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ESTUARINE CROCODILE (*Crocodylus porosus*) NESTING AND SURVEY DATA. ORD RIVER AND NORTH KIMBERLEY REGIONS FROM JANUARY 1989 -

Gordon Wyre
Manager Wildlife Branch

C.Done
Regional Manager
Kimberley

Results of a Helicopter Survey to determine Estuarine Crocodile (*Crocodylus porosus****) Nesting on the Ord River - East Kimberley - December 1995.***

Introduction

Prior to the 1988/1989 wet season, information on *Crocodylus porosus* nesting was limited to anecdotal accounts, hatchling sightings and nesting habitat descriptions recorded during population surveys (Burbidge and Messel 1979; Messel et al. 1987).

Over the ensuing years surveys specifically to locate evidence of nesting activity have been undertaken to determine activity and provide some information on recruitment to the Ord River *C.porosus* population.

In January 1989, helicopter and boat surveys undertaken by Wildlife Management International Pty.Limited and CALM confirmed the presence of *C.porosus* nesting on the Ord River. A total of 6 nests were located during this survey.

Follow up surveys have been undertaken on a yearly basis (except for 1994/1995 wet season) however no significant nesting has been recorded since the 1989 results.

Survey months have varied since 1989 and it is likely that this has been a factor in nest sightability. Previous years surveys have been based on activity in the Northern Territory as well as anecdotal and other CALM surveys which have implied that nesting occurs in the Kimberley much later than the Northern Territory.

Background Information

Crocodylus porosus lay hard shelled eggs in vegetation and soil raked up into a mound by the gravid females. Nests are usually constructed on the banks of tidal rivers, in freshwater areas associated with those rivers such as floodplain billabongs and in the case of the Ord River nesting has been recorded upstream of the tidal influence in permanent freshwater areas resulting from the outflow of water from the Lake Kununurra Diversion Dam. The common denominator for all nesting appears to be the requirement for permanent water where the female crocodile can live throughout the year. There is also a requirement for freshwater which during the nesting season is often provided by rainfall On the Ord River the length of the nesting season appears to be directly influenced by the amount of early season rain, associated thunder storm activity and the occurrence of flooding during the latter part of the wet season.

Itinerary

As in past years this survey was concentrated on the Ord River and was conducted on December 15, 1995. Previous surveys have taken place between January and April in response to wet season activity.

Methods

The same spotter (R.Gueho) used for previous surveys in 1992, 1993 and 1994 undertook this survey to ensure consistency.
The December 1995 survey used a Kawasaki 3 seat helicopter flown at approximately 30 - 40 knots at varying heights up to 20 metres above ground level.

In previous surveys it has been possible to overfly stands of *Acacia farnesiana* and *Sesbania formosa* to look through the canopy and also look obliquely under the canopy. Heavy vegetation growth, particularly of *Phragmites karka* and *Typha domingensis*, probably due to above average rainfall during the previous years precluded successful observations being made and resulted in the likelihood of nests being missed.

All nests located on the Ord River were opened to check for eggs. If eggs were present, a ZEAL N2 Filled thermometer was positioned amongst them (2-3 eggs deep), and the eggs were recovered until the temperature stabilised. Temperatures recorded in this fashion can provide an index of the general thermal conditions that the eggs are experiencing.

After the temperature had been recorded, all eggs were removed from the nest and marked with a pencil to ensure that they would be returned to the nest with the same orientation. Several eggs from each clutch were also measured to determine widths and lengths. Given the uniform size of eggs within a clutch, such a sample is adequate to characterise the clutch.

The outside appearance of each egg, particularly the extent and nature of the opaque band, was used as a guide to embryo age and condition. All clutches were well developed in the 7 - 40 day stage and given the state of decay of nest vegetation it is estimated that the eggs were between 2 and 3 weeks of age. All eggs in all nests appeared fertile and the opaque band development was similar.

All eggs were returned to the nests and the nest mounds restored to their previous condition before leaving.

GPS readings for each nest located were taken using a helicopter mounted Trimble* Transpak II*.

All reference locations refer to the 1:100000 topographic series and cover Kununurra sheet 4666, Erskine 4566 and Wyndham 4567. The two letters **DH** refer to the 100000 metre square identification and the following six numbers in bold refer to the vertical (e.g **652**) and horizontal (e.g. **793**) references

Area Surveyed

On December 15,1995, a helicopter survey was conducted over the Ord River from Terarra Bar (**DH652793**) and proceeded downstream following the western bank to the commencement of the mangal communities at location **260-882** near Green Island. The survey recommenced on the eastern bank and proceeded upstream to the start point. No offshoot creeks, freshwater billabongs or floodplain areas were surveyed due to resource constraints.

Results and Discussion

Three active and one false *C.porosus* nests were located during the survey. The survey commenced at 0630am and weather conditions were overcast, intermittent rain and a light northerly wind of approximately 5 knots. Ambient temperature ranged from 29*C* at commencement to 38*C* at completion at 1100am.

Nest #1: Located at **361-842** on the west bank of the Ord River downstream from Mattress Island. This was a large nest constructed from mainly Narrowleaf Cumbungi (*Typha domingensis*) which contained 43 well developed eggs. Average egg size was estimated at 75mm in length and 48mm in width. Nest temperature was 31*C* Female crocodile in attendance estimated at 6'-7'TL.

Nest #2: Located at **291-865** on the east bank of the Ord River. This was a large nest constructed from Narrowleaf Cumbungi (*Typha domingensis*) which contained 48 eggs. All were well developed. Average egg size was estimated at 74mm in length and 46mm in width. Nest temperature was recorded as 33*C.*
Female crocodile in attendance estimated at 7'-8'TL.

Nest #3: Located **343-821** on the east bank of the Ord River. Again this was a large nest constructed of Narrowleaf Cumbungi (*Typha domingensis*) which contained 53 eggs. All were in good condition and the opaque band was well developed. Average egg size was estimated at 74mm in length and 48mm in width with the nest temperature recorded at 29*C*
Female crocodile in attendance estimated at 7'-8'TL.

A false nest was located at **323-843** on the east bank of the Ord River. This nest was unopened due to time and resource constraints.

To provide an accurate assessment of the age of the eggs in each clutch there is a requirement to collect several eggs from the individual nests and inspect the developing embryos. This type of collection was outside the purview of this survey and consequently an estimation of age has been given. In all cases the opaque band was well developed on all eggs and was within the 7-40 day stage. Estimations were made on the state of decay of the vegetation (*Typha)* used to construct the nests and this is given at 2 to 3 weeks.
All nests had female estuarine crocodiles in attendance and these were scared from the nest using the helicopter and when on the ground by using a long oar.

On average the nests appeared to be quite large in my experience and these nests are the first recorded in surveys on the Ord River as being constructed of *T. domingensis.* In past years nest material has consisted of Noogoora Burr (*Xanthium*

occidentale) and *Ludwigia spp.* All nests sighted were fully exposed with no shading vegetation being used to offset extremes of temperature. The average distance of the nests from the waters edge was about 4 metres and wallows had been constructed adjacent to the nests.

Cattle damage was quite evident on both banks of the river and reference has been made on many occasions to the effect on crocodile nesting that is attributable to cattle.

Because nesting effort varies annually, the extent of nesting along the Ord River should be interpreted cautiously. Elsewhere in the Kimberley and the Northern Territory nesting fluctuates in response to a number of factors including rainfall, availability of habitat and presence of disturbance such as cattle.

Survey Costs

Helicopter Hire - Kawasaki @ $375.00 per hour for 3.1 hours - $1162.50.
Sundry equipment - $40.00

Dave Grosse also assisted with the survey by navigating and keeping agressive female crocodiles away from the nest while egg counts and other work was carried out.
It should be pointed out that to conduct this type of survey most effectively requires a commitment of resources that unfortunately is unavailable.

The assistance of CALMs Wildlife Branch is appreciated in contributing towards the survey costs.

R.Gueho
District Wildlife Officer
East Kimberley
December 20,1995

Attachments

Maps showing locations of nests found during this survey

References

G.Webb Pty.Limited; Final report; Saltwater Crocodile (*Crocodylus porosus*) Nesting in the North East Kimberley Region of Western Australia(1988/89 Season) 22 May 1989

C.Done: Estuarine Crocodile Nesting - Ord River CALM internal report March 13, 1991

R.Gueho: Estuarine crocodile nesting - Ord River CALM Internal report January 31, 1992.

R.Gueho: Saltwater Crocodile (*Crocodylus porosus*) nesting on the Ord River - East Kimberley, 1993 CALM Internal Report

R.Gueho: Estuarine Crocodile (*Crocodylus porosus*) nesting on the Ord River - east Kimberley 1994.

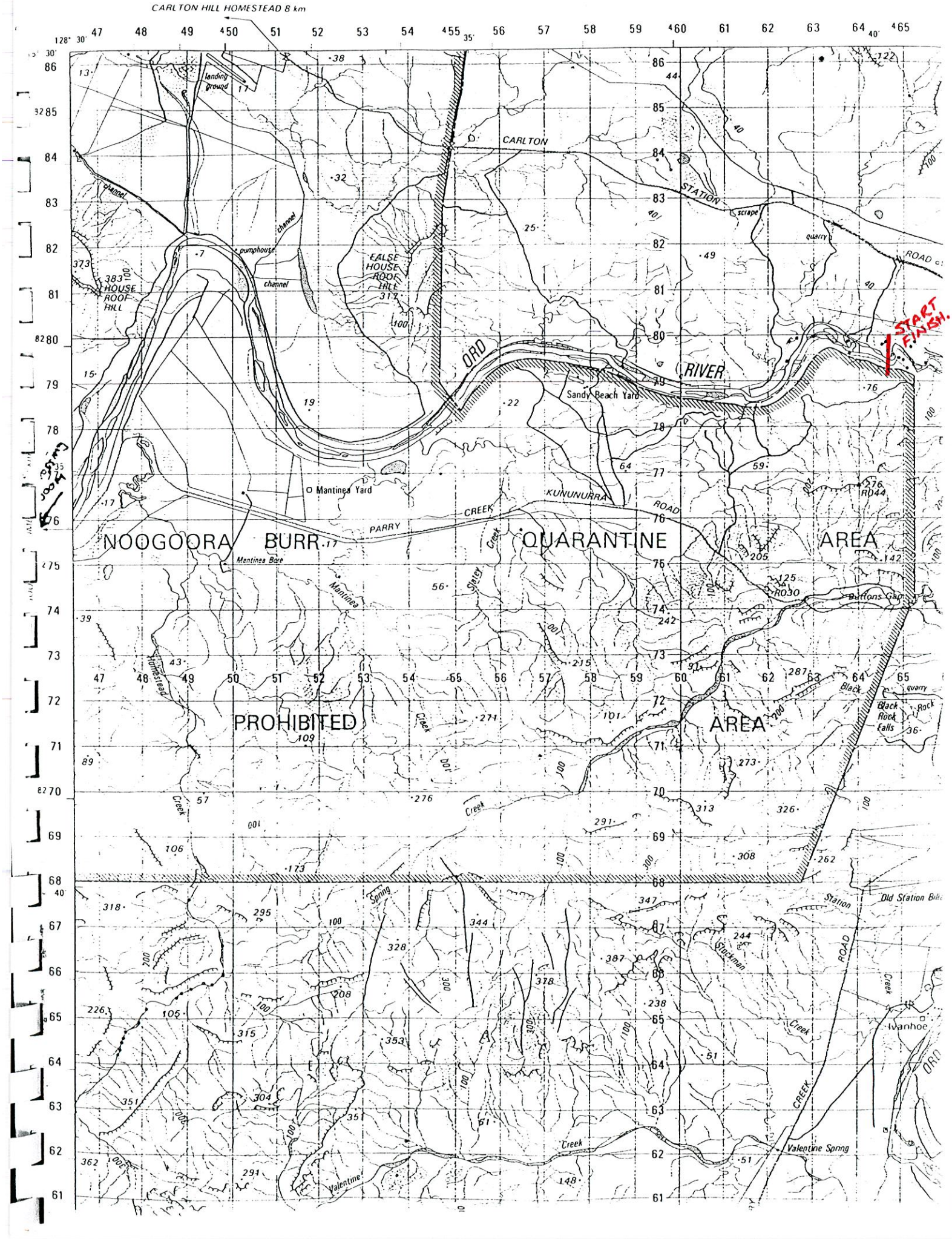
GJW Webb, SC Manolis, KE Dempsey, PJ Whitehead: Crocodilian Eggs: A Functional Overview Chapter 43, Wildlife Management Crocodiles and Alligators. Surrey Beatty and Sons ISBN-)949 324 094. 1987

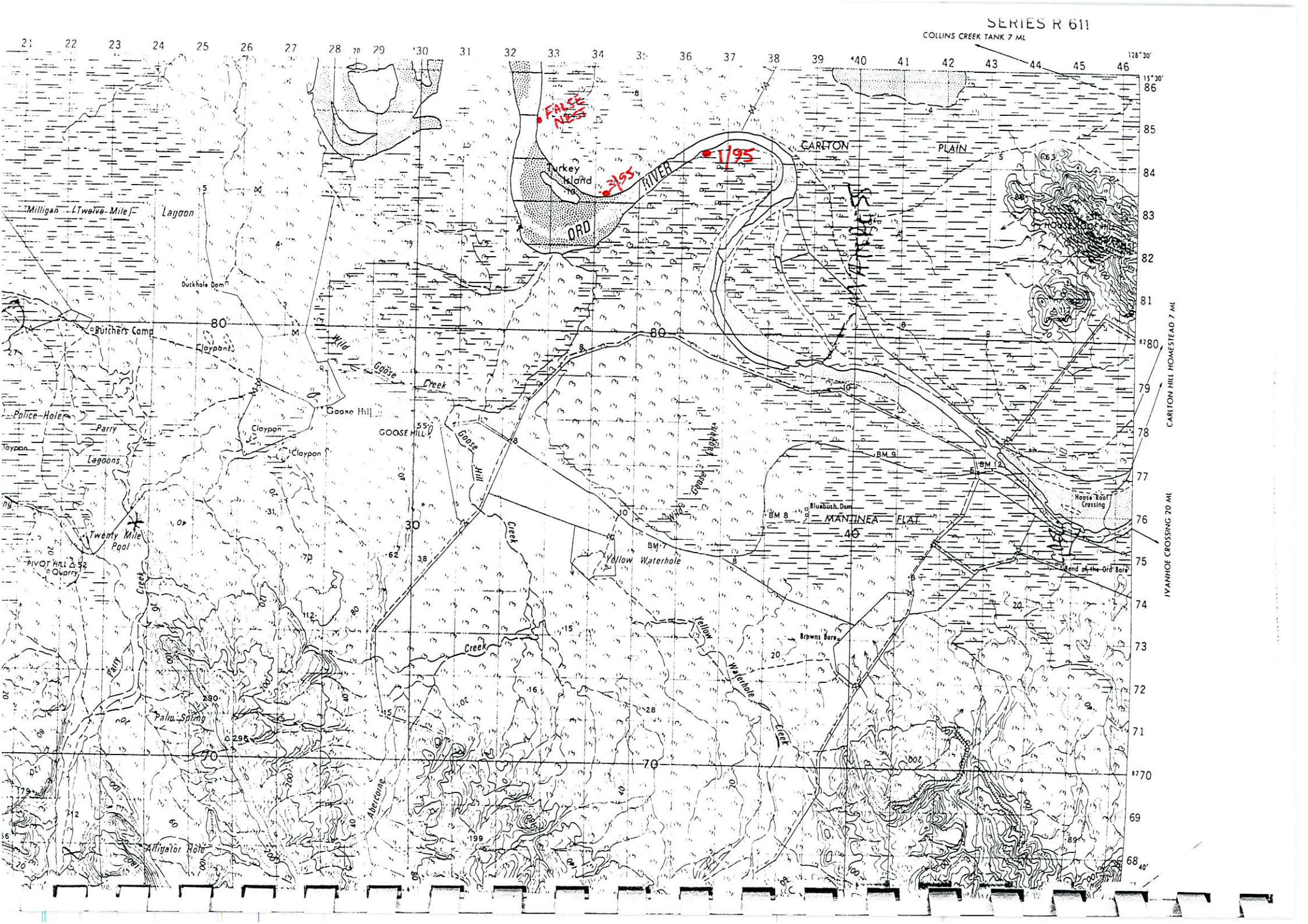
Messel H, Burbidge AA, Vorlicek GC, Wells AG, Green WJ, Onley IC and Fuller PJ: 1987 Surveys of Tidal Waterways in Kimberley Region, WA and their Crocodile populations. Monograph 20, Tidal waterways of the Kimberley surveyed during 1977, 1978 and 1986. Pergamon Press: Sydney.

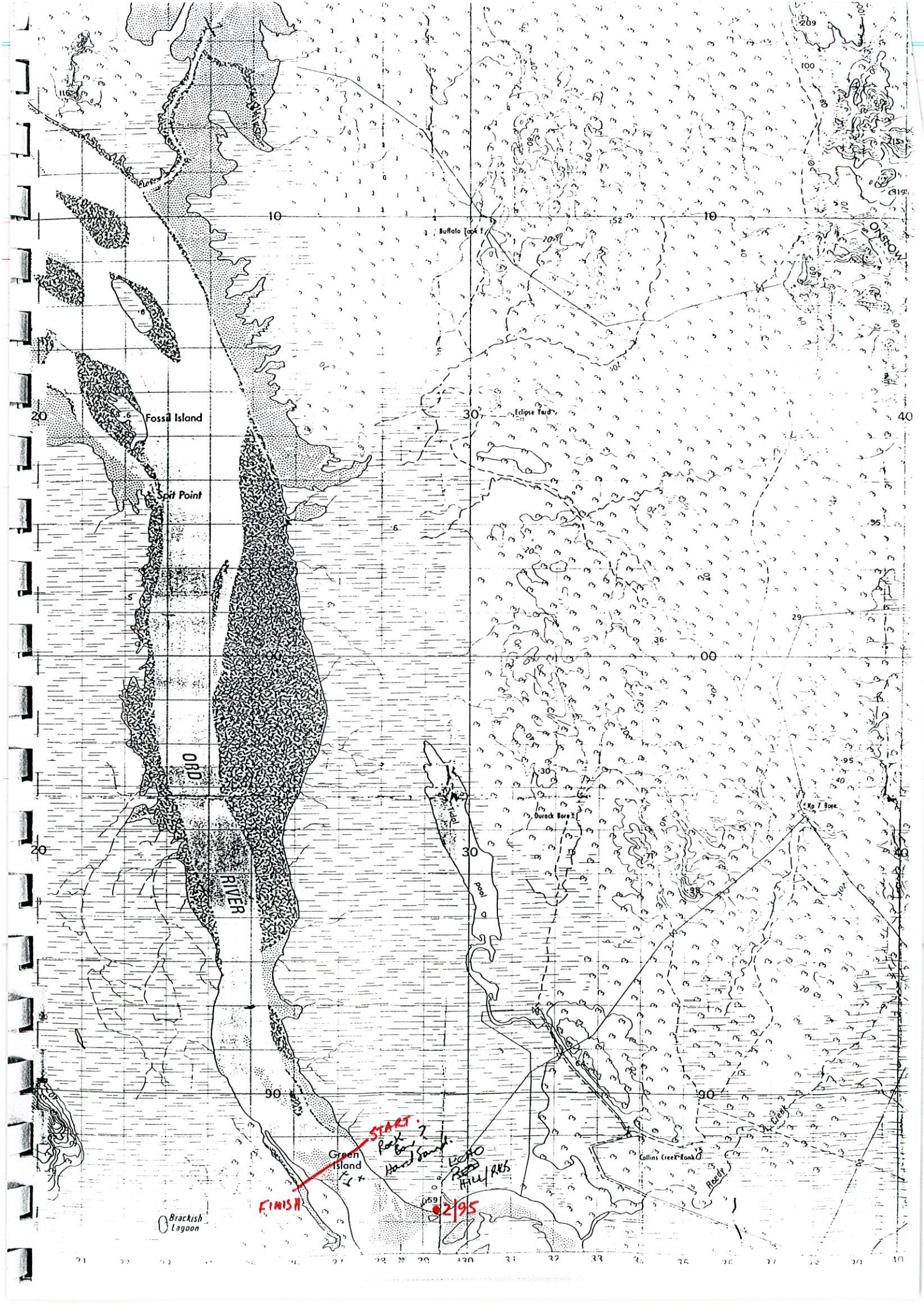
O.H.M.S.

ATTACHMENTS.
MAPS OF SURVEY AREA + NEST SITES

AUSTRALIA 1:100 000
TOPOGRAPHIC SURVEY




SERIES R 611
COLLINS CREEK TANK 7 ML
CARLTON PLAIN
Turkey Island
ORD RIVER
Milligan (Twelve Mile) Lagoon
Duckhole Dam
Butchers Camp
Claypans
Wild Goose Creek
Goose Hill
GOOSE HILL
Police Hole
Parry Lagoons
Claypan
Twenty Mile Pool
PIVOT HILL
Quarry
Parry Creek
Palm Spring
Alligator Hole
Abercoine
Yellow Waterhole
Yellow Waterhole Creek
Browns Bore
Bluebush Dam
MANJINEA FLAT
Wild Goose Hill
BM 9
BM 12
BM 8
BM 7
Hoose Roof Crossing
Legend of the Ord Bore
CARLTON HILL HOMESTEAD 7 ML
IVANHOE CROSSING 20 ML


Fossil Island
Spit Point
ORD
RIVER
Buffalo Took 1
Eclipse Yard
Durack Bore 2
Kp 7 Bore
Green Island
Brackish Lagoon
Collins Creek
START
FINISH
12/95

K.MCNAMARA
DIRECTOR
NATURE CONSERVATION DIVISION

ESTUARINE CROCODILE (Crocodylus porosus) NESTING ON THE ORD RIVER - - EAST KIMBERLEY, 1994

INTRODUCTION

In 1989, helicopter and boat surveys undertaken by Brett Ottley (G. Webb Pty Ltd) and M.Osborn (ex CALM) confirmed the presence of C. porosus nesting on the Ord River. A total of 6 nests were located during this survey.

Follow up surveys have been undertaken on a yearly basis.

No significant nesting has been recorded since the 1989 results.

The survey area is recognised as providing conditions suitable for C. porosus nesting and indeed this " wet " season for all intents and purposes has appeared to be suitable for C. porosus nesting to occur.

Typical " wet " season thunderstorm activity occurred as early as November 1993 and has affected the areas where most nesting has occurred in the past. January 1994 had below average rainfall followed with an above average February rainfall which may have resulted in flooding of any late nests.

