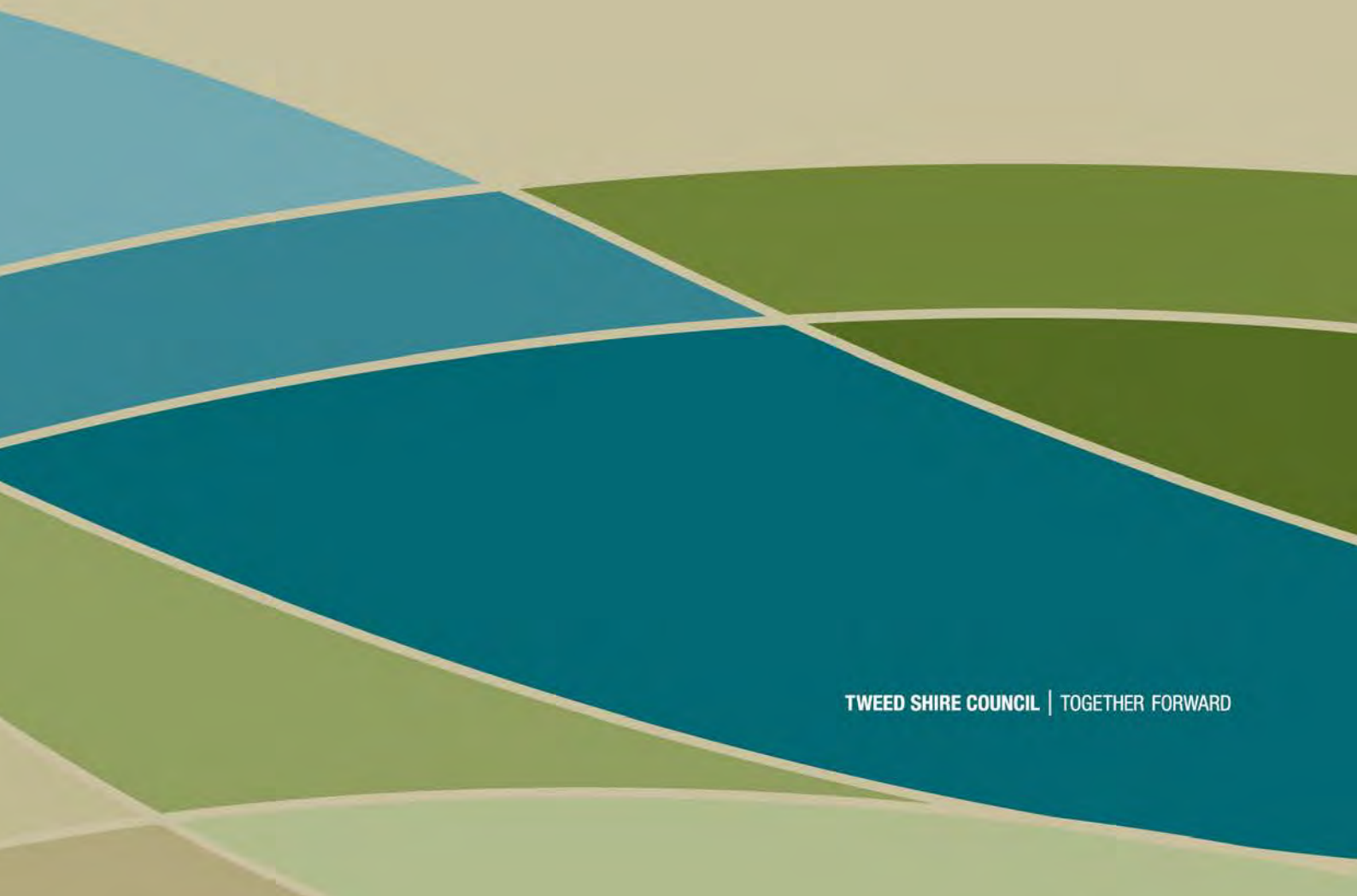
TWEED SHIRE COUNCIL

Tweed River Bank Erosion Management Plan 2014



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Executive Summary

The purpose of the Tweed River Estuary Bank Management Plan 2014 is to provide a schedule of works to stabilise river bank erosion on public land (to be undertaken by Council), as well as updated design advice for works required on private land.

The plan has been developed based on the following principals:

- Environmental values of the riparian environment will be protected and enhanced.
- High value public infrastructure and public open space will be protected.
- The visual and recreational amenity of the river environment will be protected and enhanced.
- Where practical, vulnerable river banks will be managed to increase their resilience to erosion through pre-emptive erosion management.

The severity of river bank erosion in the Tweed estuary varies considerably, however overall, the scale of the problem is large.

River reaches with the most severe and continuous bank erosion are located between Murwillumbah and Stott's Island, primarily adjacent to the Tweed Valley Way and Tumbulgum Road. Within this river reach, erosion is predominantly impacting on road reserve, as opposed to private land or public open space.

The range of bank stability conditions have been mapped to inform the preparation of this management plan.

Erosion risk	**Severe/high risk**	**Vulnerable**	**Generally Stable**
Length of bank: (Bray Park Weir to Stott's Island both banks combined = 35,855m)	9,207m	10,381m	16,267m

It is estimated that there is 5754 metres of roadway within the priority reach that is at risk of being affected by bank slips within the next five to ten years. At an estimated cost of $1500 per lineal metre to stabilise river bank erosion (based on the average cost per metre rate of erosion stabilisation work recently undertaken by Council), the total cost to stabilise severe erosion adjacent to roads could be as much as $9,000,000 over ten years. Maintenance costs would add to this figure.

Bank lengths over which various approaches to riverbank stabilisation could occur are as follows:

- Revegetation 15,863m
- Pre-emptive bioengineered stabilisation works 4,668m
- Structural protection - up to 5,754m.

Individual sites where revegetation and pre-emptive erosion stabilisation works could/should occur have been prioritised. These sites are all on public land, however site access and project design would in many cases require consultation with adjacent landowners.

Council is faced with a major challenge in funding the stabilisation of river bank erosion, and in dealing with erosion without seriously compromising the environmental and amenity values of the Tweed River. Funding models which allow Council to address problem areas **before** they present a critical risk to road stability and community safety must be found.

Any further work to stabilise river bank erosion in the Tweed River must be designed to minimise environmental impacts and maximise potential for incorporation of, or colonisation by, riparian vegetation. Increasing the resilience of river banks through revegetation, and maximising existing habitat values will be an important part of offsetting the ongoing negative impacts of large structural erosion stabilisation projects.

1.0 Introduction

The purpose of the Tweed River Estuary Bank Management Plan 2013 is to provide an update of the recommendations of the Tweed River Estuary Bank Management Plan prepared for Council in 1998 by Patterson Britton and Partners, (Patterson Britton and Partners, 1998). This report does not seek to comprehensively replace or supersede the Patterson Britton report.

This report is informed by the findings of (Patterson Britton and Partners, 1998), as well as an investigation into river bank erosion prepared in 2012 by SMEC, the Impact of Wake on Tweed River Bank Erosion Study, (SMEC, 2012). The report is constrained to the estuarine part of the main Tweed River, from Bray Park Weir to Fingal Head. The upper catchment, Rous River and Terranora Creek have not been included, as erosion in these systems is significantly different in character and scale to the main estuary.

This report does not include a comprehensive analysis of the **causes** of erosion. This report makes recommendations on stabilising bank erosion, and includes a proposed schedule of works for public land (to be undertaken by Council), as well as updated design advice for works proposed on private land.

Information contained in (Patterson Britton and Partners, 1998) is still current and relevant with respect to the major hydraulic and geomorphological forces acting on the Tweed River, which either cause or exacerbate river bank erosion. This document should be referred to for detailed advice on the primary forces causing erosion within specific reaches of the Tweed River Estuary. It can be stated with certainty that erosion is variable in both space and time, and that there is no single force or problem solely to blame for bank erosion in the Tweed River.

The Impact of wake on Tweed River Bank Erosion Study (SMEC, 2012) aimed to determine the potential impacts of vessel wake on river bank erosion within the Tweed River Estuary. The SMEC study provides information that can be considered by Council and the NSW Department of Roads and Maritime Services for possible implementation to reduce the impact of vessel operation on river bank erosion.

This plan does not address vessel wake or provide management recommendations for vessels. The issue of vessel wake induced erosion and potential options for management of this issue are contained in a separate report to Tweed Shire Council entitled 'Wake Impact on River Bank Erosion - Council Options for Management'. This report was considered on 17 October 2013 and resulted in the adoption of a series of recommendations. This report and its recommendations are included as Appendix 1 to this Management Plan.

1.1 Management Aims

Tweed River bank erosion will be managed in accordance with the following aims:

- Environmental values of the aquatic and riparian environment will be protected and enhanced.
- High value public infrastructure and public open space will be protected.
- The visual and recreational amenity of the river environment will be protected and enhanced.
- Where practical, vulnerable river banks will be managed to increase their resilience to erosion through implementation of bio-engineered approaches that incorporate erosion resistant materials and enhance vegetation growth.

1.2 Objectives

The objectives of this Plan are to:

1. Provide an updated classification of bank erosion severity within the Tweed Estuary, from the Bray Park Weir to Fingal Head.
2. Provide a prioritised schedule of river bank erosion stabilisation works to be implemented by Tweed Shire Council on public land.
3. Provide preferred design options for river bank stabilisation works in the Tweed River, with a focus on revegetation and bio-engineered design that maximise ecological and amenity values.
4. Provide updated advice to private landowners who wish to undertake river bank erosion stabilisation works on aspects of design and the statutory and environmental approvals process.

2.0 Tweed River Bank Erosion

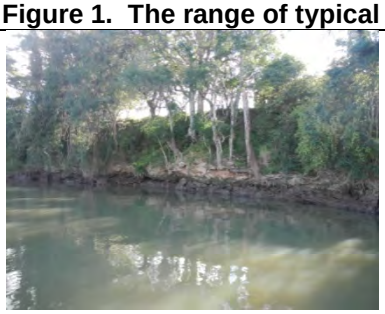
2.1 Causes of River Bank Erosion

The scale and severity of river bank erosion in the Tweed estuary varies from site to site, depending on a range of natural and anthropogenic factors including:

- Height of the river bank
- Bank position within the meander and shoal pattern of the river
- Frequency and intensity of vessel wake wave creation
- Recent flood severity
- Presence and condition of natural vegetation, at bank toe and top of bank
- Erosion resistance of river bank material
- Presence and condition of bank armouring
- Adjacent land use

A series of photos of river bank condition, ranging from stable to highly eroded, are included below to provide an overview of the range of typical Tweed River estuary bank characteristics.

Figure 1. The range of typical bank stability conditions.

		
Stable bank with bedrock toe, upper estuary.	Eroding bank adjacent to farmland, up-stream of Murwillumbah.	Stable bank, with poor riparian vegetation, adjacent to grazing land upstream of Murwillumbah.
		
Failing private revetment structure, Murwillumbah.	Erosion adjacent to parkland, Commercial Road boat ramp	Large bank slump adjacent to cane land (on public land), upstream of Murwillumbah.
		
Good quality riparian vegetation at Tygalgah.	Large block failure adjacent to Tumbulgum Road, Condong.	Under cut banks adjacent to Tweed Valley Way near Tumbulgum.

		
Full height bank revetment Tweed Valley Way.	Cotton woods and stable 'historic' small diameter bank toe revetment on Tweed Valley Way near Stott's Island.	Well constructed revetment on low bank adjacent to private property.
		
Under cut bank and failed small diameter 'historic' bank revetment Tweed Valley Way.	Severe bank erosion immediately adjacent to the Tweed Valley Way.	Stott's Island.

2.2 River Bank Erosion Stabilisation

River bank erosion stabilisation in the Tweed Estuary is undertaken almost exclusively by armouring the eroding banks, top to toe, with rock. This method of erosion stabilisation is expensive and does not achieve the optimum ecological or amenity outcomes for the river environment. However, rock armour provides reliable and immediate protection to the assets immediately landward of the river bank, which in the case of significant reaches of the Tweed estuary, are comprised of roads and residential land.

While not providing the optimum environmental outcome, armouring river banks with low angle (approx 1:1.5) rock walls (revetment) provides the most structurally appropriate form of bank protection in the river environment. Rock diameter should range from approximately 250mm to 1500mm, with design dependant on bank height, river depth and anticipated flow velocity. Rock armouring is flexible, and may settle and maintain its protective function if sediment is scoured from beneath or behind it's mass. Rock armouring is able to withstand and adsorb/dissipate wave energy and is less prone to undermining by reflected waves than rigid concrete structures.

Construction of rock revetment increases the risk that riverbanks immediately downstream will become more severely eroded.

A site by site risk based assessment of erosion consequence is required to select the most appropriate type of river bank stabilisation and erosion protection works.

Numerous works have been undertaken on Tweed River banks from Murwillumbah to Tumbulgum in response to significant erosion or slips that have placed infrastructure at risk. These works have occurred in a reactive manner, based on funding availability and assessment of risk.

Funding under Natural Disaster Relief and Recovery Arrangements (NDRRA) has been made available for many bank stabilisation projects following flood events in 2008, 2009 and 2010, with applications for further works pending for 2012 and 2013 floods.

NDRRA guidelines state that "reinstatement of natural riverbanks and foreshores is not eligible as this damage is considered an ongoing natural realignment process".

As a result, bank stabilisation works have only been undertaken on sections of riverbank where roads are at immediate risk of being damaged. This approach to river bank erosion management has resulted in the construction of bank top to toe rock armoured structures. While effective in managing erosion, these structures have a significant impact on aquatic ecology and river amenity.

Figure 2. Reactive river bank erosion stabilisation works being constructed adjacent to Tumbulgum Road, Tygalgah.

Recent works are outlined in the following table:

Table 1. Location, length and cost of recent rock protection works.

Location	Description	Approximate length	Cost
623 Tumbulgum Road, Tygalgah	Restore levee foundation, provide rock protection	90m	$98,000
River Street, South Murwillumbah	Restore levee foundation, provide rock protection	2 sites, 25m and 20m	$80,000
River Street, South Murwillumbah	Restore levee foundation, provide rock protection	Additional site 20m	$70,000
Tygalgah Levee	Restore levee foundation, provide rock protection	50m	$29,480

Location	Description	Approximate length	Cost
125 River Street, South Murwillumbah	Restore levee foundation, provide rock protection and restore floodgate	30m	$116,500
Tweed Valley Way, South Murwillumbah opposite Boral Timber	Restore eroded bank and provide rock protection	100m	$174,046
Budd Park, South Murwillumbah	Restore eroded bank at floodgate and provide rock protection	Component of larger project	$45,000
Budd Park, South Murwillumbah	Restore eroded bank and provide rock protection	200m	$150,000
Tweed Valley Way, 1km north of Riverside Drive, Tumbulgum	Restore eroded bank, and provide rock protection	50m	$160,000
Near 623 Tumbulgum Road, Tygalgah	Extend previous rock revetment to restore levee foundation and provide rock protection	50m	$110,000
156 Tumbulgum Road, Tygalgah	Restore levee foundation, provide rock protection	70m	$80,080
97-99 River Street, South Murwillumbah	Restore eroded floodgate and levee foundation, provide rock protection	30m	$39,000
Tweed Valley Way, South Murwillumbah, opposite Buchanan Street	Rectify safety issue. Restore eroded bank and provide rock protection	20m	$15,000
Commercial Road Levee, Murwillumbah	Stabilise levee slip and provide rock protection	50m	$97,496
Commercial Road Levee, Murwillumbah	Restore levee foundation and reinstate	100m	$99,500

River reaches with the most severe and continuous bank erosion are located between Murwillumbah and Stott's Island, primarily adjacent to the Tweed Valley Way and Tumbulgum Road. In public infrastructure and asset management terms, this is the most important section of the river for bank erosion management. For the purpose of further discussion, this part of the river is described as the 'priority reach'. Within the priority reach, erosion is predominantly impacting on road reserve, as opposed to private land or public open space. It is estimated that there is approximately 6000 metres of roadway within the priority reach that is at risk of being affected by bank slips within the next five to ten years. At an estimated cost of $1500 per lineal metre to stabilise river bank erosion (based on the average cost per metre rate of erosion stabilisation work recently undertaken by Council), the total cost to stabilise severe erosion adjacent to roads could be up to $9,000,000 over ten years. Maintenance costs would add to this figure.

This sum noted above is comparable to the cost of $7,700,000 estimated in the SMEC Impact of Wake Study (SMEC, 2012) to undertake rock armour bank stabilisation projects from Condong to Stott's Island. The SMEC estimate involved addressing all visible erosion, as opposed to focusing on erosion affecting roads. SMEC identified a total cost of $10,000,000 to stabilise all visibly eroding areas within the estuary, without differentiating between public or private land, or the land use that is threatened by erosion.

Between 2010 and 2013, Council expended approximately $1,200,000 on river bank stabilisation in the estuary, between Murwillumbah and Stott's Island.

2.3 Bio-engineered River Bank Erosion Management

In certain reaches of the river where erosion is occurring but does not immediately threaten important public infrastructure, erosion stabilisation using natural (revegetation) or bio-engineered (combined use of rock, logs and vegetation) approaches should be considered.

The advantages of bio-engineering can include reduced cost and improved environmental outcomes, however the risk of erosion continuing is higher. Bank stabilisation works using bio-engineered techniques must be undertaken before assets are under immediate threat.

The approach must be pre-emptive, as opposed to reactive, and should aim to increase the ability for banks to withstand erosion, generally by encouraging growth of riparian vegetation. Successful bio-engineered bank erosion stabilisation projects will have less visual impact on the river environment than top to toe bank revetment structures.

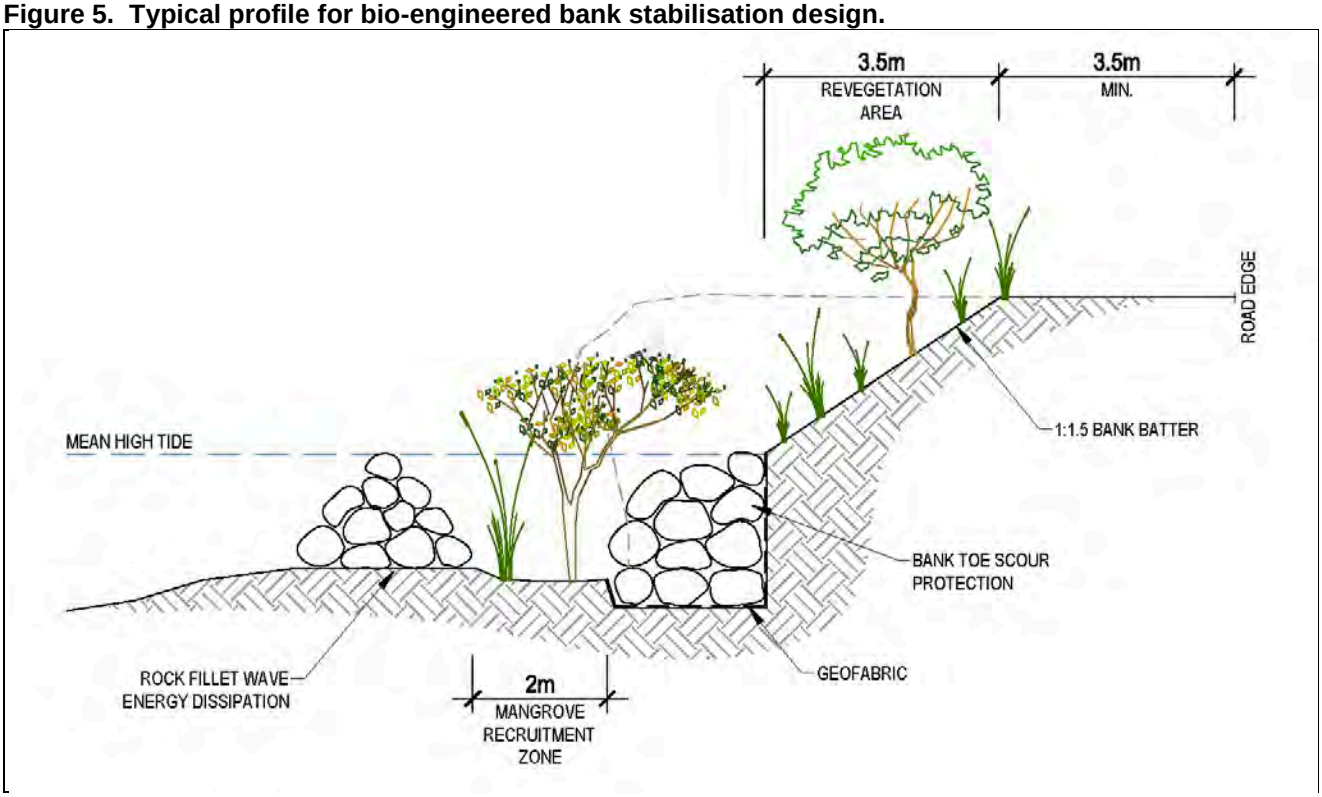
A common bio-engineered approach to river bank stabilisation is the construction of rock fillets. These structures dissipate wave energy (wind or wake) and create sheltered environments that are colonised by mangroves. Mangrove growth increases the stability of banks and provides habitat for fauna including crustaceans, fish and birds. Encouraging vegetation growth on the river bank will generally assist in screening the visual impact of rock wall construction.

Figure 3. Rock fillets are a common bio-engineered approach to bank stabilisation. The photo below shows rock fillets immediately after construction in the Manning River, prior to colonisation by mangroves.

Figure 4. Rock fillets constructed at Chinderah, with regenerating mangroves.

Areas in which pre-emptive riverbank stabilisation can be undertaken will be limited by the proximity of the road to the eroding bank. Generally it is considered that a minimum of 7.0 m between road edge and the bank will be required to undertake a bioengineered approach that includes top of bank revegetation. This allows for a planting set-back of 3.5 metres from the road edge. Further detail of this approach is included in section 4.4.

Figure 5. Typical profile for bio-engineered bank stabilisation design.



In some areas a full bank height rock stabilisation structure will be required, but may be able to include a rock fillet at its toe, allowing partial offset of the ecological and amenity impacts.

2.4 Impact of Sea Level Rise on River Bank Erosion

Council has adopted sea level rise bench marks authorised by the CSIRO. These include a rise on 1990 sea levels of 40cm in 50 years, and 90cm in 100 years.

While there has not been a detailed analysis of the potential impacts of sea level rise on river bank erosion in the Tweed Estuary, a number of general conclusions can be drawn.

As ocean levels rise, river levels will increase correspondingly. Waves (wind and wake) and tidal flows will more frequently affect parts of the upper river bank that are not currently adapted to regular inundation. In low flat areas this will result in a gradual landward progression of marine vegetation, for example mangroves, which may replace terrestrial species. In areas of steep banks existing vegetation may die off, increasing erosion vulnerability.

In many parts of the Tweed floodplain vegetation migration (under the influence of climate change) will be constrained because the river bank is cut off from the floodplain by roads and sugar cane fields.

Increased climate variability, including increased storm intensity and prolonged drought may also have an impact on river bank stability. More frequent and severe flooding has the potential to increase erosion through scour and over saturation of bank soils, whereas drought can have an impact on river salinity and the health of native vegetation.

In general, it is likely that river bank erosion will increase, rather than decrease, as a result of increased climate variability and sea level rise.

3.0 River Bank Erosion Classification

Council's Waterways Program has recently mapped and classified the severity river bank erosion in the Tweed estuary. Table 3 provides a summary of bank erosion severity, and highlights the river reaches between the Bray Park Weir and the river mouth where erosion is most serious.

This classification is based on river bank inspections undertaken in July 2013, using a GPS to record areas of bank erosion. The river was broken into reaches, and then each reach into sections, as a means of assessing stability status. Reaches have been given a colour coded erosion classification, as follows:

Table 2. Erosion classification code.

Generally stable:	Low risk of problem erosion.
Vulnerable:	Significant risk of erosion initiating, or erosion becoming worse.
Active and severe:	Bank is eroding, high risk of erosion increasing.

It is noted that there are exceptions to the overall summarised condition with in a reach. For example, within reaches classified overall as being, 'generally stable' there may be some severe, localised erosion, and vice versa. The table also provides a brief assessment of the implications of erosion, primarily as it relates to *management of Council infrastructure or land*. As such, erosion affecting private agricultural or residential land is not identified as a serious problem, *for Council*. The table does not present the environmental implications of river bank erosion.

Note: Left and right bank are indicated, this refers to left and right bank when looking down stream.

Table 3. Summary of erosion status.

