI flood levels when using the weir plus pressurised flow for high flow conditions as the water level does not reach the underside of the bridge deck (so pressurised flow does not occur).

When using the weir plus pressurised flow for high flow conditions during the PMF, the resulting flood levels are a maximum of 0.08 m higher on the upstream side of the bridge. It is noted the momentum balance equation becomes invalid for this flow scenario as water touches the underside of the bridge.

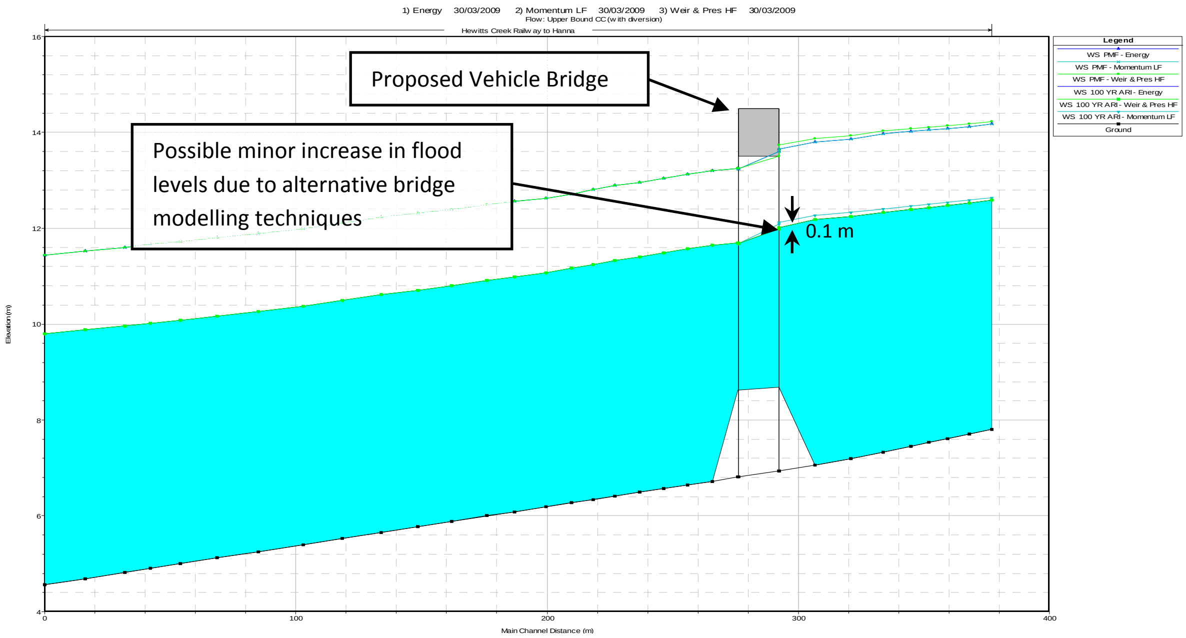


Figure 2 Comparison of Bridge Modelling Techniques for Hewitts Creek

We confirm that using alternative bridge modelling techniques does not adversely affect flood levels in Hewitts Creek. The minor increase in flood levels just upstream of the proposed vehicle bridge during the 100 year ARI (a maximum of 0.1 m) is within the 0.5 m of freeboard incorporated into the development (above the 100 year ARI flood level) to cater for modelling uncertainties. Floor levels for all proposed dwellings should therefore be based on flood levels presented in the March 2008 Sandon Point Flood Study.

WOODLANDS CREEK

Flow through the Woodlands Creek Bridge operate under low flow conditions (i.e. channel flow) for events up to the 100 year ARI and high flow conditions for the PMF. This assessment was performed with the bridge 25% blocked and using the future upper bound climate change scenario flows.

During the 100 year ARI, when using the alternate momentum balance equation, flood surface levels on the upstream side of the vehicle bridge remain the same. It is noted that there is no change in the 100 year ARI flood levels upstream of the vehicle bridge when using the weir plus pressurised flow model configuration for high flow conditions, as the water level does not reach the underside of the bridge deck (so pressurised flow does not occur).

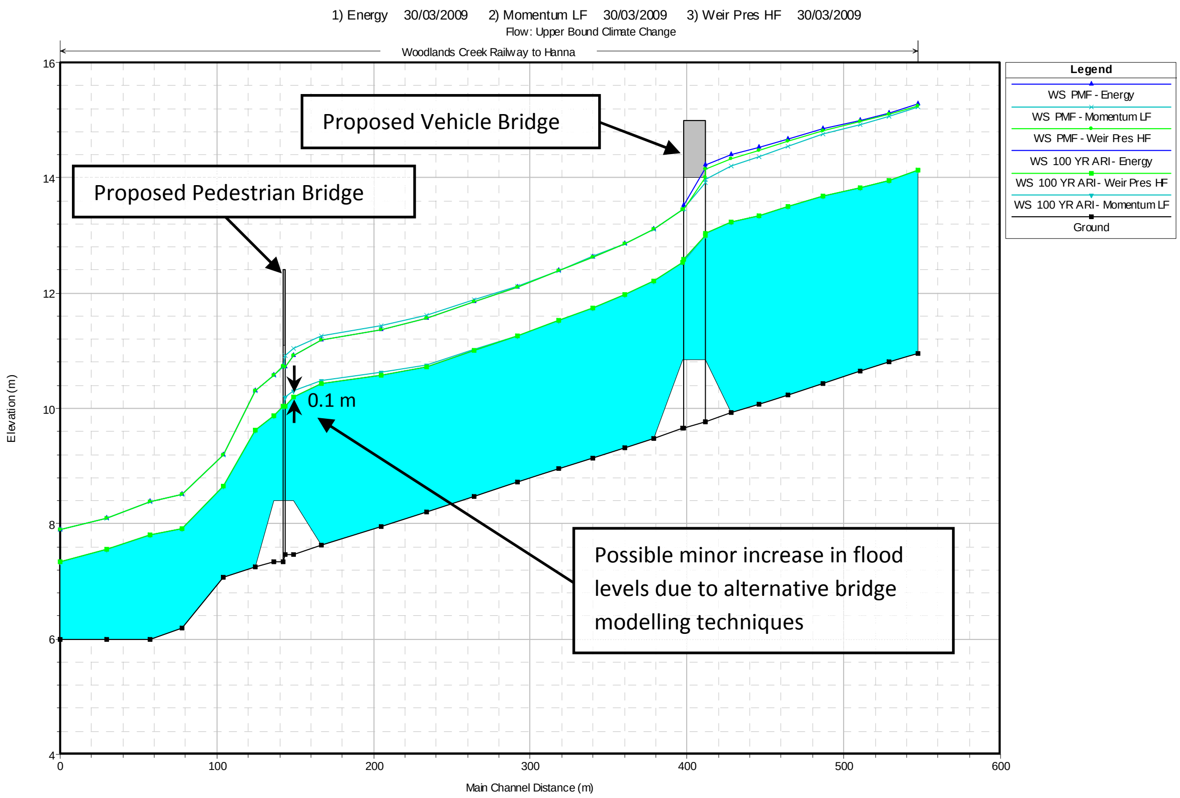


Figure 3 Comparison of Bridge Modelling Techniques for Woodlands Creek

However upstream of the proposed pedestrian bridge during the 100 year ARI when using the weir plus pressurised flow model configuration for high flow conditions, flood surface levels are lowered by up to 0.1 m. There is no change in flood levels using the momentum equation at this location.

When using the momentum balance equation method for the PMF, the resulting flood levels are up to 0.25 m lower on the upstream side of the vehicle bridge and water does not reach the underside of the bridge. Flood surface levels are also lower, using the weir plus pressurised flow model configuration for high flow conditions, by up to 0.09 m on the upstream side of the vehicle bridge.

Upstream of the pedestrian bridge, water levels are marginally higher by up to 0.11 m when using the momentum balance equation in the PMF event. No change occurs near the pedestrian bridge using the weir plus pressurised flow for high flow conditions method as the water level does not reach the underside of the bridge deck (so pressurised flow does not occur).

We confirm that using alternative bridge modelling techniques does not adversely affect flood levels in Woodlands Creek. The minor increase in flood levels during the 100 year ARI (a maximum of 0.11 m) just upstream of the pedestrian bridge is within the 0.5 m of freeboard incorporated into the development (above the 100 year ARI flood level) to cater for modelling uncertainties. Floor levels for all proposed dwellings should therefore be based on flood levels presented in the March 2008 Sandon Point Flood Study.

3.2 Beach Berm Migration

The coastal hazard assessment prepared by Cardno Lawson Treloar as part of our March 2008 Sandon Point Flood Study states that the shoreline would recede by approximately 70m to a distance of 190 m eastward of the site boundary, assuming a climate change induced sea level rise of 0.91 m by 2100. SKM have recommended we increase the level of the berm to a similar level to the magnitude of sea level rise (as this is what is believed by SKM to likely occur).

The aerial laser survey data (ALS) indicates that in 2004 the beach berm height was approximately 2.1 m AHD. Based on SKM's recommendations, berm height would reach a level of 3.0 m AHD. Figure 4 is a shade plot of Hewitts, Woodlands and Tramway Creeks with contours in 0.25 m increments which provides a good indication of where the existing beach berm is located and SKM's believed future location for the berm.

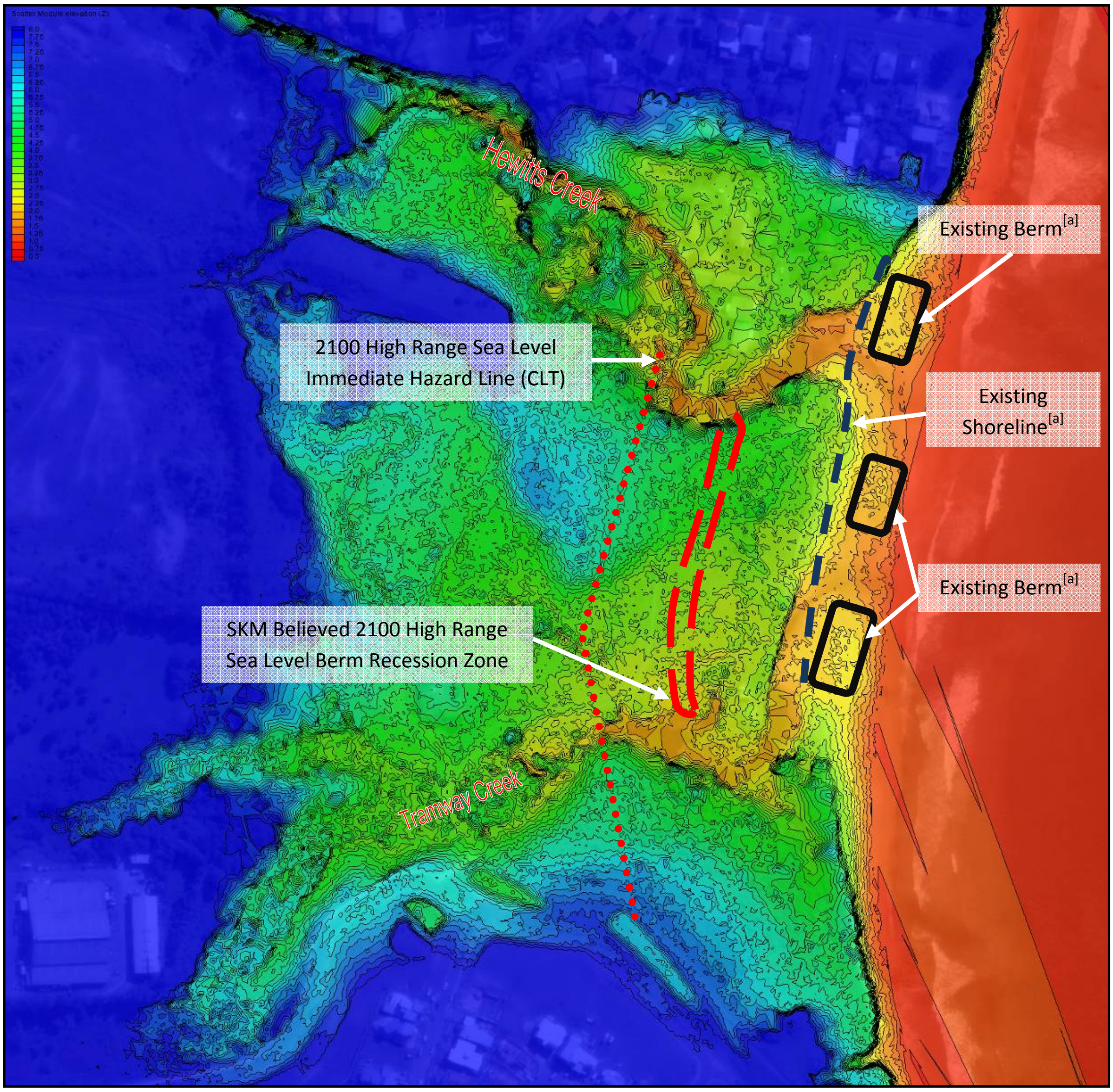


Figure 4 Shade Plot of Hewitts, Woodlands and Tramway Creeks Entrance to Ocean

*The shading shown on the above figure shows change in elevation in 0.25 m increments (between black contours) up to RL +8.0 m AHD. The shade plot was constructed to determine the height and location of the existing beach berm at the time the aerial laser survey was flown on **[a]** 23 May 2005.*

Figure 5 Photograph of Scour in Hewitts Creek Just After August 1998 Flood

The sandy bed, banks of Hewitts Creek and adjacent beach berms at the entrance to the ocean were scoured out due to the flow in Hewitts Creek. The Hewitts Creek foot bridge shown in this photograph is located 25 m upstream of McCauley's Beach and some 350 m downstream of the subject sites eastern boundary.

As recognised by SKM it is difficult to quantify effects of the inland shift of the beach berm shift and the coastal lagoon. We have formulated a conservative approach to assess any effects on flood levels that the beach berm recession may have even though the berm would likely be scoured out during a flooding event. To assess the effects of an increase in beach berm height we have performed a sensitivity analysis on the effects of increasing the downstream base levels of Hewitts Creek.

It must be noted that the hydraulic models prepared for the Sandon Point Flood Study previously were not required to extend the entire way to the ocean. Our March 2008 report identifies the boundary conditions and invert levels of the furthermost downstream cross-section used in the HECRAS hydraulic model. The invert levels for the furthermost downstream cross-sections for Hewitts, Woodlands and Tramway Creeks respectively are RL +4.7 m AHD, +4.6 m AHD and +2.2 m AHD.

As part of work undertaken in response to Agency queries of flood levels affecting on the downstream properties of Hewitts Creek, we extended our Hewitts Creek hydraulic model in October 2008 downstream to approximately 160 m inland of McCauley's beach. The most downstream invert level in this model was RL +1.6 m AHD located some 150 m upstream of the existing beach berms.

Conservatively adding the suggested 0.9 m to sediment levels and matching the bed slope profile to extend to the raised (or filled in areas) in the model cross sections results in a very minor effect on upstream flood levels. This is illustrated in **Figure 6** below which shows the 100 year and PMF flood levels for upper bound climate change scenario with a high range sea level rise.

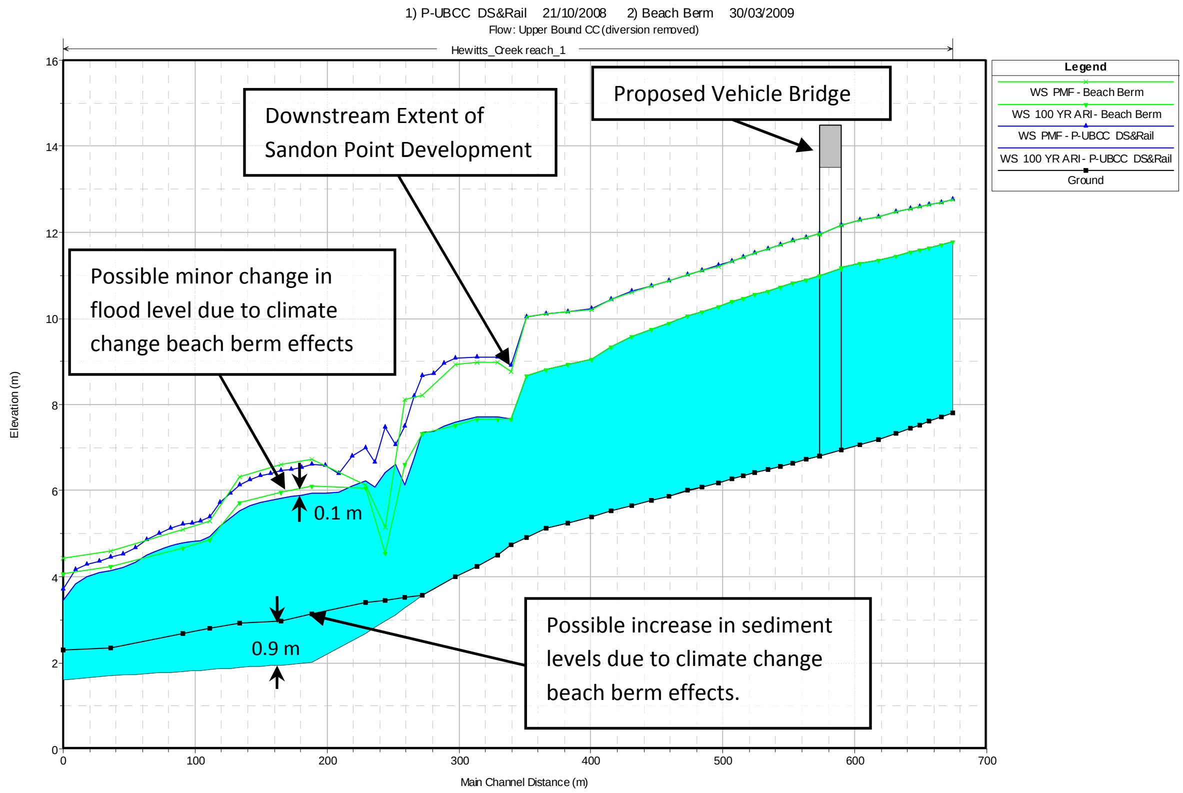


Figure 6 Conservative Climate Change Beach Berm Effects

The upper and the lower green lines denote the water surface levels at the peak of the PMF and 100 year ARI respectively for the possible upper bound climate change scenario with a raised beach berm. The upper and lower blue lines denote the water surface levels at the peak of the PMF and 100 year ARI respectively for the upper bound climate change scenario presented the March 2008 Flood Study .

Based on this conservative approach, there would be no impact on the Sandon Point development due to beach berm recession along Hewitts Creek.

Hewitts, Woodlands and Tramway Creeks have very similar morphology downstream of the railway line. Where Hewitts and Tramway Creeks discharge into the ocean across McCauley's beach, both creeks have similar existing berm profile and lagoon profiles (i.e. boundary conditions for flood modelling). It is also noted that during flooding events the two outlets discharge at analogous flow rates and offer a like cross sectional area. Further, in large flood events, any berm that did exist at either of the three creek outlets eroded well before the peak of the flood.

Therefore, we contend that any impact observed (or not) in Hewitts Creek would likely be observed (or not) in Woodlands and Tramway Creeks. As no impact from beach berm migration was observed in the modelling for Hewitts Creek, it is not likely that Woodlands and Tramway Creeks would be affected.

The Sandon point development has all floor levels for buildings located above RL +8.0 m AHD, and is well clear of any impacts associated with beach berm migration.

4 Conclusions

We conclude that:

- SKM issued their preliminary draft report on 9 December 2008, containing a suite of recommendations to the Department of Planning outlining where SKM believed further work was required. The issues related to stream stability, flooding and climate change.

- A meeting was held on 27th February 2009 at the Department of Planning, attended by representatives from the Department of Planning, Stockland, Don Fox Planning, Cardno Forbes Rigby and SKM. The purpose of this meeting was to discuss in more detail the issues SKM required addressing prior to the development approval being granted, and to attempt to settle any resolvable issues during the meeting.

- CFR tabled two different plans (see **Appendix C** of this report) showing historic geomorphic data through the site, which were at odds with SKM's position that channel failures were imminent.