ITINERARY

A helicopter survey of the Ord River was undertaken on 24/02/1994. The survey incorporated areas surveyed in previous years (1989 - 1993) and extended the downstream area by approximately 10 kilometres (both banks) to include areas of reserve **31967**.

METHOD

The same spotter (R. Gueho) used for the previous two years undertook this survey to ensure consistency.
The 1994 survey used a Robinson R22 helicopter flown at approximately 50' above ground level at a speed between 30 - 40 knots.
Where stands of Acacia (A.farnesiana?) and Sesbania were encountered, the area was first overflown looking directly through the canopy and then observations were made whilst flying below canopy height and looking obliquely under the canopy.

Map references refer to the 1:100000 topographic series and cover Kununurra Sheet 4666, Erskine 4566 and Wyndham 4567.
The two letters **DH** refer to the 100000 metre square identification and the following six numbers refer to the vertical (**e.g 652**) and horizontal (**e.g 793**) references.

AREAS SURVEYED

The survey commenced from a local feature on the Ord River known as Tarrara Bar **DH652793** and proceeded downstream to Spit Point **DH 229036** on the west bank of the Ord River. The survey proceeded to the eastern bank at **DH 259030** then upstream including Collins Creek and part of Reedy Creek eventually to the start point at Tarrara Bar.

RESULTS AND DISCUSSION

One active C.porosus nest was located on the Ord River at **15 32' 18" latitude, 128 22' 35" longitude** (from GPS unit)
(approx. **DH349829**).
This nest was inspected and found to be constructed of soil, sticks and some grasses (**Sorghum sp**). It was located very close to the waters edge under a Sesbania tree (**S.formosa**) and appeared in danger of inundation as the river was rising due to recent heavy rain.
The nest was opened to determine its age and 33 eggs recorded. One hatchling had emerged and died - possibly due to compaction of the nest owing to the materials it was constructed from.
As the eggs were returned to the nest they commenced hatching. This nest was located approximately 500 metres upstream of Goose Hill Creek (the boundary of **Reserve 31976**).
The survey continued downstream and 3 hatchlings were observed in the water at **DH315868** immediately adjacent to a large C.porosus of approximately 15' - 16' in length.

No other active or old nests were located during the survey.

Several slides and wallows were investigated on the eastern bank in the vicinity of Turkey Island, **DH 331831**, however no nests or nesting activity was observed.

As for 1993, several areas were inundated, particularly between Green Island **DH 265881** and Spit Point **DH 229036** where large volumes of fresh water runoff was observed.

The presence of cattle was again evident and approximately 20 animals were seen in Reserve 31976 on the eastern bank. Reference has been made on many occasions to the effects on C.porosus nesting that is attributable to cattle.

The Region has been active in negotiations with the owners of Carlton Hill station in relation to the presence of these cattle on the Nature Reserve and these discussions are continuing with a view to removing the animals from the Reserve.

The nest mentioned above was aged at approximately 3 months and it is possible that other nesting occurred prior to the river level rising and these are now inundated and unobservable.

Of note is the presence of large stands of a tall broad leafed grass (**Phragmites karka**) replacing areas of Narrowleaf Cumbungi (**Typha domingensis**) which were flooded in 1993.
P.karka is used extensively by crocodiles as nesting material on the Roe and Prince Regent River systems in the north west Kimberley and in past years these areas have had good nesting results.(Final Report: Saltwater Crocodile (Crocodylus porosus) Nesting in the North - East Kimberley Region of Western Australia (1988/89 Season) (22nd May 1989) G.Webb Pty Limited). (Results of a Helicopter Survey - Roe River 3/4/1990. R.Gueho CALM Report.)

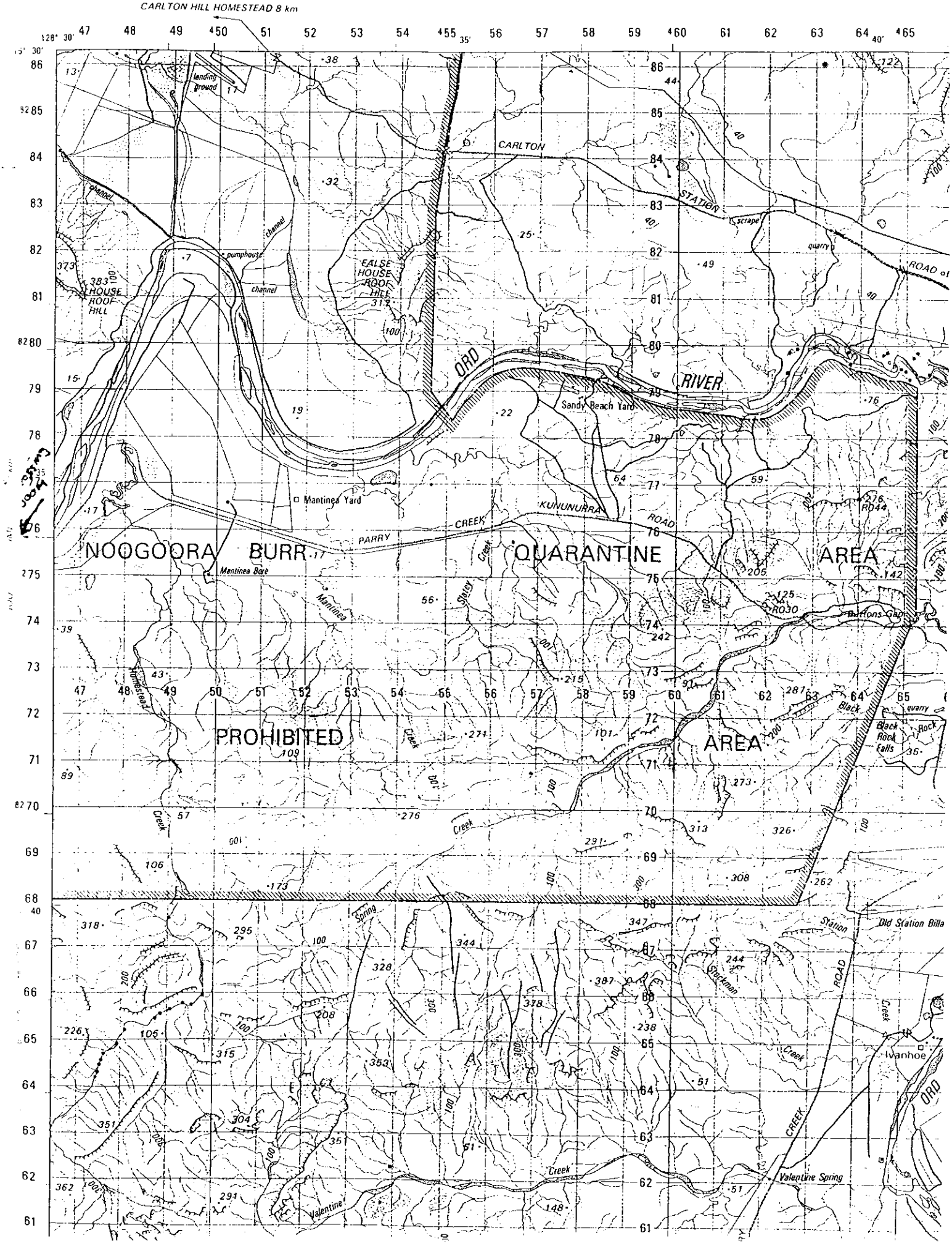
In previous years the nesting survey has been carried out following historical activity from the Northern Territory. Generally, nesting is believed to occur later in the Kimberley as the monsoon forms over Northern Australia.
It would be pertinent to hold another survey in December 1994 (depending upon thunderstorm and rainfall activity) to observe any early nesting prior to the monsoon breaking.

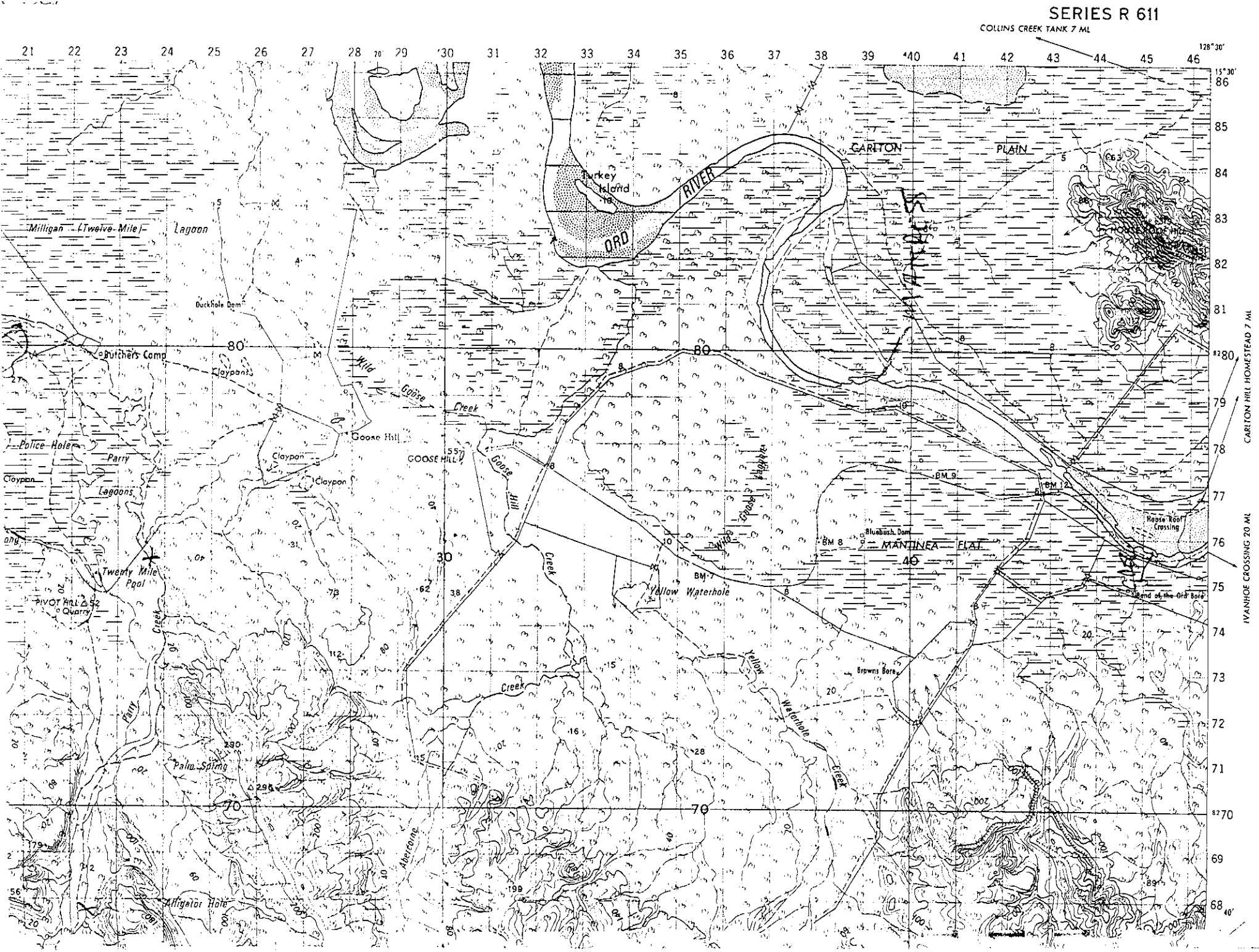
Attached for your information are maps identifying the survey areas.

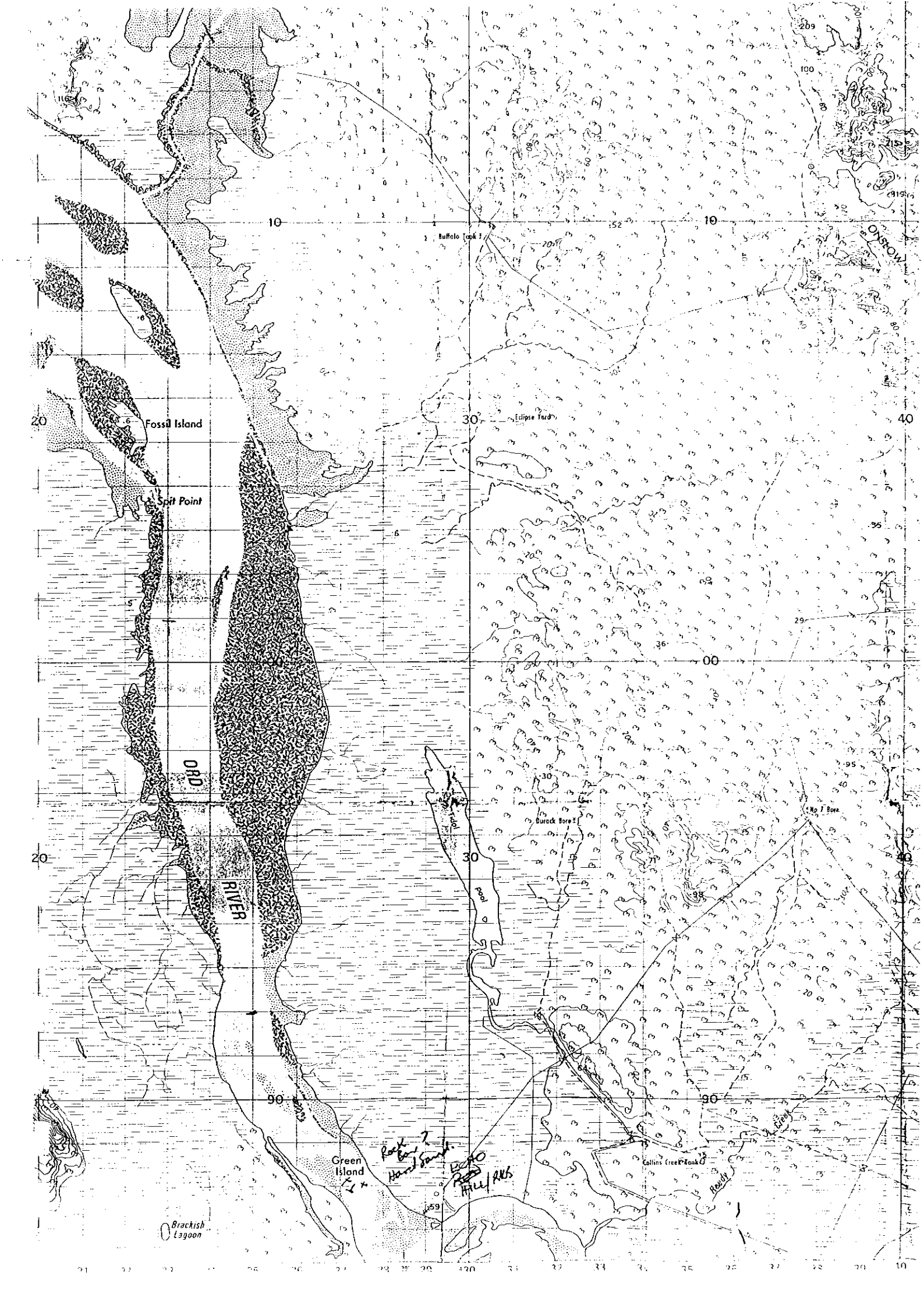
For your information

R.GUEHO
DISTRICT WILDLIFE OFFICER
EAST KIMBERLEY
01/03/1994

AUSTRALIA 1:100 000
TOPOGRAPHIC SURVEY




SERIES R 611
COLLINS CREEK TANK 7 ML
128°30'
15°30'
CARLTON
PLAIN
Turkey Island
ORD
RIVER
Milligan (Twelve Mile) Lagoon
Duckhole Dam
Butchers Camp
Claypans
Wild Goose Creek
Goose Hill
GOOSE HILL
Police Hole
Parry Lagoons
Claypan
Twenty Mile Pool
PIVOT HILL
Quarry
Parry Creek
Palm Spring
Alligator Hole
Abercorn
Goose Hill Creek
Wild Goose Creek
BM 9
BM 8
BM 7
MANTINEA FLAT
Bluebush Dam
Yellow Waterhole
Yellow Waterhole Creek
Browns Bore
Stand of the Old Bore
Roose Roof Crossing
CARLTON HILL HOMESTEAD 7 ML
IVANHOE CROSSING 20 ML


Fossil Island
Spit Point
ORD
RIVER
Buffalo Tank
Eclipse Yard
ONSLOW
Durack Bore
No 1 Bore
Collins Creek Tank
Green Island
Brackish Lagoon
pool

156.1.1.

Noted Dave. 8/6

SURVEY REPORT

Saltwater Crocodile (Crocodylus porosus) nesting on the Ord River - East Kimberley, 1993.

Introduction

Prior to the 1988/89 wet season, information on the nesting of C.porosus along the Ord River was anecdotal (pers. comm M.Osborn, M.Douglas).

Hatchlings were sighted and nesting habitat descriptions were recorded during population surveys (Burbidge & Messel 1979; Messel et al 1987) (Pers. comms M.Osborn). Helicopter and boat surveys of the area were undertaken by Brett Ottley in January 1989 at which time 6 nests were located.

Follow up surveys have been undertaken on a yearly basis since this initial survey, however no significant nesting has been recorded. (Done 1991; Gueho 1992).

Background Information

The manner in which C.porosus construct their nest mounds and the type and quantity of eggs laid has been discussed at length in reports and literature generally available and therefore it is not necessary to repeat this description.

The one common denominator in successful nesting appears to be the necessity for access to some permanent fresh water. This can be obtained by rain filling the wallow adjacent to the nest or natural availability through normal river flow.
Obviously the species needs an aquatic habitat in which it can hunt & live throughout the year.

Itinerary

Two helicopter surveys were undertaken over the Ord River on the 2/4/93 (1.2 hrs) and 7/4/93 (1.8 hrs). The survey incorporated areas surveyed in previous years and extended the downstream area by some 6 km (both banks).

Method

Various spotters have been used since 1989 and the survey procedures have varied slightly, however this survey and the 1992 survey were undertaken by the same spotter (R.Gueho) and it is envisaged that this spotter will be used in the future for consistency.

In previous years a Bell 47 Helicopter has been used to incorporate a navigator into the exercise. The 1993 survey used a Robinson R22 helicopter as it was not considered a necessary requirement for a navigator to be in attendance in this survey area.

Map references refer to the 1:100 000 series (e.g. Ref. 4566-DH458758) where the first four numbers denote the map sheet reference, the two letters (e.g. DH) refer to the 100 000 metre square identification and the following six numbers refer to the vertical (e.g. 458) and horizontal (e.g. 758) references.

Areas surveyed

On the 2/4/93, a helicopter survey was conducted over the Ord River taking in the areas from grid reference 4566 DH 290 840 - 4567 DH 253 891 on the southern bank and grid reference 4566 DH 300 876 to 4567 DH 274 890 on the northern bank.
On 7/4/93 a follow up survey took place commencing on the north bank at House Roof Crossing 4566 DH 458 758 downstream to 4567 DH 300 876 incorporating Collins Creek and part of Reedy Creek. The survey continued on the northern bank from grid reference 4567 DH 274 890 to 4567 DH 260 939.

The survey proceeded to the southern bank and commenced upstream from grid reference 4567 DH 242 930 to 4567 DH 253 891. The survey was recommenced at 4566 DH 290 840 and proceeded upstream taking in Goose Hill Creek to kilometre 5. The survey returned to the Goose Hill Creek - Ord River junction and continued upstream to grid reference 4566 DH 385 794.

The purpose of this relatively late survey was to locate any late nests and to determine to what extent nesting had occurred.

Results and Discussion

No active or old saltwater crocodile nests were located in the area of the Ord River surveyed. An attempt was made to locate the nest sites identified by grid reference in Webbs report of 22 May 1989.
This was unsuccessful for two main reasons.
Several of the areas were inundated, and cattle numbers in the survey area were substantial. Numerous cattle pads have been developed through the preferred nesting vegetation and the concentration of these animals has no doubt contributed to the lack of nesting observed.
In previous years, all nests located have been found in beds of an introduced burr (Xanthium occidentale, Noogoora Burr). This use has been identified as a possible reaction to the continual degradation of indigenous vegetation which has been predominantly used for nesting.

Apart from the obvious problems associated with cattle (reported previously) the (in my view) atypical wet season experienced in the east Kimberley in 1992/93 which resulted in extensive flooding along most parts of the Ord River no doubt either destroyed any early nests, or

more likely, simply made it too difficult for the crocodiles to successfully nest.

The Ord River is still flowing at about 1 metre above its "normal" level and this combined with spring tides increases the areas prone to flooding.

Discussion in Webbs report and previous CALM advice refers to the lack of suitable nesting habitat where the average annual rainfall does not exceed 1200 mm in Northern Australia.
The Kimberley Region is one of these areas and it is probably a fact of life that nesting will always be minimal.
Conversation with Brett Ottley of Webb & Co. P/L has revealed a belief that nesting activity levels appear to be cyclical and given the fact that nesting has been down throughout the NT it is possible the atypical nature of the season has also affected at least the East Kimberley.

It is not known to what extent harvesting of mature and sometimes gravid female C.porosus (under license) from the area upstream of Goose Hill Creek may have affected the nesting effort, however, it is probably appropriate that in the future - harvesting should not occur between November and March of any season.

The last paragraph in the general discussion section of Webbs May 1989 Nesting report is still considered pertinent and it should be read in conjunction with this report. (Attached) Also attached are copies of 1991 & 1992 survey reports by CALM staff and maps identifying the survey area.
If the Ord is spotlight surveyed this year the location of any hatchlings should be recorded for follow up when nest surveys are conducted in the 93/94 season.

