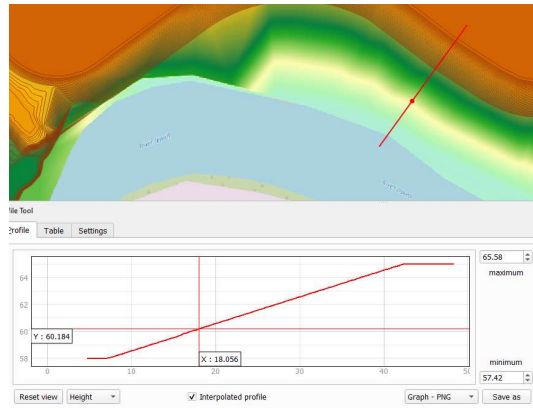
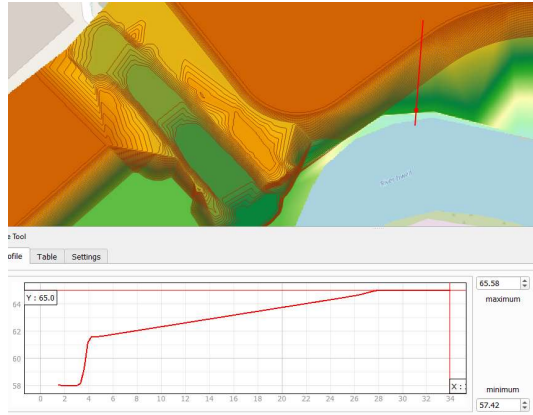
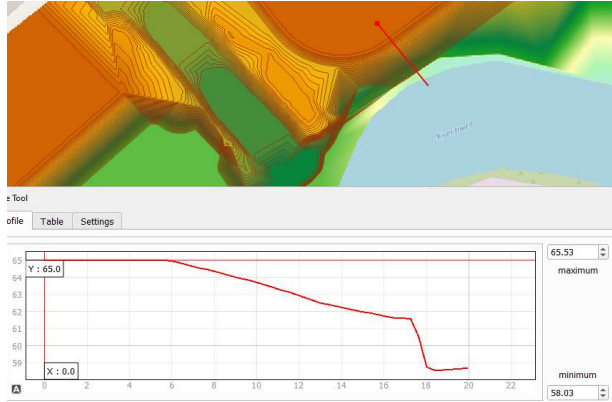
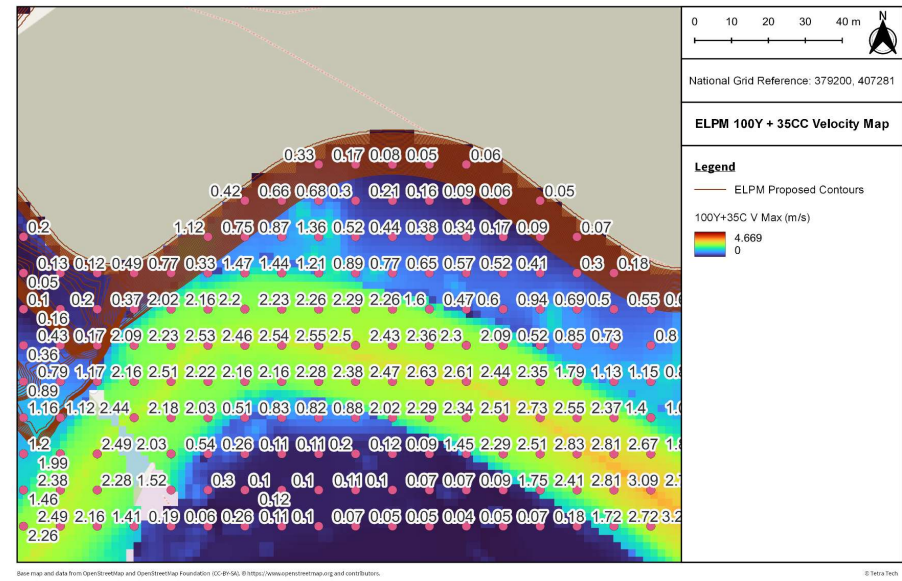
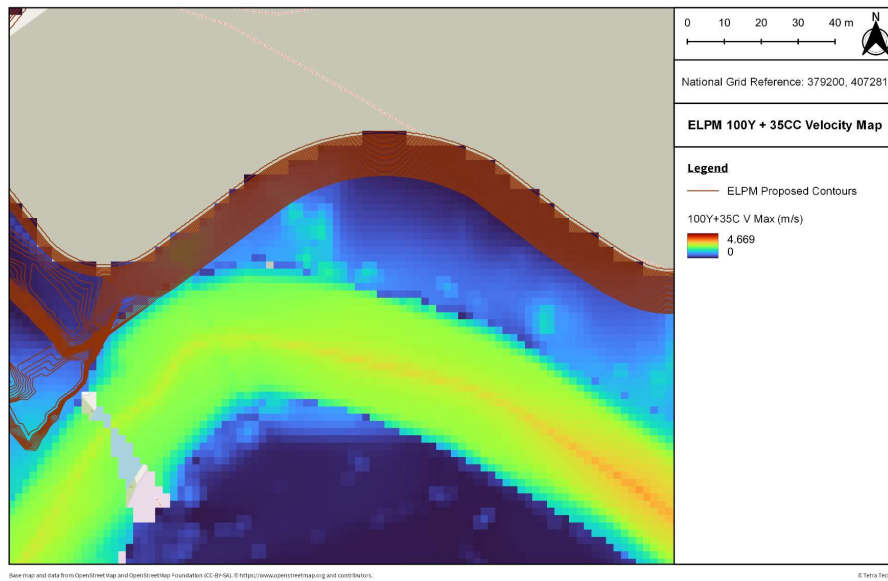






The 100Y + 35CC flood event has been used to assess anticipated velocities adjacent to the development platform. The velocities where the river bounds the proposed development platform are greater than 2m/s on the bend and greater than 2.5m/s in the centre of the channel. The velocities approaching the existing wall from upstream reach as high as 3.34m/s. Observations from the site visit showed that upstream flowpaths tended towards the existing wall before slowing down and changing direction. In order to account for the upstream velocities and uncertainty in the model, it is important to consider a factor of safety in the design to ensure the proposed options are suitable for flows that could be encountered on site. Therefore a factor of safety of 2 will be applied to the flows adjacent to the development platform for this event. Therefore, the maximum design velocity is 4.04m/s.



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Project:	ELPM	Checked By:	Matt Bell	Date:	28.10.24
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ID	Measure	Green/Grey	Description	Location
1.01	Aquatic Vegetation	Green	Native plants living-in stream used to protect the toe of a riverbank by slowing flow velocities and providing root reinforcement.	In-channel at toe.
1.02	Coir Matting	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Slope
1.03	Coir Rolls	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Toe
1.04	Brushwood	Green	Tight bundles of small diameter willow bound together. Effective at providing protection to vulnerable river bank areas.	Embankment Toe
