Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia

1 January 2009 – 31 December 2013

Department of
Environment and Conservation
Our environment, our future

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Department of Environment and Conservation
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6983
Phone: (08) 9334 0333
Fax: (08) 9334 0278
Email: info@dec.wa.gov.au
Website: www.naturebase.net

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Cover photo: Ord River crocodile, W.R. Kay

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DEFINITIONS

Draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008) – the current draft Code, that is yet to be endorsed by the natural Resource Management Ministerial Council (NRMMC). A reference to this Draft Code of Practice will also apply to any future nationally-endorsed subsequent Codes.

Ecologically sustainable development – this plan employs the definition contained in the *Environment Protection and Biodiversity Conservation Act 1999*. In general this definition includes the precautionary principle, inter-generational equity, conservation of biological diversity and ecological integrity, and improved valuation of environmental factors.

Crocodile – the crocodile species that can be utilized in accordance with this management plan: the saltwater crocodile (*Crocodylus porosus*) and freshwater crocodile (*C. johnstoni*), including their eggs.

Landholder – owner or occupier of specified lands.

Licensed Crocodile Farmer – the holder of a Licence to Farm Crocodiles issued under Regulation 14 of the *Wildlife Conservation Regulations 1970.*

Licensed Crocodile Processor – the holder of a Licence to Process Crocodiles issued under Regulation 7 of the *Wildlife Conservation Regulations 1970.*

Licensed Crocodile Taker – the holder of a Licence to Take Crocodiles (live animals and or eggs) issued under Regulation 15 of the *Wildlife Conservation Regulations 1970.*

Ranching – the rearing of wild caught crocodiles or eggs under controlled conditions such as in a licensed crocodile farm.

1. INTRODUCTION

This management plan has been developed to satisfy the requirements of the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and to meet the legislative and other requirements of the Western Australian Government.

This management plan relates only to the commercial harvest and farming of saltwater (*Crocodylus porosus*) and freshwater (*C. johnstoni*) crocodiles within Western Australia. Where the term crocodile is used in this document it refers to both the aforementioned crocodilian species.

This management plan is current for a maximum five-year period from 1 January 2009 to 31 December 2013.

In Australia the export of crocodile products requires Commonwealth Government approval under the EPBC Act.

In Western Australia, all native fauna are protected under the *Wildlife Conservation Act 1950* (WC Act), which is administered by the Department of Environment and Conservation (DEC). The utilization of protected fauna requires the issue of a licence under Regulation 15 of the *Wildlife Conservation Regulations 1970.* The commercial harvest of crocodiles in Western Australia is regulated via the issue of various licences and royalty tags under provisions of the Wildlife Conservation Act. This legislative framework applies to the entire State of Western Australia.

This management plan does not provide the framework for the management of crocodiles on lands vested in the Conservation Commission of Western Australia under the *Conservation and Land Management Act 1984* (CALM Act) and managed by DEC e.g. national parks, nature reserves, conservation parks. Crocodiles cannot usually be taken for commercial purposes in such areas, which comprise a total area in excess of 24 million hectares or approximately 9.8 percent of the State.

This plan relates only to the commercial harvest and farming of crocodiles within Western Australia. DEC regulates the management of dangerous crocodiles for the protection of human life through provisions of the Wildlife Conservation Act, and specifically Regulation 4 (Licence to Take Dangerous Fauna) of the Wildlife Conservation Regulations.

The primary goal of the management plan is to ensure that the commercial harvest of crocodiles from the wild is ecologically sustainable. This will be achieved through the application of the best available scientific knowledge, best practice management and monitoring of outcomes to ensure the viability of crocodile populations is not compromised by any action undertaken in accordance with this plan.

This management plan incorporates an adaptive approach to management. Adaptive management is the systematic acquisition and application of reliable information to improve management over time. The adaptive management provisions of this plan facilitate the investigation of different strategies using scientifically rigorous experimentation to not only support appropriate adjustments to management practices, but to improve knowledge and inform future program reviews.

This plan will set the framework for the commercial harvest of crocodiles to provide for the management of crocodile populations in accordance with the principles of *ecologically sustainable development*. Management in this context provides for the sustainable harvesting of crocodiles for incorporation into the breeding and rearing stocks of licensed crocodile farms in Western Australia and the subsequent processing of products such as meat and leather to supply the Australian and international markets. Management also assists in balancing environmental, social and economic interests through the collaborative management of a sustainable resource.

2. LEGISLATIVE FRAMEWORK

2.1. Commonwealth

The relevant provisions under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) came into force on 11 January 2002, following the incorporation of the former *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. The EPBC Act has legislative provisions requiring the development and approval of wildlife trade management plans in order for permits to be issued for the commercial export of wildlife products.

The EPBC Act states that the Commonwealth Minister responsible for the Environment and administering the EPBC Act may approve a wildlife trade management plan for a maximum of five years. The EPBC Act specifies that such approval must only be given if the Minister is satisfied that:

(a) the plan is consistent with the objects of Part 13A of the EPBC Act;
(b) an assessment of the environmental impacts of the activities of the plan has been undertaken;
(c) the plan includes management controls directed towards ensuring that the impacts of the activities covered by the plan are ecologically sustainable;
(d) the activities in the plan are not detrimental to the species to which the plan relates or any relevant ecosystem; and
(e) the plan includes measures to mitigate, monitor and respond to the environmental impacts of the activity covered by the plan.

In deciding whether to approve a plan, the Minister must also have regard to whether:

(a) legislation relating to the protection, conservation or management of the specimens to which the plan relates is in force in the State or Territory concerned; and
(b) the legislation applies throughout the State or Territory concerned; and
(c) in the opinion of the Minister, the legislation is effective.

Finally, in resolving whether to approve a plan the Minister must also be satisfied that if an animal is killed, it is done in a way that is generally accepted to minimize pain and suffering. Animal welfare standards for the humane treatment of crocodiles are detailed in the draft *Code of Practice on the Humane Treatment of Captive and Wild Australian* Crocodiles (revised April 2008) (see http://www.environment.gov.au/biodiversity/trade-use/publications/crocodile/index.html ; Appendix 1). All crocodiles must be taken in accordance with this draft Code or any subsequent relevant nationally-endorsed codes that replace that document.

2.2. Western Australia

In Western Australia, all native fauna, including both species of crocodile, are protected by the *Wildlife Conservation Act 1950*. The *Wildlife Conservation Act 1950* and associated *Wildlife Conservation Regulations 1970* make provisions for the licensing of a range of activities relating to the commercial harvesting of native fauna including crocodiles.

Crocodiles can only be taken in accordance with this management plan under a licence issued by DEC. Moreover, under this management plan the commercial harvesting of crocodiles in Western Australia is limited to the current distribution as illustrated in Figure 1.

The licensing process as it relates to crocodile harvesting is summarized in a flow chart (Figure 2) and described in more detail below. The licensing process commences with a crocodile taker applying for a *Licence to Take* Crocodiles. Other activities associated with the commercial utilization of crocodiles require licences specific to those activities such as Farmers' and Processors' licences.

