Report to the Manager, Regional Infrastructure Development, Department of Natural Resources, Townsville, North Queensland.

Scoping Report - Gulf Rivers Dams and Weirs

Initial Appraisal of Fisheries Aspects

by

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1. Summary

The Department of Natural Resources at the request of local governments is assessing the suitability of the upper Mitchell and Gilbert Rivers, in the Gulf of Carpentaria drainage division, for dam construction and associated infrastructure for irrigated agriculture.

The proposal for the Mitchell catchment is a dam at the Pinnacles (AMTD 410km) with a storage capacity of 158 150ML. The development of water storage in the area would allow irrigated agriculture in the downstream reaches from Mt Mulgrave to Gamboola.

There are several options for the Gilbert catchment including weir construction near apparently irrigable land on the Copperfield, Einasleigh, and Gilbert River to increasing the capacity of the Kidston Dam. There is also potential for construction of a new dam at North Head (AMTD 398km) on the Gilbert River with a storage capacity of 160 000ML. Another option is the construction of a dam at Bundock Creek and supplementing it with flows from the Einasleigh River.

Very little published fisheries data exists on either the Mitchell or Gilbert River catchments. A study of the upper Mitchell catchment is currently being compiled by DPI for publishing and provides the fish and water quality data for the Pinnacles Dam section of this report. Data for the Gilbert catchment was collected during a brief survey of the dam and weir sites in October 1998. The key difference between the two catchments is that the Mitchell River is generally a perennial stream and the Gilbert River has intermittent flows.

The upper Mitchell catchment has some fish species (eg. Sawfish, Purple-spotted gudgeon) undergoing a conservation status review and they may be listed as rare or threatened in the near future. None of the species found would be threatened by the placement of the Pinnacle Dam nor are there any critical fish habitats in this section of river that we are aware of. The dam would prevent further upstream migration of all the species in this section of river, however this migration is already restricted by the Mitchell Falls, except in very large wet seasons. The dam may restrict the movement of some crustacean species (eg. *Macrobrachium rosenbergii*). They require a saline component in their life cycle but adults live in the upper reaches of the catchment. The crustaceans are capable of climbing waterfalls but may have problems with dam walls especially if they are dry. They are a popular recreational species and their role in the food chain has not been established.

The upper Gilbert catchment was sampled during the dry season when very little water was present. Despite this 21 species were collected with local reports of 5-10 more during the wet season. No rare or threatened species were found and water quality was acceptable in most waterholes. Waterholes and offstream lagoons appear to be vital to the existence of a healthy fishery in these intermittent streams, acting as a refuge for whole fish communities in between times of flow. Flooding appears to be extremely important for fish movement and waterhole maintenance. During large flood events fish with estuarine components (eg. barramundi) have been reported up to the North Head dam site. This indicates that weirs downstream may require fishways depending on height of the walls and drown out frequency.

There are extremely valuable cattle and fishing industries downstream in both catchments that rely heavily on regular flooding. Flooding replenishes lagoons and allows cattle to graze away from the river channel. Floods deposit nutrients on the grazing lands and connect the lagoons and river, allowing fish movement. Floods also stimulate spawning and create the conditions necessary for successful larval and juvenile rearing. Floods push prawns out to sea, and rejuvenate the entire river system, including eel grass beds in the estuary (Jay and Simenstad, 1994). We suggest that water harvests from either catchment does not exceed 30% of average annual flow.

Sand movement in these rivers appears to be extensive and could cause some problems with dam and weir siltation and successful operation of fishway devices.

More information should be gathered on mining activities, both past and present, and their potential impacts on water quality in the dams. High levels of heavy metals have been associated with mining and any leaching into the water column has the potential to adversely affect both recreational and commercial fisheries downstream.

Consideration should also be given to the potential for blue-green algae blooms in the new impoundments.

Environmental flows would be difficult to address due to the intermittent nature of some streams. Mimicking the natural flow regime while providing water for irrigation via the river channel would also prove difficult. Water released in pulses could leave fish stranded and cause bank slumping. More research on the flow requirements of the Mitchell and Gilbert River catchments is necessary before any infrastructure development takes place.

The soils in the catchments appear to be highly erosive and continual irrigation could cause river systems to become highly turbid if tailings are not captured by settlement dams. Additionally, the soils may also have considerable saline potential. Increased salinity levels in these streams may have a negative impact on the freshwater fishery.

The inundation areas of the Pinnacles, North Head and Kidston (after raising wall) Dams may remove spawning areas of some freshwater fish. These areas need further investigation to determine if critical spawning sites exist. The dams and weirs will create large areas of permanent water, hence potentially more habitat and greater numbers of fish if there is suitable access during flooding or via fishways.

There is potential for stocking some of these dams providing an additional recreational fishery for the local communities. Sooty grunter may spawn above the dams, but other popular species such as barramundi would require annual re-stocking.

2. Introduction

2.1 Scope

The authors, from the Department of Primary Industries - Fisheries, Walkamin, were engaged by the Manager, Regional Infrastructure Development, Department of Natural Resources, Townsville, to consolidate existing fisheries data, undertake rapid assessment surveys and prepare a scoping report (including potential issues and recommendations) for Bundock Creek, Gilbert, Einasleigh, Copperfield, and Mitchell Rivers with respect to water infrastructure development. We are not reporting on or investigating whether the proposals comply with State and Federal legislation, as we assume they will. We also assume that should any of the water infrastructure developments proceed further, a full impact assessment would be conducted. An Environmental Management Plan would then be enacted to cover the construction and operation of these schemes.

Any views and recommendations expressed in this report may not necessarily be adopted by the Department of Primary Industries or by the Department of Natural Resources.

2.2 Methodology

This is primarily a desktop study, using existing data and information collected during a rapid fish assessment survey by the authors. Site observations were made and photographs taken during this assessment.

Fish were sampled using backpack and boat mounted electrofishers. Water quality was tested using a *TPS* water quality meter.

In this scoping report, the Queensland Department of Primary Industries (Freshwater Fisheries) has considered the implications of dams and/or weirs on fish assemblages and provides recommendations for minimising impacts.