1.05	Stakes	Green	Typically cut from willow, stakes take root below ground and develop into a tree or bush. Used in combination with other measures to provide stability. Dead stakes are used to provide immediately effective stability but do not produce vegetation.	Embankment Toe
1.06	Vegetation	Green	Vegetation established on bare slopes to prevent superficial erosion. Typically used in conjunction with other measures.	Embankment Toe and Slope
1.07	Willow Spiling	Green	Live willow rods woven horizontally between vertical live willow stakes driven into the river bank.	Embankment Toe
1.08	Woody Material/Stream Barbs	Green	Sourced from felled trees and entered into the watercourse to provide stability and dissipate/deflect flows.	Embankment Toe
1.09	Timber Revetment	Green	Timber boards along toe held in place with stakes.	Embankment Toe
2.01	Geo Cell Systems	Green-Grey	Three-dimensional earth-retaining structures that can be expanded and backfilled with material to stabilise the bank surface.	Embankment
2.02	Vegetated Concrete Blocks	Green-Grey	Basket filled with stone/rocks used to retain bank at steep angles filled with soil and coir matting to allow vegetation growth.	Embankment
2.03	Vegetated Gabions	Green-Grey	Basket filled with stone/rocks used to retain bank at steep angles filled with soil and coir matting to allow vegetation growth.	Embankment
2.04	Vegetated Reinforced Earth	Green-Grey	Soft building material held in place with an interlocking plate, geotextile or natural woven fabric.	Embankment
2.05	Vegetated Reinforced Mattress	Green-Grey	Flexible mats that can be rolled out and fastened to the bank slope similar to coir matting but more robust.	Embankment.
