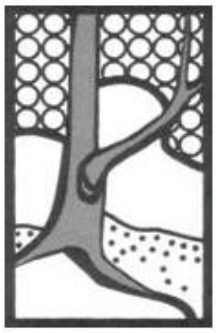

Mactaggart

Natural Resource Management

URBAN WATERWAYS ASSESSMENT

UPDATE

FOR

BATHURST REGIONAL COUNCIL

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August 2014

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1. INTRODUCTION

A comprehensive condition assessment of the Bathurst urban waterways was undertaken by Cenwest Environmental Services in 2009 and reported in the Urban Waterways Management Plan (UWMP) (Refer Mactaggart *et al.* 2010). As a follow up to this baseline study Bathurst Regional Council has engaged Mactaggart Natural Resource Management to carry out an updated assessment on a number of selected creek sites for the purpose of evaluating restoration works, monitoring current waterways management regimes and identifying threats likely to impact on ecosystem function or amenity. Sites reassessed are present along the six creeks *viz.:* Sawpit, Jordan, Hawthornden, Queen Charlotte Vale, Saltram and Raglan.

The report covers the methodological approach taken in assessing the sites, reports and discusses the condition assessment findings and concludes with points of consideration and recommendations.

2. METHODS

The waterways condition assessment pro forma developed for the UWMP was adopted for the assessment update and the same protocol for rating indicators, attributes and finally the overall stream condition was employed. Ratings and supplementary notes at each site were transcribed in the field and later recorded in digital format.

2.1. Site selection

A number of key sites were identified for reassessment by Deborah Taylor, Bathurst Regional Council, and this list was discussed for possible omissions and inclusions with the consultant. The final list of sites to be reassessed is provided in Table 1. All together there are 72 sites and the large majority of these are on Council owned or controlled land.

During the field assessment Site R18, which is an upper drainage line of Raglan Creek in the proximity of Mars Petcare, was not assessed due to inaccessibility, as the area is currently a construction site.

2.2. Field work

The field work was undertaken from the 26 May to 5 June 2014 in the same period as the baseline assessment conducted five years ago. All sites were visited and the length of the creek site, where practical, was traversed on foot. Some sites required little walking (e.g. Saltram Creek on Eleven Mile Drive) whereas others (e.g. upper reaches of Hawthornden Creek on Mount Panorama) required a more extensive survey. A visual assessment only was accorded at sites where public access was restricted or not permissible (e.g. private land on Saltram Creek downstream of Eleven Mile Drive).

The weather conditions during the survey period were mostly dry and the ambient temperature was warm to cool. Preceding the survey early autumn rainfall was above the mean for Bathurst and by mid-April the rainfall recordings began to weaken. During the survey period 11 mm was recorded towards the end of May and a further 19 mm in early June. Evidence of these rainfall events during the survey period were evident at some sites with urban runoff at drains, water turbidity, small puddles of stormwater and small flows in otherwise ephemeral sections of the creeks. The warmer than average daily temperatures and the good autumn rainfall were favourable for the growth of terrestrial and aquatic vegetation – particularly cool season grasses such as Phalaris.

Table 1. Assessment sites

Sawpit (SP)	Jordan (J)	Hawthorden (H)	Saltram (M)	Raglan (R)	Vale (V)
2	3	10	1	3	15
14	4	11	6	4	23
15	8	12	7	12	24
17	9	13		17	
19	10	14		18	
27	13	15		19	
33	14	16		20	
34		17		21	
36		18		22	
38		19		24	
39		21		26	
		22		30	
		23		31	
		28		34	
		29		35	
		30		36	
		31		37	
		32		42	
		33		43	
		34		44	
		35		45	
		36		46	
		37		47	
				48	
				49	

2.3. Presentation of results

The assessment sheets have been digitally prepared and are not contained within this report. However, key results such as condition ratings, condition trends, effectiveness of rehabilitation works, changes in impacts and threats as well as other relevant observations are presented below in the Section 3.

3. CONDITION ASSESSMENT UPDATE

Presentation of the waterways condition assessments has been organised into the six creek catchments to keep it in line with the structure of the UWMP. Many of the findings have parity across sites forming generalised trends and these are also presented in Section 3.2.

The urban waterways are characterised by drainage systems of varying morphologies and similarly to the 2009 assessment their condition ranges from highly degraded to good. The highest category, very good, remains unrepresented across all sites surveyed. Mostly the overall condition assessments are unchanged from the previous assessment and this does not reflect the fact that some sites show physical, hydrological or ecological changes (both positive and negative) at the level of a particular indicator, such as structural integrity of the instream vegetation, hydraulic deviation from natural flows and bed and bank stability. While there may be subtle changes at this level, it does not always carry enough influence to affect a difference in the overall condition rating.

Being mindful of changes that can occur at the elemental level (indicators and attributes) is important when evaluating the effectiveness and appropriateness of management practices or restoration/rehabilitation works – especially over short time scales. No change of overall rating does not equate to no change at the stream site. To illustrate, there may be significant improvements to instream vegetation structure, habitat complexity and cover with the removal of willows, but across the other indicators and attributes there may be either no change or a rating reduction.

With only five rating categories *viz.;* highly degraded, degraded, poor, good and very good, it can be problematic to assign a rating to a particular site when its condition is borderline between two categories. This conundrum is compounded when trying to maintain a level of consistency, while at the same time drawing distinctions across sites and across creeks. Site S2 (Figure 1) is one such site where the condition rating is on the borderline of ratings. The baseline assessment determined it to be 'highly degraded' on the grounds that it is devoid of any original vegetation, the stream 'channel' has been engineered and the hydrology significantly compromised with a low-flow pipe installation and alteration of the catchment hydrology. Compare this with the highly modified, low-flow piped Raglan Creek drainage line (site R4, Figure 5). The latter site was designated as being 'degraded' (not highly degraded) on the basis that the catchment hydrology in this site is less altered. A small compensation, but arguably enough to tip it towards a higher rating. Plausibly both sites could have been rated as either 'degraded' or 'highly degraded'.