R.Gueho
District Wildlife Officer
East Kimberley
7/4/1993

References:

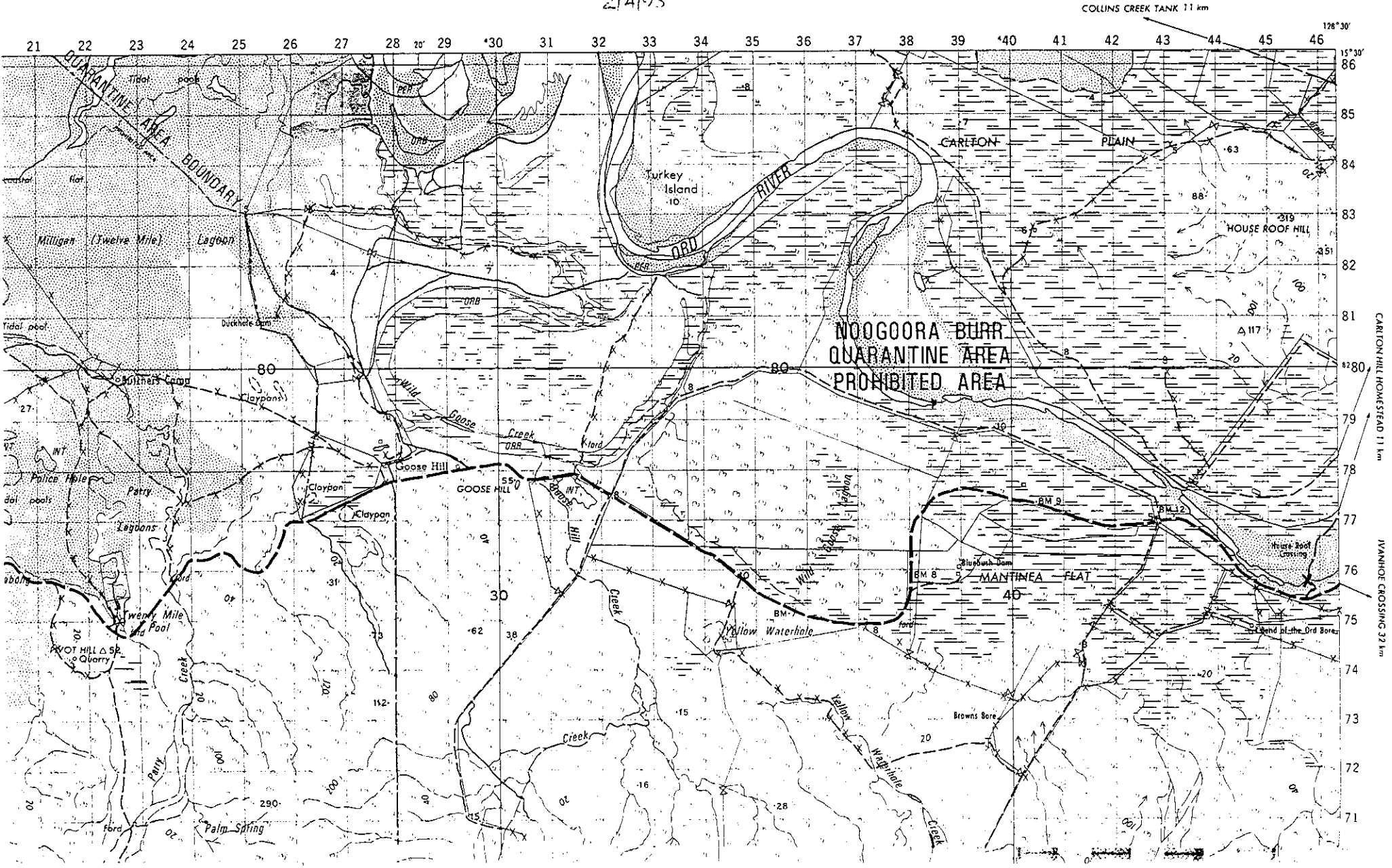
Messel H, Burbidge AA, Vorlicek G C, Wells A G, Green W J, Onley I C and Fuller P J 1987 Surveys of Tidal Waterways in Kimberley Region, WA and their crocodile populations. Monograph No 20, Tidal Waterways of the Kimberley surveyed during 1977, 1978 and 1986.
Pergamon Press: Sydney

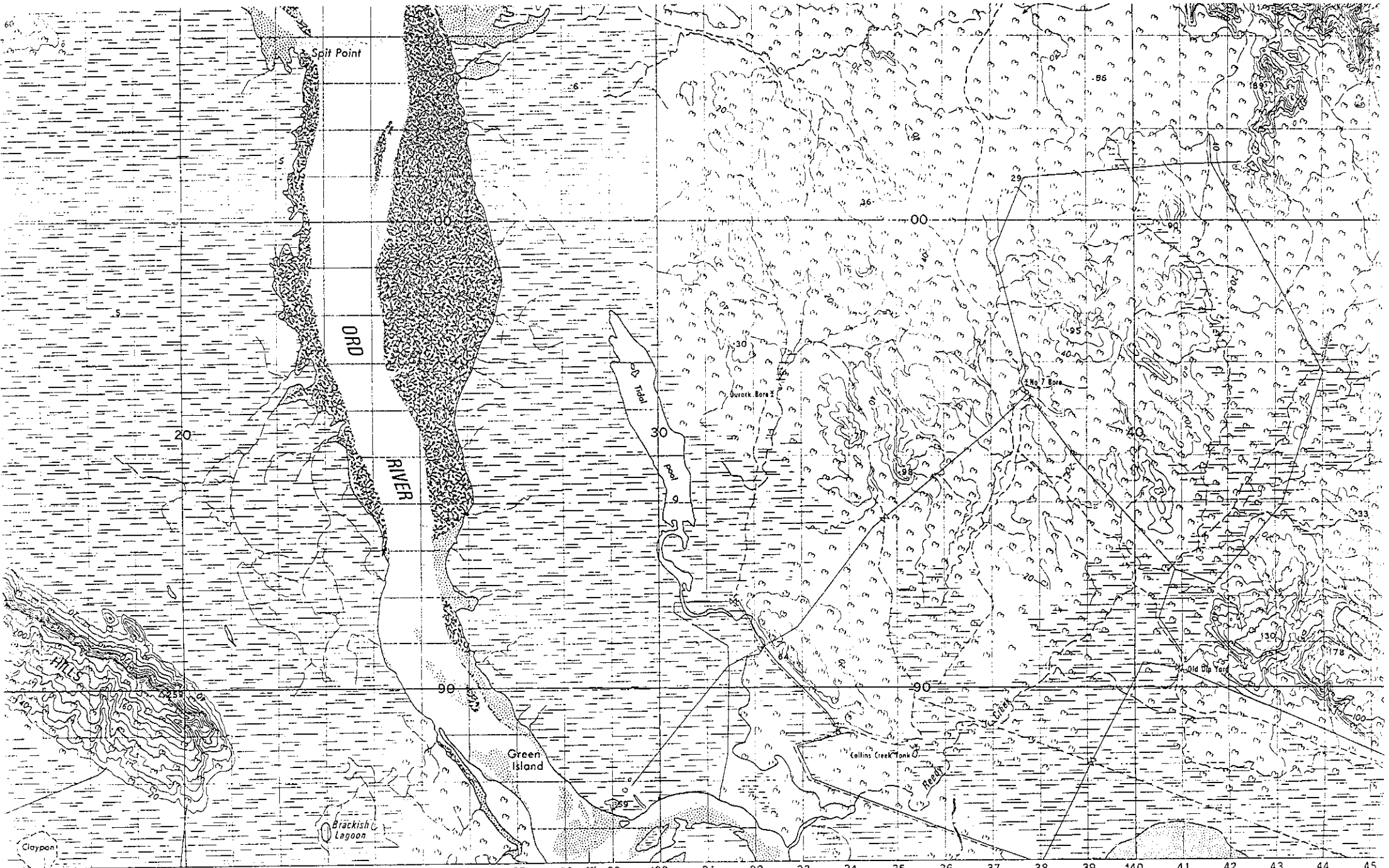
Final Report: Saltwater Crocodile (Crocodylus porosus) Nesting in the North East Kimberley Region of Western Australia (1988/89 Season) (22 May 1989) G.Webb Pty Ltd.

NE

7/4/93
2/4/93

REVISION OVERPRINT 1989
REFER TO THIS MAP AS: SHEET 4566 (EDITION 2)
SERIES R611





SCALE 1:100,000

2 4 6 8 Miles

21/4/93

7/4/93

CONTOUR INTERVAL 20 METRES
ELEVATIONS IN METRES
VERTICAL DATUM: MEAN SEA LEVEL

AHQ//

...y may simply offer no deep water refuge at low tide, such that ...es avoid them.

...Cambridge Gulf and the Prince Regent River, the most suitable and ...ve nesting habitat was found in the Roe and Prince Regent Rivers. ...e the majority of Kimberley rivers, these have well-developed grassy ...ks composed of thick stands of tall broad-leafed grasses (eg. Pragmites ...cka, Sorghum sp., Cenchrus elymoides).

Nests were found in areas where large numbers of hatchlings or small crocodiles (2-4ft) were sighted during spotlight surveys (Messel et al. 1987). Although small numbers of hatchlings were sighted in the Hunter, Lawley and Mitchell Rivers, no significant nesting habitat was recorded there. It appears that some nests are indeed made in such areas, but in small numbers, possibly in atypical habitats. Nesting in such areas may also be strongly dependent on season, as heavy rains during the late dry season may be needed to stimulate sufficient vegetation growth, for nesting later in the season.

Other areas west of the Prince Regent River may prove to contain suitable nesting habitat. Although not surveyed in this study, large numbers of hatchlings were recorded during spotlight counts in the Glenelg River (Burbidge and Messel 1979; Messel et al. 1987), which is not in a conservation reserve. It would seem highly likely that significant numbers of nests occur there, such that it is one of the only sites outside the Ord and King Rivers where eggs could be available for commercial harvesting.

To identify further nesting areas in Cambridge Gulf, it would seem beneficial to conduct spotlight surveys during the early dry season, to locate as many hatchling creches as possible. [Hatchling creches tend to remain near nests for a few months (Webb et al. 1977)].

Because nesting effort varies annually, the extent of nesting in the North-East Kimberley in the 1988/1989 season needs to be interpreted cautiously. In the Northern Territory nest numbers fluctuate greatly from year to year: for example in 1987/1988 12 nests were located in Melacca Swamp, whereas in 1988/1989 27 nests were found in the same area. In both the Northern Territory and Queensland this season (1988/1989) was considered "good", with above average numbers of nests, and the same may be true of the Kimberley. In contrast, if rainfall in the Kimberley was restricted this year, as some claim, nesting may well have been constrained.

Chris) to make pls.
Gordon J

FAX

K. McN.

Gone.

MANAGER
WILDLIFE BRANCH
ATTN: K.McNAMARA

F.Y. Action p/s
2 pages.
24/2.

156.1.6.1-SURVEY
R.GUEHO
091 680 205

Estuarine Crocodile Nesting - Ord River

A helicopter survey of the Ord River was carried out on the 30th January 1992 to assess the nesting activity of Crocodylus porosus.

The Survey commenced at House Roof Crossing (Map Ref. 4566 DH458 757) and proceeded downstream following the east bank to a reference point known as Green Island (Ref. 4567 DH265 885) then returned to House Roof Crossing following the west bank.

One active nest was located, approximately 1.3 kilometres downstream from Goose Hill Creek. (Map Ref 4566 DH323 824).

A thorough scanning of the area which has contained nests in the past failed to show any nesting activity at all.

One likely "wallow" was located adjacent to the southern end of Mattress Island (Ref 4566 DH394 794). An animal was seen in this "wallow" however no nest was sighted.

This "wallow" was under a thick stand of Mimosa trees and a nest would have been extremely difficult to see in any event.

Discussion

The survey was carried out on behalf of the Wyndham Crocodile Farm and utilised a Bell 47 Helicopter. Nigel Palmer was observer and I was Navigator/Observer. Helicopter hours utilised were 1.5.

A number of C.porosus (8) were sighted during the survey, however no active slides which would indicate possible nest sites were located.

One dead C.porosus (approx 3 metres in length) was located at Echo Rocks (Ref 4567 DH290 873). This animal had had its head removed and I suspect it had been shot and the head souvenired.

Information from Graeme Webb indicates that the nesting activity in the NT has been very good this season (i.e. approx 100 % better than last season). He is anticipating collecting in the vicinity of 10,000 eggs.

A number of factors may contribute to the low nesting effort on the Ord River.

High ambient temperatures probably contribute to high nest temperatures resulting in a higher percentage of male crocodiles being hatched and most likely result in poor survival of eggs.

Lack of consistent rains result in less vegetation growth - consequently poor incubation materials such as sticks, mud and stones may be used which are quickly eroded when rain does come.

High stocking rates of cattle contribute to incidents of nest trampling and reductions in suitable nesting vegetation and conditions.

To date only 3 nests have been located on the King River - these nests were constructed of Sticks, mud and stones and had high internal temperatures.

Recommendations

1. Wyndham Crocodile Farm be advised that no further egg collection is to take place on the King River.

2. A follow up survey takes place downstream from Echo Rocks to at least Panton Island (Ref 4567 DJ183 133) sometime within the next 4-6 weeks. This area has been poorly surveyed in the past and it would be of value to determine if nesting is/has occurred in this area. Funding for this survey would need to be supplied ex Region.

3. Future surveys should be carried out prior to allowing egg collection from the King River by W.C.F.

RG

R.GUEHO
DWO - East Kimberley

31 January, 1992
RG/df

Keiran, I think we should allow W.C.F. to collect all nests in the King River if they went to. What do you think.
Dave

I think we are going to have to discuss this further. Perhaps we should be thinking about the possibility of letting them collect all King River eggs regardless of how many of the nests there are in the C.C.

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Form CLM 808

To:
MANAGER
WILDLIFE BRANCH - COMO
ATTN: K.McNAMARA

Noted pgts

Your Ref:
Our Ref: 156.6A
Enquiries: C.DONE
Phone: 091 680 200

Subject: Estuarine Crocodile Nesting - Ord River

A survey was carried out on 11/3/91 to assess the nesting effort of Crocodylus porosus in "usual" nesting areas on the Ord River. A thorough (5 passes) scanning of the area failed to show up any nests at all.

Whilst it is not possible to be certain that there are no nests in the area it is fairly certain that there are less than the "normal" (of the previous two years) 4 - 6 nests.

I saw only only one likely "wallow" but no associated nests and this was about 1 km further north than nests have previously been noted.

Discussion

The survey was done on behalf of Wyndham Crocodile Farm and utilized a helicopter provided by them. I was observer and navigator was CALM Officer David Grosse. Time taken (helicopter hours) was 1.4. Cost was $392.00.
The particular nesting area has a fairly dense tree cover interspersed by more open grasslands. Nests usually tend to be under or adjacent to the trees and the thick canopy make observation difficult.

However, in previous years it has been possible to readily recognise nests there by looking obliquely under the canopy.

In addition I saw no active slides which would indicate possible nest sites, nor were there any crocodiles observed in that section of the river.

Information from Charlie Manolis (Webb & Co - Darwin) indicates that the nesting effort in the N.T. has been low this year (i.e. about 40% lower than last years' figure). There are many possible reasons for this but the very long, late dry season, (i.e. prior to January 1991 there was only sporadic rain) coupled with a very active previous nesting effort (1990) may be significant. It is possible that the season is delayed some 4 - 6 weeks (as appears to be the case in the N.T.) but we may not be able to check this through lack of funds.

Only two nests have been located on the King River this year also - down on the "normal" 6 - 8.

Implications

(i) Wyndham Crocodile Farm will be advised to collect no further eggs from the King River.

(ii) A follow up survey in approximately 1 months time may be of value as would surveys of the Roe, Prince Regent & Glenelg River. Funding for this work would need to be arranged.

(iii) Years of low nesting activity may happen fairly frequently and should be taken into consideration in "ranching" operation. (The nesting activity at the WCF has however been quite high this year).

C.DONE
REGIONAL MANAGER - KIMBERLEY

13 March, 1991
CD/df

Copy of letter to W.C.F. attached.

MP Notes.

9.7.1991

Results of Saltwater Crocodile (Crocodylus porosus) Survey in the Deep Bay (Kalumburu) area of Western Austalia (1991) (King Edward River and Monger Ck).

Introduction

On the 14th and 15th of July 1991, myself and Greg Harman conducted surveys in the Deep Bay area including areas of tidal rivers and creeks.

It is not known if spotlight surveys have been carried out in this area before. The Surveys are in response to frequent reports of problem crocodiles by members of the Kalumburu Aboriginal community.

During the surveys three (3) C.porosus (1 adult and 2 sub-adults) were caught and relocated to the Fremantle Crocodile Farm. (Reg 4 lic 509 refers).

Methods

The spotlight technique used has been described in detail by Messel et al (1981) and on numerous occassions in survey reports to CALM by G.Webb Pty limited. It is not considered necessary to repeat this.

The areas in Deep Bay, and Monger Creek were spotlight surveyed using a 4 metre punt. The section of the King Edward River was surveyed using a 5.2 metre V hull sports fishing boat.

For consistency one spotter was used ; Russell Gueho (CALM).

Results

A total distance of 16 kilometres was surveyed. Tidal conditions were considered optimum to spotlight surveying with all areas covered having large areas of exposed bank.

The total number of C.porosus sighted was 23 (11 animals sighted 14/7 and 12 sighted 15/7/91). The composition of the animals sighted in size classes were :- 1 hatchling from previous nesting season 1990/91, 13 non-hatchlings and 9 eyes only sighted.

These numbers correspond to densities of 1.44 crocodiles per kilometre.

Table 1. Results of spotlight survey in the King Edward River, Monger Creek and Deep bay areas.

Conditions were optimum for survey technique.

NH - non hatchlings; C.p. - C.porosus; - Density is animals per kilometre.

AREA	DIST (km)	GRID START	STOP	C.p. Total	C.p. All	Density NH
King Edward River 14/7/91	7	BK426226	BK410250	11	1.57	1.57
King Edward Monger Creek 14/7/91	5.5	BK410250	BK386223	8	1.45	1.27
Monger Creek Island (Deep Bay) 15/7/91	3.5	BK385255	BK385291	4	1.14	1.14
Total	16			23	1.44	1.38

The only hatchling seen during the surveys was at approximatley grid reference BK 4103255 on the eastern bank. This animal was small and was most certainly hatched from a nest laid in the 90/91 nesting season.

Size classes sighted (Graph 1) can only be used as a guide to the population size structure as there is possibly a variation in the ability of the one spotter over time to accurately estimate sizes. (Choquenot & Webb 1987).

DISCUSSION

A total population of 37 animals is estimated for the areas surveyed. This estimate is derived by using a 62% correction factor on spotlight counts assuming that the relationship between absolute densities and the spotlight count densities is similar to the Northern Territory.(Bayliss et al 1983)

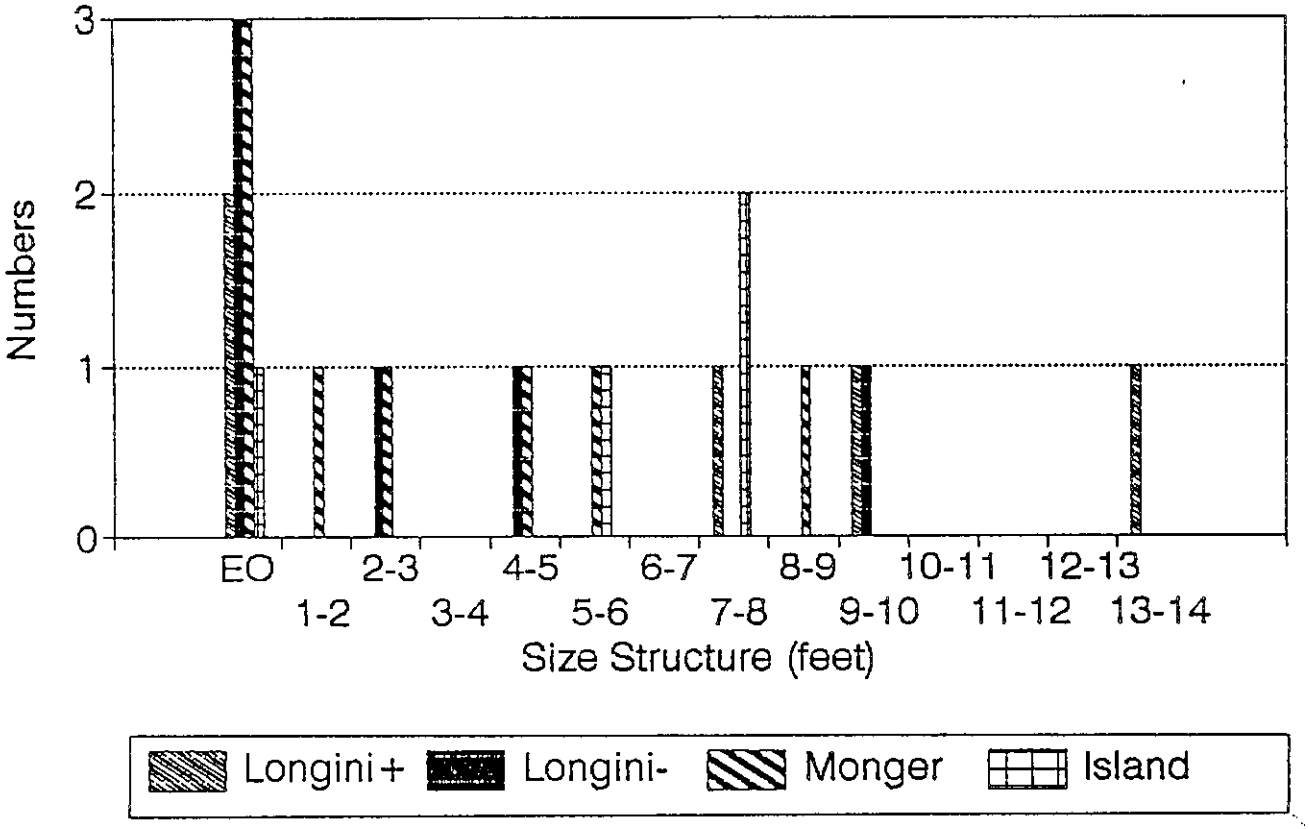
As this is the first survey in this area using this technique and the areas covered represent only a small proportion of potentially available crocodile habitat it is appropriate to state that this population estimate is probably conservative.

There are other factors to be considered which may have caused a lower number of animals to be sighted than would normally have been seen.

Firstly, there is evidence to suggest that the activities of illegal net fishermen may be affecting the population. Also increased tourism pressures have definately resulted in crocodiles being shot (inq.continuing). Animals sighted on both nights were particularly wary of the outboard motor noise and this wariness may lead to animals diving before the spotlight can pick them up.
The percentage of "Eyes-only" sighted is estimated at approximately 40% of the total sighted and may be indicative of the wariness of these animals.