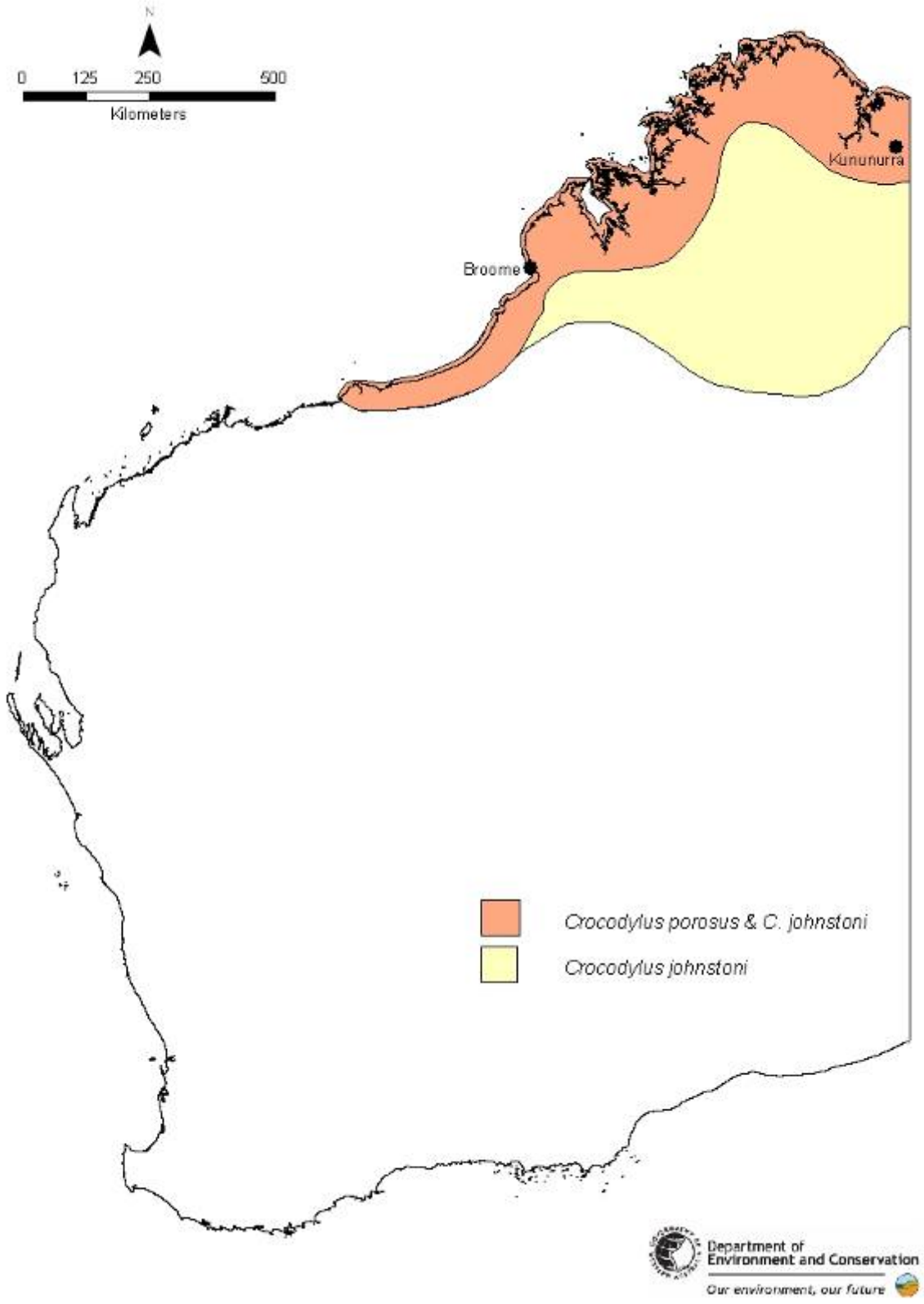

Figure 1. Saltwater and Freshwater crocodile distribution in Western Australia.

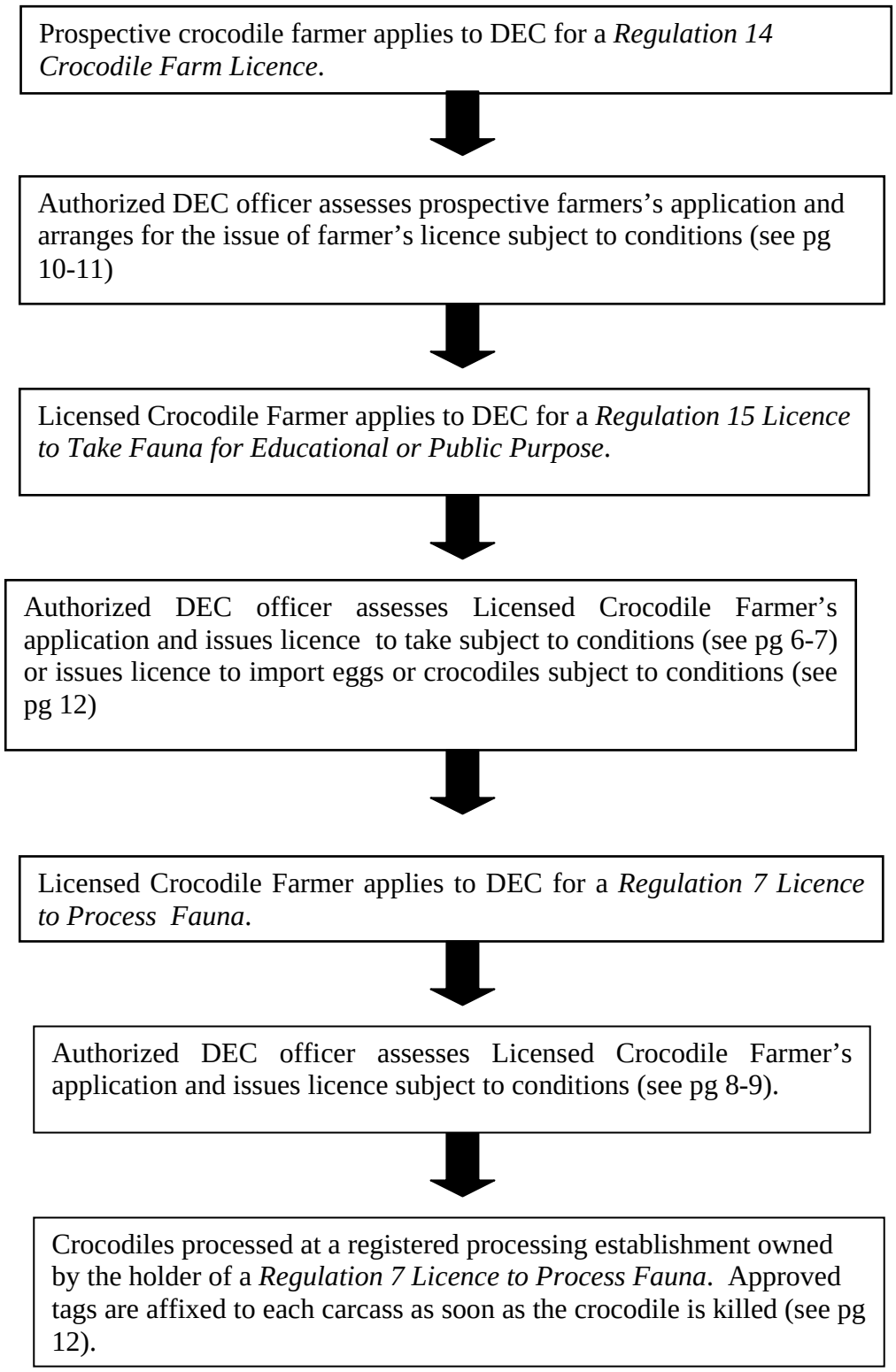

Figure 2. Western Australian licensing flowchart.

LICENCE TO TAKE CROCODILES
(Crocodile Taker's Licence)

Issued under Regulation 15 of the *Wildlife Conservation Regulations 1970*

The licence holder may take (and transport) crocodiles by means of the collection of eggs, hatchlings, sub-adults or adults by hand, noose, harpoon or trap as described in the draft Code of Practice.

Before approving an application for a Crocodile Taker's Licence, an authorized DEC officer will ensure that the applicant can provide evidence of the necessary competencies in the capture, handling, restraint and transport of crocodiles and their eggs:

Crocodile Takers' Licences are subject to conditions[1] that include, but are not limited to:

1. The Licensee shall comply with the provisions of the Wildlife Conservation Act and Regulations and any notices in force under this Act and Regulations.
2. Unless specifically authorised in the conditions of this licence or otherwise in writing by the Director General, species of fauna declared as likely to become extinct, rare or otherwise in need of special protection shall not be captured or otherwise taken.
3. No entry or collection of fauna to be undertaken on any private property or pastoral lease without the consent in writing of the owner or occupier, or from any Aboriginal Reserve without the written approval of the Department of Indigenous Affairs.
4. No fauna shall be taken from any nature reserve, wildlife sanctuary, national park, marine park, timber reserve or State forest without prior written approval of the Director General. No fauna shall be taken from any other public land without the written approval of the government authority managing that land.
5. No fauna or their progeny shall be release in any area where it does not naturally occur, nor handed over to any other person or authority unless approved by the Director General, nor shall the remains of such fauna be disposed of in such manner as to confuse the natural or present day distribution of the species.
6. This licence and written permission referred to at conditions 3 & 4 must be carried by the licensee or authorised agent at all times for the purpose of proving their authority to take fauna when questioned as to their right to do so by a Wildlife Officer, any other State of Local Government employee or any member of the public.
7. The licensee is required to give 3 days prior notice of any proposed collection of crocodiles to the Department of Environment and Conservation (DEC) Kimberley Regional Manager (or the District Wildlife Officer), telephone. 08 9168 4200 or fax.08 9168 2179.
8. No crocodiles are to be collected by the licensee prior to approval being given by the DEC Kimberley Regional Manager (or District Wildlife Officer) for both the dates and general location of proposed collections.
9. Within 14 days of the conclusion of capture of crocodiles or at the expiration of this licence (whichever occurs first), or at such time as the Director General may determine, the licensee shall furnish to the DEC Kimberley Region Manager and Director General copies of a full report on all crocodiles taken under this licence, using the Crocodile Capture Return Forms and marking individual capture locations on appropriate maps. Licences are unlikely to be renewed after expiry, if such returns are not provided.
10. The licensee shall comply with any direction concerning the taking of crocodiles given by the DEC Kimberley Regional Manager or by the District Wildlife Officer.
11. All crocodiles taken under this licence are to be scute marked following the scute marking guidelines of December 2008.

Saltwater Crocodiles

12. The Saltwater Crocodiles taken under this licence are for breeding purposes only and are not to be processed without the written permission of the Director General of DEC, citing the individual scute numbered crocodiles that may be so processed.

[1] *Note: any changes to licence conditions must be consistent with the requirements set out in this management plan.*

LICENCE TO PROCESS
(Crocodile Processor's Licence)

Issued under Regulation 7 of the *Wildlife Conservation Regulations 1970*

The licence holder may process crocodile carcasses.