3. Background

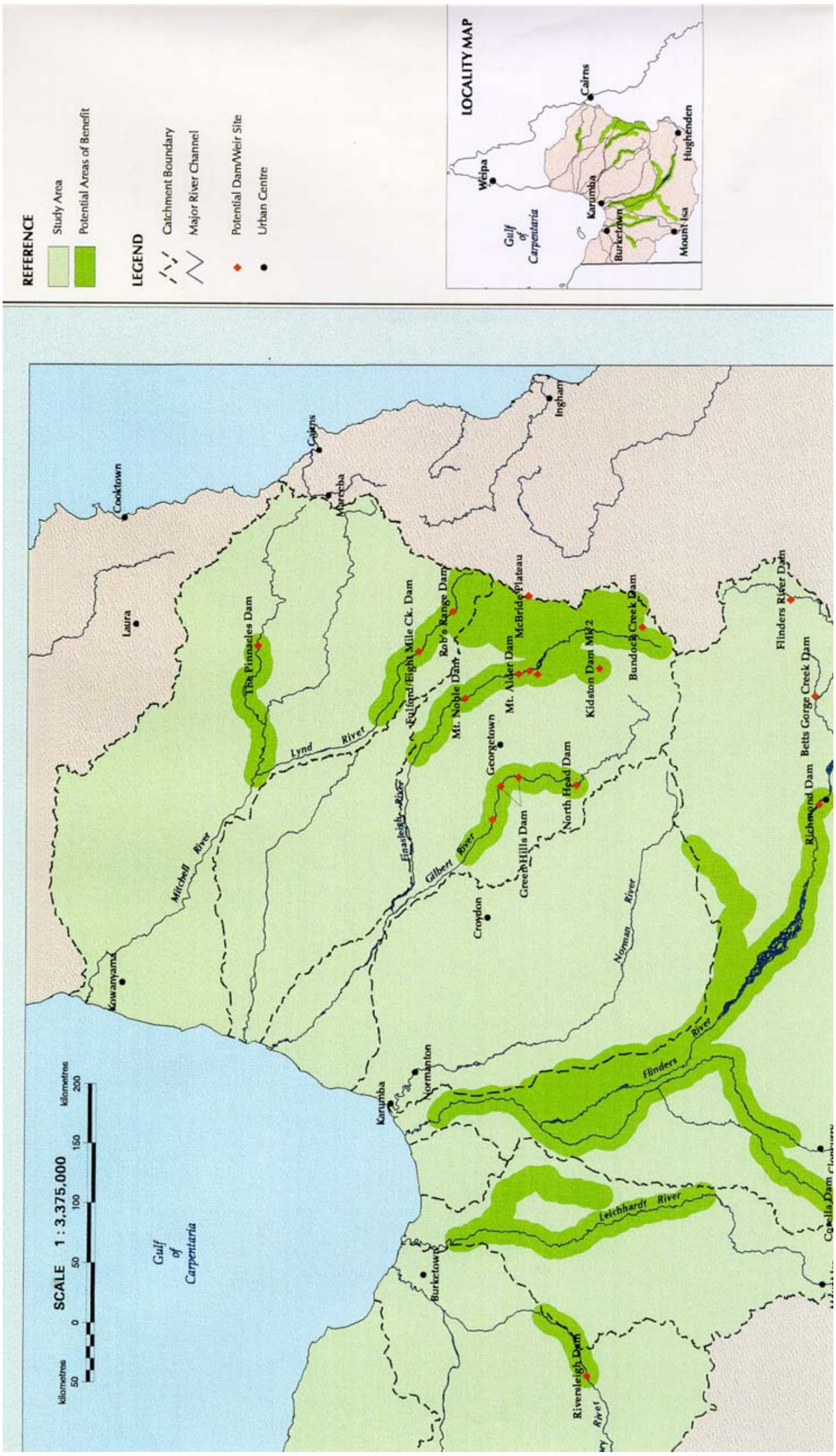
3.1 Pinnacles Dam – Mitchell River

The Department of Natural Resources has identified a potential storage site at the Pinnacles (AMTD 410 km)(Figure 1). The maximum level of development at this site could entail a dam wall of 48 metres in height resulting in an inundated area of 5,725 ha and storage volume of 879,300ML. It is believed that full development is not warranted due to the limited availability of agricultural land close to the site (Anon., 1998).

The proposed level of development is for a wall height of 38 metres, providing 158,150ML of storage.

The development of water storage in this area would allow irrigated agriculture in the downstream reaches from Mt Mulgrave to Gamboola.

Figure 1. Dam sites of the Gulf of Carpentaria drainage division.



3.2 North Head Dam and Weirs – Gilbert River

At present approximately 577ha of land is licensed for irrigation from the bed sands of the Gilbert River in the Prestwood Station to Chadshunt Station area. The expansion of agriculture in this locality depends upon the provision of reliable water storage in the district. The proposed North Head Dam would provide sufficient water storage to meet irrigation requirements for up to 4,000 ha through replenishing the bed sand system (Anon., 1998).

The Department of Natural Resources has identified a potential storage site 7km South of the North Head Station (AMTD 398 km)(Figure 1). The maximum level of development at this site would have a wall height of 28 metres, resulting in an inundated area of 2,300 ha and storage volume of 224,000Ml. The preferred storage size is 160,000Ml to reliably meet the potential demand with up to 60% transmission loss. This would be attainable with a wall height of 26 metres.

In addition to the North Head proposal, regulating weirs adjacent to the benefited irrigation area are also being considered. These weirs would be instream structures above 6 metres high and storing 5,000-10,000Ml. Sites have been identified at Green Hills Station, Prestwood Station and Rockfields Station.

The Rockfields Weir site has presented difficulties for construction with bed sand depths over 32 metres deep. It is believed a suitable site in the vicinity may exist. However it is yet to be confirmed.

3.3 Raising of Kidston Dam and weir construction - Copperfield River

Kidston dam was originally constructed in 1984 on the Copperfield River to support the Kidston Gold Mine. In mid-1996 a small group of landholders in the Einasleigh district expressed interest in developing an irrigation scheme utilising the existing water storage. It was envisaged that water would be conveyed downstream to serve apparently suitable agricultural lands on both sides of the Copperfield River near its junction with the Einasleigh River. After preliminary soil suitability work, it has become apparent that the available land resource is larger than that able to serviced from the existing storage (Anon., 1998).