2.06	Vegetated Rip Rap	Green-Grey	Layers of stone and/or boulders vegetated using poles, brush-layering or live-staking.	Embankment Toe and Slope
2.07	Vegetated Rock Rolls	Green-Grey	Rock rolls with established vegetation typically used at the toe of the bank	Embankment Toe
2.08	Retain Existing Wall	Green-Grey	Retain the existing structure and regrade embankment behind wall up to development platform.	Embankment
3.01	Geotextile	Grey	Permeable synthetic textiles used in contact with the soil to separate, filter, reinforce, protect, or drain.	Embankment Toe and Slope
3.02	Rock Rolls	Grey	Rock rolls are made of synthetic polyethylene filled with stone.	Embankment Toe
3.03	Gabion Basket	Grey	Modern gabion baskets are made of metal meshes that are filled with stones, gravels or pebbles. Sometimes, internal ballasts like concretes or sands are applied to maintain its stability.	Embankment
3.04	Steel Piling	Grey	They can be used to ensure water tightness, support, and stabilisation for development platform. Mechanically reinforcing the bank.	Embankment Toe and Slope
3.05	Rip-Rap	Grey	Collection of water-resistant rocks and stones placed along the river's edge. Rocks hold up the soil on the sides of the river, so it doesn't collapse under its weight or from the river's flow.	Embankment Toe

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ID	Measure	Green/Grey	Description	Location	Technical						Economic		Environmental	Social	Total
					Opportunities	Benefits	Constraints	Erosion Risk	Constructibility	H&S	Capitol cost	Maintenance			
1.01	Aquatic Vegetation	Green	Native plants living-in stream used to protect the toe of a riverbank by slowing flow velocities and providing root reinforcement.	In-channel at toe.	Establish native vegetation and enhance biodiversity of the site.	Carbon efficient in comparison to greyer engineering measures. Slows the flow and allows silt to build up, preventing further affects of erosion.	Not suitable for high bankside velocities or turbulent flow. Only suitable at this site in combination with other measures. Would require significant monitoring to ensure effectiveness. Max permissible velocity 2.4m/s. Max. bank slope 34°. Design life - In perpetuity.	0	1	0	1	-1	2	1	4
1.02	Coir Matting	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Slope	Establish native vegetation and enhance biodiversity of the site.	Carbon efficient in comparison to greyer engineering measures. Fully biodegradeable. Provides stability while vegetation takes hold.	Not suitable for high bankside velocities or turbulent flow. Only suitable at this site in combination with other measures. Would require significant monitoring to ensure effectiveness. Max permissible velocity 2.4m/s. Max. bank slope 45°. Design life - 3-5 years.	0	1	1	0	-1	2	1	4
1.03	Coir Rolls	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Toe	Establish native vegetation and enhance biodiversity of the site.	Carbon efficient in comparison to greyer engineering measures. Fully biodegradeable. Provides stability while vegetation takes hold. Rolls provide an element of stability as base while vegetation takes hold.	Not suitable for high bankside velocities or turbulent flow. Only suitable at this site in combination with other measures. Would require significant monitoring to ensure effectiveness. Max permissible velocity 1.8m/s. Max. bank slope 34°. Design life - 6-10 years.	-1	1	1	0	-1	2	1	3
1.04	Brushwood	Green	Tight bundles of small diameter willow bound together. Effective at providing protection to vulnerable river bank areas.	Embankment Toe	Natural option which promotes bank naturalisation.	Slows the flow and allows silt to build up, preventing further affects of erosion.	Not suitable for high bankside velocities or turbulent flow. Only suitable at this site in combination with other measures. Would require significant monitoring to ensure effectiveness. Max permissible velocity 2m/s. Max. bank slope 45°. Design life - 30-100 years.	-1	1	0	0	-1	1	0	0