- SKM issued their final Peer Review Report on 6th March which included specific 'recommended actions' to be undertaken. SKM further issued a letter dated 12 March 2009 outlining their further requirements and modified 'list of issues' after having the benefit of the site inspection.

- A joint site inspection was undertaken on 9 March 2009 attended by Anthony Barthelmess (CFR), Lih Chong (SKM) and Peter Sandercock (SKM). The historical geomorphic data extracted from the previous Hewitts Creek studies was discussed with SKM showing how the site, and the catchment, had responded geomorphically to various historic flood events.

- All 'recommended actions' arising from SKM's Peer Review report dated 6 March 2009 have been addressed by this addendum;

- All 'other issues' arising from SKM's letter dated 12 March 2009 have been addressed by this addendum;

- All matters relating to climate change have been addressed the CFR Climate Change Assessment report (March 2008) and this Addendum.

- All matters relating to flooding have been addressed the CFR Climate Change Assessment report (March 2008) and this Addendum.

- All matters relating to stream stability have been addressed the CFR Climate Change Assessment report (March 2008) and this Addendum.

- The use of alternative bridge modelling techniques does not adversely affect flood levels. The minor increase in flood levels during the 100 year ARI is a maximum of 0.11 m and is within the 0.5 m of freeboard incorporated into the development (above the 100 year ARI flood level) to cater for modelling uncertainties.

- Floor levels for all proposed dwellings should therefore be based on flood levels presented in the March 2008 Sandon Point Flood Study.

- The Sandon point development has all floor levels for buildings located above RL +8.0 m AHD, and is well clear of any impacts associated with beach berm migration.

References

USACE, US Army Corps of Engineers (2004), HEC-RAS River Analysis System: Hydraulic Reference Manual, Version 4.0, March 2008, Hydraulic Engineering Center, CPD-69

Annex A

A. Hydraulic Model Results

Summary Output Tables for Alternate Bridge Modelling Approaches

Hewitts Creek

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Railway to Hanna	416.951	100 YR ARI	Energy	150.68	7.80	12.59	10.91	12.78	0.008302	2.04	85.31	35.05	0.35
Railway to Hanna	416.951	100 YR ARI	Momentum LF	150.68	7.80	12.64	10.91	12.83	0.007838	2.00	87.24	35.45	0.34
Railway to Hanna	416.951	100 YR ARI	Weir & Pres HF	150.68	7.80	12.59	10.91	12.78	0.008302	2.04	85.31	35.05	0.35
Railway to Hanna	416.951	PMF	Energy	305.80	7.80	14.18	12.03	14.48	0.008207	2.60	150.40	46.74	0.37
Railway to Hanna	416.951	PMF	Momentum LF	305.80	7.80	14.18	12.03	14.48	0.008207	2.60	150.40	46.74	0.37
Railway to Hanna	416.951	PMF	Weir & Pres HF	305.80	7.80	14.23	12.03	14.52	0.007880	2.57	152.90	47.13	0.36
Railway to Hanna	408.012	100 YR ARI	Energy	150.68	7.71	12.52		12.71	0.007696	1.97	88.21	36.13	0.34
Railway to Hanna	408.012	100 YR ARI	Momentum LF	150.68	7.71	12.58		12.76	0.007237	1.93	90.35	36.58	0.33
Railway to Hanna	408.012	100 YR ARI	Weir & Pres HF	150.68	7.71	12.52		12.71	0.007696	1.97	88.21	36.13	0.34
Railway to Hanna	408.012	PMF	Energy	305.80	7.71	14.12		14.40	0.007604	2.51	155.52	48.10	0.35
Railway to Hanna	408.012	PMF	Momentum LF	305.80	7.71	14.12		14.40	0.007604	2.51	155.52	48.10	0.35
Railway to Hanna	408.012	PMF	Weir & Pres HF	305.80	7.71	14.18		14.45	0.007286	2.48	158.22	48.52	0.35
Railway to Hanna	399.203	100 YR ARI	Energy	150.68	7.61	12.48		12.64	0.006616	1.85	94.23	37.86	0.31
Railway to Hanna	399.203	100 YR ARI	Momentum LF	150.68	7.61	12.54		12.69	0.006207	1.82	96.60	38.33	0.30
Railway to Hanna	399.203	100 YR ARI	Weir & Pres HF	150.68	7.61	12.48		12.64	0.006616	1.85	94.23	37.86	0.31
Railway to Hanna	399.203	PMF	Energy	305.80	7.61	14.08		14.33	0.006636	2.38	164.97	49.66	0.33
Railway to Hanna	399.203	PMF	Momentum LF	305.80	7.61	14.08		14.33	0.006636	2.38	164.97	49.66	0.33
Railway to Hanna	399.203	PMF	Weir & Pres HF	305.80	7.61	14.14		14.38	0.006349	2.34	167.87	49.99	0.33
Railway to Hanna	391.774	100 YR ARI	Energy	150.68	7.53	12.43		12.59	0.006431	1.82	97.12	41.41	0.31
Railway to Hanna	391.774	100 YR ARI	Momentum LF	150.68	7.53	12.50		12.65	0.005996	1.78	99.86	41.79	0.30
Railway to Hanna	391.774	100 YR ARI	Weir & Pres HF	150.68	7.53	12.43		12.59	0.006431	1.82	97.12	41.41	0.31
Railway to Hanna	391.774	PMF	Energy	305.80	7.53	14.05		14.28	0.006112	2.28	172.98	50.46	0.32
Railway to Hanna	391.774	PMF	Momentum LF	305.80	7.53	14.05		14.28	0.006112	2.28	172.98	50.46	0.32
Railway to Hanna	391.774	PMF	Weir & Pres HF	305.80	7.53	14.11		14.33	0.005837	2.24	176.01	50.61	0.31
Railway to Hanna	384.639	100 YR ARI	Energy	150.68	7.45	12.39		12.54	0.006114	1.77	101.20	44.66	0.30
Railway to Hanna	384.639	100 YR ARI	Momentum LF	150.68	7.45	12.46		12.60	0.005671	1.73	104.29	44.94	0.29
Railway to Hanna	384.639	100 YR ARI	Weir & Pres HF	150.68	7.45	12.39		12.54	0.006114	1.77	101.20	44.66	0.30
Railway to Hanna	384.639	PMF	Energy	305.80	7.45	14.02		14.23	0.005717	2.20	179.48	51.69	0.31
Railway to Hanna	384.639	PMF	Momentum LF	305.80	7.45	14.02		14.23	0.005717	2.20	179.48	51.69	0.31
Railway to Hanna	384.639	PMF	Weir & Pres HF	305.80	7.45	14.08		14.28	0.005454	2.17	182.67	51.89	0.30
Railway to Hanna	373.531	100 YR ARI	Energy	150.68	7.33	12.33		12.47	0.005626	1.71	104.27	45.28	0.29
Railway to Hanna	373.531	100 YR ARI	Momentum LF	150.68	7.33	12.41		12.54	0.005202	1.67	107.62	45.78	0.28
Railway to Hanna	373.531	100 YR ARI	Weir & Pres HF	150.68	7.33	12.33		12.47	0.005626	1.71	104.27	45.28	0.29
Railway to Hanna	373.531	PMF	Energy	305.80	7.33	13.97		14.16	0.005295	2.13	186.75	54.75	0.30
Railway to Hanna	373.531	PMF	Momentum LF	305.80	7.33	13.97		14.16	0.005295	2.13	186.75	54.75	0.30
Railway to Hanna	373.531	PMF	Weir & Pres HF	305.80	7.33	14.03		14.22	0.005040	2.10	190.29	54.94	0.29
Railway to Hanna	360.818	100 YR ARI	Energy	150.68	7.19	12.25		12.40	0.006101	1.76	97.34	39.68	0.30
Railway to Hanna	360.818	100 YR ARI	Momentum LF	150.68	7.19	12.33		12.47	0.005621	1.72	100.55	40.58	0.29

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Railway to Hanna	360.818	100 YR ARI	Weir & Pres HF	150.68	7.19	12.25		12.40	0.006101	1.76	97.34	39.68	0.30
Railway to Hanna	360.818	PMF	Energy	305.80	7.19	13.86		14.09	0.005999	2.25	172.08	50.90	0.32
Railway to Hanna	360.818	PMF	Momentum LF	305.80	7.19	13.86		14.09	0.005999	2.25	172.08	50.90	0.32
Railway to Hanna	360.818	PMF	Weir & Pres HF	305.80	7.19	13.93		14.15	0.005685	2.21	175.65	51.01	0.31
Railway to Hanna	346.505	100 YR ARI	Energy	150.68	7.06	12.18		12.31	0.005022	1.68	105.40	40.65	0.28
Railway to Hanna	346.505	100 YR ARI	Momentum LF	150.68	7.06	12.27		12.39	0.004623	1.64	108.92	41.55	0.27
Railway to Hanna	346.505	100 YR ARI	Weir & Pres HF	150.68	7.06	12.18		12.31	0.005022	1.68	105.40	40.65	0.28
Railway to Hanna	346.505	PMF	Energy	305.80	7.06	13.80		14.00	0.005303	2.19	180.26	49.86	0.30
Railway to Hanna	346.505	PMF	Momentum LF	305.80	7.06	13.80		14.00	0.005303	2.19	180.26	49.86	0.30
Railway to Hanna	346.505	PMF	Weir & Pres HF	305.80	7.06	13.87		14.07	0.005022	2.15	183.93	49.86	0.29
Railway to Hanna	332.230	100 YR ARI	Energy	150.68	8.69	12.01	10.63	12.21	0.009533	2.07	86.38	38.66	0.37
Railway to Hanna	332.230	100 YR ARI	Momentum LF	150.68	8.69	12.12	10.63	12.30	0.008446	1.99	90.45	39.45	0.35
Railway to Hanna	332.230	100 YR ARI	Weir & Pres HF	150.68	8.69	12.01	10.63	12.21	0.009533	2.07	86.38	38.66	0.37
Railway to Hanna	332.230	PMF	Energy	305.80	8.69	13.65	11.64	13.91	0.007804	2.47	161.39	49.52	0.36
Railway to Hanna	332.230	PMF	Momentum LF	305.80	8.69	13.65	11.64	13.91	0.007804	2.47	161.39	49.52	0.36
Railway to Hanna	332.230	PMF	Weir & Pres HF	305.80	8.69	13.73	11.64	13.98	0.007273	2.42	165.58	49.52	0.35
Railway to Hanna	324			Bridge									
Railway to Hanna	315.928	100 YR ARI	Energy	150.68	8.62	11.70		11.93	0.012163	2.19	80.16	40.36	0.41
Railway to Hanna	315.928	100 YR ARI	Momentum LF	150.68	8.62	11.70		11.93	0.012163	2.19	80.16	40.36	0.41
Railway to Hanna	315.928	100 YR ARI	Weir & Pres HF	150.68	8.62	11.70		11.93	0.012163	2.19	80.16	40.36	0.41
Railway to Hanna	315.928	PMF	Energy	305.80	8.62	13.25		13.54	0.009459	2.58	150.93	49.27	0.39
Railway to Hanna	315.928	PMF	Momentum LF	305.80	8.62	13.25		13.54	0.009459	2.58	150.93	49.27	0.39
Railway to Hanna	315.928	PMF	Weir & Pres HF	305.80	8.62	13.25		13.54	0.009459	2.58	150.93	49.27	0.39
Railway to Hanna	305.563	100 YR ARI	Energy	150.68	6.72	11.65		11.81	0.006970	1.86	93.58	40.91	0.32
Railway to Hanna	305.563	100 YR ARI	Momentum LF	150.68	6.72	11.65		11.81	0.006970	1.86	93.58	40.91	0.32
Railway to Hanna	305.563	100 YR ARI	Weir & Pres HF	150.68	6.72	11.65		11.81	0.006970	1.86	93.58	40.91	0.32
Railway to Hanna	305.563	PMF	Energy	305.80	6.72	13.20		13.45	0.006879	2.37	164.20	48.99	0.34
Railway to Hanna	305.563	PMF	Momentum LF	305.80	6.72	13.20		13.45	0.006879	2.37	164.20	48.99	0.34
Railway to Hanna	305.563	PMF	Weir & Pres HF	305.80	6.72	13.20		13.45	0.006879	2.37	164.20	48.99	0.34
Railway to Hanna	295.821	100 YR ARI	Energy	150.68	6.64	11.58		11.75	0.007105	1.86	92.18	40.55	0.32
Railway to Hanna	295.821	100 YR ARI	Momentum LF	150.68	6.64	11.58		11.75	0.007105	1.86	92.18	40.55	0.32
Railway to Hanna	295.821	100 YR ARI	Weir & Pres HF	150.68	6.64	11.58		11.75	0.007105	1.86	92.18	40.55	0.32
Railway to Hanna	295.821	PMF	Energy	305.80	6.64	13.13		13.38	0.006965	2.36	162.09	48.45	0.34
Railway to Hanna	295.821	PMF	Momentum LF	305.80	6.64	13.13		13.38	0.006965	2.36	162.09	48.45	0.34
Railway to Hanna	295.821	PMF	Weir & Pres HF	305.80	6.64	13.13		13.38	0.006965	2.36	162.09	48.45	0.34
Railway to Hanna	286.355	100 YR ARI	Energy	150.68	6.57	11.49		11.67	0.007971	1.93	87.85	39.92	0.34
Railway to Hanna	286.355	100 YR ARI	Momentum LF	150.68	6.57	11.49		11.67	0.007971	1.93	87.85	39.92	0.34
Railway to Hanna	286.355	100 YR ARI	Weir & Pres HF	150.68	6.57	11.49		11.67	0.007971	1.93	87.85	39.92	0.34
Railway to Hanna	286.355	PMF	Energy	305.80	6.57	13.05		13.31	0.007579	2.42	156.89	48.29	0.35
Railway to Hanna	286.355	PMF	Momentum LF	305.80	6.57	13.05		13.31	0.007579	2.42	156.89	48.29	0.35
Railway to Hanna	286.355	PMF	Weir & Pres HF	305.80	6.57	13.05		13.31	0.007579	2.42	156.89	48.29	0.35
Railway to Hanna	276.823	100 YR ARI	Energy	150.68	6.49	11.40		11.59	0.008679	2.00	84.81	40.25	0.35
Railway to Hanna	276.823	100 YR ARI	Momentum LF	150.68	6.49	11.40		11.59	0.008679	2.00	84.81	40.25	0.35

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Railway to Hanna	276.823	100 YR ARI	Weir & Pres HF	150.68	6.49	11.40		11.59	0.008679	2.00	84.81	40.25	0.35
Railway to Hanna	276.823	PMF	Energy	305.80	6.49	12.96		13.24	0.007984	2.48	155.02	48.69	0.36
Railway to Hanna	276.823	PMF	Momentum LF	305.80	6.49	12.96		13.24	0.007984	2.48	155.02	48.69	0.36
Railway to Hanna	276.823	PMF	Weir & Pres HF	305.80	6.49	12.96		13.24	0.007984	2.48	155.02	48.69	0.36
Railway to Hanna	266.862	100 YR ARI	Energy	150.68	6.41	11.32		11.51	0.007796	1.95	88.04	41.25	0.34
Railway to Hanna	266.862	100 YR ARI	Momentum LF	150.68	6.41	11.32		11.51	0.007796	1.95	88.04	41.25	0.34
Railway to Hanna	266.862	100 YR ARI	Weir & Pres HF	150.68	6.41	11.32		11.51	0.007796	1.95	88.04	41.25	0.34
Railway to Hanna	266.862	PMF	Energy	305.80	6.41	12.89		13.16	0.007383	2.44	159.95	49.82	0.35
Railway to Hanna	266.862	PMF	Momentum LF	305.80	6.41	12.89		13.16	0.007383	2.44	159.95	49.82	0.35
Railway to Hanna	266.862	PMF	Weir & Pres HF	305.80	6.41	12.89		13.16	0.007383	2.44	159.95	49.82	0.35
Railway to Hanna	258.198	100 YR ARI	Energy	150.68	6.34	11.24		11.44	0.008162	1.99	85.41	39.80	0.34
Railway to Hanna	258.198	100 YR ARI	Momentum LF	150.68	6.34	11.24		11.44	0.008162	1.99	85.41	39.80	0.34
Railway to Hanna	258.198	100 YR ARI	Weir & Pres HF	150.68	6.34	11.24		11.44	0.008162	1.99	85.41	39.80	0.34
Railway to Hanna	258.198	PMF	Energy	305.80	6.34	12.81		13.09	0.007783	2.50	156.46	50.04	0.36
Railway to Hanna	258.198	PMF	Momentum LF	305.80	6.34	12.81		13.09	0.007783	2.50	156.46	50.04	0.36
Railway to Hanna	258.198	PMF	Weir & Pres HF	305.80	6.34	12.81		13.09	0.007783	2.50	156.46	50.04	0.36
Railway to Hanna	249.723	100 YR ARI	Energy	150.68	6.27	11.16		11.37	0.008661	2.02	82.04	37.17	0.35
Railway to Hanna	249.723	100 YR ARI	Momentum LF	150.68	6.27	11.16		11.37	0.008661	2.02	82.04	37.17	0.35
Railway to Hanna	249.723	100 YR ARI	Weir & Pres HF	150.68	6.27	11.16		11.37	0.008661	2.02	82.04	37.17	0.35
Railway to Hanna	249.723	PMF	Energy	305.80	6.27	12.71		13.02	0.008448	2.57	148.40	48.50	0.37
Railway to Hanna	249.723	PMF	Momentum LF	305.80	6.27	12.71		13.02	0.008448	2.57	148.40	48.50	0.37
Railway to Hanna	249.723	PMF	Weir & Pres HF	305.80	6.27	12.71		13.02	0.008448	2.57	148.40	48.50	0.37
Railway to Hanna	239.532	100 YR ARI	Energy	150.68	6.19	11.07		11.27	0.009291	1.99	79.25	32.16	0.36
Railway to Hanna	239.532	100 YR ARI	Momentum LF	150.68	6.19	11.07		11.27	0.009291	1.99	79.25	32.16	0.36
Railway to Hanna	239.532	100 YR ARI	Weir & Pres HF	150.68	6.19	11.07		11.27	0.009291	1.99	79.25	32.16	0.36
Railway to Hanna	239.532	PMF	Energy	305.80	6.19	12.63		12.93	0.008699	2.52	144.52	48.03	0.37
Railway to Hanna	239.532	PMF	Momentum LF	305.80	6.19	12.63		12.93	0.008699	2.52	144.52	48.03	0.37
Railway to Hanna	239.532	PMF	Weir & Pres HF	305.80	6.19	12.63		12.93	0.008699	2.52	144.52	48.03	0.37
Railway to Hanna	226.906	100 YR ARI	Energy	150.68	6.08	10.99		11.16	0.007550	1.83	88.41	38.48	0.33
Railway to Hanna	226.906	100 YR ARI	Momentum LF	150.68	6.08	10.99		11.16	0.007550	1.83	88.41	38.48	0.33
Railway to Hanna	226.906	100 YR ARI	Weir & Pres HF	150.68	6.08	10.99		11.16	0.007550	1.83	88.41	38.48	0.33
Railway to Hanna	226.906	PMF	Energy	305.80	6.08	12.56		12.81	0.007106	2.32	157.28	48.73	0.34
Railway to Hanna	226.906	PMF	Momentum LF	305.80	6.08	12.56		12.81	0.007106	2.32	157.28	48.73	0.34
Railway to Hanna	226.906	PMF	Weir & Pres HF	305.80	6.08	12.56		12.81	0.007106	2.32	157.28	48.73	0.34
Railway to Hanna	215.941	100 YR ARI	Energy	150.68	6.00	10.91		11.07	0.007446	1.81	89.47	38.88	0.32
Railway to Hanna	215.941	100 YR ARI	Momentum LF	150.68	6.00	10.91		11.07	0.007446	1.81	89.47	38.88	0.32
Railway to Hanna	215.941	100 YR ARI	Weir & Pres HF	150.68	6.00	10.91		11.07	0.007446	1.81	89.47	38.88	0.32
Railway to Hanna	215.941	PMF	Energy	305.80	6.00	12.49		12.73	0.006885	2.27	159.97	50.03	0.33
Railway to Hanna	215.941	PMF	Momentum LF	305.80	6.00	12.49		12.73	0.006885	2.27	159.97	50.03	0.33
Railway to Hanna	215.941	PMF	Weir & Pres HF	305.80	6.00	12.49		12.73	0.006885	2.27	159.97	50.03	0.33
Railway to Hanna	201.805	100 YR ARI	Energy	150.68	5.88	10.80		10.97	0.007936	1.81	87.59	38.15	0.33
Railway to Hanna	201.805	100 YR ARI	Momentum LF	150.68	5.88	10.80		10.97	0.007936	1.81	87.59	38.15	0.33
Railway to Hanna	201.805	100 YR ARI	Weir & Pres HF	150.68	5.88	10.80		10.97	0.007936	1.81	87.59	38.15	0.33
Railway to	201.805	PMF	Energy	305.80	5.88	12.39		12.64	0.007079	2.27	158.03	50.35	0.34