One option to increase water availability is to raise the existing dam by two metres. In addition to this proposal, regulating weirs adjacent to the benefited irrigation area are also being considered. These weirs would be instream structures, with one near Narrawa Station and a second in close proximity to the Einasleigh township (Figure 1).

3.4 Bundock Creek Dam – Einasleigh River

The Department of Natural Resources has identified a potential dam site at AMTD 42km on Bundock Creek, a small tributary of the Einasleigh River (Figure 1). It is envisaged this storage facility could supply irrigation for 3,000ha of land. With full supply level approximately 11 metres above the riverbed the storage would have a capacity of 33,350Ml and a surface area of some 600ha.

Initial investigations propose the spillway flows go into Lee (M^{c}Kinnon's) Creek which rejoins the Einasleigh River at The Lynd 50km downstream. It is also proposed that the small catchment of Bundock Creek could be supplemented by a diversion from the Einasleigh River to yield about 20,000Ml/annum.

4.0 Site Description

4.1 Pinnacles Dam

The volume of water carried by the Mitchell River rivals that of the Murray River, Australia's largest (Powell, 1991). The river travels west from the Great Dividing Range near Port Douglas to the Gulf of Carpentaria near Kowanyama. The site investigated was at the Pinnacles dam axis (Figure 2) near the old O.K. Bridge crossing at AMTD 410km. Our visit took place during October 1998 when river levels were low.

4.1.1 Physical Habitat

The survey site consisted of a 60 metre wide slow flowing main channel with an average water depth of 1.5 metres. A large rock outcrop separated a secondary channel from the main river. This portion of the river was not flowing. There were high rocky ridges either side of the river.

Riparian vegetation was largely intact, with minor pig and livestock damage. Trees averaged 10 metres in height and instream habitat consisted of logs, rocks and sandy substrate. No rapids were present in the immediate area, though large rapids exist downstream at the Bellevue road crossing. Access to areas immediately upstream is limited, although accessible points have rapids and riffles with mostly rocky beds.

Figure 2. Pinnacles Dam axis.

4.1.2 Water Quality

As part of the Mitchell River Environment and Water Quality project (NHT-96-2005) water quality has been collected at various locations both upstream and downstream of the dam axis over the past two years. Data from survey sites close to the dam site are summarised below.

Table 1. Water quality at Pinnacles Dam site

Site	Date	Dissolved Oxygen mg/l	Conductivity µs/cm	PH	Water Temp. ^{o}C
Mt Mulgrave	November 1996	6.99	67.20	7.26	32.3
	April 1997	7.71	89.40	7.23	28.9
	June 1997	7.26	76.80	7.56	25.2
	September 1997	7.38	75.60	7.21	28.2
	December 1997	5.7	63.90	7.69	*34.5*
	March 1998	8.91	90.80	7.41	30.9
	June 1998	5.55	49.20	7.51	24.9
	September 1998	7.31	58.10	7.69	31.8
Bellevue	November 1996	7.14	66.80	7.10	31.3
	April 1997	7.45	81.90	7.01	26.5
	June 1997	7.64	66.70	8.06	25.2
	September 1997	7.60	58.90	7.61	29.2
	December 1997	6.84	48.60	8.29	*35.8*
	March 1998	9.33	74.30	7.76	31.1
	June 1998	6.16	43.90	7.73	25.0
	September 1998	6.72	49.90	7.59	29.8

Water quality in the Mt Mulgrave to Bellevue section of the Mitchell River is good to excellent year round. Of particular interest is the high water temperature recorded during December sampling.

4.1.3 Fish Species Composition

The following data was collected as part of the Mitchell River and Environment and Water Quality study (Ryan, in press) (NHT – 96-2005) (Table 2). It is worth noting that the dam site is above the Mitchell River falls which prevents upstream movement of some species, except in very wet years. Some of the fish species found only below the falls have a marine component in their life cycle (Table 3).

Table 2. Fish sampled in close proximity to the dam axis above falls.

Common Name	Species Name
Macleay's perchlet	*Ambassis macleayi*
Sailfin perchlet	*Ambassis agrammus*
Banded grunter	*Amniataba percoides*
Toothless catfish	*Anodontiglanis dahli*
Berney's catfish	*Arius berneyi*
Lesser salmon catfish	*Arius graeffei*
Freshwater sole	*Brachirus selheimi*
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*
Mouth almighty	*Glossamia aprion*
Square-blotched goby	*Glossogobius* sp. *c*
Coal grunter	*Hephaestus carbo*
Sooty grunter	*Hephaestus fuliginosus*
Spangled perch	*Leiopotherapon unicolor*
Chequered rainbowfish	*Melanotaenia splendida inornata*
Purple-spotted gudgeon	*Mogurnda adspersa*
Purple-spotted gudgeon	*Mogurnda mogurnda*
Bony bream	*Nematalosa erebi*
Black catfish	*Neosilurus ater*
Hyrtl's tandan	*Neosilurus hyrtlii*
Sleepy cod	*Oxyeleotris lineolatus*
Striped sleepy cod	*Oxyeleotris selheimi*
Gilbert's grunter	*Pingalla gilberti*
Guppy	*Poecilia reticulata*
Rendahl's tandan	*Porochilus rendahli*
Barcoo grunter	*Scortum barcoo*
Longtom	*Strongylura kreffti*
Archerfish	*Toxotes chatareus*
Mitchell Prawn	*Macrobrachium rosenbergii*

(Ryan, in press)

Table 3. Additional Mitchell River species found downstream of falls

Common Name	Species Name
Triangular shield catfish/Forktail	*Arius leptaspis*
Shovel-nosed catfish	*Arius midgleyi*
Snub nosed garfish	*Arrhamphus sclerolepis*
River shark	*Carcharhinus leucas*
Barramundi	*Lates calcarifer*
Ox-eye herring/Tarpon	*Megalops cyprinoides*
River sawfish	*Pristis pristis*
Gulf saratoga	*Scleropages jardinii*

(Ryan, in press)

4.2 North Head Dam and Weirs

The Gilbert River has a catchment area of 46,900km^2 and a mean annual discharge of 5,580,000 Ml (Zeller, 1998). It is an intermittent stream with main periods of flow during the wet season from January – April. The sites investigated were at the North Head Dam site, North Head Station, Green Hills Station, and Prestwood Station near Western Creek. The visit took place during October 1998 when river levels were low.