1.05	Stakes	Green	Typically cut from willow, stakes take root below ground and develop into a tree or bush. Used in combination with other measures to provide stability. Dead stakes are used to provide immediately effective stability but do not produce vegetation.	Embankment Toe	Promote naturalisation if live stakes used.	Lower maintenance, carbon efficient compared to greyer structural options.	Required in combination with other measures. Max permissible velocity 1.5m/s. Max. bank slope 45°. Design life - 40-100 years.	-2	1	0	0	1	1	0	1
1.06	Vegetation	Green	Vegetation established on bare slopes to prevent superficial erosion. Typically used in conjunction with other measures.	Embankment Toe and Slope	Promote naturalisation.	Slows the flow and allows silt to build up, preventing further affects of erosion. Also protects against erosion from rainfall and surface water run-off.	Not suitable for high bankside velocities or turbulent flow. Only suitable at this site in combination with other measures. Would require significant monitoring to ensure effectiveness. Would require seasonal mowing/cutting and may require reseeded. Max permissible velocity 2.4m/s. Max. bank slope 34°. Design life - In perpetuity.	0	2	1	1	-1	2	1	6
1.07	Willow Spiling	Green	Live willow rods woven horizontally between vertical live willow stakes driven into the river bank.	Embankment Toe	Mud and silt is gradually deposited in and around the rough surface of the willow spiling, with the spreading willow roots stabilising the river bank and creating a natural wildlife habitat.	During Spring and Summer, these living willow rods and posts send out shoots and root into the river bank, hence holding the soil firm and protecting against erosion	Willow will take time to root and grow which might make it ineffective in the short term and at risk of detachment. Max permissible velocity 2.5m/s. Max. bank slope 84°. Design life - 40-100 years	-1	1	0	-1	0	1	0	0
1.08	Woody Material/Stream Barbs	Green	Sourced from felled trees and entered into the watercourse to provide stability and dissipate/deflect flows.	Embankment Toe	Woody material can be sourced from felled trees in the local area promoting reuse of material and acting as a carbon sink. Promote sediment deposition.	Lower maintenance, carbon efficient compared to greyer structural options. Interrupt flow and support longevity of solution.	Deflecting flows may have geomorphological impacts that require modelling. Not a structural solution for an embankment but can protect it. Required in combination with other measures.	-2	1	-1	1	1	1	1	2
1.09	Timber Revetment	Green	Timber boards along toe held in place with stakes.	Embankment Toe	Promote naturalisation if used in combination with live stakes.	Lower maintenance, carbon efficient compared to greyer structural options.	Required in combination with other measures. Max permissible velocity 2m/s. Max. bank slope 34°. Design life - In perpetuity.	0	1	0	0	-1	1	0	1
2.01	Geo Cell Systems	Green-Grey	Three-dimensional earth-retaining structures that can be expanded and backfilled with material to stabilise the bank surface.	Embankment	Provides opportunity for bank to become vegetated.	Can provide greater structural stability than greener measures while also allowing vegetation to take hold on the embankment.	Vegetation unlikely to add to strength of the structure. Unlikely to be suitable on steeper slopes. Max permissible velocity 4m/s. Max. bank slope 60°. Design life - 5-20 years	2	0	0	-1	-1	0	0	0