A summary table (Table 2) is presented to show the 2009 and 2014 condition ratings for each site and an indication of the direction the condition is trending. In addition, figures 1 to 6 below represent each creek showing paired condition maps. One map indicates the condition ratings as per 2009 assessment and the other map indicates the condition rating as per the current assessment. The maps draw a visual comparison between each assessment period.

Table 2. Summary table showing condition *rating* comparisons for 2009 and 2014 assessment periods and overall condition *trend* at each assessed site. Colour legend - highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

Sawpit (SP)			Jordan (J)			Hawthornden (H)			Saltram (M)			Raglan (R)			Vale (V)		
2009	2014	Trend	2009	2014	Trend	2009	2014	Trend	2009	2014	Trend	2009	2014	Trend	2009	2014	Trend
2		=	3		↑	10		=	1		↑	3		=	15		=
14		=	4		↑	11		=	6		=	4		=	23		=
15		↑	8		↓	12		=	7		↑	12		=	24		↑
17		↓	9		↓	13		=				17		=			
19		=	10		↑	14		↑				19		=			
27		↓	13		↑	15		↑				20		=			
33		=	14		=	16		↑				21		=			
34		↑				17		=				22		↓			
36		↓				18		↑				24		=			
38		↓				19		↑				26		↑			
39		=				21		=				30		↑			
						22		=				31		↓			
						23		=				34		=			
						28		=				35		=			
						29		=				36		=			
						30		↑				37		=			
						31		=				42		↑			
						32		=				43		=			
						33		↑				44		=			
						34		=				45		=			
						35		=				46		=			
						36		=				47		=			
						37		=				48		=			
												49		↑			

3.1. Creek catchment condition trends

3.1.1. Sawpit Creek

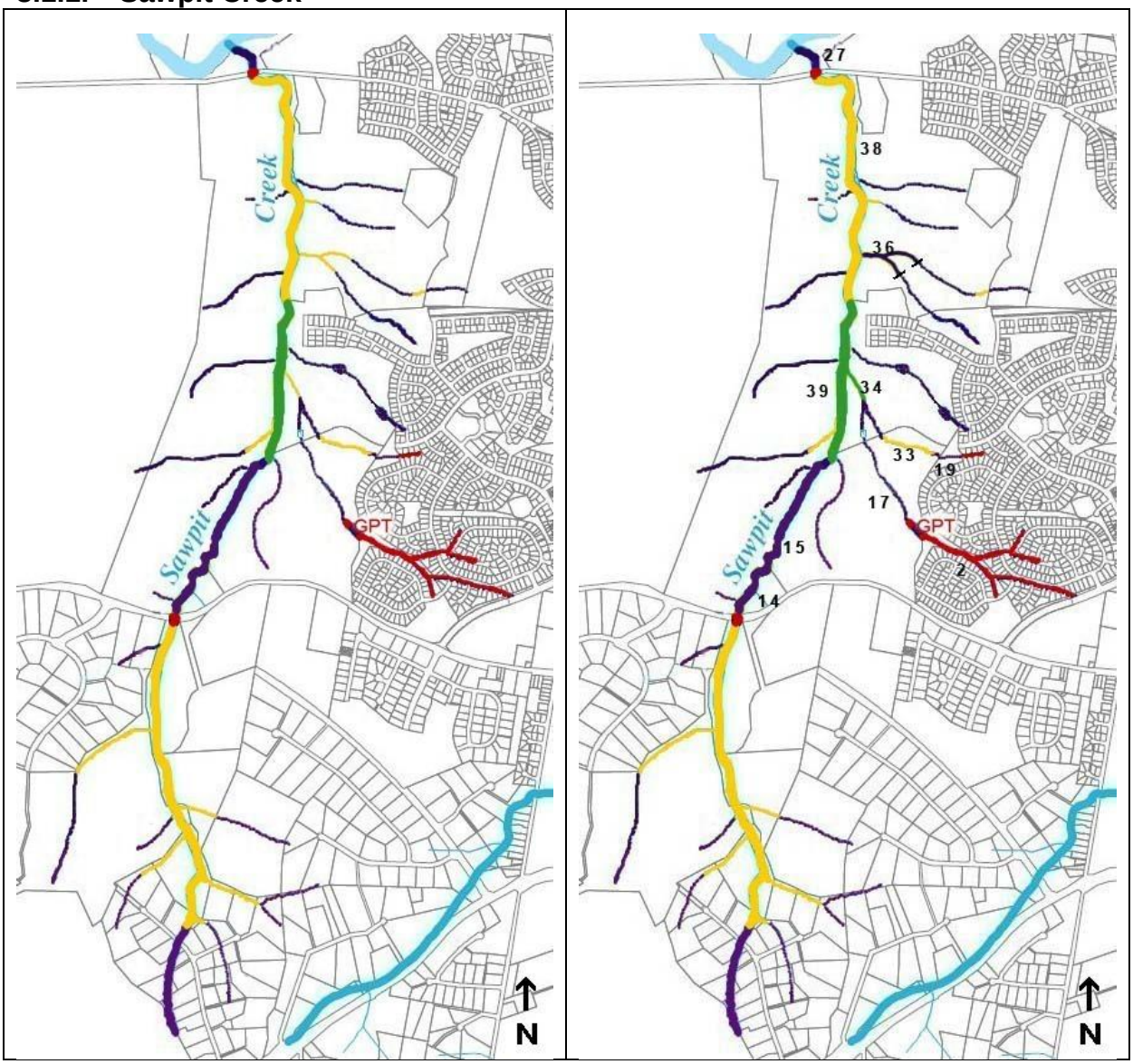
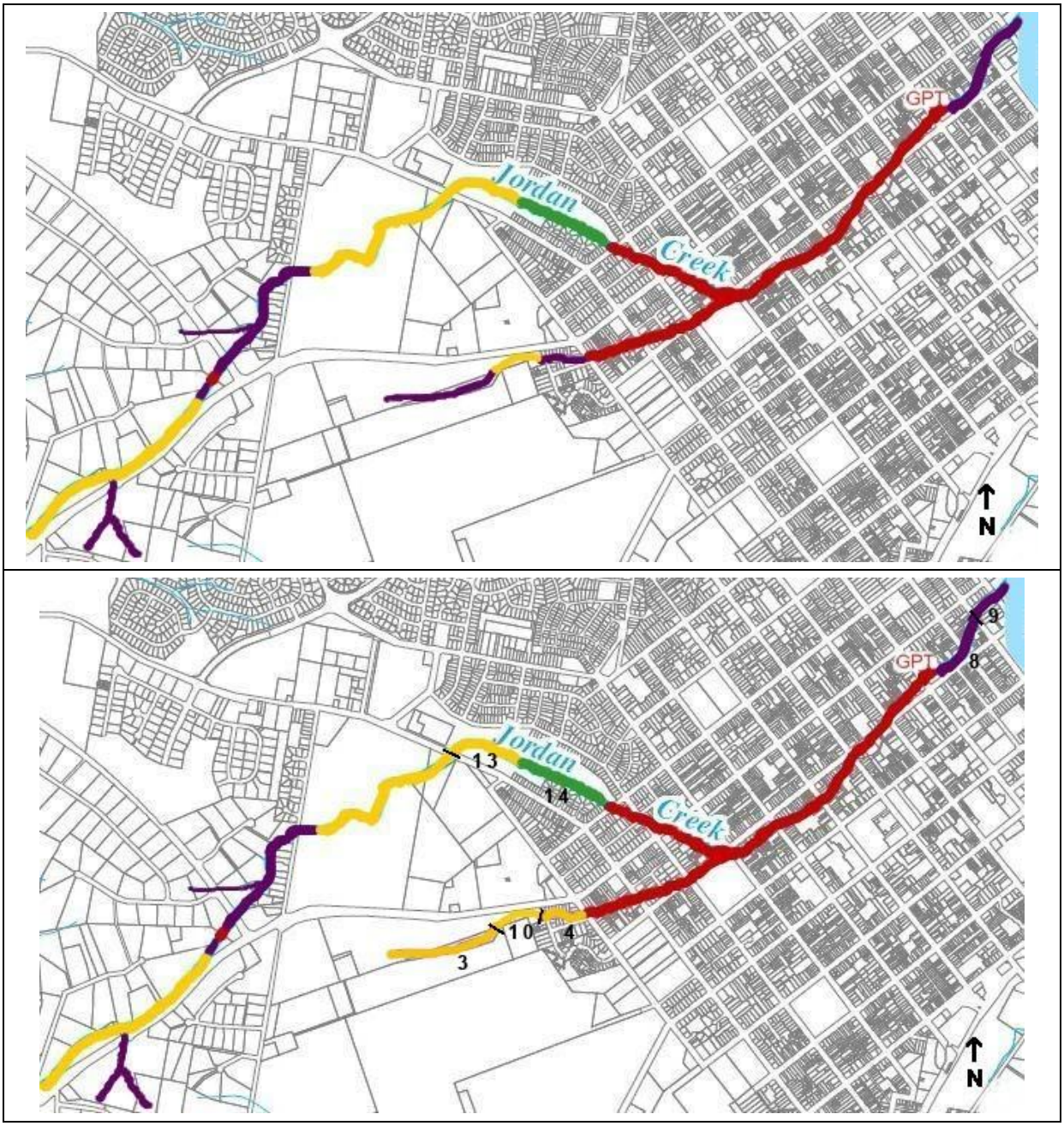