CROCODILE SURVEY. DEEP BAY

C. porosus 14-15/7/91



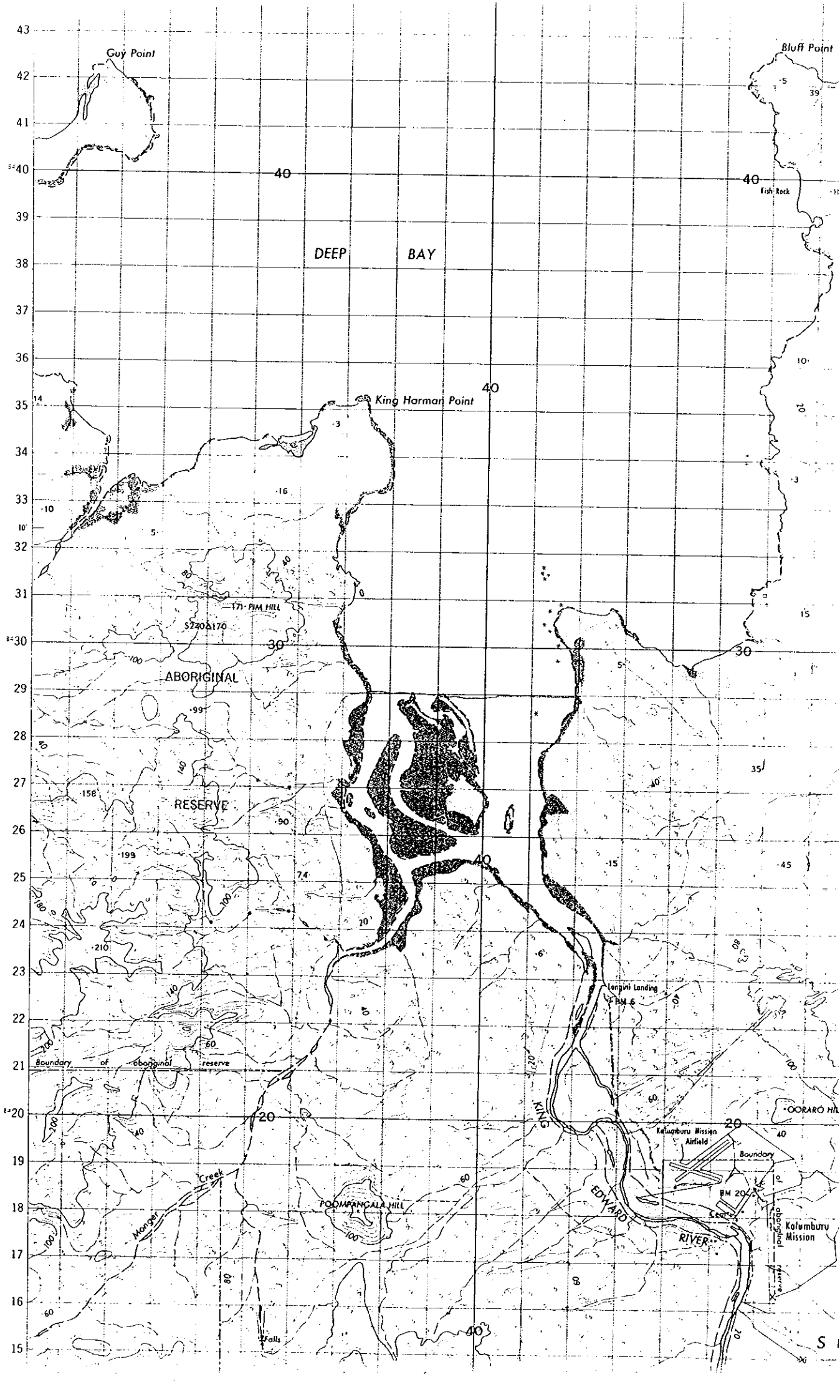
Three animals were captured and removed from the King Edward River in response to problem crocodile classification.
Historically, through data obtained by the attempt at farming by the Kalumbaru Mission, there are indications that the area has potential as breeding habitat. The densities and population size structure tend to indicate a healthy system and the area is one that should be surveyed on a regular basis considering its proximity to Kalumbaru and the future of tourism in the area.

For your information

R.P.GUEHO
DISTRICT WILDLIFE OFFICER
KUNUNURRA 2/9/91

Attachment: Map of area surveyed.

Reference: Results of Saltwater Crocodile (Crocodylus porosus) Surveys in the Cambridge Gulf Area of Western Australia (1990). G.Webb Pty. Ltd.


Guy Point
Bluff Point
DEEP BAY
King Harman Point
Fish Rock
PIM HILL
ABORIGINAL RESERVE
Longuit Landing
BM 6
Boundary of aboriginal reserve
KING EDWARD RIVER
Kalumburu Mission Airfield
Boundary
BM 20
Kalumburu Mission
POOMPANGALA HILL
Monger Creek
Falls

Noted. Done 9/4.
156.1.1

REGIONAL MANAGER

MANAGER,WILDLIFE

RE:HELICOPTER SURVEY - ROE RIVER
PROPOSED COLLECTION OF CROCODILE EGGS FROM GLENELG RIVER FOR WYNDHAM CROCODILE FARM.

On Friday 23/3/1990 I carried out a survey of the Roe river (PRNR) for nesting activity by C.porosus
Twenty five nests were sighted comprising:-

(a) 11 active nests
(b) 12 old nests - most likely early 1990
(c) 2 recently flooded nests.

The location of these nests can be seen on the attached map.
Two adult C.porosus were observed in the vicinity of the active nests (females).
Two adult C.porosus (males) were observed mid - stream at the points indicated on the map.

I then proceeded to Pantijan station and with Nigel (WCF) and two representatives from the Mowajum community conducted a survey along the Glenelg river with the intention of harvesting eggs from any nests located.
2 1/2 hours survey failed to locate any evidence of nesting activity.
I believe this lack of activity can be directly attributed to the prescence of large numbers of feral donkeys and cattle.
Numbers of donkeys and cattle observed would be in the vicinity of 1000 plus and it is not difficult to appreciate the degradation and pressure on the riverine habitat.
There is however, much potential nesting habitat available to crocodiles should the removal of feral animals be effected.

The Glenelg now comprises open grassy river flats along much of its length due in part to feral animal movement breaking down the the original river banks and as a consequence this has contributedto increased siltation and shallowing of much of the fresh water region of the river.

On Saturday 24/3/1990, I spoke with Bradley NESBIT, advisor to the Mowajum community, regarding the survey and the feral animal problem along the Glenelg. He advised that he believed it would be possible to obtain fuding from ANPWS for conservation projects on Aboriginal lands. This was raised with the possibility of fencing suitable crocodile nesting habitat in mind.

I believe this activity, combined with a suitable programme to remove the donkeys/ cattle in the area would contibute a great deal to the re- establishment of the Glenelg as a C. porosus breeding area.

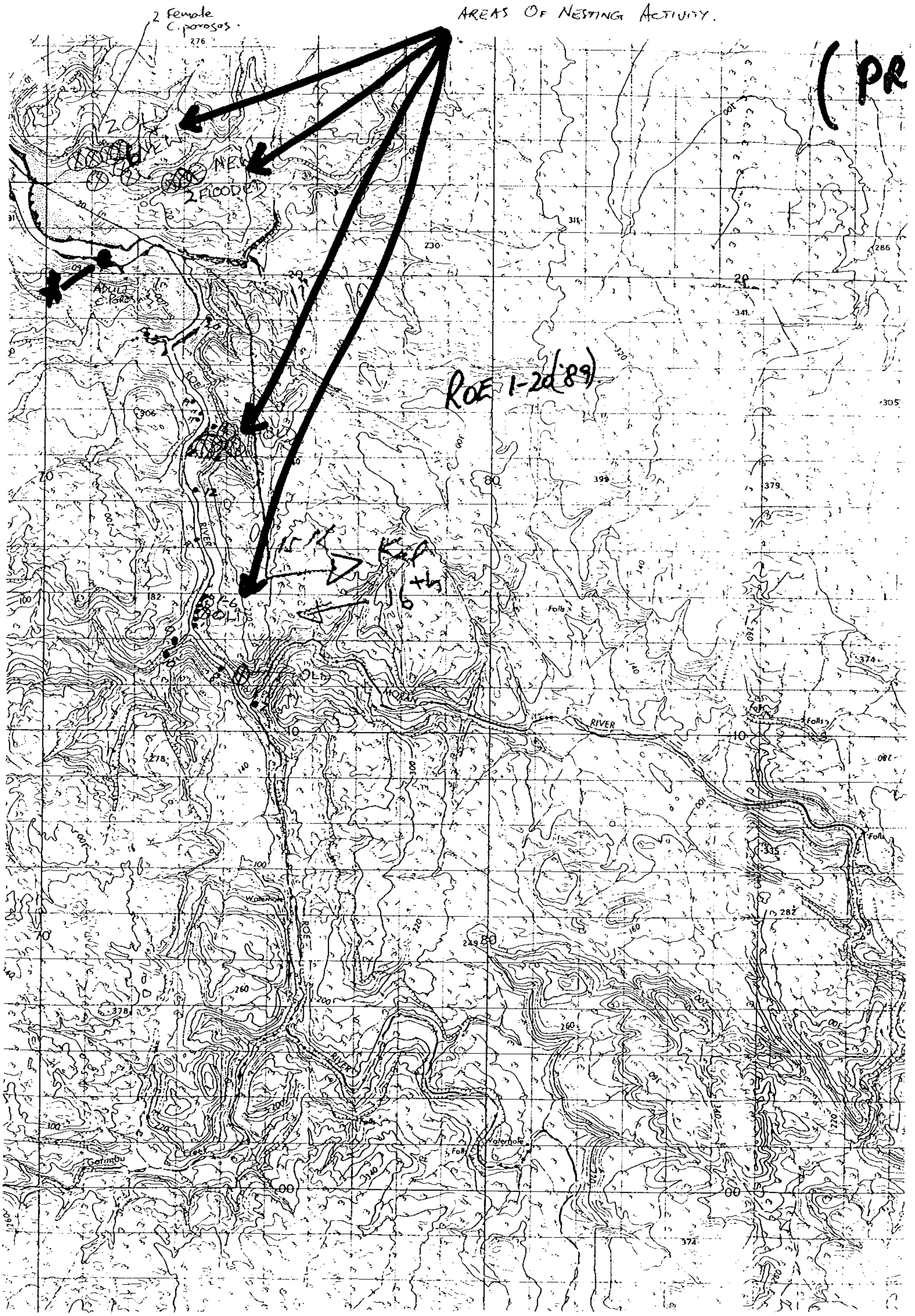
One point the Mowajum community should be aware of in relation to fencing the area is the increased pressure the area would receive after access tracks are developed.

Nesbit also requested input from CALM to the community outlining the benefits of removing the feral animals from the area i.e. restoration of C.porosus breeding habitat, restoration of the river and the return of indigenous fauna (noticeable in its abscence).
He feels confident that the community will receive any input from CALM with an open mind and that our concerns for the area and the possibility of increased people traffic can be attended to.

For your information.

R Gueho

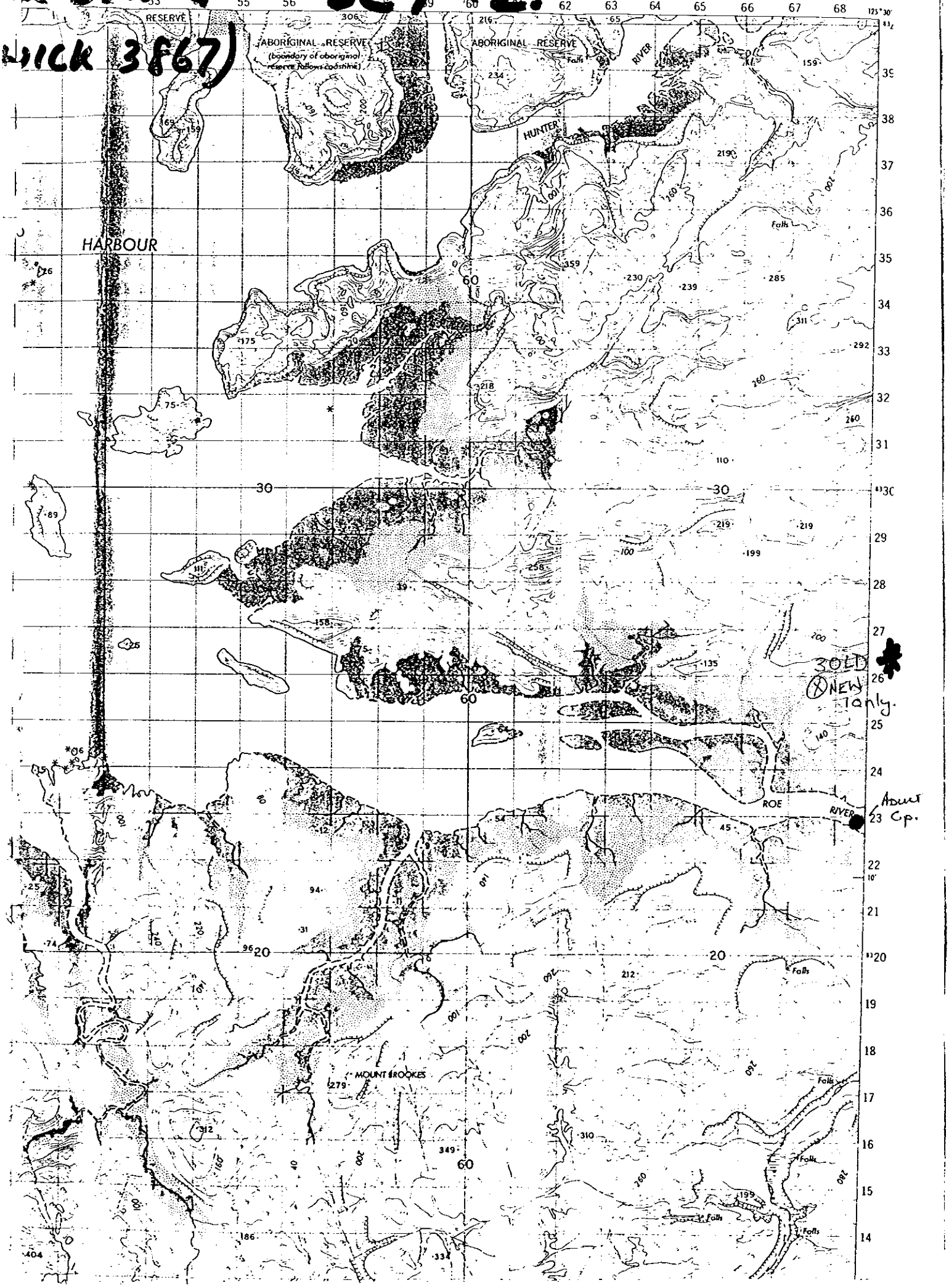
R.P.GUEHO
DISTRICT WILDLIFE OFFICER
3/4/1990



2 Female C. porosus.
AREAS OF NESTING ACTIVITY.
(PR
NEW
NEW
2 FLOODED
Adult C. porosus
ROE 1-20 ('89)
ROE
RIVER
OLD
MORAN
RIVER
Waterhole
Falls
Galimbu
Creek

STING - SET 2.

WICK 3867)



G.WEBB PTY. LIMITED
Wildlife Research & Management Consultants,
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WINNELLIE, N.T. 0821
Tel: 089 221355
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Final Report

Saltwater Crocodile (Crocodylus porosus) Nesting in the North-East Kimberley Region of Western Australia (1988/89 Season)

(22nd May 1989)

Introduction

Prior to the 1988/89 wet season, information on the nesting of Crocodylus porosus in the North-East Kimberley region was restricted to anecdotal accounts (personal communications from Malcolm Douglas, Mike Osborn, Father Sanz) and to hatchling sightings and nesting habitat descriptions recorded during population surveys (Burbridge and Messel 1979; Messel et al. 1987). There were no primary data on nesting and as such, no objective means of assessing the levels of egg and/or hatchling harvests that may be appropriate if a crocodile farm were established in the Kimberley. Recognising this situation, the Western Australian Department of Conservation and Land Management (CALM) engaged G. Webb Pty. Ltd. to conduct nesting surveys and report on the results. The study in its entirity was assisted by CALM wildlife officers and Peter Allen of Wyndham (who financed the egg collection survey discussed below). Assistance in the field was also provided by Geoffrey Munglamara, an Aboriginal from Kalumburu Mission.

Background Information

Crocodylus porosus lay their hard-shelled eggs in a mound of vegetation and soil raked up by gravid females. Nests are usually constructed on the banks of tidal rivers, in freshwater swamps associated with those rivers, or in floodplain billabongs, some of which are covered with floating rafts of vegetation, upon which the nests are often made (Webb et al. 1977, 1983; Magnusson 1980, Whitaker 1980; Cox 1985). One common denominator appears to be the need for permanent water -- an aquatic environment in

which the adult female can live throughout the year. The nesting season is typically prolonged (Webb et al. 1979, 1983; Whitaker 1980; Graham 1981; Cox 1985) and in the Northern Territory, it lasts from November to May (i.e. the north Australian "wet" season).

Itinerary

The nesting surveys were concentrated in two areas, Cambridge Gulf and the coastal rivers between Cambridge Gulf and the Prince Regent River. Three helicopter surveys (23-24 January 1989; 4-5 February 1989; 3 May 1989), one boat survey (5 February 1989) and one egg/hatchling collection which used a helicopter and a boat (1 March 1989), were conducted in Cambridge Gulf. A single helicopter survey (14-16 March 1989) was conducted between Cambridge Gulf and the Prince Regent River. The results of these surveys were presented to CALM in three interim reports, which are superceded by this report.

Methods

The survey procedures varied slightly during the study, but the spotter (Brett Ottley) was constant in all surveys. In Cambridge Gulf, a Bell 47 helicopter was used for both surveying and egg collection. In addition, surveys were also conducted from a 3.4 m long boat powered by an outboard engine (in order to ascertain the number of nests being missed from the air). For the survey of wetlands and rivers between Cambridge Gulf and the Prince Regent River, a Jet Ranger helicopter was used. A spotlight search of the the King River was also undertaken when hatchlings were collected.

All nests located in Cambridge Gulf and those in the Prince Regent and Roe Rivers which were accessible, were opened to check for eggs. If eggs were present, a thermometer was positioned amongst them (2-3 eggs deep), and the eggs were recovered until the temperature stabilised. The "spot nest" temperature recorded in this fashion is an index of the general thermal conditions that the eggs are experiencing.

After the nest temperature had been recorded, all eggs were removed from the nest. The upper surface of each egg was marked with a pencil so that they could be returned at the same orientation. From each nest, egg widths and lengths were measured with calipers on a sample of 5 or 10 eggs. Given the uniform size of eggs within a clutch, such a sample is adequate to characterise the clutch.

The outside appearance of each egg, particularly the extent and nature of the opaque band, was used as a guide to embryo age and condition. All clutches were older that 1 day of age, and had various stages of opaque banding (Webb et al. 1986, 1987). The lack of a band was used to indicate "infertility", and

most eggs so diagnosed were opened to confirm the diagnosis. Amongst fertile eggs, 1 egg (and in two cases 2 eggs) per clutch were sacrificed to obtain an embryo for aging. Fertile eggs which appeared dead (retarded opaque band development; badly discoloured; invaded by fungus) were opened and death confirmed. Eggs without such obvious signs were assumed to contain live embryos, although some dead ones may well have been included amongst them. All unopened eggs were returned to the nests, and the nest mounds were restored to their previous condition before leaving.

When eggs were collected, the same procedure was folowed, but eggs were packed in nesting material within insulated "eskies" and transported back to Darwin, where they were incubated at 32° C.

Map references generally refer to the 1:100,000 series (e.g. **Refn 4566-433776),** where the first four numbers denote the map sheet reference, and the following six numbers the vertical (e.g. 433) and horizontal (e.g.776) references. In some cases references refer to 1:250,000 maps (e.g. **Refn SD 52.14-CH 7674),** where the two letters and following four digits (e.g. SD 52.14) refer to the map sheet, and the following two letters and four numbers (e.g. CH 7674) refer to grid blocks and vertical and horizontal references.

Areas Surveyed

1. Cambridge Gulf

On 23-24 January 1989, helicopter surveys were conducted over the Ord River, Goose Hill Swamp area, Parry Creek, Parry Lagoon swamps, Collins Creek, Reedy Creek, the tidal pool off Collins Creek, the coastal tidal creeks on the east bank of the Ord in the Mount Connection area, King River and associated tidal pools, the east bank of the West Arm, both banks of the Pentacost River as far as the road crossing, and Bulla Nulla Creek (Fig. 1)

On 4-5 Febuary 1989, helicopter surveys were conducted over the sections of the King and Ord Rivers in which nests were located on the first survey, in addition to surveys of the Forrest River, Thompson River, Lyne River, the False Mouths of the Ord. Sections of the Pentacost River were also resurveyed (Fig. 1). On 5 Febuary 1989, the upper reaches of the King River were surveyed from a 3.4 m aluminium boat at high tide.

On 1 March 1989 the 8 nests previously located on the King River (7 with eggs, 1 without egs) were visited with a view to collecting all eggs. On the night of the 1 March 1989, a spotlight survey was undertaken to pick up hatchlings from nests that appeared to have hatched.

On 3 May 1989 the potential and known nesting areas in Cambridge Gulf were resurveyed. The purpose of this survey was to locate any late season nests. The area surveyed (Fig 3) included both banks of the following rivers, the Ord River from House Roof Hill **(Refn 4566-433776)** downstream to Fossil Island **(Refn 4567-216040)**, the Forrest River and the mainstream Islands between the Forrest River Mission **(Refn 4467-755205)** and Milligan Range escarpment **(Refn 4467-852139)**, the King River between the Pump Station **(Refn 4566-045745)** and the upper limits of the tidal influence **(Refn 4566-027703)**, Durack River from its mouth **(Refn SD 52.14-CH 7674)** to the escarpment edge **(Refn SD 52.14-6678)** and Pentacost River from the mouth of the Durack River **(Refn SD 52.14-CH 7674)** upstream to Bindoola Creek **(Refn SD 52.14-CH 7664)**.

2. Cambridge Gulf to Prince Regent River

A C. porosus nesting survey of all major river systems between Cambridge Gulf and the Prince Regent River was conducted on 14-16 March 1989. Surveys were conducted with Brett Ottley spotting and Chris Done navigating. The following areas were surveyed (Fig. 2):

1. Lacrosse Island, in the Cambridge Gulf **(Refn 4568-255695)**;
2. The tidal creeks in Joseph Bonarparte Gulf **(Refn 4468-905877 to 4468-847903)**;
3. The tidal creek to the immediate west of Buckle Head **(Refn 4469-732021)**;
4. Berkley River **(Refn 4469-685135)**;
5. Drysdale River **(Refn 4270-665560)** and Placid creek, at the mouth of the Drysdale River **(Refn 4270-635528)**;
6. King Edward **(Refn 4269-408255)** and Carson rivers **(Refn 4269-454030)**;
7. The creeks in Vansittart Bay **(Refn 4169-085250 to 4169-018297)**;
8. Cape Bougainville **(Refn 4170-906559)**;
9. The tidal creeks on the eastern side of Admiralty Gulf **(Refn 4168-800920)**;
10. Lawley River system **(Refn 4068-145795)**;
11. Mitchell River **(Refn 4068-905950)**;
12. The tidal creek opposite Scott Strait **(Refn 3968-485792)**;
13. Roe **(Refn 3967-595240)** and Moran Rivers **(Refn 4067-745106)**;
14. Hunter river **(Refn 3967-605375)**; and,
15. Prince Regent River system **(Refn 3967-225905)**.