Licences to Process fauna are subject to conditions[1] that include, but are not limited to:

1. The licensee shall comply with the provisions of the Wildlife Conservation Act and Regulations and any notices in force under this Act and Regulations.
2. Records of returns shall be maintained at the processing works and be available for inspection by officers of the Department of Environment and Conservation.
3. Returns detailing the processing carried out during the month shall be forwarded to the Director General by the fifteenth (15) day of the following month.
4. This licence shall be displayed in a prominent position in the premises at the property specified on the licence.
5. The only crocodiles that may be processed are those lawfully held by the licensee under a Regulation 14 licence or have been imported under licence into Western Australia.
6. Further to condition 1, only crocodiles which have been taken from the wild for ranching purposes, bred in captivity or imported under licence may be processed. Crocodiles taken from the wild for breeding purposes under a Regulation 15 licence may not be processed unless they have died accidentally during normal farming operations.
7. Where a crocodile has been taken and processed in accordance with conditions 2 and 5, the licensee shall ensure the skin is immediately affixed with an approved tag.
8. Crocodile flesh is to be packaged in a manner that permits identification of individual carcasses as approved by the Director General.
9. The processor shall advise the Director General in writing by 30 September of each year of the number of crocodiles of each species expected to be processed in the next calendar year. Where a licence to process is taken out after 30 September, the processor shall provide an estimate of the number of crocodiles of each species to be processed in the forthcoming calendar year within one month of receipt of this licence.
10. A crocodile processed under this licence shall not be used or sold for human consumption unless the manner of processing complies with Local Authority by-laws and any Health Act or similar statutory requirements.
11. Further to condition 6 above, the licensee shall not process any crocodile under the authority of this licence unless the processing is lawful through any obligation conferred or imposed on him by or under any Act or agreement to which the State is a party and which is ratified or approved by an Act.
12. The licensee shall maintain in duplicate, complete daily records, by species, of crocodiles processed under this licence using the appropriate Crocodile Processing Record Form approved by the Director General.
13. Within 15 days of the end of each month the licensee shall forward the original records referred to in condition 8 above for crocodiles processed during each month. Duplicate copies of the records are to be kept at the processing establishment for inspection as required by a Wildlife Officer.

[1] *Note: any changes to licence conditions must be consistent with the requirements set out in this management plan.*

Further to this, sub-regulations 7-11(b) inclusive of Regulation 7 set out the manner in which crocodile carcasses and skins are to be marked/tagged, and prohibit the possession or disposal of any unmarked/tagged carcasses or skins.

LICENCE TO FARM AND BREED CROCODILES FOR SALE AND COMMERCIAL DISPLAY
(Crocodile Farmer's Licence)

Issued under Regulation 14 of the Wildlife Conservation Regulations 1970

The licence holder may farm captive-bred and ranch wild-caught crocodiles or eggs.

Licences to Farm crocodiles are subject to conditions that include, but are not limited to:

1. The licensee shall comply with the provisions of the *Wildlife Conservation Act* and *Regulations* and any notices in force under this Act and Regulations.
2. The maximum number of each species specified below may be varied subject to lawful acquisition and breeding.
3. Wherever the words crocodile or crocodiles appear on this licence those words shall mean the taxa known as *Crocodylus porosus* and *Crocodylus johnstoni*.
4. Live crocodiles shall not be obtained, accepted, transferred, sold or otherwise disposed of by the licensee or any person operating under the licensee's authority unless the licensee has:
   4.1 first obtained in writing the consent of the Director General to do so; or
   4.2 complied with condition number 9 of this licence.
5. The licensee shall apply in writing to the Director General to obtain the consent referred to in condition 4.1.
6. Crocodiles shall not be processed by the licensee unless he has been issued a Licence to Process crocodiles in accordance with Regulation 7 of the *Wildlife Conservation Regulations*.
7. Where the licensee is also licensed to process crocodiles in accordance with Regulation 7 of the *Wildlife Conservation Regulations*, the provisions of part 4.1 of condition 4 of this licence do not apply provided that crocodiles processed are obtained or accepted in accordance with the Regulation 7 Licence to Process held by the licensee.
8. Crocodiles shall not be taken from the wild, whether from Crown land or private land, without the authority of a licence to do so issued in accordance with the Act.
9. The licensee shall provide such care and supervision as is necessary to comply with condition numbers 10, 11 and 12 of this licence.
10. Crocodiles held under this licence shall be provided with adequate shelter, food and water and with clean surroundings in accordance with the *Wildlife Conservation Regulations* and the Code of Practice.
11. The licensee shall secure the services of a qualified veterinarian for the treatment of diseased or injured crocodile stock.
12. Crocodiles held under this licence shall be kept under secure conditions and shall not be able to escape.
13. The condition and specifications for the holding of crocodiles under this licence may be varied at the discretion of the Department of Environment and Conservation (DEC) and the licensee shall immediately comply with any direction given by the Department which varies such conditions and specifications.
14. The licensee shall ensure that husbandry methods in respect of the crocodiles shall comply with any standards set by the Director General and without limiting the generality of the above, such standards shall apply to food, water, pen design and temperature control.
15. The Licensee shall report deaths of crocodiles as soon as possible and take action to preserve any carcass for post-mortem examination, if required by DEC.
16. The Licensee shall maintain suitable accommodation to receive problem crocodiles from DEC without prior notice.
17. A book of stock records shall be kept and made available for inspection at all times and the licensee shall cause, on a daily basis, to have entered therein:
    17.1 The name, address and licence number of the licensed crocodile farmer or any other approved licensee from whom crocodiles were received and the condition, sex, length, age,

and place of origin of the crocodiles received;

17.2 Similar entries shall be made in respect of any crocodiles disposed of in accordance with condition number 5 of this licence;

17.3 Details of any other stock acquisitions taken from the wild under licence from DEC or from the problem crocodile program (condition 16) including the length, sex and precise location of taking from the wild;

17.4 Details of stock increases through breeding and stock decreases through deaths, stipulating whether the cause of death was by natural causes; predation; slaughter for processing; euthanasia due to disease; injury or congenital defect; or any other cause.

18. The licensee shall record in duplicate details of crocodile stock on the monthly crocodile return forms supplied by the Director General and shall furnish the original monthly return to the Director General within fifteen (15) days of the end of the calendar month to which it pertains.
19. Any chiller unit used for the holding of the carcasses of crocodiles shall be registered with the DEC.
20. For inspection purposes, the licensee shall allow officers of DEC access to the crocodile farm and the crocodiles to which this licence pertains.
21. Day to day or routine type enquiries related to the operation of this licence shall be made through the District Wildlife Officer.
22. The licensee shall comply with all Local Authority by-laws and zonings and any Health Act requirements.

[1] *Note: any changes to licence conditions must be consistent with the requirements set out in this management plan.*

LICENCE TO EXPORT OR IMPORT FAUNA

Issued under Regulation 18 (Export) and 19 (Import) of the *Wildlife Conservation Regulations 1970*

The licence holder may export or import crocodiles and crocodile products.

Licences to Export or Import Fauna are subject to conditions[1] that include, but are not limited to:

1. Every consignment of crocodiles or crocodile products must be accompanied by an export or import licence issued by the Department of Environment and Conservation.
2. Licenses are valid only for single consignments and for the date(s) specified on the licence.
3. Licenses to export crocodiles or crocodile products will be issued only if the relevant authority in the State or Territory to which the consignment is destined approves the importation of the fauna to that State or Territory.
4. The consignment specified in the licence is derived from fauna taken in accordance with an approved management program for the species specified.

NB: Export of crocodile products from Australia requires a separate permit issued by the Commonwealth Department of the Environment, Water, Heritage and the Arts.

[1] *Note: any changes to licence conditions must be consistent with the requirements set out in this management plan.*

TAGS

Under Regulation 50 of the *Wildlife Conservation Regulations 1970*, crocodile skins or carcasses cannot be bought, sold, transported or held in possession unless a tag has been affixed to the skin or carcass.

Licensed crocodile processors must attach tags to the skin or carcass of commercially processed crocodiles as a condition of their licence. Tags are obtained from DEC and supplied by DEWHA.

Tags:

- Are coded for the species being processed;
- Are individually numbered with a year designation;
- Are issued to a specific licensed crocodile processor and are not transferable;
- Must be attached to the skin (raw, tanned or finished) or carcass of crocodiles that are commercially processed prior to exporting; and
- Have a self-locking mechanism that can only be removed by cutting the tag, skin or carcass.

3. BIOLOGY, ECOLOGY AND CONSERVATION OF CROCODILES

3.1 Biology and ecology

Cogger (1993) provides a general description of Crocodilia; Grigg and Gans (1993), Cooper-Preston and Jenkins (1993) and Molnar (1993) discuss morphology, physiology, natural history, biogeography and phylogeny. Detailed discussion of many topics concerning crocodile biology may be found in Webb *et al.* (1987).

Considerable research has been conducted into the biology and status of *C. porosus* and *C. johnstoni* in northern Australia, particularly in the Northern Territory. Their biology, population dynamics, recovery since protection and management have been the subject of intensive research efforts over the last 30 years, the details of which are contained in a variety of publications (e.g. Magnusson 1980; Bayliss and Messel 1990; Messel and Vorlicek 1985, 1986; Webb *et al.* 1984, 1987; Webb and Manolis 1989, 1992; Mawson 2004; Fukuda *et al*. 2007).

3.1.1 Diet

The diets of *C. porosus* vary with the size of individuals. Hatchlings feed mainly on small crabs, prawns and insects (Webb and Manolis 1989). Crabs and prawns are the major food items in tidal rivers for crocodiles up to 2 m long. With increasing size, crocodiles feed on a greater variety of food items and the diet of crocodiles over 2 m long includes fish, crabs, turtles, birds and mammals. Large prey such as cattle and horses are eaten only by the largest of crocodiles. Large crocodiles will also scavenge.