Figure 1: Sawpit Creek condition assessment comparison between the 2009 (LHS) and selected 2014 sites (RHS). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

The overall condition rating for Sawpit Creek has remained mostly unchanged since the previous assessment period; however some sites showed subtle trends either towards an improved or degraded state. These trend trajectories were often not significant enough across attributes or indicators to affect a change in overall condition rating. Degradation is mostly due to stock grazing on private land (S17, S33, S36 and S38), localised erosion and nutrient loading (across most sites) and weed invasion (e.g. S14 and S27); whereas the improvements have resulted from management initiatives such as stock exclusion (S15, S34 and S39), riparian zone replanting (S39), weed management (S27) and the installation of instream erosion control structures (S15).

The recent plantings in the stream section engineered with a low-flow pipe (S2) contribute little, if anything, towards the Sawpit Creek aquatic ecosystem due to its disconnection to an open channel. However, when the plantings mature and being to self-regenerate they are likely to provide important visual amenity, habitat connectivity and biodiversity benefits in the area.

3.1.2. Jordan Creek



Condition assessment 2014

Figure 2: Jordan Creek condition assessment comparison between the 2009 (top) and selected 2014 sites (bottom). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

Jordan Creek restoration works have delivered a change in condition since the previous assessment where exotic trees and shrubs have been cleared (J3 and J4). The structure of the Box-Gum Woodland in the upper reaches of Blayney Road Common has improved and the increase in the available light to the stream channel in the Browning Street Reserve has allowed for instream vegetation to grow and regenerate, while enhancing its value for habitat and channel erosion control. Restoration works involving the staged processes of clearing, replanting, engineered channel stabilisation structures and weed management are contributing to the improved condition of Jordan Creek where these practices occur. Where these practices are absent (e.g. J8 and J9) the trend towards ecological and geomorphological degradation is continuing.