Results and Discussion

NEST LOCATIONS

1. General

Based on experiences in the Northern Territory, habitats suitable for C. porosus nesting are scarce in the North-East Kimberley. They were located in a small number of rivers, and within these, they were often restricted to small patches. The mangrove-saltpan habitats found toward the mouths of most tidal rivers are unsuitable for nesting. The only nesting habitats located were grass plains abutting the mangrove fringe, and three areas of freshwater swamp associated with mangroves (one flooded nest was found in one of these swamps).

Altogether, 39 nests were located in Western Australia (Tables 1 and 2; Figs 3-9); 37 were constructed in the 1988/1989 nesting season and 2 were from an earlier season. Fourteen nests were found in the Cambridge Gulf and 25 were from locations extending west of the Gulf to the Prince Regent River (see below).

Table 1: General survey results.

Date	Method	Area	No. of nests found
23-24 Jan 1989	Heli	Cambridge Gulf	10
4-5 Feb 1989	Heli	Cambridge Gulf	1
5 Feb 1989	Boat	King River	3
14-16 Mar 1989	Heli	North-East Kimberley	25
3 May 1989	Heli	Cambridge Gulf	0

Table 2. Details of C. porosus nests located in the North-East Kimberley during the 1988/1989 nesting season. Grid References refer to the 1:100,000 Topographic maps. NE = not examined.

Nest No.	Grid Reference	Hatched/ Unhatched	Nest Type	Notes
Ord 1	4567-274864	Unhatched	Bank	
Ord 2	4566-275863	Unhatched	Bank	
Ord 3	4566-276861	Unhatched	Bank	
Ord 4	4566-276860	Unhatched	Bank	
Ord 5	4566-276858	Unhatched	Bank	
Ord 6	4566-276857	Unhatched	Bank	
King 1	4566-019714	Unhatched	Bank	
King 2	4566-023734	Unhatched	Bank	
King 3	4566-025736	-	Bank	False nests
King 4	4566-026737	Unhatched	Bank	
King 5	4566-026715	Unhatched	Bank	
King 6	4566-023728	Unhatched	Bank	
King 7	4566-020729	Unhatched	Bank	
King 8	4566-026716	Unhatched	Bank	
Drysdale 1	4270-787536	Hatched	Bank	NE
Admiralty Gulf Creek 1	4168-847863	-	Swamp	Flooded/NE
Prince Regent 1	3967-366924	Unhatched	Bank	
Prince Regent 2	3966-550662	Hatched	Bank	87/88 season/NE
Roe 1	4067-733124	Hatched	Bank	NE
Roe 2	4067-733125	Unhatched	Bank	
Roe 3	4067-734126	Hatched	Bank	NE
Roe 4	4067-734127	Hatched	Bank	NE
Roe 5	4067-734128	Hatched	Bank	NE
Roe 6	4067-734128	Unhatched	Bank	
Roe 7	4067-746106	Unhatched	Bank	
Roe 8	4067-739114	Unhatched	Bank	NE
Roe 9	4067-728118	Unhatched	Bank	NE
Roe 10	4067-726117	Hatched	Bank	NE
Roe 11	4067-733143	Unhatched	Bank	
Roe 12	4067-733153	Hatched	Bank	NE

Table 2. continued

Nest No.	Grid Reference	Hatched/ Unhatched	Nest Type	Notes
Roe 13	4067-732159	Hatched	Bank	NE
Roe 14	4067-732159	Unhatched	Bank	NE
Roe 15	4067-721187	Unhatched	Bank	
Roe 16	4067-736168	Hatched	Bank	NE
Roe 17	4067-734170	Hatched	Bank	NE
Roe 18	4067-733172	Hatched	Bank	NE
Roe 19	4067-733173	Unhatched	Bank	
Roe 20	4067-736191	Hatched	Bank	NE
Cape Bouganville 1	4170-907558	-	Sand Dune	2-3 yrs old

The majority of nests located were bank nests, that is nests constructed on the banks of tidal rivers, usually 1-3 m from the high tide level (Magnusson 1980, Webb et al 1977). This reflects in part the restricted availablity of nesting habitat in the areas surveyed, especially when compared to the Northern Territory, where only 24% of recorded nests are on banks (unpublished data).

2. Cambridge Gulf

No new nests were located on the final Cambridge Gulf resurvey (3 May 1989) of known or potential nesting areas. Nests located in the earliar surveys were in two regions:

1. West bank of the Ord River (Fig.3): adjacent to the current Parry Lagoons Nature Reserve, and within the proposed nature reserve 31967 (6 nests), and,

2. On the east and west bank of the upper reaches of the King River (Fig.4), which is outside present or proposed reserves (7 nest with eggs).

The relationship between nests located by helicopter (5) and additional nests located by boat (3) gives an indication of sightability. The position of the nests previously located by helicopter were easily discernible from the boat by the well used tracks made by the female crocodile through the mangroves to her nest. All nests on the King River would be visible from the air early in the season when the mounds are still large and have not been eroded by the

weather or overgrown with vegetation. The reasons that the 3 additional nests were not found by helicopter on the first survey were:

1. one nest was under a canopy and was well hidden; and,

2. at the time of these surveys all the nests were old and those missed from the helicopter but located by boat had been weathered to small mounds and were overgrown with weeds and grasses.

3. the pilot's inexperience on the first survey, which meant that the observer had to keep redirecting the pilot to the detriment of spotting, may have led to an incomplete cover of the area for the observer.

3. Cambridge Gulf to Prince Regent River

Survey results were as follows:

1. Lacrosse Island, in the Cambridge Gulf (Refn 4568-255695):

No significant areas of nesting habitat were located. A small freshwater soak behind the sand dunes **(Refn 4568-255695)** could support a small number of adults and nests may be constructed there in some years -- none were found on this survey.

2. The tidal creeks in Joseph Bonarparte Gulf (Refn 4468-905877 to 4468-847903):

Mangrove lined creeks with no significant nesting habitat or nests located.

3. The tidal creek to the immediate west of Buckle Head (Refn 4469-732021):

Potential nesting habitat was located at the upstream section of the tidal creek to the west of Buckle Head **(Refn 4469-695015)**. There was a small area of Phragmites karka(cane grass) swamp and good stands of broad-leaved grasses along the banks. A 3-4 foot C. porosus was seen, but no nests were located.

4. Berkley River (Refn 4469-685135):

The tidal extent of the Berkley River is demarcated by an escarpment waterfall. Between the waterfall and the mouth, there are mangroves abutting the gorge through which the river runs. Some very small patches of grass bank occur behind this mangrove fringe, which may

be used for nesting on some years. No nests were found, and the area is not considered a significant one with regard to C. porosus nesting

5. **Drysdale River (Refn 4270-665560) and Placid creek, at the mouth of the Drysdale River (Refn 4270-635528):**

The small eastern arm of Drysdale River had nesting habitat in the upper reaches of the tidal section **(Refn 4270-780515 to 4269-808507)**. In these areas the dominant plant was the mangrove fern (Acrostichum speciosum). One hatched nest from the 1988/89 wet season was located **(Refn 4270-787536)** and we were shown two sites **(Refn 4270-697576 and 4269-798506: Fig. 5)**, at which C. porosus had nested on previous years, by Geoffery Munglamara who had collected the eggs for Father Sanz. The main beds of mangrove fern beside the Drysdale River were flooded during the survey and any old nests, if present, would have been underwater. Placid Creek is a tidal creek with mangrove and saltpan abutting the creek -- no areas of nesting habitat nor nests were identified. The G. Munglamara said that "small" salties had been caught in Placid Creek, but he knew of no known nest sites there.

6. **King Edward (Refn 4269-408255) and Carson rivers (Refn 4269-454030):**

Suitable nesting areas were located along the upstream sections of both the King Edward and Carson Rivers **(Refn 4269-455176 to 4268-306935 and 4269-454030 to 4269-515983)**. The river bank habitat was dominated by tall, broad-leafed grasses, which appeared identical to those used by nesting C. porosus elsewhere. A possible nest was located **(Refn 4269-474015)** downstream of where the Gibb River road crosses the Carson River, although due to tall grass and small trees, the helicopter could not land. The area had been scoured by flood waters and the suspect nest was badly eroded, making positive identification from the air impossible. The site has been recorded as a possible nest, but has been excluded from all tables. According to the Aboriginals from Kalumburu, no C. porosus occur that far upstream, although we could see no reason why this should be so.

7. **The creeks in Vansittart Bay (Refn 4169-085250 to 4169-018297):**

Mangrove lined creeks with no significant nesting habitat or nests located.

8. Cape Bougainville (Refn 4170-906559):

A C. porosus nest site at Cape Bouganville **(Refn 4170-906559: Fig. 6)**, was shown to us by Geoffery Munglamara. The area is in a small bay and the nest was at the back of a sand dune. The only freshwater was from runoff and seepage out of a rocky hill behind the beach, which collects in a pool behind the sand dunes next to the nest site. Mangrove fern grows in the fresh water, but it was brown and withered at the time of our visit. The nest mound was still visible but was definitely not from the 1988/89 season -- it may well have been a few seasons old. It appeared to be composed of beachsand, shellgrit and a small amount of spear grass (Sorghum intrans) and is atypical of most C. porosus nests we have encountered. The area is small and it would be difficult to imagine it supporting more than one female (according to G. Munglamara, only one nest was ever located there in any one season).

9. The tidal creeks on the eastern side of Admiralty Gulf (Refn 4168-800920);

An extensive shallow, freshwater swamp, dominated by paperbark (Melalueca sp.) with an understory of cane grass (P. karka), exists at the head of the small tidal creek on the eastern side of the Admiralty Gulf **(Refn 4168-846864)**. A flooded nest from the 1988/89 season was found in cane grass at the base of a paperbark tree **(Refn. 4168-847863: Fig. 7)**. The area had been flooded by the recent rains, and the flooding had flattening patches of cane grass and the beds of grasses which line the channels draining into the swamp from the surrounding escarpment. There may well have been some other nests obscured by the flattened vegetation. Permanent water (throughout the dry season) appears limited to a small tidal creek draining the swamp, and this may well limit the number of adult females that live and nest in what otherwise appears to be excellent nesting habitat.

10. Lawley River system (Refn 4068-145795):

The river banks are lined with mangroves and saltpans, with no obvious nesting habitat or nests located. Some hatchlings were reported in the Lawley River by Messel et al. (1987).

11. Mitchell River (Refn 4068-905950):

The tidal extent of the Mitchell River is demarcated by an escarpment waterfall. Between the waterfall and the mouth of the river, mangroves abut the rocky river banks. No significant patches of nesting habitat were located, although an odd nest may be made in

small patches of grass behind the mangrove fringe. Some hatchlings were reported in the Mitchell River by Messel et al. (1987).

12. The tidal creek opposite Scott Strait (Refn 3968-485792):

Mangrove lined creek with no significant nesting habitat or nests located.

13. Roe (Refn 3967-595240) and Moran Rivers (Refn 4067-745106):

The best nesting habitat so far located in Western Australia, is along the Roe and Moran Rivers. Well developed banks of cane grass (P. karka) and tall, broad-leafed grasses (Cenchrus elymoides and other species) provide ideal nesting sites (Webb et al. 1977; 1983). Twenty (20) nests were located in a 10 km section **(Refn 4067-736191 to 4067-746106: Fig.8)** leading from the Roe to the Moran River. This habitat appears to be in a near pristine state showing no evidence of degradation due to cattle grazing.

14. Hunter river (Refn 3967-605375):

Mangrove lined banks with no significant nesting habitat or nests identified. Some hatchlings were reported in the Hunter River by Messel et al. (1987)

15. Prince Regent River system (Refn 3967-225905):

Although more limited than in the Roe and Moran Rivers, patches of cane grass and broad-leafed grasses also occur on the Prince Regent River. Two nests were located (Fig. 9), one on the mainstream from the 1988/89 season **(Refn 3967-366924)** and an old nest on a side creek **(Refn 3966-550662)**, at a site found by Done in 1987 (It did not appear to have been used this season). Due to logistic constraints, the complete Prince Regent River was not surveyed, and all good areas of nesting habitat may not have been identified. In addition, the banks of the Prince Regent had been scoured by flood waters resulting from the recent heavy rains, and these may well have destroyed 1988/89 nests.

TIME OF NESTING

The estimated time of nesting for all nests examined is summarised in Table 3. With the exception of 1 nest, all were laid in December-January, suggesting that the time of nesting is contracted to a brief period after the

onset of the first storms of the wet season. No late survey was carried out between between Cambridge Gulf and the Prince Regent, so we can only assume that it follows the trends described in Cambridge Gulf (i.e. no late nesting).

Table 3. Details of the twenty nests with eggs examined, and the nest temperatures, which are used for correcting the age of embryos. NA = not applicable.

Nest No.	Clutch Size	30 C Age at examination (Days)	Nest Temp.	Estimated Real Age (Days)	Date Laid
Ord 1	58	55	31.9	44	23 Dec 88
Ord 2	38	65	33.2	49	18 Dec 88
Ord 3	44	68	34.5	50	17 Dec 88
Ord 4	57	66	34.5	48	19 Dec 88
Ord 5	47	30	33.5	22	13 Jan 89
Ord 6	41	71	32.5	55	11 Dec 88
King 1	60	71	34.8	52	14 Dec 88
King 2	59	68	38.5	50	16 Dec 88
King 3	-	-	-	-	-------
King 4	48	46	33.8	34	31 Dec 88
King 5	52	24	32.8	18	17 Jan 89
King 6	43	63	34.5	46	21 Dec 88
King 7	56	64	-	47	20 Dec 88
King 8	48	66	35.0	48	19 Dec 88
Prince Regent 1	24	85.4	33.5	73.0	3 Jan 89
Roe 2	42	67.7	29.9	58.9	17 Jan 89
Roe 6	41	70.0	32.9	53.5	22 Jan 89
Roe 7	39	58.8	30.5	58.8	17 Jan 89
Roe 11	31	68.9	31.5	57.2	19 Jan 89
Roe 15	27	63.2	29.5	54.9	21 Jan 89
Roe 19	36	14.9	-	12.1	5 Mar 89
MEANS	44.6 ± 2.4	NA	33.2 ± 0.5	NA	NA

Relative to C. porosus nesting in the Northern Territory (Webb et al. 1979, 1983) and Papua New Guinea (Whitaker 1980; Graham 1981; Cox 1985), which extends from November to May with a definite peak between December and February, nesting in the Kimberley is a far more contracted affair.

NEST TEMPERATURES AND CLUTCH CHARACTERISTICS

Of the twenty-two nests visited, twenty contained eggs (King 3 and Cape Bougainville 1 had no eggs) (Table 2 and Table 3). The average clutch size was 44.6 ± 2.4 (SE) eggs, which is less than in the Northern Territory (50.0 ± 0.6; Webb and Cooper-Preston 1989). However, if the areas are examined separately the Cambridge Gulf average was 50.1 ± 2.1 eggs per clutch, whereas the Prince Regent/Roe had an average of only 34.3 ± 2.7 eggs.

Nest temperatures differed significantly between the two areas. In the Prince Regent/Roe it averaged 31.3 ± 0.7° C which is similar to that of nests in the Northern Territory (31.7 ± 0.1; Webb and Cooper-Preston 1989). Although these temperatures were probably lowered by the period of intense rain and flooding prior to the survey, the nests were probably kept from overheating by shade produced by the tall vegetation, mangroves and the escarpment preventing prolonged exposure to the sun. In the Cambridge Gulf, where most nests were well exposed, mean nest temperature was 34.1 ± 0.5° C and the highest temperature was 38.5° C. These are exceedingly high relative to nest temperatures recorded in the Northern Territory, and are in the critical or lethal range (>35° C; Webb and Cooper-Preston 1989). It is difficult to avoid the conclusion that embryo mortality due to high temperatures is a significant problem for C. porosus nesting in the Cambridge Gulf area.

Within the Cambridge Gulf, temperatures in the Ord nests (33.4 ± 0.4° C) were lower than those in the King (34.9 ± 0.8° C). This appears to be related to the degree of shelter. In the Ord, the nests were reasonably-sized mounds in a tall burr, Xanthium occidentale, and they tended to be sited in the partial shade of trees. In the King, the mounds were small, constructed in areas where grassy vegetation was sparse (caused to some degree by grazing), and were largely without shade.

Although clutch size differed between the Cambridge Gulf and Prince Regent/Roe areas, egg sizes were similar (Tables 4 and 5). Mean egg weight (93.2 ± 3.8 g) was predicted from the egg length and width (Webb et al. 1983) and was appreciably less than in the Northern Territory (109 ± 0.79). Because of the differing clutch sizes, predicted clutch mass between the two areas also differed. Female C. porosus in Cambridge Gulf had an average of 4.64 ±0.24 kg; whereas those in the Prince Regent/Roe had 3.21 ± 0.36 kg.

If total clutch mass scales to female size as it does in the Northern Territory, the approximate female sizes can be predicted [Y = 0.312X + 6.72, where Y = total length in feet and X = clutch mass in kilograms). Predicted sizes (Tables 4 and 5) are consistent with those estimated by observers on site: however the possibility of larger crocodiles with smaller clutch masses cannot be rejected.

Table 4 . Clutch characteristics of the nests from Cambridge Gulf.

Nest No.	Clutch Size	Egg Measures Length mm.	Width mm.	Pred. Wt. gm	Clutch mass (kg)	Pred. Female TL (ft)	Obser. Female TL (ft)
Ord1	58	66.0	44.9	75.2	4.36	8.1	
Ord2	38	77.7	46.7	101.3	3.85	7.9	
Ord3	44	73.0	46.7	93.4	4.11	8.0	7.5
Ord4	57	77.8	50.6	115.4	6.58	8.8	7-8
Ord5	47	69.1	45.1	81.2	3.82	7.9	
Ord6	41	79.7	49.0	112.9	4.63	8.2	
King1	60	68.4	46.3	84.3	5.06	8.3	8-9
King2	59	71.7	47.2	93.0	5.49	8.4	8
King4	48	70.5	44.8	82.4	3.96	8.0	8.5
King5	52	70.5	45.9	86.4	4.49	8.1	
King6	43	77.3	49.1	109.2	4.70	8.2	
King7	56	75.3	47.4	99.8	5.59	8.5	
King8	48	67.9	44.4	76.6	3.68	7.9	
MEAN	50.1	72.7	46.8	93.2	4.64	8.2	

Table 5. Clutch characteristics of the nests from the Prince Regent and Roe Rivers

Nest No.	Clutch Size	Egg Measurements Length mm.	Width mm.	Pred. Wt. gm	Clutch Mass (kg)	Pred. Female TL (ft)	Obser. Female TL(ft)
Prince Regent1	24	70.6	48.2	94.8	2.28	7.4	8.5
Roe 2	42	77.3	50.8	115.3	4.84	8.2	
Roe 6	41	67.8	46.3	83.4	3.42	7.8	7.5
Roe 7	39	76.9	46.8	100.3	3.91	7.9	
Roe 11	31	70.1	47.7	92.1	2.86	7.6	
Roe 15	27	67.8	44.4	76.4	2.06	7.4	
Roe 19	36	72.7	45.1	87.2	3.13	7.7	
MEAN	34.3	71.9	47.0	92.8	3.21	7.7	

EGG COLLECTION

Eggs and hatchlings were collected from the King River nests on the 1 March 1989. When nests with eggs were examined on the 5 Febuary, a total of 268 eggs were returned to the nests. Only 80 eggs were left in the nests at the time of collection (Table 6). In two nests, the excavation was consistent with a female saltwater crocodile having released the young, but in four nests they appeared to have been excavated by predators, possibly varanids. On the night of 1 March a spotlight search was undertaken to pick up any hatchlings produced from those nests -- only three hatchlings were found (all collected) from the water adjacent to nest King 8.

The above results suggests that the initial disturbance of the nests, during the survey, may have enhanced predation by releasing smells from within the nest. This would be consistent with the findings in other studies of Alligator mississippiensis (Deitz and Hines 1980), Crocodylus porosus (Magnusson 1982), C. johnstoni (Smith 1987) and Caiman yacare (Crawshaw and Schaller 1980).

Table 6. Details of nests examined on 1 March 1989. "*" indicates no hatchlings located by spotlight, suggesting that the eggs were eaten by predators.

Nest	No. Eggs remaining on 5 Feb.	No. eggs/ hatchlings collected	Dead Eggs	Viable Eggs	Notes	No.
King 1	53	-	-	-	Hatched/Predated *	
King 2	51	-	-	-	Hatched/Predated *	
King 3	-	-	-	-	False Nest	
King 4	43	-	-	-	Predated *	
King 5	42	23	4	19	Predated *	
King 6	11	5	-	5	Predated/hatching *	
King 7	41	26	18	8	Predated/hatching *	
King 8	27	26	1	25	Hatching (3 h's in water)	
Total	**268**	**80**	**23**	**57**		
		29.8%	**8.6%**	**21.3%**		

Of the 57 eggs collected 38 were in the process of hatching and the remaining 19 from King 5 were incubated by G.Webb Pty. Ltd. (Table 7.) Of the 55 hatchlings produced 10 were obviously abnormal and 45 appeared

normal. The abnormal hatchlings showed deformities consistent with high temperature incubation: kinked spines, curled tails and runted animals with large yolk masses. Three of these abnormal hatchlings were destroyed.

Table 7. The fate of the 57 eggs collected from the King River.

Nest No.	No. Viable Eggs collected	No. eggs Inc.	No. Hatchlings Nor.	Abn.	Notes
King 1	-	-	-	-	
King 2	-	-	-	-	
King 4	-	-	-	-	
King 5	19	19	14	3	2 dead eggs
King 6	5	-	3	2	2 abn. destroyed, both severe kinked spines.
King7	8	-	7	1	1 Runt destroyed.
King8	25	-	21	4	3 Runts; 1 curled tail.
Total	57	19 33%	45 78.9%	10 17.5%	

EGG AND EMBRYO CONDITION

The condition of eggs in Cambridge Gulf differed slightly (Table 8) from those between Cambridge Gulf and the Prince Regent Rivers (Table 9). Infertility accounted for 6.8% of the eggs in the Cambridge Gulf and 3.8% in the Prince Regent-Roe. Such infertility percentages are in general agreement with nests from the Northern Territory, and may be overestimates -- very early embryonic death (<1 day) are often difficult to detect, but can vary from none to 100% of a clutch.