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Hanna													
Railway to Hanna	201.805	PMF	Momentum LF	305.80	5.88	12.39		12.64	0.007079	2.27	158.03	50.35	0.34
Railway to Hanna	201.805	PMF	Weir & Pres HF	305.80	5.88	12.39		12.64	0.007079	2.27	158.03	50.35	0.34
Railway to Hanna	188.580	100 YR ARI	Energy	150.68	5.77	10.71		10.86	0.007221	1.76	90.73	39.28	0.32
Railway to Hanna	188.580	100 YR ARI	Momentum LF	150.68	5.77	10.71		10.86	0.007221	1.76	90.73	39.28	0.32
Railway to Hanna	188.580	100 YR ARI	Weir & Pres HF	150.68	5.77	10.71		10.86	0.007221	1.76	90.73	39.28	0.32
Railway to Hanna	188.580	PMF	Energy	305.80	5.77	12.31		12.54	0.006529	2.20	163.24	51.33	0.32
Railway to Hanna	188.580	PMF	Momentum LF	305.80	5.77	12.31		12.54	0.006529	2.20	163.24	51.33	0.32
Railway to Hanna	188.580	PMF	Weir & Pres HF	305.80	5.77	12.31		12.54	0.006529	2.20	163.24	51.33	0.32
Railway to Hanna	173.814	100 YR ARI	Energy	150.68	5.65	10.61		10.76	0.006629	1.69	94.17	40.37	0.31
Railway to Hanna	173.814	100 YR ARI	Momentum LF	150.68	5.65	10.61		10.76	0.006629	1.69	94.17	40.37	0.31
Railway to Hanna	173.814	100 YR ARI	Weir & Pres HF	150.68	5.65	10.61		10.76	0.006629	1.69	94.17	40.37	0.31
Railway to Hanna	173.814	PMF	Energy	305.80	5.65	12.23		12.45	0.005987	2.12	167.77	50.46	0.31
Railway to Hanna	173.814	PMF	Momentum LF	305.80	5.65	12.23		12.45	0.005987	2.12	167.77	50.46	0.31
Railway to Hanna	173.814	PMF	Weir & Pres HF	305.80	5.65	12.23		12.45	0.005987	2.12	167.77	50.46	0.31
Railway to Hanna	158.201	100 YR ARI	Energy	150.68	5.53	10.49		10.65	0.006983	1.77	90.77	37.71	0.31
Railway to Hanna	158.201	100 YR ARI	Momentum LF	150.68	5.53	10.49		10.65	0.006983	1.77	90.77	37.71	0.31
Railway to Hanna	158.201	100 YR ARI	Weir & Pres HF	150.68	5.53	10.49		10.65	0.006983	1.77	90.77	37.71	0.31
Railway to Hanna	158.201	PMF	Energy	305.80	5.53	12.11		12.35	0.006492	2.24	161.57	49.68	0.33
Railway to Hanna	158.201	PMF	Momentum LF	305.80	5.53	12.11		12.35	0.006492	2.24	161.57	49.68	0.33
Railway to Hanna	158.201	PMF	Weir & Pres HF	305.80	5.53	12.11		12.35	0.006492	2.24	161.57	49.68	0.33
Railway to Hanna	142.886	100 YR ARI	Energy	151.23	5.40	10.38		10.54	0.007290	1.81	89.48	38.54	0.32
Railway to Hanna	142.886	100 YR ARI	Momentum LF	151.23	5.40	10.38		10.54	0.007290	1.81	89.48	38.54	0.32
Railway to Hanna	142.886	100 YR ARI	Weir & Pres HF	151.23	5.40	10.38		10.54	0.007290	1.81	89.48	38.54	0.32
Railway to Hanna	142.886	PMF	Energy	314.31	5.40	11.98		12.24	0.007094	2.34	160.24	49.65	0.34
Railway to Hanna	142.886	PMF	Momentum LF	314.31	5.40	11.98		12.24	0.007094	2.34	160.24	49.65	0.34
Railway to Hanna	142.886	PMF	Weir & Pres HF	314.31	5.40	11.98		12.24	0.007094	2.34	160.24	49.65	0.34
Railway to Hanna	124.955	100 YR ARI	Energy	151.23	5.25	10.27		10.41	0.006405	1.71	95.03	40.94	0.30
Railway to Hanna	124.955	100 YR ARI	Momentum LF	151.23	5.25	10.27		10.41	0.006405	1.71	95.03	40.94	0.30
Railway to Hanna	124.955	100 YR ARI	Weir & Pres HF	151.23	5.25	10.27		10.41	0.006405	1.71	95.03	40.94	0.30
Railway to Hanna	124.955	PMF	Energy	314.31	5.25	11.89		12.11	0.006176	2.19	169.97	50.39	0.32
Railway to Hanna	124.955	PMF	Momentum LF	314.31	5.25	11.89		12.11	0.006176	2.19	169.97	50.39	0.32
Railway to Hanna	124.955	PMF	Weir & Pres HF	314.31	5.25	11.89		12.11	0.006176	2.19	169.97	50.39	0.32
Railway to Hanna	108.623	100 YR ARI	Energy	151.23	5.12	10.17		10.31	0.006248	1.65	95.50	38.41	0.30
Railway to Hanna	108.623	100 YR ARI	Momentum LF	151.23	5.12	10.17		10.31	0.006248	1.65	95.50	38.41	0.30
Railway to Hanna	108.623	100 YR ARI	Weir & Pres HF	151.23	5.12	10.17		10.31	0.006248	1.65	95.50	38.41	0.30
Railway to Hanna	108.623	PMF	Energy	314.31	5.12	11.80		12.01	0.005771	2.10	179.22	56.58	0.31
Railway to Hanna	108.623	PMF	Momentum LF	314.31	5.12	11.80		12.01	0.005771	2.10	179.22	56.58	0.31
Railway to Hanna	108.623	PMF	Weir & Pres HF	314.31	5.12	11.80		12.01	0.005771	2.10	179.22	56.58	0.31
Railway to Hanna	93.831	100 YR ARI	Energy	151.23	5.00	10.08		10.21	0.006215	1.61	97.16	37.76	0.29
Railway to Hanna	93.831	100 YR ARI	Momentum LF	151.23	5.00	10.08		10.21	0.006215	1.61	97.16	37.76	0.29
Railway to Hanna	93.831	100 YR ARI	Weir & Pres HF	151.23	5.00	10.08		10.21	0.006215	1.61	97.16	37.76	0.29
Railway to Hanna	93.831	PMF	Energy	314.31	5.00	11.72		11.92	0.005779	2.07	173.32	51.20	0.31
Railway to Hanna	93.831	PMF	Momentum LF	314.31	5.00	11.72		11.92	0.005779	2.07	173.32	51.20	0.31

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Railway to Hanna	93.831	PMF	Weir & Pres HF	314.31	5.00	11.72		11.92	0.005779	2.07	173.32	51.20	0.31
Railway to Hanna	82.077	100 YR ARI	Energy	151.23	4.91	10.02		10.14	0.005481	1.52	103.29	39.50	0.28
Railway to Hanna	82.077	100 YR ARI	Momentum LF	151.23	4.91	10.02		10.14	0.005481	1.52	103.29	39.50	0.28
Railway to Hanna	82.077	100 YR ARI	Weir & Pres HF	151.23	4.91	10.02		10.14	0.005481	1.52	103.29	39.50	0.28
Railway to Hanna	82.077	PMF	Energy	314.31	4.91	11.67		11.85	0.005130	1.96	183.34	54.10	0.29
Railway to Hanna	82.077	PMF	Momentum LF	314.31	4.91	11.67		11.85	0.005130	1.96	183.34	54.10	0.29
Railway to Hanna	82.077	PMF	Weir & Pres HF	314.31	4.91	11.67		11.85	0.005130	1.96	183.34	54.10	0.29
Railway to Hanna	71.666	100 YR ARI	Energy	151.23	4.82	9.95		10.08	0.006278	1.58	99.45	37.30	0.29
Railway to Hanna	71.666	100 YR ARI	Momentum LF	151.23	4.82	9.95		10.08	0.006278	1.58	99.45	37.30	0.29
Railway to Hanna	71.666	100 YR ARI	Weir & Pres HF	151.23	4.82	9.95		10.08	0.006278	1.58	99.45	37.30	0.29
Railway to Hanna	71.666	PMF	Energy	314.31	4.82	11.60		11.79	0.005711	2.03	174.88	50.88	0.30
Railway to Hanna	71.666	PMF	Momentum LF	314.31	4.82	11.60		11.79	0.005711	2.03	174.88	50.88	0.30
Railway to Hanna	71.666	PMF	Weir & Pres HF	314.31	4.82	11.60		11.79	0.005711	2.03	174.88	50.88	0.30
Railway to Hanna	55.953	100 YR ARI	Energy	151.23	4.69	9.88		9.98	0.005031	1.47	111.37	41.67	0.27
Railway to Hanna	55.953	100 YR ARI	Momentum LF	151.23	4.69	9.88		9.98	0.005031	1.47	111.37	41.67	0.27
Railway to Hanna	55.953	100 YR ARI	Weir & Pres HF	151.23	4.69	9.88		9.98	0.005031	1.47	111.37	41.67	0.27
Railway to Hanna	55.953	PMF	Energy	314.31	4.69	11.53		11.71	0.004889	1.93	186.46	49.29	0.28
Railway to Hanna	55.953	PMF	Momentum LF	314.31	4.69	11.53		11.71	0.004889	1.93	186.46	49.29	0.28
Railway to Hanna	55.953	PMF	Weir & Pres HF	314.31	4.69	11.53		11.71	0.004889	1.93	186.46	49.29	0.28
Railway to Hanna	39.873	100 YR ARI	Energy	151.23	4.56	9.80	7.69	9.90	0.005001	1.46	110.77	38.97	0.27
Railway to Hanna	39.873	100 YR ARI	Momentum LF	151.23	4.56	9.80	7.69	9.90	0.005001	1.46	110.77	38.97	0.27
Railway to Hanna	39.873	100 YR ARI	Weir & Pres HF	151.23	4.56	9.80	7.69	9.90	0.005001	1.46	110.77	38.97	0.27
Railway to Hanna	39.873	PMF	Energy	314.31	4.56	11.44	8.73	11.62	0.005002	1.95	180.94	46.34	0.29
Railway to Hanna	39.873	PMF	Momentum LF	314.31	4.56	11.44	8.73	11.62	0.005002	1.95	180.94	46.34	0.29
Railway to Hanna	39.873	PMF	Weir & Pres HF	314.31	4.56	11.44	8.73	11.62	0.005002	1.95	180.94	46.34	0.29

Woodlands Creek

	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Railway to Hanna	561.631	100 YR ARI	Energy	67.30	10.96	14.13	13.15	14.25	0.010389	2.03	58.46	38.41	0.38
Railway to Hanna	561.631	100 YR ARI	Momentum LF	67.30	10.96	14.13	13.15	14.25	0.010389	2.03	58.46	38.41	0.38
Railway to Hanna	561.631	100 YR ARI	Weir Pres HF	67.30	10.96	14.13	13.15	14.25	0.010389	2.03	58.46	38.41	0.38
Railway to Hanna	561.631	PMF	Energy	140.30	10.96	15.27	13.91	15.42	0.009061	2.36	109.08	48.94	0.37
Railway to Hanna	561.631	PMF	Momentum LF	140.30	10.96	15.22	13.91	15.37	0.009659	2.41	106.46	48.48	0.38
Railway to Hanna	561.631	PMF	Weir Pres HF	140.30	10.96	15.25	13.91	15.40	0.009276	2.38	108.11	48.77	0.37
Railway to Hanna	543.366	100 YR ARI	Energy	67.30	10.80	13.96		14.07	0.009314	1.91	61.02	38.72	0.36
Railway to Hanna	543.366	100 YR ARI	Momentum LF	67.30	10.80	13.96		14.07	0.009313	1.91	61.03	38.72	0.36
Railway to Hanna	543.366	100 YR ARI	Weir Pres HF	67.30	10.80	13.96		14.07	0.009314	1.91	61.02	38.72	0.36
Railway to Hanna	543.366	PMF	Energy	140.30	10.80	15.13		15.25	0.008201	2.24	114.68	51.60	0.35
Railway to Hanna	543.366	PMF	Momentum LF	140.30	10.80	15.06		15.20	0.008886	2.30	111.26	51.06	0.37
Railway to Hanna	543.366	PMF	Weir Pres HF	140.30	10.80	15.10		15.23	0.008444	2.26	113.42	51.40	0.36
Railway to Hanna	524.548	100 YR ARI	Energy	67.30	10.64	13.82		13.90	0.007167	1.68	68.10	38.81	0.31
Railway to Hanna	524.548	100 YR ARI	Momentum LF	67.30	10.64	13.82		13.90	0.007166	1.68	68.10	38.81	0.31
Railway to Hanna	524.548	100 YR ARI	Weir Pres HF	67.30	10.64	13.82		13.90	0.007167	1.68	68.10	38.81	0.31
Railway to Hanna	524.548	PMF	Energy	140.30	10.64	15.00		15.11	0.007101	2.09	122.67	56.37	0.33
Railway to Hanna	524.548	PMF	Momentum LF	140.30	10.64	14.92		15.03	0.007852	2.17	118.24	53.61	0.34
Railway to Hanna	524.548	PMF	Weir Pres HF	140.30	10.64	14.97		15.08	0.007364	2.12	121.03	55.59	0.33
Railway to Hanna	500.802	100 YR ARI	Energy	67.30	10.43	13.68		13.75	0.005968	1.57	71.76	40.61	0.29
Railway to Hanna	500.802	100 YR ARI	Momentum LF	67.30	10.43	13.68		13.75	0.005967	1.57	71.76	40.61	0.29
Railway to Hanna	500.802	100 YR ARI	Weir Pres HF	67.30	10.43	13.68		13.75	0.005968	1.57	71.76	40.61	0.29
Railway to Hanna	500.802	PMF	Energy	140.30	10.43	14.85		14.95	0.006060	1.96	124.21	47.90	0.31
Railway to Hanna	500.802	PMF	Momentum LF	140.30	10.43	14.75		14.86	0.006760	2.04	119.58	47.65	0.32
Railway to Hanna	500.802	PMF	Weir Pres HF	140.30	10.43	14.82		14.92	0.006302	1.99	122.54	47.81	0.31
Railway to Hanna	478.813	100 YR ARI	Energy	67.30	10.23	13.50		13.60	0.008211	1.83	62.38	37.59	0.34
Railway to Hanna	478.813	100 YR ARI	Momentum LF	67.30	10.23	13.50		13.60	0.008210	1.83	62.38	37.59	0.34
Railway to Hanna	478.813	100 YR ARI	Weir Pres HF	67.30	10.23	13.50		13.60	0.008211	1.83	62.38	37.59	0.34
Railway to Hanna	478.813	PMF	Energy	140.30	10.23	14.68		14.80	0.007588	2.19	111.73	43.79	0.34
Railway to Hanna	478.813	PMF	Momentum LF	140.30	10.23	14.55		14.69	0.008746	2.30	106.35	43.56	0.36
Railway to Hanna	478.813	PMF	Weir Pres HF	140.30	10.23	14.63		14.76	0.007976	2.23	109.82	43.71	0.35
Railway to Hanna	460.169	100 YR ARI	Energy	67.30	10.07	13.35		13.45	0.007772	1.79	62.34	36.33	0.33
Railway to Hanna	460.169	100 YR ARI	Momentum LF	67.30	10.07	13.35		13.45	0.007771	1.79	62.35	36.33	0.33
Railway to Hanna	460.169	100 YR ARI	Weir Pres HF	67.30	10.07	13.35		13.45	0.007772	1.79	62.34	36.33	0.33
Railway to Hanna	460.169	PMF	Energy	140.30	10.07	14.53		14.66	0.007675	2.22	111.86	45.87	0.34
Railway to Hanna	460.169	PMF	Momentum LF	140.30	10.07	14.37		14.53	0.009249	2.37	104.75	45.58	0.37
Railway to Hanna	460.169	PMF	Weir Pres HF	140.30	10.07	14.47		14.61	0.008182	2.27	109.37	45.77	0.35
Railway to Hanna	442.699	100 YR ARI	Energy	67.30	9.92	13.23		13.32	0.007336	1.75	64.01	35.10	0.32
Railway to Hanna	442.699	100 YR ARI	Momentum LF	67.30	9.92	13.23		13.32	0.007335	1.75	64.01	35.10	0.32
Railway to Hanna	442.699	100 YR ARI	Weir Pres HF	67.30	9.92	13.23		13.32	0.007336	1.75	64.01	35.10	0.32
Railway to Hanna	442.699	PMF	Energy	140.30	9.92	14.40		14.53	0.007615	2.21	113.25	46.76	0.34
Railway to Hanna	442.699	PMF	Momentum LF	140.30	9.92	14.21		14.37	0.009603	2.41	104.36	46.40	0.38
Railway to	442.699	PMF	Weir Pres	140.30	9.92	14.34		14.47	0.008238	2.28	110.21	46.75	0.35