3.1.3. Hawthornden Creek

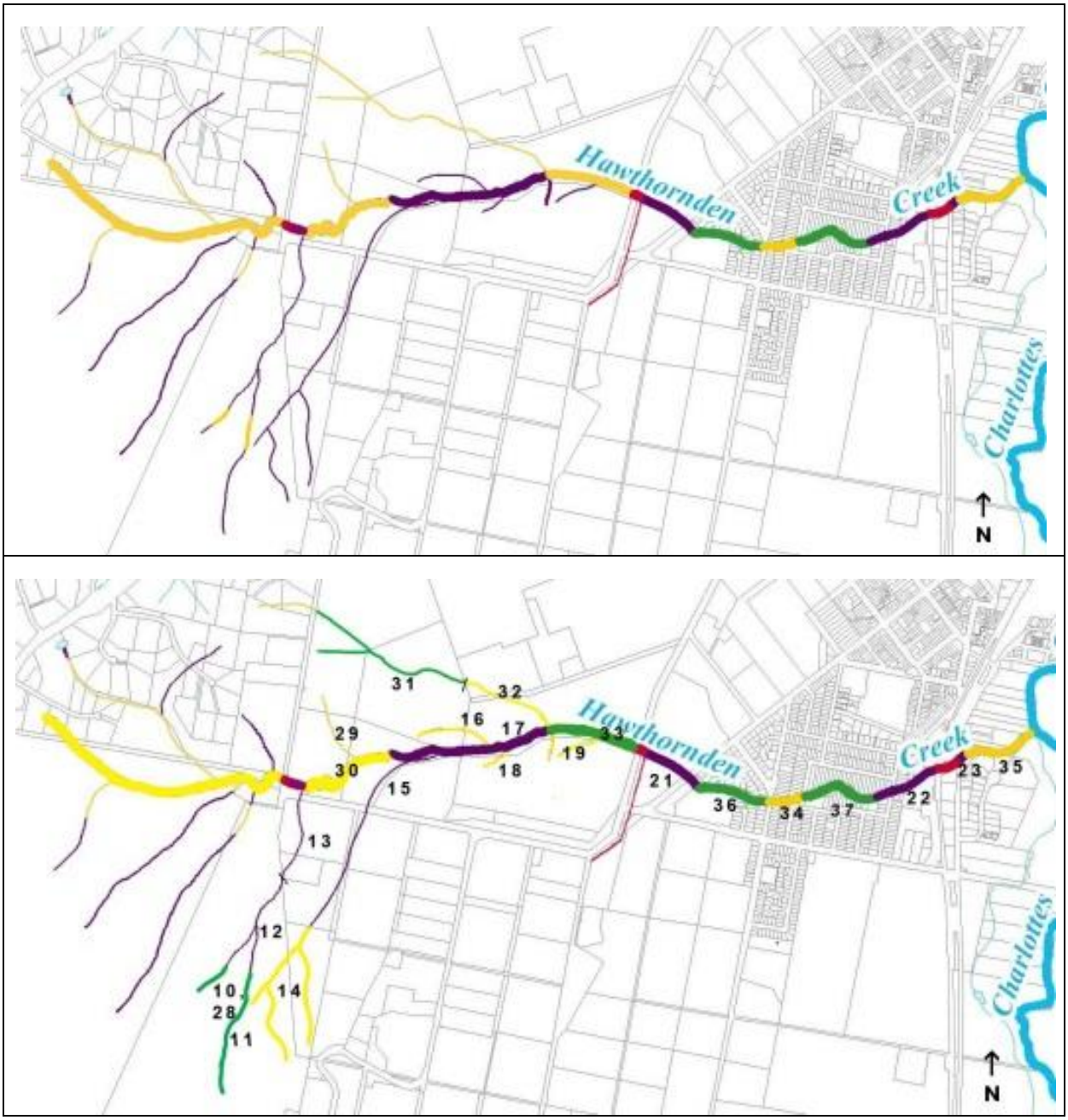


Figure 3: Hawthornden Creek condition assessment comparison between the 2009 (top) and selected 2014 sites (bottom). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

Hawthornden Creek is diverse in respect to its morphology along its length, current management regime, restoration practices and condition trends. However, there are some generalised trends that can be drawn from the assessments that reflect management decisions and ecosystem processes. First, in areas excluded from stock since the previous assessment (H10, H11, H14, H18, H19 and H28) the condition rating of the waterways has improved[1], most notably because of the increased groundcover, improved channel stability and regeneration of native species. In some areas where stock is excluded the impacts of grazing kangaroos is reducing the cover of vegetation. As yet this is not critically affecting waterways resilience or condition.

A positive change in condition was also observed in H33 (upstream of Panorama Avenue) where the willow-dominated site was cleared. The extant Eucalypt fringing woodland is slowly regenerating and in concert with the now dense cover of groundcover vegetation provides valuable riparian habitat resources and channel stability.

Significant geomorphic changes were observed in Hawthornden Creek where Schauberger Sills and other instream erosion control structures have been installed as part of 'Stage 1' works along the main creek channel (H17, H30) and at the confluence with a tributary stream (H15). The trend is towards channel aggradation, increased cover of bed and bank groundcover vegetation and improved channel stability. While these trends are significant the depth of gullying in the main trunk limits the site to any geomorphic condition rating increase. 'Stage 2' erosion control structures have more recently been installed at the confluence with tributary streams (H19 and H32) and along the main creek trunk in the downstream section of H17 and upstream section of H33. It appears there has not been enough time lapsed from installation to assessment for these latter structures to retain significant amounts of sediment.

Compared to sites where willows were removed the retention of these species in the creek below TAFE (H21) has not affected a change in stream condition. The site is further compromised by the lack of extant Eucalypts and the immaturity of the new riparian plantings. The willows continue to inhibit the growth of bed and bank vegetation and therefore limit habitat value and channel stability. A mix of trees and shrubs (both native and exotic) either densely planted or invading the stream channel (as opposed to the floodplain) has significantly reduced available light reaching the stream bed and bank (H18, H22, H35). The consequent low cover of grasses and forbs has tended to expose the channel to erosion with the condition unlikely to improve while they remain *in situ*.

A subtle trend towards riparian vegetation degradation was observed in areas where there is an abundance of exotic grasses that are not grazed or mown. These areas are often found in public recreational areas within the urban environment (e.g. Jaques Park). The grasses have become dense and moribund, thereby reducing habitat value, species diversity and the ability of less dominant species to regenerate. Despite these degrading trends in vegetation composition the ground herbage is critical in providing geomorphic stability and structure for protecting water quality.

[1] The rate of change is not as significant as indicated for sites H10 and H11, as despite the baseline assessment determining these sites as being 'degraded', they were borderline to being rated as 'poor'.