The diets of *C. johnstoni* is largely a piscivorous (fish-based) one. However, a wide variety of other prey items are taken including aquatic and terrestrial invertebrates and small vertebrates such as frogs and tadpoles (Webb *et al.* 1983a).

3.1.2 Nesting ecology

The breeding season of *C. porosus* occurs during the wet season between October and May. Females construct a mound of grasses and reeds that is typically located close to permanent water (Webb *et al.* 1977). Freshwater swamps near tidal rivers and saltmarsh habitats are the most frequently used nesting habitats. Mangrove swamps are rarely used for nesting. The extent and timing of nesting is related to rainfall and water levels in the late dry season. Years with high rainfall and cool conditions between August and November are associated with high nesting effort. Conversely, years with poor rainfall and hot conditions between August and November are associated with low nesting effort.

The average clutch size of *C. porosus* is 53.1 eggs (Webb *et al.* 1983b). The size of the clutch is proportional to the size of the individual. The clutch of first-time breeders is normally around 30 eggs. Large crocodiles produce larger eggs than smaller crocodiles. Around 6.5% of eggs that are laid are infertile. *Crocodylus porosus* eggs suffer high mortality. Flooding of the nest is the major cause of egg mortality and may kill over 50% of the eggs laid each year (Magnusson 1982).

Freshwater crocodiles nest in sandy banks along river edges towards the end of the dry season (July-September). Clutch size averages 13 eggs (Webb *et al.* 1983c), ranging from 4-20. Predation by varanids, flooding and overheating appear to be the biggest causes of egg mortality (Webb *et al.* 1983c).

3.1.3 Survivorship and growth

There is a high mortality rate of crocodiles from egg to maturity. Webb and Manolis (1993) predicted rates of survival for several size classes of *C. porosus* in the wild: at least 30% of eggs usually hatch; 12% of hatchlings survive to one year; 85% of one year old crocodiles survive to two years; 85% of two year olds survive to three years of age; 85% of three year olds survive to four years of age; 85% of four year olds survive to five years of age. It is estimated that less than one percent of eggs survive to maturity. It follows that about 18 crocodiles would survive to five years from 1000 eggs laid, and

similar survival rates have been estimated for *C. johnstoni* (Webb and Smith 1984). The actual rates of survival between age five years of age and maturity have never been estimated. Webb and Manolis (1993) predict that less than one per cent survive to breed. The survival rate of mature animals is unknown. Females normally reach maturity at 2.3 m total length and approximately 12 years of age. Males mature at around 3.35 m and about 16 years of age. The normal maximum size of *C. porosus* is around 4.6 to 5.2 m for males and 3.1 to 3.4 m for females. *Crocodylus porosus* may live for more than 50 years.

3.2 Distribution

C. porosus are found in most of the major river systems of the Kimberley including the Ord, Patrick, Forrest, Durack, King, Pentecost, Prince Regent, Lawley, Mitchell, Hunter, Roe and Glenelg Rivers and Parrys Creek. The largest populations occur in the rivers draining into the Cambridge Gulf, the Prince Regent and the Roe River systems of the east and northwest Kimberley. Much lower densities occur in the rivers draining into King Sound and Stokes Bay in the west Kimberley. Lone male crocodiles have also been recorded as resident in isolated rivers in the Pilbara region including the Sherlock River. Vagrant crocodiles have been recorded in marine habitat at Derby, Broome (Cable Beach and Willies Creek) and as far south as Carnarvon on the mid-west coast.

Nesting habitat for *C. porosus* is limited and only the Ord, King and Roe River systems support suitable vegetation for nesting to significant level. A few nests have been recorded in other river systems such as the Drysdale and Prince Regent Rivers and Admiralty Gulf Creek. *C. porosus* occur in four of the ten conservation reserves >2,000 ha in area in the Kimberley that have rivers running through them (Table 1).

Table 1. Existing Western Australian conservation reserves where crocodiles occur.

Conservation Reserve	Area (ha)	*C. porosus*	*C. johnstoni*
Prince Regent Nature Reserve	634,952	Present**	Present**
Geikie Gorge National Park and Conservation Park	8,468	Absent	Present**
Drysdale River National Park	448,264	Absent	Present**
Ord River Nature Reserve	79,842	Present**	Present(*)**
Parry Lagoons Nature Reserve	36,111	Present**	Present
Purnululu (Bungle Bungle) NP/CP	319,325	Absent	Present**
Windjana Gorge National Park	2,134	Absent	Present**
Coulomb Point Nature Reserve	28,676	Present(*)	Absent
Brooking Gorge CP	7,967	Absent	Present**
Tunnel Creek NP/Devonian Reef CP	41,462	Absent	Present**

(*): indicates that the species occasionally occurs in the reserve.
**: indicates that the species breeds in the reserve.

C. johnstoni occupies the same river systems as *C. porosus* in the Kimberley region, with most animals occurring above waterfalls that exclude the larger species. *C. johnstoni* is also common in the Fitzroy River system. This species has also established large populations with the creation of two dams that impound sections of the Ord River to form Lakes Kununurra (N>7,500) and Argyle (N>25,000). *C. johnstoni* breeds in all of the river systems where it occurs. Freshwater crocodiles occur in all ten of the conservation reserves >2,000ha in area in the Kimberley that have rivers running through them.

3.3. Conservation Status

The conservation status of the commercially harvested crocodile species in Western Australia largely reflects their former abundance and historical utilization. Both commercially harvested crocodile species in Western Australia are currently listed as a 'Other Specially Protected Fauna' under the provisions of the *Wildlife Conservation Act*, but are not listed under the EPBC Act (Table 2). In addition, the World Conservation Union (IUCN) Red List of Threatened Species identifies both of the crocodile species subject to commercial harvesting in Western Australia as Lower Risk, falling into the sub-category of Least Concern, which encompasses species that do not qualify for the conservation dependent and near threatened sub-categories (Table 2).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments - including the Government of Australia - the aim of which is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES accords varying degrees of protection to more than 30,000 species of animals and plants, which are listed in the three CITES Appendixes. Both of the crocodile species commercially harvested in Western Australia are listed in the CITES Appendix II (for Australia, Papua New Guinea and Indonesia; Appendix I elsewhere) (Table 2).

Table 2. Conservation status of crocodile species that are the subject of this management plan.

Instrument	Crocodile Species	
	Saltwater Crocodile	Freshwater Crocodile
WA Government: *Wildlife Conservation Act 1950*	Listed as *Other Specially Protected Fauna*	Listed as *Other Specially Protected Fauna*
Australian Government: *Environment Protection and Biodiversity Conservation Act 199*9	Not listed as Threatened Fauna	Not listed as Threatened Fauna
2006 IUCN Red List of Threatened Species	Lower Risk/least concern	Lower Risk/least concern
Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Appendix II	Appendix II

3.4. Threats, Issues and Assessment of Impacts

In the context of commercial crocodile harvesting in Western Australia:

- threats to the conservation status of harvested crocodile species are limited;
- issues relating to the conservation and harvesting of crocodiles are well understood;
- assessments of the impacts of harvesting on crocodiles are comprehensive; and
- none of the harvesting methods have any significant or long-term impacts on habitat important to the survival of crocodiles.

3.4.1. Threats and issues pertinent to the conservation status of crocodiles

The conservation of crocodiles in Western Australia is potentially threatened by a range of environmental and anthropogenic factors. Many of these potential threats – from drought and flood to disease - are ecosystem and environmental processes beyond the control of DEC. Nevertheless, as evidenced by the scientific literature, these processes are not considered a long-term threat to the conservation of crocodiles (Table 3).

Potential anthropogenic threats to the conservation of crocodiles principally arise from the commercial harvest and habitat destruction (through such activities as pastoralism, mining and damming of waterways or the extractive use of surface water sources for mining or agriculture purposes). In 20 years of commercial harvesting in WA, viable populations of the harvested crocodile species have been maintained across their natural range and, moreover, the distributional range of saltwater crocodiles appears to have expanded, with increasing numbers of sub-adult and adult male crocodiles being recorded at Broome and vagrant animals also being recorded further south along the Pilbara coast, Ningaloo Reef and as far south as Carnarvon. None of these more southerly records is indicative of an expansion of the permanently occupied range of saltwater crocodiles. Accordingly, commercial harvesting is not considered a threat to the genetic integrity or conservation status of crocodiles in Western Australia (Table 3).

However, to ensure that the commercial crocodile harvest in Western Australia remains sustainable and does not jeopardise the viability of crocodile populations across their range in the future, DEC enacts a range of management controls, including:

(i). **Undertaking regular and ongoing monitoring of crocodile populations.**

The strictly standardized survey techniques employed in Western Australia for the broad-scale monitoring of crocodile populations in core areas subject to harvest are widely regarded as best practice, both in Australia and overseas (Bayliss 1987; Stirrat *et al*. 2001; Mawson 2004). In Western Australia core crocodile habitat is monitored annually in the east Kimberley, with surveys of more extensive areas of crocodile habitat conducted less regularly. Additional surveys have been conducted in preparation for the impending arrival of cane toads (*Chaunus marinus*) to provide additional baseline data to assist in interpreting any changes to the densities and or distribution of crocodiles in Western Australia.