	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Hanna			HF										
Railway to Hanna	426.223	100 YR ARI	Energy	67.30	10.85	13.04	12.07	13.15	0.014043	2.00	53.95	33.84	0.43
Railway to Hanna	426.223	100 YR ARI	Momentum LF	67.30	10.85	13.04	12.07	13.15	0.014039	2.00	53.96	33.84	0.43
Railway to Hanna	426.223	100 YR ARI	Weir Pres HF	67.30	10.85	13.04	12.07	13.15	0.014043	2.00	53.95	33.84	0.43
Railway to Hanna	426.223	PMF	Energy	140.30	10.85	14.23	12.74	14.37	0.011395	2.40	102.09	46.01	0.42
Railway to Hanna	426.223	PMF	Momentum LF	140.30	10.85	13.97	12.74	14.16	0.015940	2.70	90.46	44.50	0.49
Railway to Hanna	426.223	PMF	Weir Pres HF	140.30	10.85	14.14	12.74	14.30	0.012827	2.51	98.14	45.95	0.44
Railway to Hanna	418			Bridge									
Railway to Hanna	411.793	100 YR ARI	Energy	67.30	10.85	12.53		12.75	0.036626	2.71	37.49	28.35	0.67
Railway to Hanna	411.793	100 YR ARI	Momentum LF	67.30	10.85	12.53		12.75	0.036585	2.71	37.50	28.35	0.67
Railway to Hanna	411.793	100 YR ARI	Weir Pres HF	67.30	10.85	12.53		12.75	0.036626	2.71	37.49	28.35	0.67
Railway to Hanna	411.793	PMF	Energy	140.30	10.85	13.44		13.76	0.031686	3.36	66.15	36.78	0.67
Railway to Hanna	411.793	PMF	Momentum LF	140.30	10.85	13.44		13.76	0.031598	3.36	66.22	36.81	0.67
Railway to Hanna	411.793	PMF	Weir Pres HF	140.30	10.85	13.44		13.76	0.031686	3.36	66.15	36.78	0.67
Railway to Hanna	392.751	100 YR ARI	Energy	67.30	9.48	12.20		12.34	0.013680	2.09	51.47	32.30	0.42
Railway to Hanna	392.751	100 YR ARI	Momentum LF	67.30	9.48	12.20		12.34	0.013652	2.08	51.51	32.30	0.42
Railway to Hanna	392.751	100 YR ARI	Weir Pres HF	67.30	9.48	12.20		12.34	0.013680	2.09	51.47	32.30	0.42
Railway to Hanna	392.751	PMF	Energy	140.30	9.48	13.11		13.32	0.016062	2.77	83.11	37.87	0.48
Railway to Hanna	392.751	PMF	Momentum LF	140.30	9.48	13.11		13.33	0.015995	2.77	83.24	37.89	0.48
Railway to Hanna	392.751	PMF	Weir Pres HF	140.30	9.48	13.11		13.32	0.016062	2.77	83.11	37.87	0.48
Railway to Hanna	374.319	100 YR ARI	Energy	67.30	9.32	11.97		12.09	0.013520	2.02	55.43	37.46	0.41
Railway to Hanna	374.319	100 YR ARI	Momentum LF	67.30	9.32	11.97		12.09	0.013471	2.02	55.50	37.48	0.41
Railway to Hanna	374.319	100 YR ARI	Weir Pres HF	67.30	9.32	11.97		12.09	0.013520	2.02	55.43	37.46	0.41
Railway to Hanna	374.319	PMF	Energy	140.30	9.32	12.86		13.03	0.014777	2.60	92.12	44.94	0.46
Railway to Hanna	374.319	PMF	Momentum LF	140.30	9.32	12.86		13.04	0.014677	2.59	92.35	45.06	0.45
Railway to Hanna	374.319	PMF	Weir Pres HF	140.30	9.32	12.86		13.03	0.014777	2.60	92.12	44.94	0.46
Railway to Hanna	354.291	100 YR ARI	Energy	67.30	9.14	11.75		11.84	0.011453	1.84	62.88	44.59	0.38
Railway to Hanna	354.291	100 YR ARI	Momentum LF	67.30	9.14	11.75		11.84	0.011383	1.84	63.02	44.63	0.38
Railway to Hanna	354.291	100 YR ARI	Weir Pres HF	67.30	9.14	11.75		11.84	0.011453	1.84	62.88	44.59	0.38
Railway to Hanna	354.291	PMF	Energy	140.30	9.14	12.63		12.76	0.012037	2.33	107.65	60.18	0.41
Railway to Hanna	354.291	PMF	Momentum LF	140.30	9.14	12.64		12.77	0.011915	2.32	108.09	60.34	0.41
Railway to Hanna	354.291	PMF	Weir Pres HF	140.30	9.14	12.63		12.76	0.012037	2.33	107.65	60.18	0.41
Railway to Hanna	332.479	100 YR ARI	Energy	68.60	8.95	11.53		11.60	0.009442	1.67	70.18	49.02	0.35
Railway to Hanna	332.479	100 YR ARI	Momentum LF	68.60	8.95	11.54		11.61	0.009349	1.67	70.44	49.08	0.35
Railway to Hanna	332.479	100 YR ARI	Weir Pres HF	68.60	8.95	11.53		11.60	0.009442	1.67	70.18	49.02	0.35
Railway to Hanna	332.479	PMF	Energy	145.90	8.95	12.39		12.51	0.011060	2.22	117.67	62.05	0.40
Railway to Hanna	332.479	PMF	Momentum LF	145.90	8.95	12.40		12.52	0.010898	2.21	118.34	62.21	0.39
Railway to Hanna	332.479	PMF	Weir Pres HF	145.90	8.95	12.39		12.51	0.011060	2.22	117.67	62.05	0.40
Railway to Hanna	305.960	100 YR ARI	Energy	68.60	8.72	11.25		11.35	0.013023	1.93	64.61	52.54	0.40
Railway to Hanna	305.960	100 YR ARI	Momentum LF	68.60	8.72	11.26		11.36	0.012746	1.91	65.15	52.74	0.40
Railway to Hanna	305.960	100 YR ARI	Weir Pres HF	68.60	8.72	11.25		11.35	0.013023	1.93	64.61	52.54	0.40
Railway to Hanna	305.960	PMF	Energy	145.90	8.72	12.10		12.23	0.013019	2.38	116.38	68.93	0.43
Railway to Hanna	305.960	PMF	Momentum LF	145.90	8.72	12.12		12.25	0.012668	2.35	117.63	69.29	0.42
Railway to	305.960	PMF	Weir Pres	145.90	8.72	12.10		12.23	0.013019	2.38	116.38	68.93	0.43

	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Hanna			HF										
Railway to Hanna	278.429	100 YR ARI	Energy	68.60	8.48	11.01		11.08	0.008013	1.53	77.60	59.44	0.32
Railway to Hanna	278.429	100 YR ARI	Momentum LF	68.60	8.48	11.03		11.09	0.007732	1.52	78.68	59.79	0.32
Railway to Hanna	278.429	100 YR ARI	Weir Pres HF	68.60	8.48	11.01		11.08	0.008013	1.53	77.60	59.44	0.32
Railway to Hanna	278.429	PMF	Energy	145.90	8.48	11.85		11.95	0.008666	1.96	134.77	75.79	0.35
Railway to Hanna	278.429	PMF	Momentum LF	145.90	8.48	11.88		11.97	0.008325	1.94	136.86	76.31	0.35
Railway to Hanna	278.429	PMF	Weir Pres HF	145.90	8.48	11.85		11.95	0.008666	1.96	134.77	75.79	0.35
Railway to Hanna	247.890	100 YR ARI	Energy	68.60	8.21	10.72		10.81	0.012432	1.87	67.43	55.21	0.40
Railway to Hanna	247.890	100 YR ARI	Momentum LF	68.60	8.21	10.76		10.84	0.011509	1.82	69.45	55.88	0.38
Railway to Hanna	247.890	100 YR ARI	Weir Pres HF	68.60	8.21	10.72		10.81	0.012432	1.87	67.43	55.21	0.40
Railway to Hanna	247.890	PMF	Energy	145.90	8.21	11.56		11.68	0.012376	2.30	120.54	74.95	0.42
Railway to Hanna	247.890	PMF	Momentum LF	145.90	8.21	11.61		11.72	0.011545	2.25	123.96	76.14	0.40
Railway to Hanna	247.890	PMF	Weir Pres HF	145.90	8.21	11.56		11.68	0.012376	2.30	120.54	74.95	0.42
Railway to Hanna	219.249	100 YR ARI	Energy	68.60	7.96	10.57		10.61	0.004239	1.16	93.76	58.77	0.24
Railway to Hanna	219.249	100 YR ARI	Momentum LF	68.60	7.96	10.62		10.66	0.003895	1.12	96.64	59.28	0.23
Railway to Hanna	219.249	100 YR ARI	Weir Pres HF	68.60	7.96	10.57		10.61	0.004239	1.16	93.76	58.77	0.24
Railway to Hanna	219.249	PMF	Energy	145.90	7.96	11.37		11.45	0.005860	1.65	144.04	67.83	0.29
Railway to Hanna	219.249	PMF	Momentum LF	145.90	7.96	11.43		11.50	0.005440	1.60	148.07	68.60	0.28
Railway to Hanna	219.249	PMF	Weir Pres HF	145.90	7.96	11.37		11.45	0.005860	1.65	144.04	67.83	0.29
Railway to Hanna	180.729	100 YR ARI	Energy	68.60	7.62	10.42		10.47	0.005477	1.32	93.32	68.07	0.27
Railway to Hanna	180.729	100 YR ARI	Momentum LF	68.60	7.62	10.49		10.53	0.004837	1.27	97.83	69.35	0.25
Railway to Hanna	180.729	100 YR ARI	Weir Pres HF	68.60	7.62	10.42		10.47	0.005477	1.32	93.32	68.07	0.27
Railway to Hanna	180.729	PMF	Energy	145.90	7.62	11.18		11.26	0.007039	1.80	151.28	83.89	0.32
Railway to Hanna	180.729	PMF	Momentum LF	145.90	7.62	11.26		11.33	0.006231	1.72	157.95	84.76	0.30
Railway to Hanna	180.729	PMF	Weir Pres HF	145.90	7.62	11.18		11.26	0.007039	1.80	151.28	83.89	0.32
Railway to Hanna	163.215	100 YR ARI	Energy	68.60	8.41	10.20	9.50	10.29	0.017700	1.96	63.22	58.55	0.47
Railway to Hanna	163.215	100 YR ARI	Momentum LF	68.60	8.41	10.30	9.50	10.38	0.013910	1.80	69.53	61.72	0.42
Railway to Hanna	163.215	100 YR ARI	Weir Pres HF	68.60	8.41	10.20	9.50	10.29	0.017700	1.96	63.22	58.55	0.47
Railway to Hanna	163.215	PMF	Energy	145.90	8.41	10.92	10.04	11.05	0.017775	2.46	113.20	80.75	0.50
Railway to Hanna	163.215	PMF	Momentum LF	145.90	8.41	11.03	10.04	11.15	0.014815	2.32	122.96	83.84	0.46
Railway to Hanna	163.215	PMF	Weir Pres HF	145.90	8.41	10.92	10.04	11.05	0.017775	2.46	113.20	80.75	0.50
Railway to Hanna	158			Bridge									
Railway to Hanna	150.650	100 YR ARI	Energy	68.60	8.40	9.88		9.99	0.026176	2.10	56.05	55.73	0.55
Railway to Hanna	150.650	100 YR ARI	Momentum LF	68.60	8.40	9.88		9.99	0.026176	2.10	56.05	55.73	0.55
Railway to Hanna	150.650	100 YR ARI	Weir Pres HF	68.60	8.40	9.88		9.99	0.026176	2.10	56.05	55.73	0.55
Railway to Hanna	150.650	PMF	Energy	145.90	8.40	10.58		10.73	0.024727	2.64	101.19	75.35	0.57
Railway to Hanna	150.650	PMF	Momentum LF	145.90	8.40	10.58		10.73	0.024727	2.64	101.19	75.35	0.57
Railway to Hanna	150.650	PMF	Weir Pres HF	145.90	8.40	10.58		10.73	0.024727	2.64	101.19	75.35	0.57
Railway to Hanna	138.605	100 YR ARI	Energy	68.60	7.25	9.63		9.72	0.013809	1.89	67.71	58.49	0.41
Railway to Hanna	138.605	100 YR ARI	Momentum LF	68.60	7.25	9.63		9.72	0.013809	1.89	67.71	58.49	0.41
Railway to Hanna	138.605	100 YR ARI	Weir Pres HF	68.60	7.25	9.63		9.72	0.013809	1.89	67.71	58.49	0.41
Railway to Hanna	138.605	PMF	Energy	145.90	7.25	10.30		10.43	0.016779	2.49	110.41	70.38	0.47
Railway to Hanna	138.605	PMF	Momentum LF	145.90	7.25	10.30		10.43	0.016779	2.49	110.41	70.38	0.47
Railway to	138.605	PMF	Weir Pres	145.90	7.25	10.30		10.43	0.016779	2.49	110.41	70.38	0.47

	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
Hanna			HF										
Railway to Hanna	118.255	100 YR ARI	Energy	68.60	7.07	8.66	8.66	8.98	0.083003	3.43	35.86	49.13	0.94
Railway to Hanna	118.255	100 YR ARI	Momentum LF	68.60	7.07	8.66	8.66	8.98	0.083003	3.43	35.86	49.13	0.94
Railway to Hanna	118.255	100 YR ARI	Weir Pres HF	68.60	7.07	8.66	8.66	8.98	0.083003	3.43	35.86	49.13	0.94
Railway to Hanna	118.255	PMF	Energy	145.90	7.07	9.18	9.08	9.59	0.075635	4.07	63.85	57.17	0.94
Railway to Hanna	118.255	PMF	Momentum LF	145.90	7.07	9.18	9.08	9.59	0.075635	4.07	63.85	57.17	0.94
Railway to Hanna	118.255	PMF	Weir Pres HF	145.90	7.07	9.18	9.08	9.59	0.075635	4.07	63.85	57.17	0.94
Railway to Hanna	91.931	100 YR ARI	Energy	68.60	6.19	7.92	7.43	8.03	0.016816	1.51	52.84	57.75	0.43
Railway to Hanna	91.931	100 YR ARI	Momentum LF	68.60	6.19	7.92	7.43	8.03	0.016816	1.51	52.84	57.75	0.43
Railway to Hanna	91.931	100 YR ARI	Weir Pres HF	68.60	6.19	7.92	7.43	8.03	0.016816	1.51	52.84	57.75	0.43
Railway to Hanna	91.931	PMF	Energy	145.90	6.19	8.51		8.69	0.017959	2.02	88.04	62.24	0.47
Railway to Hanna	91.931	PMF	Momentum LF	145.90	6.19	8.51		8.69	0.017959	2.02	88.04	62.24	0.47
Railway to Hanna	91.931	PMF	Weir Pres HF	145.90	6.19	8.51		8.69	0.017959	2.02	88.04	62.24	0.47
Railway to Hanna	71.904	100 YR ARI	Energy	68.60	6.00	7.81		7.85	0.004697	0.84	86.90	71.05	0.23
Railway to Hanna	71.904	100 YR ARI	Momentum LF	68.60	6.00	7.81		7.85	0.004697	0.84	86.90	71.05	0.23
Railway to Hanna	71.904	100 YR ARI	Weir Pres HF	68.60	6.00	7.81		7.85	0.004697	0.84	86.90	71.05	0.23
Railway to Hanna	71.904	PMF	Energy	145.90	6.00	8.38		8.46	0.006496	1.22	128.52	74.94	0.28
Railway to Hanna	71.904	PMF	Momentum LF	145.90	6.00	8.38		8.46	0.006496	1.22	128.52	74.94	0.28
Railway to Hanna	71.904	PMF	Weir Pres HF	145.90	6.00	8.38		8.46	0.006496	1.22	128.52	74.94	0.28
Railway to Hanna	43.756	100 YR ARI	Energy	68.60	6.00	7.55		7.62	0.016125	1.19	58.69	78.74	0.40
Railway to Hanna	43.756	100 YR ARI	Momentum LF	68.60	6.00	7.55		7.62	0.016125	1.19	58.69	78.74	0.40
Railway to Hanna	43.756	100 YR ARI	Weir Pres HF	68.60	6.00	7.55		7.62	0.016125	1.19	58.69	78.74	0.40
Railway to Hanna	43.756	PMF	Energy	145.90	6.00	8.09		8.19	0.014292	1.47	109.48	99.36	0.40
Railway to Hanna	43.756	PMF	Momentum LF	145.90	6.00	8.09		8.19	0.014292	1.47	109.48	99.36	0.40
Railway to Hanna	43.756	PMF	Weir Pres HF	145.90	6.00	8.09		8.19	0.014292	1.47	109.48	99.36	0.40
Railway to Hanna	14.314	100 YR ARI	Energy	68.60	6.00	7.35	6.56	7.36	0.005008	0.65	119.05	121.09	0.22
Railway to Hanna	14.314	100 YR ARI	Momentum LF	68.60	6.00	7.35	6.56	7.36	0.005008	0.65	119.05	121.09	0.22
Railway to Hanna	14.314	100 YR ARI	Weir Pres HF	68.60	6.00	7.35	6.56	7.36	0.005008	0.65	119.05	121.09	0.22
Railway to Hanna	14.314	PMF	Energy	145.90	6.00	7.91	6.87	7.94	0.005003	0.89	187.49	123.39	0.24
Railway to Hanna	14.314	PMF	Momentum LF	145.90	6.00	7.91	6.87	7.94	0.005003	0.89	187.49	123.39	0.24
Railway to Hanna	14.314	PMF	Weir Pres HF	145.90	6.00	7.91	6.87	7.94	0.005003	0.89	187.49	123.39	0.24

Summary Output Table for Beach Berm Modelling

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
reach_1	416.951	100 YR ARI	P-UBCC DS&Rail	100.50	7.80	11.78		11.95	0.009562	1.83	59.42	29.17	0.36
reach_1	416.951	100 YR ARI	Beach Berm	100.50	7.80	11.78		11.95	0.009562	1.83	59.42	29.17	0.36
reach_1	416.951	PMF	P-UBCC DS&Rail	177.90	7.80	12.78		13.02	0.009509	2.26	92.10	36.43	0.38
reach_1	416.951	PMF	Beach Berm	177.90	7.80	12.78		13.02	0.009513	2.26	92.09	36.43	0.38
reach_1	408.012	100 YR ARI	P-UBCC DS&Rail	100.50	7.71	11.70		11.86	0.008999	1.78	61.09	29.99	0.35
reach_1	408.012	100 YR ARI	Beach Berm	100.50	7.71	11.70		11.86	0.008999	1.78	61.09	29.99	0.35
reach_1	408.012	PMF	P-UBCC DS&Rail	177.90	7.71	12.70		12.93	0.008909	2.19	94.84	37.48	0.36
reach_1	408.012	PMF	Beach Berm	177.90	7.71	12.70		12.93	0.008913	2.19	94.82	37.48	0.36
reach_1	399.203	100 YR ARI	P-UBCC DS&Rail	100.50	7.61	11.64		11.78	0.007703	1.68	65.31	31.56	0.32
reach_1	399.203	100 YR ARI	Beach Berm	100.50	7.61	11.64		11.78	0.007703	1.68	65.31	31.56	0.32
reach_1	399.203	PMF	P-UBCC DS&Rail	177.90	7.61	12.65		12.85	0.007747	2.07	100.85	39.16	0.34
reach_1	399.203	PMF	Beach Berm	177.90	7.61	12.65		12.85	0.007751	2.07	100.83	39.15	0.34
reach_1	391.774	100 YR ARI	P-UBCC DS&Rail	100.50	7.53	11.59		11.72	0.007672	1.66	66.14	33.03	0.32
reach_1	391.774	100 YR ARI	Beach Berm	100.50	7.53	11.59		11.72	0.007672	1.66	66.14	33.03	0.32
reach_1	391.774	PMF	P-UBCC DS&Rail	177.90	7.53	12.60		12.79	0.007537	2.03	104.04	42.42	0.34
reach_1	391.774	PMF	Beach Berm	177.90	7.53	12.60		12.79	0.007541	2.03	104.02	42.41	0.34
reach_1	384.639	100 YR ARI	P-UBCC DS&Rail	100.50	7.45	11.53		11.67	0.007654	1.65	65.64	35.51	0.32
reach_1	384.639	100 YR ARI	Beach Berm	100.50	7.45	11.53		11.67	0.007654	1.65	65.64	35.51	0.32
reach_1	384.639	PMF	P-UBCC DS&Rail	177.90	7.45	12.55		12.74	0.007180	1.98	108.36	45.32	0.33
reach_1	384.639	PMF	Beach Berm	177.90	7.45	12.55		12.73	0.007184	1.98	108.34	45.32	0.33
reach_1	373.531	100 YR ARI	P-UBCC DS&Rail	100.50	7.33	11.46		11.58	0.007030	1.58	68.79	33.29	0.31
reach_1	373.531	100 YR ARI	Beach Berm	100.50	7.33	11.46		11.58	0.007030	1.58	68.79	33.29	0.31
reach_1	373.531	PMF	P-UBCC DS&Rail	177.90	7.33	12.48		12.65	0.006716	1.92	111.00	46.27	0.32
reach_1	373.531	PMF	Beach Berm	177.90	7.33	12.48		12.65	0.006720	1.92	110.97	46.26	0.32
reach_1	360.818	100 YR ARI	P-UBCC DS&Rail	100.50	7.19	11.36		11.49	0.007657	1.63	66.24	31.38	0.32
reach_1	360.818	100 YR ARI	Beach Berm	100.50	7.19	11.36		11.49	0.007657	1.63	66.24	31.38	0.32
reach_1	360.818	PMF	P-UBCC DS&Rail	177.90	7.19	12.37		12.56	0.007522	2.00	102.28	40.99	0.33
reach_1	360.818	PMF	Beach Berm	177.90	7.19	12.37		12.56	0.007527	2.00	102.25	40.98	0.33
reach_1	346.505	100 YR ARI	P-UBCC DS&Rail	100.50	7.06	11.27		11.39	0.006016	1.54	72.50	32.91	0.29
reach_1	346.505	100 YR ARI	Beach Berm	100.50	7.06	11.27		11.39	0.006016	1.54	72.50	32.91	0.29
reach_1	346.505	PMF	P-UBCC DS&Rail	177.90	7.06	12.29		12.46	0.006329	1.92	109.72	41.75	0.31
reach_1	346.505	PMF	Beach Berm	177.90	7.06	12.29		12.46	0.006333	1.92	109.69	41.74	0.31
reach_1	332.230	100 YR ARI	P-UBCC DS&Rail	100.50	6.94	11.18	9.55	11.30	0.006437	1.58	69.53	32.25	0.30
reach_1	332.230	100 YR ARI	Beach Berm	100.50	6.94	11.18	9.55	11.30	0.006437	1.58	69.53	32.25	0.30
reach_1	332.230	PMF	P-UBCC DS&Rail	177.90	6.94	12.18	10.22	12.36	0.006813	1.99	105.73	39.93	0.32
reach_1	332.230	PMF	Beach Berm	177.90	6.94	12.18	10.22	12.36	0.006818	1.99	105.70	39.92	0.32
reach_1	324			Bridge									
reach_1	315.928	100 YR ARI	P-UBCC DS&Rail	100.50	6.81	10.99		11.12	0.007049	1.59	68.00	32.85	0.31
reach_1	315.928	100 YR ARI	Beach Berm	100.50	6.81	10.99		11.12	0.007049	1.59	68.00	32.85	0.31
reach_1	315.928	PMF	P-UBCC DS&Rail	177.90	6.81	11.97		12.16	0.007251	1.98	104.96	42.30	0.33
reach_1	315.928	PMF	Beach Berm	177.90	6.81	11.97		12.16	0.007258	1.98	104.92	42.29	0.33
reach_1	305.563	100 YR	P-UBCC	100.50	6.72	10.91		11.04	0.007428	1.64	65.48	33.23	0.32

