Final report on erosion mitigation projects at Deep Reach Pool (Nhanggangunha), October 2014 – July 2015 and future recommendations

Contents

1. Background

This report follows on from erosion mitigation initial works and structure maintenance and gully rehabilitation carried out in October 2014, February 2015 and July 2015 by Department of Parks and Wildlife staff, Ngurrawaana Rangers, volunteers and a Parks and Wildlife Remote Regions crew at the toe of Deep Reach Pool.

The first two field work periods were jointly funded by Parks and Wildlife and NRM Rangelands Pilbara Corridors Project following a long and collaborative process between Parks and Wildlife, Department of Water, NRM Rangelands, Ngurrawaana Rangers, Yindjibarndi Aboriginal Corporation and Traditional Owners between June 2013 and September 2014. The Pilbara Corridors Project provided $25,000 external funding overall, for the employ of the Ngurrawaana Rangers, while the Department provided in-kind support (staff hours and materials). The third field work period was supported by Parks and Wildlife utilising a Remote Regions crew who had travelled to the park for a 10-day period; two whole days were contributed to erosion control out of their 10-day program. The Ngurrawaana Rangers were involved throughout. The TOTAL COST of the erosion mitigation project not including MCNP ranger time is currently $45,000, which includes a hydrological engineer visit, Ngurrawaana Ranger hours, and materials (cement, hessian bags, geotextile and tools).

The background to the erosion situation at Millstream Chichester National Park (MCNP) within the Fortescue River (at Crossing Pool and Deep Reach Pool) has been well covered elsewhere and will not be discussed here in detail. More information on the erosion mitigation project can be found in the following documents:

- Deep Reach – erosion at toe; movement 18/01 to 09/02 (Parks and Wildlife, 2014)
- Erosion at toe of Deep Reach following Tropical Cyclone Christine (Parks and Wildlife, 2014)
- Proposed strategy for management of erosion at the toe of Deep Reach pool, Millstream Chichester National Park, in the “flood season” of 2014/2015 (Parks and Wildlife, 2014)
- Millstream Chichester National Park Erosion Mitigation Project, Deep Reach Pool (Nhanggangunha), October 2014 (Parks and Wildlife, 2014)
- Recommendations for the maintenance of erosion control structures at Deep Reach Pool (Nhanggangunha), Millstream Chichester National Park, following a minor discharge event in January 2015
- Maintenance of erosion control structures at Deep Reach Pool (Nhanggangunha), Millstream Chichester National Park, in February 2015; and response to a subsequent pool discharge event in March

Information about erosion along the Fortescue River within MCNP more generally includes:

- Groundwater Modelling Services for the Millstream Aquifer Model (Sinclair Knight Merz, 2011)
- River Management Options for Crossing Pool on the Fortescue River at Millstream (Chester, B 1998)
- River Management Options for Crossing Pool on the Fortescue River at Millstream Final Report (Sinclair Knight Merz 1999)
- Riverbed erosion in the area of Millstream National Park (Barnett, J. C. 1979)
- Environmental Effects at Millstream of Flooding after Cyclone Joan (December 1975) (Dames and Moore, 1976)

These documents can be made available on request; please contact the Millstream Chichester National Park (MCNP) office on 08 9184 5144. Photos in this report will be limited to the situation as it currently stands; photos of past works and detailed notes can be found in the above documents.

2. Control structures and previous work

2.1 Stage 1

Following comprehensive consultation between all key stakeholders (Department of Water, Parks and Wildlife, Yindjibarndi Aboriginal Corporation, Pilbara Corridors Project/NRM) and a site visit by a hydrological engineer (Bill Till) and the development of a plan, low-impact, low-cost mitigation strategies were implemented in mid-October 2014 at the toe of Deep Reach Pool. This included felling a dozen large dead paperbark trees into the erosion gully and building a series of log dams on the bottom of the gully. On top of the gully at the most critical points low fences were constructed to support sandbag "walls". These structure were called structures A and B. Stage one took nine days with a team of four Ngurrawaana Rangers, two MCNP staff and several park volunteers who were in the park at that time. The project was funded by PCP ($15,000). Parks and Wildlife senior management visited the site on one day to provide advice.

Stage 1 was subject to one minor pool discharge event in early January 2015, at which time structure A failed completely while structure B performed well.

