YOUNG RIVER CATCHMENT

FARMERS ROAD CREEK

STREAM REHABILITATION DEMONSTRATION REACH

SITE ASSESSMENTS & OUTCOMES
AFTER 5 YEARS

Prepared by Steve & Geraldine Janicke

August 2016

Acknowledgements

Land Owner: **Ken Scholz**

Property Location: **Oldfield 873**

Thanks are due to Ken Scholz for permission to revisit the creek rehabilitation site on his Young River property and for his keen interest in the future management of the streams passing through his property.

Thanks to Claudia Magaña Project Officer (South Coast NRM, Esperance) for her assistance and input in the field.

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Recommended reference

Janicke, S & G. (2016) *Young River Catchment, Farmers Road Creek, Stream Rehabilitation Demonstration Reach, Site Assessments and Outcomes.*

Contents

Introduction

The stream rehabilitation site was established in 2011 on what was called the Farmers Road Creek (not an official name). It was hoped that ongoing observations of the site would demonstrate what can be achieved and what stream management issues may arise. The work also provided an ideal opportunity to investigate the ways in which long-term environmental outcomes for saline stream rehabilitation on the South Coast can be assessed.

Stream rehabilitation, from a farm profitability perspective, may be viewed as a cosmetic measure, however there is some potential to enhance property value. Ken, the landowner met us on site and his perspective regarding the outcome of the project was encouraging. He commented, "cosmetically, I would much rather be looking across to this than across a salt scald." Ken also felt that, "if I were purchasing a block, I would feel happier to purchase this now looking like this, it has improved the value of the property." These observations suggest that 'liveability' is an issue that cannot be dismissed as unimportant for farming and lifestyle success. There is a connection between the quality of the natural environment and the welfare of the farming community.

The other aspect of stream rehabilitation is about preserving natural elements of the landscape, especially those that represented the landscape prior to large-scale land clearing. This is a bio-diversity and ecological issue. There is also the wider issue of the impacts of local stream degradation on natural assets downstream. In this case, the Young River and its end point, Stokes Inlet.

The structural stability of the streambed, banks and floodplain, and erosion and sedimentation processes, provide the controls on the living things; plants and animals that can thrive there. A degraded stream is one in which habitat diversity has been drastically reduced and undesirable non-native species of plants and animals gain dominance. Successful ecological outcomes of rehabilitation work involve the reintroduction of habitat elements to create a naturally functioning stream channel. The rate and manner in which the natural processes of erosion and sedimentation take place determines whether habitat diversity is created, maintained or destroyed. Thus, assessing whether environmental goals have been achieved requires monitoring elements of the system that have to do with channel stability, habitat diversity and bio-diversity.

Full scientific assessments give greater accuracy, but are intensive, costly and cannot easily be achieved for the majority of rehabilitation projects. Methods that do not always require specialist expertise for assessing outcomes and that provide valid insight for project managers, are desirable and achievable (Gollan *et al* (2012)).

The reason for doing a reassessment of this site was to determine the usefulness of some simple monitoring methods put in place in 2011. Usefulness in this case means: the capacity to evaluate, with some degree of confidence and accuracy, the environmental outcomes of the site works as well as understanding what natural processes are unfolding.

The Farmers Road Creek flowed through a paddock managed under a cropping and grazing regime prior to fencing off the floodway and revegetation. The following monitoring methods were initiated in 2011.

- Photo points were established (24 locations).
- Erosion and sedimentation monitoring
    - Longitudinal bed slope survey (2400 meters).
    - Channel cross-section surveys (5 locations).
    - Erosion pin arrays (7 sets of three pins were placed in banks).
    - An array of 8 stakes was placed across a large sediment plume at the confluence of the creek with drainage from a hillside salt scald.
    - A series of loose sediment depths were measured for 11 cross sections
- Two flood level markers were installed.

- A basic salinity and macro-invertebrate assessment was undertaken.

Vegetation transects were initially not done due to the negligible vegetation.

During the 2011 site assessment, the confluence of the creek with the Young River main channel was also surveyed to describe its channel form and to see what influences the sub-catchment might be having on the river. However, this site was not revisited in 2016 due to time constraints. The 2016 assessment required a full day in the field.

Basic Catchment facts

Location No	Oldfield 873
Property ID	3171641
Reach position along tributary	6.8 to 9.2 km from Young River
Rehabilitation reach length	2400 m
Sub-catchment area upstream of Farmers Rd	Approximately 715 Ha
Catchment area at downstream end of the rehabilitation reach	Approximately 1100 Ha

Figure 1: The relationship between the demonstration reach and the Young River main trunk.

Photo point monitoring

Photo point monitoring has been used extensively over recent decades for documenting conditions and developments at rehabilitation sites. The ready availability of digital cameras has no doubt facilitated this. The authors have found that a systematic approach to obtaining photo point images is essential if the information obtainable from a photo is to be useful.

Finding the photo point locations

The 2011 Photo point locations were found using a handheld GPS and hardcopy prints of the images. See Figure 2 for an aerial view of the rehabilitation site with Photo point locations. The GPS was used to locate each photo point and the hardcopy image was used to refine the position of the camera. Once the camera position was selected the new coordinates were recorded. It was noted that the 2011 and 2016 GPS readings showed variability in Eastings between -4 to +3 meters and in Northings -5 to +7 meters, which is comparable to general variation in the instruments. Two factors were identified that affect the reproducibility of images for comparative purposes. First, the inherent variability in GPS readings over time and secondly differences in viewfinder and lens characteristics when different cameras are used. For the 2016 audit, panoramic images were created and cropped to match, as best as possible, the original 2011 images.