3.1.4. Saltram Creek

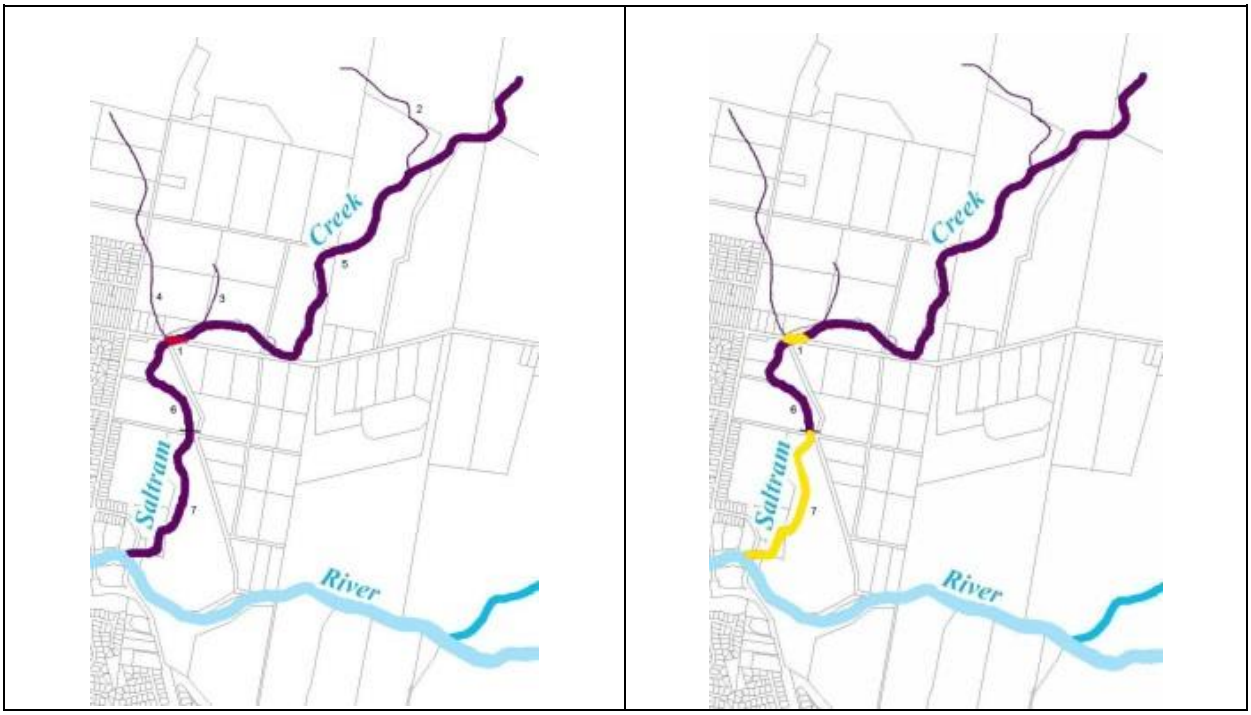
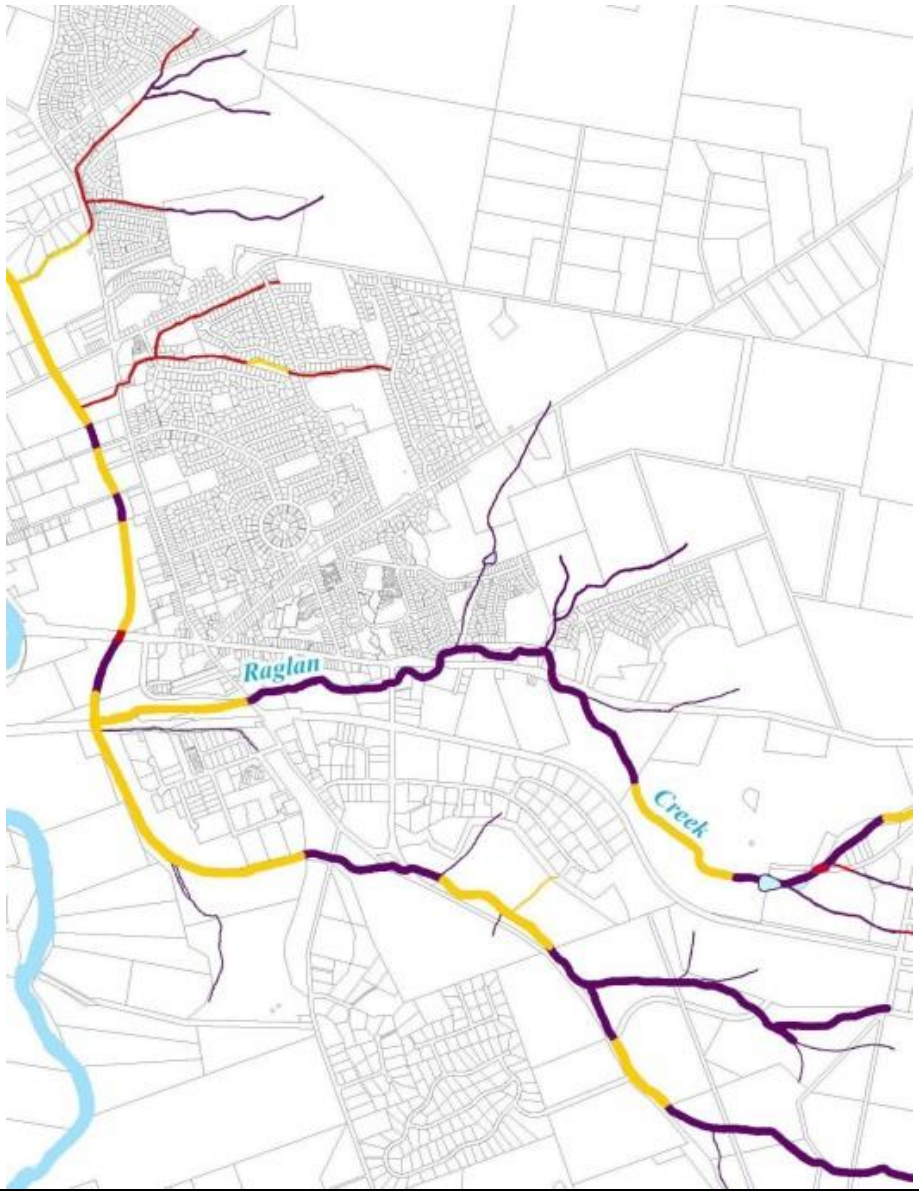


Figure 4: Saltram Creek condition assessment comparison between the 2009 (LHS) and selected 2014 sites (RHS). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

The removal of upperstorey exotic trees, particularly willows, on Eleven Mile Drive (M1) and at the confluence with Macquarie River (M7) has had a significant influence on the condition ratings in these stream sections of Saltram Creek. Instream vegetation has flourished and along with erosion and deposition sequences in the stream, which create small pools fringed with macrophytes and grasses, the habitat has become more complex. Further, in a stream with highly mobile sediments a well vegetated stream channel has contributed to sediment aggradation and channel stability. Despite the notable changes in instream vegetation there are consequent losses to the ecosystem with the removal of an upperstorey canopy.