reach_1	305.563	100 YR ARI	DS&Rail Beach Berm	100.50	6.72	10.91		11.04	0.007428	1.64	65.48	33.23	0.32
reach_1	305.563	PMF	P-UBCC	177.90	6.72	11.89		12.08	0.007537	2.03	103.60	42.38	0.33
reach_1	305.563	PMF	DS&Rail Beach Berm	177.90	6.72	11.89		12.08	0.007545	2.03	103.55	42.38	0.33
reach_1	295.821	100 YR ARI	P-UBCC	100.50	6.64	10.83		10.97	0.007592	1.64	64.73	30.92	0.32
reach_1	295.821	100 YR ARI	DS&Rail Beach Berm	100.50	6.64	10.83		10.97	0.007592	1.64	64.73	30.92	0.32
reach_1	295.821	PMF	P-UBCC	177.90	6.64	11.81		12.01	0.007731	2.03	101.80	41.93	0.34
reach_1	295.821	PMF	DS&Rail Beach Berm	177.90	6.64	11.81		12.01	0.007740	2.03	101.75	41.92	0.34
reach_1	286.355	100 YR ARI	P-UBCC	100.50	6.57	10.74		10.89	0.008756	1.71	60.94	28.03	0.34
reach_1	286.355	100 YR ARI	DS&Rail Beach Berm	100.50	6.57	10.74		10.89	0.008756	1.71	60.94	28.03	0.34
reach_1	286.355	PMF	P-UBCC	177.90	6.57	11.71		11.93	0.008716	2.11	96.89	41.22	0.36
reach_1	286.355	PMF	DS&Rail Beach Berm	177.90	6.57	11.71		11.93	0.008728	2.11	96.84	41.21	0.36
reach_1	276.823	100 YR ARI	P-UBCC	100.50	6.49	10.64		10.80	0.009716	1.79	58.04	26.97	0.36
reach_1	276.823	100 YR ARI	DS&Rail Beach Berm	100.50	6.49	10.64		10.80	0.009716	1.79	58.04	26.97	0.36
reach_1	276.823	PMF	P-UBCC	177.90	6.49	11.61		11.84	0.009577	2.19	93.44	41.54	0.37
reach_1	276.823	PMF	DS&Rail Beach Berm	177.90	6.49	11.61		11.84	0.009593	2.19	93.37	41.54	0.37
reach_1	266.862	100 YR ARI	P-UBCC	100.50	6.41	10.56		10.71	0.008531	1.73	60.91	28.05	0.34
reach_1	266.862	100 YR ARI	DS&Rail Beach Berm	100.50	6.41	10.56		10.71	0.008531	1.73	60.91	28.05	0.34
reach_1	266.862	PMF	P-UBCC	177.90	6.41	11.52		11.75	0.008741	2.15	96.48	42.44	0.36
reach_1	266.862	PMF	DS&Rail Beach Berm	177.90	6.41	11.52		11.74	0.008757	2.15	96.41	42.43	0.36
reach_1	258.198	100 YR ARI	P-UBCC	100.50	6.34	10.47		10.63	0.008956	1.76	59.76	27.67	0.34
reach_1	258.198	100 YR ARI	DS&Rail Beach Berm	100.50	6.34	10.47		10.63	0.008956	1.76	59.76	27.67	0.34
reach_1	258.198	PMF	P-UBCC	177.90	6.34	11.43		11.67	0.009396	2.21	92.87	41.16	0.37
reach_1	258.198	PMF	DS&Rail Beach Berm	177.90	6.34	11.43		11.66	0.009415	2.21	92.79	41.15	0.37
reach_1	249.723	100 YR ARI	P-UBCC	100.50	6.27	10.39		10.55	0.009646	1.79	57.98	26.70	0.35
reach_1	249.723	100 YR ARI	DS&Rail Beach Berm	100.50	6.27	10.39		10.55	0.009646	1.79	57.98	26.70	0.35
reach_1	249.723	PMF	P-UBCC	177.90	6.27	11.33		11.58	0.010185	2.26	88.35	38.86	0.38
reach_1	249.723	PMF	DS&Rail Beach Berm	177.90	6.27	11.33		11.58	0.010208	2.26	88.26	38.85	0.38
reach_1	239.532	100 YR ARI	P-UBCC	100.50	6.19	10.28		10.44	0.011263	1.80	56.20	26.29	0.38
reach_1	239.532	100 YR ARI	DS&Rail Beach Berm	100.50	6.19	10.28		10.44	0.011263	1.80	56.20	26.29	0.38
reach_1	239.532	PMF	P-UBCC	177.90	6.19	11.22		11.47	0.011027	2.23	84.20	35.45	0.39
reach_1	239.532	PMF	DS&Rail Beach Berm	177.90	6.19	11.22		11.47	0.011056	2.24	84.12	35.41	0.39
reach_1	226.906	100 YR ARI	P-UBCC	100.50	6.08	10.16		10.31	0.009392	1.68	60.90	28.84	0.35
reach_1	226.906	100 YR ARI	DS&Rail Beach Berm	100.50	6.08	10.16		10.31	0.009392	1.68	60.90	28.84	0.35
reach_1	226.906	PMF	P-UBCC	177.90	6.08	11.12		11.33	0.009106	2.07	93.52	39.34	0.36
reach_1	226.906	PMF	DS&Rail Beach Berm	177.90	6.08	11.12		11.33	0.009134	2.07	93.41	39.32	0.36
reach_1	215.941	100 YR ARI	P-UBCC	100.50	6.00	10.06		10.20	0.009786	1.68	60.57	28.82	0.35
reach_1	215.941	100 YR ARI	DS&Rail Beach Berm	100.50	6.00	10.06		10.20	0.009786	1.68	60.57	28.82	0.35
reach_1	215.941	PMF	P-UBCC	177.90	6.00	11.02		11.23	0.009159	2.05	93.87	39.69	0.36
reach_1	215.941	PMF	DS&Rail Beach Berm	177.90	6.00	11.02		11.23	0.009191	2.05	93.75	39.66	0.36
reach_1	201.805	100 YR ARI	P-UBCC	100.50	5.88	9.90		10.05	0.011415	1.74	57.99	27.89	0.38
reach_1	201.805	100 YR ARI	DS&Rail Beach Berm	100.50	5.88	9.90		10.05	0.011415	1.74	57.99	27.89	0.38
reach_1	201.805	PMF	P-UBCC	177.90	5.88	10.88		11.10	0.010136	2.08	90.58	38.78	0.38
reach_1	201.805	PMF	DS&Rail Beach Berm	177.90	5.88	10.88		11.09	0.010180	2.08	90.43	38.75	0.38
reach_1	188.580	100 YR ARI	P-UBCC	100.50	5.77	9.75		9.90	0.011381	1.72	58.63	28.70	0.38
			DS&Rail										

reach_1	188.580	100 YR ARI	Beach Berm	100.50	5.77	9.75		9.90	0.011381	1.72	58.63	28.70	0.38
reach_1	188.580	PMF	P-UBCC DS&Rail	177.90	5.77	10.76		10.96	0.009543	2.04	92.60	39.76	0.37
reach_1	188.580	PMF	Beach Berm	177.90	5.77	10.75		10.96	0.009592	2.04	92.42	39.71	0.37
reach_1	173.814	100 YR ARI	P-UBCC DS&Rail	100.50	5.65	9.58		9.73	0.011667	1.71	58.78	29.26	0.38
reach_1	173.814	100 YR ARI	Beach Berm	100.50	5.65	9.58		9.73	0.011667	1.71	58.78	29.26	0.38
reach_1	173.814	PMF	P-UBCC DS&Rail	177.90	5.65	10.62		10.82	0.009131	1.99	94.60	40.48	0.36
reach_1	173.814	PMF	Beach Berm	177.90	5.65	10.62		10.82	0.009187	1.99	94.38	40.42	0.36
reach_1	158.201	100 YR ARI	P-UBCC DS&Rail	100.50	5.53	9.35		9.53	0.013899	1.87	54.03	27.46	0.41
reach_1	158.201	100 YR ARI	Beach Berm	100.50	5.53	9.35		9.53	0.013899	1.87	54.03	27.46	0.41
reach_1	158.201	PMF	P-UBCC DS&Rail	177.90	5.53	10.44		10.67	0.010300	2.13	88.86	37.32	0.38
reach_1	158.201	PMF	Beach Berm	177.90	5.53	10.44		10.66	0.010378	2.13	88.61	37.27	0.38
reach_1	142.886	100 YR ARI	P-UBCC DS&Rail	100.90	5.40	9.05		9.27	0.019360	2.09	48.36	25.41	0.48
reach_1	142.886	100 YR ARI	Beach Berm	100.90	5.40	9.05		9.27	0.019360	2.09	48.36	25.41	0.48
reach_1	142.886	PMF	P-UBCC DS&Rail	182.50	5.40	10.22		10.49	0.012629	2.31	83.64	37.50	0.42
reach_1	142.886	PMF	Beach Berm	182.50	5.40	10.21		10.48	0.012763	2.32	83.30	37.44	0.42
reach_1	124.955	100 YR ARI	P-UBCC DS&Rail	100.90	5.25	8.93		9.13	0.004296	1.98	50.98	27.09	0.45
reach_1	124.955	100 YR ARI	Beach Berm	100.90	5.25	8.93		9.13	0.004296	1.98	50.98	27.09	0.45
reach_1	124.955	PMF	P-UBCC DS&Rail	182.50	5.25	10.16		10.39	0.002617	2.15	90.69	40.20	0.39
reach_1	124.955	PMF	Beach Berm	182.50	5.25	10.15		10.38	0.002646	2.16	90.29	40.13	0.39
reach_1	108.623	100 YR ARI	P-UBCC DS&Rail	100.90	5.12	8.81		9.00	0.016672	1.95	51.71	27.15	0.45
reach_1	108.623	100 YR ARI	Beach Berm	100.90	5.12	8.81		9.00	0.016672	1.95	51.71	27.15	0.45
reach_1	108.623	PMF	P-UBCC DS&Rail	182.50	5.12	10.11		10.31	0.009374	2.00	93.19	37.45	0.36
reach_1	108.623	PMF	Beach Berm	182.50	5.12	10.10		10.30	0.009493	2.01	92.79	37.28	0.37
reach_1	93.831	100 YR ARI	P-UBCC DS&Rail	100.90	4.91	8.67		8.84	0.006905	1.83	55.09	27.54	0.41
reach_1	93.831	100 YR ARI	Beach Berm	100.90	4.91	8.67		8.84	0.006905	1.83	55.09	27.54	0.41
reach_1	93.831	PMF	P-UBCC DS&Rail	182.50	4.91	10.04		10.21	0.004504	1.82	101.34	41.91	0.35
reach_1	93.831	PMF	Beach Berm	182.50	4.91	10.03		10.20	0.004565	1.83	100.83	41.68	0.35
reach_1	82.077	100 YR ARI	P-UBCC DS&Rail	100.90	4.74	7.66	7.66	8.67	0.008048	4.72	32.56	21.13	0.92
reach_1	82.077	100 YR ARI	Beach Berm	100.90	4.74	7.66	7.66	8.67	0.008048	4.72	32.56	21.13	0.92
reach_1	82.077	PMF	P-UBCC DS&Rail	182.50	4.74	8.92		10.05	0.005892	5.23	65.61	32.71	0.84
reach_1	82.077	PMF	Beach Berm	182.50	4.74	8.76		10.02	0.006879	5.50	60.61	30.29	0.91
reach_1	71.666	100 YR ARI	P-UBCC DS&Rail	100.90	4.50	7.71	7.27	8.42	0.005472	3.87	36.07	20.66	0.72
reach_1	71.666	100 YR ARI	Beach Berm	100.90	4.50	7.66	7.27	8.40	0.005817	3.95	35.07	20.32	0.74
reach_1	71.666	PMF	P-UBCC DS&Rail	182.50	4.50	9.11		9.90	0.003972	4.27	72.40	30.39	0.65
reach_1	71.666	PMF	Beach Berm	182.50	4.50	8.99		9.84	0.004473	4.44	68.60	29.68	0.69
reach_1	55.953	100 YR ARI	P-UBCC DS&Rail	100.90	4.25	7.72		8.31	0.004137	3.53	40.97	22.16	0.62
reach_1	55.953	100 YR ARI	Beach Berm	100.90	4.25	7.67		8.28	0.004375	3.59	39.92	21.84	0.64
reach_1	55.953	PMF	P-UBCC DS&Rail	182.50	4.25	9.11		9.81	0.003389	4.05	78.19	31.40	0.60
reach_1	55.953	PMF	Beach Berm	182.50	4.25	8.99		9.75	0.003774	4.20	74.38	30.58	0.63
reach_1	39.873	100 YR ARI	P-UBCC DS&Rail	100.90	4.00	7.58		8.23	0.004759	3.68	38.81	21.59	0.64
reach_1	39.873	100 YR ARI	Beach Berm	100.90	4.00	7.52		8.20	0.005119	3.77	37.45	21.01	0.66
reach_1	39.873	PMF	P-UBCC DS&Rail	182.50	4.00	9.07		9.75	0.003516	4.04	80.84	35.03	0.59
reach_1	39.873	PMF	Beach Berm	182.50	4.00	8.93		9.69	0.003994	4.22	76.00	33.78	0.62
reach_1	36.582*	100 YR ARI	P-UBCC DS&Rail	100.90	3.85	7.49		8.18	0.005241	3.76	34.11	18.77	0.67
reach_1	36.582*	PMF	P-UBCC	182.50	3.85	8.95		9.72	0.003958	4.19	72.13	33.68	0.62

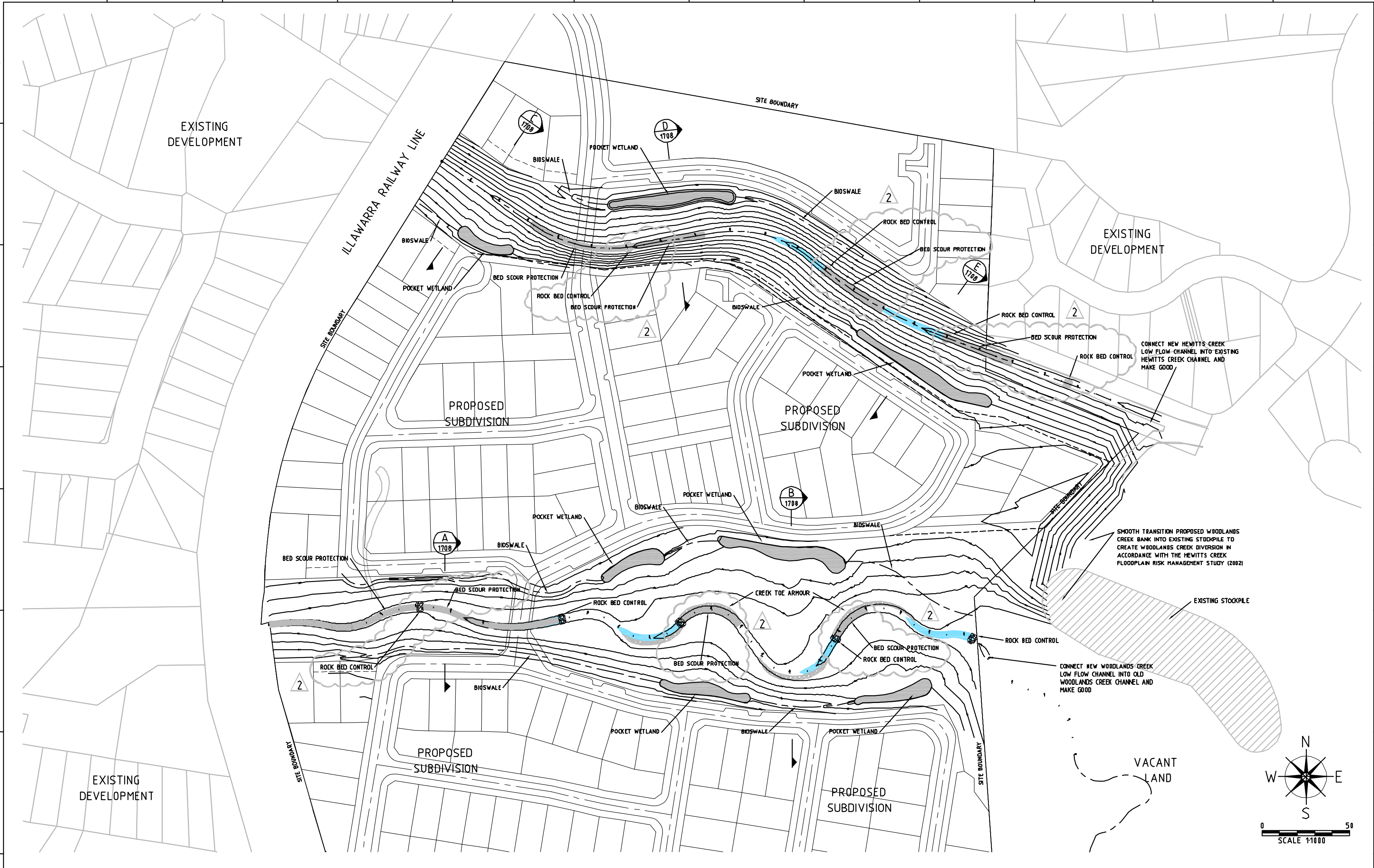
			DS&Rail										
reach_1	33.291*	100 YR ARI	P-UBCC DS&Rail	100.90	3.71	7.38		8.13	0.006313	3.88	30.11	16.76	0.69
reach_1	33.291*	PMF	P-UBCC DS&Rail	182.50	3.71	8.72		9.66	0.005419	4.53	60.56	30.16	0.67
reach_1	30	100 YR ARI	P-UBCC DS&Rail	100.90	3.56	7.36		8.07	0.006310	3.75	28.78	14.50	0.65
reach_1	30	100 YR ARI	Beach Berm	100.90	3.56	7.33		8.05	0.006491	3.78	28.39	14.26	0.66
reach_1	30	PMF	P-UBCC DS&Rail	182.50	3.56	8.68		9.61	0.005810	4.47	55.83	26.41	0.66
reach_1	30	PMF	Beach Berm	182.50	3.56	8.22	8.03	9.50	0.008760	5.14	44.76	22.31	0.79
reach_1	27.5*	100 YR ARI	P-UBCC DS&Rail	100.90	3.42	6.76	6.76	7.96	0.012999	4.97	21.87	10.38	1.00
reach_1	27.5*	PMF	P-UBCC DS&Rail	182.50	3.42	8.18	8.18	9.53	0.008412	5.40	47.70	26.82	0.87
reach_1	25	100 YR ARI	P-UBCC DS&Rail	100.90	3.28	6.12	6.47	7.80	0.022685	5.74	17.58	7.54	1.19
reach_1	25	100 YR ARI	Beach Berm	100.90	3.52	6.60	6.60	7.88	0.014082	5.01	21.25	11.21	0.98
reach_1	25	PMF	P-UBCC DS&Rail	182.50	3.28	7.50	7.95	9.40	0.014560	6.25	39.65	26.18	1.03
reach_1	25	PMF	Beach Berm	182.50	3.52	8.11	8.11	9.38	0.008536	5.25	56.31	32.92	0.82
reach_1	22.5*	100 YR ARI	P-UBCC DS&Rail	100.90	3.12	6.61	6.61	7.60	0.014212	4.93	24.81	11.68	0.94
reach_1	22.5*	PMF	P-UBCC DS&Rail	182.50	3.12	7.05	7.69	9.22	0.026283	7.37	30.94	15.55	1.30
reach_1	20	100 YR ARI	P-UBCC DS&Rail	100.90	2.96	6.43	4.86	6.70	0.002179	2.30	43.90	13.68	0.41
reach_1	20	100 YR ARI	Beach Berm	100.90	3.44	4.55	5.34	7.32	0.071973	7.37	13.69	12.61	2.26
reach_1	20	PMF	P-UBCC DS&Rail	182.50	2.96	7.47	5.78	7.96	0.002932	3.10	60.25	20.40	0.49
reach_1	20	PMF	Beach Berm	182.50	3.44	5.16	6.26	8.86	0.059221	8.53	21.40	12.78	2.10
reach_1	17.5*	100 YR ARI	P-UBCC DS&Rail	100.90	2.82	6.09		6.65	0.004283	3.40	34.31	16.50	0.65
reach_1	17.5*	PMF	P-UBCC DS&Rail	182.50	2.82	6.65	6.40	7.86	0.007404	5.05	44.21	19.40	0.88
reach_1	15	100 YR ARI	P-UBCC DS&Rail	100.90	2.68	6.23		6.55	0.002467	2.53	40.67	16.78	0.46
reach_1	15	100 YR ARI	Beach Berm	100.90	3.39	6.06	5.49	6.61	0.005514	3.30	30.83	14.88	0.68
reach_1	15	PMF	P-UBCC DS&Rail	182.50	2.68	6.99		7.65	0.003774	3.62	56.11	23.50	0.59
reach_1	15	PMF	Beach Berm	182.50	3.39	6.13	6.47	7.84	0.016271	5.78	31.97	15.78	1.18
reach_1	11.7619*	100 YR ARI	P-UBCC DS&Rail	100.90	2.51	6.11		6.51	0.006021	2.83	39.35	20.00	0.51
reach_1	11.7619*	PMF	P-UBCC DS&Rail	182.50	2.51	6.80		7.58	0.009269	4.01	55.53	26.43	0.66
reach_1	8.5238*	100 YR ARI	P-UBCC DS&Rail	100.90	2.34	5.97		6.42	0.012036	3.08	39.30	21.43	0.56
reach_1	8.5238*	PMF	P-UBCC DS&Rail	182.50	2.34	6.39	6.32	7.42	0.023645	4.70	49.69	27.41	0.80
reach_1	5.2857*	100 YR ARI	P-UBCC DS&Rail	100.90	2.17	5.93		6.23	0.017631	2.46	47.36	39.38	0.54
reach_1	5.2857*	PMF	P-UBCC DS&Rail	182.50	2.17	6.58		7.01	0.021939	3.06	76.10	46.58	0.62
reach_1	2.0476	100 YR ARI	P-UBCC DS&Rail	100.90	2.00	5.95		6.04	0.009790	1.60	83.43	43.31	0.34
reach_1	2.0476	100 YR ARI	Beach Berm	100.90	3.14	6.10		6.18	0.009855	1.53	85.04	43.86	0.34
reach_1	2.0476	PMF	P-UBCC DS&Rail	182.50	2.00	6.60		6.76	0.013535	2.05	112.67	45.94	0.41
reach_1	2.0476	PMF	Beach Berm	182.50	3.14	6.74	5.47	6.89	0.013534	1.98	114.07	46.52	0.41
reach_1	1.96827*	100 YR ARI	P-UBCC DS&Rail	100.90	1.98	5.90		5.97	0.006748	1.37	100.49	54.34	0.29
reach_1	1.96827*	PMF	P-UBCC DS&Rail	182.50	1.98	6.55		6.66	0.009034	1.76	136.45	58.54	0.34
reach_1	1.88894*	100 YR ARI	P-UBCC DS&Rail	100.90	1.97	5.86		5.92	0.005435	1.23	114.33	65.22	0.26
reach_1	1.88894*	PMF	P-UBCC DS&Rail	182.50	1.97	6.50		6.59	0.006729	1.59	157.59	69.40	0.30
reach_1	1.80962	100 YR ARI	P-UBCC DS&Rail	100.90	1.95	5.83		5.87	0.004784	1.15	125.19	78.14	0.24
reach_1	1.80962	100 YR ARI	Beach Berm	100.90	2.97	5.98		6.02	0.004579	1.09	130.10	78.52	0.24
reach_1	1.80962	PMF	P-UBCC DS&Rail	182.50	1.95	6.46		6.54	0.005579	1.46	175.41	79.77	0.27
reach_1	1.80962	PMF	Beach Berm	182.50	2.97	6.60		6.67	0.005376	1.40	180.01	80.13	0.27