2.02	Vegetated Concrete Blocks	Green-Grey	Concrete blocks used to retain bank at steep angles with soil-filled voids allowing vegetation growth.	Embankment	Restore element of biodiversity along eroded bank. Can become totally covered in vegetation	Can be stacked at steep angles. Can become totally covered in vegetation.	Risk of washout to green material. Filling voids with soil may have impacts on energy dissipated by the structure. Vegetation unlikely to add to strength of the structure. Max permissible velocity 4.1m/s. Max. bank slope 34°. Design life - 50 years.	2	1	1	-1	-1	0	0	2
2.03	Vegetated Gabions	Green-Grey	Basket filled with stone/rocks used to retain bank at steep angles filled with soil and coir matting to allow vegetation growth.	Embankment	Restore element of biodiversity along eroded bank. Can become totally covered in vegetation	Can be stacked at steep angles. Can become totally covered in vegetation.	Risk of washout to green material. Filling voids with soil may have impacts on energy dissipated by the structure. Vegetation unlikely to add to strength of the structure. Max permissible velocity 4.5m/s. Design life - 15 years.	2	1	1	-2	-1	0	0	1

2.04	Vegetated Reinforced Earth	Green-Grey	Soft building material held in place with an interlocking plate, geotextile or natural woven fabric.	Embankment	Provides structural support while also including opportunity for vegetation.	Conforms to obstacles so may be suitable for working around existing features.	Strength develops over time so may be more vulnerable to flood events shortly after installation. Max permissible velocity 3.3m/s. Max. bank slope 90°. Design life - greater than 10 years.	1	1	1	-1	0	0	0	2
2.05	Vegetated Reinforced Mattress	Green-Grey	Flexible mats that can be rolled out and fastened to the bank slope similar to coir matting but more robust.	Embankment.	Vegetation can cover hard engineered parts to recreate a greener bank.	Resist fluvial shear stress and turbulent forces of traction and uplift. Easy installation can be rolled out and pinned down.	Risk of washout to green material. Filling voids with soil may have impacts on energy dissipated by the structure. Not as much energy dissipation as gabion baskets. Max permissible velocity 4.2m/s. Max. bank slope 45°. Design life - 5-50 years.	2	1	-1	-1	-1	0	0	0
2.06	Vegetated Rip Rap	Green-Grey	Layers of stone and/or boulders vegetated using poles, brush-layering or live-staking.	Embankment Toe and Slope	Can used locally sourced or repurposed stones or boulders.	Increases stability of the bank/toe while simultaneously establishing riparian growth within the rock revetment.	Risk of washout to green material. Filling voids with soil may have impacts on energy dissipated by the structure. Not as much energy dissipation as gabion baskets. Max permissible velocity 3.4m/s. Max. bank slope 34°. Design life - In perpetuity.	1	0	0	-1	-1	0	0	-1
2.07	Vegetated Rock Rolls	Green-Grey	Rock rolls with established vegetation typically used at the toe of the bank	Embankment Toe	Vegetation can cover hard engineered parts to recreate a greener bank.	Easy installation can be rolled out and pinned down.	Risk of washout to green material. Filling voids with soil may have impacts on energy dissipated by the structure. Not as much energy dissipation as gabion baskets. Used in combination with other measures. Max permissible velocity 4m/s. Max. bank slope 90°. Design life - In perpetuity.	2	1	1	0	0	0	0	4
2.08	Retain Existing Wall	Green-Grey	Retain the existing structure and regrade embankment behind wall up to development platform.	Embankment	Maintain existing wall which avoids or minimises in-channel works. More opportunity to retain existing vegetation and localised habitat.	Maintain existing wall which avoids or minimises in-channel works. More opportunity to retain existing vegetation and localised habitat.	Subject to structural investigation of wall. May require maintenance works.	1	1	1	1	-1	0	0	3