It was also noted that having durable features (such as a rock outcrop) in a photo proved very useful for matching camera position and orientation. These desirable features may of course not be available for all photo points. Two transcription errors were found in the 2011 coordinates (these had been recorded in a note book) and this resulted in extra time being needed to relocate the original photo points using the 2011 printed images. Downloading saved coordinates as Waypoints helps ensure that readings are accurately recorded. Two GPS units were used in the field to reduce the risk of an instrument failure and loss of data. The desktop processing of images for comparisons worked relatively well despite the differences in field of view.

The use of a photo board in the image

Modern cameras store meta-data about the image within the digital image file and some cameras are fitted with a GPS as well. However, it has been found that a photo-board offers a readily recognisable ID for each image. Photo point views can look very similar along a stream reach and matching GPS coordinates to image numbers can lead to incorrectly identified and sorted images. This in turn can confuse comparisons and interpretations and may add a lot of unnecessary time to data processing.

Information obtainable from photo point monitoring

In 2011, the field of view of the photo points focussed on the dominant stream channel. The photos were taken from the perspective of the geomorphology of the creek. Photo points of the wider riparian fringe were not generally included on the basis of; “Why record the pasture grasses and weeds at every location?” However, in hindsight this perspective may have been useful to record the progress of erosion of the valley sides and salt scalds (Photo point 22). In the 2016 assessment, a second set of panoramic photos were taken of the left and right bank and included in the photo audit document for later comparisons (Appendix 4 in a separate document).

The following types of information were obtained from a comparison between the 2011 and 2016 images; channel changes due to erosion and sedimentation, natural colonisation of plants, changes in ground cover and revegetation health. These factors enable assessment of the nature and scale of changes taking place along the riparian zone and the ecological elements that have been created or enhanced.

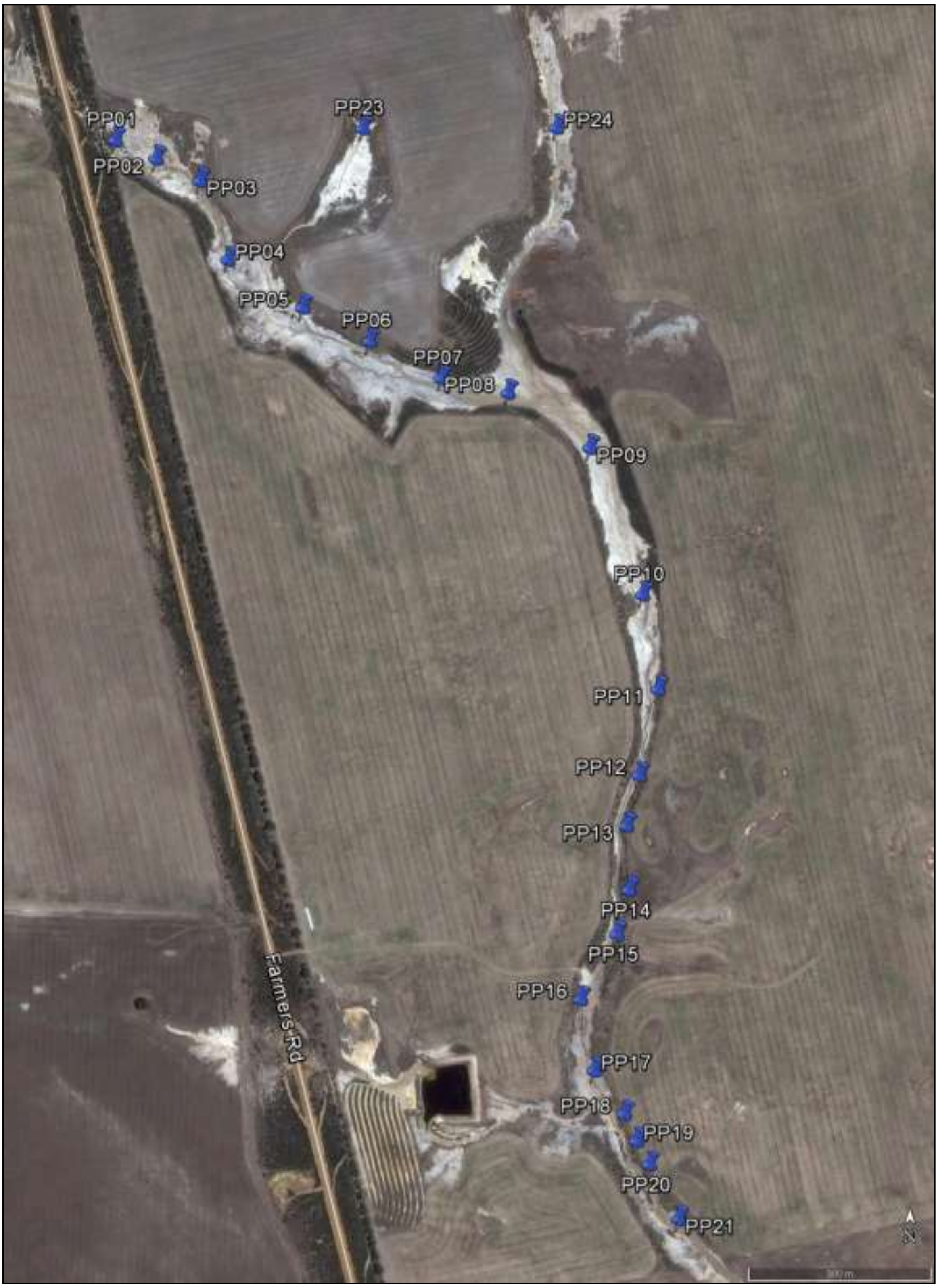

Figure 2: An aerial view of the rehabilitation site with Photo point locations.