Table 8. The general condition of C. porosus eggs from nests in the Cambridge Gulf.

Nest No.	No. of Eggs	Infertile Eggs	Dead Eggs	Live Eggs Remaining	Killed for Aging
Ord1	58	1	4	53	1
Ord2	38	3	1	34	1
Ord3	44	-	4	40	1
Ord4	57	1	1	55	2
Ord5	47	15	3	29	1
Ord6	41	1	3	37	1
King1	60	3	3	54	1
King2	59	3	4	52	1
King3	-	-	-	-	
King4	48	-	4	44	1
King5	52	7	6	39	1
King6	43	2	29	12	1
King7	56	1	31	24	1
King8	48	7	14	27	1
Total	**651**	**44**	**107**	**500**	**14**
		6.8%	**16.4%**	**76.8%**	

Table 9. The general condition of C. porosus eggs located in Roe and Prince Regent River.

Nest No.	No. of Eggs	Infertile Eggs	Dead Eggs	Live Eggs Remaining	Killed for Aging
Prince Regent 1	24	-	1	23	1
Roe 2	42	1	5	36	1
Roe 6	41	1	4	36	1
Roe 7	39	2	1	36	1
Roe 11	31	1	2	28	2
Roe 15	27	3	5	19	1
Roe 19	36	1	-	35	1
Total	**240**	**9**	**18**	**213**	**8**
		3.8%	**7.5%**	**88.8%**	

The 16.4% of Cambridge Gulf eggs noted as "dead" is probably an underestimate. The distinction between live and dead was made by external appearence during the first surveys, and was not confirmed by incubation (a great many of these eggs had disappeared before the egg collection). Flooding, the major cause of mortality in most areas (Magnusson 1980; Webb et al. 1983; unpublished data), did not appear to have affected the nests in the Cambridge Gulf. In contrast, overheating appeared to be a very significant cause of mortality (65.5% of dead eggs; Table 10) and may well have accounted for a significant proportion of the scattered developmental failures (30.9% "Unknown").

Table 10. Probable causes of mortality in unhatched C. porosus nests from the Cambridge Gulf.

Nest No.	No. of Eggs	Crushed	Flooded	Overheating	Unkn.	Total	(%)
Ord1	58	-	-	-	4	4	(6.9)
Ord2	38	-	-	-	1	1	(3.0)
Ord3	44	1	-	-	3	4	(9.1)
Ord4	57	1	-	-	-	1	(2.0)
Ord5	47	-	-	-	3	3	(6.4)
Ord6	41	-	-	-	3	3	(7.3)
King1	60	-	-	-	3	3	(5.0)
King2	59	1	-	-	3	4	(6.8)
King4	48	-	-	-	4	4	(8.3)
King5	52	-	-	-	2	2	(3.8)
King6	43	-	-	29	-	29	(67.4)
King7	56	-	-	13	-	13	(23.2)
King8	48	-	-	13	-	13	(27.0)
Total	**651**	**3**	**-**	**55**	**26**	**84**	**12.9**
% of total eggs		0.5	0.0	8.5	4.0	12.9	
% of dead eggs		3.6	0.0	65.5	30.9		

In the Prince Regent/Roe 7.5% of eggs were noted as dead (Table 11) from their external appearence. This is probably more accurate than the estimate for the Cambridge Gulf nests, as the eggs were more advanced when examined, which makes the distinction between live and dead ones far easier (live eggs were fully opaque, such that banded eggs were opened and found to be dead)

Dead eggs were scattered through clutches, rather than being grouped in a way that would suggest flooding or part of the clutch having reached critical temperatures. Accordingly, there were no obvious causes of the mortality (Table 11). In most cases the embryos had died early in incubation, when the opaque bands were narrow and even. That no embryos were found in the eggs suggests that death occurred within the first 2 weeks, when the embryo was small and the eye unpigmented -- certainly within the first 25 days.

Table 11. Probable causes of mortality in unhatched C. porosus nests from Prince Regent and Roe Rivers.

Nest No.	No. of Eggs	Crushed	Flooded	Overheating	Unkn.	total	(%)
Prince Regent 1	24	-	-	-	1	1	4.2
Roe 2	42	-	-	-	5	5	11.9
Roe 6	41	-	-	-	4	4	9.8
Roe 7	39	-	-	-	1	1	2.6
Roe 11	31	-	-	-	2	2	6.5
Roe 15	27	-	-	-	5	5	18.5
Roe 19	36	-	-	-	-	-	
Total	**240**	-	-	-	**18**	**18**	
% of total eggs		0.0	0.0	0.0	7.5	7.5	
% of dead eggs		0.0	0.0	0.0	100		

THE SIZE OF THE BREEDING POPULATION

It is highly unlikely that females nest twice in a season, so that each nest that was definitely known to contain eggs (13 in Cambridge Gulf; 23 between Cambridge Gulf and the Prince Regent River), can be assumed to have resulted from a different female. However, what proportion of females nest each year? In the Northern Territory, a mean correction factor of 15.5 non-hatchlings per nest found was derived as a general correction for predicting non-hatchling numbers from nest counts (Webb et al. 1989),

which indicates 713 non-hatchlings in the areas surveyed. The subdivision of these into adult females etc would need to be made on the basis of catching results and spotlight surveys.

However, the corrections referred to above were made in two of the highest density nesting areas within the Northern Territory, and their application to Kimberley Rivers (other than the Roe and Glenelg) may be restricted. For example, over the last ten years in Darwin Harbour 550 non-hatchling C. porosus have been removed, 312 of which were females, and 74 of which were longer than 229 cm total length (7.5 feet; the length at which females are generally considered to mature); some 100 non-hatchlings are now removed annually. Yet we have not found a nest in Darwin Harbour although the presence of one or two nests per year has been revealed by the odd hatchling. Clearly, in such low density areas the correction from non-hatchling numbers to nest numbers changes.

In our opinion, any realistic assessment of the extent of the breeding population will need to await spotlight counts, and ideally catching results, from the areas over which the nesting surveys were conducted.

General Discussion

The results of the surveys indicate that nesting across the Kimberley is more similar to that in the southern parts of the Northern Territory "Top End" (Victoria River, southern Gulf of Carpentaria) than to that of the northern parts. There is simply a lack of breeding habitat across northern Australia in areas with less than 1200 mm of annual rainfall.

This situation is reflected in relatively low densities of C. porosus, as recorded in the spotlight counts of Burbidge and Messel (1977) and Messel et al. (1987). Historical data from the Northern Territory has shown that rivers with low densities today, had low densities in the past, before serious commercial hunting (Webb et al. 1988). It seems unlikely that the Kimberley ever contained high densities of C. porosus.

In Cambridge Gulf, particularly in the Ord River, cattle grazing is having a profound affect on the extent of grass banks abutting the river. As these are used for nesting, we appear to be seeing a continuous degrading of potential nesting habitat in that river -- it may account in part for the low density of nesting recorded there, and for the fact that all nests found were in beds of an introduced burr. Yet in the Pentacost, Durack and Forrest Rivers, suitable grass banks appeared in tact, yet there was no nesting and no hatchlings sighted in spotlight surveys (Messel et al. 1987). In these the rivers, at the point where potentially suitable grass banks are located, the rivers appear shallow and have large, exposed sand bars even at high tide tide(Messel et

al. 1987); they may simply offer no deep water refuge at low tide, such that adult females avoid them.

Between Cambridge Gulf and the Prince Regent River, the most suitable and extensive nesting habitat was found in the Roe and Prince Regent Rivers. Unlike the majority of Kimberley rivers, these have well-developed grassy banks composed of thick stands of tall broad-leafed grasses (eg. Pragmites karka, Sorghum sp., Cenchrus elymoides).

Nests were found in areas where large numbers of hatchlings or small crocodiles (2-4ft) were sighted during spotlight surveys (Messel et al. 1987). Although small numbers of hatchlings were sighted in the Hunter, Lawley and Mitchell Rivers, no significant nesting habitat was recorded there. It appears that some nests are indeed made in such areas, but in small numbers, possibly in atypical habitats. Nesting in such areas may also be strongly dependent on season, as heavy rains during the late dry season may be needed to stimulate sufficient vegetation growth, for nesting later in the season.

Other areas west of the Prince Regent River may prove to contain suitable nesting habitat. Although not surveyed in this study, large numbers of hatchlings were recorded during spotlight counts in the Glenelg River (Burbidge and Messel 1979; Messel et al. 1987), which is not in a conservation reserve. It would seem highly likely that significant numbers of nests occur there, such that it is one of the only sites outside the Ord and King Rivers where eggs could be available for commercial harvesting.

To identify further nesting areas in Cambridge Gulf, it would seem beneficial to conduct spotlight surveys during the early dry season, to locate as many hatchling creches as possible. [Hatchling creches tend to remain near nests for a few months (Webb et al. 1977)].

Because nesting effort varies annually, the extent of nesting in the North-East Kimberley in the 1988/1989 season needs to be interpreted cautiously. In the Northern Territory nest numbers fluctuate greatly from year to year: for example in 1987/1988 12 nests were located in Melacca Swamp, whereas in 1988/1989 27 nests were found in the same area. In both the Northern Territory and Queensland this season (1988/1989) was considered "good", with above average numbers of nests, and the same may be true of the Kimberley. In contrast, if rainfall in the Kimberley was restricted this year, as some claim, nesting may well have been constrained.

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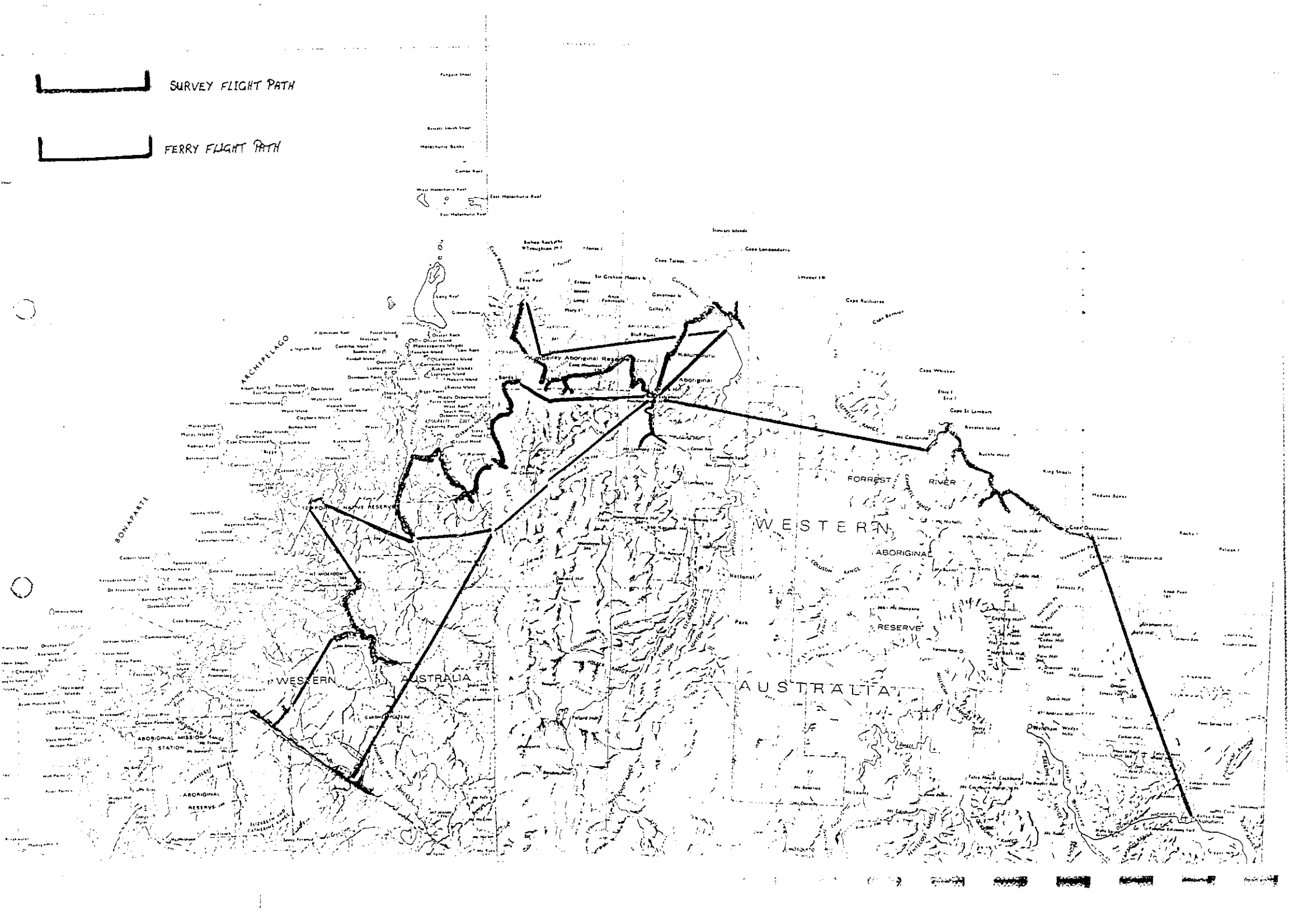

SURVEY FLIGHT PATH
FERRY FLIGHT PATH
WESTERN AUSTRALIA
FORREST RIVER
ABORIGINAL RESERVE
BONAPARTE ARCHIPELAGO

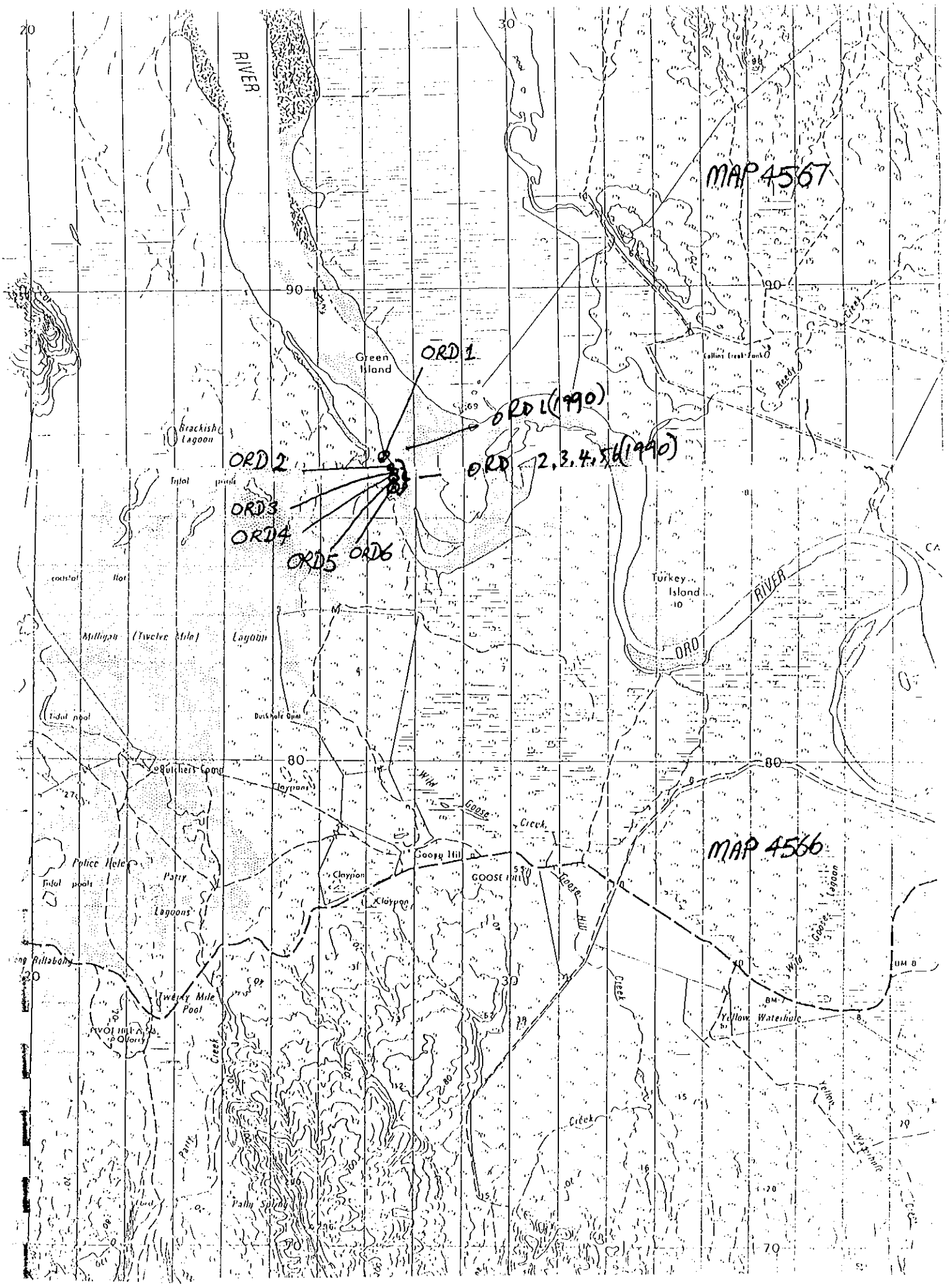


Figure 3. Location of Crocodylus porosus nests on the Ord River, Cambridge Gulf (1988/89 nesting season).

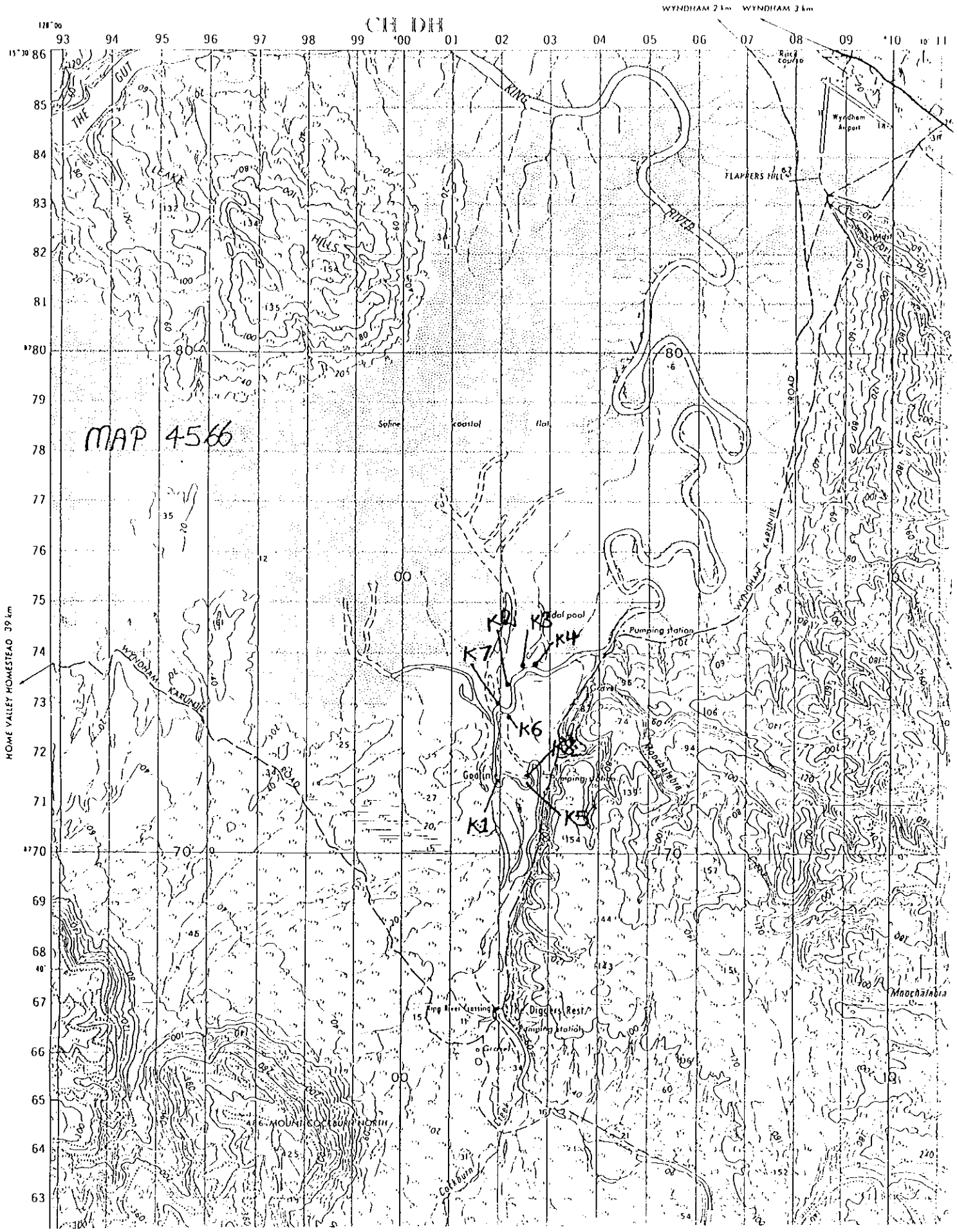


Figure 1. Location of Crocodylus porosus nests on the King River, Cambridge Gulf (1988/89 nesting season).