reach_1	1.73205*	100 YR ARI	P-UBCC DS&Rail	100.90	1.93	5.78		5.83	0.005631	1.24	118.74	74.43	0.26
reach_1	1.73205*	PMF	P-UBCC DS&Rail	182.50	1.93	6.41		6.49	0.006602	1.58	166.89	78.15	0.29
reach_1	1.65448*	100 YR ARI	P-UBCC DS&Rail	100.90	1.92	5.72		5.78	0.006752	1.37	111.97	73.46	0.28
reach_1	1.65448*	PMF	P-UBCC DS&Rail	182.50	1.92	6.34		6.43	0.007997	1.71	157.77	76.08	0.32
reach_1	1.57691*	100 YR ARI	P-UBCC DS&Rail	100.90	1.91	5.65		5.72	0.008585	1.54	103.95	72.67	0.31
reach_1	1.57691*	PMF	P-UBCC DS&Rail	182.50	1.91	6.25		6.36	0.010036	1.87	148.14	73.60	0.34
reach_1	1.49934	100 YR ARI	P-UBCC DS&Rail	100.90	1.89	5.54		5.64	0.012110	1.78	93.67	72.01	0.35
reach_1	1.49934	100 YR ARI	Beach Berm	100.90	2.92	5.74		5.81	0.010517	1.58	102.19	72.15	0.33
reach_1	1.49934	PMF	P-UBCC DS&Rail	182.50	1.89	6.14		6.27	0.013442	2.09	136.83	72.34	0.37
reach_1	1.49934	PMF	Beach Berm	182.50	2.92	6.33		6.43	0.011911	1.89	144.95	72.52	0.36
reach_1	1.42324*	100 YR ARI	P-UBCC DS&Rail	100.90	1.87	5.36		5.52	0.016399	2.06	78.42	72.15	0.42
reach_1	1.42324*	PMF	P-UBCC DS&Rail	182.50	1.87	5.95		6.13	0.017301	2.38	121.53	75.27	0.44
reach_1	1.34714*	100 YR ARI	P-UBCC DS&Rail	100.90	1.86	5.18		5.37	0.019103	2.17	69.94	70.89	0.46
reach_1	1.34714*	PMF	P-UBCC DS&Rail	182.50	1.86	5.72		5.96	0.020791	2.58	110.51	77.56	0.50
reach_1	1.27105	100 YR ARI	P-UBCC DS&Rail	100.90	1.84	4.95		5.19	0.024466	2.34	59.22	69.71	0.53
reach_1	1.27105	100 YR ARI	Beach Berm	100.90	2.80	4.85		5.25	0.056658	3.03	45.34	56.72	0.78
reach_1	1.27105	PMF	P-UBCC DS&Rail	182.50	1.84	5.40		5.74	0.030050	2.95	93.48	79.43	0.60
reach_1	1.27105	PMF	Beach Berm	182.50	2.80	5.30		5.79	0.059329	3.59	77.61	78.59	0.83
reach_1	1.20236*	100 YR ARI	P-UBCC DS&Rail	100.90	1.83	4.85		5.02	0.019027	2.11	73.88	77.98	0.47
reach_1	1.20236*	PMF	P-UBCC DS&Rail	182.50	1.83	5.29		5.53	0.022810	2.63	109.87	83.17	0.53
reach_1	1.13367*	100 YR ARI	P-UBCC DS&Rail	100.90	1.81	4.80		4.90	0.011230	1.70	96.48	81.85	0.36
reach_1	1.13367*	PMF	P-UBCC DS&Rail	182.50	1.81	5.24		5.38	0.014235	2.16	137.51	104.06	0.42
reach_1	1.06498	100 YR ARI	P-UBCC DS&Rail	100.90	1.80	4.78		4.83	0.005893	1.29	128.76	106.09	0.27
reach_1	1.06498	100 YR ARI	Beach Berm	100.90	2.69	4.67		4.72	0.010567	1.45	109.60	100.82	0.35
reach_1	1.06498	PMF	P-UBCC DS&Rail	182.50	1.80	5.22		5.29	0.007725	1.65	179.24	122.51	0.31
reach_1	1.06498	PMF	Beach Berm	182.50	2.69	5.10		5.19	0.012417	1.82	158.16	121.81	0.39
reach_1	.974486*	100 YR ARI	P-UBCC DS&Rail	100.90	1.78	4.71		4.77	0.007427	1.43	116.89	110.59	0.30
reach_1	.974486*	PMF	P-UBCC DS&Rail	182.50	1.78	5.12		5.21	0.008867	1.74	165.95	122.96	0.34
reach_1	.883993*	100 YR ARI	P-UBCC DS&Rail	100.90	1.77	4.62		4.69	0.009172	1.54	105.29	113.02	0.33
reach_1	.883993*	PMF	P-UBCC DS&Rail	182.50	1.77	5.00		5.12	0.010368	1.83	150.96	123.54	0.36
reach_1	.793499*	100 YR ARI	P-UBCC DS&Rail	100.90	1.75	4.49		4.60	0.011372	1.64	91.50	113.83	0.37
reach_1	.793499*	PMF	P-UBCC DS&Rail	182.50	1.75	4.86		5.01	0.012348	1.91	134.47	126.01	0.39
reach_1	.703006*	100 YR ARI	P-UBCC DS&Rail	100.90	1.73	4.34		4.47	0.013650	1.70	76.01	109.53	0.40
reach_1	.703006*	PMF	P-UBCC DS&Rail	182.50	1.73	4.67		4.87	0.016101	2.06	115.28	125.57	0.44
reach_1	.612513*	100 YR ARI	P-UBCC DS&Rail	100.90	1.72	4.21		4.34	0.014085	1.63	71.45	103.50	0.40
reach_1	.612513*	PMF	P-UBCC DS&Rail	182.50	1.72	4.52		4.72	0.014897	1.87	109.87	134.84	0.42
reach_1	0.52202	100 YR ARI	P-UBCC DS&Rail	100.90	1.70	4.15		4.23	0.006218	1.05	88.51	106.49	0.26
reach_1	0.52202	100 YR ARI	Beach Berm	100.90	2.35	4.24		4.31	0.005219	0.93	94.60	112.84	0.24
reach_1	0.52202	PMF	P-UBCC DS&Rail	182.50	1.70	4.45		4.59	0.008135	1.34	123.08	126.00	0.31
reach_1	0.52202	PMF	Beach Berm	182.50	2.35	4.59		4.71	0.005910	1.13	138.38	142.69	0.27
reach_1	.43129*	100 YR ARI	P-UBCC DS&Rail	100.90	1.67	4.08		4.17	0.007901	1.19	87.55	123.41	0.30
reach_1	.43129*	PMF	P-UBCC	182.50	1.67	4.37		4.51	0.009470	1.45	129.18	157.20	0.34

			DS&Rail										
reach_1	.34056*	100 YR ARI	P-UBCC DS&Rail	100.90	1.65	3.99		4.08	0.011153	1.42	89.37	150.04	0.36
reach_1	.34056*	PMF	P-UBCC DS&Rail	182.50	1.65	4.28		4.41	0.011002	1.58	134.46	157.94	0.36
reach_1	.24983*	100 YR ARI	P-UBCC DS&Rail	100.90	1.62	3.84		3.95	0.016513	1.71	80.79	133.06	0.43
reach_1	.24983*	PMF	P-UBCC DS&Rail	182.50	1.62	4.16		4.29	0.014979	1.84	128.51	158.76	0.42
reach_1	0.1591	100 YR ARI	P-UBCC DS&Rail	100.90	1.60	3.44	3.44	3.70	0.048296	2.59	53.14	96.67	0.71
reach_1	0.1591	100 YR ARI	Beach Berm	100.90	2.30	4.07	3.48	4.11	0.005001	0.93	122.88	158.65	0.24
reach_1	0.1591	PMF	P-UBCC DS&Rail	182.50	1.60	3.72	3.72	4.05	0.048294	2.94	82.89	117.00	0.73
reach_1	0.1591	PMF	Beach Berm	182.50	2.30	4.43	3.76	4.49	0.005001	1.07	181.60	166.54	0.25

Annex B

B. Creek Design Plans



REV	DATE	BY	APP.	DETAILS
1	19/07/07	CJG	PJM	MINOR UPDATE TO ROAD
2	06/04/09	CJG	AJB	REVISED TO SUIT PEER REVIEW COMMENTS

DRAWING STATUS

DESIGN BY	AJB	08/03/07
DRAWN BY	AJB	08/03/07
DRAFTING CHECK	PJS	25/03/07
DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

SCALE: (on A1 Original) 1:1000

HEIGHT DATUM AHD

Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

PROJECT TITLE
SANDON POINT RESIDENTIAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
HEWITTS AND WOODLANDS CREEK GENERAL ARRANGEMENT

Project No.	Com No.	Drawing No.	REV
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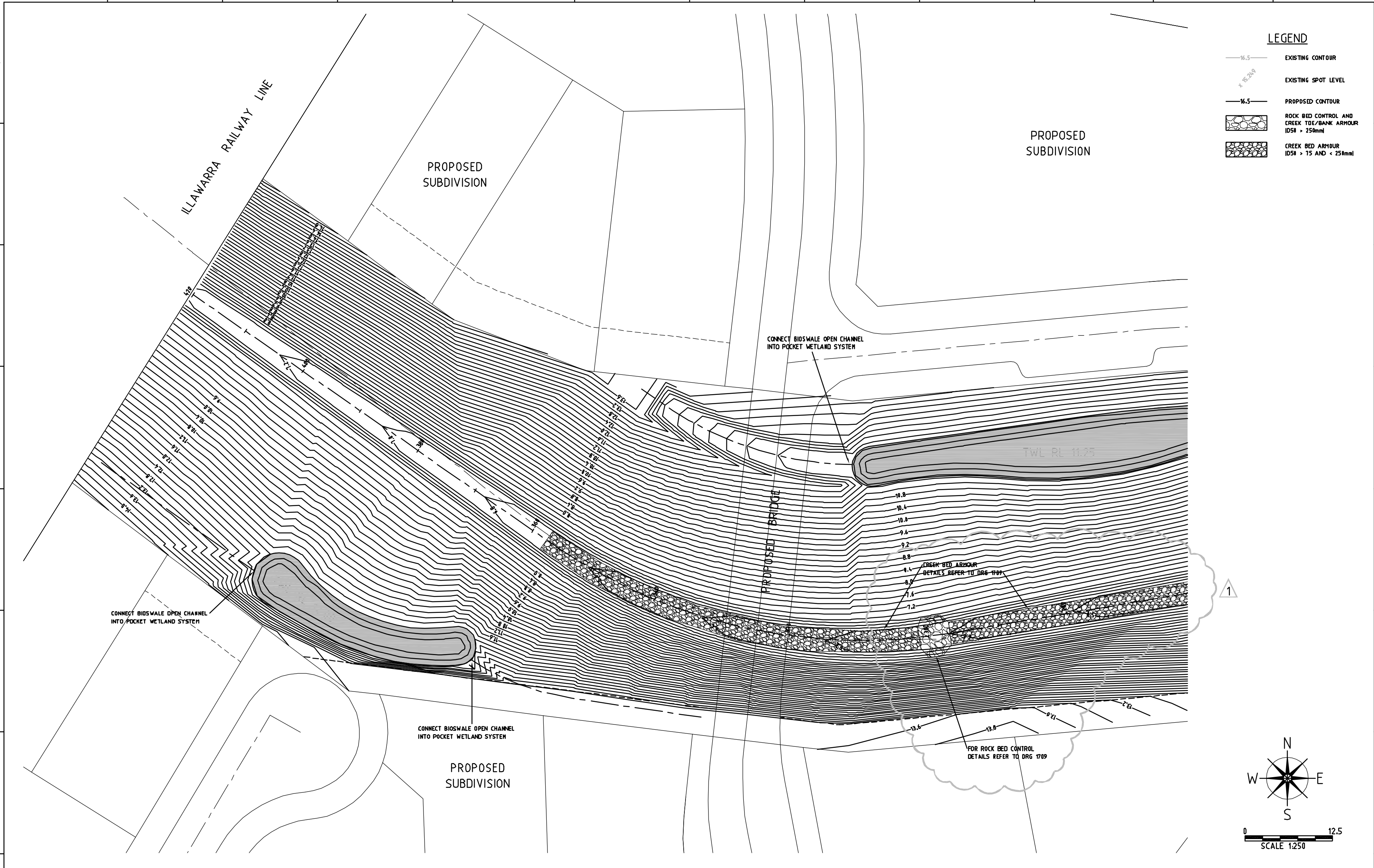

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

SCALE: (on A1 Original) 1:250

HEIGHT DATUM AHD

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PROJECT TITLE
SANDON POINT RESIDENTIAL SUBDIVISION
for
STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
CREEK REHABILITATION DETAIL LAYOUT PLAN

Project No.	Com No.	Drawing No.	REV
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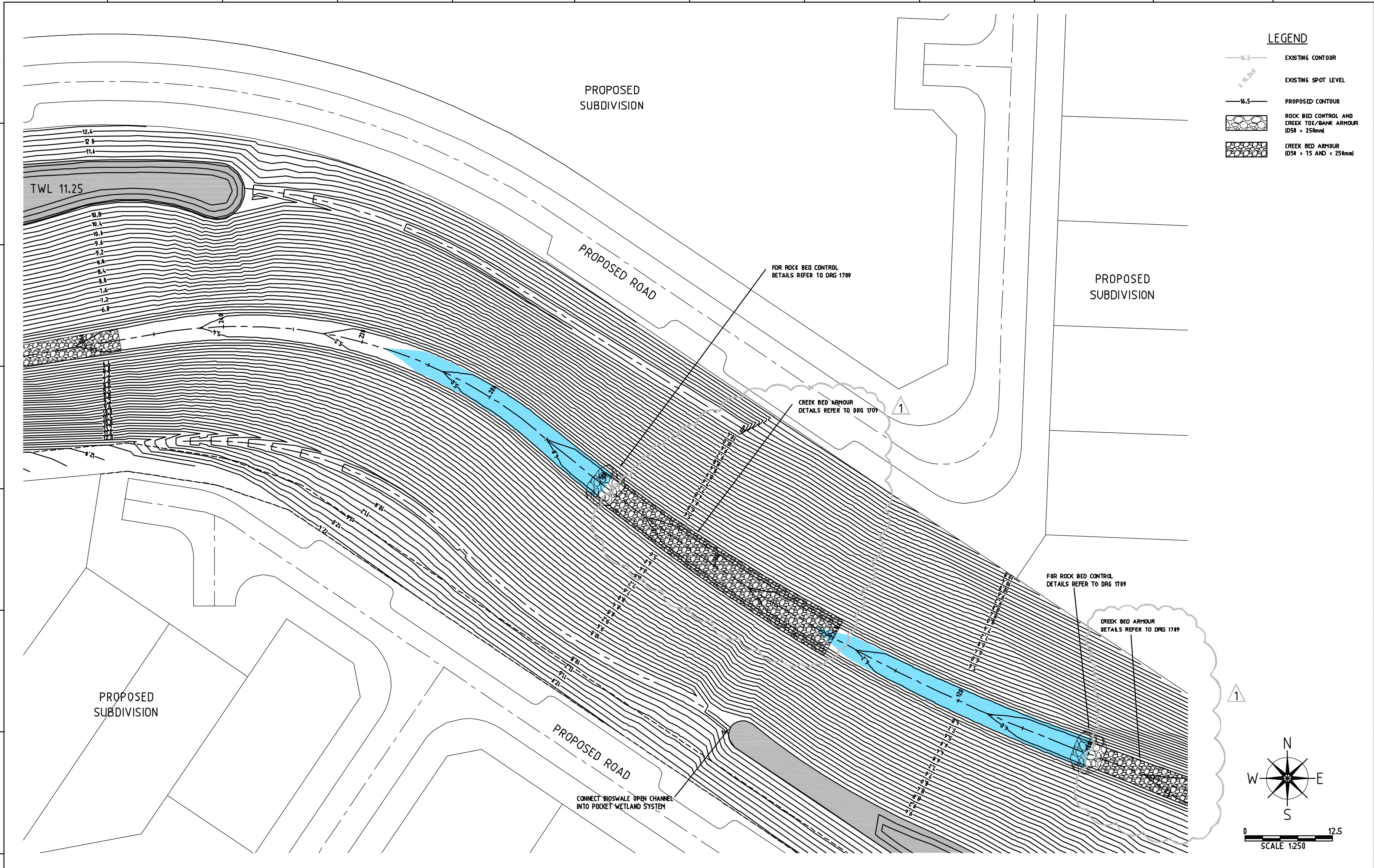