Samphire regeneration

Photo Point 01 shows a marked increase in the coverage of Samphire across the valley floor.

Figure 3: Photo point 01. 28th February 2011 and 10th June 2016. Self-sown Samphires are colonising the scald.

Lack of natural regeneration in the broad channel areas.

Photo point 08 shows little change across a broad sediment deposition area suggesting that conditions remain hostile to opportunistic colonisation by Samphires. It can be noted that the path of low water flow has been quite variable.

Figure 4: Photo point 08. 28th February 2011 and 10th June 2016 looking across the channel to a tributary entering from the left bank.

The success of revegetation projects

Photo points 08 and 12 show dramatic changes to the riparian verge although little has changed in the valley floor after 5 years. The direct seeding has clearly been successful by adding typical riparian structural elements into the environment.

Figure 5: Zoom in to Photo point 08. 28th February 2011 and 10th June 2016. Direct seeding on either side of a tributary entering the main channel.

Figure 6: Photo point 12. 28th February 2011 and 10th June 2016. Healthy growth of planted seedlings.

Erosion and Sedimentation monitoring

Assessment methods tested

The benefit of undertaking a systematic survey prior to rehabilitation works is that it reveals detail of the system that helps to decide what project monitoring approach would be useful. That can emerge during the course of the survey. During the 2011 channel survey, a longitudinal bed slope profile was obtained for the entire length of the rehabilitation reach (2.4 Km). This provided an objective view of the relatively higher energy (steeper) and lower energy (flatter) sections during storm runoff flow. The bed slope and cross-section surveys provided a type of 'floor plan' of the reach to which the ecological furniture can be added and arranged.

It was recognised that significant changes to the overall bed slope would be a long-term process (>15 years) and there would be little value repeating that survey after only five years. This might not be the case for channels in sand or deep soil profiles where more frequent surveys could be useful for monitoring changes. The bed-slope profile of 2011 provided information about the actual and potential pattern of erosion and channel change along the rehabilitation reach. This was complemented by observations captured in the photo point audit.

In addition to a lengthwise slope profile, five channel cross-sections were also surveyed to represent the different cross-sectional forms present. The surveyed cross-sections would be useful to show significance changes in channel geometry in the medium to long term (>5 years). These were not resurveyed during the 2016 site visit.

The two peak flood level indicator posts were examined and it was found that these had partly filled with sediment and were non-functional. No one had maintained them during the five years and no data was forthcoming. The original idea was that these could provide information about the maximum depth and width of large flood flows and this could be useful for planning what features might be appropriate to add to the rehabilitation efforts and importantly, where best to place them. Such features could include, adding further plants in the optimum location, placing rocky riffles, bank stabilisation structures and habitat additions such as logs. The exercise highlighted the obvious fact that monitoring techniques that do not require ongoing site visits and maintenance, are preferred.

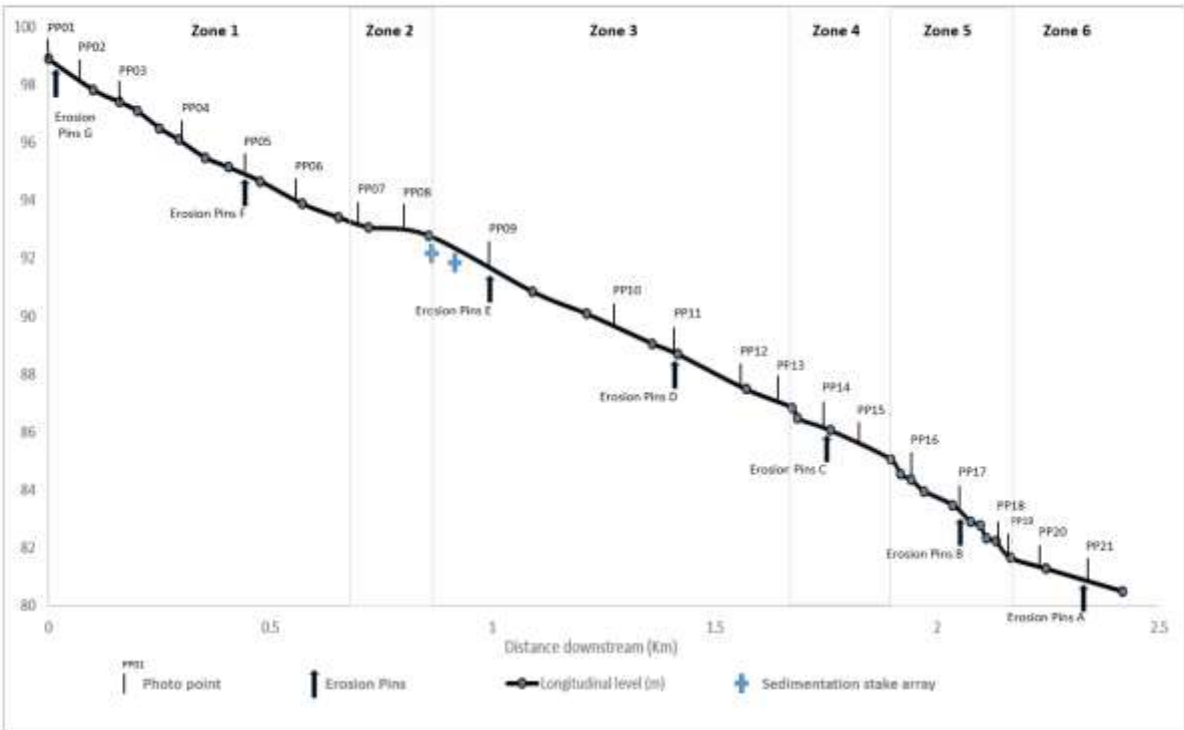

Figure 7: The longitudinal bed-slope of the demonstration reach and indicates the location of photo points, erosion pins and stakes.

