

## Appendix A Levee Options

**WAGGA WAGGA LEVEE UPGRADE  
OPTIONS STUDY**

Levee	Existing Levee	Raising Required (m)	Flood Issues	Limitations	Upgrade Option(s)
<b>Main</b>	<b>Sept 2010 100yr flood + 900mm freeboard</b>				
0 - 1140	Uniform embankment levee. Levee height 2 m. Crest width 3 m Levee generally well formed, batters 2-2.5:1 slopes (minor oversteep)	0		Ch 750-1000 located between river bank and industry complex including large building close to levee.	No levee raising required. Minor "gravel to crest" works.
1140-1320	Uniform embankment levee. Levee height 2 m. Crest width 2-2.5 m Levee generally well formed, batters 3-4:1 slopes	0.2		Ch 1000-1320 located in open paddock	Ch 1000-1320. Embankment raised on centreline/inside to retain outer batter and limit works to inside batter.
1320-1340	Flowerdale Road crossing of levee.	0		Road access to be maintained	As road is above DCL, no closure required.
1340-1830	Embankment levee from Flowerdale Road to Ch 1840. Crest width 2.5-4 metres. Levee height 1.5-2 metres. Levee generally well formed, batters 3:1 inside, 2:1 outside Local access road crosses levee at Ch 1730	0.2		Ch 1350-1540 adjacent to open industrial yard with stored construction materials. Also materials stockpiled outside of levee Buildings close to levee (inside) Ch 1540-1640 Local access road across levee at Ch 1730 to be maintained.	Embankment levee raised close to centreline - Ch 1750-1820 to avoid trees on outside. Embankment levee raised on centreline/outside - Ch 1350-1540 to minimise major inner batter works. Slight re-alignment (Ch 1620-1730) to utilise high ground. Steeper 3.5:1 outer batter (Ch1560-1620) to limit extent of outer batter.
1830-2200	Olympic Highway crossing. (Ch 2050-2160)	0		Major highway, above DCL.	No levee required.
2200-2550	Embankment levee, uniform batters and well grassed Crest width 2.5 metres. Levee height 2.5 metres. Local access road crosses levee at Ch 2410, creating 0.2m low point	0.15		Nil	Raise crest only, with gravel "top-up" - max 200mm. Raise access crossing - minor earthworks plus gravel topping.
2550-2760	Embankment levee, uniform batters and well grassed Crest width 2.5 metres. Levee height 2.5 metres.	0.25		Internal batter close to transport yard. Very minor raising required. Avoid impact on well formed/grassed batters as a standard levee will require significant works.	Raise crest only, with sheet pile support wall to retain impact of works.
2760-2970	Embankment levee, uniform batters and well grassed Crest width 2.5 metres. Levee height 2.5 metres.	0		Nil	No levee raising required. Minor "gravel to crest" works.
2970-3130	Embankment levee, uniform batters and well grassed Crest width 2.5 metres. Levee height 2.5 metres.	0.4		Internal batter close to transport yard.	Embankment levee raised on centreline/outside to minimise impact/works on inside. Provide steeper outer batter (3.5:1) to minimise earthworks
3130-3150	Billagha Street crossing	0.6		Minor Road. Access no longer required (Ref WWCC)	Continue levee, with no ramps.
3150-3190	Short raised "mound" adjacent to road crossing, plus small "strip mound" in golf course (behind green)	0.5			At Ch 3160 (into golf course) expand existing "strip mound" at back of putting green and extend into high ground as embankment levee, with some landscaping. Provide 4:1 batters on both sides of levee.
3190-3500	Area of general filling, very flat batters, at golf course	0		Foundations to be evaluated, however wide foundation area is likely to compensate for any deficiencies	Terminate embankment levee into raised golf course at each end of section (Ch 3220 and Ch 3480). No levee required between Ch 3220 - 3480.
3480-4000	Area of general filling (150-200 m wide), approx 1 m above dwellings	1.0-1.5		Foundations to be evaluated, however wide foundation area is likely to compensate for any deficiencies	Embankment levee on centreline, possibly with flat batters to suit surroundings, but minimise impact on trees on outside.
4000-4030	Narrung Street crossing (above design flood level) Street formation raised to cross levee at levee crest level.	0.9		Road access to be maintained Significant cost to raise road.	As road is above DFL, leave open and use temporary closure as needed. No headwalls at levee, only batter to surface.
4030-4200	Embankment levee beside Narrung Street Crest width 3 metres. Levee height 2.5 metres. Flat, well formed internal batter (4:1) with inner toe at street formation.	1.1		Narrung Street formation - levee toe to be fixed at current location Impact on trees near outer batter, and walking track, to be minimised. External batter is steep.	Embankment levee raised on centreline/inside but needs to be steeper (than current) inner batter. Raising designed is to protect outer area trees and walking track. Sheet pile provided at crest and trim outer batter, to 3.5:1, to improve stability and erosion resistance.