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

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HEIGHT DATUM AHD

Cardno Forbes Rigby
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PROJECT TITLE
SANDON POINT
RESIDENTAL SUBDIVISION
for
STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
CREEK REHABILITATION
DETAIL LAYOUT PLAN

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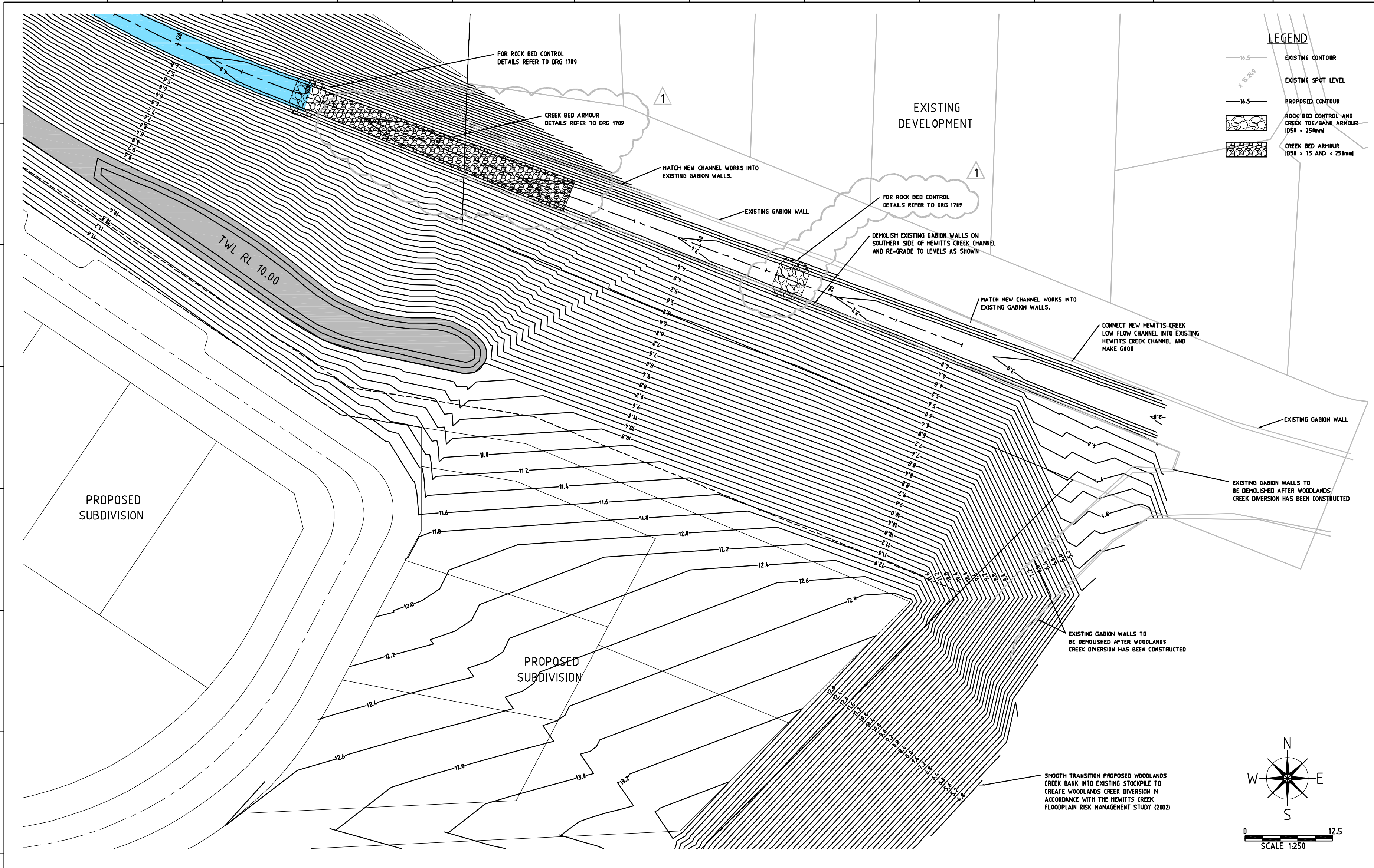

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

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HEIGHT DATUM AHD

Cardno Forbes Rigby

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PROJECT TITLE
SANDON POINT RESIDENTAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
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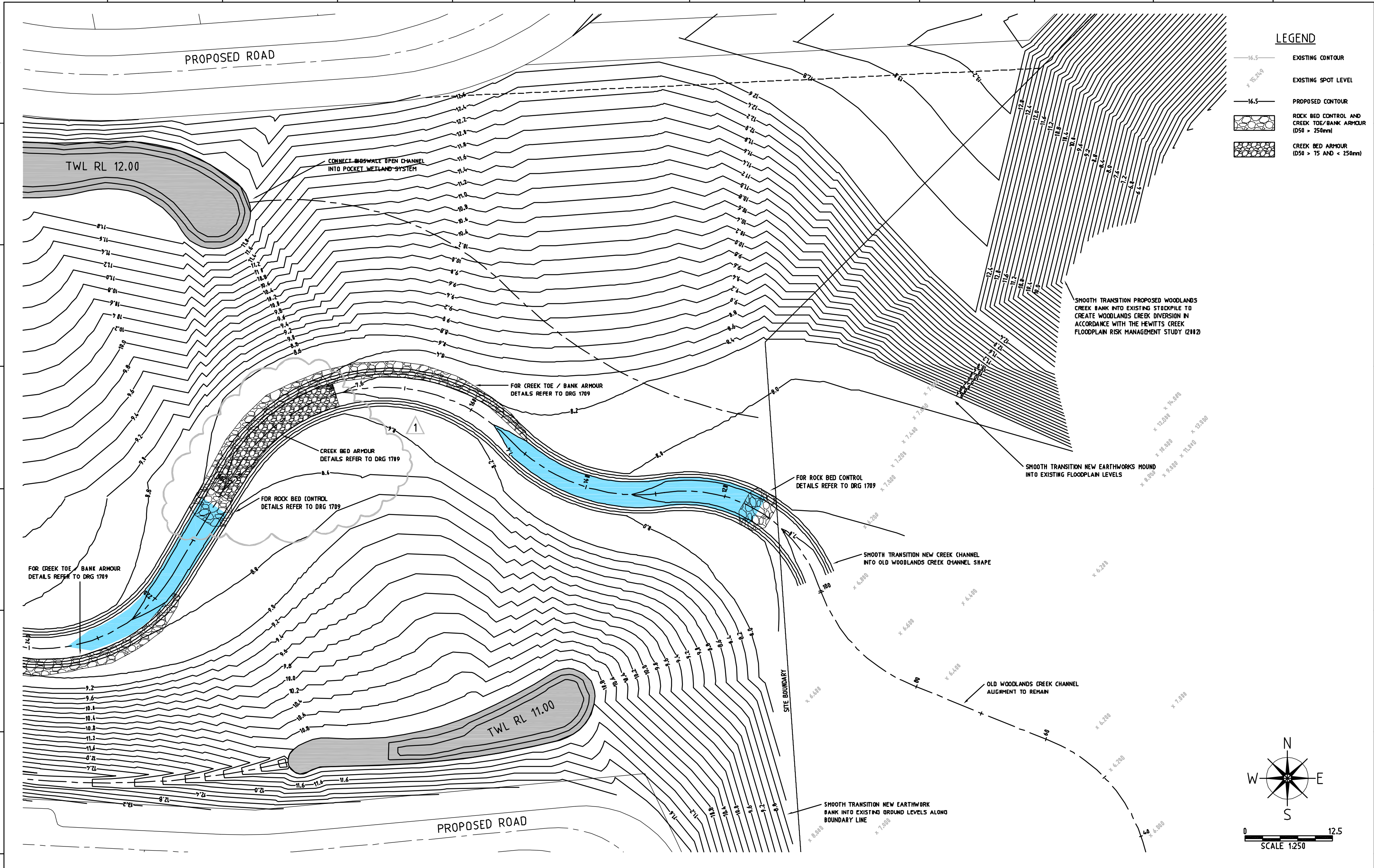

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FINAL APPROVAL	PSN	05/07/07

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HEIGHT DATUM AHD

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PROJECT TITLE

SANDON POINT RESIDENTAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE

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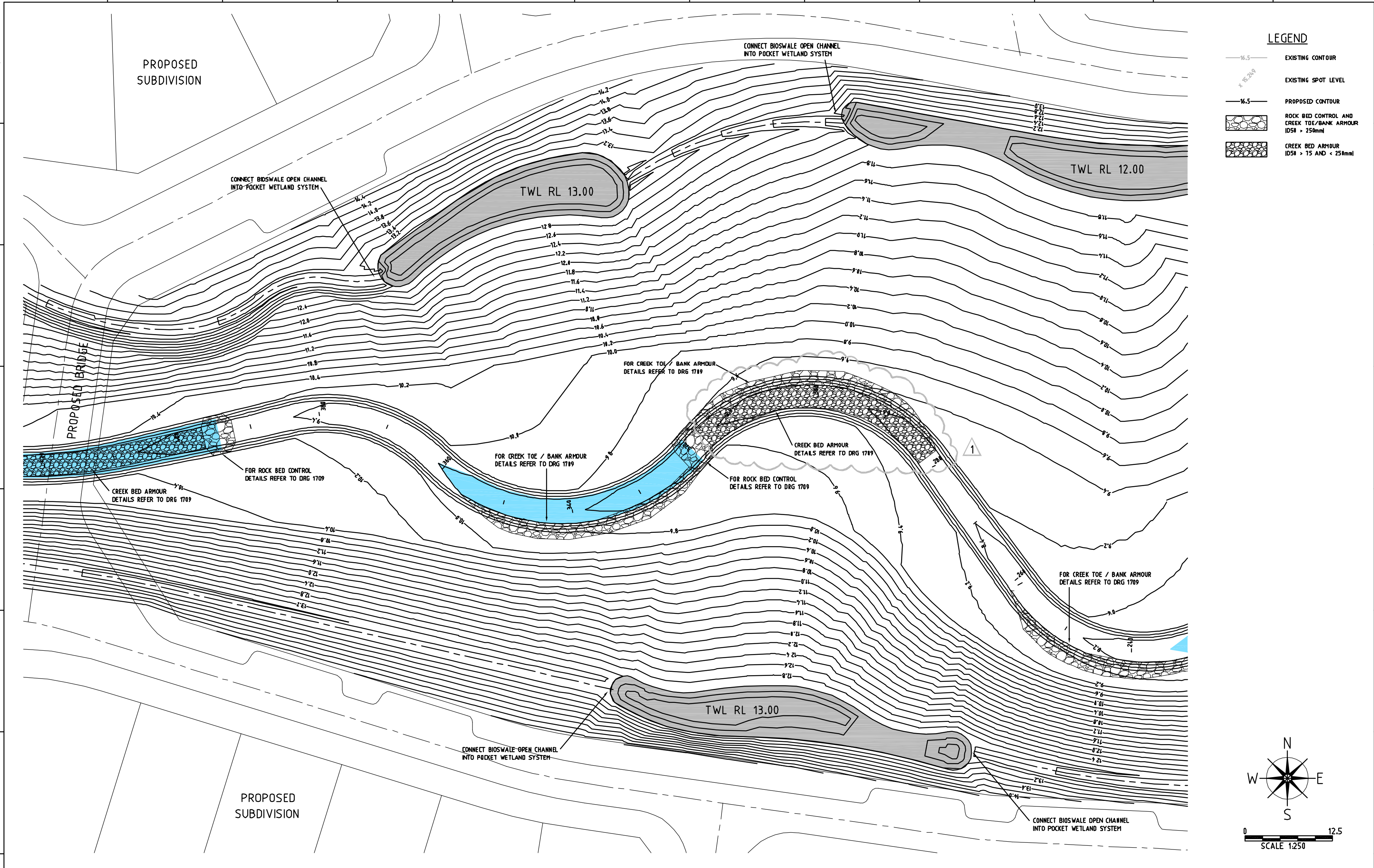

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

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HEIGHT DATUM AHD

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PROJECT TITLE
SANDON POINT RESIDENTAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

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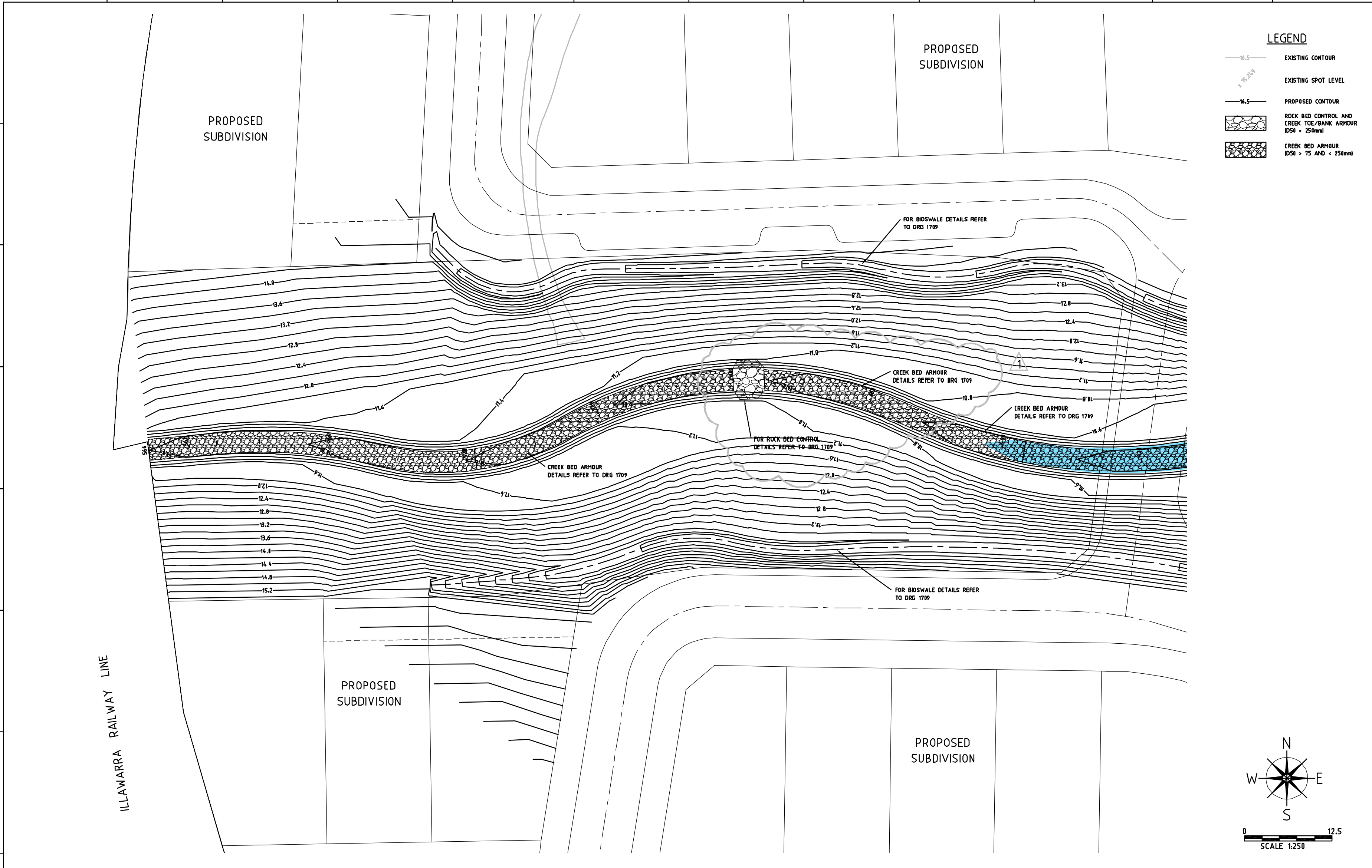

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

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HEIGHT DATUM AHD

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PROJECT TITLE
SANDON POINT RESIDENTAL SUBDIVISION
for
STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
CREEK REHABILITATION DETAIL LAYOUT PLAN

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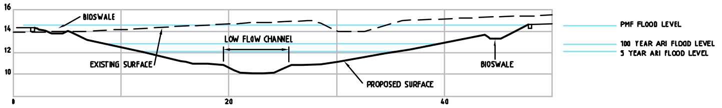

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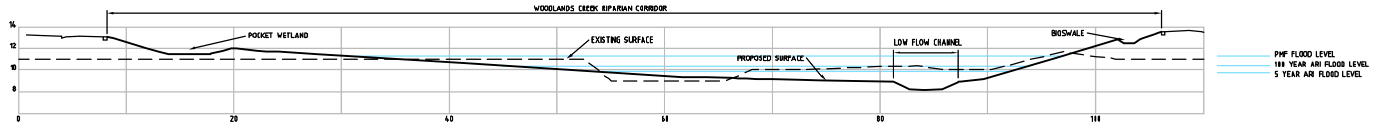

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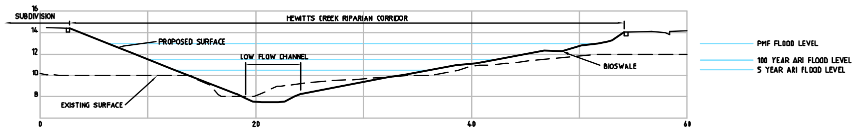

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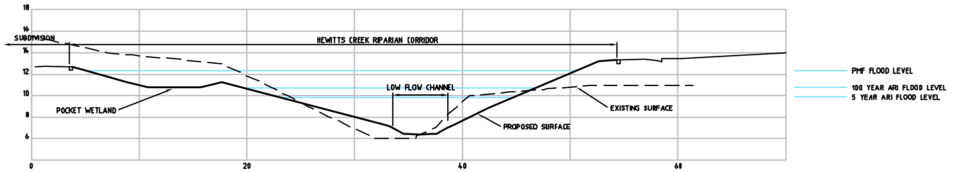

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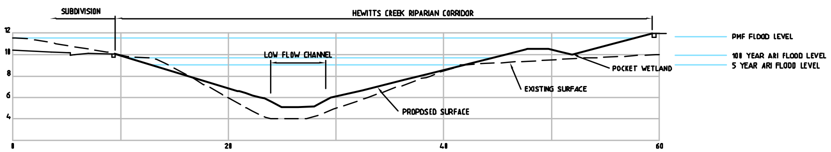

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DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

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SCALE: (on A1 Original) 1:200N

HEIGHT DATUM AHD

FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
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Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN 003 936 981

PROJECT TITLE
SANDON POINT
RESIDENTAL SUBDIVISION
for
STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
CREEK
CROSS SECTIONS