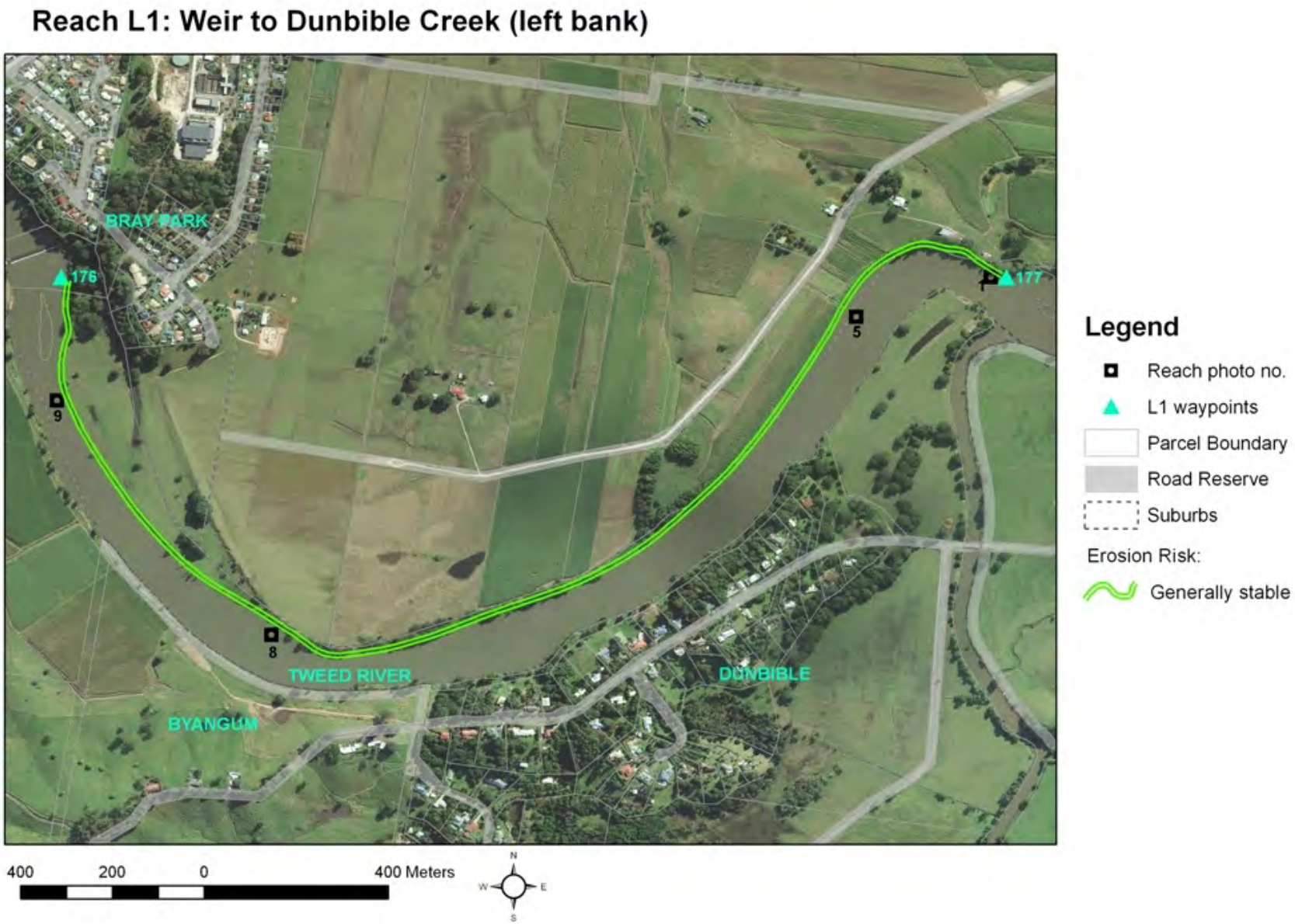
Reach	Overall classification	Management Implication
Bray Park Weir to Dunbible Creek - Left	Generally stable	Some opportunities for bank revegetation should be pursued with land owners.
Bray Park Weir to Dunbible Creek - Right	Generally stable, but includes a 200 m section highly vulnerable, and a section of 100 which is severely eroded.	No public assets at risk. Erosion in this location will impact on the operation of a cane farm and grazing land. Erosion on outside river bend. Environmental and landowner benefits would be gained through stabilisation.
Dunbible Creek to Murwillumbah Bridge - Left	Vulnerable, with some severe erosion.	No public assets at immediate risk, however Commercial Road flood levee wall and park land at the boat ramp are adjacent to a vulnerable and eroding bank. Cane farm affected by severe erosion over a significant length.
Dunbible Creek to	Generally stable, with a	Several private homes need

Reach	Overall classification	Management Implication
Murwillumbah Bridge - Right	significant vulnerable bank upstream of Murwillumbah bridge on Council land, and some sections of severe erosion on private land.	protection. Ongoing loss of grazing land will also occur if not stabilised. Council land should be managed to increase bank resilience.
Murwillumbah Bridge to Condong Bridge - Left	Variable. Some severe erosion, some stable areas. Significant potential to improve river bank management and reduce erosion in upper part of reach.	No public assets at risk. Proposed area for investment by Council Waterways Program.
Murwillumbah Bridge to Condong Bridge - Right	**High vulnerability with severe erosion present. Recent major slips requiring bank stabilisation by Council. High risk of multiple additional bank slips in the area. Residential land is almost all protected by rock walls - if not, it is severely eroding.**	**Approx. 700m of Tweed Valley Way potentially affected by erosion and requiring ongoing stabilisation work as slips occur.**
Condong Bridge to Tumbulgum - Left	**Significant erosion over most of the reach, some severe. Multiple slips affecting Tumbulgum Road. Most of the reach is vulnerable to erosion. One stable section supports good native vegetation and will be enhanced through revegetation.**	**Approx 2.5 km length of Tumbulgum Road threatened by erosion and requiring ongoing stabilisation work as slips occur.**
Condong Bridge to Tumbulgum - Right	**Vulnerable, with sections of severe erosion over majority of reach.**	**Approx. 1.5 km length of Tweed Valley Way threatened by erosion and requiring ongoing stabilisation work as slips occur. Parkland at Condong and Condong School grounds also require protection.**
Tumbulgum to McCauley's Road boat ramp - Left	**Severe erosion upstream of Tumbulgum Bridge, however generally stable downstream of bridge to McCauley's Road boat ramp.**	**Approx. 600 metre section of Dulguigan Road threatened by erosion and will require ongoing stabilisation work.**
Tumbulgum to Stotts Island - Right	**Severe erosion. Over much of the reach, stability is only provided by recent heavy duty rock armour, or old rock armour, which is at high risk of failure.**	**Approx. 1000 metre section of Tweed Valley Way threatened, and will require ongoing stabilisation work at multiple locations.**

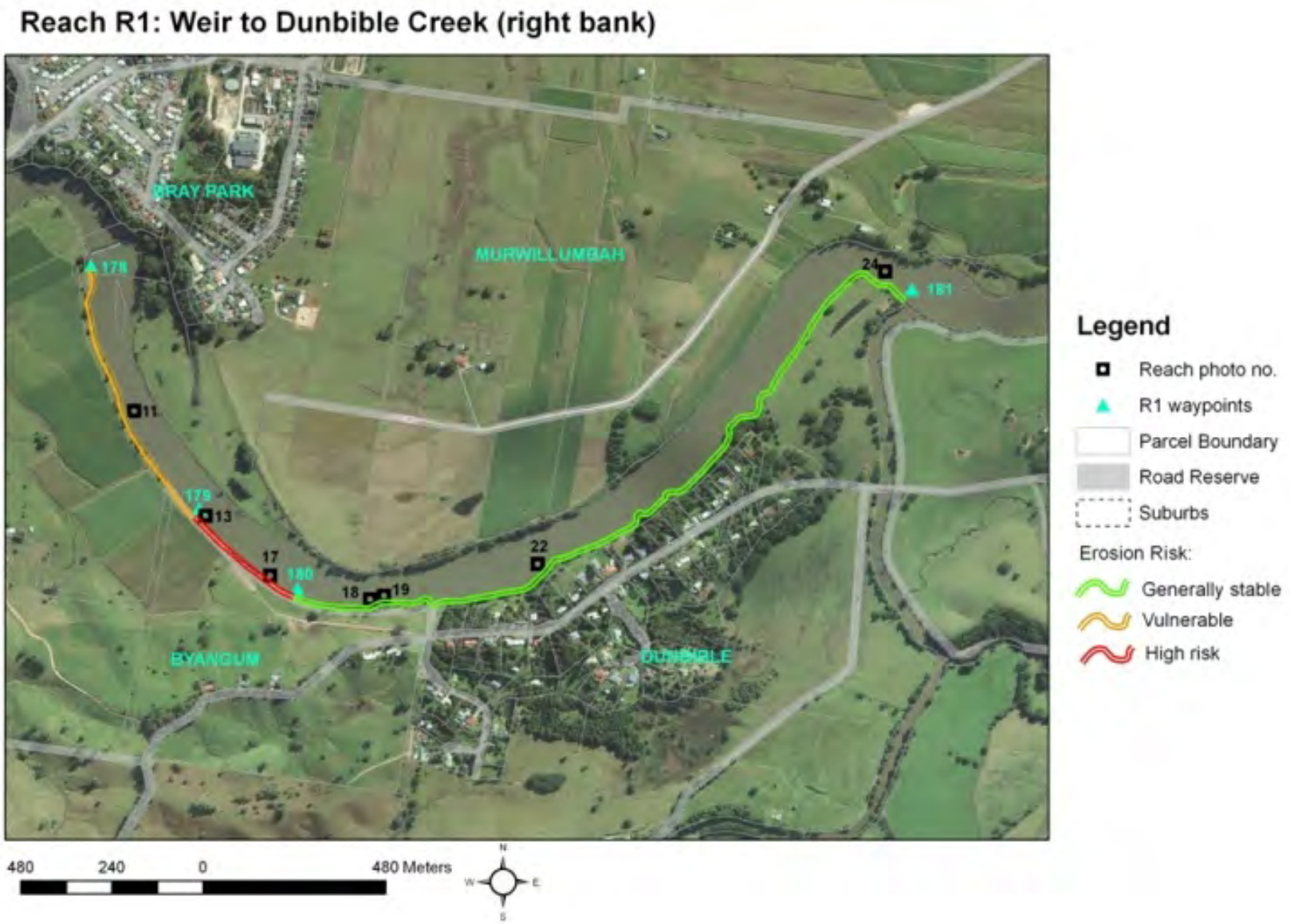
Reach	Overall classification	Management Implication
Stotts Island	Some areas vulnerable, and showing signs of active erosion. The majority of the bank is stable.	Highly significant nature reserve that should be protected from erosion. No potential for armouring of bank.
McCauley's Road boat ramp to River Road, Banora Point - Left	Generally stable. One bad slip.	Slip on grazing land.
Stotts Island east to Dodd's Island west - Right	Generally stable, signs of loss of mangroves due to scouring/undermining.	Bank adjacent to road reserve/cane land.
Dodd's Island to Chinderah boat ramp - Right	Severe erosion present on Dodd's Island. Dodd's channel to Chinderah stable.	Dodd's Island is private land.
Chinderah boat ramp to Barneys Point Bridge - Right	Generally stable, however river bank behind caravan park has been poorly armoured with concrete debris. Area is unstable and has very low amenity value.	Land behind caravan park is public open space and requires significant work to achieve a good amenity outcome.
Barneys Point Bridge to Tweed Bar - Right	Stable. Entire river foreshore is armoured. Maintenance required at some locations.	Ad hoc maintenance required.
River Road Banora Point to Barney's Point Bridge - Left	Severe erosion present on River Road and adjacent to Oxley Cove Canal Estate entrance. Natural bank downstream of canal estate vulnerable.	Stabilisation work required - urgent at canal estate entrance.
Barneys Point Bridge to Tweed Bar - Left	Generally stable. Some natural erosion on Ukerebagh Island. Some vulnerable areas adjacent to golf course.	No major maintenance or management required.
Terranora	Multiple minor erosion problems that can be addressed as resources permit. Most significant erosion area is downstream of Ray Pascoe Park on Kennedy drive.	Risk of exposure of old landfill material adjacent to Ray Pascoe Park.
Rous River	Not formally mapped. Significant areas of erosion vulnerability adjacent to private cane land.	Some areas of Dulguigan Road threatened.

Erosion has been presented graphically in the following series of maps, 1 - 18. Within the maps, more detail of erosion variability is shown than for the summarised condition assessments in the table above. Maps 1-18 include numbered camera icons, which correspond to photographs of bank condition, included as **Appendix 2.**

Map 1

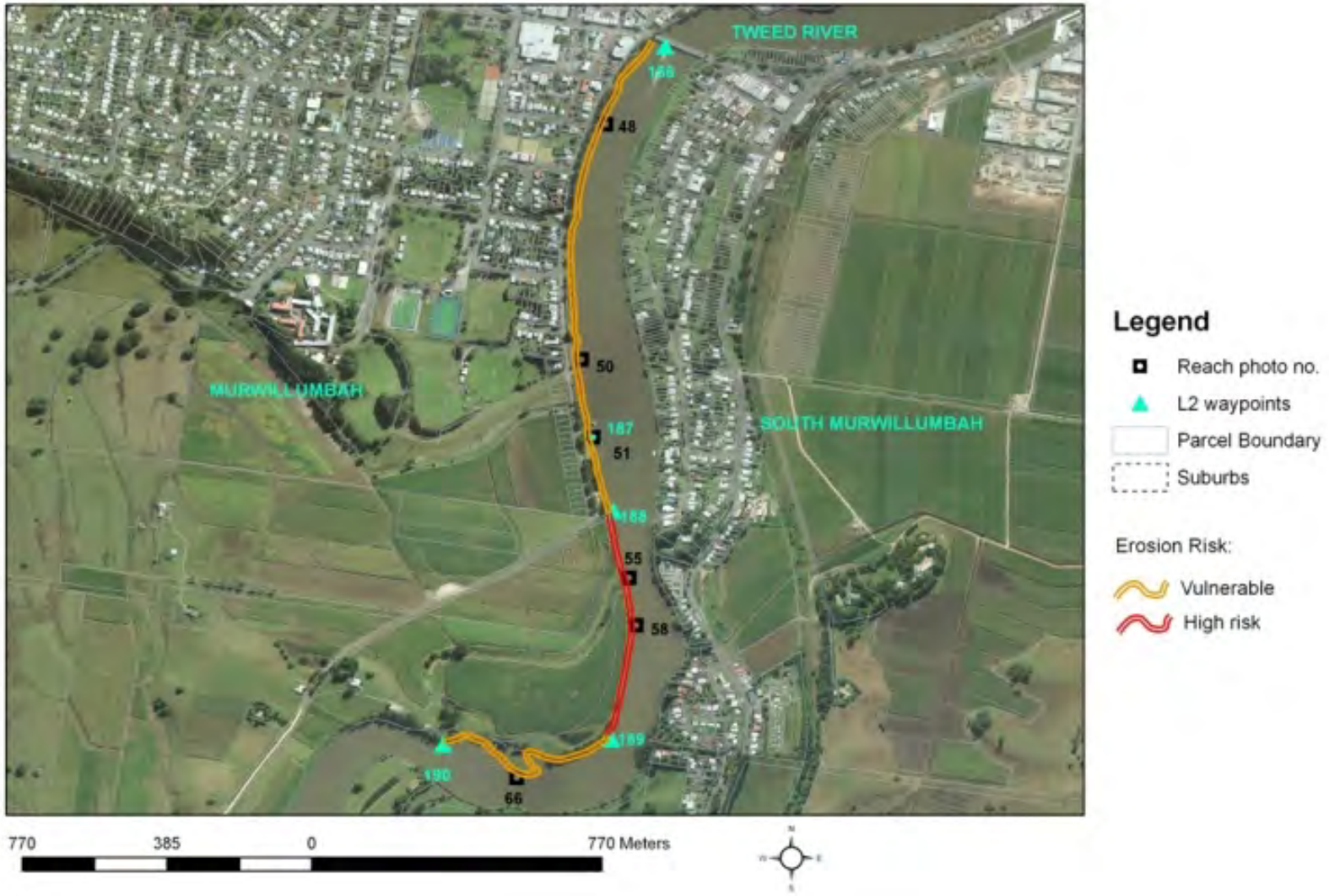

Reach L1: Weir to Dunbible Creek (left bank)
BRAY PARK
176
177
9
8
5
TWEED RIVER
DUNBIBLE
BYANGUM
Legend
Reach photo no.
L1 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
400
200
0
400 Meters
N
W
E
S

Map 2

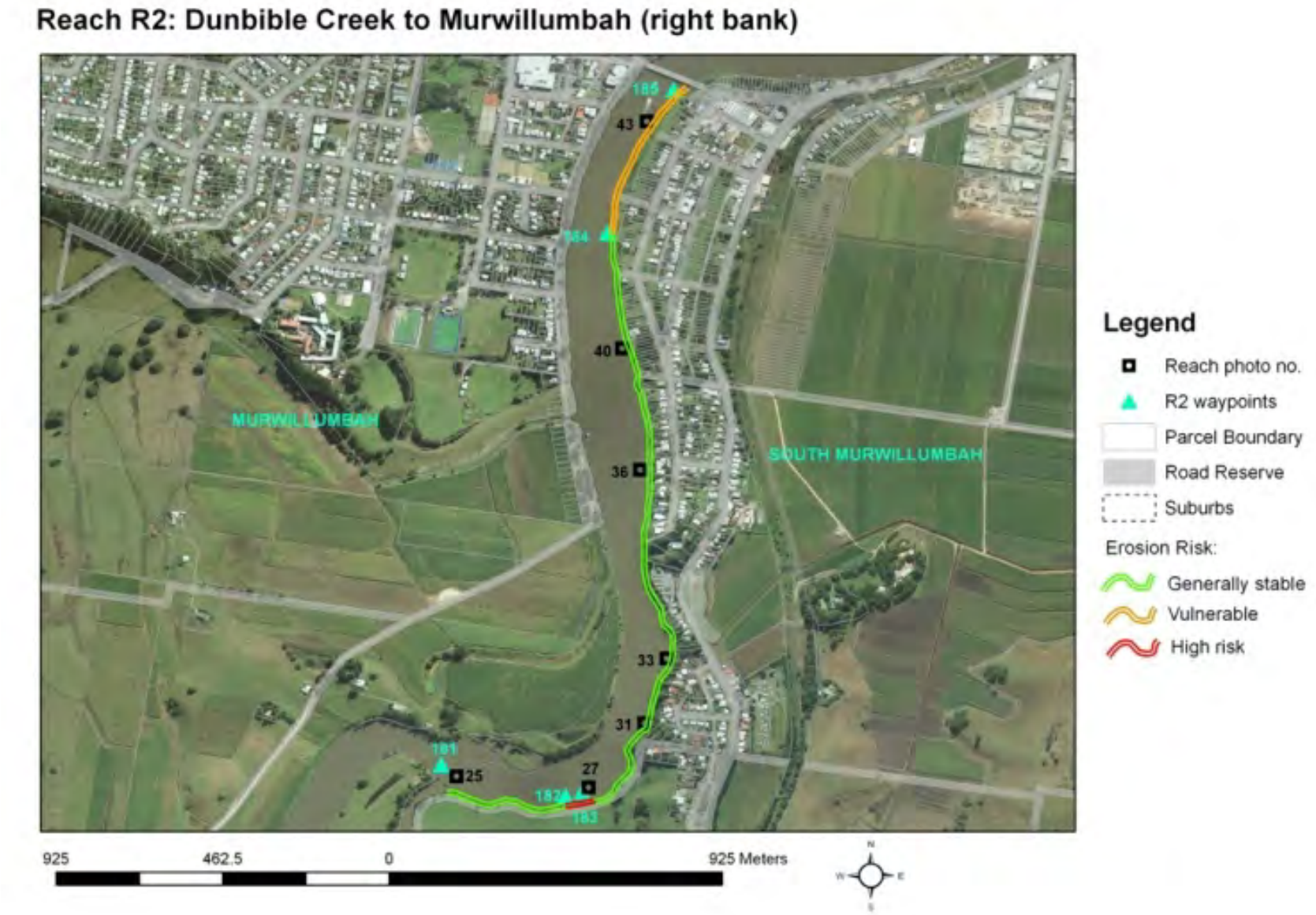

Reach R1: Weir to Dunbible Creek (right bank)
BRAY PARK
MURWILLUMBAH
BYANGUM
DUNBIBLE
178
179
180
181
11
13
17
18
19
22
24
Legend
Reach photo no.
R1 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
480
240
0
480 Meters
N
W
E
S

Map 3

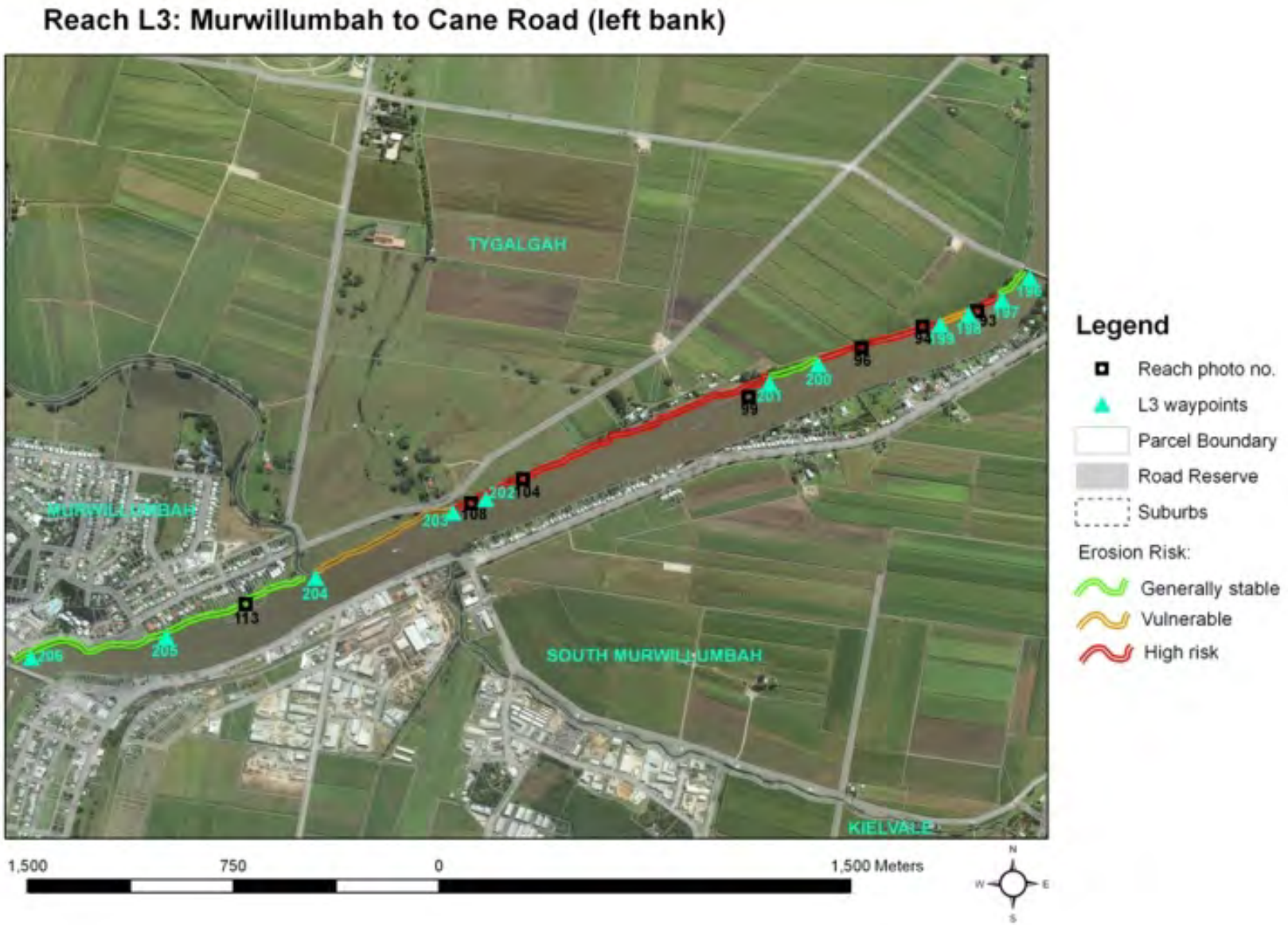
Reach L2: Dunbible Creek to Murwillumbah (left bank)