3.01	Geotextile	Grey	Permeable synthetic textiles used in contact with the soil to separate, filter, reinforce, protect, or drain.	Embankment Toe and Slope	No opportunities.	Easy installation. Longer lifespan than biodegradable alternatives.	Synthetic material and no opportunity for naturalisation. Max permissible velocity 4m/s. Max. bank slope 34°. Design life - 50 years.	2	1	-1	-1	-1	-2	0	-2
3.02	Rock Rolls	Grey	Rock rolls are made of synthetic polyethylene filled with stone.	Embankment Toe	Vegetation can eventually colonise the rock rolls when sediment is captured.	Easy installation. Promotes sediment deposition and can allow vegetation to establish.	Only effective in combination with other measures. Max permissible velocity 4m/s. Max. bank slope N/A. Design life - In perpetuity.	2	1	1	-1	-1	-1	0	1
3.03	Gabion Basket	Grey	Modern gabion baskets are made of metal meshes that are filled with stones, gravels or pebbles. Sometimes, internal ballasts like concretes or sands are applied to maintain its stability.	Embankment	Effective solution at areas where the options are constrained by space.	Resist fluvial shear stress and turbulent forces of traction and uplift. Better at dissipating energy compared to green option. Can be stacked at steep angles. Flexibility and durability.	Typically more expensive than alternatives. Limited opportunity for establishment of vegetation. Max permissible velocity 2m/s. Max. bank slope 34°. Design life - In perpetuity.	2	1	1	-2	-1	-2	0	-1
3.04	Steel Piling	Grey	They can be used to ensure water tightness, support, and stabilisation for development platform. Mechanically reinforcing the bank.	Embankment Toe and Slope	Effective solution at areas where options are constrained by available space.	Long lifespan and can be implemented relatively quickly.	Typically more expensive than alternatives. Limited opportunity for establishment of vegetation.	2	1	1	-2	-1	-2	0	-1
3.05	Rip-Rap	Grey	Collection of water-resistant rocks and stones placed along the river's edge. Rocks hold up the soil on the sides of the river, so it doesn't collapse under its weight or from the river's flow.	Embankment Toe	Can used locally sourced or repurposed stones or boulders.	Long lifespan and can be implemented relatively quickly.	Limited opportunity for establishment of vegetation. Max permissible velocity 3.4m/s. Max. bank slope 34°. Design life - In perpetuity.	2	1	1	-1	-1	-1	0	1



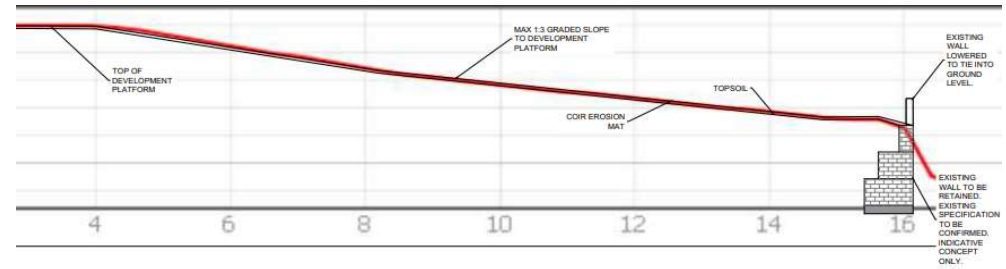
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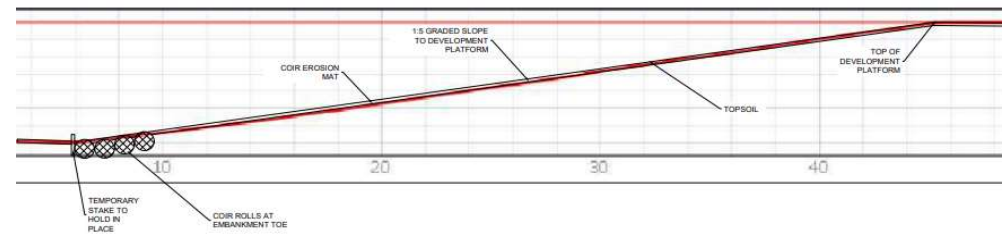
ID	Measure	Green/Grey	Description	Location	Score	Comments	
1.01	Aquatic Vegetation	Green	Native plants living-in stream used to protect the toe of a riverbank by slowing flow velocities and providing root reinforcement.	In-channel at toe.	4	Opportunity to install in riparian zone in channel following completion of works. Helps create friction to alleviate energy of river flows	
1.02	Coir Matting	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Slope	4	Can be used to during the reprofiling of the slope to provide erosion protection until vegetations takes hold. Will replace wall in sections providing betterment.	
1.03	Coir Rolls	Green	Biodegradable coconut fibres used to provide stability and vegetation rooting base. Require anchoring (often with stakes). Can be used to hold reprofiled bank material in place.	Embankment Toe	3	Can be used at the toe of the embankment to allow for easy installation within the river. Provides erosion protection until vegetation takes hold. Will replace wall in sections providing betterment.	
1.06	Vegetation	Green	Vegetation established on bare slopes to prevent superficial erosion. Typically used in conjunction with other measures.	Embankment Toe and Slope	6	Opportunity to install native species on embankment with floodplain.	