4.2.1 Physical Habitat

The North Head Dam survey site consisted of a 15 metre long, 4 metre wide and 2 metre deep waterhole surrounded by sand. Large boulders are the only source of habitat. This waterhole has not dried up in recent history (*pers.com*. B.Hughes). The main river channel is over 150 metres wide with high rocky ridges either side. Riparian vegetation was largely intact with trees averaging 10 metres in height.

North Head Station had very little water. The survey site was a small waterhole on the left bank only 10 metres long and 3 metres wide and appeared to be highly disturbed by cattle. The substrate was thick with detritus and instream habitat non-existent.

The Gilbert River at Green Hills had no water though a tributary just above the weir axis, Western Creek, did contain a reasonable waterhole (Figure 3). The sample site was 60 metres long, 10 metres wide and approximately 2 metres at the deepest point. The substrate consisted of decaying leaf litter and thick silt over a sand base and several logs provided instream habitat. There was high disturbance from cattle and feral pigs.

Water was more abundant around the Prestwood station weir site (Figure 4). The sample site was several kilometres upstream of the homestead. The lagoon at this site was approximately 100 metres long, 25 metres wide and 1.5 metres at the deepest point. Instream habitat consisted of undercut banks, tree roots, log jams and leaf litter covering a sandy substrate. Riparian vegetation was largely intact with minimal cattle and feral pig disturbance.

Figure 3. Green Hills Station – Western Creek

Figure 4. Prestwood Station Waterhole – Gilbert River

4.2.2 Water Quality

Water quality was collected during the brief inspection of sites in October 1998. In general water quality was acceptable to good considering no surface flows had occurred for several months. No data was collected at Green Hills Station due to a malfunction with the water quality meter, however the water quality appeared to be lower than elsewhere in the catchment with high turbidity as a result of cattle and possibly mining activities in the Western Creek catchment (Station Manager, pers.com). The collected data for each site has been summarised below (Table 4).

Table 4. Water quality at fish survey sites on the Gilbert River

Site	Dissolved Oxygen mg/l	Conductivity µs/cm	pH	Water Temperature ^{o}C
North Head Dam Site	7.28	202	5.99	29.2
North Head Homestead	8.3	255	6.17	30.8
Green Hills Station	N/A	N/A	N/A	N/A
Prestwood Station	7.79	118.3	7.75	33.8

4.2.3 Fish Species Composition

There was a high species abundance and diversity for a river that appears to be dry for some of the year (Table 5). All fish species identified in this survey are freshwater spawners, suggesting that some portions of the river contain critical habitat which sustain these fish through the dry season. The sample sites were often quite small but contained large numbers of fish and usually freshwater crocodiles.

Table 5. Fish species sampled between North Head and Prestwood Stations – Gilbert River.

Common Name	Species Name
Sailfin perchlet	*Ambassis agrammus*
Macleay’s perchlet	*Ambassis macleayi*
Banded grunter	*Amniataba percoides*
Toothless catfish	*Anodontiglanis dahli*
Salmon catfish	*Arius leptaspis*
Sooty grunter	*Hephaestus fuliginosus*
Spangled perch	*Leiopotherapon unicolor*
Chequered rainbow Fish	*Melanotaenia splendida inornata*
Bony bream	*Nematolosa erebi*
Hyrtl's tandan	*Neosilurus hyrtlii*
Sleepy cod	*Oxyeleotris lineolatus*
Striped sleepy cod	*Oxyeleotris selheimi*
Gilbert's grunter	*Pingalla gilberti*
Leathery grunter	*Scortum neili*
Archerfish	*Toxotes chatareus*
Redclaw crayfish	*Cherax quadricarinatus*
Freshwater prawn	*Macrobrachium* sp.

Reports from local station holders suggest that several other species have previously been present in this section of river. These include saratoga, barramundi and sawfish.

4.3 Raising of Kidston Dam and Weir construction – Copperfield River

The Copperfield River is part of the Gilbert River catchment area and joins the Einasleigh River just north of the Einasleigh township. Flows in this stream are typical for the Gilbert River catchment with high seasonal variability, peaking during the summer months. The sites surveyed included The Gorge near Einasleigh, Narawa Station and Kidston Dam.

Some portions of the Kidston Dam wall appeared to be in a poor condition.

4.3.1 Physical Habitat

The Gorge survey site was approximately 90 metres long and 10 metres wide with depth unknown. It was unique in this river due to the sheer rock walls, which may have been formed from lava flows (Figure 5). No riparian vegetation existed but this is most likely due to the rocky nature of the substrate. Instream habitat included undercut banks, rock outcrops and occasional logs. This site is approximately 6 km downstream of the Narawa weir site and was chosen because of the permanency of the water.

Figure 5. The Gorge – Copperfield River.

Narawa Station is the proposed site for a regulating weir. There were extensive sand beds in this section of the river with only a small shallow waterhole on the left bank (Figure 6). Riparian vegetation appeared intact and there was little disturbance from livestock. Undercut banks were the main type of fish habitat. It was thought that the hole may dry out before the wet season.

Figure 6. Copperfield River at Narawa Station.

Figure 7. Kidston Dam.

Kidston Dam was almost at full supply during our survey. Fish habitat types were varied and extensive with standing timber, large boulders, weed beds and sedges and rushes (Figure 7).

4.3.2 Water Quality

Water quality was good at most sites although the dissolved oxygen at Narawa was quite low (Table 6). Acceptable minimum dissolved oxygen levels for aquatic animals is 4.0 mg/l (Hart, 1974). The reading of 2.2 mg/l may be explained by the influence of ground water, which is devoid of oxygen, or by algae within the lagoon consuming oxygen overnight. The reading was taken at 8:00am.

Table 6. Water quality at various sites in the Copperfield River.