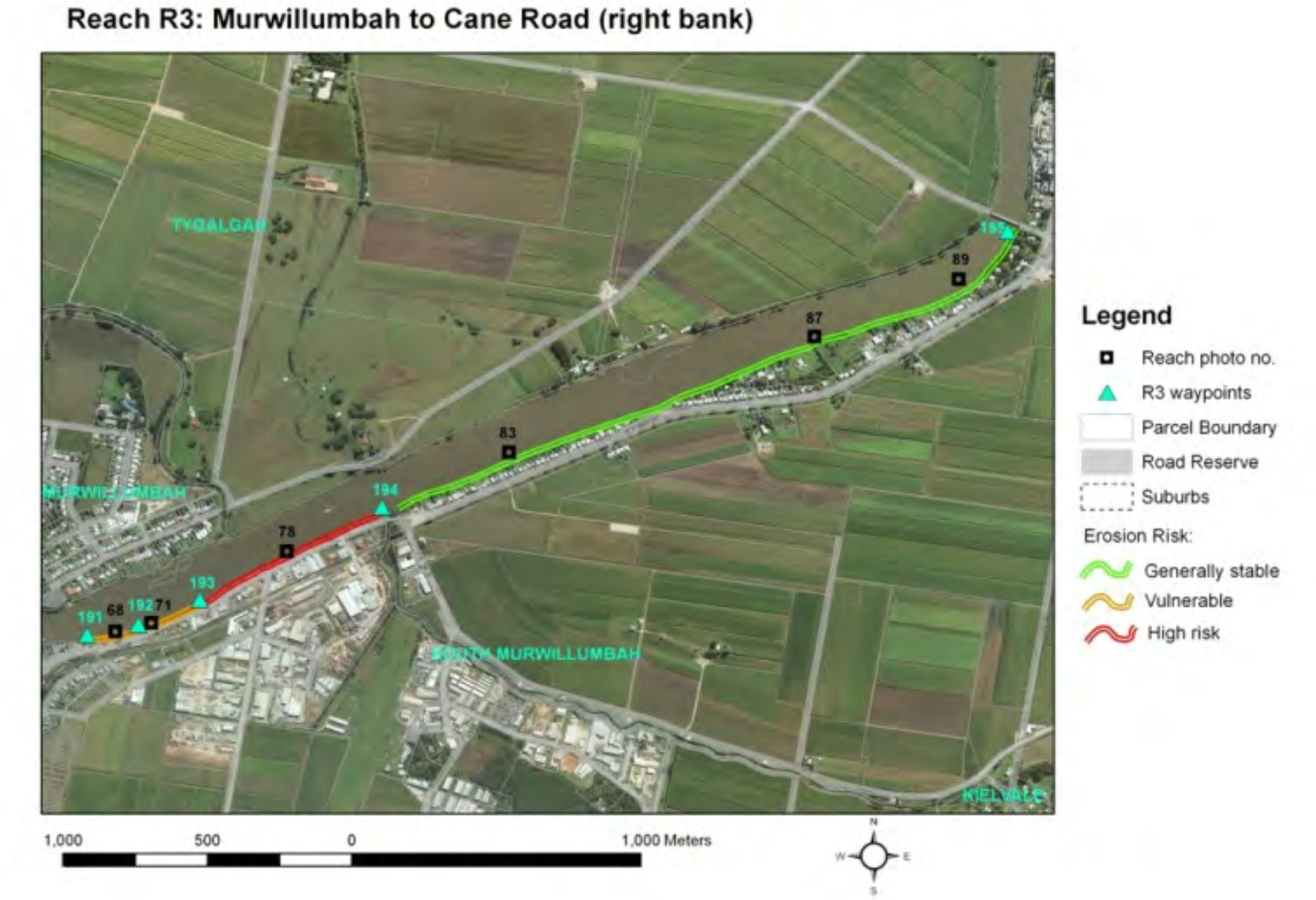
Map 4


Reach R2: Dunbible Creek to Murwillumbah (right bank)
185
43
184
40
36
33
31
27
25
182
183
181
MURWILLUMBAH
SOUTH MURWILLUMBAH
925
462.5
0
925 Meters
Legend
Reach photo no.
R2 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk

Map 5

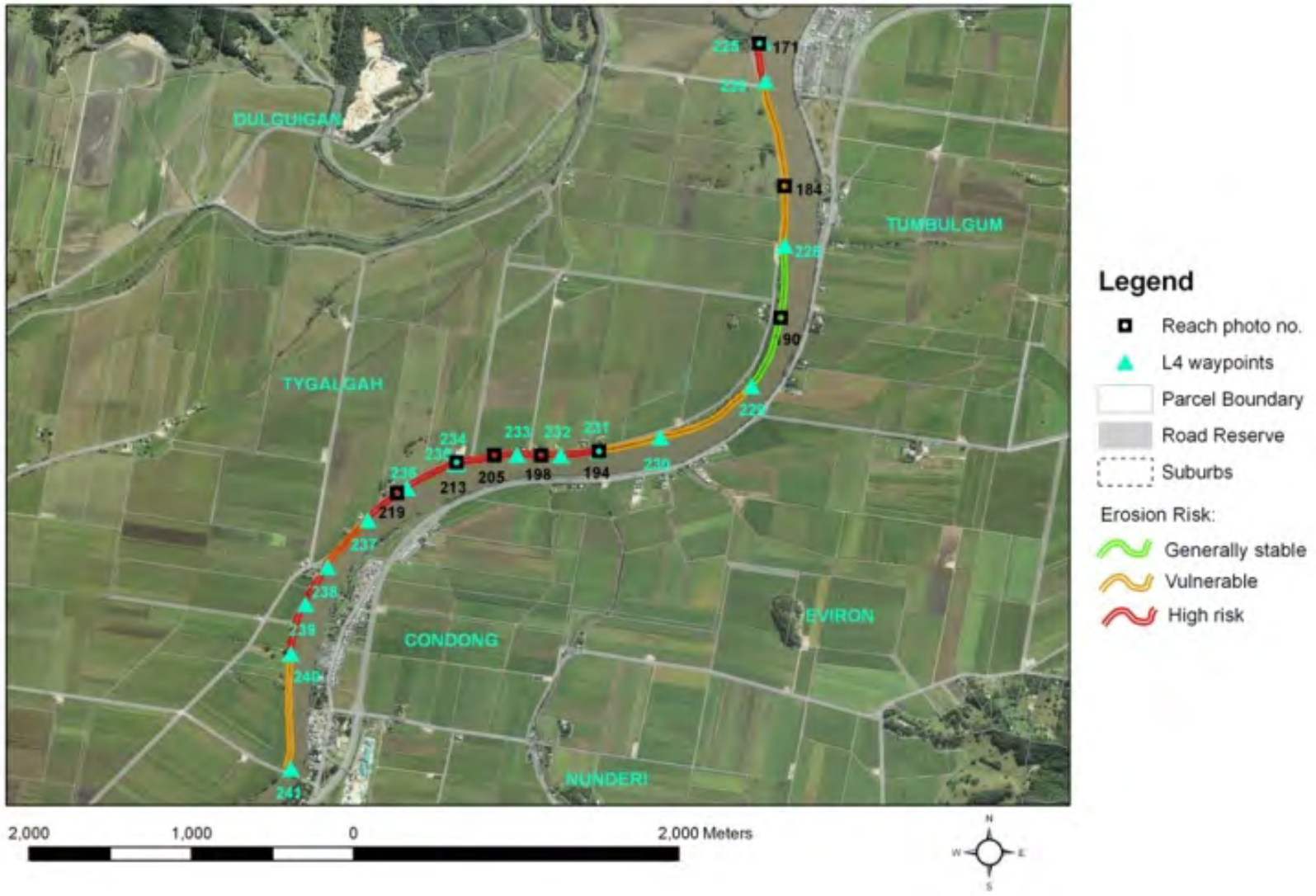

Reach L3: Murwillumbah to Cane Road (left bank)
TYGALGAH
MURWILLUMBAH
SOUTH MURWILLUMBAH
KIELVALE
Legend
Reach photo no.
L3 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
1,500
750
0
1,500 Meters
N
W
E
S

Map 6


Reach R3: Murwillumbah to Cane Road (right bank)
TYGALGAH
MURWILLUMBAH
SOUTH MURWILLUMBAH
KIELVALE
191
68
192
71
193
78
194
83
87
89
195
Legend
Reach photo no.
R3 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
1,000
500
0
1,000 Meters
N
W
E
S

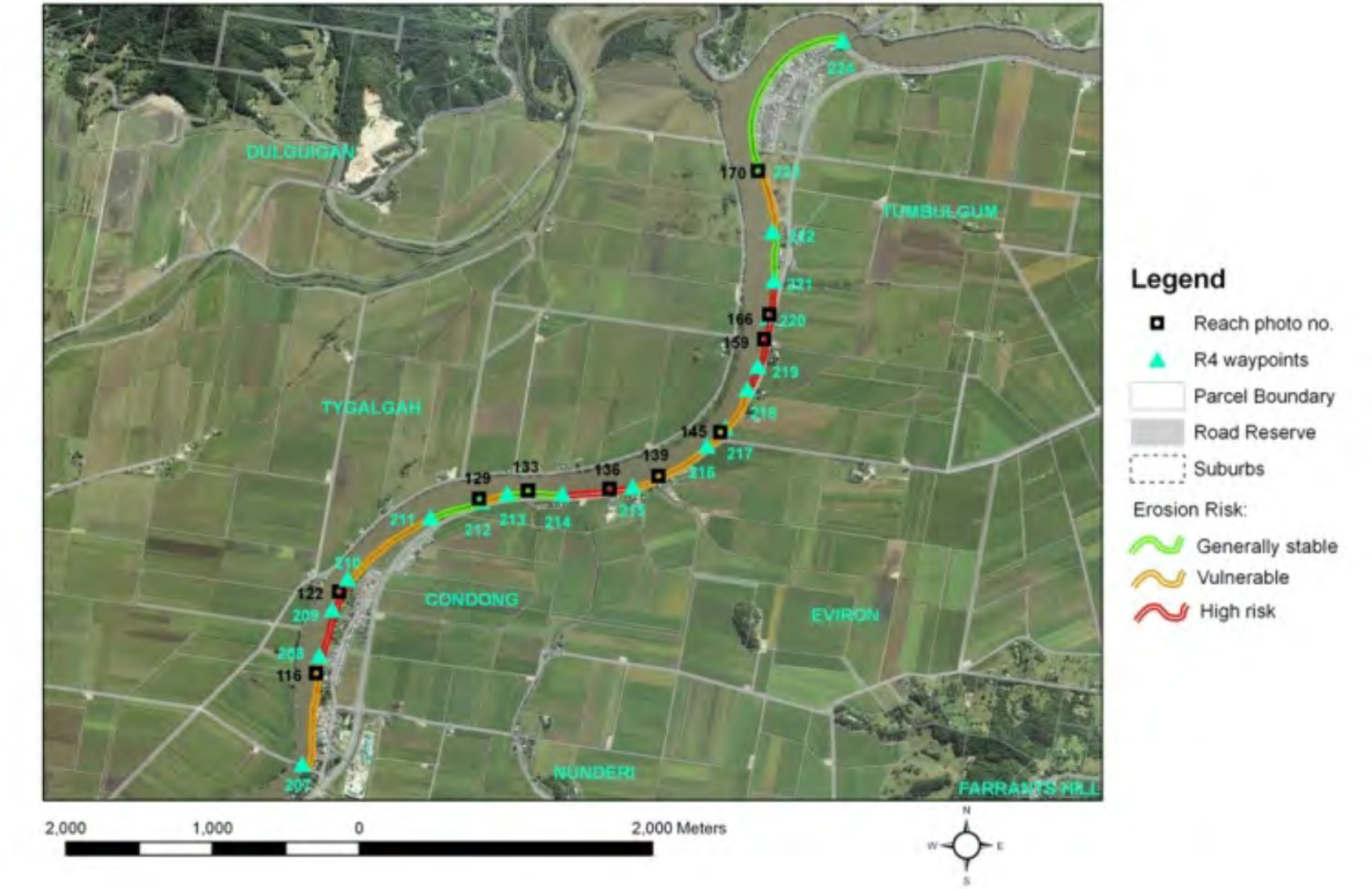
Map 7

Reach L4: Cane Road to Rous River (left bank)

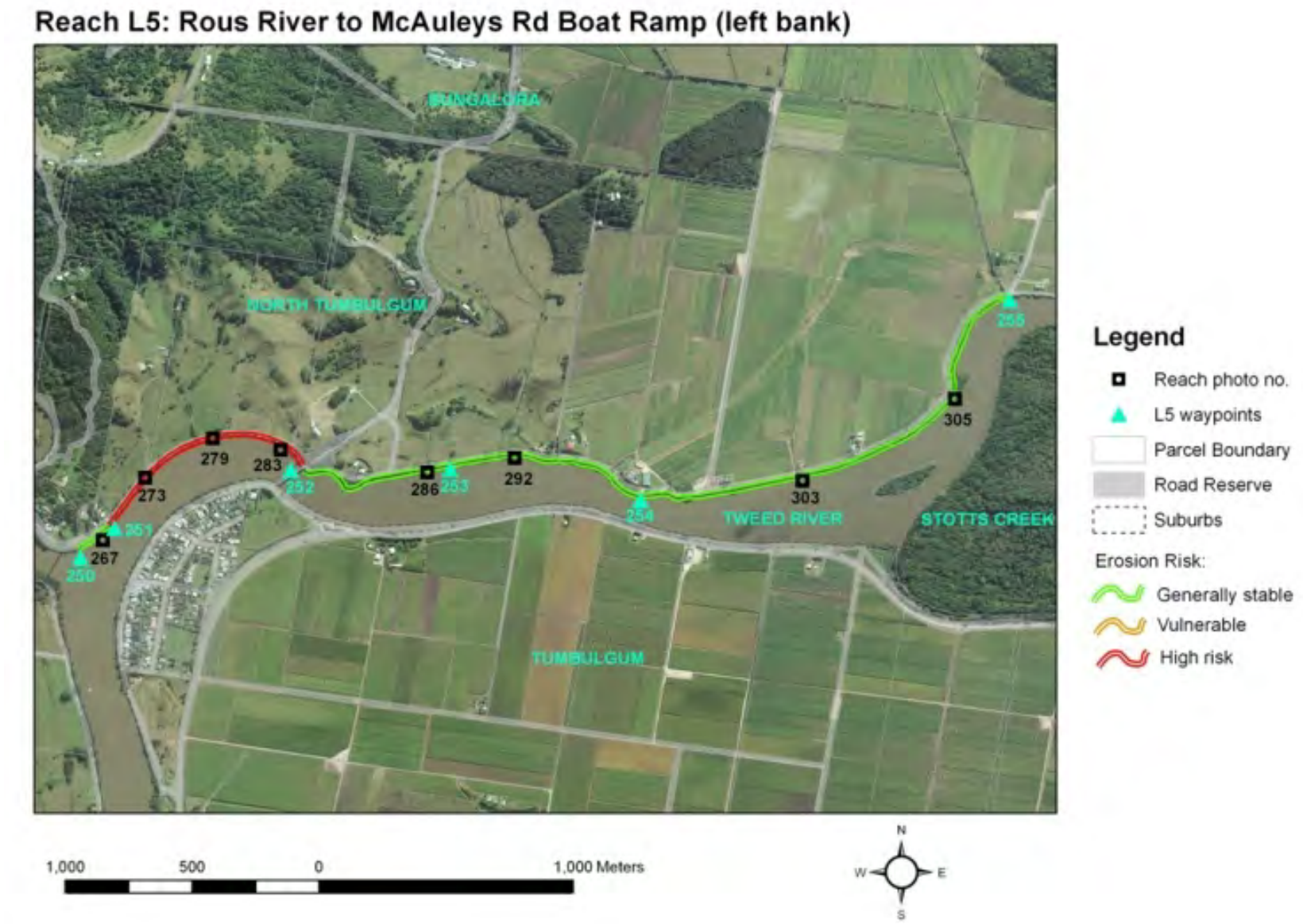


Map 8

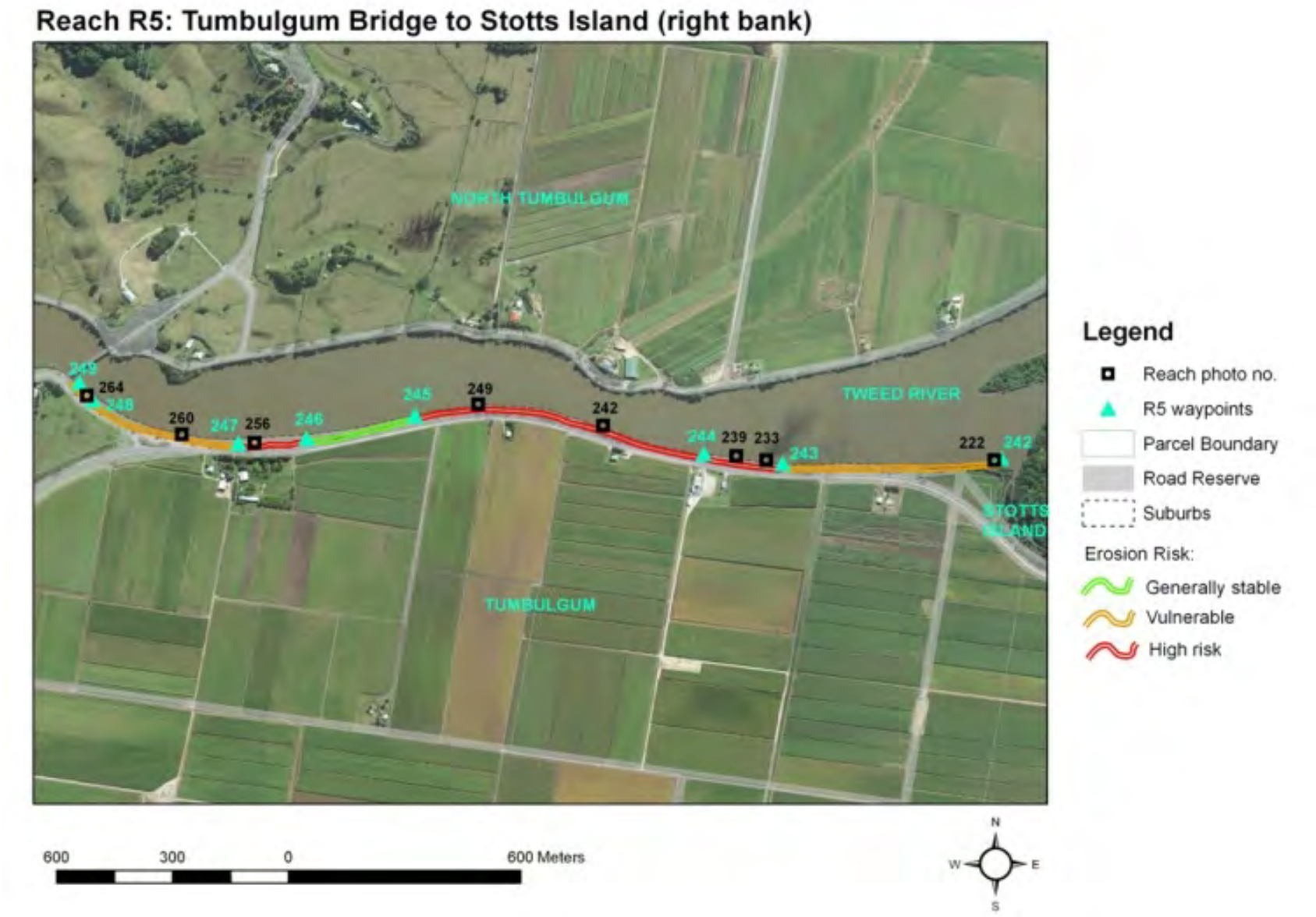
Reach R4: Cane Road to Tumbulgum Bridge (right bank)



Map 9

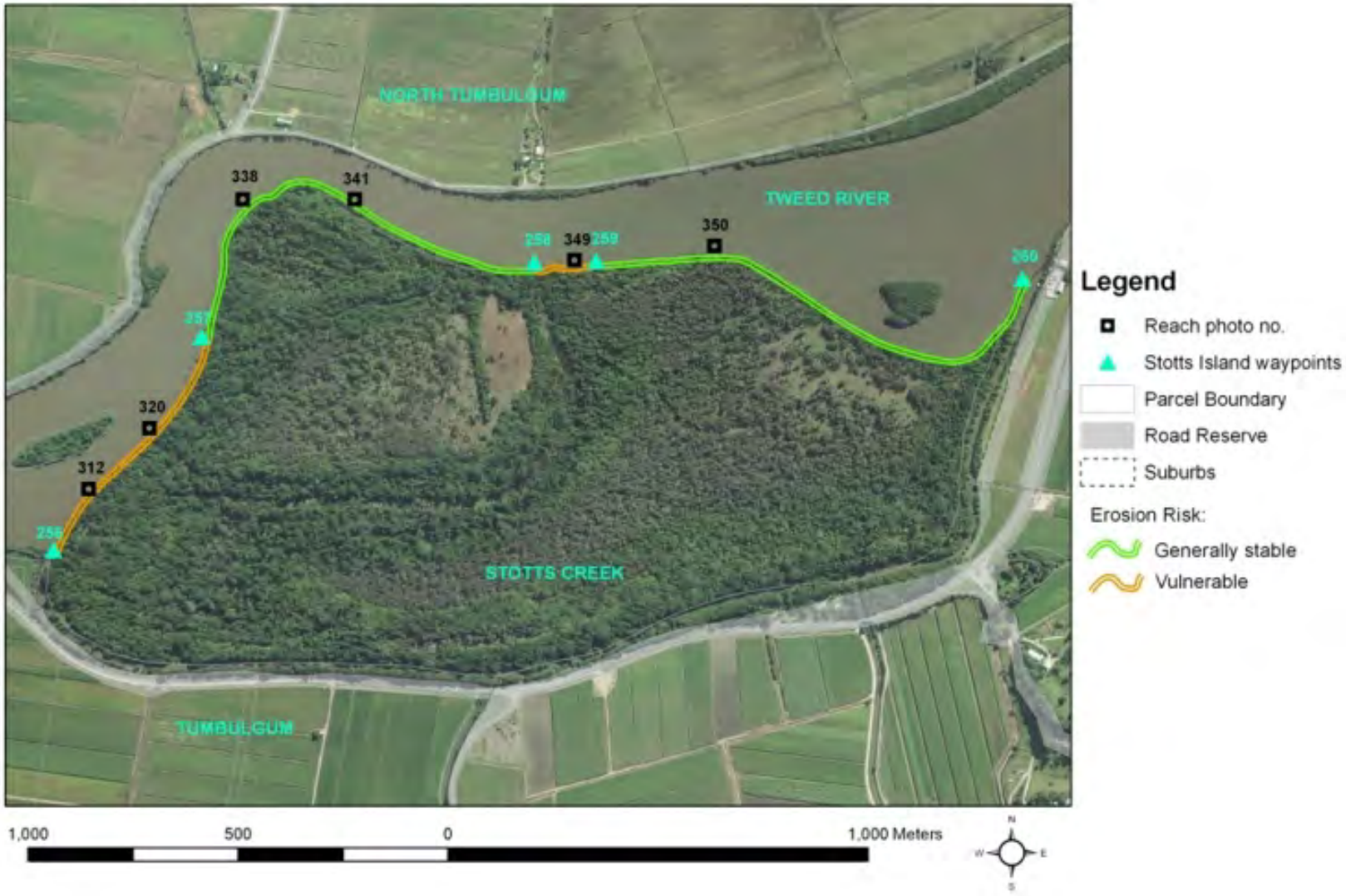

Reach L5: Rous River to McAuleys Rd Boat Ramp (left bank)
BANGALORA
NORTH TUMBULGUM
TUMBULGUM
TWEED RIVER
STOTTS CREEK
250
251
252
253
254
255
267
273
279
283
286
292
303
305
Legend
Reach photo no.
L5 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
1,000
500
0
1,000 Meters
N
W
E
S

Map 10

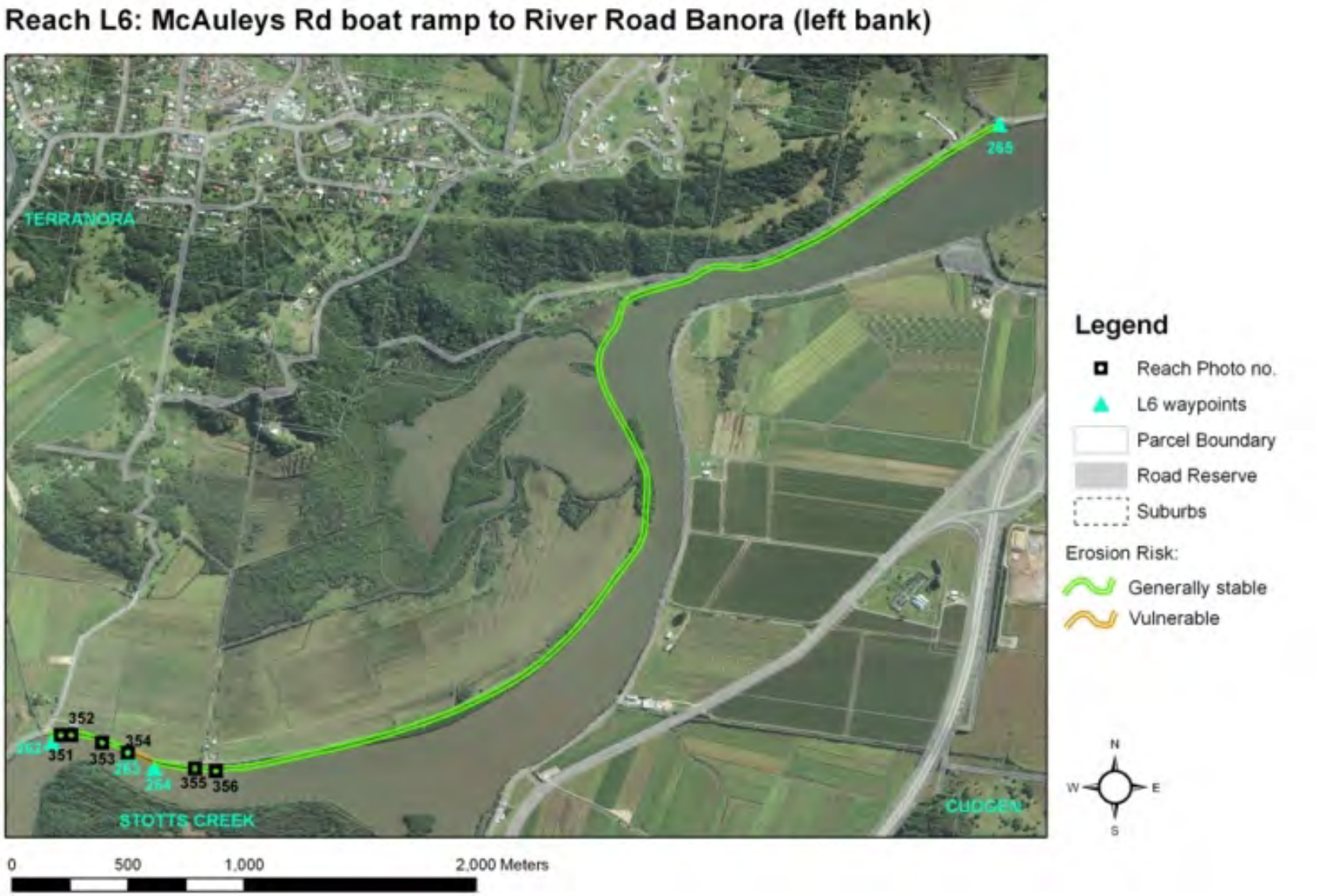

Reach R5: Tumbulgum Bridge to Stotts Island (right bank)
NORTH TUMBULGUM
TWEED RIVER
TUMBULGUM
STOTTS ISLAND
249
264
248
260
247
256
246
245
249
242
244
239
233
243
222
242
Legend
Reach photo no.
R5 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
600
300
0
600 Meters
N
W
E
S