Grazing of the riparian zone and instream vegetation continues to impact on the creek downstream of Eleven Mile Drive and the condition rating remains stable.

3.1.5. Raglan Creek



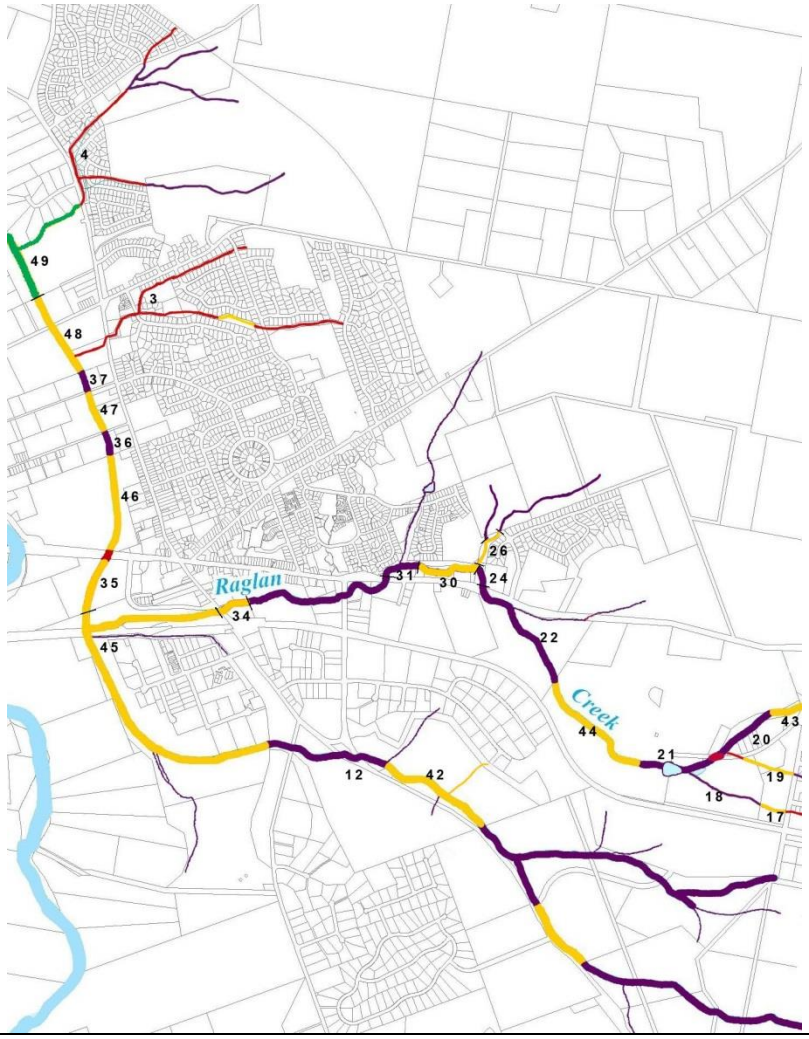


Figure 5: Raglan Creek condition assessment comparison between the 2009 (LHS) and selected 2014 sites (RHS). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

Most of the sites assessed for the update have remained relatively stable in terms of overall condition rating. This overall stability does not reflect the subtle changes evident in some stream sections that have positively or negatively influenced the condition, but have not carried enough weight to affect an overall rating change.

A replanting program has been undertaken along the engineered drainage lines of sites R3 and R4 and similarly to site S2 the contribution these plantings have on aquatic ecosystems is minimal where there is a disconnect to an open channel. However, when they mature they are likely to add considerable value to local biodiversity, habitat connectivity and the aesthetic amenity of the area – as in the case for site R43 where the instream groundcover vegetation has also been left unslashed.

The main Raglan Creek channel running along the floodplain is essentially unchanged. Exceptions were observed in site R35 where instream vegetation has flourished with the exclusion of livestock and R49 where the instream vegetation has developed good structural integrity and species diversity compared with the Typha dominated communities upstream. The smothering of the creek channel with Typha generally diminishes habitat value and reduces species diversity.

Grazing is still practiced in some areas of Raglan Creek. The creek channel on the floodplain, where horses access for watering and grazing (R36 and R37), is devoid of vegetation except for a narrow fringe of aquatic and semi-aquatic macrophytes (sedges, rushes and grasses). The central body of water remains open. A dense growth of Typha occupies the whole channel upstream of this grazed area and is truncated at the paddock boundary (a public road forms the downstream boundary). Horse grazing would not be responsible for the complete absence of Typha in the grazed sections and it is suggested that other means, such as mechanical or chemical removal, may be the cause. Horse access to the creek has been restricted in R36 since the previous survey with a moderate improvement in fringing vegetation.

Livestock grazing, channel erosion, instream pugging and the unfettered growth of willows and other exotic trees and shrubs contribute to the degradation of R21 and R22 – particularly the latter that was cleared of invasive species prior to the baseline assessment. Uncontrolled stock access to the fenced-off restoration area (R44) is impacting on the riparian vegetation with all the plantings now being destroyed.

The removal of willows and other exotic trees and shrubs in heavily infested sites has tended to improve the overall condition rating (R34 and R26). This is achieved through the enhancement of instream vegetation and aquatic habitat and the increase in vegetation cover that aid bed and bank stability.

Stock exclusion in site R42 has enhanced riparian groundcover composition, instream habitat and channel stability. The deep gully, however, is the greatest factor that limits an improvement in stream condition. Similarly to other areas where the riparian zone is newly planted to improve vegetation structure and species composition, the contribution is likely to improve when the plantings mature.