2.2 Stage 2

Stage 2 was completed in February 2015 and took a period of six days for a team of four Ngurrawaana Rangers and three MCNP staff and was funded by PCP ($10,000). Stage two included reconstruction of the failed structure A, creation of a new structure in an area identified as of concern (structure C), and the 'hardening' of the pool edge and protection of tree roots from cattle tramping. An important inclusion in Stage 2 was the use of 'geotextile' underneath sandbags. As sandbags had proved the most critical component of the structures a large quantity were produced in Stage 2 (500). No more trees were felled in Stage 2.

Stage 2 was subject to three minor pool discharge events, one in March 2015 and two in May 2015. During these three events all structures performed well although the most critical area (structure B) suffered some soil loss and subsequent slumping. The impact of the geotextile was noticeable. Due to increased soil moisture levels and the sedimentation and reduced water velocity in the bottom of the erosion gully, rehabilitation on the gully bottom was prominent in the March-June 2015 period, especially *Sesbania* and *Passiflora* plants and *Cyperus* sedges.

At the completion of Stage 2 Yindjibarndi Elders Uncle Harry, Middleton Cheedy and Angas Mack visited the site with ABC northwest, the Ngurrawaana Rangers and MCNP staff. The visit involved a site inspection and interviews. The elders were very pleased with the work conducted and Ngurrawaana involvement. The interview and text is available here: http://www.abc.net.au/news/2015-06-05/saving-deep-reach/6498134