	Steeper outer batter (2.5:1) with walking track before tree lined river bank.				
4220-4260	Olympic Highway crossing	0	Major highway, above design flood level.	No levee required.	
4260-4380	Low embankment included in terraced, landscaped fill.	0.9	Need to preserve landscaped area  Need to avoid small sub-station and possible underground services	Embankment raising in sympathy with landscaping, to include flat batters, on inside. Finish levee into high road/bridge embankment before bridge. Trim outer batter to 4:1 slope.	
4380-4400	Timber bridge access ramp	0	Access ramp, above DCL.	No levee required.	
4400-4460	Low embankment levee Crest width 3 metres. Levee height 1-1.5 metres.	0.8	Many trees close to outer batter Car park close to levee Ch 4410-4440	Sheet pile wall, excavate/trim inner batter to create additional space	
4460-4860	Large concrete retaining wall forms inside face of levee  Crest width 3 metres. Levee height 2 metres. Steep river bank and a number of large trees on bank.	0.6	Cadell PI roadway on immediate inside of retaining wall  Large trees along river bank at outer toe of levee Conventional outer batter will extend into river.	Raise concrete retaining wall, maintain external batter/crest in current form. Minor trimming possible.	
4860-5070	Embankment levee Crest width 3 metres. Levee height 2-3 metres.  Concrete pathway on crest of levee	0.6	River bank in proximity to levee Block of units close to levee (inside) Ch 4880-4940  Powerlines at inside toe Dense trees at outer toe	Embankment levee raised on inside and outer batter trimming May need to provide partial retaining wall (eg timber) in upper embankment outer batter, to minimise "footprint" Provide both sides wall (box culvert ?) at block of flats Ch 4880-4940	
5070-5220	Embankment levee  Crest width 2.5 metres. Levee height 1.5-2 metres. Concrete pathway on crest of levee	0.7	Development near inside of levee  Few large trees close to toe, but wide area at toe for levee works Adjacent to Wagga beach.	Embankment levee raised on centreline + upper wall on outer batter to limit encroachment onto beach	
5220-5240	Johnston Street road crossing	1.65	Road access to be maintained Significant road. Costly to raise roads.	Floodgate + headwalls at each end at adjacent levee	
5240-5405	Concrete retaining wall	0.55	Existing wall design details to be confirmed Development on either side of wall limits scope for works, especially beside Johnston Street	Raise concrete wall (dowelling + raised wall section)	
5405-5460	No levee. Apparent high ground behind levee alignment.	0	No survey. Likely levee not required, but need detail survey to confirm.	May need to extend retaining wall from Ch 5240-5405 section Possible small embankment levee &/or landscaping	
5460-5550	No levee. Apparent high ground behind levee alignment.	0	No survey. Likely levee not required, but need detail survey to confirm.	No levee	
5550-6000	Embankment levee leading into high ground at church. Crest width 3 metres. Levee height 2 metres.	0.7	Significant stand of trees at outer toe of levee Walking track between outer levee toe and "well-treed" river bank  Keep away from river bank if possible, as parts are steep. Large trees, near inside toe of levee, towards church (Ch 5550-5650)	Embankment levee raised on centreline/inside May need to provide partial retaining wall (eg timber) in upper embankment batter, to minimise "footprint"	
6000-6560	Stabilising rock armour placed along river bank  Steep river side levee batter Narrow crest width (2 m). Levee height 2-3m Inside levee batter moderate/steep slope	0.6	Limited space caused by river bank and motel (ie both sides)  Space available on outer walking track, south of motel.	Embankment levee raised on outside (Ch 6320-6480) and inside (Ch 6000-6320, 6480-6560). May need to trim and flatten batters and include retaining walls (timber-outside, crib walls-inside) to fit available space and provide access.	
6560-6850	Embankment levee from railway bridge to Bentley Close Crest width 2.5m, levee height 3 m  Outer toe at tree line, inner toe close along sealed road (Reddoch Drive)	0.7	Reddoch Drive near inside toe Trees at outer toe of levee - need to remove some  May require steeper outer batter to minimise tree loss. Power line clearance and pole in embankment.	Embankment levee raised on centreline along Reddoch Dr + Provide partial retaining wall (eg timber) in upper embankment batter, to minimise "footprint" + Provide steeper outer embankment batter to minimise "footprint"	
6850-6870	Railway crossing	0.6	Rail access to be maintained	Floodgate + headwalls at each end at adjacent levee	
6870-7240	Embankment levee from end of concrete wall to railway bridge. Inner toe of embankment very close to property Ch 7000-7100.	0.5	Power lines to be addressed Private property at toe of levee (inside) ch 7000-7100	Embankment levee raised on centreline/inside (at ends) If space critical, provide partial retaining wall (eg timber) in upper (outer) embankment batter.	