Map 11

Reach: Stotts Island

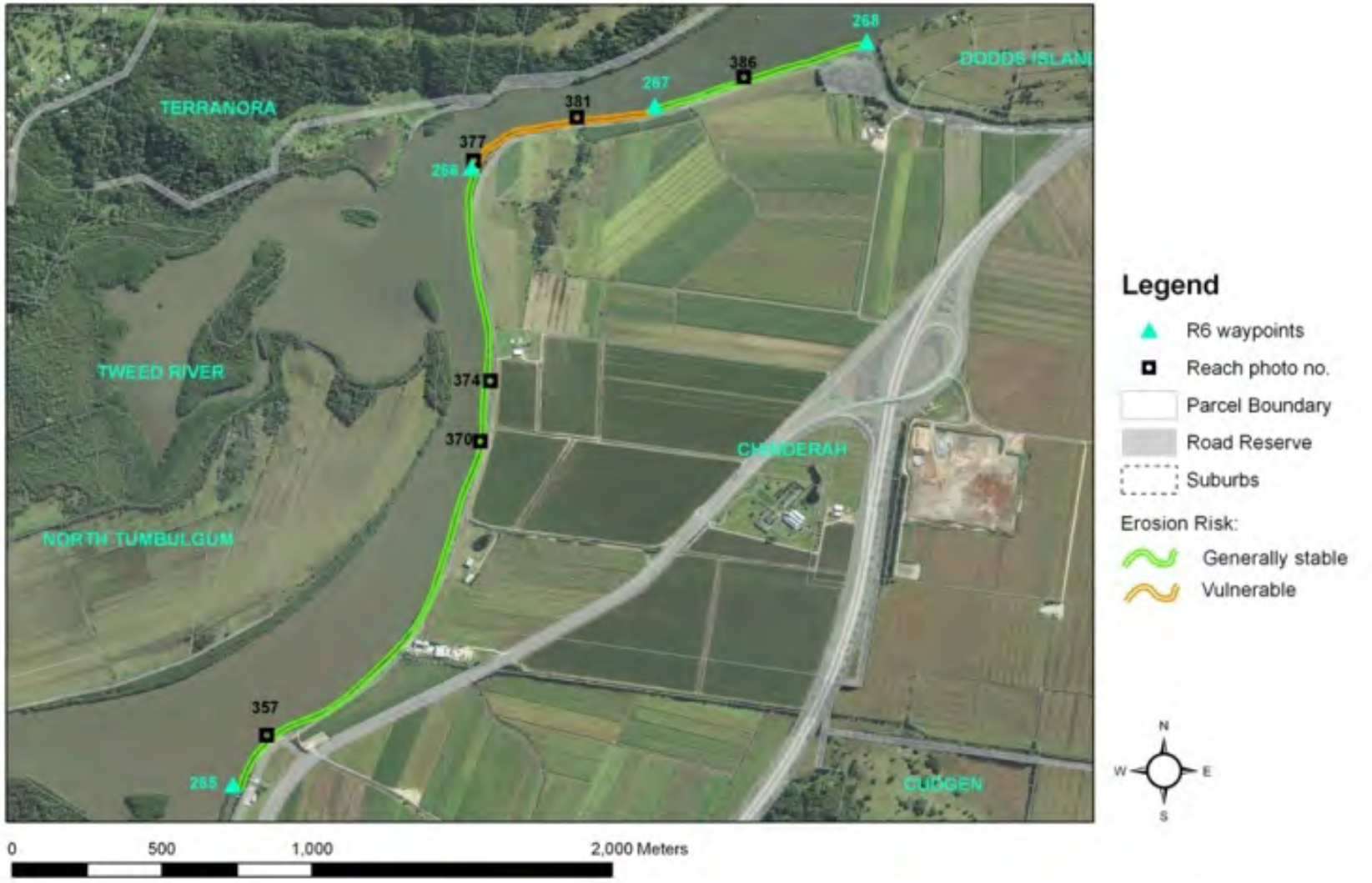


Map 12


Reach L6: McAuleys Rd boat ramp to River Road Banora (left bank)
TERRANORA
STOTTS CREEK
CUDGEN
265
352
351
353
354
264
355
356
Legend
Reach Photo no.
L6 waypoints
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
Vulnerable
N
W
E
S
0
500
1,000
2,000 Meters

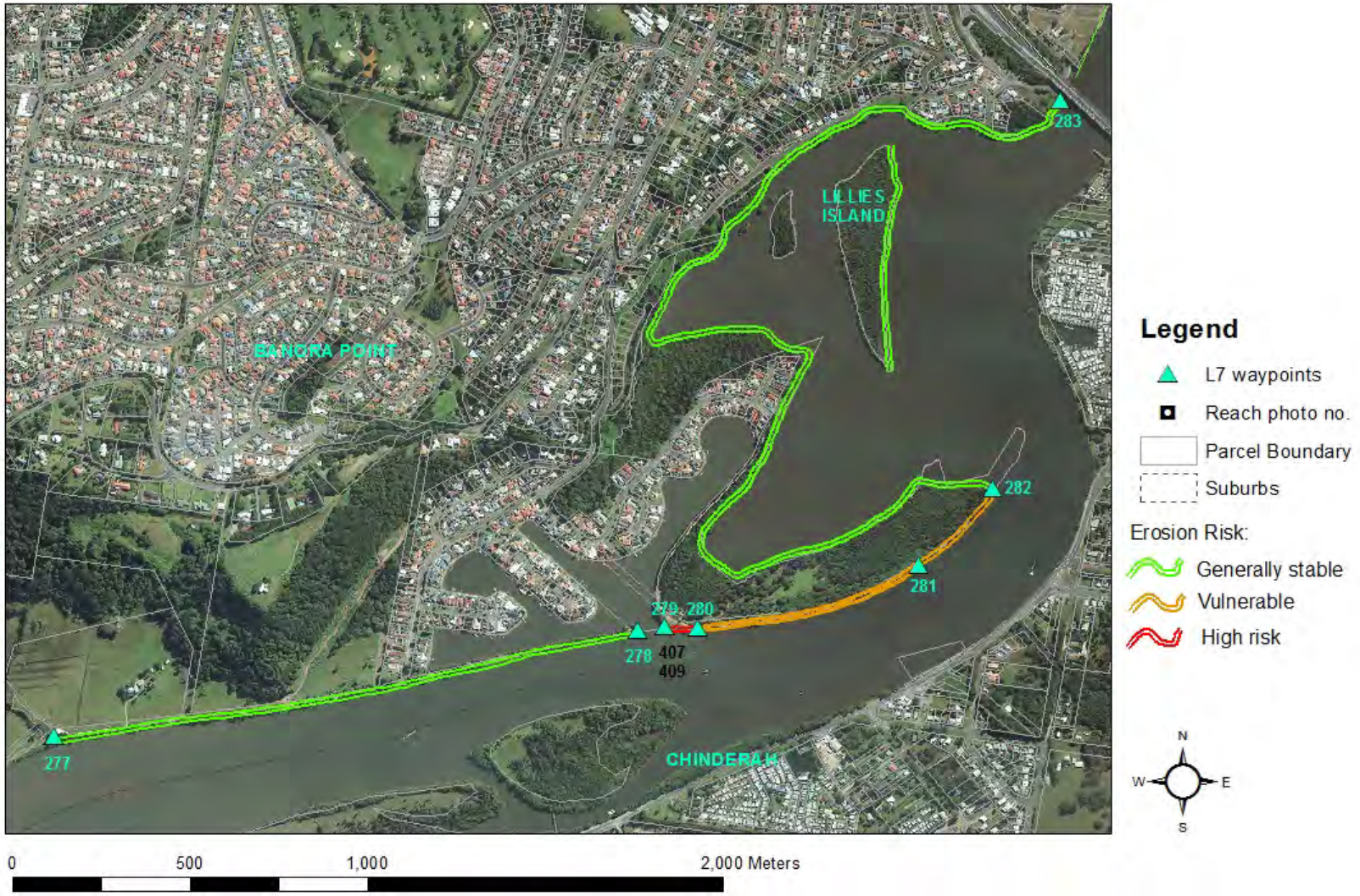
Map 13

Reach R6: Stotts Island to Dodds Island channel (right bank)



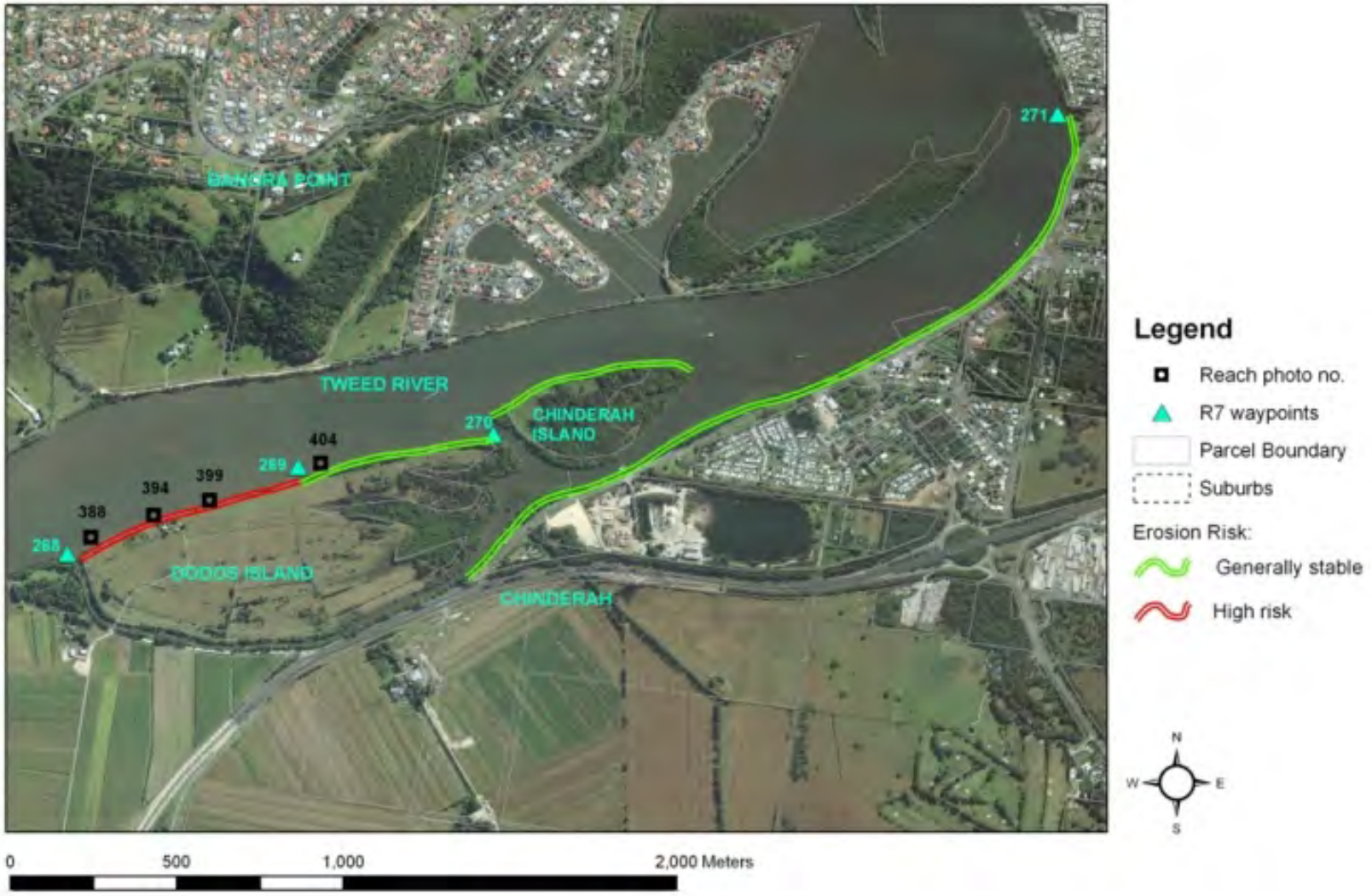
Map 14

Reach L7: River Road Banora Point to Barneys Point Bridge (left bank)

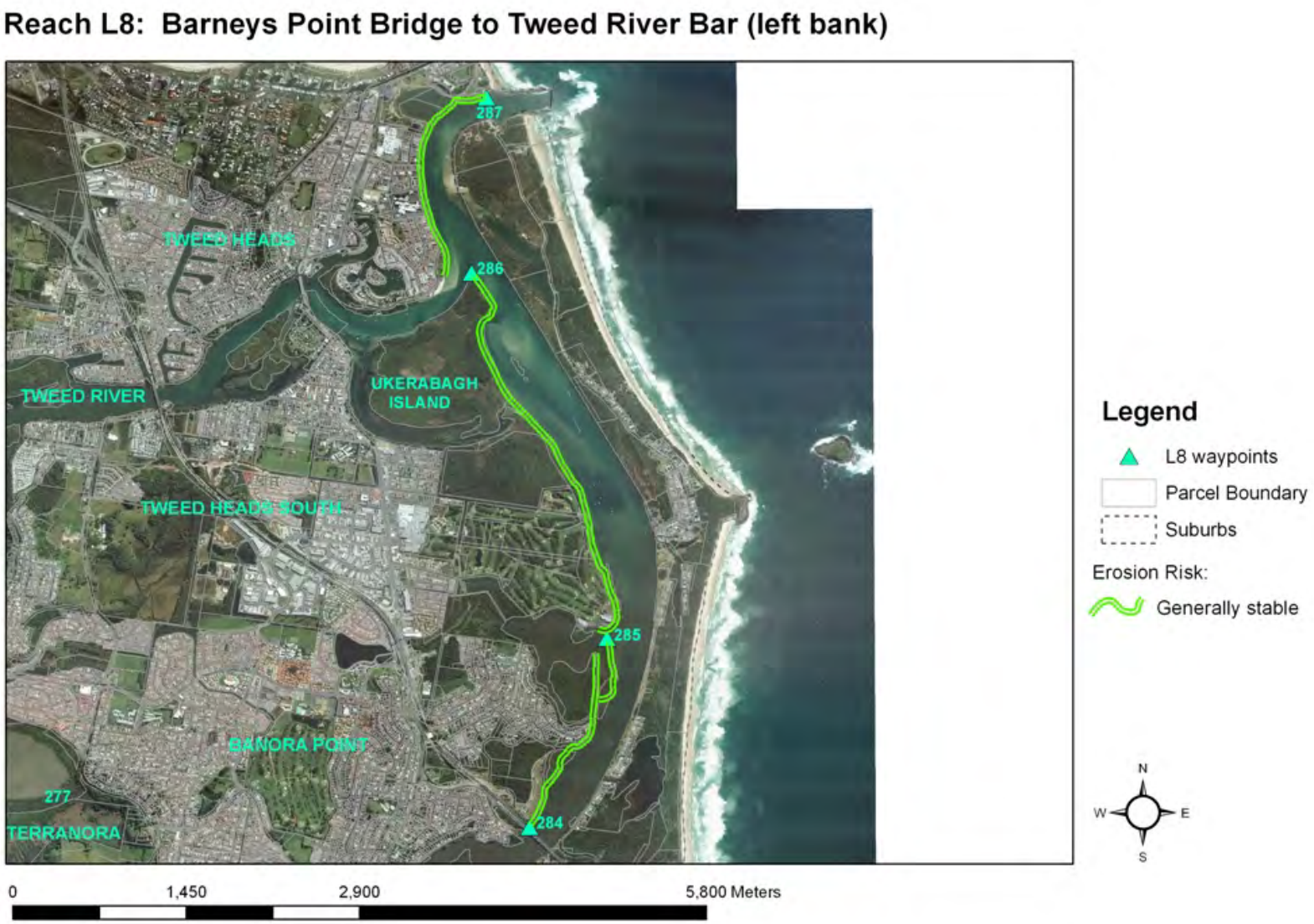


Map 15

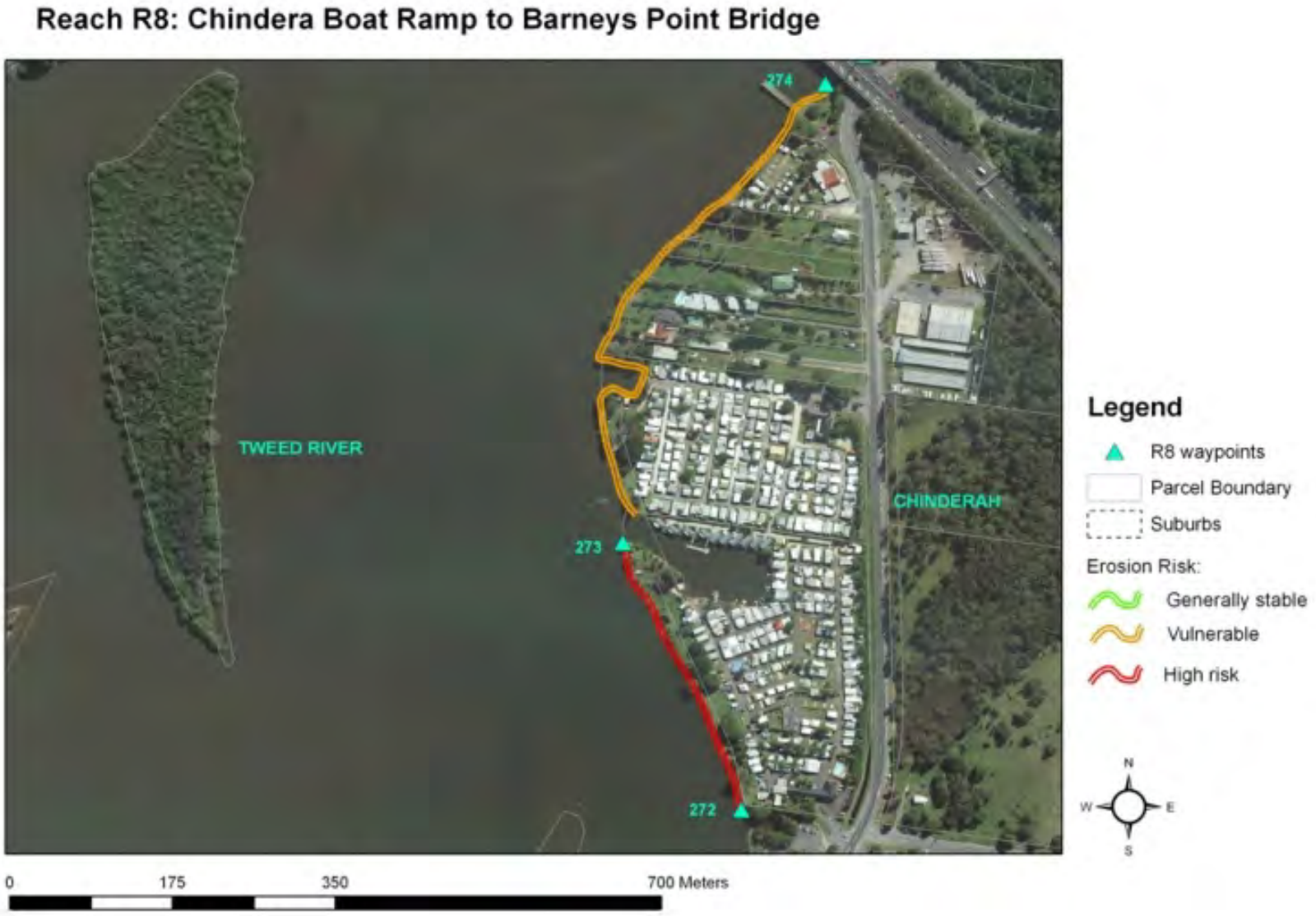
Reach R7: Dodds Island to Chindera Boat Ramp



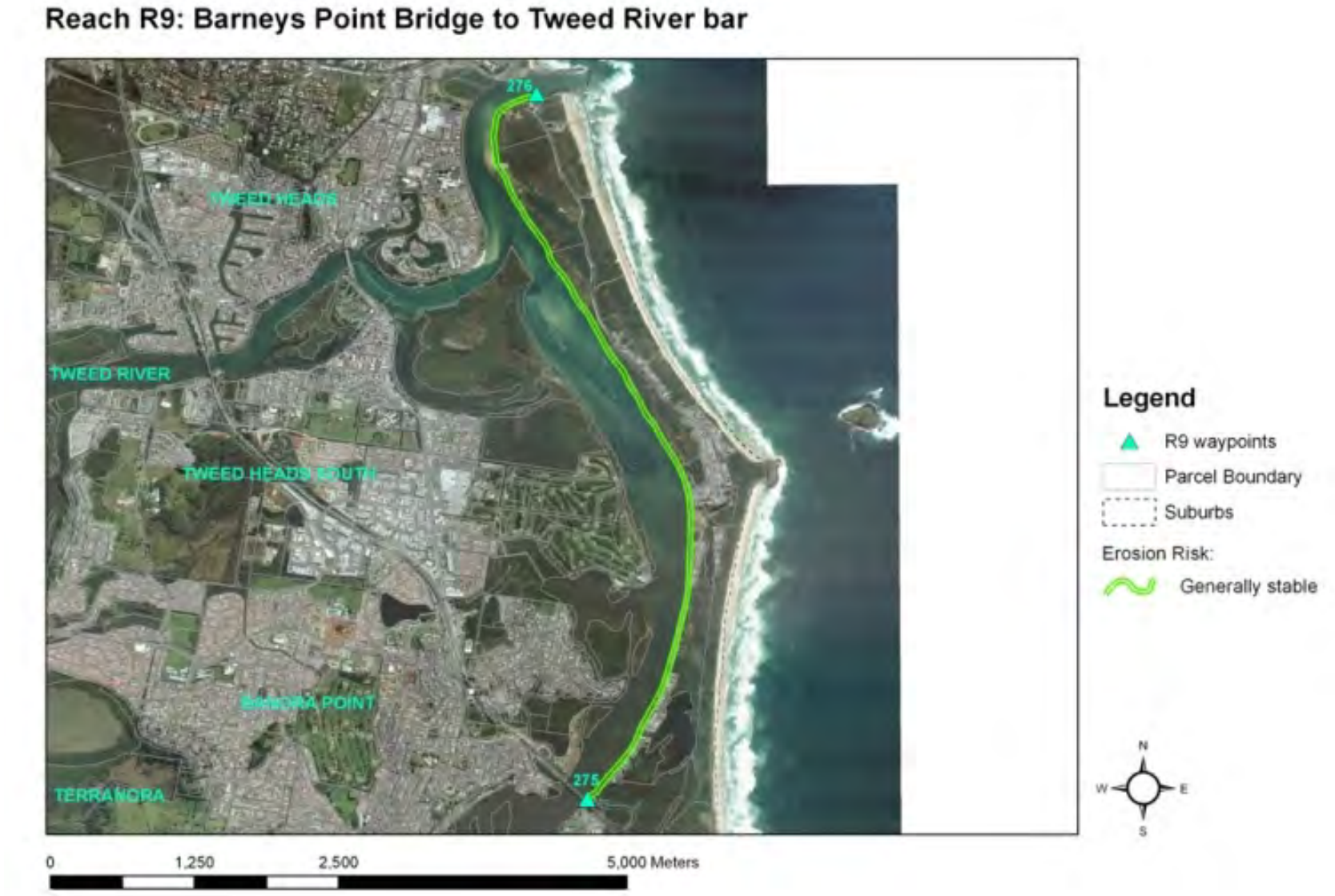
Map 16


Reach L8: Barneys Point Bridge to Tweed River Bar (left bank)
287
286
285
284
277
TWEED HEADS
TWEED RIVER
UKERABAGH ISLAND
TWEED HEADS SOUTH
BANORA POINT
TERRANORA
Legend
L8 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
N
W
E
S
0
1,450
2,900
5,800 Meters

Map 17


Reach R8: Chindera Boat Ramp to Barneys Point Bridge
274
TWEED RIVER
CHINDERAH
273
272
0
175
350
700 Meters
Legend
R8 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
Vulnerable
High risk
N
W
E
S

Map 18


Reach R9: Barneys Point Bridge to Tweed River bar
276
TWEED HEADS
TWEED RIVER
TWEED HEADS SOUTH
BANORA POINT
TERRANORA
275
Legend
R9 waypoints
Parcel Boundary
Suburbs
Erosion Risk:
Generally stable
N
W
E
S
0
1,250
2,500
5,000 Meters

4.0 Erosion Stabilisation

Council's approach to bank stabilisation works can be broadly grouped into areas where:

- no work is required,
- areas suitable for revegetation,
- areas suitable for pre-emptive bio-engineered stabilisation, and
- areas that are likely to require full structural protection.