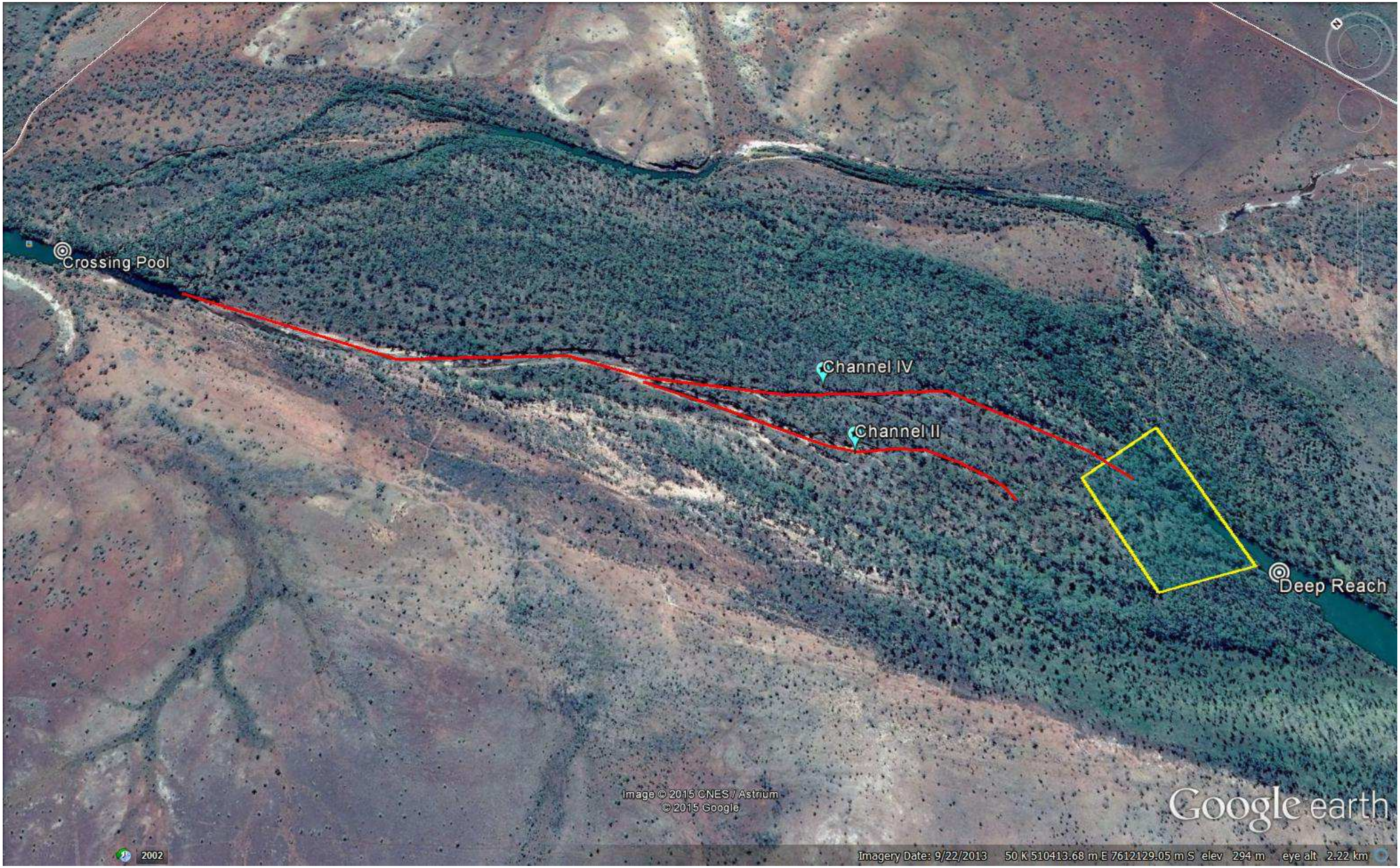
2.3 Stage 3

Surface water engineer Bill Till revisited the site in June 2015 (his initial visit was in August 2014). In his opinion had no work been carried out at Deep Reach, the erosion gully would already have intersected the pool. He provided additional advice. We also visited Palm Pool were a series of substantial waterfalls had formed as a result of erosion but subsequently stabilised, either temporarily or long term, due to striking a band of consolidated clay. The impact and timing of this stabilisation is unknown but is at least four years old.

Stage 3 was completed in July 2015 in a period of two days with four Ngurrawaana Rangers, four Parks and Wildlife Remote Regions crew and two MCNP staff. Stage 3 involved the construction of a new structure (D) across the toe of the pool and the rehabilitation of structure B, using sandbags (400) and geotextile. Work to rehabilitate the downstream gully was continued and several large dead or unhealthy paperbarks were felled into the gully to promote continuing stabilisation.

Stage 3 has not been subject to any discharge events. The growth of vegetation and sedimentation on the floor of the erosion gully has noticeably developed and is a key component of works. The majority of photos in this document show the works as they stand at the completion of Stage 3 in July 2015.

Map 1 – erosion channels between Crossing Pool and Deep Reach Pool showing area of control inside the yellow box.



Map 2 – zoomed in area showing points of control covered in this document (markers are not precise)

3. Current control structures and areas of concern

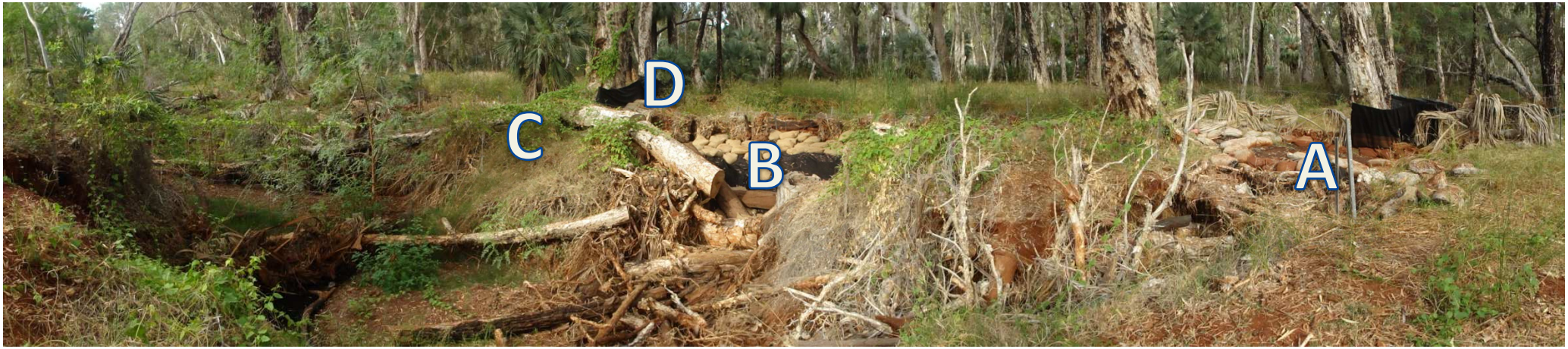
There are three main components to the erosion mitigation strategies as it has been currently implemented:

(1) Prevent headcut incursion into the toe of the pool by the construction of structures at the headcut edge to reduce/eliminate soil loss at this most critical spot. Eventually this strategy is likely to fail and headcut incursion will be initiated. However the longer the headcut remains stable, the more time the downstream gully has to rehabilitate

(2) Use local materials and brought materials to slow water energy and allow gully floor rehabilitation, plant growth and sediment capture. This process is undertaken within the erosion gully itself and will be called 'gully rehabilitation'. This is likely to be the most effective long term strategy to moderate pool level lowering impact when it does occur

(3) Monitor and construct structures as required in side gullies of concern

3.1 Headcut control structures



There are four main structures A-D. C was beginning to show some sign of failure so in July 2015 structure D was constructed to draw water energy away from this point, reduced erosion in a newly identified area, and improve overall functionality of the control structures

3.1.1 Structure A

Structure A is placed on a headcut about 20m from the pool edge in a direct line. The initial October 2014 structure A failed completely (resulting in a loss of 3-5m of soil) and was remodelled based on structure B. The new structure survived three discharge events with no removal of dirt and no requirement for maintenance. The new structure A shifted erosion downstream, showing its efficacy in redirecting erosional energy. The newly eroded area is of little concern at present being on the far side of the gully. The initial structure A was intentionally collapsed onto the gully floor in July 2015 adding to materials within the gully.

When structure A failed in the first instance, material placed in the erosion gully in October 14 prevented the loss of the dirt, which subsequently assisted gully rehabilitation.

3.1.2 Structure B

Structure B has always been, and remains, the most critical area of erosion with the highest potential to intersect the pool in the short term. This area of headcut is only 3-5m from the pool edge. The original structure B performed well over all four discharge events however by the end of May 2015 soil loss (of around 2m) and slumping of the entire structure was observed. In July much of the structure was removed, rehabilitated and replaced. Logs that had had soil removed from underneath were collapsed and the structure was bolstered by an extra 200 sandbags. At this point geotextile was laid underneath most of the structure. The use of geotextile is recommended for any future structures. The combination of geotextile and sandbags can be used to create a 'floor' which can project the soft soil below. Undercutting must be closely monitored. A component of work on structure B is the 'hardening' of the pool edge directly adjacent, and the protection of the soil from cattle trampling by laying geotextile.

^^ note how the geotextile follows the contour of the soil underneath. The sandbags and textile are 'tucked in' at the bottom to prevent undercutting. The logs in the middle of the picture originally sat on soil, which was subsequently removed by discharge events; these were collapsed in July 2015. The intention is to have water run off the structure without the removal of any soil

^^ structure B at left with pool edge hardening at right (the pool edge is marked by the sedges and typha). The geotextile ‘carpet’ was designed to prevent soil trampling by cattle, which can only easily cross the river at this point between Deep Reach and Crossing Pool due to the wide, deep and steep erosion gullies between the two pools. It has performed very well. Note that some of the bags are splitting open and in some cases crumbling. The bags are dirt/pebbles/rock mixed with cement; how well the inside of the bags have remained consolidated when the hessian has split has been variable. They have a lifespan of 2-5 years. Future bags should probably have the cement ratio increased from 10% to 20-25%.

3.1.3 Structure C

Structure C was designed to prevent erosion downstream of structure B, which diverted water energy to this point. The erosion at structure C is not a defined channel/headcut as at A and B however it has the potential to form an incised channel and intersect the pool. It is currently around 8-10m from the toe of the pool. During discharge events in May 2015 structure C failed in a number of places and although repairable to an appropriate standard with not too much effort, due to erosional energy in alternate places, an entirely new structure (D) was implemented that should effectively reduce the energy at structure C by redirecting water energy away from this point.

^^ structure C showing failure in the top right and on the 'floor' (note exposed tree roots indicating a loss of soil)

3.1.4 Structure D

Structure D is a completely new structure constructed in July 2015. This is a low sandbag wall in front of a ring-lock fence draped with geotextile. The purpose of this structure is to divert water energy away from the long, shallow erosion gully that has been slowly progressing toward the toe of the pool on the opposite side of the fence. This channel has a very mild gradient but if left unchecked it could intersect the pool and then deepen. Structure D has the added benefit of directing water away from structure C and redirecting water away from the erosion gully more generally. The success of this structure may prove to be pivotal in ongoing success. How it performs during its first discharge event needs to be closely monitored. It may require better contouring to get the water to redirect into the most appropriate places, which is ideally toward the current natural pool outflow channels on the north side of the pool.