Site	Dissolved Oxygen mg/l	Conductivity µs/cm	pH	Water Temperature ^{o}C
The Gorge	8.10	217	7.16	27.4
Narawa Station	*2.2*	203.6	6.91	26.1
Kidston Dam	9.29	112.2	7.57	27.1

4.3.3 Fish Species Composition

Kidston Dam held the majority of fish observed in the catchment probably due to the permanency of the water (Table 7). Very little water was flowing into the dam at the time of survey although there may be waterholes holding fish further upstream. During the wet season it is also possible that suitable sooty grunter spawning sites exist upstream. Fodder species such as bony bream were also highly abundant. A more extensive fish survey is likely to find additional species and provide a better picture of the fishery.

Table 7. Fish species sampled in the Copperfield River.

Common Name	Species Name
Banded grunter	*Amniataba percoides*
Square-blotched goby	*Glossogobius* sp. *c*
Sooty grunter	*Hephaestus fuliginosus*
Spangled perch	*Leiopotherapon unicolor*
Chequered rainbowfish	*Melanotaenia splendida inornata*
Purple-spotted gudgeon	*Mogurnda mogurnda*
Bony bream	*Nematolosa erebi*
Sleepy cod	*Oxyeleotris lineolatus*
Striped sleepy cod	*Oxyeleotris selheimi*
Archerfish	*Toxotes chatareus*
Redclaw crayfish	*Cherax quadricarinatus*

4.4 Bundock Creek Dam and Einasleigh River

Bundock Creek is an intermittent tributary of the Einasleigh River originating in the Great Dividing Range south of Mount Remarkable. It has a catchment area of 20,200ha and has an estimated runoff of 4,800 ML in 80% of years (Anon., 1998). Unfortunately storm rains prevented access to the dam site at the time of our survey. Alternative sites were investigated, including a roadside lagoon on Bundock Creek near the Kennedy Development Road crossing, and several sites on the Einasleigh River in the Carpentaria Downs region.

The Einasleigh River is a major tributary of the Gilbert River, which flows into the Gulf of Carpentaria. During the dry season, flow ceases and the river becomes a series of large and small lagoons. These lagoons were the focus of the fish surveys.

4.4.1 Physical Habitat

The Bundock Creek lagoon was approximately 1km long and 50m wide. There was a small outflow from the lagoon, which may have been triggered by overnight rain. Instream habitat types included weed beds, occasional logs, and undercut banks. The substrate was mostly sand and silt with leaf litter. Immediately downstream of the lagoon the bed contained large stones and rocks which may form rapids in periods of flow. Riparian vegetation was mostly intact and cattle and pig damage was minimal.

Three sites were sampled on the Einasleigh River. The first was Washpool Lagoon, an offstream billabong on Carpentaria Downs Station (Figure 8). This lagoon fills from overland flows when the Einasleigh River floods (Bob Lowe pers. com.). The lagoon is highly disturbed by cattle and surrounding vegetation is sparse. The substrate is very muddy and instream habitat almost non-existent.

Figure 8. Washpool Lagoon

The second survey site was at the Gregory Development Road crossing of the Einasleigh River. This site was approximately 1.5km long, 75m wide, and greater than 3m deep in sections. This portion of stream was in good health with dense riparian vegetation, an abundance of instream habitat and minimal cattle disturbance (Figure 9).

Figure 9. Einasleigh River at Gregory Development Road crossing.

Red Rock was the final fish survey site. It consisted of a small series of rocky pools ranging between 50-75m long and all approximately 10 metres wide. Due to the abundance of rock, riparian vegetation was sparse and bank disturbance was not an issue. Instream habitat consisted of several logjams and rocky outcrops.

4.4.2 Water Quality

Water quality at the four sample sites in the Einasleigh River catchment was suitable for aquatic communities. The high conductivity at Bundock Creek lagoon (Table 8) could suggest the presence of sodic soils in the area. Further investigation may be necessary.

Table 8. Water Quality at four sample sites in the Einasleigh River catchment.

Site	Dissolved Oxygen mg/l	Conductivity µs/cm	pH	Water Temperature ^{o}C
Bundock Ck Lagoon	5.60	463	7.56	23.3
Washpool Lagoon	9.91	114.9	7.50	30.0
Road crossing Lagoon	5.47	237.2	6.29	29.8
Red Rock Lagoon	7.50	262.0	7.68	29.2

4.4.3 Fish Species Composition

Fish species diversity in the Einasleigh River was very similar to the Gilbert River although composition was slightly different (Table 9). We assume that a more extensive survey would find all species common to both streams. The Bundock Creek survey site contained just two species(*) (Table 9) suggesting further sampling at different times is necessary.

Table 9. Fish Species sampled from four sites in the Einasleigh River catchment.

Common Name	Species Name
Macleay's Perchlet	*Ambassis macleayi*
Banded Grunter	*Amniataba percoides*
Lesser Salmon Catfish	*Arius graeffei*
Triangular Shield Catfish/Forktail	*Arius leptaspis*
Fly-specked Hardyhead	*Craterocephalus stercusmuscarum*
Mouth Almighty	*Glossamia aprion*
Sooty Grunter	*Hephaestus fuliginosus*
Spangled Perch*	*Leiopotherapon unicolor*
Chequered Rainbow Fish*	*Melanotaenia splendida inornata*
Bony Bream	*Nematolosa erebi*
Black Catfish	*Neosilurus ater*
Hyrtl's Tandan	*Neosilurus hyrtlii*
Sleepy Cod	*Oxyeleotris lineolatus*
Striped Sleepy Cod	*Oxyeleotris selheimi*
Leathery Grunter	*Scortum hillii*
Redclaw Crayfish	*Cherax quadricarinatus*

5.0 Potential Issues Affecting Storage Development

Due to the preliminary nature of this project, detailed information on the dams/weirs and their operation is limited. As a result, only a brief overview of issues are presented below.

5.1 Barrier to fish migration

A major consequence of the construction of storages on watercourses is the obstruction of fish passage (Mallen-Cooper, 1992). These barriers prevent fish migrations (Drinkwater and Frank, 1994), divide fish populations and stop home range movement. Such movements may be to find food sources and habitat, for social reasons such as overcrowding or predator avoidance, for spawning, or a consequence of poor environmental conditions.

Restriction of fish movement by weirs and dams has led to the disappearance of migratory species above structures in many streams throughout Australia (Mallen-Cooper, 1992). Impoundments are also thought to be the cause of decline of many obligate riverine species (Ward and Stanford, 1995).