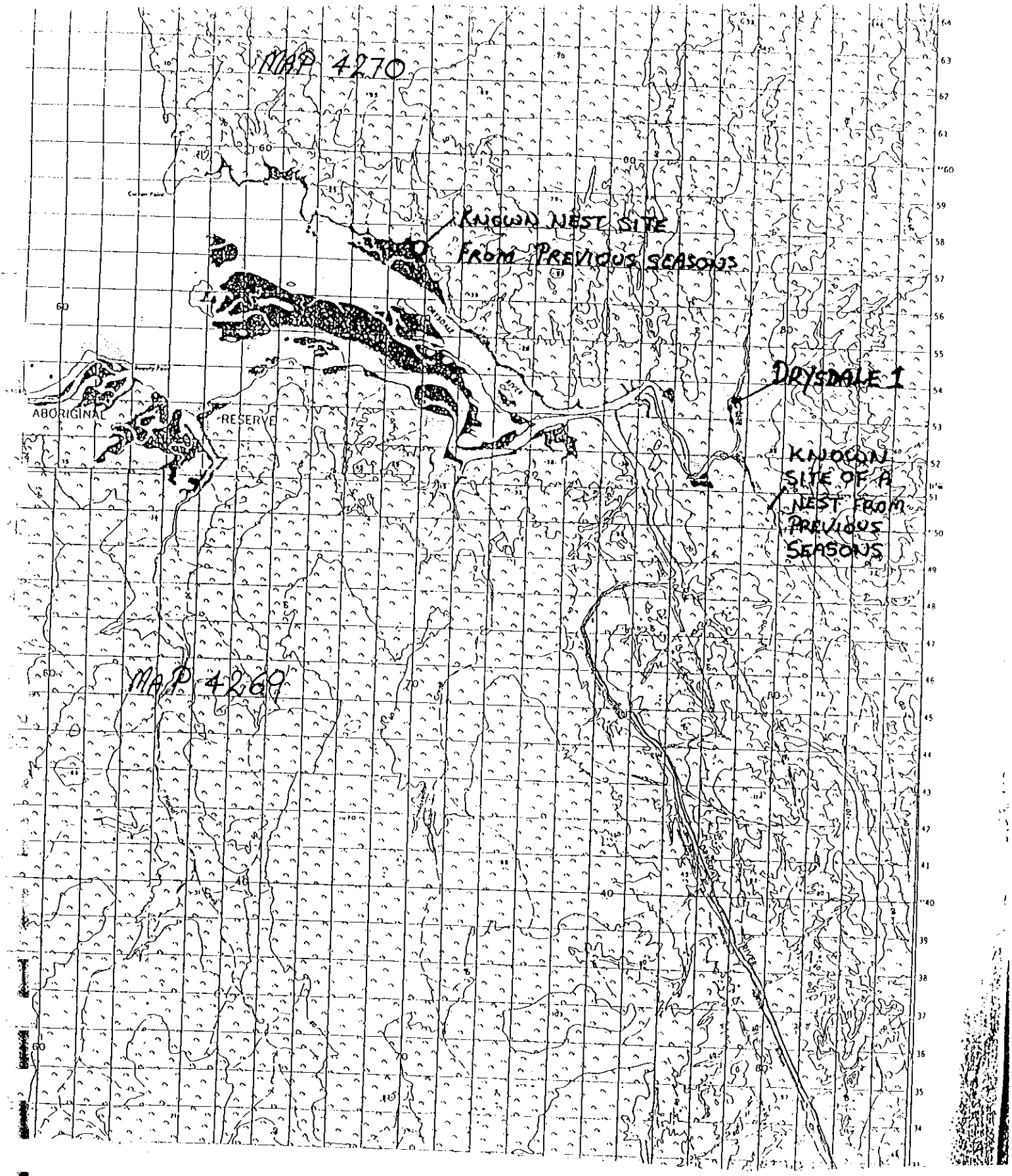
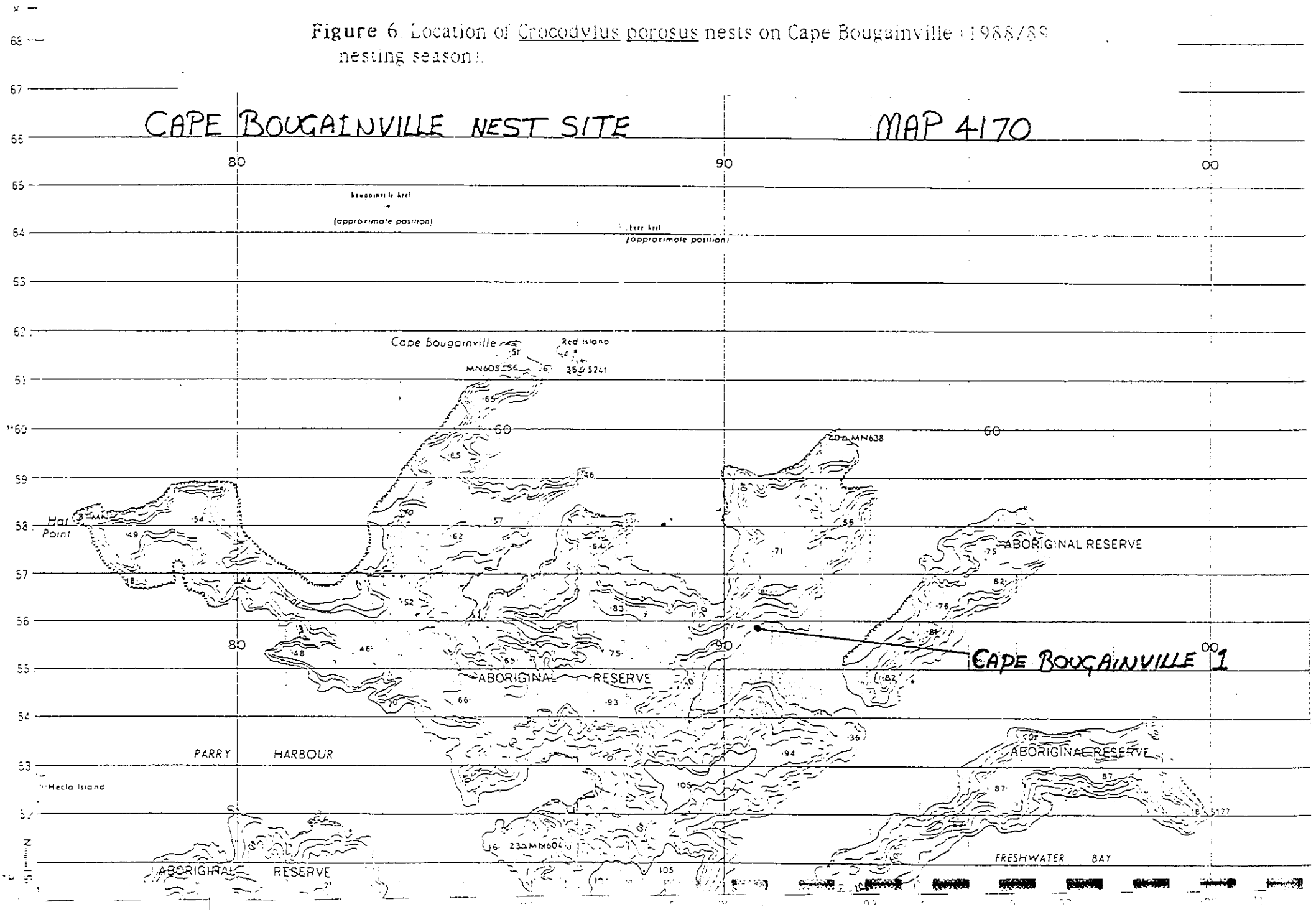


Figure 5. Location of Crocodylus porosus nests on the Drysdale River (1988/89 nesting season)

Figure 6. Location of Crocodylus porosus nests on Cape Bougainville (1988/89 nesting season).



NEST SITE IN
ADMIRALTY GULF CREEK

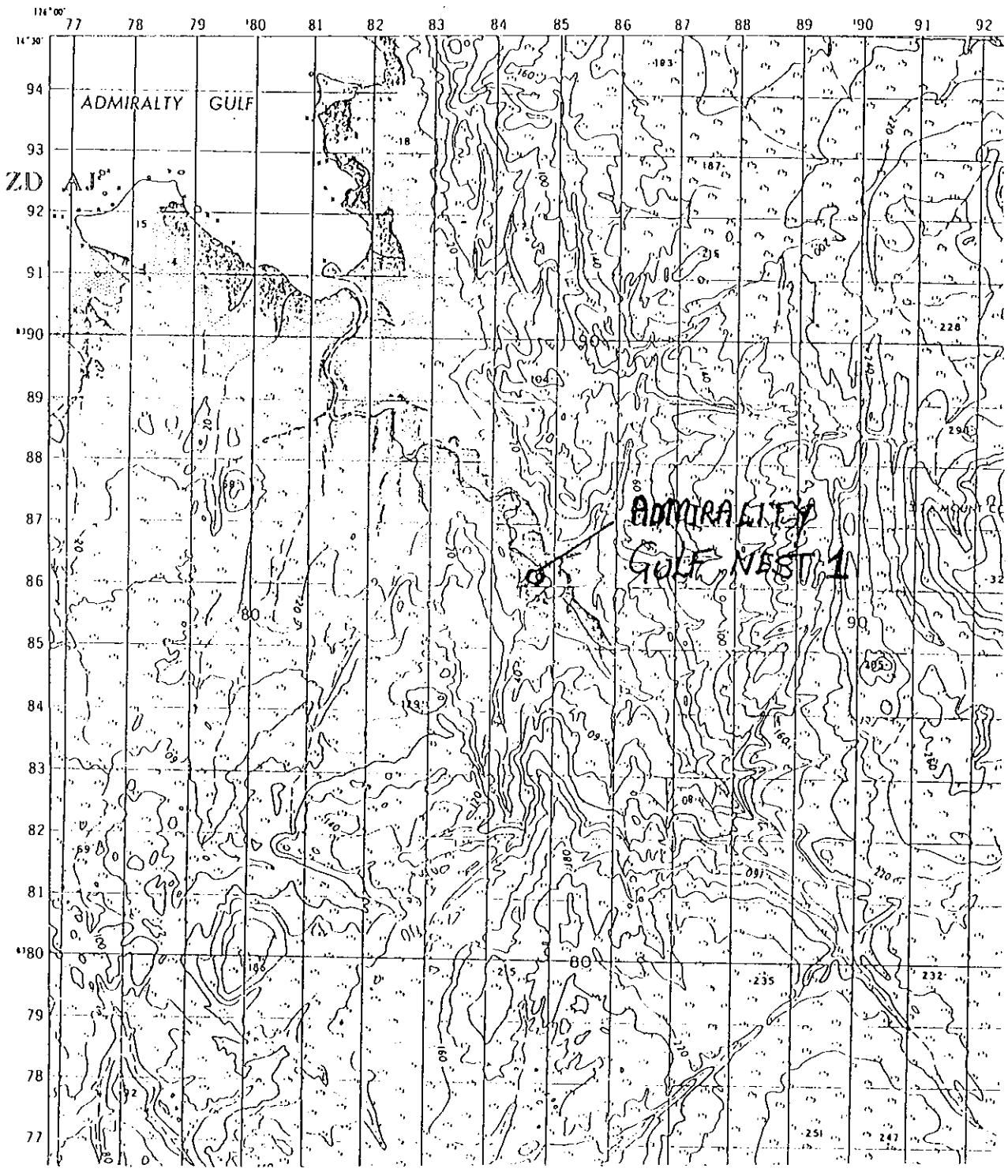


Figure 7. Location of Crocodylus porosus nests on the tidal creeks on the eastern side of Admiralty Gulf (1988/89 nesting season).

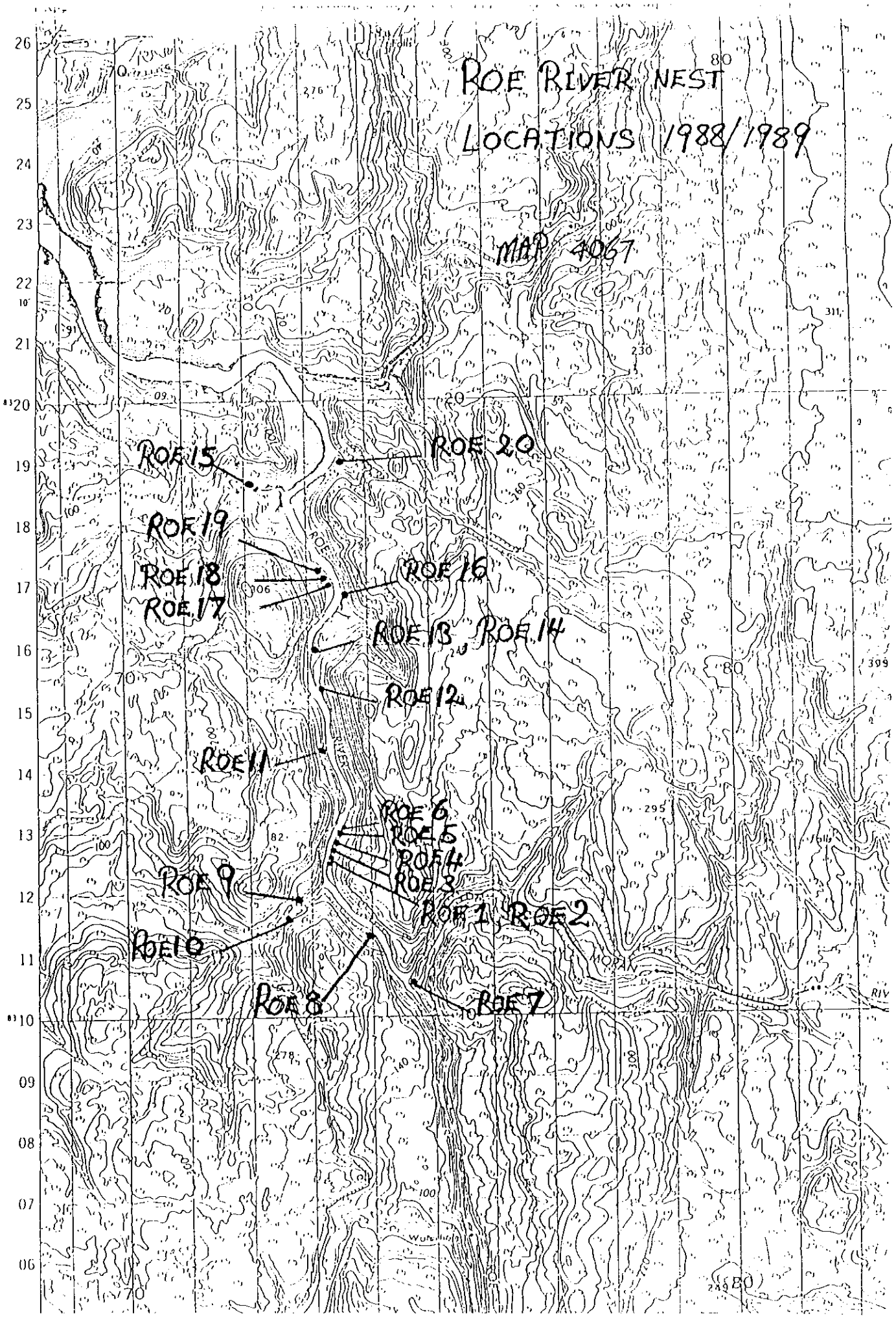


Figure 8. Location of Crocodylus porosus nests on the Roe River (1988/89 nesting season).

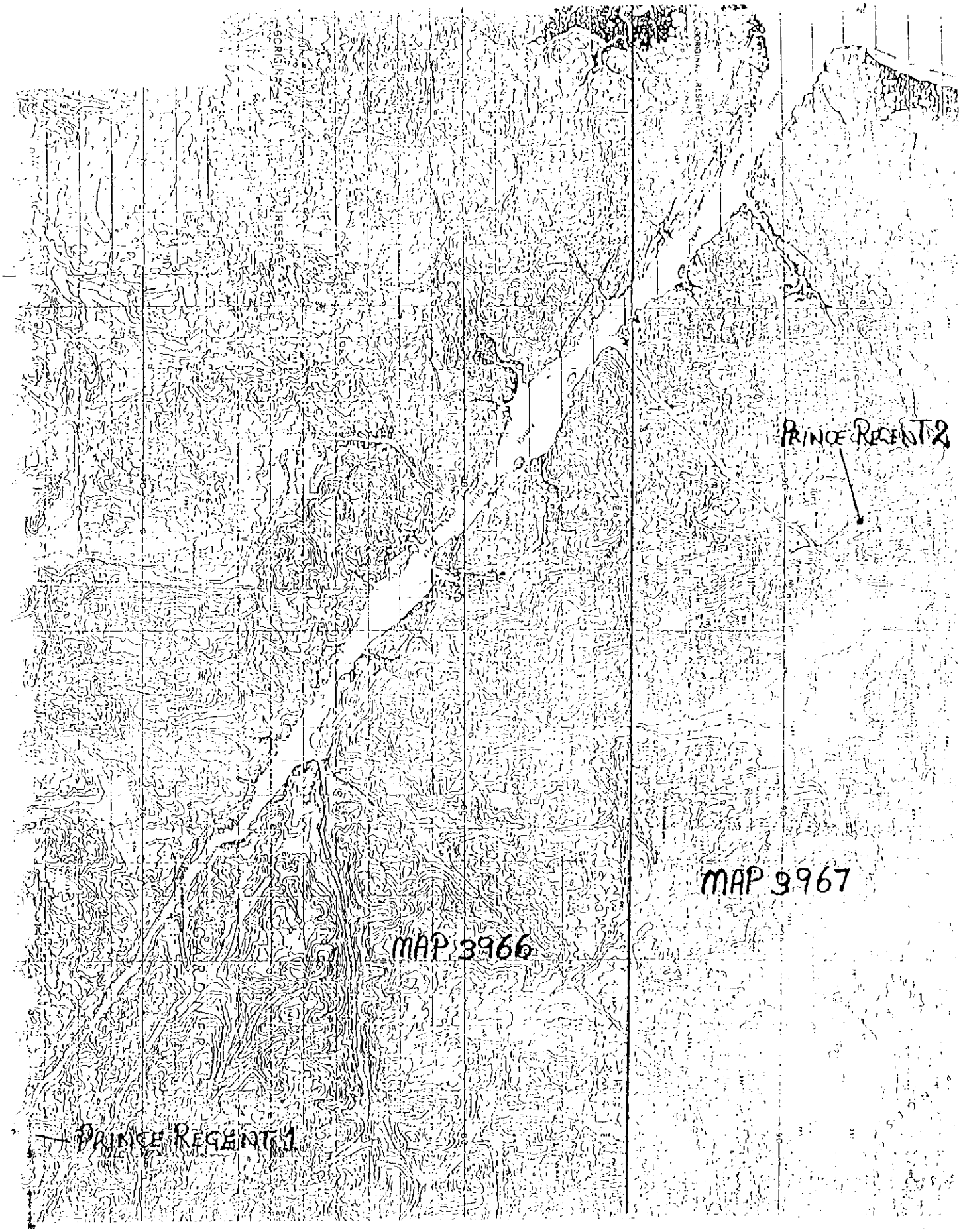


Figure 9. Location of Crocodylus porosus nests on the Prince Regent River [illegible] 1988/89 nesting season.

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Form CLM 80B

To: To: Chris Done

From: Russell Gueho

Your Ref:
Our Ref:
Enquiries:
Phone:

Re:Crocodile Nesting Survey 3/5/89

Subject:

A helicopter survey, in company with Brett Ottley (G.Webb & Associates) was undertaken in the following areas on 3/5/89.
No active nest were located.

1. Lower Ord River - False house Roof Hill to Fossil Island Group - no nests located.

2. Forrest River - no nests located.

3. King River - no active nests located.

4. Pentecost River - no nests located.

5. Durack River - no nests located.

See attached maps for areas surveyed.

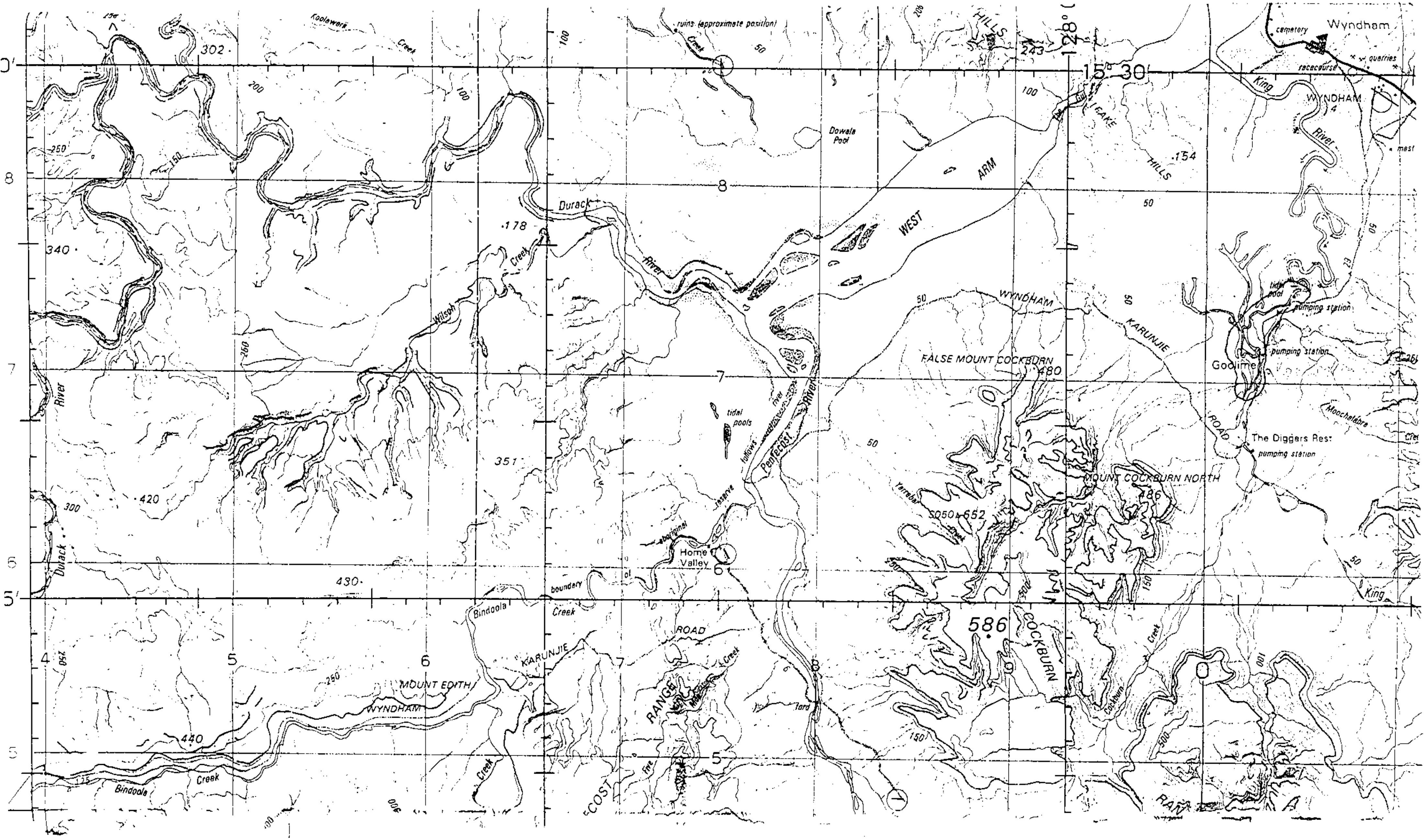
For your information.