^^ Structure B (left) and D (centre). Structure D hides structure C (behind fence at left). The toe of the pool is at right. When the pool discharges the areas of main overflow are to the left over structure A (not shown), over structure B and in the entire area covered by structure D. This new structure is designed to take the water/energy form left to right, away from critical areas of erosion. It needs to be monitored closely. Based on the effect of previous structures, structure D will certainly have some effect on water flow, and hopefully in the way intended

^^ Structure D looking downstream

3.1.5 Notes on structures

The structures have performed well. The addition of geotextile has been important and its use continued. Overall the low sandbag walls have been most effective in altering the way the water flows over the most critical headcut areas. About 1100 sandbags have been produced. It is getting increasingly difficult to find suitable material for preparation of sandbags on site. The use of used car tyres should be investigated. The impact of structure D remains to be seen. If the structures fail as much material as possible should be removed as soon as practical: fencing wire, star pickets and geotextile. It is not anticipated that the entire structures will wash away in the event of failure; it is more likely that in the event of failure it will be undercutting that will be the cause causing the structures to slump. The sandbags do not need to be removed.

Should the structures continue to work they will likely need ongoing maintenance and modification as the impact of each structure on subsequent areas of erosion is very difficult to anticipate accurately. The mitigation structures are providing projection to the most critical points and their success is essential in allowing time for gully floor rehabilitation, discussed below.

3.2 Erosion gully rehabilitation

If the mitigation structures are the key short-term (2-10 years) elements in preventing gully incursion into the pool, gully rehabilitation is the long-term goal of the erosion mitigation project. Extent of pool level drop is determined by the height differential between the current pool level and the bottom of the erosion gully. This difference increases as the gully moves downstream to Crossing Pool. The river is essentially trying to find stabilisation of its gradient between Deep Reach and Crossing Pool (now that the level at Crossing Pool has dropped well below the level of Deep Reach due to erosion), then downstream to Palm Pool/Gregory Gorge. It should be anticipated that this will, one day, occur. However if the upstream end of the erosion gully can be rehabilitated to a level closer to the current pool level, lowering effects should be moderated significantly. When gully breakthrough into the pool is observed, the ideal situation is to have a shallow, rather than a pronounced, and stabilised gradient between the pool level and the erosion gully. A level drop of less than 1m followed by pool stabilisation would be ideal. A vegetated, stabilised erosion gully will prevent further scouring in the gully floor, improved sedimentation, and moderation of effects on the whole system.

3.2.1 Current situation gully rehabilitation

Currently works in the erosion gully have been limited to the top 100m, with particular attention paid to the top 50m. Works have involved felling dead paperbarks into the gully and construction of log dams and fences inside the gully. Over the 12 months of the project (Oct 14-Sept 15) there has been significant improvement in the conditions inside the gully. Continuing work in the gully in addition to structure maintenance should be seen as a high priority.

^^ Main erosion gully 20m from headcut looking downstream following initial works Oct 14, note tree on right as reference

^^ Main erosion gully following final works July 15

^^ Main erosion gully looking upstream toward headcut, Oct 14

^^ Main erosion gully looking upstream toward headcut, July 15. Some collapse of log dam.

^^ Main erosion gully looking downstream from headcut, Oct 14. Note log diagonal from bottom right to centre as reference, and Millstream palm top right for scale

^^ Main erosion gully looking downstream from headcut, July 15. Diagonal log was cut in July 15

^^ Main erosion gully 60m from headcut prior to any works, September 14. Note cluster of Millstream palms at top left as reference. Note deeply incised channel on the gully floor

^^ Main erosion gully 60m from headcut, July 15. Trees have been felled (Oct 14) and log dams constructed. Note rehabilitation of incised channel

^^ Main erosion gully (channel IV), 1km downstream of the toe of Deep Reach Pool. Eventually works could begin in these downstream areas

3.2.2 Notes on gully rehabilitation

In areas where works have occurred gully rehabilitation has been outstanding. This relates to the top 100m of the erosion gully. Beyond this point, where no works have been carried out, erosion has incised channels into the gully floor and sedimentation and vegetative growth is limited. There is a clear causal relationship between gully works and gully rehabilitation – the gully will not rehabilitate itself in the short to medium term.