(ii). **Setting commercial harvest quotas at levels that are considered ecologically sustainable for crocodile populations.**

Western Australia typically sets fixed harvest quotas for eggs, hatchling and non-hatchling cohorts of crocodile populations that have been demonstrably sustainable in practice. See Action 11 for additional information on quota setting.

(iii) **Management of problem crocodiles.**

Crocodiles that pose a threat to human safety or to primary production (i.e. problem crocodiles) may be removed from the wild under the provisions of a Regulation 4 licence (to take dangerous fauna) issued by DEC and provided to licensed crocodile farms for commercial purposes. As a condition of commercial crocodile farm licences, licensees are required to accept problem *C. porosus* as stipulated by DEC and subject to such conditions as

DEC may impose with respect to the use of those animals for breeding or slaughter for commercial use. Problem crocodiles taken under licence will not be considered as part of the commercial harvest quota and may be taken from areas that are not part of the commercial harvest zone.

(iv). **Providing refuge habitat.**

In Western Australia, crocodiles usually cannot be commercially harvested in conservation reserves. Conservation estate within the Kimberley region (where the bulk of the crocodile population exists) of the State amounts to a total area in excess of 2,883,757 hectares (see Table 1). Lands supporting other crocodile populations are vested in other Crown Reserves and Aboriginal Lands. The proportion of land that actually constitutes riparian habitat suitable for crocodiles is a much smaller subset of these areas. The circumstances whereby crocodiles may be harvested from a conservation reserve includes where such actions are deemed a *necessary operation* under the *Conservation and Land Management Act 1984* or where an area management plan specifies that the management of overabundant populations was warranted or to protect the human life from large crocodiles that have been assessed as posing a direct threat to safety and welfare. A *necessary operation* would include such things as reducing overabundant populations to prevent environmental damage or unacceptable animal welfare outcomes such as starvation. Area management plans are approved by the Conservation Commission of WA, which is independent of DEC.

DEC also has limited management responsibilities for unallocated Crown land (UCL) and unmanaged reserves (UMR) outside the metropolitan area and townsites. The area of UCL and UMR for which DEC has limited management responsibilities totals about 90 million hectares. The commercial harvesting of crocodiles usually cannot be undertaken on UCL and UMR, but may occur when dangerous crocodiles threaten humans frequenting tourist destinations or fishing sites. Furthermore, the commercial crocodile harvest is patchy within the Crocodile Management Areas leaving many other areas that are unharvested or provide refuge habitat.

3.4.2. Assessment of the impacts of commercial crocodile harvest on other species, habitats and ecosystems

Impacts on species, habitats and ecosystems resulting from actions detailed within this management plan are unlikely to be significant, and in many instances are expected to be positive (Table 4).

Table 3. Threats and issues pertinent to the long-term conservation of crocodiles.

Threats	Comments	Selected References*
Drought	Rainfall via its impact on aquatic plant productivity is the single most important factor impacting on saltwater crocodile populations and droughts can greatly reduce saltwater crocodile breeding success and juvenile recruitment. Freshwater crocodiles nest in sand banks and are not dependent on vegetation to construct nests. Crocodiles are well adapted to a dynamic environment and populations recover after drought-driven population crashes. Therefore drought is not considered a threat to the long-term conservation of crocodiles.	Webb *et al.* (1977); Webb and Smith (1987); Cooper-Preston and Jenkins (1992).
Flood	Heavy rainfall associated with monsoonal falls and cyclones can cause localized mortality of juvenile crocodiles and destroy nests of both species. Large volumes of water moving quickly through key nesting habitat can also erode nesting substrate (vegetation and sandbanks), which may not be redeposited for several years at some locations.	Webb *et al.* (1977); Webb and Smith (1987).
Climate change	Shifts in climate regimes have the potential to significantly impact on all biodiversity including the commercially harvested species of crocodiles. How human-induced changes to the climate will manifest in the future is unknown at present. Modelling indicates that northern WA is likely to become warmer and wetter, but with a greater range in rainfall extremes. This will lead to variable responses across the landscape, but is likely to result in more frequent and intense dry season wildfires which could affect riparian vegetation communities. Rising sea levels may also submerge critical *C. porosus* breeding habitat in near coastal areas. Since rainfall is the most significant factor influencing crocodile breeding success a program of regular monitoring is necessary to ensure that harvest quotas are responsive to fluctuating densities of crocodiles and will alert managers to potential problems.	Hennessy *et al.* (2007)
Disease	The range of reported parasites and pathogens that affect crocodile populations is not extensive, and none recorded from wild crocodiles in Australia seem to be of significance at present. Of more importance is the range of diseases that affect captive colonies where animals are held at higher densities and in closer proximity to other animals. Any diseases that cause short-term reductions in crocodile would be taken into account through standard surveys. Diseases do not appear to be important agents of mortality in crocodiles over the long-term and, therefore, are not considered to pose a threat to their conservation.	Huchzermeyer (2002); Moravec *et al.* (2004)
Habitat loss and modification	Changes to crocodile habitat associated with cattle grazing do not appear to have had any significant impact on their populations given the long history of pastoralism in the Kimberley and the steady recovery of *C. porosus* populations following the cessation of commercial hunting. Neither have modifications to river flows associated with the construction of dams for power generation and agriculture had any adverse impacts to date. However, significant sedimentation in the lower Ord River following the construction of the dams may ultimately lead to degradation of habitat in the long term. In fact the population of *C. johnstoni* has greatly increased following the creation of Lakes Kununurra and Argyle on the Ord River. Accordingly, habitat loss and modification are not considered a threat to the long-term conservation of crocodiles.	Mawson (2004)

Table 3. cont'd Threats and issues pertinent to the long-term conservation of crocodiles.		
Introduced Organisms	Cane toads (*Chaunus marinus*) will soon cross the WA/NT border and enter the Kimberley region. In other parts of Australia where crocodiles and toads have first interacted there have been significant local declines in *C. johnstoni* populations, and smaller declines in *C. porosus* populations presumably because of the more restricted sharing of habitat between *C. porosus* and *Chaunus marinus*. None of the interactions has resulted in the complete loss of crocodile populations to date, but neither have affected populations recovered to pre-toad levels. A similar response is expected in WA crocodile populations. A reduction in native goanna (*Varanus* sp.) due to cane toads may result in improved recruitment of crocodiles due to a lower incidence of egg predation.	Van Dam, *et al.* (2002); Letnic *et al.* (2008)
Harvesting – general	In 20 years of managed harvest in Western Australia, viable populations of the harvested crocodile species have been maintained across their natural range. Therefore, harvesting (at the historical levels) is not considered a threat to the long-term conservation of crocodiles.	Mawson (2004)
Harvesting – genetic	Harvesting has the potential to alter the genetic structure and genetic diversity of a population. It is recognised that crocodilian genetics are highly conservative, and there is no empirical or modelled evidence of genetic impacts at current levels of crocodile harvesting, and given the mating systems of wild crocodiles and the emphasis on harvest of eggs and hatchlings this is not unexpected. The infrequent removal of large male problem crocodiles similarly would not be expected to have an impact on population genetics since these animals do not all participate in matings in any year. Added to this is the fact that crocodiles are long-lived, providing an extended period in which to contribute their genes to future generations. Therefore harvesting is not considered a threat to the long-term genetic integrity of crocodile populations. The management of genetics in captive populations is far more important, particularly if improved blood lines are to be developed with the view to increasing the quantity and quality of the products derived from processed animals.	Isberg *et al.* (2004).
Predation	The only non-human predator of *C. porosus* hatchlings and juveniles is larger *C. porosus*. In those areas where salt and freshwater crocodiles are sympatric *C. porosus* is a known predator of *C. johnstoni*. Larger crocodiles of both species are at risk of drowning in commercial fishing nets. Crocodiles are also at risk from indirect threats from current and historical chemical (DDE and toxaphene) use associated with agriculture. Therefore, predation is not considered a threat to the long-term conservation of crocodiles but may warrant future monitoring in the case of chemical impacts.	Cooper-Preston and Jenkins (1993); Yoshikane *et al.* (2006)

Table 4. Impacts of the commercial crocodile harvest on other species, habitat and ecosystems.

Potential Impacts	**Comments**	**Selected References***
Land degradation caused by the erosion of soil	The commercial crocodile harvest is unlikely to cause land degradation due to the erosion of soil. *Licensed* crocodile *takers* generally operate from pre-existing boat launching ramps and main waterways. Disturbance to nests is minimal and has no impact on standing vegetation.	
Detrimental effects on water bodies, watercourses, wetlands and natural drainage systems	There is no evidence that suggests the commercial crocodile harvest will have detrimental effects on water bodies, watercourses, wetlands and natural drainage systems.	
Vegetation clearing or modification	No vegetation is likely to be cleared or modified as a consequence of the commercial crocodile harvest.	
Detrimental effects on threatened flora species, populations or their habitats	There is no evidence that the commercial crocodile harvest has a detrimental effect on threatened flora species, populations or their habitats. Only one species of Declared Rare Flora occurs in Kimberley riparian systems and it is restricted to gorges in inland waterways.	
Endangering, displacing or disturbing native fauna, or creating a barrier to their movement	Native fauna is unlikely to be endangered, displaced or disturbed as a consequence of the commercial crocodile harvest.	
Detrimental effects on threatened fauna species, populations or their habitats	There is no evidence that the commercial crocodile harvest has a direct detrimental effect on threatened fauna species, populations, or their habitats provided harvests remain within quota limits.	
Detrimental impacts on ecological communities of conservation significance	Ecological communities of conservation significance are unlikely to be impacted by the commercial crocodile harvest as no listed ecological communities occur in riparian habitat occupied by crocodiles in the Kimberley.	
Positive effects on introduced predators	The commercial crocodile harvest does not generate any by-products that would benefit introduced predators.	
Positive effects on introduced herbivores	The commercial crocodile harvest, in particular the removal of large male problem crocodiles, may provide a very local benefit to domestic stock and other large introduced herbivores, but the benefit would not persist as other crocodiles would quickly occupy the vacated territory.	
Introduction and/or dispersal of invasive weeds	There is no evidence that the commercial crocodile harvest contributes to the introduction and/or dispersal of invasive weeds more so than other land users.	