	Inner toe for Ch 6900-7000, space available Track provides space for outer batter extension, some trees in levee.				
7240-7300	Concrete walls on both batters. Inner wall well above DFL	0		Retaining wall stability (check damaged buttress section)	No works - confirm retaining wall stability
7300-7620	Embankment levee beside Marshall's Creek Access track between outer levee toe and "treed" creek bank.  Steep inner batters Levee 2-3 metres high, crest 2.5-5 metres wide.	0.5		3-4 m space available either side of embankment Electrical sub-station along inner toe (3-4 m space)  Creek bank on outer toe (3-4 m space) Small number of trees to be removed near levee.	Embankment levee raised on inside. Outside track on crest of levee If space (on outside) critical, partial retaining wall (eg timber) in upper outer embankment batter.
7620-7660	Hammond Ave crossing.	2.3		Significant road/bridge crossing. Costly to raise road/bridge.	Floodgate + headwalls at each end at adjacent levee
7660-8180	Embankment levee beside Marshall's Creek  Large drainage channel on inside near toe of levee (3m bench) Significant levee (height 3-4m), crest width 3m  Adjacent creek bank well timbered.	0.5		Channel on inside  Tree lined creek bank on outside Cycleway on outside (to be re-located)	Embankment levee raised on centreline/inside to avoid most trees and outer batter 3.5:1. Locate inside toe to avoid channel Cycleway to be relocated (crest of levee ?) If space (on outside) critical, provide partial retaining wall (eg timber) in upper outer embankment batter.
8180-8340	Embankment levee, adjacent (on inside) of Koorringal Road and cycleway  Deep excavation for drainage channel on inside. Levee internal batter partly excavated for access ramp Crest width 3 m Leve height 2.5 m	0.5		Deep drainage channel on inside  Cycleway on outside (to be re-located) Koorringal Road on outside of cycleway	Embankment levee on inside with fill over access track, but avoid channel. 3.5:1 outer topsoil batter Embankment levee on outside. 3.5:1 outer batter (clay fill + topsoil)
8340-8380	Copland St/Koorringal Rd round-about	1.9		Significant roads and intersection. Costly to raise roads.	Floodgate + headwalls at end of adjacent levee
8380-8800	Railway crossing to Copland Street Embankment levee, adjacent (on inside) of Koorringal Road and cycleway Crest width 3 m	0.6		Cycleway (minor concern) Power lines along Koorringal Road	Embankment levee raised on inside Embankment levee raised on centreline
8800-end	No levee	0-0.6		Avoid major encroachment into cemetery  Avoid major power poles.	Embankment levee on continued alignment (beside road) to high ground
<b>North</b>	<b>Sept 2010 20yr flood + 750mm freeboard</b>				
Ch 0 - 540	Low embankment levee on outside of Hampden Avenue	0.3		Line of trees on outside  Street formation on inside	Embankment levee on centreline/inside to minimise impact on trees plus avoid street formation
Ch 540 - 620	Road crossing	1	Road below DFL	Road access to be maintained Significant road. Costly to raise road.	Barrier required (proprietary item, gates) as road below DFL Alternative is to raise road by approximately 0.25 metres and use temporary filling (fill, sandbags) as needed for freeboard.
Ch 620 - 1380	Low embankment levee outside Gardiner Street	0.8		Street formation on inside	Embankment levee on centreline/inside to minimise earthworks plus avoid street formation. Toe of new levee to be within inner toe of existing levee.
Ch 1380 - 1835	Low embankment levee outside Gardiner Street	0.5		Street on inside, trees on outside, close at Ch 1400-1640.	Embankment levee on centreline/inside to minimise earthworks plus avoid street formation. Toe of new levee to be within inner toe of existing levee.
Ch 1835 - 1855	Road crossing (Gardiner Street)	0.6	Road above DFL	Road access to be maintained Significant road. Costly to raise road.	Provide temporary barrier (earthfill, sandbags) for freeboard only.
Ch 1855 - 2080	Embankment levee	0.5		Some trees near inside toe of levee	Embankment levee to remain within inside toe of existing levee.
Ch 2080 - 2100	Road crossing (Fuller St.)	0.6	Road above DFL	Road access to be maintained Significant road. Costly to raise road.	Provide temporary barrier (earthfill, sandbags) for freeboard only.