Material exists along the entire erosion gully for use in rehabilitation. This should be supplemented by low sediment trap fences. These could be constructed with geotextile and ring lock fencing or by an alternative method, such as used car tyres supported by pickets. Caution should be taken to make sediment traps semi-permeable otherwise water energy will dig around the side of the structures. Large dead or dying paperbarks that have been destabilised by erosion or weakened by fire should be felled into the gully at any available opportunity (i.e. available staff skill in technical chainsaw work). In the case of unhealthy living trees coppicing following felling has often improved their health considerably so efforts should be made to retain the root ball.

The gully rehabilitation should be done annually in conjunction with structure maintenance. If a summer period passes without a discharge event or without damage to the structures, gully rehabilitation should be planned and implemented regardless – the further downstream gully rehabilitation progresses the more moderate the eventual effects of gully breakthrough into Deep Reach. However gully rehabilitation should not be undertaken so quickly that quality is reduced – significant amount of work needs to be made over a short area (i.e. 100m) to have the desired effect. This may include the coppicing of living trees if this is the material available.

3.3 Side gullies

Side gullies refer to a number of shallow gullies upstream of the channel IV headcut. They have not shown any movement since works commenced and appear to be stable. During discharge events they do not appear to be subjected to fast flowing water for very long, unlike the main headcut area. However given their proximity to the pool they should be monitored after each flow event. Some period of river flow could cause them to be rejuvenated. The side gully height differential to the pool is moderate. They have not shown any rehabilitation or sedimentation despite the construction of fences.

Should the main headcut area breakthrough become imminent there is some potential advantage to pre-emptively lowering the height of the pool by artificial breaking through of one of the side gullies. This could lower pool level by 50-100cm and draw water away from the main headcut, preventing overtopping in this location and the continual scouring action of a constant flow of water. It would also promote vegetation consolidation on the south side of the pool and allow additional time for gully rehabilitation. However this would be only a temporary solution.

^^ Main side gully, Oct 14. Toe of pool is top left corner

^^ Main side gully no significant change, July 15

4. Future recommendations

4.1 Factors affecting ongoing decisions

The future recommendations are entirely dependent on the success or failure of the structures following discharge events. There are a number of potential outcomes:

(a) The structures continue to prevent incursion of the erosion gully and/or slow the rate of headward erosion; the current headcut areas remain the critical areas of concern. In this case following each discharge event there is likely to be some minor to moderate maintenance of existing structures. Dependent on the level of structure maintenance required, work should proceed downstream of the current extent of gully rehabilitation.

(b) The structures fail, or imminent failure is considered inevitable in the short term, and headward erosion intersects the pool and pool level lowering is initiated. At this point as much non-biodegradable material should be removed from site (i.e. ring-lock fencing and star pickets) as possible. Media releases and on-site visits with stakeholders, especially Yindjibarndi, should be commenced immediately. Environmental monitoring, especially to measure the impact of erosion on spring discharge at Chinderwarriner Pool and flow rates from the northern side of Deep Reach, should begin. Long-term monitoring programs should be developed and implemented. The extent of failure will determine downstream actions. If the erosion gully rehabilitation has been significant prior to pool level lowering, the effects of lowering may be moderated. If this is the case, further works downstream of the headcut may be warranted.

(c) Erosion gullies which currently appear stable are rejuvenated during discharge events and threaten to intersect the pool edge. Actions at this point will depend on the extent of gully rejuvenation. If too many gullies are working back toward the pool simultaneously it may no longer be feasible or practical to implement mitigation strategies and works will have to be abandoned. The actions following mitigation failure are the same in any scenario: remove non-biodegradable materials and initiate community consultation and environmental monitoring.