Results

Bank erosion

Sets of erosion pins had been placed into the banks of the dominant channel to measure erosion at various arbitrary locations. Six of the original seven sets of erosion pins were found and these yielded some indication of the amount of bank erosion that had taken place along the reach. All pin arrays indicated some level of bank scouring had occurred (Table 1 below).

Table 1: Lengths (in millimetres) of erosion pin exposed after 5 years.

Lenth of pin exposed 2011-16	Erosion Pin 1	Erosion Pin 2	Erosion Pin 3	Mean pin exposure	Photo Points
Erosion Pins A	10	10	20	13	pp20/21
Erosion Pins B	100	50	10	53	PP17
Erosion Pins C	10	30	60	33	PP14
Erosion Pins D	10	10	10	10	PP11
Erosion Pins E					PP09
Erosion Pins F	10	30	100	47	PP05
Erosion Pins G	120	0	10	43	PP01

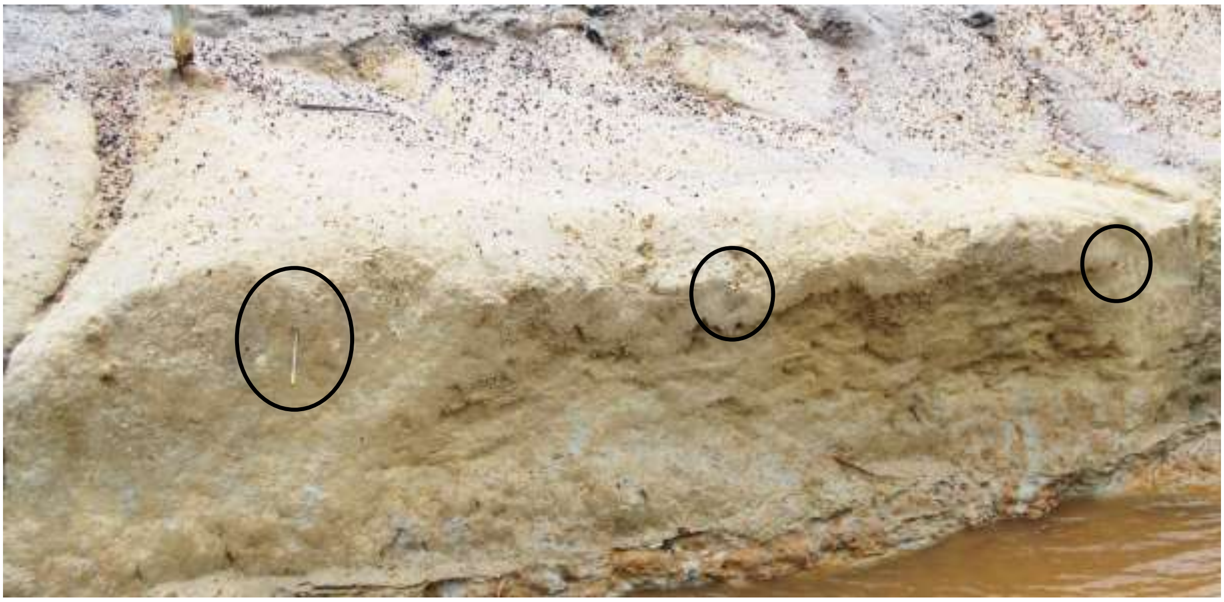

Figure 8: The erosion pin array at site G showing the variability across a 2 meter span.

Pins at site E had been washed away, however several wooden stakes (Figure 9 below) had also been placed at this site in 2011 and showed that the edge of the bank had eroded back approximately 2 meters.

The variability in the length of pins exposed between sites and within sites supported the notion that an array of pins (minimum of 3) at each site, rather than isolated pins, would give a better interpretation of erosion rates. However, it seemed questionable whether this sort of data would prove useful for assessing rehabilitation outcomes. Nevertheless, simple tools such as stakes and pins are cheap, easy to install and can provide information about where erosion is occurring and this can be useful for understanding how a floodway is developing and for deciding what further stabilisation works could be worthwhile.

Figure 9: Wooden stakes that had been placed on the edge of the bank in 2011. The receding bank was a relatively local feature along 50 meters of the channel and opposite an incoming tributary.

Bed erosion

Seven of the twenty-one photo points along the main channel indicated that bed deepening had occurred since 2011. These were Photo Points 01, 02, 03, 06, 14, 15 and 19. In all cases, however, the bed deepening could be attributed to the removal of loose sediment deposited from earlier periods of erosion. In other words, sediment moves down the floodway as slugs. The consolidated streambed is in the exposed clay horizon.

Figure 10: Photo point 01. 28th February 2011 (left) and 10th June 2016 (right). Note the deepening of the channel observable in these photos.

Site 01 is a short distance downstream of the road culvert which focuses strorm flow and has created a trench-like channel in the basement clay horizon. The loose sediment shown in 2011 suggests a temporary bed level that high storm flows can shift further downstream. Thus the photo point comparison does not indicate whether the consolidated clay bed of the channel has been deepened. At the time the bed slope survey was done, a steel spike was used to probe the depth of loose sediment above the consolidated clay bed. The average depth near photo point 01 was 0.2 - 0.3 meters. In hindsight, re-assessment of the depth of loose sediment may have been a useful measure. Thus loose sediment depths taken along the rehabiltation reach may provide a better method for assessing sedimentation outcomes in reaches that have a firm base of clay or rock.