Mitchell River

Due to its location in the catchment, the position of Pinnacle Dam may not have a significant impact on the Mitchell River fisheries resources. This conclusion is drawn from the fact that the Mitchell Falls, a short distance downstream of the Pinnacle Dam axis, acts as a natural fish barrier except in extreme wet seasons. One aquatic species that may be affected is the Mitchell Prawn, *Macrobrachium rosenbergii*. It requires an estuarine component in its life cycle and therefore needs to be able to travel unimpeded along the river. This species is capable of ascending waterfalls with a continuous water flow. However we have doubts about their ability to climb dry dam walls. At this point in time, no successful fishways exist in Australia to move fish over dam walls of this height.

Gilbert Catchment

Fish passage may be more critical in intermittent streams such as the Gilbert, Einasleigh and Copperfield Rivers. These river systems flow for a few months a year depending on the extent of the wet season. It is critical that fish move during this period for spawning and larval dispersal, and to access dry season refuges (lagoons). Both juveniles and adults then need to migrate into permanent waterholes to survive long periods of no flow. A dam or weir wall may prevent such movement. Unfortunately little data exists on the Copperfield River before and after the construction of Kidston Dam. Such information would allow us to make reasonable predictions of the effects of restricted fish movement in the Gilbert River catchment.

Being mostly a desktop study with a brief site and fish survey, we were unable to determine the location of potential fish spawning sites and critical habitat above North Head Dam. If such sites do exist, the dam would prevent fish from moving upstream to the sites, potentially causing a decline in fish abundance.

Bundock Creek Dam, due to its location within the catchment, would have little impact on fish movement. Should diversion from the Einasleigh River occur, efforts should be made to prevent large numbers of migrating fish from being inadvertently channelled into the impoundment.

Given the flow regime and high silt movement in the Gilbert catchment, the provision of fish passage would be challenging. Any fishway for the proposed infrastructure would necessarily be considered experimental and would therefore require a commitment to associated monitoring and modification if necessary.

More research into fish movement in these catchments is essential before any major instream structure is constructed.

5.2 Flow alteration

Flow is the single most important physical characteristic that influences the ecology of rivers and streams (Walker *et al*., 1995) and the biota of a river is generally well adapted to the flow regime. The Mitchell and Gilbert Rivers fish biota are adapted to the reasonably predictable low flows between May and November, and flood flows during the December to April monsoon season. The permanent alteration of this regime can detrimentally affect ecosystems, especially the composition of fish communities.

If the river channel below North Head Dam is used to distribute irrigation water, then there may eventually be a reduction in numbers of opportunistic species such as Spangled perch. Additionally, species which require lagoons (eg. Saratoga) could have fewer habitats and therefore a lower population. Conversely, if the Mitchell River was to have highly reduced flows, Sleepy cod may become dominant at the expense of running water species such as Sooty grunter. DPI Fisheries have observed this scenario in the Burdekin River after a long drought. Efforts should be made to maintain the rivers current flow regime where possible (see *5.3 Environmental flow determination*).

Should the river channel be used to release water from any of the proposed impoundments, it should not be pulsed. Pulsed flows of concern are those which rapidly alter the water depth and velocity on a daily basis. These are detrimental to fish that rely on shallow margins to reproduce. For example, rainbowfish attach eggs to vegetation in shallow water and Sooty grunter spawn in shallow rapids. Depending on the timing of the water releases, eggs laid at the height of the pulse could be high and dry once the pulse passes. In addition to this, exposed river rocks or sand absorb heat during the day and water washing over these hot surfaces can become lethal to fish. Similarly, rocks and sand exposed on a cold night can create very cold water when inundated. Additionally, continual wetting and drying of riverbanks can cause them to slump.

Very low flows may occur downstream of the impoundment while it fills each season. This can be very pronounced in both the Mitchell and Gilbert catchments due to the great river lengths. Rainfall and subsequent flooding at the top of the catchment may never reach the lower sections of river. This could reduce flood flows downstream of the impoundments and stop interconnectivity of some sections of river, affecting fish movement and spawning.

Controlling flow also affects sediment transport (Olive and Olley, 1997). Most of the proposed developments are not large enough to have a significant impact on *major floods* which are required to resuspend and transport sediment and nutrients, realign the river channel and scour out waterholes and floodplain lagoons (Petts, 1996, Walters, 1993). These flows increase productivity and enhance interconnectivity on the floodplains (Ward and Stanford, 1995). Data collected by Herbert *et al*. (1995) indicate most fish species use offstream lagoons for dry season refuges in the large Gulf river systems. Any reduction in flood events may not allow fish to access waterholes or allow trapped fish to move back into the river to complete their life cycle (Drinkwater and Frank, 1994).

A dam at Bundock Creek may only have minor impacts on the aquatic environment due to the small size of the catchment. However, flows over the spillway into Lee Creek may impact adversely on the river channel, especially if a diversion from the Einasleigh River creates high water velocities. Problems could include large-scale erosion and scouring of the river channel, loss of aquatic habitat such as weed beds, and damage to local infrastructure.

A dam at the Pinnacles on the Mitchell River, or at North Head on the Gilbert River would change flood frequency, size and intensity during smaller wet seasons. If the river channel were used to distribute water, it would also change the Gilbert River from an intermittent to a perennial stream. Should the Gilbert River become a perennial stream, fish species abundance and diversity would probably change.

Given the size of the weirs proposed for the Gilbert catchment, they are likely to have little impact on the flow regime of the river systems.