4.2 To work or not to work

There will without question be work to undertake in the 2015/16 season and likely well beyond that. The exact nature of required work is dependent on the extent and frequency of discharge events. Possible scenarios include:

(1) Single minor/major discharge event has no effect on structures; structures perform; concentrate on gully rehabilitation as a priority after each discharge event

(2) Single or multiple minor/major discharge events (as in the 2014/15 season) damages structures but structures continue to perform; maintain structures as a priority after each discharge event

(3) Single or multiple minor/major discharge events damage structures irreparably but breakthrough is not achieved; concentrate efforts on gully rehabilitation as a priority; begin removal of materials; begin community consultation

(4) Single or multiple minor/major discharge events damage structures irreparably and breakthrough is achieved; remove materials as a priority and begin community consultation

(5) No discharge events, no change; concentrate on gully rehabilitation

It is critical that the situation is monitored after every flow event no matter how minor and actions taken to address structure failure *after each event* wherever possible (i.e. events could be so close together, as in May 2015, that immediate works are impractical). In this sense management must be adaptive. At the very least if there are no discharge events in the 2015/16 some time should nevertheless be spent on gully rehabilitation as this is critical to long term success.

5. Funding requirements

At the very least one period of work should be undertaken in the 2015/16 period, either as a response to discharge events or solely on gully rehabilitation. Gully rehabilitation can be postponed until after the wet season if there are no discharge events. It is the best option to wait until after the first discharge event to initiate first works as this will determine best practice control strategies.

Costs are based on the 2014/15 works utilising the Ngurrawaana Rangers who should continue to be involved in the project. A three-day week for a team of four rangers is $5000 inclusive of their vehicle. In the past, 6-9 days for a team of four, plus two MCNP staff has been sufficient to complete maintenance work. Therefore, a requirement of $15,000 is the baseline figure required for maintenance work following the first discharge event. A further $10-15,000 will be required following a second discharge event should the structures require additional maintenance. If the structures fail $15,000 will still be required to remove materials and undertake additional gully rehabilitation. If maintenance does not require the entire period funded the remainder of the time/money should be allocated to gully rehabilitation. Thus $15,000 is the minimum expected funding requirement for 2015/16 and $25,000 is the likely maximum, not including MCNP in-kind support (staff and materials).

In July 2016 the Remote Regions/Ngurrawaana Ranger partnership should be continued as per 2014/15 and three days of the ten-day Remote Regions swing should be committed entirely to erosion control. If the structures do not require maintenance the entire three days should be spent on gully rehabilitation. With four RR crew, four Ngurrawaana Rangers and two MCNP a significant portion of the gully can be rehabilitated. Note also that neither MCNP staff nor Ngurrawaana Rangers have the competency or 'tickets' to fell large trees, therefore felling trees as a component of gully rehabilitation is likely to be possible only with Remote Regions involvement. The RR work period is funded internally by Parks and Wildlife, however $5,000 is required for the employ of the Ngurrawaana Rangers. This will fall in the 2016/17 financial year. The application for a RR team is due in February/March 2016. Given the success of last year's program at Millstream there can be some confidence that the funding application will be approved for July 2016.

Funding of a minimum $15,000 should be secured as soon as possible, prior to the commencement of the wet season, to allow immediate response should a discharge event occur. This should be secured either externally or internally to Parks and Wildlife without impacting on the indigenous Joint Management fund (i.e. the erosion control is a 'special' project and should be funded independently of other work on country programs). This situation is likely to repeat indefinitely in every year until incursion of erosion gullies into the pool becomes a reality.

6. Conclusion

Monitoring followed by consultation is the first step after each discharge event, followed by a decision about future actions. Whatever the decision it should be implemented quickly and efficiently: a delay in implementing works could lead to failure of the project. If there are no discharge events gully rehabilitation should proceed regardless. The best case scenario is for a number of seasons with good rainfall that result in aquifer recharge without significant river discharge events. The worst case scenario is a series of major floods that cause breakthrough of erosion gullies into the pool and subsequent extreme pool lowering. The actual outcome is likely to fall somewhere between those two extremes. It is important that all collaborators continue to communicate about the situation at Deep Reach. It is also important that MCNP staff continue to monitor the situation at Palm Pool (i.e. do the 'waterfalls' begin to work back toward the toe of this pool following a discharge event).

Given the importance of Deep Reach Pool as a conservation, cultural and recreational asset of immense value all efforts should be made to moderate the effects of erosion in the short, medium and long-term. Given its historical cultural significance this project should continue to involve indigenous employment (Ngurrawaana Rangers) and Yindjibarndi consultation.

It is feasible given the project success between October 2014 and July 2015 that works implemented over the next 5-10 years will have a significant moderating effect on the impact of erosion when breakthrough does finally occur. To achieve this result continuity in management of erosion at Deep Reach must be maintained and efforts applied wherever possible and as required.

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September 21, 2015