Figure 11: Photo point 06. 28th February 2011 and 10th June 2016. Note the channel deepening and exposure of more of the rock bar.

The situation at site 06, above, is similar to that discussed for photo point 01. Loose sediment depths taken a short distance upstream in 2011, , were 0.15 - 0.3 meters. It can be noted that the existence of solid basement rock extending across a channel can naturally provide a check on bed deepening proceeding upstream.

Figure 12: Photo point 14. 28th February 2011 and 10th June 2016. Note, the channel sediment has been carried downstream with the exposed root on the right bank now well above the water level.

Sedimentation

The consequence of bed and bank erosion is sediment moving downstream. Excess sediment overwhelms many small and medium sized riparian habitat features that support a diversity of terrestrial and aquatic organisms. The food chain is broken at the most basic level. Accumulating sediment along the valley floor has important consequences for rehabilitation by dividing the flow path into many shifting channels and backwaters. This is well illustrated looking upstream from the boundary between the Young River Reserve at the lower end of the creek system and into the farmland. Figure 12 shows that Samphire has clearly found this suitable for colonisation. One undesirable outcome may be increased mosquito populations. Rehabilitation in these areas will not look like the original riparian form.

Figure 13: Looking upstream from the Young River Reserve boundary (2011)

Monitoring sediment quantities and movement in streams is notoriously difficult to do with any degree of confidence that the measurements describe the situation accurately. This is a result of the extremely high variability of sediment distribution along the channel and over time. This type of monitoring generally requires specialist services.

Nevertheless, loose sediment depths were measured at 11 cross-sections in 2011 using a steel spike. One to five depth readings were taken across the floodway at each site. This was not repeated in 2016 due to time constraints. Depths varied from 0 to 800 mm and the average of the 39 measurements was 340 mm down to consolidated clay (the point of resistance).

Eight stakes had also been placed in 2 rows of 4 across the large sediment plume shown at photo point 08 (Figure 14). The height of 6 of these stakes was measured to determine if the central area of the plume had changed in the five-year period. Two end stakes (No 1 and No 5) were omitted being in the middle of a narrow flow path at the time of assessment. All 6 stakes showed an increased depth of sediment varying from 15 to 175 mm with an average increase of 93 mm.

Figure 14: Location of the stakes in the channel downstream of the tributary confluence.

Any apparent increase in sediment deposition at other sites appeared to be relatively minor. For example, as shown at photo point 12 in Figure 15.

Figure 15: Photo point 12. 28th February 2011 and 10th June 2016. Note that there seems to be some sediment deposition since 2011.

Figure 16: View across the sediment plume at Photo point 08, 10th June 2016 showing large amounts of sediment coming from a relatively small salt scalded area to the north. The stake array is to the right of the view shown in the photo.

Figure 17: Exposed Mallee roots show the amount of topsoil removed along the flow path towards the top end of the salt scald. The verge has been revegetated and grasses are moving into the bare areas.

Conclusions

Photo Points can be used to gain an understanding of local erosion activity, however, quantifying this is difficult, but probably not necessary for considering the progress of the rehabilitation.

The value of Photo points is enhanced by including a durable feature, either natural or artificial, in the field of view since this provide a reliable benchmark and a suitable scale.

The demonstration site started with some advantages, namely that the entire reach was almost completely bare of native plants and the flowing waters deficient in organisms. The absence of the many intricate features that make up the natural riparian ecosystem common to the area, was easily observed.

An audit of natural stream features at a relatively natural site of similar form to the rehabilitation site, would be of great benefit for comparing progress at the rehabilitation site.

Erosion pins can be used to quantify the scale and rate of erosion provided enough are placed to represent the variation in channel cross-section. This suggests a necessary distinction should be made between assessments aimed at tracking environmental processes and assessments aimed at auditing specific rehabilitation outcomes, although they are not mutually exclusive.

By way of comparison, 7 of the 21 main channel photo points indicated that loose sediment had been moved downstream. The other 14 photo points showed similar bed levels from 2011 to 2016. Only the large plume at photo point 08 indicated substantial sediment accumulation.

The variability in the distribution of sediment suggested that depths from a few locations are not particularly useful or reliable for determining whether sediment production and movement have changed. Nevertheless, the results from the sediment depth probe and the photo points, suggested that the 39 measurements distributed along the demonstration site did provide some measure of the relative amount of sediment in the system and could be repeated in the future and added to.

The establishment of the fringing vegetation may also have served to intercept sediment moving into the channel from the paddocks upslope and this was evidenced by the undisturbed grass and Samphire ground cover. This in turn suggests that the primary sediment sources are now likely to be the bed and banks along the main channel and tributaries.

Revegetation outcomes

The target area for revegetation was the fringe of the valley floor where the land starts to slope uphill. Revegetation of the central floodway is desirable, but is not easy to achieve in the harsh saline conditions where the shallow topsoil has been washed away. Nevertheless, gradual colonisation of these areas, primarily with Samphire and various salt tolerant species, is expected. This has occurred at nearby Yerritup Creek where extensive rehabilitation was undertaken some 4 years prior to the Farmers Road Creek site. There the issues were much the same. Figure 18 shows the transformation at one site on Yerritup Creek. The sparse fringing trees were planted, but the floodway naturally colonised with a mix of Samphire, sedges and various grasses.

Although revegetation at the Yerritup Creek site bears little resemblance to the pre-clearing form of the channel, signs of which were observed downstream, a significant environmental outcome has been to stabilise the bare scalded areas. This serves to reduce bed and bank erosion and the movement of sediment downstream.