5.3 Environmental flow determination

Allocated environmental flows are usually a percentage of original flows that mimic historical flow regimes. The development of these water allocation strategies requires a detailed knowledge of the needs of the stream biota in terms of quality, timing and frequency of seasonal flows, food sources, habitat preferences, and water quality (Walters, 1993). This information is not yet available for the Gilbert and Mitchell catchments and a lengthy and detailed study would be required to obtain it. With the information available we can highlight some potential environmental flow issues in these catchments. For example:

- Irrigation demands are usually highest during the dry season when river flows are at their lowest. If water is distributed from the impoundment via the river channel, problems arise in trying to mimic historical flows. To avoid this water can be distributed through a channel or pipe system.
- Sub-surface flows are thought to occur in the Gilbert River during the dry season. These flows assist in maintaining water levels in waterholes throughout the river system and will need to be measured and included in any environmental flow calculations.
- There is some debate on how much water can be removed from a catchment while maintaining river health. The general rule of thumb is 30% of average annual flow, provided annual flood events continue to occur.
- Flooding is an important part of river health and should be considered when determining environmental flows. In the construction phase suitable outlet valves should be installed to create artificial flood events when necessary. Additionally, sufficient amounts of water need to be allocated for this purpose.
- Water quality within the dams may be different to those being experienced in the river system below. Should this dam water be released, it may have detrimental effects on fish spawning and health. Multi-level off-takes would assist in releasing water of similar quality to the river system below.

The above are just some indications of many potential problems associated with impoundments and environmental flows. Serious investigation is required should development become imminent. The upper Mitchell has been included in the Barron WAMP due to its supplementation as part of the Mareeba-Dimbulah Irrigation Scheme. Perhaps this could be extended downstream to include the proposed irrigation areas. The Gilbert River catchment has had little or no research conducted on flows and as such requires further investigation.

5.4 Loss or change in habitat

The movement of silt, sand and gravel is an integral and vital part of stream processes. Sediments supply nutrients and structure to floodplains and estuaries, reshape river channels and lagoons, and assists to scour out aquatic plant build-up.

If flow is restricted by a dam, sediment loads, which normally are resuspended and transported downstream during high flows, accumulate on the riverbed (Petts, 1996). This accumulation may lead to the loss of many downstream waterholes, a vital area of fish habitat during the dry season.

Suitable spawning sites for some species may be rare in the Gilbert catchment and any loss of these sites could have a serious impact on fish populations. Identification of critical habitat would be crucial in an environmental impact study before any construction work takes place. If rare critical spawning habitats such as a large set of rapids were to be flooded we would suggest an alternative dam site be sought or alternative water supply options considered.

Weir sites in the Gilbert, Copperfield and Einasleigh rivers would probably act as dry season refuges as long as fish can access them. The construction of North Head Dam and raising of Kidston dam would impinge on some fish habitat upstream and further investigation is necessary. Bundock Creek Dam would impact on a relatively small amount of fish habitat unless downstream flows are reduced significantly.

The Mitchell River is such an extensive system that on a catchment scale the construction of Pinnacles Dam may not have a major impact on fish habitat. However on a local level, some critical fish habitat sites may be flooded. Further investigation within the flood margin is necessary to identify such sites and predict possible impacts on the fishery.

We recognise that an artificial lake is not automatically a 'bad' ecosystem. It is frequently overlooked that reservoirs have natural and wildlife values as well (Voltz, 1995). From a fisheries viewpoint, the increased volume of permanent water, particularly upstream of the dam walls, should allow fish numbers to increase dramatically. Several new areas of habitat could be created by the inundation of the surrounding timbered and grassy plains. A similar increase in fish abundance could also occur in the supplemented stream below the dam, provided the water releases are not pulsed on a daily basis.

Pending more detailed investigations, the alteration and loss of habitat within the inundation areas should be considered as a potential, albeit small, fishery threat.

5.5 Blue-green algae potential

Blue-green algal blooms can alter the physical and chemical properties of water especially oxygen content, taste and odour. Most blooms also add toxins to the water. Water contaminated with blue-green algae that contains high concentrations of toxins pose a health risk to humans and animals following ingestion or physical contact.

Many streams and impoundments throughout Australia have been subjected to outbreaks of blue-green algae. These were particularly prominent in 1991 and again in 1995-6. There are many theories as to the exact cause of these outbreaks, but there is no doubt that reduction in flow is a major contributor. Other factors implicated are high nutrient loads (particularly of phosphorus), relatively high temperatures, calm conditions, poor mixing of the water column and long periods of stable weather patterns (Anon., 1997).

We understand that very little research has been conducted on nutrient loads in the Gulf catchment, especially in the locality of the proposed infrastructure development. While nutrient input is assumed to be fairly low, the potential for blue-green algae outbreaks should not be under-estimated. In the future, nutrient levels could be boosted from agricultural development and runoff associated with the increased water supply, both in the impoundments and in areas downstream. This, in conjunction with the prevailing hot still weather conditions in the Gulf district, makes the proposed infrastructure development sites prime areas for blue-green algae outbreaks.

An emergency treatment of blue-green algal blooms would be to flush the system. Provision for the appropriate quantities of water and the delivery system need to be factored into the design and operation of the proposed impoundment. Water should be reserved for flushing flows, and outlet works should be of suitable capacity to deliver them.

Procedures and contingency plans should be developed to minimise harmful effects of blooms and other water quality problems.

5.6 Water quality changes

Once a river is impounded there are going to be changes to water quality both within the impoundment and downstream.

With the construction of water storages for irrigation there are concerns about water quality problems associated with intensive agriculture in the Gulf Rivers catchments. Previous research has shown that irrigation areas have the potential for serious longer term water quality problems from insecticide and pesticide runoff, increased turbidity and increased salinity (Mosley, 1996). Maintaining water quality at acceptable standards in the effected river systems is vital to sustaining a healthy fishery.

Water quality within a new impoundment can vary significantly from that found previously in the river system. For instance, temperature change is less variable due to the increased water body. Additionally, during the summer months, stratification can occur with the top 3 to 4 metres of water warmer than the lower section of the dam. This inhibits mixing and causes the lower section to become de-oxygenated.

The temperature within the impoundment can also be much cooler than that in the river system below. Maximum water temperatures in the Gulf rivers can reach 35^{o}C, so an influx of cool water released from an impoundment could interrupt cues for spawning or migration of fish and kill fish larvae and eggs.

Both temperature and oxygen should be monitored with respect to water releases to ensure temperature matches the river below and oxygen levels are suitable. The fitment of a multi-level offtake for water releases can assist in releasing the most suitable quality water.

Dams can also act as sinks, collecting chemicals and heavy metals which accumulated over a long period of time. Chemicals and heavy metals may originate from current and previous mining activities within the catchment. Investigations and risk analysis into such activity may be necessary to ensure the impoundment does not become contaminated. Fish and crustaceans can bio-accumulate chemicals and heavy metals making them unfit for human consumption. Mining and farming development should be controlled within the dam catchment area.