Project No.	Com No.	Drawing No.	REV
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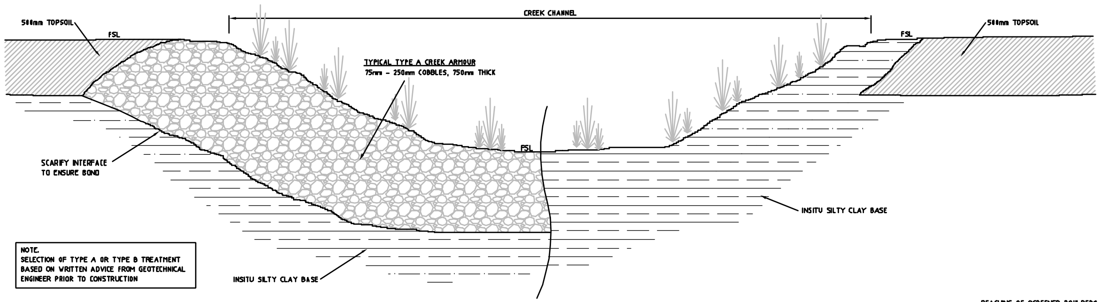
A1

DO NOT SCALE | IF IN DOUBT ASK



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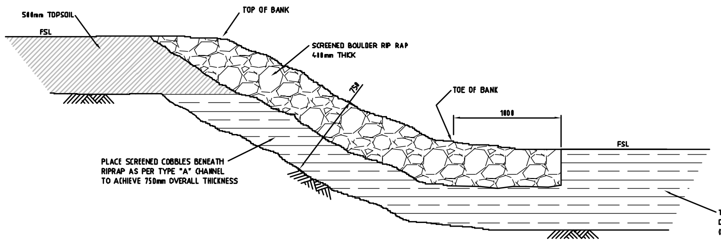
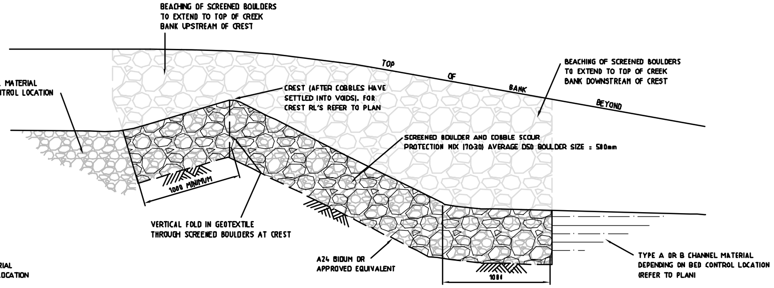
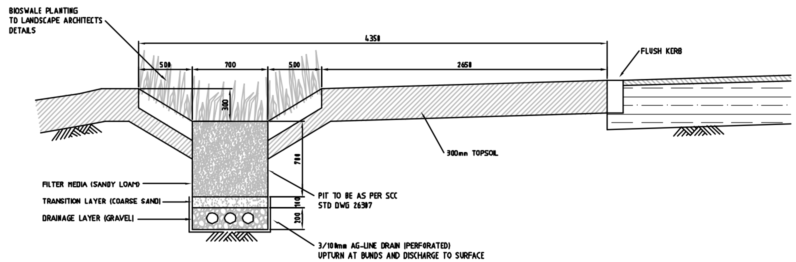


TYPICAL CREEK TOE / BANK ARMOUR



TYPICAL ROCK BED CONTROL



TYPICAL BIOSWALE DETAIL

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FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

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HEIGHT DATUM AHD

Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

PROJECT TITLE
SANDON POINT RESIDENTAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
CREEK DETAILS

Project No.	Com No.	Drawing No.	REV
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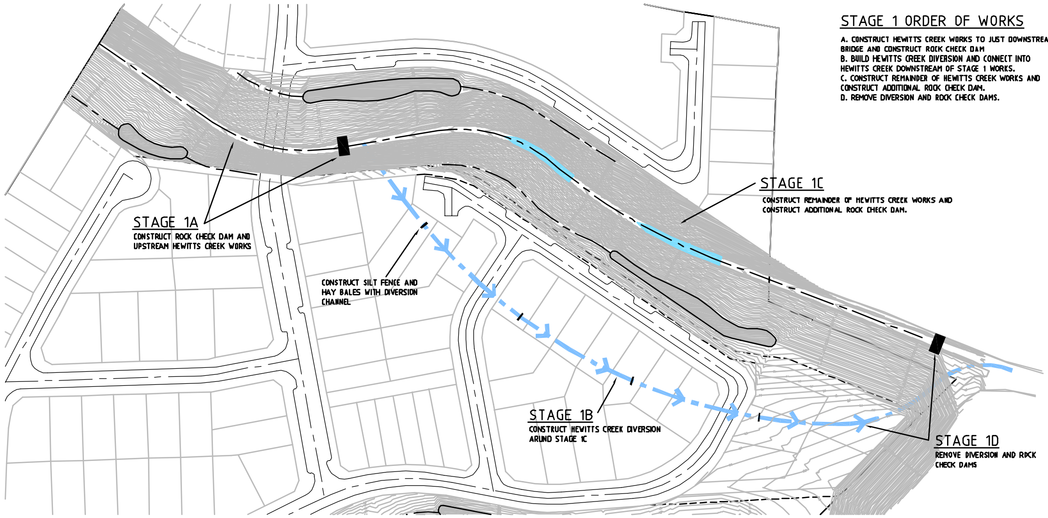
A1

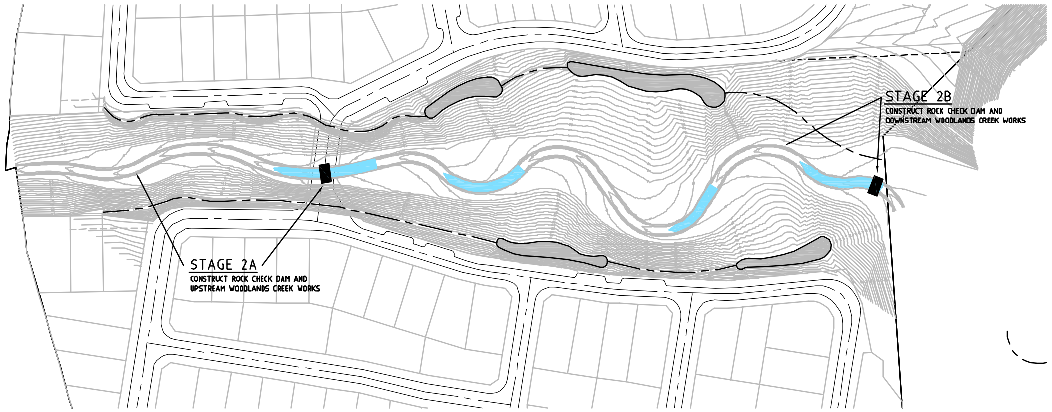
DO NOT SCALE IF IN DOUBT ASK



STAGE 1 WORKS

STAGE 1 ORDER OF WORKS

A. CONSTRUCT HEWITTS CREEK WORKS TO JUST DOWNSTREAM OF BRIDGE AND CONSTRUCT ROCK CHECK DAM
B. BUILD HEWITTS CREEK DIVERSION AND CONNECT INTO HEWITTS CREEK DOWNSTREAM OF STAGE 1 WORKS.
C. CONSTRUCT REMAINDER OF HEWITTS CREEK WORKS AND CONSTRUCT ADDITIONAL ROCK CHECK DAM.
D. REMOVE DIVERSION AND ROCK CHECK DAMS.



STAGE 2 WORKS

GENERAL NOTES

G1. ALL SURFACE WATER AND EROSION AND SEDIMENT CONTROL MEASURES AS DETAILED ON THE APPROVED MANAGEMENT PLANS MUST BE IN PLACE BEFORE THE COMMENCEMENT OF CONSTRUCTION AND CONTINUE TO OPERATE AFTER COMPLETION OF THE CONSTRUCTION UNTIL THE VEGETATION IS ESTABLISHED.

G2. MEASURES USED TO MANAGE EROSION AND SEDIMENT CONTROL WILL INCLUDE.
a. WETLANDS TO POND DIRTY RUNOFF FROM DISTURBED AREAS AND EXISTING UPSTREAM CATCHMENT. SEDMENT WILL SETTLE OUT OF SUSPENSION IN THESE PONDS.
b. SEDIMENT CONTROL FENCES TO FILTER RUNOFF FROM DISTURBED AREAS AND STOCKPILES.
c. CHECK DAMS TO FILTER LARGER FLOWS OF SEDIMENT LADEN RUNOFF TO TRAP SEDIMENT.
d. HAY BALE SEDIMENT TRAPS TO RECEIVE SMALLER FLOWS OF SEDIMENT LADEN RUNOFF TO TRAP SEDMENT.

G3. ALL SITE RUNOFF SHOULD BE DISCHARGED INTO SEDIMENTATION TRAPS OR CHECK DAMS DOWN SLOPE OF DISTURBED AREAS TO COLLECT, CONVEY AND TREAT SEDIMENT-LADEN RUNOFF.

G4. WETLAND REVEGETATION TO OCCUR AS SOON AS PRACTICAL AFTER CONSTRUCTION. IN ACCORDANCE WITH THE VEGETATION MANAGEMENT PLAN.

G5 SILT FENCES SHOULD BE INSTALLED ON THE DOWNSLOPE SIDE OF ALL STOCKPILES.

G6. MEASURES SHALL BE TAKEN TO MINIMISE THE RISK OF EROSION TO DISTURBED AREAS. BARE AREAS SHOULD BE STABILISED WITHIN 14 DAYS OF THE COMPLETION OF CONSTRUCTION ACTIVITIES. TEMPORARY STABILISATION TECHNIQUES SUCH AS EROSION MATTING, SEDIMENT SCREENS, HAY BALE ENERGY DISSIPATERS, MULCHING, HYDROSEEDING AND RIPARIAN VEGETATION SHOULD BE ESTABLISHMENT SHOULD BE IMPLEMENTED ON DISTURBED AREAS AS REQURED, IN ACCORDANCE WITH THE VMP.

G7. REGULAR INSPECTION AND MAINTENANCE OF ALL WORKS AND REHABILITATED AREAS SHALL BE UNDERTAKEN

G8 FOLLOWNG REVEGETATION, TEMPORARY EROSION CONTROL MEASURES ARE TO BE REMOVED. THIS MAY INVOLVE CLEANING AND REMOVAL OF DIVERSION WORKS, SEDINENT TRAPS AND CHECK DAMS

G9. EROSION AND SEDIMENT CONTROL STRUCTURES TO BE INSPECTED WEEKLY AND AFTER EVERY STORM AND RUNOFF EVENT TO CHECK THEY ARE OPERATING SATISFACTORILY AND TO SCHEDULE ANY MAINTENANCE WORK AND REPAIRS THAT MAY BE REQUIRED. REGULAR MAINTENANCE WILL INCLUDE:
a. SEDINENT REMOVAL FROM DRAINS AND CHECK DAMS.
b. REPLACEMENT AS REQUIRED.

G11. WATER CART TO BE AVAILABLE ON SITE FOR DUST REDUCTION PURPOSES AS REQUIRED.

G11. ANY INCIDENTS ON SITE LIKELY TO CAUSE POLLUTION MUST BE REPORTED IMMEDIATELY TO THE SUPERINTENDENT.

G12. ALL WORKS ARE TO BE CARRIED OUT IN ACCORDANCE WITH "MANAGING STORMWATER, SOIL & CONSTRUCTION" PRODUCED BY THE NSW DEPARTMENT OF HOUSING. (THE BLUE BOOK)

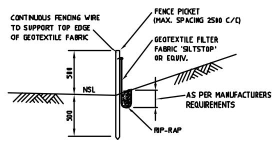
G13. THIS PLAN SHOWS TYPICAL SOIL & WATER MANAGEMENT MEASURES THAT WILL BE REQUIRED BUT IS NOT INTENDED TO LIMIT THE CONTRACTOR TO ANY PARTICULAR CONSTRUCTION METHODOLOGY.

G14. ANY REVEGETATED AREAS WHICH FAIL TO ESTABLISH WITHIN THREE MONTHS MUST BE REVEGETATED IN ACCORDANCE WITH THE VMP.

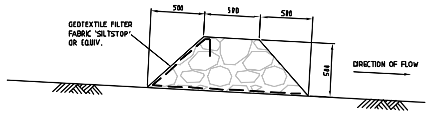
G15. EARTHWORKS AND TRENCHING TO BE STAGED TO KEEP WORK AREAS TO A MANAGEABLE SIZE

G16. EXCAVATED MATERIAL FROM TRENCHES TO BE STOCKPILED UPHILL OF TRENCH UNTIL BACKFILLING

G17. PUBLIC ROADS TO BE KEPT CLEAR OF DEBRIS AT ALL TIMES. CONTRACTOR TO PROVIDE SHAKER PAD FOR VEHICLES ENTERING/LEAVING SITE.



SEDIMENT CONTROL FENCE
N.T.S.



TYPICAL ROCK CHECK DAM DETAIL
N.T.S.

REV	DATE	BY	APP.	DETAILS
1	19/07/07	CJG	PJN	MINOR UPDATE TO ROAD

DRAWING STATUS		
DESIGN BY	AJB	29/03/07
DRAWN BY	AJB	29/03/07
DRAFTING CHECK	PJS	25/04/07
DESIGN CHECK	AJB	05/07/07
FINAL APPROVAL	PSN	05/07/07

FOR APPROVAL

SCALE: (on A1 Original) 1:1000

HEIGHT DATUM AHD

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

PROJECT TITLE
SANDON POINT RESIDENTAL SUBDIVISION
for
STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
SOIL AND WATER MANAGEMENT PLAN

Project No.	Com No.	Drawing No.	REV
106062	1	1710	1

A1

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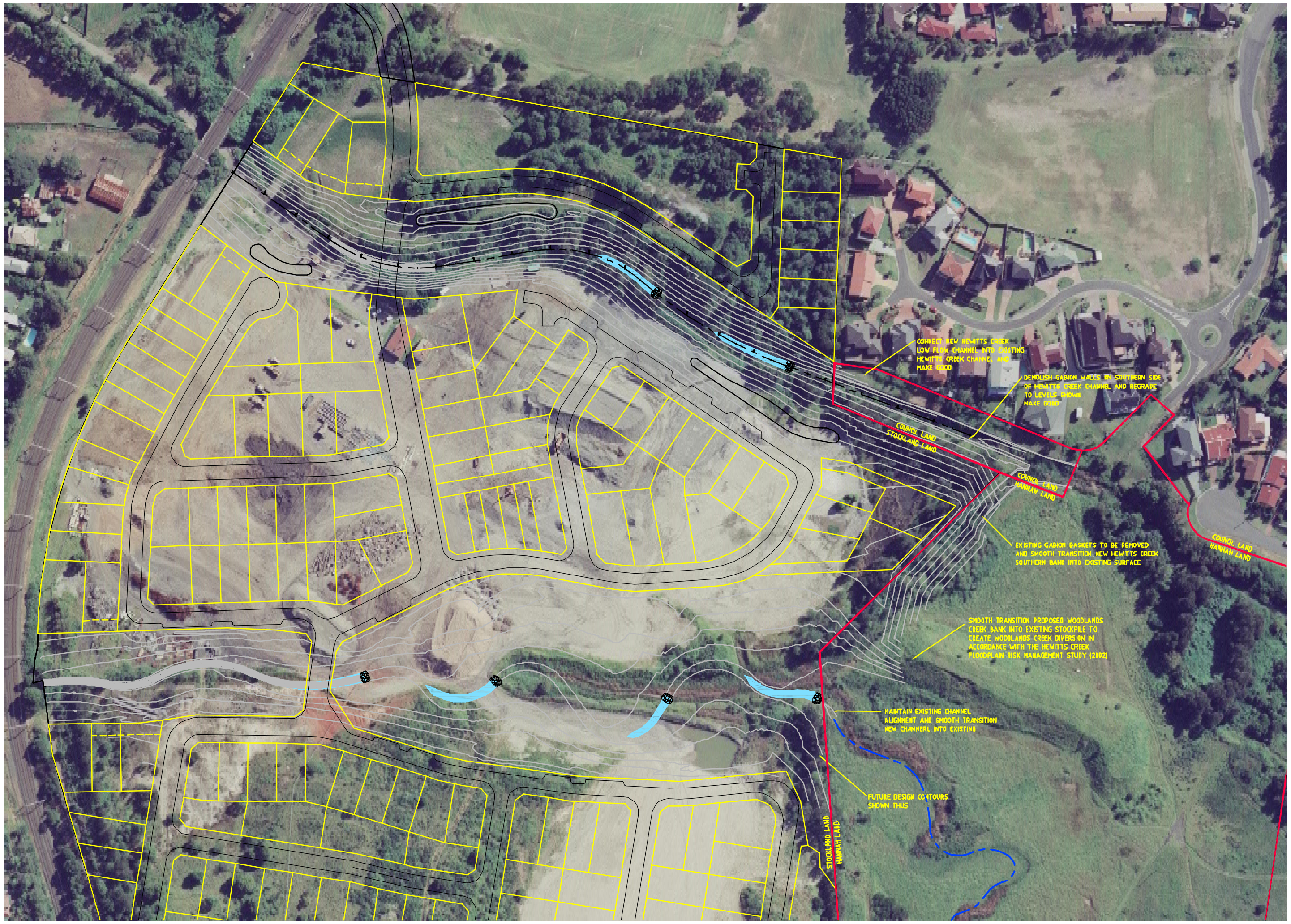
DO NOT SCALE IF IN DOUBT ASK



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REV	DATE	BY	APP.	DETAILS

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DRAWN BY	AJB	12/04/07
DRAFTING CHECK		
DESIGN CHECK		
FINAL APPROVAL		

PRELIMINARY

SCALE: (on A1 Original) 1:1000

HEIGHT DATUM AHD

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PROJECT TITLE
SANDON POINT RESIDENTIAL SUBDIVISION for STOCKLANDS DEVELOPMENTS PTY LTD

DRAWING TITLE
TAILOUT WORKS ON DOWNSTREAM LAND

Project No.	Com No.	Drawing No.	REV
106062	1	1711	P2

A1

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Annex C

C. Additional Plans

Comparison Between Geomorphic Features 1976 - 2002

WOODLANDS CREEK and TRAMWAY CREEK SANDON POINT

Legend

- Piped Section of Woodlands Creek
- Geomorphic Features 2002
- Geomorphic Features 1976

N, E, S, W

Scale 1:2,500 (at A3)

Metres

0 25 50 100 150

Cardno Forbes Rigby

1 - Hewitts Creek at George St Residence

2 - Hewitts Creek at Jennifer St

3 - Hewitts Creek at Lachlan St Culvert

4 - Woodlands Ck at Princes Highway

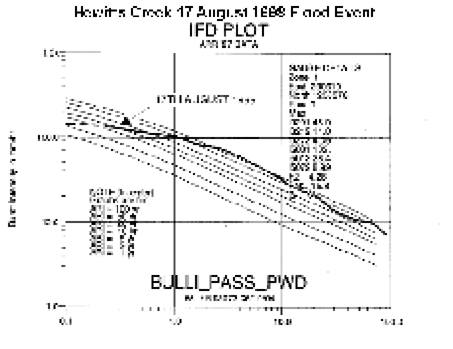
5 - Hewitts Ck at footbridge downstream of Site

Distribution of Sediment in the Hewitts Creek Catchment

August 1998 Flood Event

Legend

Scale 1:7,500 (at A2)



Date	Total Rainfall	Duration	Flooding	Approx. ARI
4-Mar-78	293mm	5 days	Severe	
20-Mar-78	321mm	3 days	Severe	
14-Oct-83	195mm	1 day	Severe	
6-Aug-86	170mm	3 days	Serious	
20-Aug-87	106mm	3 days	Minor	
29-Aug-88	600mm	5 days	Severe	5
2-Feb-90	300mm	3 days	Severe	
31-Jul-90	264mm	3 days	Severe	
6-Jun-91	310mm	6 days	Severe	10
8-Feb-92	142mm	6 hrs	Serious	
14-May-95	114mm	6 hrs	Severe	
31-Aug-96	230mm	6 hrs	Very severe	
17-Aug-98	316mm	3 hrs	Extreme	100
24-Oct-99	118mm	1 hr	Severe	