Figure 18 Yerritup Creek Site looking upstream (2005) and looking across the floodway (2011).

Vegetation transect assessment at the demonstration site

Figure 19: Google Earth 2015 image showing location of 3 Vegetation Transects across Farmers Road Creek.

Prior to rehabilitation the Farmers Road Creek flowed unfenced through a paddock managed under a cropping and grazing regime. The condition of the creek floodway was largely bare ground with pasture and weed species dominating the riparian verge while occasional Samphire or Rhagodia plants survived in the floodway. Most of the shallow sandy topsoil had been eroded away exposing the clay substrate. As a result, it was considered that establishing vegetation transects prior to the rehabilitation works, was not useful. If remnant native vegetation had been present, initial transects would have been desirable.

Three vegetation transects were established (Figure 19) in 2016, transect 1 downstream of photo point 03, transect 2 downstream of photo point 07 and transect 3 downstream of photo point 09.

The vegetation transects started at zero metres from the western or southern boundary and assessments were made for each five-metre section along a 50 metre tape. The assessment measures for each five-meter section are listed in **Table 2**.

Table 2 The measures chosen for the vegetation transect in the June 2016 assessment.

No. Native Plants touching the tape. (**Density**)	No. Native species (**Species diversity**)
Height (m) of tallest plant within 1m of tape.	% plant cover within 1m of tape
Number/% cover of Weeds touching the tape	% cover leaf and twig litter within 1m of tape
Weed names	Other observations – fauna

The measure, ‘Number of Weeds touching the tape’ proved too difficult to estimate with respect to pasture grasses. In the second vegetation transect, this was changed to ‘% area of Weeds within 1m of tape’. The main weeds were those associated with pasture grasses and weeds and it was noted that under the direct seeding areas these were shaded out and were not a problem. Where they did exist, they produced a dense ground cover and dried into a good cover of leaf litter.

The ‘percentage leaf and twig cover was also measured however the dried pasture grasses and weeds fully covered the ground in some places. Although this may have been an improvement since 2011 due to no grazing pressure after the area was fenced, it is not a measure that can be used to show outcomes for revegetation.

Results

Vegetation Transect 1

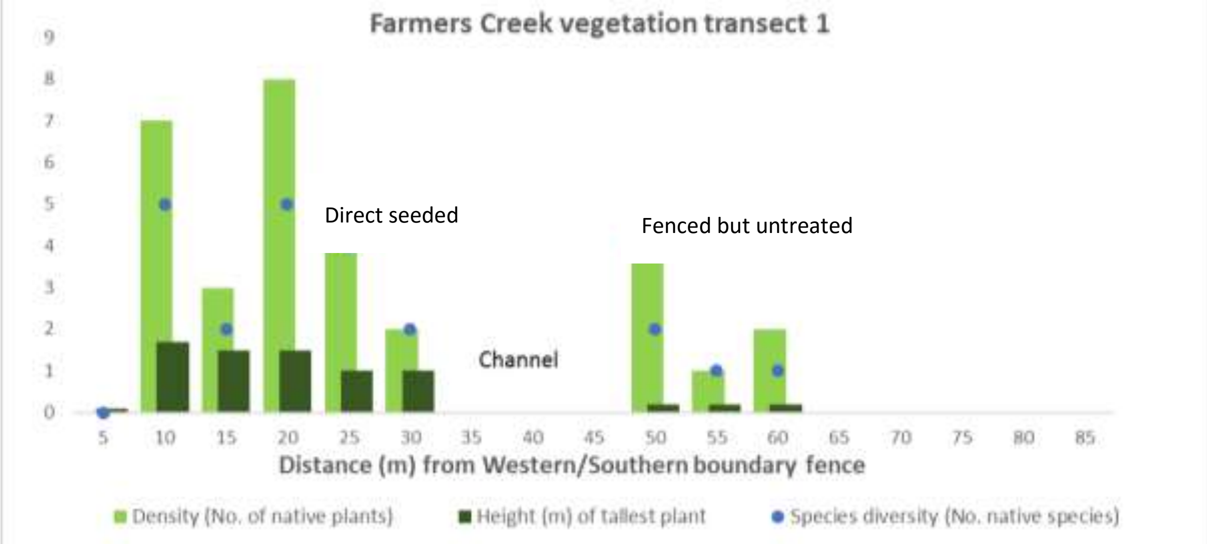

Figure 20: Plant density (number of native plants), height, and species diversity (number of native species) for Transect 1.

The measure for 'percentage plant cover' was similar for both sides of the channel with pasture grasses and weeds also covering the ground. Yet the Photos (Figure 21 and Figure 22) show the distinct difference with direct seeding on the western (right) bank. The measures; 'height of tallest plant', number of native plants' and 'number of native species' are more instructive to the change with revegetation.

Figure 21: The western (right) bank at transect 1. This area had been direct seeded.

Figure 22: The eastern (left) bank at transect 1 (2016). This area had not been revegetated however, after fencing and stock exclusion, there has been some regeneration of Samphire and Rhagodia plants among the pasture grasses and weeds.