4. GOALS AND AIMS

4.1. Goal

The overarching goal of this management plan is:

To maintain viable populations of crocodiles throughout their ranges in accordance with the principles of ecologically sustainable development.

The principles of *ecologically sustainable development* are defined in the *Environment Protection and Biodiversity Conservation Act 1999*.

In order to attain the overarching goal, this management plan has seven aims each of which encompasses a particular facet of crocodile management. When the aims are combined, they set strategic directions for the management of the commercial crocodile harvest in Western Australia.

Under each aim are one or more actions that detail both how the aim will be delivered and operational directions for crocodile management. A range of performance indicators for each action have also been developed so that progress towards achieving the goal and aims of the management plan can be measured.

Throughout the life of this plan, performance indicators will be monitored annually with a major assessment and review at the end of the five-year term of the management plan.

4.2. Aims

The aims of this management plan are:

1. MANAGE THE COMMERCIAL CROCODILE INDUSTRY VIA LICENSING

Manage the utilization of crocodile species in accordance with the provisions of the Wildlife Conservation Act and Regulations, Western Australian Government policies, the *Wildlife Conservation Regulations* and the draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008) and this management plan.

2. ENSURE HUMANE TREATMENT OF CROCODILES

Promote highest possible animal welfare outcomes and ensure that the commercial harvest of crocodiles under this plan is carried out in accordance with the *Wildlife Conservation Regulations* and the draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008).

3. MONITOR INDUSTRY COMPLIANCE

Monitor the crocodile industry to ensure compliance with this management plan, licence conditions, the requirements of the *Wildlife Conservation Act* and Regulations and the draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008).

4. MONITOR CROCODILE POPULATIONS

Monitor crocodile populations and licence commercial harvest of crocodiles and eggs within the limits set out in the commercial quota to ensure crocodiles are utilized in accordance with the goal of the management plan. Direct and indirect monitoring will be undertaken in all areas where crocodiles are commercially harvested.

5. FACILITATE ADAPTIVE MANAGEMENT AND RESEARCH

Promote adaptive management experiments and studies using historical data from crocodile industry returns and population data to improve our understanding of crocodiles and their interaction with environmental, social and economic systems. Facilitate research into other aspects of crocodile ecology and/or harvest management as required to fill knowledge gaps.

6. UNDERTAKE PROGRAM REPORTING AND REVIEW

Undertake regular reporting and a final program review in consultation with relevant stakeholders to ensure that the management program is working as intended and that outcomes remain consistent with the goal of the management plan.

7. PROMOTE COMMUNITY AWARENESS AND PARTICIPATION

Promote greater understanding of the program through informed public and private sector participation in management of the commercial utilization of crocodiles.

5. MANAGEMENT ACTIONS AND PERFORMANCE INDICATORS

AIM 1: MANAGE THE COMMERCIAL CROCODILE INDUSTRY VIA LICENSING

In order to ensure that viable populations of crocodiles are maintained throughout their ranges, the commercial crocodile industry in Western Australia is closely regulated via a range of licensing and tag procedures provided for under the Wildlife Conservation Act and Regulations. The legislative basis for licensing and licensing procedures is described in detail in Section 2.2.

ACTION 1: All relevant activities are licensed in accordance with the applicable Western Australian legislation and DEC policy.

All applications for licences relating to commercial crocodile industry operations in Western Australia are to be assessed, processed and issued in accordance with the provisions of the *Wildlife Conservation Act 1950*, the *Wildlife Conservation Regulations 1970* and relevant DEC policy.

Performance Indicator 1: All licences relating to commercial crocodile industry operations in Western Australia are assessed, processed and issued in accordance with Western Australian legislation and DEC policy.

All (100%) of the licences issued will be audited on an annual basis to ensure that:

- licences are being issued in accordance with the relevant legislation and policy;
- DEC procedures are being followed correctly;
- accurate information is being entered into appropriate databases; and
- licences are being assessed and issued appropriately.

The annual audits will be conducted in DEC's central (and only) licensing office. This performance indicator is also a measure of success in the training of staff who approve and issue licences and the quality of application forms.

ACTION 2: Licence conditions are effective and reflect current Western Australian legislation, DEC policy and the goal and aims of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013.

To effectively and efficiently manage commercial crocodile operations in Western Australia, licence conditions must be effective and consistent with Western Australian legislation, DEC policy and the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013. Accordingly, the standard licence conditions for each licence type will be reviewed, and where necessary amended, in response to changes in Western Australian legislation and/or DEC policy. Licensees will be advised of any changes to their licence conditions in writing.

Performance Indicator 2.1: Licence conditions are reviewed at least annually and where necessary amended.

Performance Indicator 2.2: Licensees are advised in writing of any changes to licence conditions within one month of such changes being approved by the Director of Nature Conservation or his delegate.

AIM 2: ENSURE HUMANE TREATMENT OF CROCODILES

Animal welfare in crocodile harvesting is of prime concern to DEC. The draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008) is the proposed national animal welfare standard for the commercial harvest of crocodiles. Accordingly, compliance with the draft Code and any fully endorsed Code will be required of the commercial crocodile industry. Any approved subsequent code/s will similarly be adopted as the animal welfare standard for the commercial harvest of crocodiles in Western Australia. Conditions attached to crocodile taker's, farmer's and processor's licences provide financial disincentives for acting other than in accordance with the Wildlife Conservation Regulations and Code, once it is endorsed by the Natural Resource Management Ministerial Council.

ACTION 3: DEC will work to ensure that all *licensed* crocodile *takers* are competent to achieve animal welfare standards consistent with the goal of the draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008).

Performance Indicator 3: All prospective applicants for a *Licence to Take* Crocodiles must demonstrate to a DEC Wildlife Officer that they are conversant with all aspects of the Wildlife Conservation Regulations relevant to animal welfare and draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008).

ACTION 4: DEC staff will monitor compliance with the Wildlife Conservation Regulations relevant to animal welfare and draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008) by commercial crocodile industry operators.

Authorized DEC officers undertake a mixture of targeted and opportunistic inspections of *licensed* crocodile farming and processing facilities. DEC does not tolerate breaches of the Wildlife Conservation Regulations and, where crocodiles have been found to be taken other than in accordance with the regulations and licence conditions, Caution Notices are issued or further prosecution action taken that may result in cancellation of licences and/or fines. This policy approach to animal welfare breaches demonstrates DEC's commitment to ensuring that the commercial harvest of crocodile is humane.

Performance Indicator 4: All licensees who are found to have breached licence conditions relating to animal welfare are issued with Caution Notices or are prosecuted as appropriate.

ACTION 5: DEC will facilitate research into improving animal welfare outcomes associated with the commercial harvest and farming of crocodiles.

DEC will work with external research organisations to identify and investigate animal welfare issues relevant to the commercial harvest and farming of crocodiles. Such research may include aspects of the biology and ecology of crocodiles as they relate to the commercial harvest, or harvest techniques, captive husbandry or disease management. Contributions by DEC may include funding and/or in-kind support such as the provision of harvest data.

Performance Indicator 5: Issues of significance associated with the animal welfare aspects of the commercial harvest are identified and where these are identified a research prospectus is prepared and distributed to universities and other research institutions during the life of this plan.

AIM 3: MONITOR INDUSTRY COMPLIANCE

Monitoring commercial crocodile industry compliance with the provisions of Western Australian legislation, DEC policy, the goal and aims of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 and licence conditions is essential to effectively maintaining viable populations of crocodiles throughout their ranges and to ensure public confidence in the management of crocodiles in Western Australia.

ACTION 6: DEC staff will undertake a mixture of both targeted and opportunistic monitoring of compliance by commercial crocodile industry licensees.

In order to assess industry compliance, authorized officers of DEC will, on both a regular and opportunistic basis, inspect crocodiles taken by *licensed* crocodile *takers* and all premises registered for farming and processing crocodiles. The inspecting officers will check to ensure that the crocodiles have been taken in accordance with the Wildlife Conservation Act and Regulations, the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 and licence conditions. Assessments to ensure compliance with the Wildlife Conservation Regulations relevant to animal welfare and draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008) will be a priority.

Performance Indicator 6.1: On receipt of an application for a *Licence to Take* Crocodiles, the authorized DEC officer assessing the application will ensure that the applicant:

- has written permission from a landholder to access private property or Crown Land;
- can demonstrate the necessary expertise to capture, handle and transport crocodiles safely and humanely; and
- the requested number of eggs/crocodiles is within the harvest limits set down in the annual quota.