Table 4 shows the total length of river bank between the Bray Park Weir and Stott's Island, where revegetation, pre-emptive/bio-engineered stabilisation works and structural protective works are likely to be appropriate and/or required. This assessment has been undertaken based on field assessment and an assessment of width between road edge and riverbank using 2012 aerial photography.

Table 4. Total length appropriate to stabilisation approach.

Stabilisation approach	Bank length (metres)
Revegetation	15,863
Pre-emptive bioengineered works	4668
Structural protection	Up to 5754*

There are 10,667m of river bank within 7.5 metres of the road, with 5,754 m classified as severely eroded.

Section 5.0 includes a prioritised schedule of works to be undertaken by Council.

Given the highly variable nature of erosion within the immediate proximity of the Tweed Valley Way and Tumbulgum Road, a prioritised list of sites to undertake reactive, structural protection works has not been prepared. Councils Works Unit have determined that stabilisation of severe slips is best undertaken on an as needs basis.

4.1 No work required by Council

The focus of works proposed in this plan is on eroding river banks on Council or State controlled land. There are significant lengths of the river where erosion threatens private property, including both residential and agricultural land. This report does not make recommendations for erosion stabilisation on private property (though it does provide technical guidelines for this work), and as such, private property has not been classified in terms of the appropriate stabilisation approach. The management aims stated in section 1.1 of this document are relevant however, and will be applied when Council considers any river bank stabilisation project proposed on private land.

Council will work with landowners to assist in managing erosion. Council's River Health Grants program is specifically intended to assist rural landowners undertake works that will improve riparian vegetation and bank stability.

4.2 Revegetation

Where bank erosion does not present a threat to public assets and the distance between the river bank and roads exceeds 8 metres, revegetation of the river bank with native riparian vegetation should be undertaken. Riparian revegetation has many benefits, including increasing river bank stability and resistance to erosion during and after floods. It must be recognised however that revegetation of river banks does not begin to address mechanisms

of erosion until vegetation attains a significant level of maturity, estimated to be at least five years in the case of trees, and that revegetation alone will not be effective in protecting banks from erosion by wake waves.

Appendix 3 includes an assessment of areas where revegetation could/should be undertaken. A total bank length of 15,863m comprising an area of 181,099sqm has been identified as potentially suitable for revegetation. Prioritisation of revegetation sites should be toward those areas where additional positive benefits can be accrued, in particular the buffering of existing native vegetation, or increasing connectivity with core habitat or existing riparian corridors.

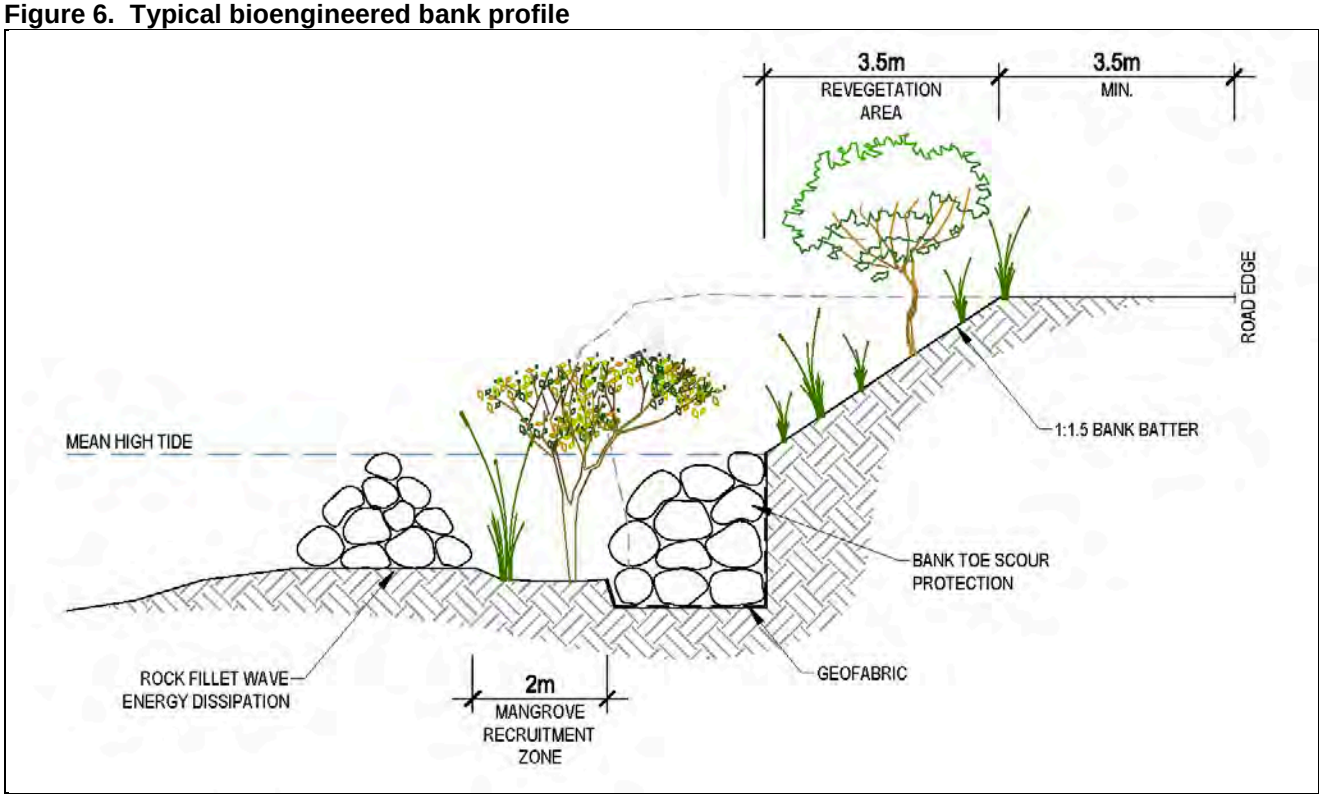
4.3 Restoration of existing toe revetment

A common feature in the estuary is the presence of old rock revetment that has been hand placed at the toe of the river bank. In many locations this revetment is still providing effective protection from bank toe scour, however it can also be seen to have outflanked in many locations, with severe bank erosion occurring as a result. An advantage of the low level bank toe revetment is that it has frequently been colonised by vegetation on the top of bank. It would be advantageous to maintain and restore these areas. This will not be possible by the usual means of working with machinery from the top of bank, due to the need to remove top of bank vegetation. The possibility of restoring and extending the benefit provided by areas of old bank toe protection should be investigated as it may provide an important additional approach to pre-emptive erosion management.

4.4 Pre-emptive erosion stabilisation using bio-engineered designs

A minimum distance of approximately 7.5 metres is required between the road edge and river bank edge to undertake river bank stabilisation using a bio-engineered approach. This allows for a 3.5 metre setback from the road edge to any planting incorporated into the top of bank stabilisation works, and also allows for a minimum 3.5 metre work zone where bank battering and revegetation could occur.

Figure 6. Typical bioengineered bank profile



Site specific designs for individual banks will be required, but will usually include the following elements:

- wave energy dissipation
- bank toe stabilisation
- bank battering
- revegetation
- maintenance

In some locations a low level toe protection structure, battering and revegetation will be sufficient to achieve bank stability. Rock fillets for wave energy dissipation and encouraging colonisation by mangroves will only be effective where a wide shallow intertidal bench is present.

A total length of 4668 m is potentially suitable for this type of erosion stabilisation.

4.5 Designs for structural protection

The choice of a detailed design for each bank stabilisation project will be dependent on site specific factors, predominantly influenced by bank height, water depth and proximity of infrastructure. It is possible for designs to combine elements of both the structural and bio-engineered approaches shown above, and vary along the length of bank being treated in accordance with variable bank condition.

The design of all bank stabilisation works should include consideration of elements that can mitigate post-construction environmental impacts. This will primarily involve creating opportunities for vegetation to either naturally recolonise intertidal areas, or plantings to be incorporated into the upper bank profile.

Where revegetation or a bio-engineered bank stabilisation approach is not considered sufficient to manage erosion threats to infrastructure, structural stabilisation options must be considered.

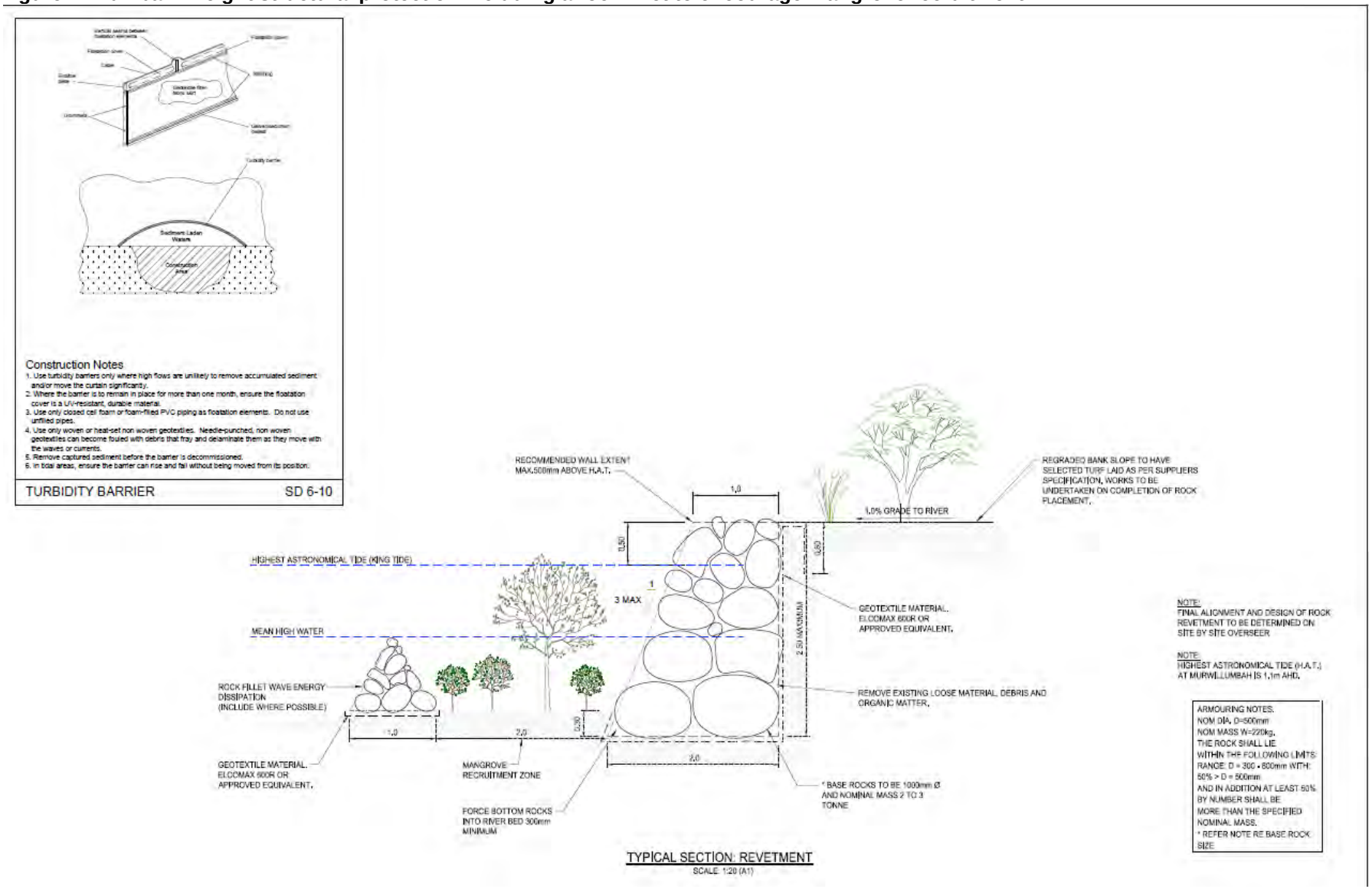
In the case of TSC managed land adjacent to roads, the total bank length equal to or less than 7.5 m of the road edge is 10,667 m. The portion of this overall total where erosion is severe, is 5,754 metres. It is likely that a large proportion of this length will need to be structurally stabilised.

Wherever possible the principal of incorporating rock fillets to encourage mangrove colonisation of the bank toe should be employed in addition to full structural protection of river banks. This is depicted in figure 7.

The typical design detail shown in figure 7 is considered by Council to be best practice for the stabilisation of river bank erosion where structural protection of the river bank to protect assets is required.

This design should be investigated and employed wherever possible by both Council and land owners when river bank stabilisation works are being proposed in the Tweed Estuary. In assessing or reviewing applications or designs for structural river bank stabilisation works, Council will assess the degree to which the elements of this typical design have been incorporated, and the commitment made towards mitigating the aesthetic and ecological impacts of rock wall construction.

Figure 7. Full bank height structural protection including a rock fillet to encourage mangrove recruitment.



5.0 Prioritised Schedule of Council Works

5.1 Revegetation

Table 5. Prioritised sites for riparian revegetation. Site locations are shown in Figure 8 following the table.

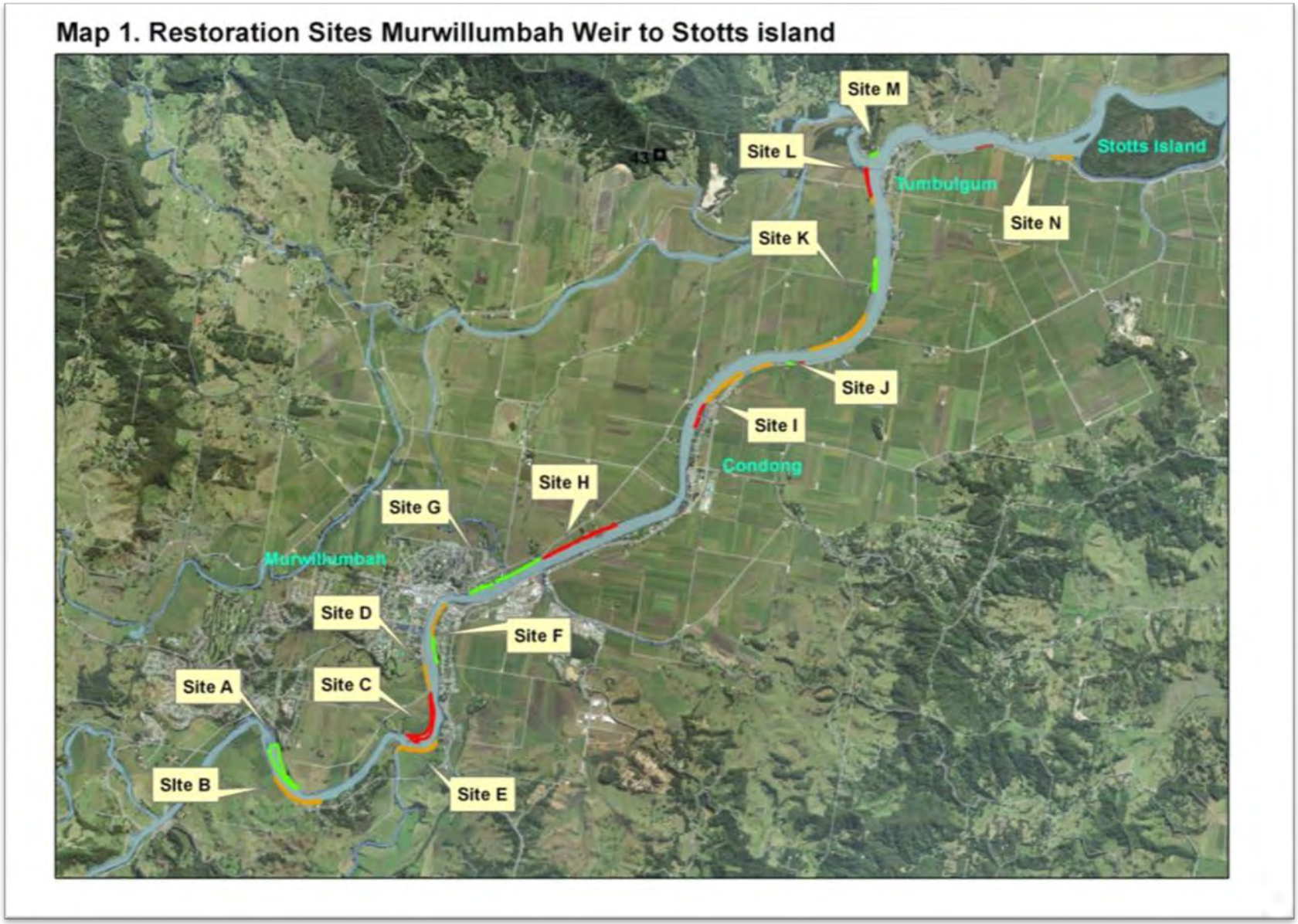
Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
Tumbulgum Road, Tygalgah 1 (Site K)	High	1385	29,000	Bank is vulnerable to erosion along upstream site and stable, protected by mangrove and phragmites on downstream site. Revegetation. High Priority. Good width available, the most significant reach of mangroves upstream of Stott's Island. Existing vegetation (except mangroves) is very weedy.	$87,000
Tumbulgum Road, Tygalgah 2 (Site L)	High	455	5,900	Active and recent erosion of the low bank, which is vulnerable, due to ongoing damage of mangrove root systems by waves and cattle. Revegetation and stock exclusion fencing required. Good width available, especially on the downstream reach. Good connectivity to mangroves at Rous River mouth. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse.	$17,700
Condong Boat Ramp - downstream of park (Site I)	High	600	10,000	Area downstream of boat ramp has high restoration potential. Planting will increase the riparian buffer width adjacent to mangroves. Potential conflict with adjacent agricultural land use.	$30,000
Downstream Bray Park Weir (Site A)	High	750	50,000	High priority over the longer term given it is the largest floodplain in study area under Crown ownership. Very large area (5+ ha). Currently grazed by adjacent landowner. Potential for vegetation to increase flows to opposite vulnerable bank (Site B). Detailed restoration plan required.	$150,000
Byangum Below Weir (Site B)	High	765	15,000	Vulnerable to severe erosion. Road Reserve (plus small area of Crown waterway). High priority over the longer term as this section will continue to erode without management intervention. Requires consultation with cane farmer. Vertical sections of bank require battering. Possible rock armouring along toe if bank continues to be undercut. Work should ideally begin before revegetation of Site A	$45,000

Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
				opposite bank which may increase scour potential due to deflected flows. Detailed restoration plan required.	
Upstream Murwillumbah (Site C)	High	1000	34,500	Erosion severe along most of site with some areas of mass failure (slumping). Crown Land (waterway) and small area of TSC Crown Land. High priority over the long term due to large area of Crown Land available. Narrow riparian zone (existing), mostly less than 7m to cane headland. Bank may require battering to stabilise. This is a large area of Crown waterway with extensive area of cane under cultivation by two adjacent landowners. Requires consultation prior to restoration planning.	$103,500
Dunbible (Site E)	High	600	14,000	Generally stable, 70m section of severe erosion. (photo 27). Road Reserve. Negotiate with adjacent landowner for stock exclusion fencing. Investigate impact on views from Art Gallery. Battering could help stabilise eroding section of bank. Approximately 20m wide, revegetation could be undertaken in stages.	$42,000
Tweed Valley Way, Windmill Corner road reserve (Site N)	Medium-High	480	4800	Downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion. Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. Slip and severe erosion near floodgate upstream of site N1. Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.	$14,400
Tweed Valley Way Condong (Site J)	Med-Low	415	3700	Bank is vulnerable to erosion along most of Site J, stable where mangroves and cottonwoods are along bank toe, area of severe erosion between flood gates. TSC Road Reserve. Moderate priority due to narrow extent between River and Tweed	$11,000

Location	Priority	Site length (m)	Area (m^2)	Description	Estimate cost* (planting and 1 years maintenance)
				Valley Way and weedy condition of vegetation. Potential to increase cottonwoods along the lower bank. Good linkage to Condong Site I. Powerlines along Road side needs to be accounted for in site plans.	
North Tumbulgum (Site M)	Med-Low	100	1000	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge. Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. Requires consultation with adjacent house owners. Battering may help stabilise area in photo 267. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.	$3,000
Total					**$503,600**

*Cost estimate calculation on basis of 25 trees per $100m^2$ at $12 per tree, (planted and maintained for 1 year).

Figure 8. Location of sites referred to in table 5 and 6



5.2 Pre-emptive erosion management

Table 6: Prioritised sites for pre-emptive (bio-engineered) erosion management. Site locations are shown in Figure 8.

Location	Priority	Length	Area	Description	Estimate cost
Murwillumbah, Myall Creek (Site H)	High	1525	14,282	Generally stable upstream and areas of severe erosion downstream. Waterway & State Crown Land. Grazing occurs along this section of river with no riparian exclusion fencing. Rock toe revetment + fencing and revegetation. Investigate potential for rock fillets in conjunction with toe armouring to encourage Phragmites growth. Two landowners only between Myall Creek and Condong Bridge. High revegetation potential downstream to Condong Bridge on Freehold land.	Fence $20, 000 Reveg $42,000 Earthworks and rock $100,000 Total:$162,000
Condong Boat Ramp (Site I)	High	230	2,300	High risk / severe erosion adjacent to boat ramp. TSC Public Recreation Reserve and Waterway (Crown Land) Toe revetment and rock fillets required. Detailed design required which maximises opportunities to incorporate vegetation. Needs community consultation and to acknowledge existing uses of the site..	$100,000
Commercial Road Boat Ramp (Site D)	High	285	1335	Vulnerable, recent slumping as bank continues to become undercut. Road Reserve. High priority for stabilisation as bank continues to erode. Rock toe revetment, battering and revegetation will be required. Investigate potential for fillets to encourage Phragmites.. Limited width for revegetation due to car parking/public recreation space Requires detailed design which maximises opportunities to incorporate vegetation. Investigate appropriateness of revegetation on the river side of levy wall downstream to Murwillumbah Bridge (not mapped as part of this study).	$40,000
Stott's (Site N)	Medium - High	480	4825	Downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion. Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. Slip and severe erosion near floodgate upstream of site N1. Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.	$80,000

Location	Priority	Length	Area	Description	Estimate cost
North Tumbulgum (Site M)	High	100	1013	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge. Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. Requires consultation with adjacent house owners. Battering may help stabilise area in photo 267. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.	$50,000
Total					**$432,000**

5.3 Prioritised sites for structural protection works

Table 7: Prioritised sites for structural works, excluding erosion affecting roads in priority reach.

Location	Priority	Length	Description	Estimate cost
Philp Parade, South Tweed	Medium-high	200m	Erosion of Terranora Creek bank adjacent to Philp Parade. Bank approx 1.5 m high. Existing revetment has failed. Bank approx 4m from road edge.	$150,000
Oxley Cove Canal Estate, Banora Point	Medium	60m	Existing rock revetment has failed on the downstream side of entrance to Oxley Cove canal estate. This area has high tidal current and flood flow velocity as well as deep water. Work last undertaken in 2007. Erosion is severe but does not present a safety risk or threaten high value infrastructure or land. Rebuilding the wall will require placement of significant quantities of large rock.	$50,000
Chinderah Public Foreshore at Hacienda Caravan Park	Medium	200-300m	Public foreshore in this location is protected by ad-hoc revetment comprised of concrete building waste and rock. Erosion looks bad, but is not severe in terms of the risk posed to public land. Existing revetment provides very poor visual and user amenity, including safety risks from exposed reinforcing steel.	$200,000
Ray Pascoe Park, Kennedy Drive Tweed Heads.	Low-medium	40m	Erosion affecting public open space on Banks of Terranora Creek. No risk to infrastructure and erosion of relatively minor consequence to use of park.	$30,000

Location	Priority	Length	Description	Estimate cost
Condong School, Condong	Low-medium	70m	Erosion of river bank on crown land adjacent to school.	$50,000
Crown land opposite Condong Boat Ramp	Low-medium	200m	Erosion on river bank on crown land, adjacent to houses on Tumbulgum Road.	$150,000
Total				**$630,000**

6.0 Planning and Environmental Approvals

When river bank erosion stabilisation projects involve earth works or the placement of rock or any other material into a waterway, approval and permits are required to be sought from Council and a number of state government agencies.