3.1.6. Vale Creek

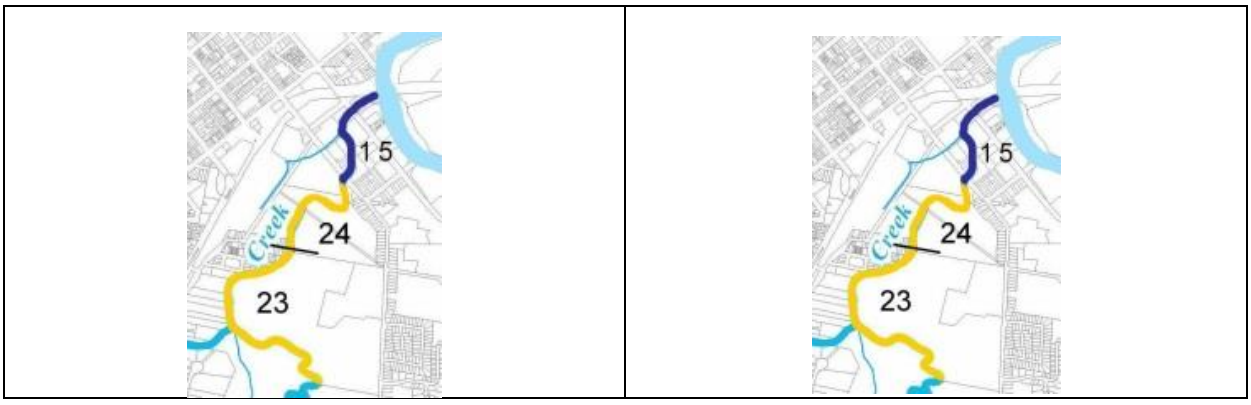


Figure 6: Vale Creek condition assessment comparison between the 2009 (LHS) and selected 2014 sites (RHS). Highly degraded (red), degraded (purple), poor (yellow), good (green) and very good (turquoise).

The condition of Vale Creek in the sites selected is essentially unchanged since the previous survey. Cattle are still grazing site V23 and continue to impact on instream and riparian vegetation, aquatic habitat and to some degree channel stability. The impact is gradual over time and has not exceeded a threshold that would shift the ecosystem to another state – it has already shifted from its natural, pre-European settlement state to its currently expressed 'alternate stable state'.

Further downstream where there is no livestock grazing and the riparian zone was cleared of exotic trees and shrubs prior to the previous survey the characteristics and condition of the stream section is relatively stable. The instream vegetation is increasing in cover and is effective in reducing sediment flux and enhancing aquatic habitat. The predominately exotic groundcover vegetation on the banks and floodplain has become moribund and is of poor species composition and structure. While the density of vegetation affords considerable protection against erosion it is limited in terms of its provision for instream and riparian habitat.

The stream section at the confluence with the Macquarie River is similar to other creek sites where exotic trees and shrubs dominate (e.g. lower Jordan Creek) and inhibit the growth of groundcover species on the bed and banks. As a consequence erosion continues, the creek bed becomes deeper and aquatic habitat compromised. However, the vegetation provides some habitat value for faunal species.

3.2. Key findings:

Assessment attributes

- ***Riparian vegetation***
  - Generally in poor condition across sites due to prior clearing, grazing, urban development, pasture improvement and weed invasion.
- ***Instream habitat***
  - Generally improving with the exclusion of stock, installation of erosion control structures and the removal of exotic trees and shrubs.
- ***Hydrology***
  - Catchment hydrology remains fairly stable and cannot be readily improved in the built environment. However, with the adoption of 'water sensitive urban design' principles into future developments and subdivisions, hydrologic processes are more likely to mimic those of the natural environment: thereby positively influencing catchment runoff and infiltration rates;
  - Stream hydraulics is improving where instream vegetation is colonising – water flow is slowed and de-energised and the flow path altered for the betterment of bed and bank stability and aquatic habitat;
  - Deeply incised channels still adversely affect catchment hydrology and flood behaviour and the disconnection from the floodplain also interferes with natural stream processes.
- ***Geomorphology***
  - With the exclusion of stock and restrictions to mowing the riparian zone the stream bed and banks are more stable with the increased density of vegetation;
  - The installation of instream erosion control features have all resulted in the aggradation of sediment, reduced sediment flux downstream, improved bed and bank stability and improved growing environment for instream groundcover species.
- ***Water quality***
  - pH is within the normal range across all waterways sampled;
  - Electrical conductivity of the water is mostly within the range for freshwater streams, however two sites (J8 and R26) indicated high values that exceed 800 µs/cm;
  - Litter continues to pose a problem in all the waterways, particularly where runoff is generated from the built environment;

- Eutrophication is particularly problematic in Sawpit Creek where runoff from agricultural land is loaded with nutrients and sediments;
- Oils and pollutants arise from the built environment and end up in the stream following rainfall events.

- ***Aquatic habitat***
  - The aquatic habitat is dependent on both the riparian and instream characteristics. Restoration work, such as willow removal, installation of instream erosion control structures and stock removal, has often triggered the instream habitat to self-recover. The consequent increase in instream vegetation cover has the added benefit of improving channel stability. The loss of overhanging vegetation can also negatively impact on water temperature and aquatic habitat.

Management practices

- ***Livestock exclusion***
  - Significantly improves ecosystem resilience and waterways condition and tends to maintain this status if the area remains stock excluded;
  - In areas excluded from livestock the riparian and instream habitat has tended to remain stable or has improved since the baseline assessment. These trends are evidenced by improvements or maintenance of the structural integrity, self-regeneration, vegetation cover and species composition of riparian and instream vegetation. Generally, stock exclusion has also positively influenced channel stability and water quality;
  - Grazing pressure can switch from cattle grazing to kangaroo grazing. In upper Hawthornden Creek behind the gun club, for example, kangaroos have impacted on the cover of grasses on the slopes creating bare patches prone to erosion.
- ***Livestock grazing***
  - Sites that were recently or currently grazed are trending negatively in terms of ecosystem resilience and waterways condition;
  - Areas on private land tenure (e.g. S36, S38) and council leased land (R37) are showing signs of degradation. The significant impacts observed were the compromised state of the riparian and instream vegetation (reduced integrity, cover and plant regeneration) and the increased risk of stream bed and bank erosion through trampling and vegetation loss. Instream pugging also degrades the instream habitat and increases nutrient loading into the stream. With the removal of stock this trend can reverse, though the recovery is dependent on the period of stock exclusion and prevailing weather conditions.
- ***Installation of instream erosion control measures***
  - Positively contributes to ecosystem resilience and waterways condition;
  - The installation of Schauberger Sills in the main trunk of Sawpit and Hawthornden Creeks and one arm of Raglan Creek has effectively contributed to sediment deposition and the reduction in the rate of sediment movement downstream. An assessment of these sills maybe necessary to ascertain their functional capacity as sediment continues to build behind them.
- ***Removal of riparian and instream exotic trees and shrubs***
  - Tends to improve ecosystem resilience and waterways condition following a lag period;