Vegetation Transect 2

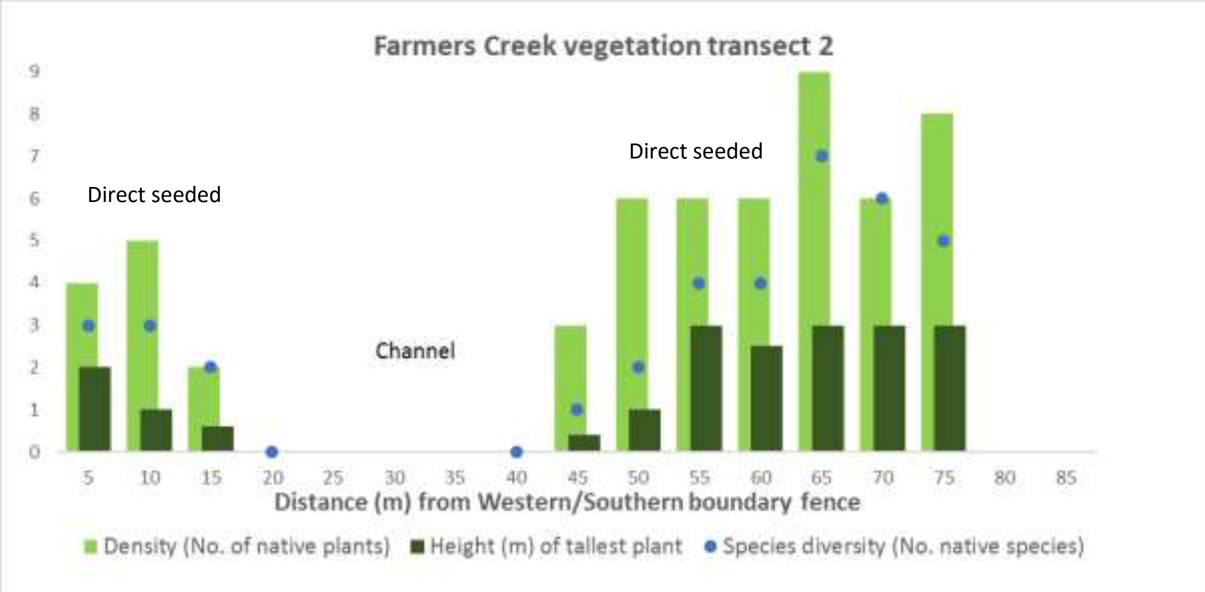

Figure 23: Plant density (number of native plants), height, and species diversity (number of native species) for Transect 2.

At transect 2, both sides of the Creek were direct seeded, however the left (northern) bank shows a higher density of species and planting. The graphs suggest there is an edge effect within 15 metres of the channel where vegetation height, density and diversity are reduced.

Figure 24: The southern (right) bank at transect 2. This area had been direct seeded.

Figure 25: The northern (left) bank at transect 2. This area had been direct seeded however the seeding furrows are fairly wide apart and in many places the trees and shrubs are less than 30 cms apart (i.e. it seems to have been densely sown.).

Vegetation Transect 3

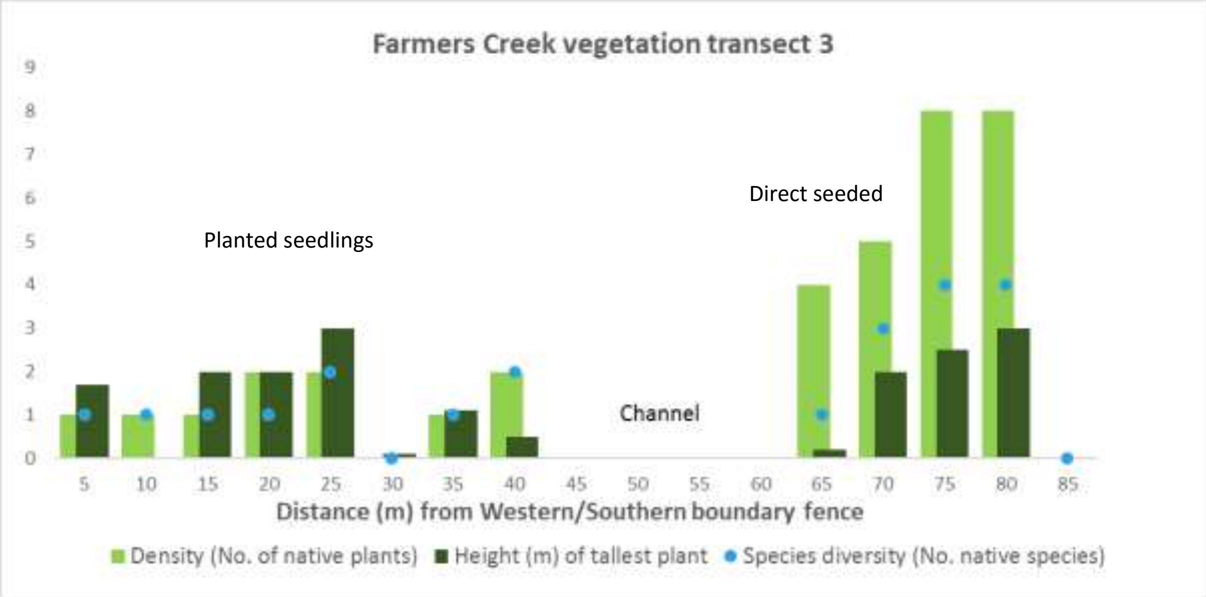

Figure 26: Plant density (number of native plants), height, and species diversity (number of native species) for Transect 3.

The left (western) bank which was planted with seedlings shows the decreased density of planting and reduced number of species when compared to the direct seeded area on the right (eastern) bank.

Figure 27: The western (right) bank at transect 3. This area had been planted with seedlings.

Figure 28: The eastern (left) bank at transect 3. The transect was near the end of the direct seeded area (in the left of the photograph). Further downstream the left bank was planted with seedlings only.

Area not revegetated

An 80 metre section of the right hand bank between PP08 and PP09, was not planted at all in order to see what plants would recolonise the verge area unassisted. No assessment was undertaken of the vegetation in 2016 however it can be seen to be dominated by pasture grasses which also act to stabilise the soil surface.