The types of approvals required are different for Council and private land owners. For private landowners, the approval pathway is different when works are in tidal and non-tidal waters.

6.1 Council Work

Council is required to seek a Part V activity approval under the Environmental Planning and Assessment Act 1979 for river bank stabilisation projects. Preparation of an application for Part V approval requires the undertaking of a review of environmental factors (REF). The REF process is aimed at identifying and assessing the significance of any potential impact of the proposed project on matters such as flora, fauna, water quality, cultural heritage etc.

If works are to be undertaken on Crown Land (or within a Crown waterway reserve), land owners consent to lodge an application to undertake the activity must be sought from the Department of Lands. Upon receipt of an approval to undertake works, a temporary license to occupy the Crown land and undertake the works must also be sought.

If works are to be undertaken within a waterway, a permit from the NSW Department of Primary Industries Fisheries must also be sought.

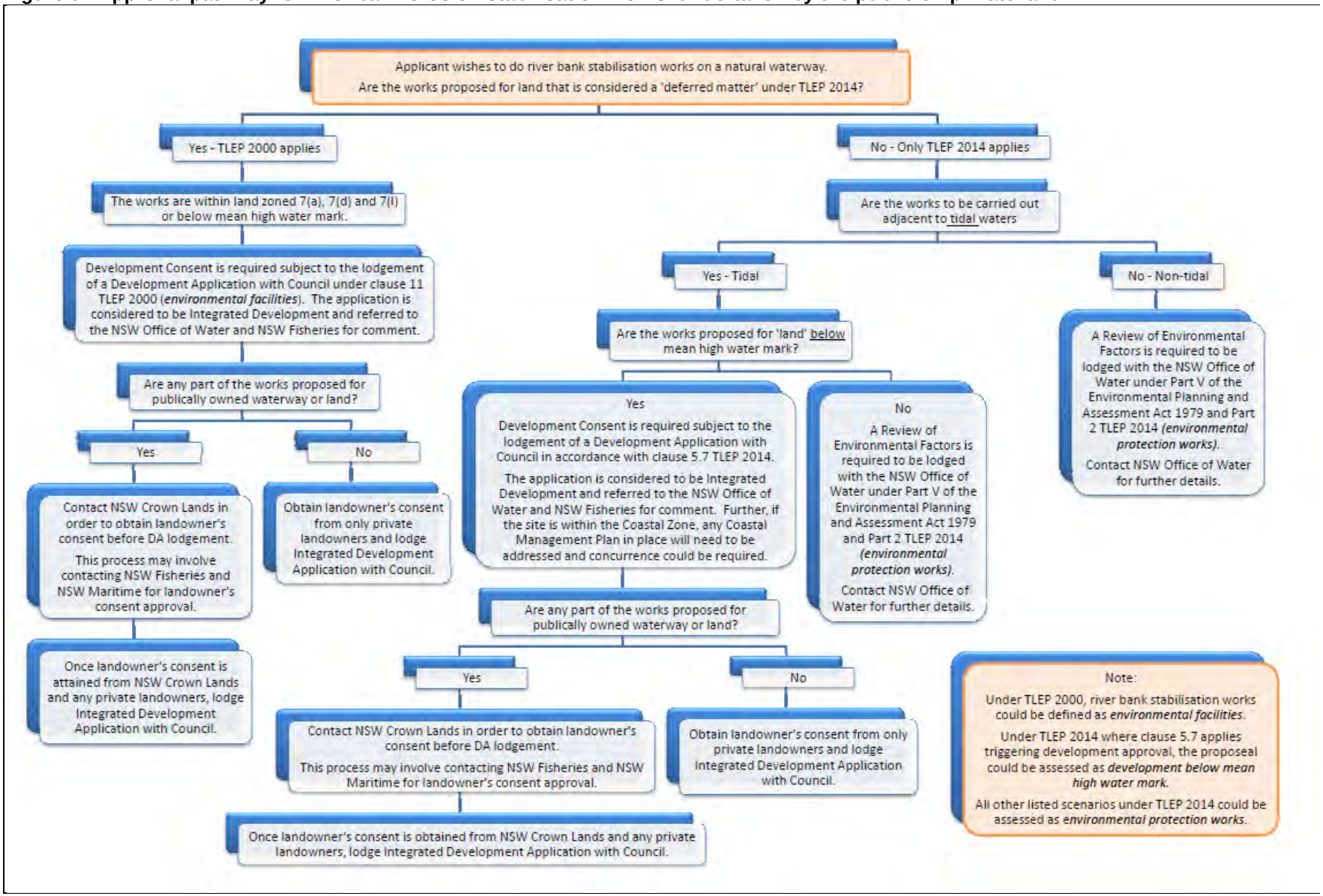
This process is applicable for works in both tidal and non-tidal waterways.

6.2 Work on Private Land

The Tweed LEP 2014 is the planning instrument that defines the permissibility and approval process required for work and activities in the Tweed Shire.

The flow chart provided as figure 9 provides basic guidance on the approval pathway for river bank erosion stabilisation works. Advice should be sought from the Tweed Shire Council Development Assessment Unit for works within a tidal area, or from the NSW Office of water in non-tidal areas.

Figure 9. Approval pathway for river bank erosion stabilisation works undertaken by the public on private land



7.0 Recommendations

1. As the institution with primary responsibility for management of the Tweed River, Council must continue to take a proactive, ongoing role in addressing river bank erosion. Council should work with the community, State Government agencies and river users to stabilise river banks, addressing the impact of erosion on roads, river amenity and the environment.

2. Council must stabilise areas of river bank erosion that threaten infrastructure, but also as a matter of urgency, implement trials of pre-emptive river bank stabilisation techniques that can mitigate the ecological and amenity impacts of full bank height rock armour work. This should include maintenance of existing (historical) bank toe revetment.

3. All work to stabilise river bank erosion in the Tweed River must be designed to minimise environmental impacts and maximise potential for incorporation of, or colonisation by riparian vegetation.

4. Increasing the ecological value and erosion resistance of river banks through revegetation, and maximising existing habitat values will be an important part of offsetting the ongoing negative impacts of large structural erosion stabilisation projects. A compensatory approach to habitat enhancement should be applied where full height structural works are undertaken.

5. River bank stabilisation and revegetation at sites identified in table 5.1, 5.2 and 5.3 should be aimed to be delivered over a ten year program of works.

6. Council must work to identify a source of funding that can be used to address severe bank erosion adjacent to roads, prior to erosion becoming an immediate threat to road stability and public safety.

Appendix 1: Summary of Council Report on Wake Management Options

TITLE:
SUBMITTED BY: Natural Resource Management

Valid

LINKAGE TO INTEGRATED PLANNING AND REPORTING FRAMEWORK:

4	Caring for the Environment
4.3	Maintain and enhance Tweed's waterways and its catchments

SUMMARY OF REPORT:
This report provides Council with information relating to erosion of the Tweed River (estuary only) banks, and deals specifically with the impact that power boat wake has on river bank erosion and consequent impact on road infrastructure.

The report provides Council with an opportunity to adopt a position on power boat wake, as it relates to river bank erosion, that could inform:

- development of a policy relating to commercial use of the river for activities that may create significant wake.
- a submission to NSW Department of Roads and Maritime Services on the issue of wake management in their review of the Tweed River Estuary Boating Plan of management.

The report contains a detailed description of the current state of river bank erosion, and highlights potential costs to manage the problems in the next five to ten years.

The report includes a summary of community submissions to the Impact of Wake on Tweed River Bank Erosion Study (2012).

RECOMMENDATION:
That Council:

1. **Continues to take a proactive, ongoing role in addressing river bank erosion. Council should work with the community, State Government agencies and river users to address the issue of river bank erosion, and its impact on roads and the environment. Council's activities in managing river bank erosion should acknowledge that wake waves are one of several important factors that cause erosion.**

2. **Continues to stabilise areas of river bank erosion as required, but also as a matter of urgency, implement trials of pre-emptive river bank stabilisation techniques that can mitigate the ecological and amenity impacts of full bank height rock armour work.**

3. **Investigates funding options for pre-emptive stabilisation of river bank erosion adjacent to Tumbulgum Road and the Tweed Valley Way. Council should also**

liaise with the Department of Roads and Maritime Services to identify sources of funding that can be used to build the resilience of river banks adjacent to the Tweed Valley Way, rather than rely on disaster relief funding and emergency repairs as a primary means of managing river bank erosion.

4. **Writes to both the NSW Office of Environment and Heritage and NSW Roads and Maritime Services highlighting the level of erosion vulnerability of certain sections of the Stotts Island river bank, and recommend to Roads and Maritime Services and Office of Environment and Heritage that the river reach adjacent to Stotts Island be designated as a no towing zone.**

5. **Writes to NSW Roads and Maritime Services (RMS) advising the department that Council considers use of wake enhancement devices and wake surfing on the Tweed River to be incompatible with Council's objective of reducing river bank erosion and the related impacts on roads and the environment. RMS be requested to ban use of such devices and wake surfing on the Tweed River.**

6. **Proactively partners with and supports the Tweed Water Ski Club led boat driver education program, as a means of maximising the effectiveness of this program and encouraging best practice vessel use to achieve environmental outcomes and reduction of wake impact on river bank erosion.**

7. **Adopts a policy position that precludes operation of commercial towing activities on the Tweed River, and that this position be embodied in the report requested from officers as per item 13 of the Council meeting Thursday 20 June 2013, that being:**

   That Council brings forward a report no later than the April 2014 Council meeting outlining a comprehensive planning proposal capable of adoption by Council to regulate commercial wakeboarding operations and events throughout the Tweed Shire.

Appendix 2: Photographs of river bank condition corresponding to maps 1-18

Reach: L1

001

005

008

009

Reach: R1

011

013

017

018

Reach: R1

019

022

024

Reach: L2

048

050

051

055

Reach: L2

058

066

Reach: R2

025

027

031

033

Reach: R2

036

040

043

Reach: L3

093

094

096

099

Reach: L3

104

108

113

Reach: R3

068

071

078

083

Reach: R3

087

089

Reach: L4

171

184

190

194

Reach: L4

198

205

213

219

Reach: R4

116

122

129

133

Reach: R4

136

139

145

159

Reach: R4

166

170

Reach: L5

267

273

279

283

Reach: L5

286

292

303

305

Reach: R5

233

234

239

242

Reach: R5

249

256

260

264

Reach: L6

351

352

353

354

Reach: L6

355

356

Reach: R6

357

370

374

377

Reach: R6

357

370

374

377

Reach: R6

381

386

Reach: L7

407

409

Reach: R7

388

394

399

404

Reach: R8

476

480

490

495

Reach: R9

497

500

Reach: Stott's Island

312

320

338

341

Reach: Stott's

349

350

Appendix 3: Potential Restoration Sites Murwillumbah Weir to Stott's Island

This document details bank restoration activities which maximise opportunities to incorporate vegetation on public land along the Tweed River between Murwillumbah (Bray Park) Weir and Stott's Island. This study was undertaken as a desk top analysis of public land suitable for undertaking bank stabilisation works incorporating vegetation, and is limited to land that is generally greater than 7m from the shoulder of public roads to the top of the river bank. The rationale for a 7m minimum distance for restoration activities is to ensure the required 3.5m clear buffer from the shoulder of public roads is maintained, and therefore allows a 3.5m minimum strip for revegetation, considered to the minimum viable width to assist in bank stabilisation.

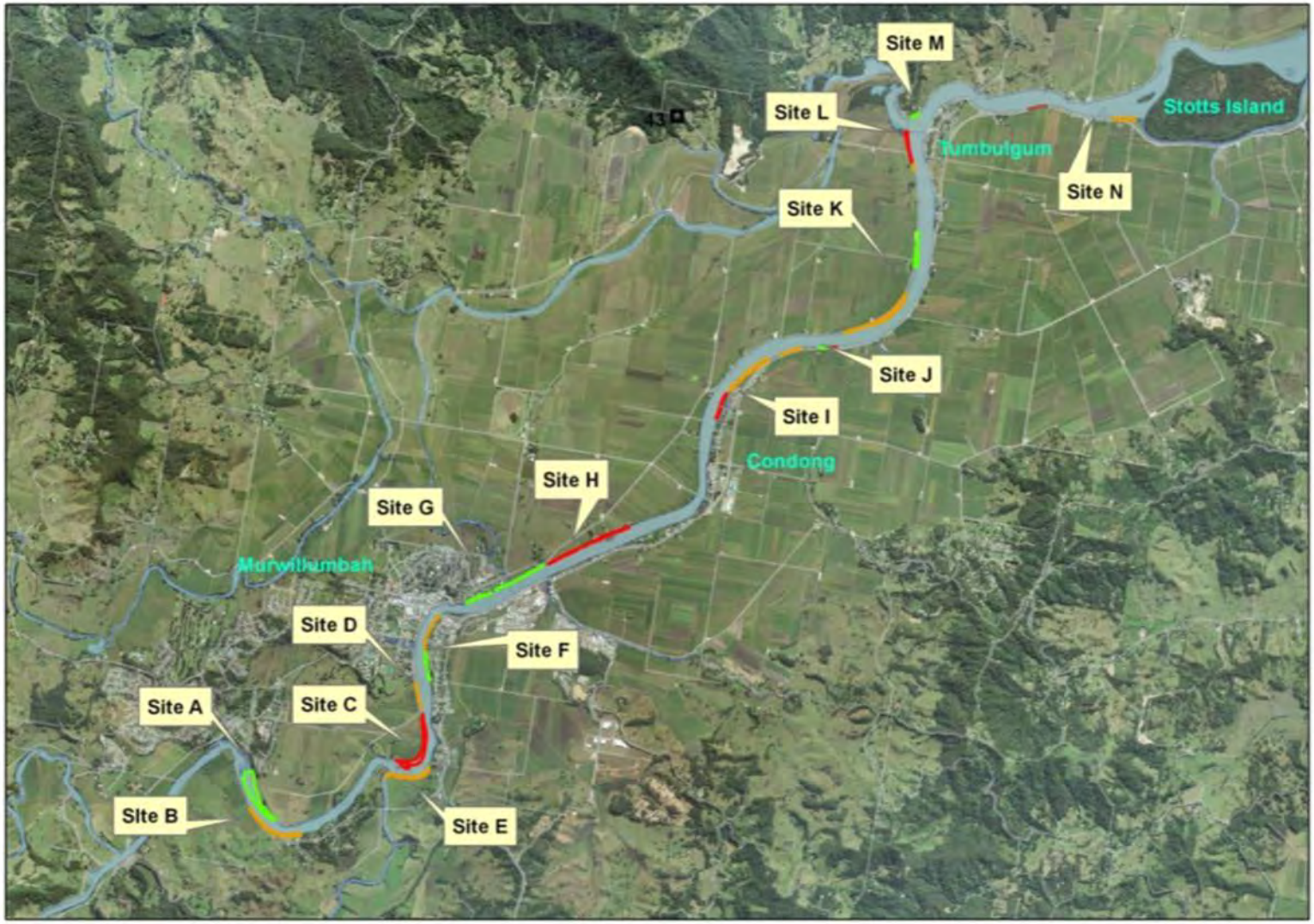
Restoration activities detailed in this study include: revegetation and/or bush regeneration; bank battering combined with revegetation; bank toe armouring using rock incorporating vegetation on the river bank; bioengineering approaches including rock fillets to encourage natural vegetation establishment along the lower bank. Figure 2 details the area and/or length of river bank identified as suitable to incorporate these techniques within the study area.

The Tweed River between the weir at Bray Park and Stott's Island was assessed from the water for erosion risk in August 2013 to inform the Tweed River Bank Management Plan. Figure 1 summarises the erosion risk and bank condition for both left and right banks of the river from field observations and associated data collection.

Table 1. Erosion Risk - Tweed River, Murwillumbah Weir to Stott's Island.

Erosion risk	**Severe/high risk**	**Vulnerable**	**Generally Stable**
Length of bank (both banks combined = 35,855m)	9,207m	10,381m	16,267m

Map 1. Restoration Sites Murwillumbah Weir to Stotts island



Restoration Sites

Bank restoration and erosion stabilisation activities have been categorised as either: revegetation; pre-emptive erosion management (incorporating bioengineering approaches); and re-active erosion management (including structural bank stabilisation works).

Table 2 below summarises the total bank length over which these typical bank restoration and erosion stabilisation activities can be undertaken.

Fourteen sites on public land were identified in the study as being suitable for vegetation restoration activities (Map 1). These sites were selected based on their being an acceptable minimum width of bank available for revegetation. In some cases adjacent sites may be linked over time to provide contiguous habitat.

The length of public river bank vulnerable to or at high risk of erosion and not suitable for revegetation or a pre-emptive bio-engineered approach to stabilisation is also shown in table 2. The primary basis of exclusion from the revegetation or pre-emptive stabilisation category is narrow linear width.

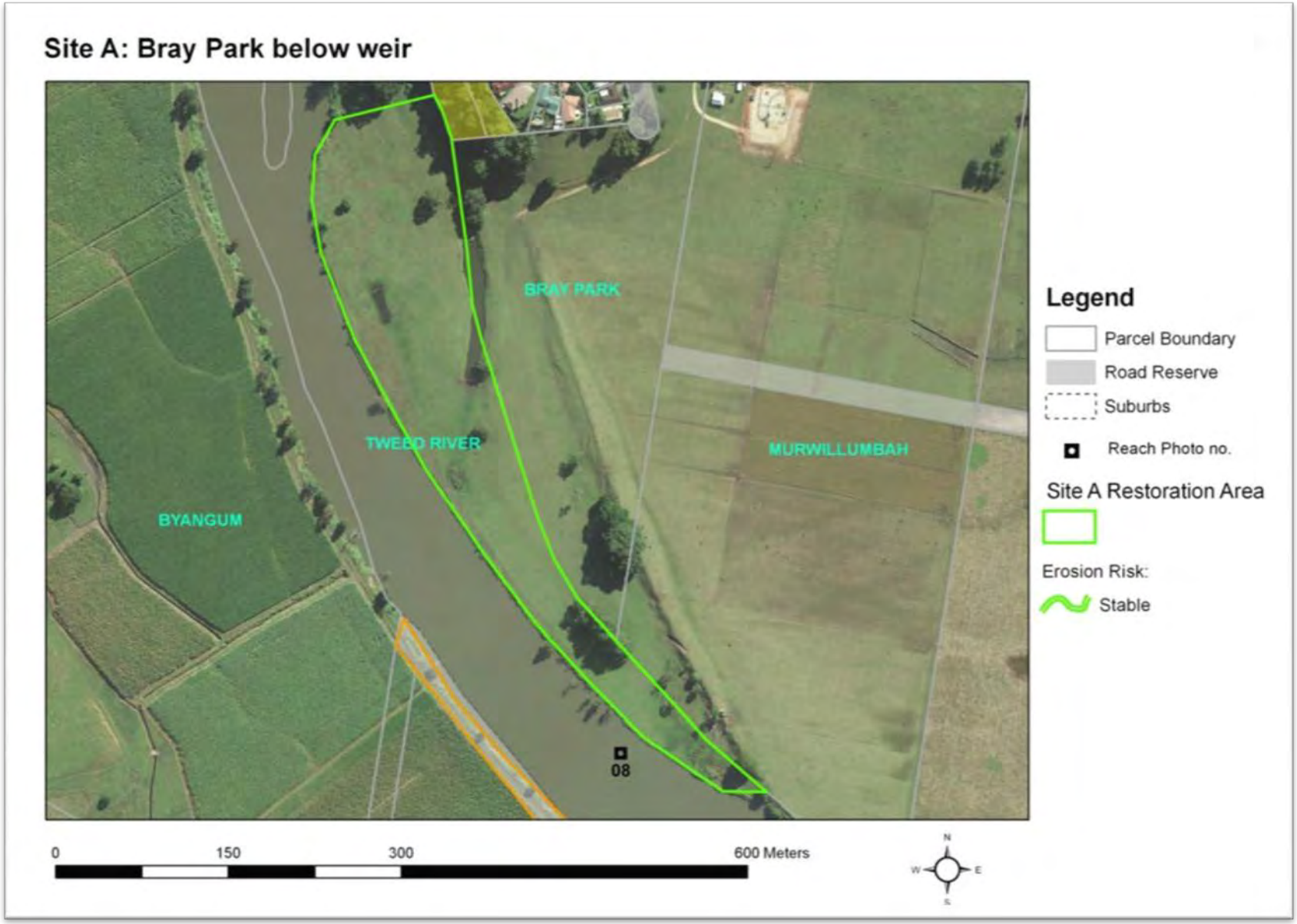
All individual sites where full structural works are required to address bank erosion have not been mapped as part of this project. These reactive management sites will be prioritised for works as erosion threatens assets such as roads and powerlines, and as funds become available.

Eroding river banks on private land have not been included in this assessment, however restoration works on these sites may be eligible for funding through Councils River Health Grant program or other external grants.

Table 2. Length of Bank by Restoration Activities, Murwillumbah Weir to Stotts Island.

Restoration Activity	**Length of bank (m)**	**Area (m^2)**
Revegetation	15,863.5	18,1099
Pre-emptive erosion management	4,668	n/a
Re-active erosion management	10,667 (includes 5,754m of severe erosion)	n/a

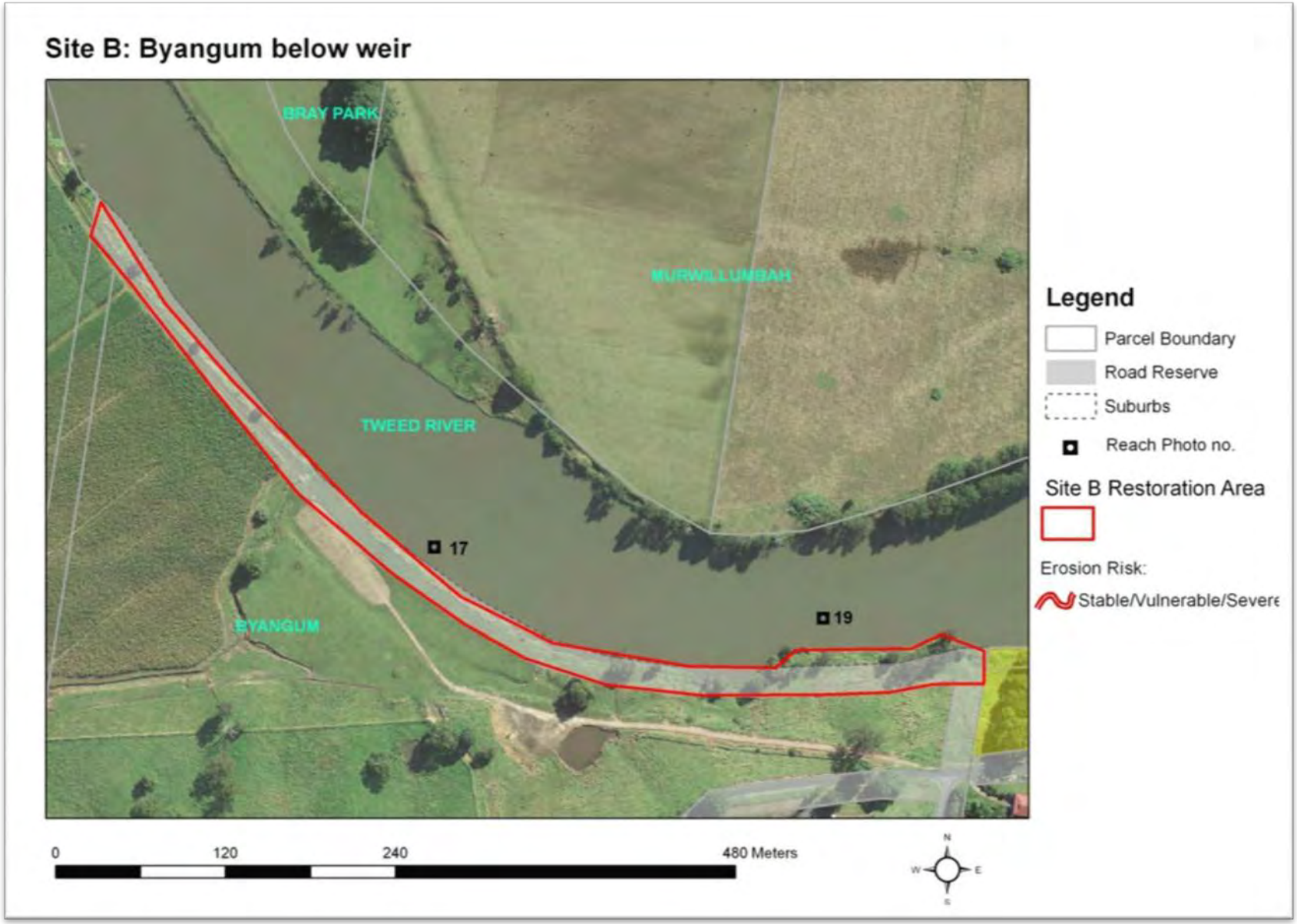
Proposed bank restoration activities and priorities are detailed for each site in the document below, as well as a brief discussion on constraints and/or opportunities for implementation. It should be noted that each site will require detailed designs which maximises opportunities to incorporate vegetation.