Performance Indicator 6.2: All crocodile processing works in Western Australia are inspected at least annually during the life of this plan by authorized DEC officers to ensure compliance with Western Australian legislation and licence conditions.

ACTION 7: Activities not in accordance with the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 and Western Australian legislation will be investigated and, where an offence has been committed and it is appropriate, a Caution Notice may be issued or the offenders will be prosecuted as appropriate.

Investigation and prosecution of activities not in accordance with the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 and Western Australian legislation is essential for accountability and for maintaining public,

industry and stakeholder confidence in the effectiveness of the plan as a mechanism for maintaining the viability of crocodile populations, and thus the commercial crocodile industry.

Performance Indicator 7: Reports of unlicensed activities and activities in breach of licence conditions are investigated to the fullest extent possible and, where sufficient evidence is available, offenders are issued with Caution Notices or prosecuted as appropriate.

ACTION 8: The accuracy of industry returns will be continually monitored during the life of this plan.

It is a licence condition that commercial crocodile industry licensees submit monthly returns to DEC (on the DEC approved return forms provided). The data obtained from these returns are essential for monitoring whether the industry is harvesting crocodiles within approved quotas and for reporting to the Commonwealth Government, industry and the public.

Performance Indicator 8: During the life of this plan, all incoming industry returns are scrutinized and discrepancies are investigated and resolved.

> Auditing of industry returns encompasses manual assessment of returns, application of the customized licensing database utilized by DEC which includes numerous validation rules that assist in ensuring the integrity of data, and extensive verbal and written communication between DEC staff and industry operators.

ACTION 9: A compliance database will be maintained to support investigations, inspections and audits.

> A compliance database for use in crocodile management investigations, inspections and audits will be maintained for use by staff involved with crocodile management. The database facilitates compliance reporting to the Commonwealth Government and other stakeholders and also easy access to information for relevant authorized DEC officers.

Performance Indicator 9: A compliance database is maintained.

> Relevant compliance information stored in the customized database includes reports of alleged breaches of the Wildlife Conservation Act and/or licence conditions, investigation activities undertaken and outcomes of investigations. Data input is accurate and timely.

AIM 4: MONITOR CROCODILE POPULATIONS

Monitoring populations of commercially harvested crocodile species, both directly and indirectly, is essential for maintaining viable populations of crocodiles throughout their ranges.

The two crocodile species that are the subject of this management plan are widespread (see Figure 1) and abundant (relative to pre-hunting status) in their respective ranges in Western Australia.

The biology of crocodiles in Australia is well documented including their habitats, distributions (Section 3), diets and reproduction, and this knowledge is continually improving. In particular, the reproductive biology of crocodiles has been researched extensively. While there are variations between the crocodile species, these are well understood and accounted for in the quotas set for each species. In addition, there is abundant information from direct (periodic) and indirect (continuous both temporally and spatially) monitoring of crocodiles.

The commercial harvest of crocodiles is directly linked to the availability of suitable habitat in the Kimberley region of Western Australia (e.g. Fukuda *et al.* 2007). Generally, commercial harvesting of crocodiles will be biased towards larger breeding age animals (to provide breeding stock for crocodile farms) and eggs and hatchlings.

Results of aerial surveys conducted annually since 1993 show that crocodile populations have for the most part shown small but steady increases primarily in response to protection from unregulated harvest/shooting (Mawson 2004; DEC unpublished survey reports 2005-2007 inclusive).

ACTION 10: Aerial (rotary-wing) and boat spotlight population surveys will be conducted annually, with additional survey work conducted as required (e.g. to provide information on the impact of cane toads in areas not subject to normal survey or harvest). Details of the areas subject to annual survey are provided in Appendix 2. Surveys are typically undertaken in July (the coolest month) when crocodiles are most likely to be basking on banks and when water temperatures are lowest. Surveys may be conducted in other months of the year to accommodate logistical requirements or the need for expanded survey effort in additional areas.

Spotlight surveys

The spotlight survey technique has been described previously by Messel *et al.* (1981), and involves travelling the river in an open boat, scanning the water surface and banks with a 100W spotlight. Crocodiles are detected by a red "eyeshine". Once spotted, crocodiles are approached and identified (*C. porosus* or *C. johnstoni*), and total length estimated (in one foot categories). If a crocodile submerges before it can be identified, it is recorded as an "eyes only" (EO). The estimated size of all crocodiles approached, their position in the water (midstream, on bank, shallow water on edge, etc.), and their locations in the river (using maps in Messel *et al.* 1987) are recorded. Surveys are typically conducted in July of each year.

Helicopter surveys
The helicopter survey technique typically involves flying at a speed of approximately 60-70 km/h, at an altitude of about 20-30 m, and about 20 m towards the midstream (Webb *et al.* 1990). The physical characteristics of Lake Argyle do not allow a constant speed to be maintained in many of the small inlets and bays comprising this water body. *Crocodylus porosus* sighted are recorded as small (2-4'), medium (4-7'), large (7-11') or extra-large (>11'), and their locations marked on maps by a navigator. With *C. johnstoni*, only counts are recorded. Water levels in Lake Argyle may vary from year to year, significantly influencing the perimeter of the lake that can be surveyed. Details of the survey areas are provided in Appendix 2.

Performance Indicator 10: Aerial and boat spotlight surveys are undertaken annually in accordance with this plan.

ACTION 11: Commercial crocodile harvest quotas are as set out below (Table 2).
The commercial quota for a species is the maximum number of individuals that can be commercially harvested in a calendar year. Quotas have been set at a fixed level for the life of the management plan on the basis of current and previous population estimates in monitored areas and the limited potential for significant expansion in range or increase in population size due to the limits on available habitat. There is no requirement for the DEC to allow the full quota to be taken in any year and decisions on what proportion of the annual quota for each species will be allocated and from which parts of the known range of each species will be based on the recent survey data, previous harvests and consideration of recent climatic conditions.

Table 5: Annual Harvest Quotas.

Crocodylus porosus		*Crocodylus johnstoni*	
Eggs /Hatchlings	520	Eggs /Hatchlings	1900
Non-Hatchlings	50	Non-Hatchlings	200

Hatchlings are defined as crocodiles <2’ in length
Non-hatchlings are defined as crocodiles >2’ in length.

When the annual quota for a species has been reached no additional licences to take crocodiles or eggs will be issued to crocodile *takers* until the following year, subject to survey data indicating that a harvest is sustainable the next year.

Unless undertaken as part of an adaptive management experiment approved by the Commonwealth (see Action 15), commercial quotas will be set as described in Table 5 of this Management Plan. It is important to note that the most recent scientific information available is considered when determining the proportion of the annual quotas allocated and that analysis of this information may result in quotas being decreased in order to maintain the viability of crocodile populations and to meet the other objectives of this plan.

Performance Indicator 11: All commercial crocodile harvest quotas are set and allocated in accordance with the provisions of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 throughout the life of the plan.

AIM 5: FACILITATE ADAPTIVE MANAGEMENT AND RESEARCH

Adaptive management experiments and studies using historical data from crocodile industry returns and population data are essential to improving our understanding of crocodiles and their interaction with environmental, social and economic systems and thereby effectively maintaining viable populations of crocodiles throughout their ranges. Research into particular aspects of crocodile ecology or harvest management can also assist in ensuring that the commercial harvest is sustainable over the long term. While there has been a body of research on the ecology and management of crocodiles, there are information gaps which, when filled, may lead to improved management of the commercial harvest and commercial farming and processing.

ACTION 12: Historical data relating to the commercial crocodile harvest in Western Australia will be analysed during the life of this plan to identify trends; this analysis will be considered in future crocodile management programs.

Previous crocodile management programs have generated a wide range of information relating to the commercial harvesting of crocodiles in Western Australia. This information will be analysed to provide data on trends in crocodile populations, utilization rates, average size and other specific information relating to either the commercial harvest or crocodile populations generally.

The analysis of historical data relating to the commercial crocodile harvest in Western Australia may be undertaken by a range of individuals or organisations including tertiary students, university professionals, consultants or DEC staff.

Performance Indicator 12.1: Analysis of historical crocodile harvest and management data is undertaken during the life of this plan.

> Data analysis research proposals must be accompanied by a project plan that clearly identifies the goals and objectives of the proposed research and outlines performance indicators that enable an assessment of the success (or otherwise) of the research.

Performance Indicator 12.2: The results of analysis and research using historical crocodile harvest and management data are published in an appropriate forum.

> Consideration of research findings and the results of any analysis are essential not only for the development of future management plans, but also for facilitating the adaptive management of crocodile populations, which in turn will aid in maintaining viable populations of crocodiles throughout their ranges. The appropriate forum will vary according to the type of research or analysis. At a minimum, the results of any research undertaken using DEC data should be provided to DEC and, ideally, be made publicly available on DEC's website.

ACTION 13: Where practicable, management experiments will be performed to test deliberate management interventions during the life of this plan.

Under such active adaptive management, management activities are conducted as a deliberate experiment. Alternative strategies are viewed as treatments and are implemented through statistically valid experimental design; monitoring is the data-collection step of the experiment. Active adaptive management can establish cause-and-effect relationships between activities and changes in ecological conditions.