Noted.
Done. 4/5/89.

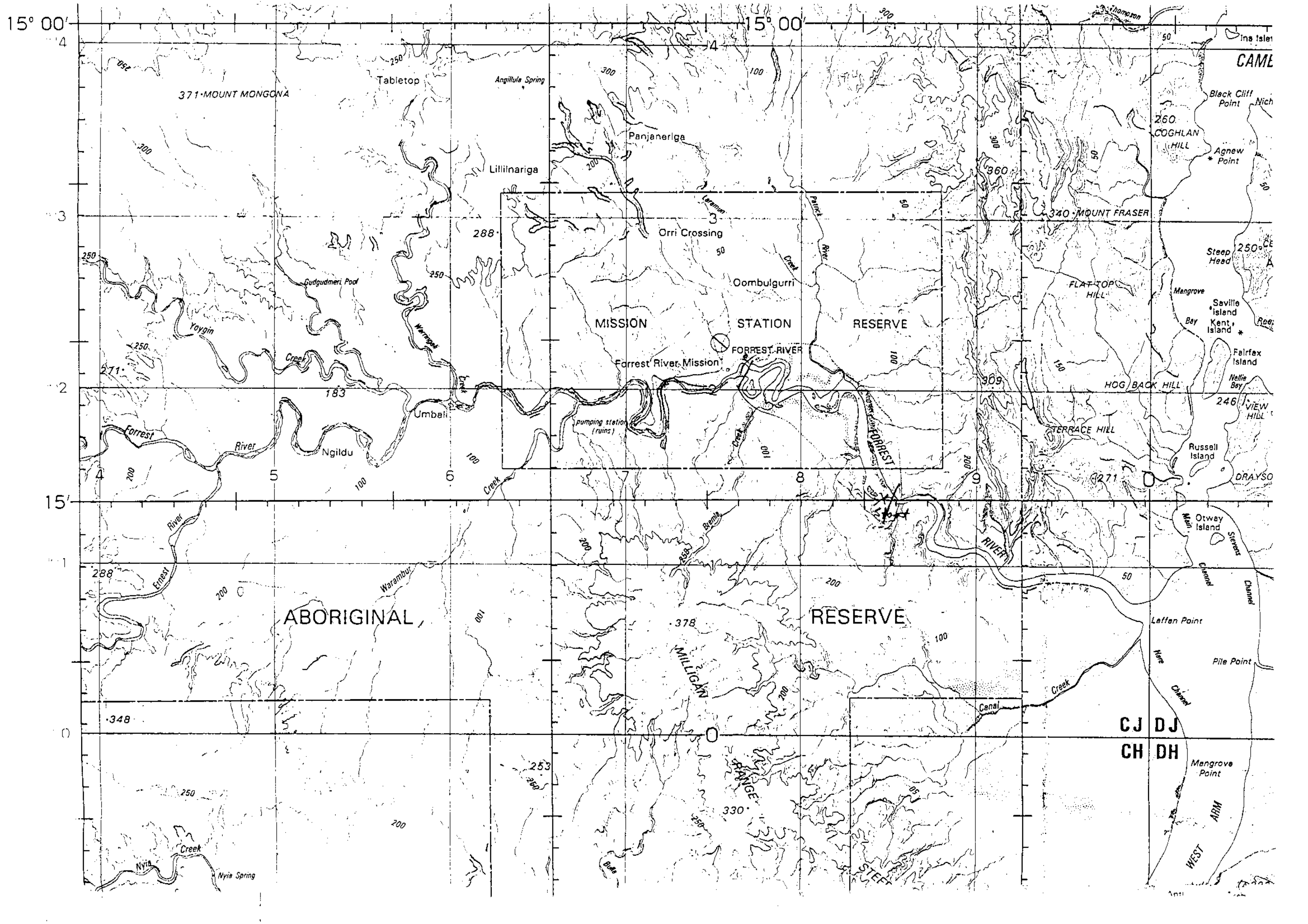
RGueho

R.GUEHO
DWO

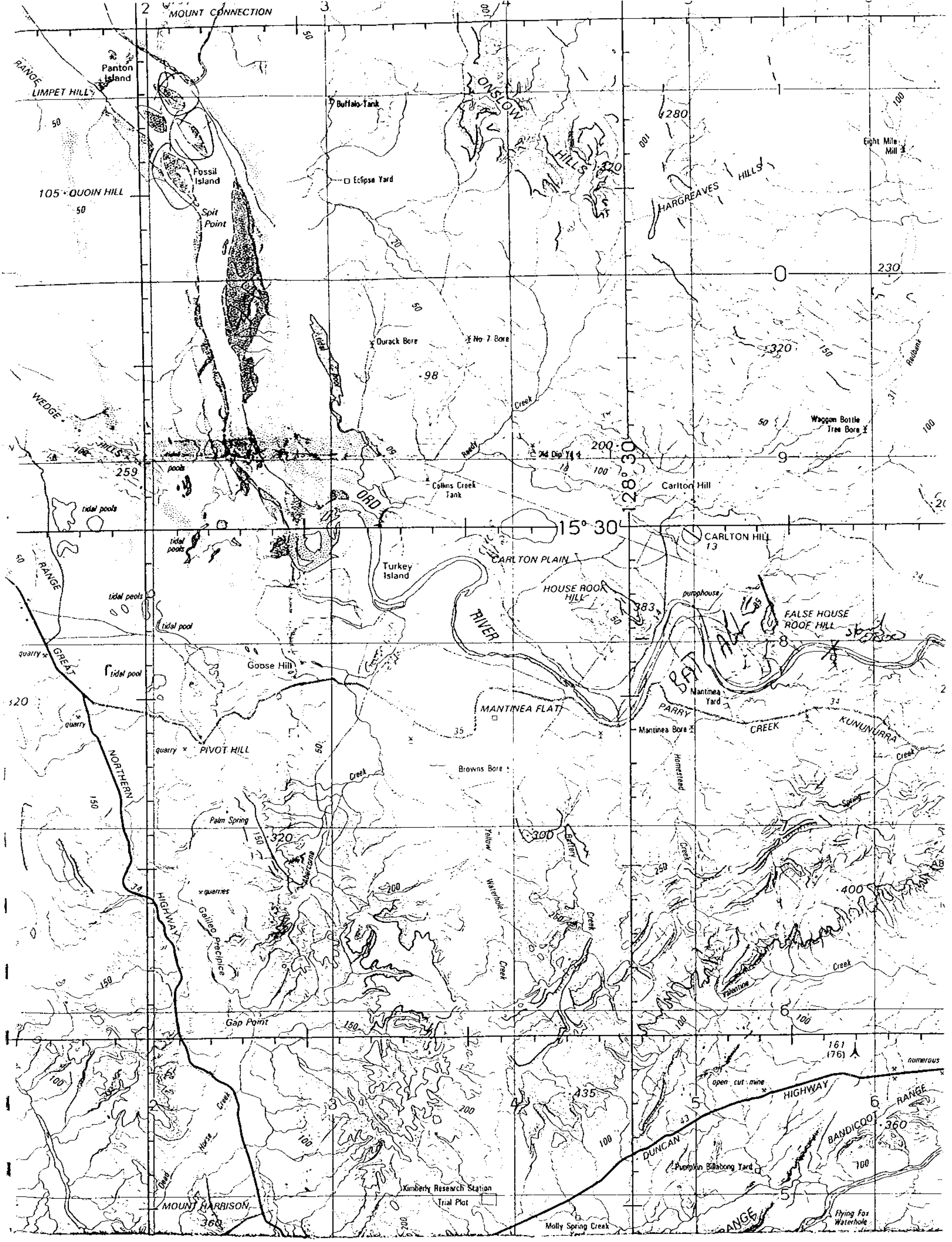
3/5/89
RG/df



Wyndham
cemetery
racecourse
quarries
WYNDHAM
King River
HILLS
FAKE HILLS
Dowala Pool
WEST ARM
Durack River
Wilson Creek
Koolawera Creek
ruins (approximate position)
tidal pools
Pentecost River
river follows
reserve boundary
aboriginal
Home Valley
FALSE MOUNT COCKBURN
MOUNT COCKBURN NORTH
COCKBURN
WYNDHAM KARUNJIE ROAD
Goolime
pumping station
The Diggers Rest
Moochalabra Creek
Yerrabah Creek
Bindoola Creek
KARUNJIE ROAD
MOUNT EDITH
WYNDHAM
PENTECOST RANGE
Five Mile Creek
Cockburn Creek
ford
15° 30'
128°



15° 00′
371·MOUNT MONGONA
Tabletop
Angillula Spring
Panjanerlga
Lillilnariga
Gudgudmeri Pool
Yaygin
Creek
Warringali
Umbali
Forrest
River
Ngildu
Orri Crossing
Oombulgurri
MISSION
STATION
RESERVE
FORREST RIVER
Forrest River Mission
pumping station (ruins)
FORREST
Patrick
River
Laramun
340·MOUNT FRASER
260
COGHLAN HILL
Agnew Point
Black Cliff Point
CAMB
Ina Islet
Thompson
Steep Head
FLAT TOP HILL
Mangrove
Bay
Saville Island
Kent Island
Fairfax Island
Nellie Bay
HOG BACK HILL
246
VIEW HILL
TERRACE HILL
Russell Island
DRAYSO
Otway Island
Main
Channel
Stevens
RIVER
15′
Ernest
Warambur
ABORIGINAL
RESERVE
Bremla
MILLIGAN
RANGE
Laffen Point
Hare
Pile Point
Canal
Creek
CJ DJ
CH DH
Mangrove Point
WEST ARM
Nyia
Nyia Spring
Butle
STEEP


MOUNT CONNECTION
Panton Island
RANGE
LIMPET HILL
Buffalo Tank
ONSLOW
HILLS
Eight Mile Mill
HARGREAVES
HILLS
Fossil Island
Eclipse Yard
105 · QUOIN HILL
Spit Point
Durack Bore
No 7 Bore
Creek
Reedy
WEDGE
HILLS
Waggon Bottle Tree Bore
Collins Creek Tank
Carlton Hill
tidal pools
ORD
15° 30'
128° 30'
CARLTON HILL
CARLTON PLAIN
Turkey Island
HOUSE ROOF HILL
pumphouse
FALSE HOUSE ROOF HILL
RIVER
tidal pools
tidal pool
quarry
GREAT
Goose Hill
Mantinea Yard
MANTINEA FLAT
PARRY
CREEK
KUNUNURRA
Mantinea Bore
quarry
NORTHERN
PIVOT HILL
Browns Bore
Palm Spring
Homestead
Yellow
Waterhole
Creek
Battery
quarries
HIGHWAY
Galileo Precipice
Valentine
Gap Point
numerous
open cut mine
HIGHWAY
RANGE
BANDICOOT
DUNCAN
Pumpkin Billabong Yard
Kimberly Research Station
Trial Plot
MOUNT HARRISON
Molly Spring Creek Yard
RANGE
Flying Fox Waterhole

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Form CLM 608

TO :REGIONAL MANAGER, KIMBERLEY
4 CHIEF WILDLIFE OFFICER, COMO
REF:156.1

File.

RE :ESTUARINE CROCODILE NESTING SITES

Melaris 31/1/89

On Monday and Tuesday January 23/24 1989, I attended a helicopter survey to locate estuarine crocodile nesting sites in the Kununurra/Wyndham areas.
The attached maps show the locations of ten(10) active nests, six of which are on the Ord River, and four of which are on the King River.
Complete flight details (in map form) are held in the regional office map cabinet for future reference.
Several of the nests were checked and eggs dated at approximately 60 to 65 days old. Females were in attendance at all nest sites.
The areas surveyed were -

1. Ord River, both east and west banks, from the Kununurra Diversion Dam up to and including Fossil Island, and the following tributaries of the Ord ; Reidy Ck.,Collins Ck. and swamp, Goose Hill Ck. and offshoot creek south of Turkey Island, tidal creeks north of Mount Connection, tidal pools south-east of Wedge Hills, the Ord River Nature Reserve mangrove and swamp area, Wild Goose swamp, and various waterways and swamps connecting Parry Lagoons Nature Reserve with the Ord River in flood.
2. The upper reaches of tidal Parry Creek.
3. The King River from approximately ten(10) kilometres upstream from the mouth (both banks of the river) to two(2) kilometres upstream of the King River pumping station including tidal overflows near Gooline, and west of the Moochalabra pumping station. Also Moochalabra Ck. up to the dam wall.
4. The west arm of Cambridge Gulf (south-east bank only) from Slaty Creek to the mouth of the Pentecost River.
5. The Pentecost River tidal areas up to the Gibb River road crossing (east and west bank) including Yanabar creek.
6. Durack River mouth entrance.
7. Nulla-Nulla Creek and Dowala pool.

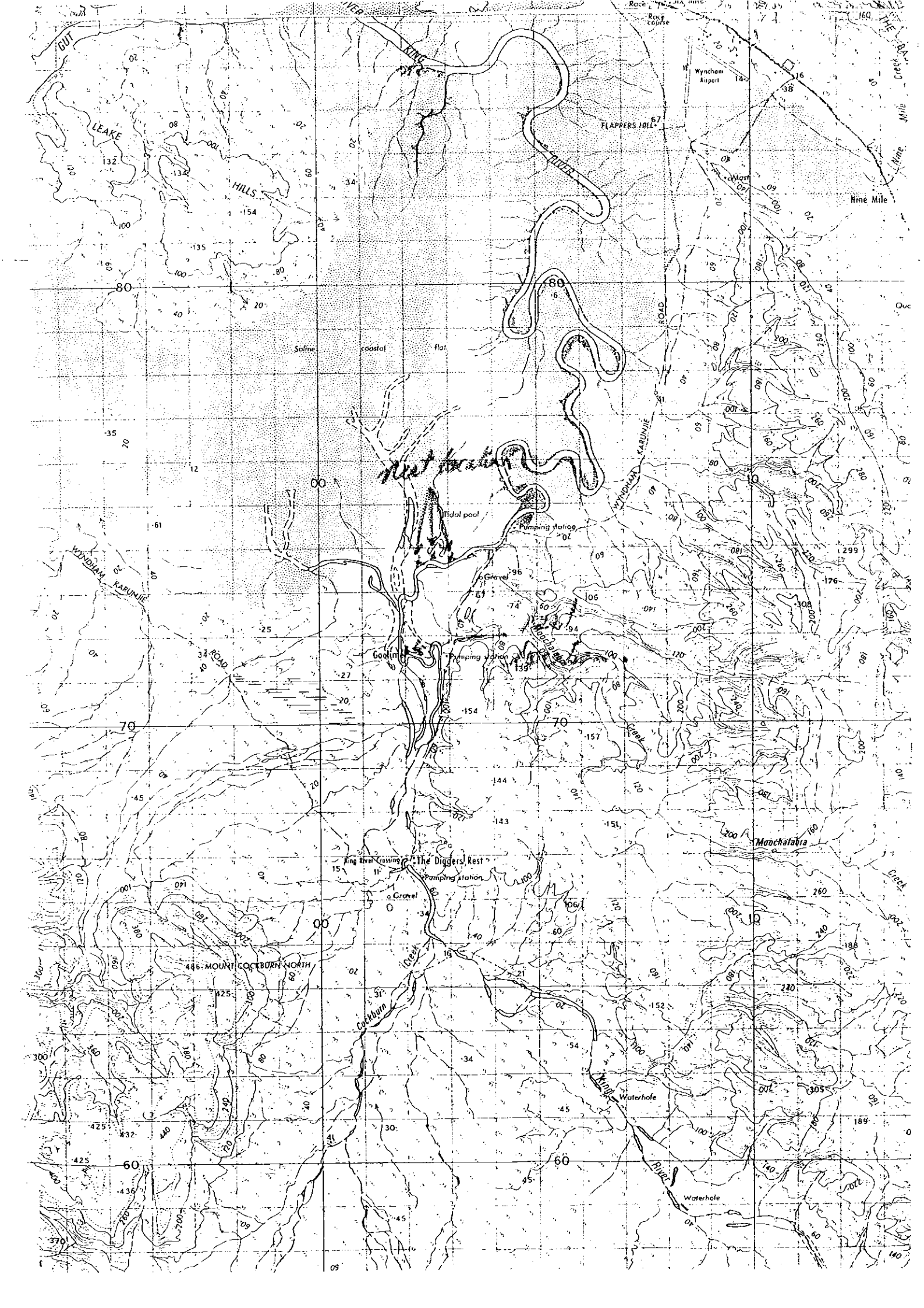
The Ord river nest sites were constructed with either mangrove litter,spikerush,dead Noogoora burr stalks and mud or a combination of these. They were amongst (mostly underneath) mangrove (sp. to be identified) in a patch of partially inundated spikerush (Eleocharis sphaceleta) mainly close to the river proper (10m), the furthest being about 50-60 m.from the water's edge. Each nest had a wallow within 2 to 3 m. of the nest mound, with another wallow nearby underneath dense vegetation.

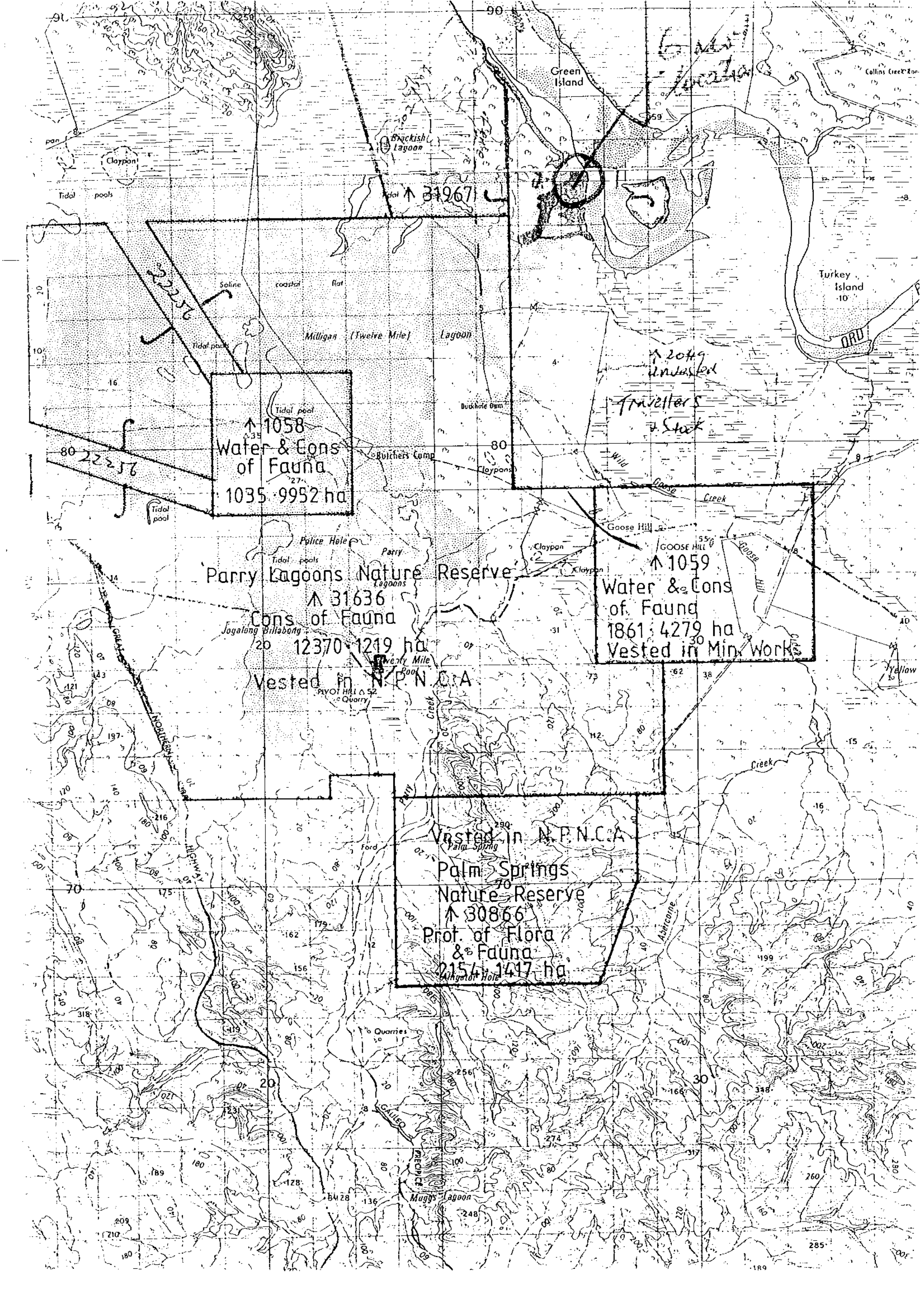
Dave Trish Mike

The King river nests were constructed of dead canegrass (Poaceae family) and mud within 3 m. of the high tide mark and under wattle (possibly A.holosericea).

Forwarded for your information.

M.G. OSBORN.
DISTICT WILDLIFE OFFICER, KUNUNURRA.
27/1/89.


GUT
LEAKE
HILLS
KING
RIVER
FLAPPERS HILL
Wyndham Airport
Nine Mile
Saline coastal flat
WYNDHAM KARUNJIE ROAD
Tidal pool
Pumping station
Gravel
Goodimbi
Mouchalabra
The Diggers Rest
King River Crossing
Pumping station
Gravel
Cockburn Creek
486 MOUNT COCKBURN NORTH
Waterhole
Waterhole


Green Island
Brackish Lagoon
Claypan
Tidal pools
↑ 31967
Turkey Island
ORD
Saline coastal flat
Milligan (Twelve Mile) Lagoon
22256
Tidal pool
↑ 1058
Water & Cons of Fauna
1035·9952 ha
22257
Butchers Camp
Buckhole Dam
↑ 20119 unvested
Travellers & Stock
Claypans
Goose Creek
Goose Hill
GOOSE HILL
↑ 1059
Water & Cons of Fauna
1861·4279 ha
Vested in Min. Works
Police Hole
Parry
Parry Lagoons Nature Reserve
↑ 31636
Cons of Fauna
12370·1219 ha
Vested in N.P.N.C.A
Jogalong Billabong
Twenty Mile Pool
PIVOT HILL
Quarry
GREAT NORTHERN HIGHWAY
Parry Creek
Vested in N.P.N.C.A
Palm Spring
Palm Springs Nature Reserve
↑ 30866
Prot. of Flora & Fauna
2154·1417 ha
Ford
Quarries
GALILEO PRECIPICE
Muggs Lagoon
Abercorn
Creek
Yellow