- Removal of mid and overstorey exotic vegetation increases the available light reaching the ground, which allows for the increased growth and cover of riparian and instream groundcover vegetation. There can be a corresponding improvement in species composition and structural integrity of instream vegetation, which mitigates against channel erosion and can enhance waterways habitat. There can also be a corresponding loss of temperature regulation and faunal habitat with tree and shrub removal.
- In areas where there is extant native vegetation the reduced competition from exotic species if they are removed provides a more favourable habitat for native species to regenerate (e.g. H33).

- ***Riparian zone replantings in open channels***
  - Contribution towards improving overall waterways condition is dependent on their stage of growth and maturity;
  - As plantings mature and self-regenerate it could be predicted that the contribution towards improving ecosystem resilience, riparian vegetation and instream habitat would increase over time.
- ***Riparian zone replantings in low flow piped channels***
  - There have been extensive plantings along low-flow piped channels in Sawpit and Raglan Creeks. The plantings are in the early stages of development and once they attain some maturity they should contribute positively to the local biodiversity and the aesthetic appeal of these drainage reserves. Their contribution towards the functioning of an aquatic ecosystem is more perfunctory due to the disconnection to an open channel.
- ***Limited or no waterways rehabilitation or restoration works***
  - Steady and continued degradation or at best the maintenance of a stable state;
  - Many systems have crossed their ecological and geomorphic thresholds and now function in a new stable state. These areas would require large scale restoration works to set the system on a new trajectory towards an improved condition;
  - Non-integrated restoration, such as the removal of exotic trees and shrubs while allowing for unmitigated channel erosion in the deeply incised stream sections (e.g. Sawpit and Jordan Creeks at the confluence with the Macquarie River) or the recolonisation of weed species (H22) has wins and losses in terms of habitat and channel stabilisation;
  - Areas that are impractical to restore due to infrastructure constraints (e.g. roads and dams) remain stable and no condition change is likely under the current scenario (e.g. H13).
- ***Lack of natural or human induced disturbance factors***
  - A lack of disturbance can have an overall positive or negative contribution to the condition of the waterways and how the stream responds to a disturbance depends on its type, intensity, periodicity and duration;

- In many streams where there is a lack of natural or human disturbances, ecosystem processes and species composition can shift to a degrading state. For example there may be undesirable changes in species diversity, species dominance, regeneration, vegetation structure, habitat complexity and channel hydraulics (due to type of plants present) and nutrient uptake by plants. The type, intensity, periodicity and duration of the disturbance is critical to prevent further degradation;
- For example, in some sites the no-mow practices are protecting the riparian vegetation and addressing the risks of erosion as well as litter, sediment, nutrient and other pollutant inflows to the stream. Where groundcover vegetation is dominated with exotic grasses and forbs, the vegetation can become moribund and degraded without some form of disturbance. As replantings grow and outcompete the exotic grasses the trend may shift in a positive direction;
- Disturbances can exceed geomorphic and ecological thresholds and over time the ecosystem can reach a new stable state. Raglan Creek along the floodplain is an example where this has happened. Large sections of the creek have become dominated with Typha and while this can begin to diminish the overall integrity of the system the benefit of a vegetated stream outweighs the trend towards low species diversity;
- In lieu of disturbances the maturing of riparian vegetation can begin to out-compete exotic grasses thereby reducing their dominance.

4. CONCLUSIONS AND RECOMMENDATIONS

It is a general observation that targeted restoration activities and management practices that aim to optimise restoration or self-recovery have had a positive contribution towards stream condition. The rates of improvement vary and maybe significant enough to trigger a shift from a degrading state to a recovering state or alternatively the rate may be unperceptively slow. Despite the best restoration attempts, however, some sites are limited to the degree of improvement due to inherent problems or constraints such as the depth of gully, location within built environment, land use and land tenure. In these situations improvements have to be judged on what can be achieved pragmatically as opposed to setting unrealistic goals of returning the aquatic system back to a near natural state. For example, the deeply incised lower Vale Creek is no longer a swampy meadow/chain-of-ponds system in a broad open plain and to return it to its natural state is both unrealistic and undesirable. It now functions as a sinuous stream and accordingly, should be managed to enhance its function in this new form.

Some general recommendations include:

- Revisit grazing leases on Raglan Creek Floodplain;
- Investigate means to ‘disturb’ areas of Typha dominated streams to improve species and structural diversity. Options may include off stream wetlands, engineered pools and riffles or other instream structures. Note, this recommendation does not suggest the dredging of the creek to remove Typha, rather options could be investigated to modify the channel morphology to create depth complexity. This could create different zones of vegetation along a depth gradient.
- In upper Hawthornden Creek, for example, the threat from over grazing by kangaroos above the gun club needs to be monitored to assess erosion on the slopes and drainage lines;
- Periodic assessment of Schauberger Sills maybe necessary to ascertain their functional capacity as sediment continues to build behind them;

- Consider the need for some kinds of disturbance in areas were the vegetation has become moribund and species composition and vegetation structure is beginning to degrade e.g. Jaques Park. Periodic mowing, although a worthwhile option, can be problematic as changing the status quo can lead to community misunderstanding and demands for repeat mowing;
- Retest sites indicating high salinity levels in the water and endeavour to understand causation;
- Focusing on the overall ratings as a guide to evaluating streams and developing management options at each site is limited and it is suggested an examination of the attributes and indicators should be made when developing a management plan.

5. REFERENCES

Mactaggart, B., D. Goldney, and W. D. Erskine. (2010). *Bathurst Urban Waterways Management Plan.* Cenwest Environmental Services, Bathurst.