Figure 29: Un-revegetated section of the right hand bank.

Revegetation Conclusions

The changes that have taken place over the five-year period clearly indicate the successful reinstatement of riparian vegetation structure.

Fencing the creek and excluding stock resulted in increased plant and litter cover from pasture grasses and weeds and some natural regeneration of native plants. However, where the verge was not actively revegetated, species diversity remained low. The left bank, at transect 1, passed over some naturally regenerated Samphires and Rhagodia resulting in a diversity score of 2 (out of 7).

Planted seedlings have successfully matured to shrubs and trees however the density and species diversity was not as high as that for direct seeded areas. The direct seeded sections were clearly more complex in structure.

Planting seedlings was time consuming, taking several days to plant a section. From the farmer's perspective, direct seeding is quick. Ken commented that, "Direct seeding was so easy, it makes you want to do it." It is hard to weigh up the costs of either method, the work behind the scenes in growing the seedlings or preparing (smoking) seeds for direct seeding needs to be taken into account however the benefits of direct seeding are evident.

The bare floodway appears more difficult to rehabilitate. Observations on nearby Yerritup Creek suggest that Samphire will actively colonise these areas over the next five years and that may provide a control of storm flows and stabilise the dominant channel.

Although species lists have been kept, maps to show what was planted where, had not been produced - this is probably a common difficulty in monitoring outcomes, details can get lost in the busy season of planting.

Systematic observations of birds and terrestrial animals, in the various habitat zones, would start to build a baseline data set.

Other observations

Birds observed/heard

- A little wren was heard in the dense shrubbery near Photo point 03.
- Wedge Tailed Eagle
- Grey Butcher Bird
- White browed Babbler – flock of more than 30.

Other animal indications observed

- Kangaroo tracks
- A variety of ants
- Fox tracks

Salinity and macro-invertebrate assessment

No water quality or aquatic organism assessment was undertaken during the 2016 assessment.

General Conclusions

A number of general principles have been affirmed by comparative observations at the demonstration site. These are: -

- The type and sophistication of ecological assessment methods will depend on the initial conditions along a stream reach at the commencement of rehabilitation works.
- As the rehabilitation proceeds and outcomes unfold then the monitoring tools need to be upgraded to accommodate the changing scenario. In other words, those methods adopted for the initial period, say 5 years, may not be as useful for the next 5-year period.
- Simple outcome monitoring can rely on observations of the presence or absence of riparian features prior to and following rehabilitation works. The necessary requirement is a sufficient audit of features at the beginning of the rehabilitation.
- Little can be learnt from the rehabilitation exercise and passed on to others without occasional long-term outcome assessment and recording these in a formal and readily accessible report.
- Images of random or unique parts of the stream reach are not useul for capturing the overall character of a reach. A systematic photo audit is required.
- A distinction should be made between a photo-audit and general photo-features. A photo-audit is a sequential series of photo-points located along a channel and it provides a virtual description (visual tour) of the entire reach, whereas arbitrary photo-features are less systematic and do not represent the reach as a whole.
- Overall, the authors felt that an adequate set of photo points (better more than less) of the two types, photo audit and specific features, can provide an inexpensive assessment tool for describing environmental outcomes over medium to long periods of time. The proviso, as for other monitoring tools, is that the nature of the photo points may need to be updated to match the changing riparian conditions.
- Other monitoring tools should complement the photo audit by revealing those features that are not obvious in a photograph, for example sediment depth, plant density, habitat changes, species composition and opportunistic sightings of birds and other animals.
- Ecological outcomes can move from a 'before and after model' of rehabilitation success towards an 'audit model' by which the developing environmental values of the site are documented over time.
- Site documentation should be 'future-proofed' so that it is available over periods of decades, not just for the acquittal of a project.

References

John Gollan, Lisa Lobry de Bruyn, Nick Reid & Lance Wilkie (2012) *Can Volunteers Collect Data that are Comparable to Professional Scientists? A Study of Variables Used in Monitoring the Outcomes of Ecosystem Rehabilitation* in Environmental Management 50:969–978

Appendix 1 - Photo point coordinates June 2016

Photo No	Easting	Northing
001	308346	6278263
002	308413	6278235
003	308486	6278200
004	308534	6278074
005	308656	6277999
006	308766	6277947
007	308884	6277888
008	308993	6277867
009	309128	6277780
010	309218	6277544
011	309246	6277392
012	309218	6277252
013	309200	6277170
014	309205	6277066
015	309187	6276994
016	309130	6276888
017	309154	6276773
018	309205	6276703
019	309226	6276660
020	309247	6276623
021	309297	6276535
022		
023	308749	6278291
024	309063	6278298

Appendix 2 - stake heights at the large depositional plume.

	Year (height mm)		
Stake No	**2011**	**2016**	**Change (mm)**
1	795		
2	790	615	-175
3	790	755	-35
4	775	630	-145
5	900		
6	780	650	-130
7	775	720	-55
8	790	775	-15
Average	**799**	**691**	**-93**

Appendix 3 - Erosion pin measurements or amount of exposure in 2016

Changes 2011-16	Erosion Pin 1	Erosion Pin 2	Erosion Pin 3	Mean	Photo Points
Erosion Pins A	10	10	20	13	pp20/21
Erosion Pins B	100	50	10	53	PP17
Erosion Pins C	10	30	60	33	PP14
Erosion Pins D	10	10	10	10	PP11
Erosion Pins E					PP09
Erosion Pins F	10	30	100	47	PP05
Erosion Pins G	120	0	10	43	PP01

Appendix 4 – Photo Point Audit (see separate document)

Contained in a separate document.