Management of water quality within the impoundment and land use practices below can dictate water quality downstream of an impoundment. Water infrastructure developments in both the Gilbert and Mitchell catchments are to allow intensive irrigated agriculture to expand in the region. With this development comes soil tillage, pesticides, herbicides, fertiliser and tree clearing. All these have some impact on water quality and need to be carefully managed to minimise impacts.

Agriculture could lead to erosion problems in both the Gilbert and Mitchell River catchments. The soil in these areas is already experiencing erosion problems (Figure 10) and tillage of the topsoil and flood irrigation could increase this problem.

Large-scale erosion generally leads to turbidity problems in the local rivers and streams. This turbidity reduces productivity due to reduced light infiltration and a reduction in algae and aquatic macrophytes which are the primary producers for fish.

To reduce the loss of topsoil to the aquatic environment, trickle or sprinkler irrigation should be encouraged and settlement ponds constructed to catch waste water. Such ponds may also allow water reuse for either irrigation or cattle watering. Additionally, consideration of crop selection and planting times can have a positive effect on soil erosion by giving good ground coverage during the wet season runoff.

Figure 10. Erosion in potential Mitchell River irrigation area

Fertiliser run-off can also cause water quality problems. Increased nutrient in the Gilbert or Mitchell Rivers could cause algal blooms that lead to wildly fluctuating pH and low dissolved oxygen levels at sunrise. Fish have certain water quality parameters in which they can survive and any change outside these limits can cause fish kills.

To avoid fertiliser loss, application times should be planned when there is the least chance of runoff such as before the wet season storms.

Tailings and other drainage water from farms should be discharged into artificial lagoons and either recycled or left in the lagoon until water quality is within the parameters set by the Australian and New Zealand Environment and Conservation Council's water quality guidelines for fresh and marine waters (Anon., 1992). We have found fish in North Queensland will survive without detriment in water up to 36^{o}C, and oxygen levels down to 4mg/l at 8am. These values are outside the limits recommended above, but are more in line with local conditions, and could be substituted for the relevant ANZEC figures.

Salinity is a problem common to many irrigated farms in Australia and is expected to impact 12 million hectares in the next 30 years. Irrigation salinity results from an accumulation of salt in the plant root zone or on the soil surface as a result of saline groundwater rising within two metres of the ground surface or irrigation water leaching soluble salts from the soil then evaporating or transpiring (Naryan and Walker, 1999). It can take many years to become a problem but once it exists it is difficult to overcome.

Salt is already present in the soils of the Gulf of Carpentaria because it was an inland sea in recent geological history (Ridpath *et al*, 1991). The impacts of irrigation could create high soil and water tailings salinity in a short period of time making the land useless and significantly reducing water quality in the surrounding streams and rivers.

Any increase in salinity in the freshwater areas could have impacts on the fisheries resource. Many of the fish present have some salinity tolerance as adults, while others such as Saratoga have zero tolerance. It is unknown what levels of salinity local aquatic plant species, or eggs and larvae of freshwater fish species can tolerate.

To limit these long term effects a management measures will be needed to limit the flow of nutrients and pollutants entering the dam and rivers downstream. The plan should promote best practices for reducing irrigation induced salinity problems, improved irrigation methods, buffer zones to control stock access, enhancement of stormwater quality, effluent disposal alternatives, and a revision of pesticide and herbicide use.

5.7 Recreation uses

Both North Head and Pinnacle Dams and their surrounding shorelines would be potentially suitable for a wide range of recreational activities which should have little detrimental effect on the environment. As past experience has shown, impoundment fisheries are extremely popular and beneficial to the local economy.

Both impoundments would be suitable for stocking with a wide range of local fish species including Northern Saratoga, Sooty Grunter, Sleepy Cod, Longtom, Coal Grunter, Barcoo Grunter, Snub-nosed Gar, and Barramundi. Some recreational species will complete their life cycle in impounded waters, but others need access to upstream and downstream habitats. Migratory or catadromous species, such as Barramundi, may have to be regularly restocked and/or prevented from escaping.

Stocking of fish into public impoundments requires a permit under the Fisheries Act, and is undertaken in partnership between DPI and the local community. It is not undertaken unless there is support, input and the commitment of a local community stocking group. Initial and ongoing stockings will require funds to purchase fingerlings.

A successful impoundment fishery requires appropriate access and infrastructure. Consideration should be given to the requirements of impoundment fishing during the construction of any water infrastructure eg. spillway design, the option of a barrier net to prevent downstream escapement from high dams, provision of fish habitat and operation of the impoundment. DPI should be consulted on these issues.

Besides fishing, the dam can provide a suitable environment for recreation such as bush walking, picnicking, canoeing, sailing, and water skiing. These activities would have limited detrimental effect on the environment but could be affected by the presence of crocodiles.

6.0 Conclusions

The Pinnacles Dam as proposed would probably have negligible impact on freshwater fisheries in the Mitchell River as a catchment providing suitable environmental flows are maintained and flood events continue to occur. There is potential for some localised impacts on recreational species, however further investigation is necessary to quantify them. Blue-green algae potential should be further investigated, as should the saline potential of soils in the proposed irrigation area.

Within the Gilbert River catchment there are concerns about fish passage with Weir development and further investigations are needed into fish habitat above the North Head Dam site. Kidston Dam already prevents fish movement but raising of the dam wall could reduce flood events which may impact on the fishery in the long term. Environmental flows in this catchment are also an issue as high volumes of water may flow under the bed sands which assists in maintaining instream waterholes during the dry season. These flows need to be measured and factored into environmental flow calculations. Irrigation of soils in this area may cause salinity problems which could impact on the fishery, and further research into this possibility is necessary. Bundock Creek Dam probably poses the least threat to the fishery in this catchment, provided any diversions from the Einasleigh River do not become excessive or channel migrating fish into the impoundment. There are concerns about spillway flows damaging Lee Creek.

Continued monitoring of fish stocks is recommended for the entire length of river systems potentially affected by water infrastructure development, including before, during and after any works. The information gained from the data collected would be a future reference source for other developments and provide an insight to potential impacts.

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