2.08	Retain Existing Wall	Green-Grey	Retain the existing structure and regrade embankment behind wall up to development platform.	Embankment	3	Maintain existing wall which avoids or minimises in-channel works. More opportunity to retain existing vegetation and localised habitat. Subject to structural investigation of wall. May require maintenance works.	

Option	Options IDs	Option description	Appraisal	Preferred Option
Option 1 - Do Nothing		Leave the site as is and use the existing wall to provide the defence for the new development platform.	Removal of existing wall presents opportunity for naturalisation of some sections along the watercourse. Existing wall would need structural inspection to ensure it is in suitable condition for the development. Visual inspection suggests that it likely unsuitable and therefore this is not considered a suitable options.	Do nothing is not suitable as works are required to facilitate the proposed development. Do not take forward.
Option 2 - Do Minimum		Do minimum to maximise the residual life of the existing wall and banks, additional work to make them permanent.	Removal of existing wall presents opportunity for naturalisation. Existing wall would likely need significant repair to provide required structural support for the development platform. Maintenance of existing vegetation and banks present opportunities for social and environment enhancements.	Investigation will be required to understand if retaining the wall is suitable.
Option 3 - Green Engineering Option	1.01, 1.02, 1.03, 1.06, 1.09	Use green options in the development of the platform.	Has significant environmental, social and cost benefits in comparison to grey engineering measures. Due to velocities anticipated in flood event green measures are not suitable across all location and would not provide required level protection from flood and erosion. Green measures are suitable where the velocities are lower. There is also space constraints immediately adjacent to the channel which measures green measures are not suitable,	Green options provide environmental and social enhancements but are unsuitable across the entire site due to the technical constraints.
Option 4 - Combination of Green/Grey Engineering Options	1.01, 1.02, 1.03, 1.06, 3.03, 3.05	Replace the existing wall with green/grey or grey where the velocities are high and there is constrained space. In areas of lower velocity with less space constraints use greener measures.	Due to velocities anticipated in flood event green measures are not suitable across all location and would not provide required level protection from flood and erosion. Green measures are suitable where the velocities are lower and green/grey or green measures are required where the the velocities are higher and there are space constraints which limit which options can be utilised.	Utilising a mix of green and grey options meets the technical requirements for the site while also providing social and environmental benefits where possible/mitigating impact of grey measures. Preferred option.
Option 5 - Grey Engineering Option	3.02, 3.03, 3.05	Use grey measures across the entire platform.	This option does not take advantage of the potential for green measures and environmental enhancements. Would likely lead to an overengineered solution because green measures are likely to be suitable in some locations.	There is scope to provide green and green/grey measures at the site and therefore a sole grey option is not considered.

Preferred Option	Measure IDs	Measure Description
Option 2/3 - Combination of retaining existing wall and using soft engineered embankments.	1.01 - Aquatic Vegetation	Establish native aquatic vegetation in channel at toe of embankment and enhance biodiversity of the site. Slows the flow and allows silt to build up, preventing further affects of erosion.
	1.02 - Coir Rolls	Coir rolls used at the base of the embankment slope. Provides stability while allowing native vegetation to establish and can enhance biodiversity of the site. Carbon efficient in comparison to greyer engineering measures. Fully biodegradeable. Will replace existing wall in some sections to provide a betterment on the current condition.
	1.03 - Coir Matting	Coir matting used on the embankment slope. Provides stability while allowing native vegetation to establish and can enhance biodiversity of the site. Carbon efficient in comparison to greyer engineering measures. Fully biodegradeable. Will replace existing wall in some sections to provide a betterment on the current condition.
	1.06 - Vegetation	Promote naturalisation and slows the flow and allows silt to build up, preventing further affects of erosion.
	2.08 - Retain Existing Wall	Following EA consultation it is proposed to retain existing wall. Subject to structural investigation.



SECTION 1: RETAINED WALL WITH SOFT ENGINEERED REGRADED 1:3 EMBANKMENT



SECTION 2: SOFT ENGINEERED EMBANKMENT WITH 1:5 GRADING