Site A: Bray Park below weir
BRAY PARK
TWEED RIVER
MURWILLUMBAH
BYANGUM
08
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site A Restoration Area
Erosion Risk:
Stable
0
150
300
600 Meters
N
W
E
S

Site A - Bank Restoration Activities

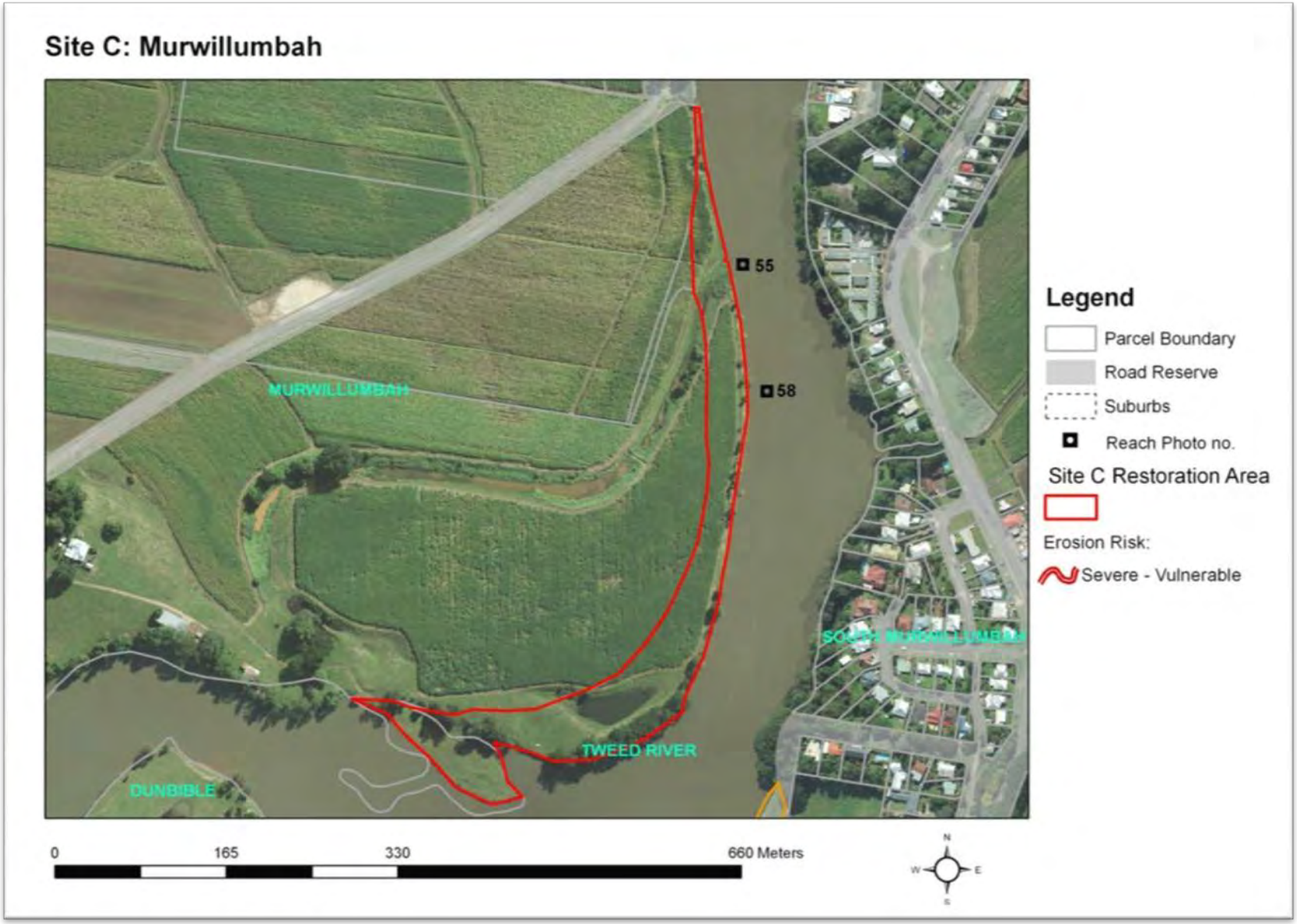
Length (m)	750m
Width (m)	Up to 100m
Area m^2	50,837
Bank height (m)	1-2
Erosion Risk	Stable with some minor undercutting becoming worse towards downstream end of site.
Tenure	Crown Land (waterway)
Restoration activity and priority	Revegetation. High priority over the longer term given it is the largest floodplain in study area under Crown ownership.
Constraints/opportunities	• Very large area to revegetate (5+ ha). • Currently grazed by adjacent landowner. • Potential for vegetation to increase flows to opposite vulnerable bank (Site B). • Detailed restoration plan required.

Photo 08– looking upstream, site A located on the floodplain at right of photo.


Site B: Byangum below weir
BRAY PARK
MURWILLUMBAH
TWEED RIVER
17
19
BYANGUM
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site B Restoration Area
Erosion Risk:
Stable/Vulnerable/Severe
0
120
240
480 Meters
N
W
E
S

Site B - Bank Restoration Activities

Length (m)	765m
Width (m)	10 - 30
Area m^2	15,092
Bank height (m)	1-4
Erosion Risk	Upstream section: Vulnerable. Mid-section: Severe. Downstream section: Stable (bedrock control).
Tenure	Road Reserve (plus small area of Crown waterway)
Restoration activity and priority	Revegetation. High priority over the longer term as this section will continue to erode without management intervention.
Constraints/opportunities	• Requires consultation with cane farmer. • Vertical sections of bank require battering. • Possible rock armouring along toe if bank continues to be undercut. • Work should ideally begin before revegetation of Site A opposite bank which may increase scour potential due to deflected flows. • Detailed restoration plan required.
 Photo 17 – severe erosion on mid-section of site, grassed bank upstream considered vulnerable to erosion.	 Photo 19 – Downstream section of site. Bank is stable due to bed rock control on right bank.


Site C: Murwillumbah
55
58
MURWILLUMBAH
TWEED RIVER
DUNBIBLE
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site C Restoration Area
Erosion Risk:
Severe - Vulnerable
0
165
330
660 Meters
N
W
E
S

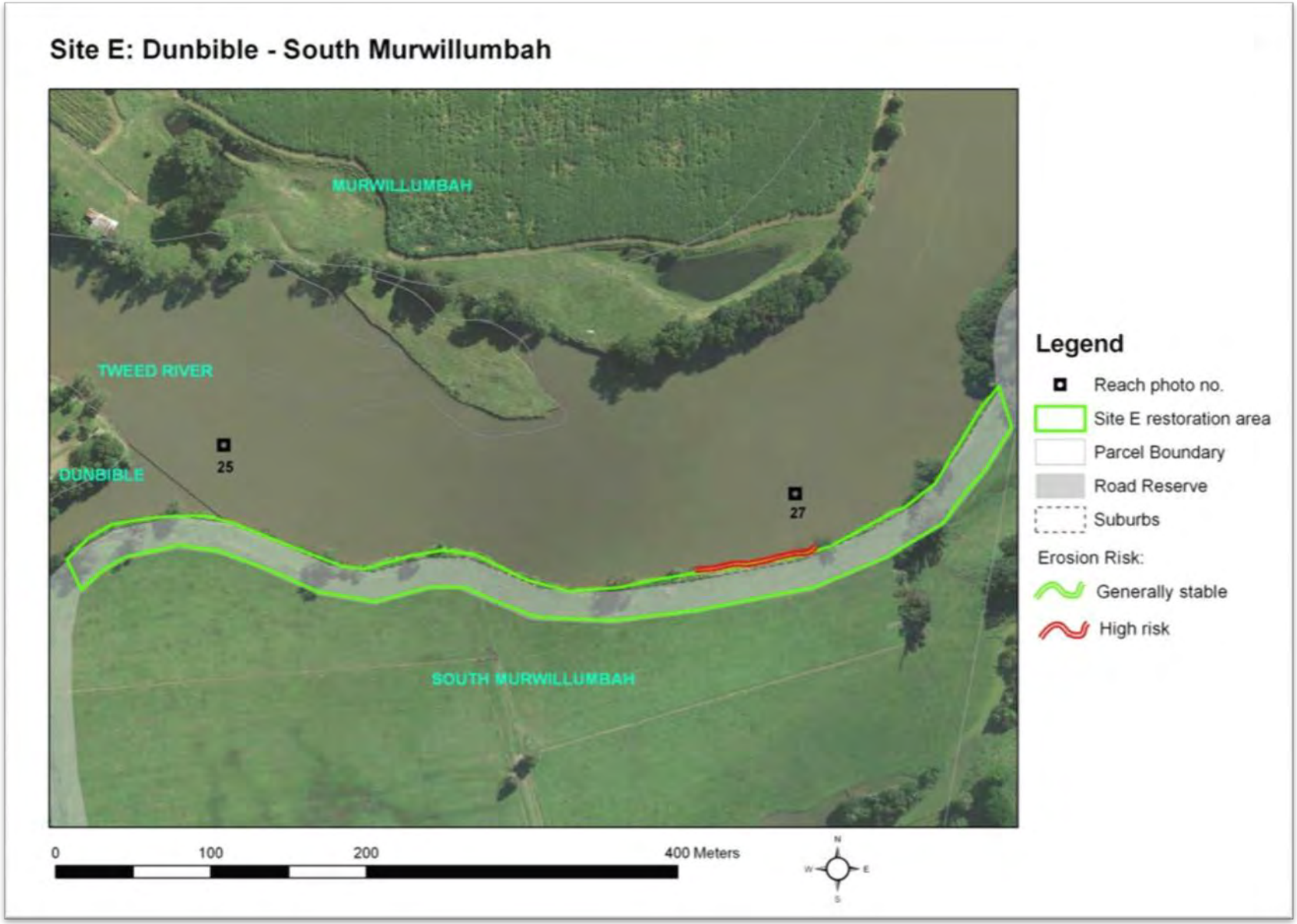
Site C - Bank Restoration Activities

Length (m)	1000m
Width (m)	Up to 65m
Area m^2	34,500
Bank height (m)	1-4
Erosion Risk	Severe along most of site with some areas of mass failure (slumping). Vulnerable along low-lying upstream section of site.
Tenure	Crown Land (waterway) and small area of TSC Crown Land
Restoration activity and priority	Revegetation. High priority over the long term due to large area of Crown Land available.
Constraints/opportunities	• Narrow riparian zone, mostly less than 7m to existing cane headland. • Bank is slumping in sections, and may require battering to stabilise. • Camphor laurel on bank at bend in river in process of being undercut, these could be progressively removed to allow native regrowth. • This is a large area of Crown waterway with extensive area of cane under cultivation by two adjacent landowners. Requires consultation prior to restoration planning.
 Photo 55 – looking upstream	 Photo 58 – showing bank slump with cane land on top of bank.

Site D: Commercial Road Murwillumbah

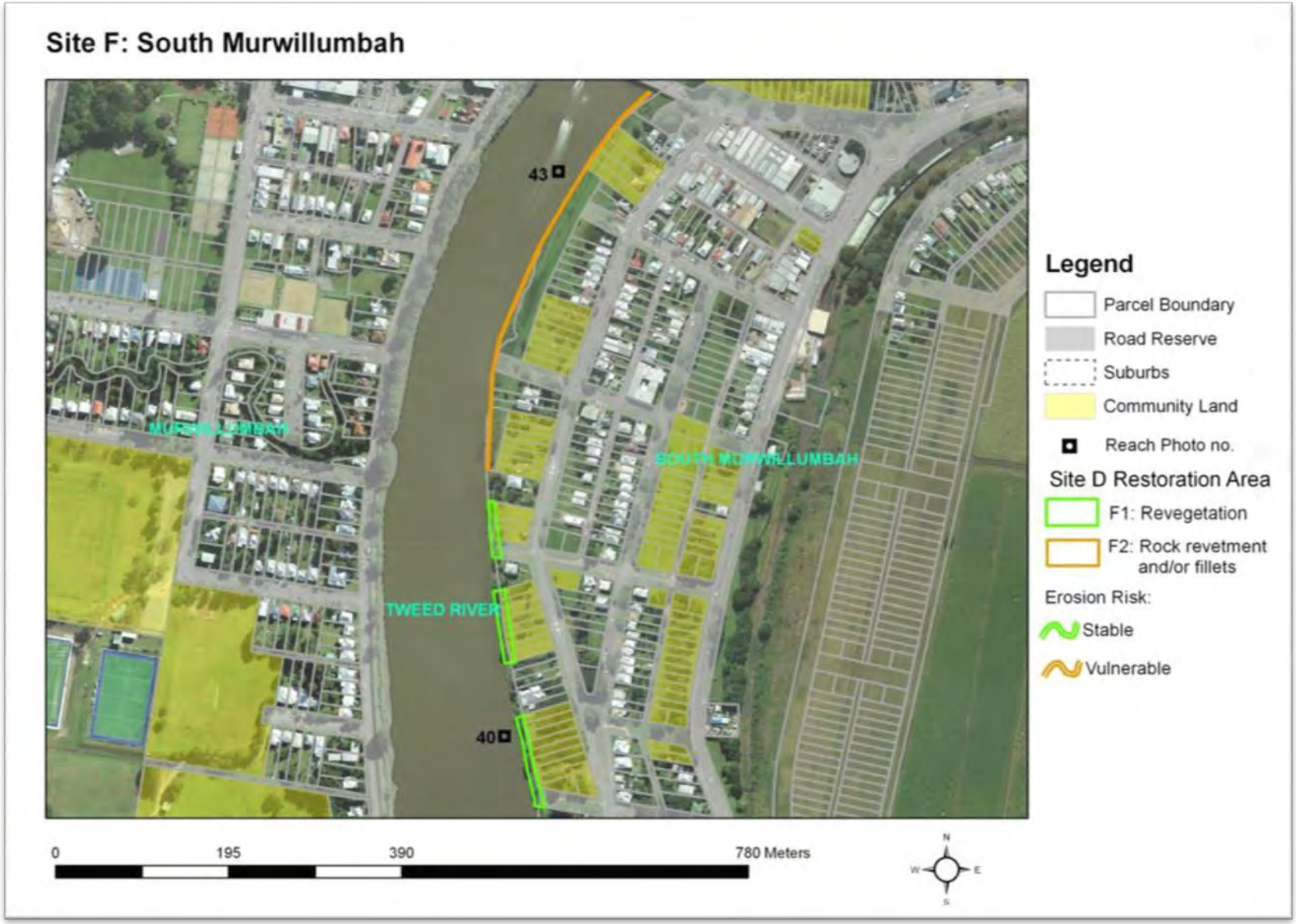
Site D - Bank Restoration Activities

Length (m)	285m
Width (m)	7-10m
Area m^2	1335
Bank height (m)	~1.0
Erosion Risk	Vulnerable, recent slumping as bank continues to become undercut.
Tenure	Road Reserve
Restoration activity and priority	Rock toe revetment and investigate potential for fillets. High priority as bank continues to erode.
Constraints/opportunities	• Existing rock revetment along toe at upstream end of site (towards boat ramp) may be adequate to protect bank. • Limited width for revegetation due to car parking/public recreation space • Requires detailed design which maximises opportunities to incorporate vegetation. • Investigate appropriateness of revegetation inside of levy wall to Murwillumbah Bridge (not mapped as part of this study).
 Photo 50 – rock revetment of slump downstream of site D	 Photo 51 – active bank erosion adjacent to boat ramp.


Site E: Dunbible - South Murwillumbah
MURWILLUMBAH
TWEED RIVER
DUNBIBLE
25
27
SOUTH MURWILLUMBAH
Legend
Reach photo no.
Site E restoration area
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Generally stable
High risk
0
100
200
400 Meters
N
W
E
S

Site E - Bank Restoration Activities

Length (m)	600m
Width (m)	20m
Area m^2	14,194
Bank height (m)	1 – 4
Erosion Risk	Generally stable, 70m section of severe erosion (photo 27 below)
Tenure	Road Reserve
Restoration activity and priority	Revegetation. High priority.
Constraints/opportunities	• Negotiate with adjacent landowner for stock exclusion fencing. • Investigate impact on views from Art Gallery. • Battering could help stabilise eroding section of bank. • Road reserve ~20m wide, revegetation could be undertaken in stages.
 Photo 25 – Site E right bank	 Photo 27 – active bank erosion


Site F: South Murwillumbah
43
40
TWEED RIVER
SOUTH MURWILLUMBAH
Legend
Parcel Boundary
Road Reserve
Suburbs
Community Land
Reach Photo no.
Site D Restoration Area
F1: Revegetation
F2: Rock revetment and/or fillets
Erosion Risk:
Stable
Vulnerable
0
195
390
780 Meters
N
W
E
S

Site F - Bank Restoration Activities

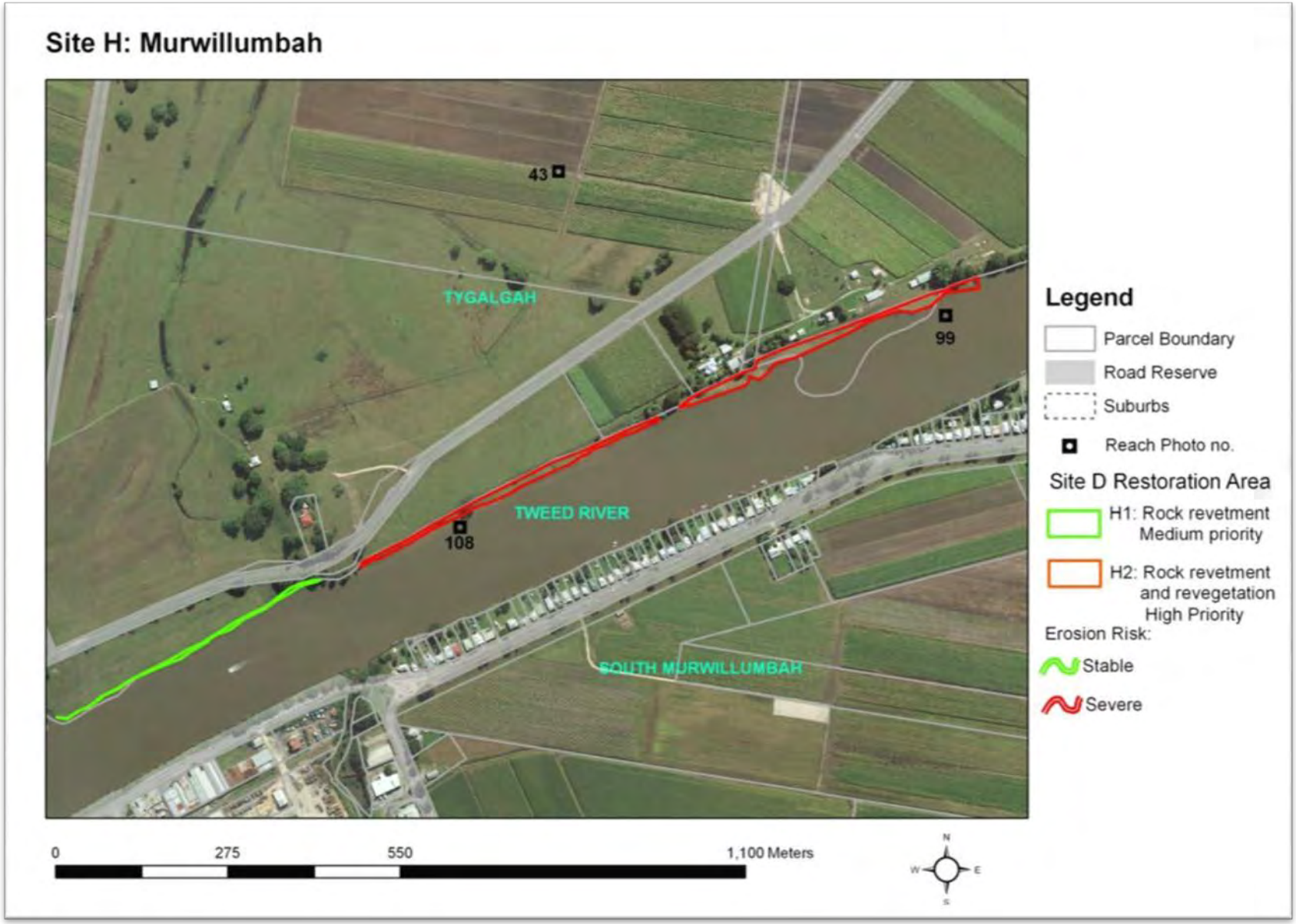
Length (m)	473m (combined)
Width (m)	~10m
Area m^2	5735
Bank height (m)	~1.0
Erosion Risk	Generally stable - vulnerable
Tenure	Community Land (Tweed Shire Council), Crown Waterway
Restoration activities and priority	Revegetation in upstream areas: Medium Priority. Rock revetment/fillets along bank adjacent to levy bank: Medium priority.
Constraints/opportunities	• Sections of bank are slumping along this reach - requires investigation of need/potential for battering or rock revetment. • Tidal bench present along lower section of this site, investigate rock fillet potential. • Potential to revegetate riverside of levy bank, consult with Council engineers. • Requires consultation with South Murwillumbah community (revegetation may impact on access/views).
 Photo 40 – Site F1 showing slump at drain outlet	 Photo 43 – Site F2 minor bank erosion with levy bank in background

Site G: Murwillumbah

Site G - Bank Restoration Activities

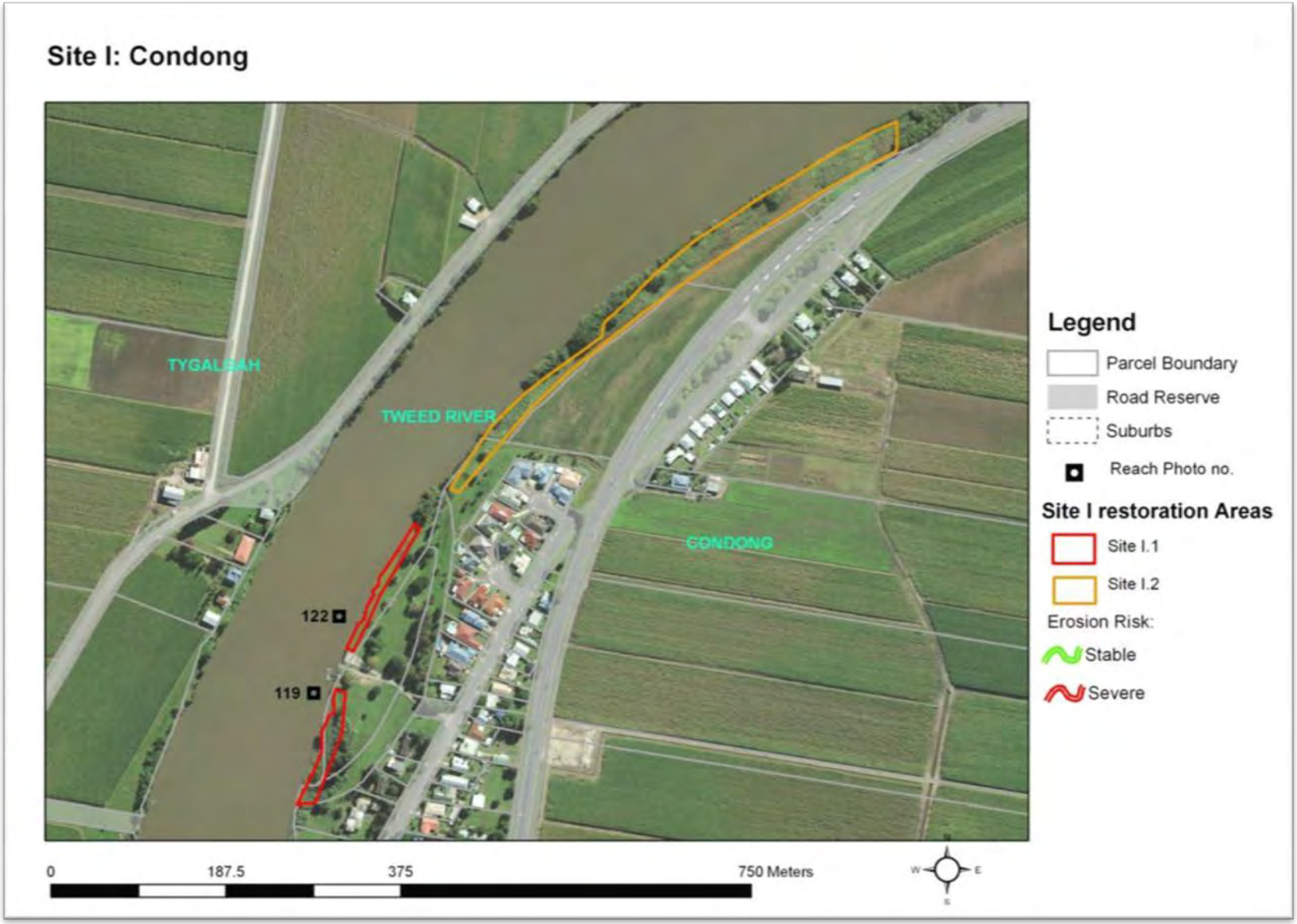
Length (m)	445 (combined)
Width (m)	7-15
Area m^2	5200
Bank height (m)	~1.0
Erosion Risk	Generally stable with minor erosion along the bank toe
Tenure	State Crown
Restoration activity and priority	Rock revetment +/- fillets +/- revegetation. Low priority unless erosion becomes worse.
Constraints/opportunities	• Revegetation could block views and river access of adjacent houses, therefore low potential for planting trees. • Possible to batter and stabilise with lomandra/phragmites in higher risk areas. • Tidal bench along much of this reach, potential to stabilise bank toe with rock revetment and/or install rock fillets. • Crown Lands licence required for environmental enhancement structures (e.g. rock fillets).