Ch 2100 - 2300	Embankment levee, adjacent to Marah St  Crest width 3 - 3.5 m	0.7		Private property (fenced) on outside. Some trees near fence  Marah Street and table drain on inside	Embankment levee to avoid street formation (pavement and table drain) and minimise impact on private property. Embankment levee to remain within inside toe of existing levee.

Ch 2300 - 2820	Embankment levee, adjacent to Marah St on inside  Crest width 3 - 3.5 m	0.7		Private property (fenced) on outside. Some close trees near fence  Marah Street and table drain on inside	Embankment levee to avoid street formation (pavement and table drain) and minimise impact on private property. Embankment levee to remain within inside toe of existing levee.
Ch 2820 - 3000	Embankment levee in paddock beside Dunn Street. Crest width 3 m	0.7		Fence on inside	Embankment levee on centreline to avoid works at inside toe area.
Ch 3000 - 3080	Embankment levee in paddock. Crest width 3.5 m	0.7		Fence on inside	Embankment levee on centreline
Ch 3080 - 3150	No levee. Earthfill mound above design level	0		Geotechnical investigation to confirm materials	No levee.
Ch 3150 - 3215	Embankment levee.	0.7			Embankment levee on centreline
Ch 3215 - 3240	Road crossing (Hampden Avenue)	0.75	Road at DFL	Road access to be maintained Significant road. Costly to raise road.	Provide temporary barrier (earthfill, sandbags) for freeboard only.
Ch 3240 - 3680	Embankment levee in paddock	0.75		Trees on inside Ch 3530-3620	Embankment levee raised on centreline, but inside at Ch 3250-3350
Ch 3680 - 3700	Road crossing (Mill Street)	0.9	Road below DFL	Road access to be maintained Significant road. Costly to raise road.	Barrier required (proprietary item, gates) as road below DFL Alternative is to raise road by approximately 0.25 metres and use temporary filling (fill, sandbags) as needed for freeboard.
Ch 3700 - 3915	Embankment levee	0.5		Development on outside Ch 3850-3920	Embankment levee raised on inside to minimise earthworks
Ch 3915 - 3935	Road crossing (Marah Street)	0.8	Road below DFL	Road access to be maintained Significant road. Costly to raise road.	Barrier required (proprietary item, gates) as road below DFL Alternative is to raise road by approximately 0.15 metres and use temporary filling (fill, sandbags) as needed for freeboard.
Ch 3935 - 4140	Embankment levee in open paddock	0.5		Development on inside Ch 3940-3985	Embankment raised on centreline Ch 3940-3985, on outside at Ch 4100 (to avoid tre) and remainder on inside.
Ch 4140 - 4374	Embankment levee in proximity to Lagoon	0.3		Bank of lagoon (heavily treed)  Hampden Avenue formation	Embankment raised on inside to avoid lagoon banks/trees plus produce minimum eathworks.
<b>Bank Two</b>	<b>Sept 2010 20yr flood + 750mm freeboard</b>				
Ch 000 - 025	Road crossing	0.75	Road at DFL	Road access to be maintained Significant road. Costly to raise road.	Provide temporary barrier (earthfill, sandbags) for freeboard only.
Ch 025 - 255	Embankment levee on outside of Mill Street.  Crest width 3 m.	0.8		Mill Street and drainage near inside toe.  Fence/tree line near outside toe.	Embankment raised on centreline/outside to avoid street formation. Trees, on outside, need to be removed.
Ch 255 - 284	Road crossing	1.0	Road below DFL	Road access to be maintained	Barrier required (proprietary item, gates) as road below DFL Alternative is to raise road by approximately 0.25 metres and use temporary filling (fill, sandbags) as needed for freeboard.
Ch 284 - 738	Embankment levee on outside of East Street. Crest width 2.5 - 3 m.	1.0		Table drain separates sealed road (East St) and levee toe. Fence on outside near toe. Partly tree lined near outside	Embankment raised on centreline/outside to avoid road formation.
Ch 738 - 755	Road crossing	1.4	Road below DFL	Road access to be maintained	Barrier required (proprietary item, gates) as road below DFL Alternative is to raise road by approximately 0.65 metres and use temporary filling (fill, sandbags) as needed for freeboard.
Ch 760 - 820	No levee	1.1		No space constraints	Embankment levee
Ch 820 - 1150	Embankment levee. Crest width 2.5 - 3 m.	0.9		Raise on the centreline or outside to keep away from property	Embankment raised on centreline/outside
Ch 1150 - 1300	Embankment levee. Crest width 3 m.	0.8		Raise on the centreline or outside to keep away from property	Embankment raised on centreline/outside
Ch 1300 - 1361	Embankment levee. Wide crest 4 m wide.	0.8		Raise on the centreline or outside to keep away from property	Embankment raised on centreline/outside. At end of section, ramp down to road.