Photo 113 – showing minor erosion along bank toe


Site H: Murwillumbah
43
TYGALGAH
99
TWEED RIVER
108
SOUTH MURWILLUMBAH
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site D Restoration Area
H1: Rock revetment Medium priority
H2: Rock revetment and revegetation High Priority
Erosion Risk:
Stable
Severe
0
275
550
1,100 Meters
N
W
E
S

Site H - Bank Restoration Activities

Length (m)	1525 (combined)
Width (m)	<5-15
Area m^2	14282
Bank height (m)	<1-4
Erosion Risk	Generally stable upstream and areas of severe erosion downstream.
Tenure	Waterway & State Crown
Restoration activities and priority	Rock toe revetment along upper section of site: Medium priority. Rock toe revetment + revegetation along mid section of site: High Rock toe revetment + revegetation along lower section of site: High
Constraints/opportunities	• Grazing occurs along this section of river with no riparian exclusion fencing. • Two landowners only between Mayal Creek and Condong Bridge. • High revegetation potential downstream to Condong Bridge on Freehold land. • Investigate potential for rock fillets in conjunction with toe armouring. • Crown Lands licence required for environmental structures (e.g. fillets).
 Photo 99 – severe bank erosion	 Photo 108 – bank collapse is occurring along most of this site


Site I: Condong
TYGALGAH
TWEED RIVER
CONDONG
122
119
Legend
Parcel Boundary
Road Reserve
Suburbs
Reach Photo no.
Site I restoration Areas
Site I.1
Site I.2
Erosion Risk:
Stable
Severe
0
187.5
375
750 Meters
W
E
S

Site I - Bank Restoration Activities

Length (m)	900 (combined)
Width (m)	7-25
Area m^2	19019
Bank height (m)	<1-3
Erosion Risk	High risk / severe particularly downstream of boat ramp. Vulnerable (undercutting) in downstream site I.2.
Tenure	TSC Crown Land (Public Recreation Reserve) and Waterway (Crown Land)
Restoration activities and priority	Toe revetment and rock fillets. High Requires detailed design which maximises opportunities to incorporate vegetation.
Constraints/opportunities	• Erosion severe along recreation reserve bank. Investigate battering/fillets potential. Need approval from Manager Recreation Services + community consultation. • Revetment is required in association with planting and a trial of rock fillets upstream of the pontoon. • Downstream area I.2 adjacent to cane land has high restoration potential. Mangroves line the bank along most of this zone, loss of sediment around roots. Potential revegetation/buffer zone of 1.35ha up to 25m wide.
 Photo 119 – bank toe erosion above boat ramp	 Photo 122 – bank toe erosion downstream of boat ramp

Site J: Tweed Valley Way Condong

Legend

Site J restoration area

- J1
- J2
- J3
- Parcel Boundary
- Road Reserve
- Suburbs
- Reach photo no.

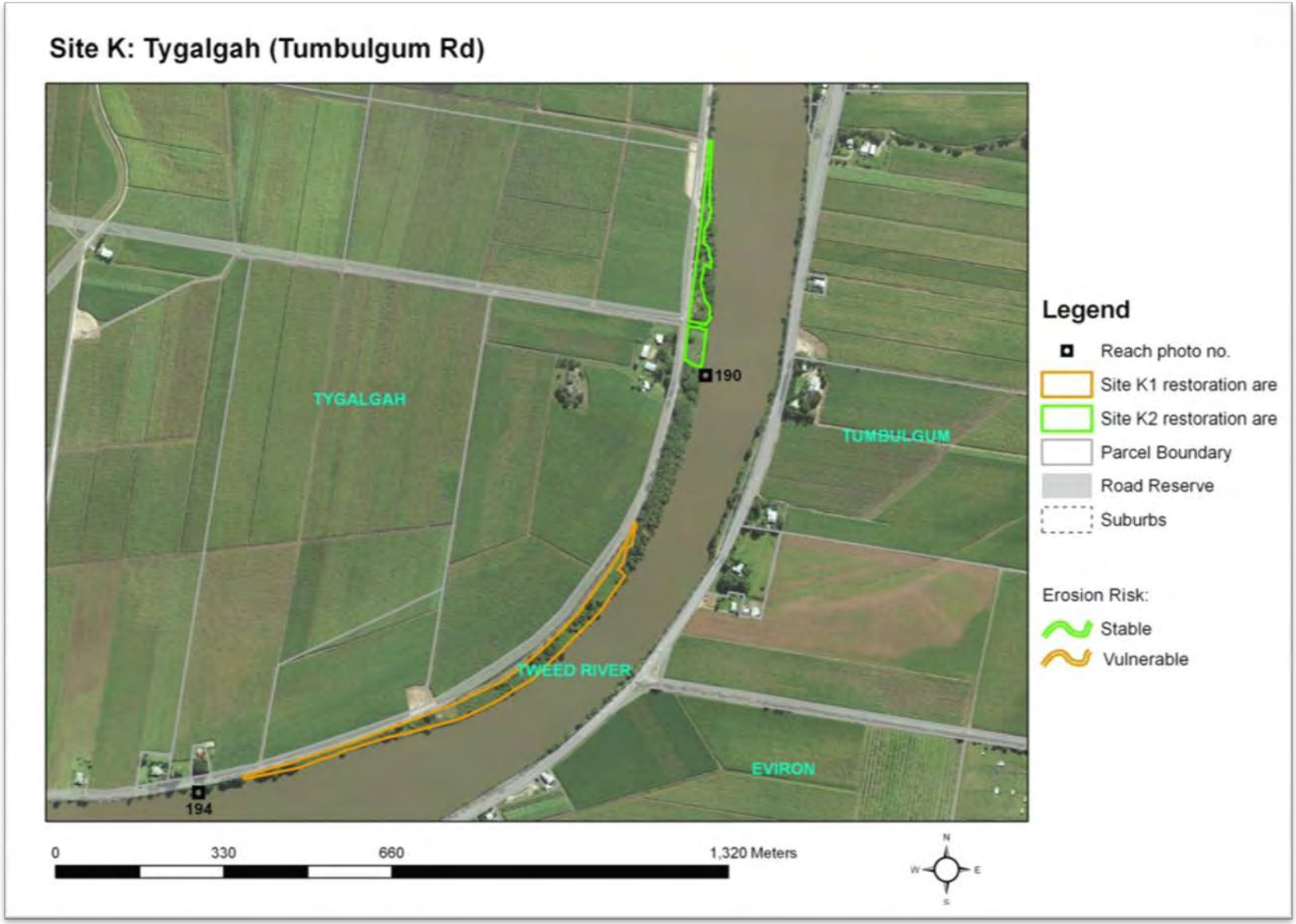
Erosion Risk:

- Stable
- Vulnerable
- High risk

0 140 280 560 Meters

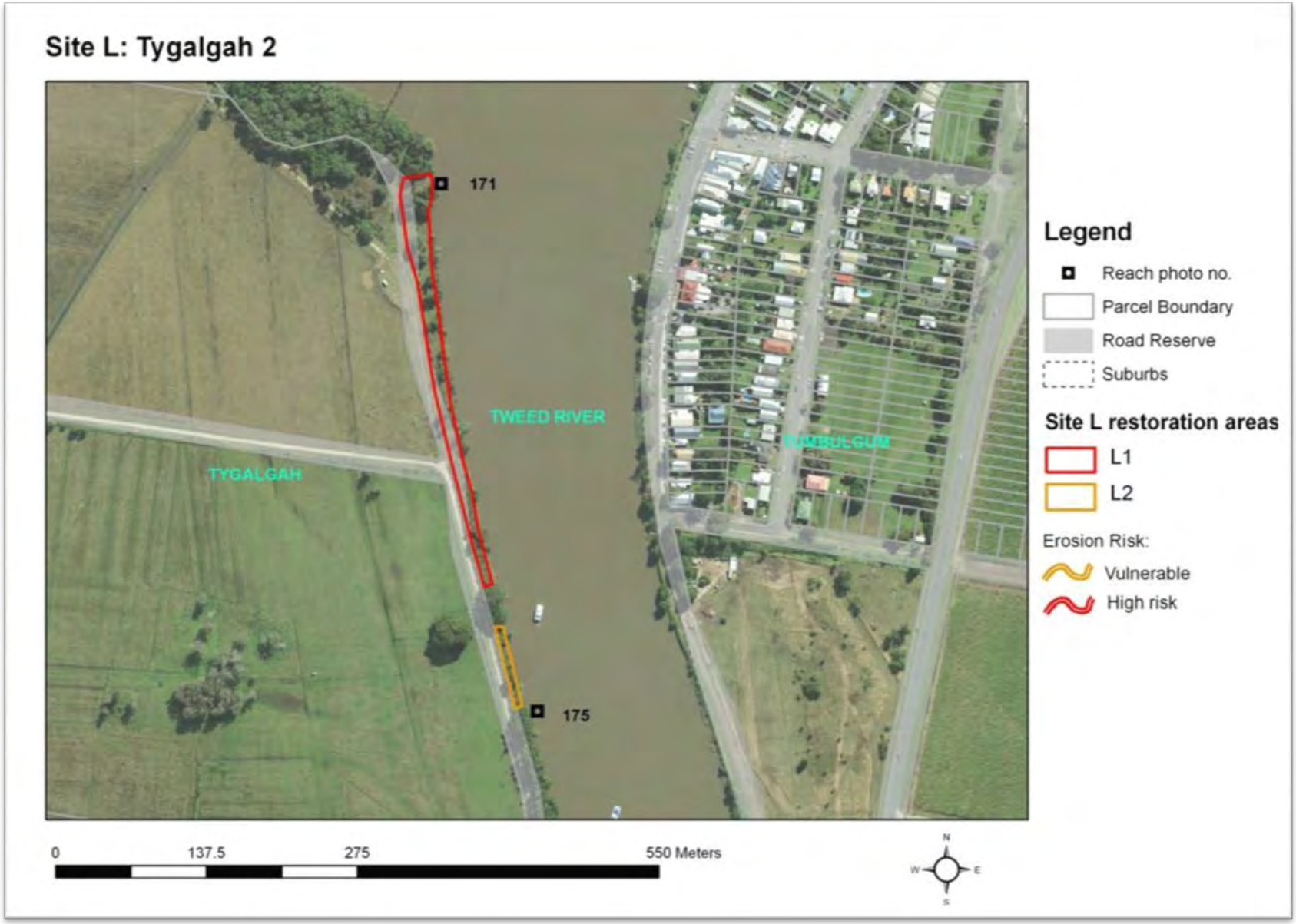
Site J - Bank Restoration Activities

Length (m)	415 (combined)
Width (m)	7-20
Area m^2	3778
Bank height (m)	<1-3
Erosion Risk	Bank is vulnerable to erosion along most of Site J, stable where cottonwoods are along bank toe, area of severe erosion between flood gates.
Tenure	TSC Road Reserve
Restoration activities and priority	Revegetation. Moderate priority due to narrow extent between River and Tweed Valley Way and weedy condition of vegetation.
Constraints/opportunities	• Potential to increase cottonwoods along the lower bank. • Good linkage to Condong Site I. • Generally these areas are very weedy. Mangroves and cotton woods exist throughout site. • Powerlines along Road side needs to be accounted for in site plans.
 Photo 129 – bank undercutting increases risk of failure especially where camphor laurel occur.	 Photo 134 – Bahna grass provides some bank protection but does not protect bank from slumping if toe is eroding.


Site K: Tygalgah (Tumbulgum Rd)
TYGALGAH
TUMBULGUM
TWEED RIVER
EVIRON
190
194
Legend
Reach photo no.
Site K1 restoration are
Site K2 restoration are
Parcel Boundary
Road Reserve
Suburbs
Erosion Risk:
Stable
Vulnerable
0
330
660
1,320 Meters
N
W
E
S

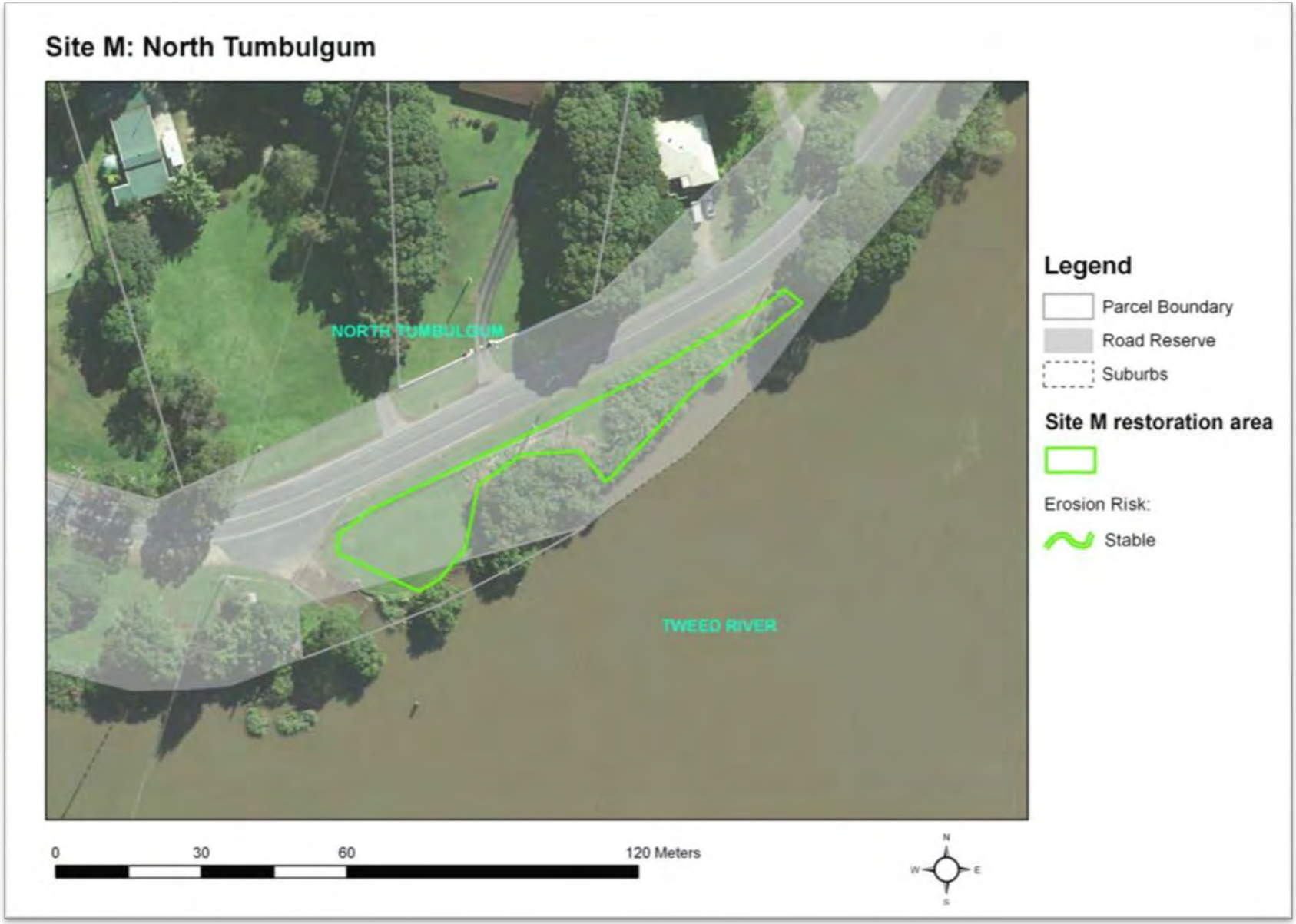
Site K - Bank Restoration Activities

Length (m)	1385 (combined)
Width (m)	7-30
Area m^2	29020
Bank height (m)	<1.0 – 2m
Erosion Risk	Bank is vulnerable to erosion along upstream site and stable, protected by mangrove and phragmites on downstream site.
Tenure	Waterway (Crown Land)
Restoration activities and priority	Revegetation. High Priority. Good width available, the most significant reach of mangroves upstream of Stotts Island. Existing vegetation (except mangroves) is very weedy.
Constraints/opportunities	• Priority revegetation site due to length and width and buffer to mangrove habitat. • Area upstream of site is experiencing bank failure and there is a narrow area between River and Tumbulgum Rd, little opportunity to batter. Investigate fillets and bank revetment. • Potential view blockage issues in Site K1 opposite homestead.
 Photo 190 – Mangroves along reach.	 Photo 194 – bank erosion immediately upstream of site (note this area is too narrow to revegetate and may require alternative approaches (fillets and or toe revetment).


Site L: Tygalgah 2
171
175
TWEED RIVER
TYGALGAH
TUMBULGUM
Legend
Reach photo no.
Parcel Boundary
Road Reserve
Suburbs
Site L restoration areas
L1
L2
Erosion Risk:
Vulnerable
High risk
0
137.5
275
550 Meters
N
W
E
S

Site L - Bank Restoration Activities

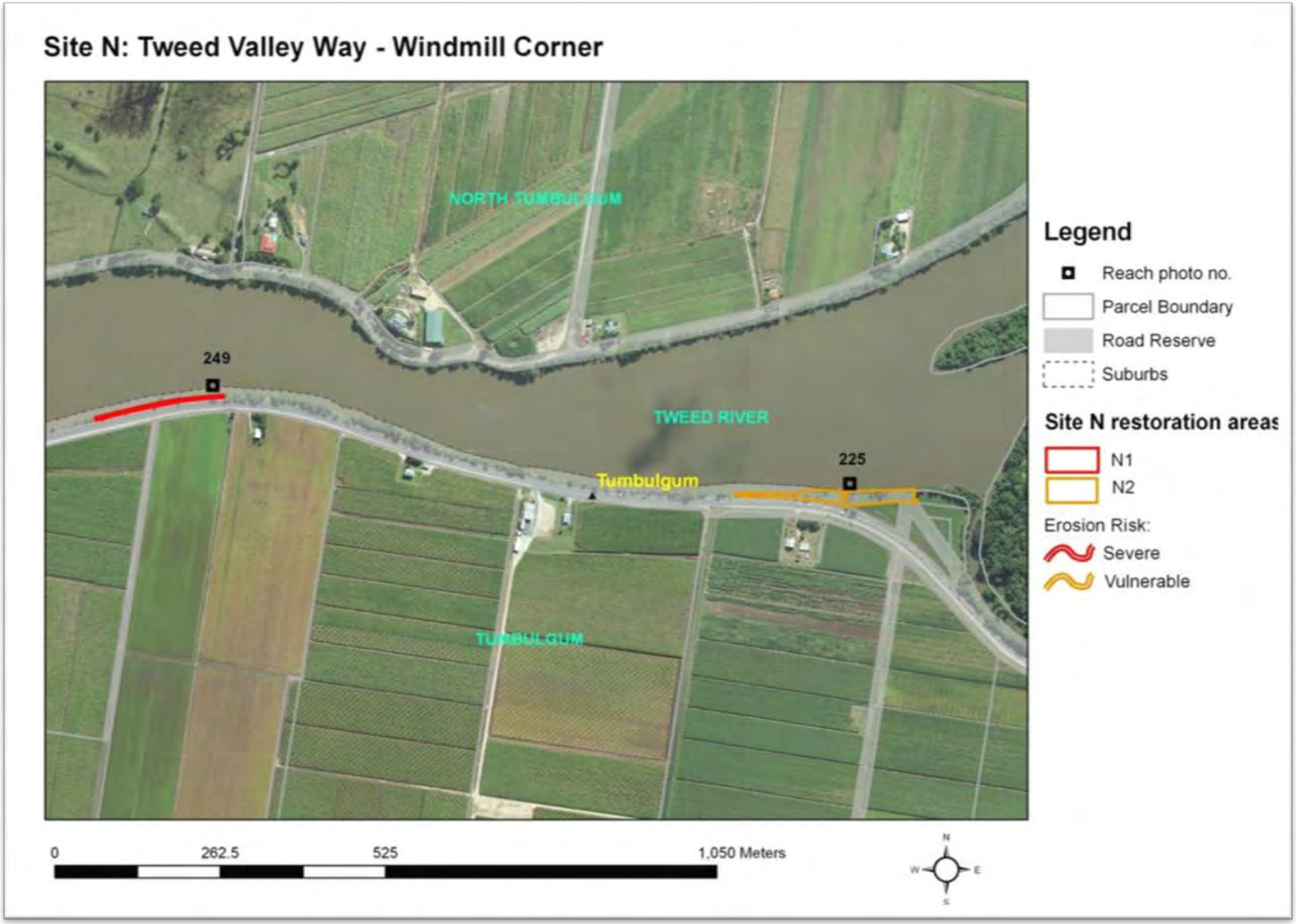
Length (m)	455 (combined)
Width (m)	7-30
Area m^2	5946
Bank height (m)	<1-3
Erosion Risk	Active and recent erosion of the low bank, which is vulnerable to ongoing damage of mangrove root systems by waves and cattle.
Tenure	Road Reserve & Waterway (Crown Land)
Restoration activities and priority	Revegetation and stock exclusion fencing. High priority.
Constraints/opportunities	• Good width available, especially on the downstream reach. Good connectivity to mangroves at Rous River mouth. • Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. • Site requires fencing, consult with land manager.
 Photo 171– Downstream site J, bank erosion possibly exacerbated by grazing.	 Photo 175 – camphor laurel along bank showing undercutting (note photo taken at high tide).


Site M: North Tumbulgum
NORTH TUMBULGUM
TWEED RIVER
Legend
Parcel Boundary
Road Reserve
Suburbs
Site M restoration area
Erosion Risk:
Stable
0
30
60
120 Meters
N
W
E
S

Site M - Bank Restoration Activities

Length (m)	100
Width (m)	7-20
Area m^2	1013
Bank height (m)	<1-3
Erosion Risk	Bank is fairly stable due to mangrove protection of toe, however recent erosion is occurring in the downstream edge of this area and further along the bank downstream to Tumbulgum Bridge.
Tenure	Road Reserve
Restoration activities and priority	Revegetation Medium-Low priority. Small area.
Constraints/opportunities	• Very narrow riparian area between river and road on bank experiencing severe erosion downstream of this site. • Camphor laurels are present along much of this reach, being undercut which may lead to eventual collapse. • Requires discussion with Recreation Services as to status of old boat ramp (fenced off). • Requires consultation with adjacent house owners. • Battering may help stabilise area in photo below. Broad tidal bench would allow rock fillets, bedrock exposed downstream of this site.

Photo 267– Bank erosion on downstream end of this site.


Site N: Tweed Valley Way - Windmill Corner
NORTH TUMBULGUM
249
TWEED RIVER
225
Tumbulgum
TUMBULGUM
Legend
Reach photo no.
Parcel Boundary
Road Reserve
Suburbs
Site N restoration areas
N1
N2
Erosion Risk:
Severe
Vulnerable
0
262.5
525
1,050 Meters
N
W
E
S

Site N - Bank Restoration Activities

Length (m)	480 (combined)
Width (m)	7-20
Area m^2	4825
Bank height (m)	<2-4
Erosion Risk	Bank is very susceptible to erosion; downstream sections are vulnerable whilst much of the reach upstream is experiencing severe erosion.
Tenure	Road Reserve
Restoration potential	Medium - High. High potential at Windmill Corner, more difficult on upstream section due to narrow width of river bank between river and Tweed Valley Way.
Constraints/opportunities	• Very narrow riparian area along most of Tweed Valley Way. The sites mapped are the only areas with greater than 7m available for planting (accounting for a 3.5m clear zone from road shoulder). • Old revetment is providing toe stability, however variable condition is leading to moderate slips. Undercuts are present. • Slip and severe erosion near floodgate upstream of site N1. • Wide tidal bench upstream of N2/Windmill Corner may permit trial of rock fillets.
 Photo 225 – old rock revetment at Windmill Corner (L2)	 Photo 249 – Undercutting at site L1

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