All proposals to undertake active adaptive management experiments will be reviewed and critically assessed by DEC with reference to the following criteria:

- the proponents' awareness of relevant background information;
- whether the proposal considers alternative models and hypotheses;
- whether the proposal is scientifically rigorous and statistically valid;
- whether the proposal incorporates a monitoring program;
- that there is substantial evidence that the risk of permanent damage to crocodile populations is low;
- that the proposal is consistent with the goal of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 and relevant Western Australian legislation; and
- that the proposal includes consideration of how management may be modified to accommodate the new knowledge gathered from the intervention.

All experiments that affect the commercial utilization of crocodiles must also demonstrate how the experiment provides for reasonable business planning and investment.

Performance Indicator 13.1: All proposals to undertake active adaptive management experiments are reviewed and assessed by DEC in accordance with the criteria outlined in this plan.

Performance Indicator 13.2: All necessary approvals are obtained prior to experiments testing deliberate management interventions commence.

> In situations where experiments will impact on the overall commercial harvest quota DEC will seek approval from the Commonwealth Department of the Environment, Water, Heritage and the Arts.

Performance Indicator 13.3: All adaptive management experiments are continuously monitored and conducted according to approval conditions.

> As per the criteria outlined above, all active adaptive management experiment proposals must have monitoring programs incorporated. Monitoring programs must be maintained during the life of the experiment. All monitoring must be conducted in accordance with any conditions imposed with the approval.

Performance Indicator 13.4: Results of all experiments testing deliberate management interventions are published in an appropriate forum.

> The appropriate forum for dissemination will vary according to the type of research and the target audience. However, it is expected that any research conducted as an

active adaptive management experiment in accordance with the provisions of this plan will be made available to the DEC for inclusion on DEC's website.

ACTION 14: DEC will facilitate research into the ecology and harvest management of crocodiles.

DEC will work with external research organisations to identify and investigate issues relevant to the commercial harvest of crocodiles. Such research may include aspects of the biology and ecology of crocodiles as they relate to the commercial harvest, or harvest techniques. Contributions by DEC may include funding and/or in-kind support such as the provision of harvest data.

Performance Indicator 14.1: During the life of this plan, significant issues associated with the ecology of harvested species and the management of the commercial harvest that are identified will be incorporated into a research prospectus and distributed, if required.

AIM 6: UNDERTAKE PROGRAM REPORTING AND REVIEW

Good management of the commercial crocodile industry is essential for maintaining viable populations of crocodiles throughout their ranges. A program review and concomitant reporting is vital to evaluate the success of the plan in achieving its stated goal and aims as well as ensuring that managers remain fully informed.

ACTION 15: An annual report will be submitted to the Commonwealth.

An annual report detailing the operation of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 will be prepared and submitted to the Commonwealth. The report will provide information on the previous year's harvest statistics, crocodile farm statistics and industry compliance, whether any adaptive management experiments were undertaken. The report will also audit the management plan aims against the performance indicators so that progress towards achieving the goals of the management plan can be measured.

Performance Indicator 15: An annual report will be provided to the Commonwealth by 31 March of the following year.

The annual report will include the following information:

1. Harvest statistics for each species taken including:
- Numbers of crocodile eggs taken (actual and authorized);
- Numbers of crocodile hatchlings taken (actual and authorized);
- Number of crocodile non-hatchlings taken (actual and authorized);
- Sex ratio (adults only) of the harvest; and
- Average body size of harvested animals for each sex taken (where known).

2. Number of licences issued for "problem" crocodiles and details of the fate of each crocodile covered under those licences.

3. Industry compliance statistics including:
- number of premises inspected;

- number of Caution Notices issued and reason for issue;
- number of alleged offences investigated and outcomes;
- number of prosecutions undertaken (offence and outcome); and
- any joint surveillance/enforcement activities completed with other agencies.

4. Any unusual situations that arose (e.g. disease outbreaks, drought or flood conditions, market factors, etc).

5. Progress against performance indicators.

ACTION 16: A final review of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 will be undertaken at the end of the life of the Plan and a report submitted to the Commonwealth.

A review of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 will commence no later than twelve months prior to the expiry of the Plan and will assess the success of the Plan in achieving its goal. The review will also assist in the development and improvement of any subsequent plan. A final report detailing the operation of the Plan will be prepared and submitted to the Commonwealth. The report will provide information on quotas, harvest rates and surveys conducted during the term of the Plan. The report will also identify whether any adaptive management experiments were undertaken during the term of this plan. Finally, the review will audit plan aims against performance indicators so that progress towards achieving the goal of the management plan can be measured.

Performance Indicator 16.1: A final report on the operation of the Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 2009–2013 will be prepared during 2014, submitted to the Commonwealth by 31 March 2014 and posted on DEC's website by 30 June 2014.

The final report will include the following information for each year in the life of the Plan:

- Actual harvest for each species compared to quota;
- Sex ratio and average size for each species;
- Any research undertaken or sponsored by DEC; and
- An audit of plan aims against performance indicators;

AIM 7: PROMOTE COMMUNITY AWARENESS AND PARTICIPATION

The public profile of crocodile management in Western Australia is currently low, in part due to the limited public knowledge of the existence of the crocodile industry, but also due to the small number of stakeholders involved in the commercial crocodile industry. Consequently community awareness of and participation in crocodile management is considered a key component to the success of the program, and thus the maintenance of viable populations of crocodiles.

ACTION 17: Relevant public documents will be made available on DEC's website.

The provision of information to members of the public promotes understanding of the Management Plan for the Commercial Harvest of Crocodiles in Western Australia and allows

members of the community to form better-educated opinions regarding crocodile management issues.

Performance Indicator 17: Throughout the life of this plan, DEC's website will contain the following information as a minimum standard:

- The current management plan (including the current quotas);
- the current annual report submitted to the Commonwealth;
- information sheets on crocodile biology and management; and
- relevant contact information.

Additional relevant information will be posted on DEC's website as available and appropriate.

ACTION 18: Publicly available information will be provided to interested parties on request.

The provision of information to members of the public promotes understanding of the Management Plan for the Commercial Harvest of Crocodiles in Western Australia and allows members of the community to form better-educated opinions regarding crocodile management issues.

Performance Indicator 18: Publicly available crocodile management information is distributed to interested parties as soon as practicable after such a request via:

- copies of this management plan
- Fauna Notes that will be developed during the first 12 months of the life of this management plan.

ACTION 19: Where appropriate, relevant DEC staff will participate in media interviews and prepare media releases.

Participation in media interviews and the preparation of media releases can be an effective mechanism for communicating information regarding crocodile management to a broad audience and, moreover, improves program transparency and accountability, and therefore public confidence.

Performance Indicator 19.1: Relevant DEC staff will participate in interviews with the media where appropriate.

Performance Indicator 19.2: Media releases are prepared for issues of interest to the community when appropriate.

ACTION 20: Relevant information regarding licensing arrangements will be developed as required and distributed to all licensees.

Licensees will be provided with written information relevant to their licensing arrangements to assist in achieving a high level of compliance with the licensing framework.

Performance Indicator 20: As a minimum, all crocodile takers, farmers and processors who are issued with a *Licence to Take, Farm or Process* Crocodiles for the first time, or who have not held a valid licence during the term of the current management plan, will be provided with written information on the following:

- pre-requisites for obtaining a licence
- licence conditions;
- regulations for taking crocodiles;
- a copy of the draft Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles (revised April 2008); and
- Fauna Notes prepared on the two crocodile species (see Performance Indicator 18) and any revisions thereof that are available on the DEC website.

REFERENCES

Bayliss, P. (1987). Survey methods and monitoring within crocodile management programmes. Pp 157-75. *In;* Wildlife Management: Crocodiles and Alligators. Ed G.J.W. Webb, S.C. Manolis and P. J. Whitehead. Surrey Beatty and Sons Pty Ltd. In association with thCosnervation Commuission of the Northern Territory.

Bayliss, P. and Messel, H. (1990). The population dynamics of estuarine crocodiles. *In*: An assessment of long-term census data. Proceedings 9th Working Meeting IUCN-SSC Crocodile Specialist Group, Lae, PNG. IUCN: Gland, Switzerland, pp. 1-44.

Cogger, H. (1993). General description and definition of the Order Crocodylia, *In*: Fauna of Australia, Vol. 2A, Amphibia and Reptilia. (ed. by C.J. Glasby, G.J. Ross and P.L. Beesley), AGPS, Canberra, pp. 235.

Cooper-Preston, H. and Jenkins, R.W.G. (1993). Natural history of the Crocodylia. *In*: Fauna of Australia, Vol. 2A, Amphibia and Reptilia. (ed. By C.J. Glasby, G.J. Ross and P.L. Beesley), AGPS: Canberra, pp. 337-343.

Fukuda, Y., Whitehead, P. and Boggs, G. (2007). Broad-scale environmental influences on the abundance of saltwater crocodiles (*Crocodylus porosus*) in Australia. *Wildlife Research* 34, 167-176.

Grigg, G. and Gans, C. (1993. Morphology and physiology of the Crocodylia, *In*: Fauna of Australia, Vol. 2A Amphibia and Reptilia (ed. by C.J. Glasby, G.J.B. Ross and P.L. Beesley), AGPS, Canberra, pp. 326-336.\

Hennessy, K., B. Fitzharris, B.C. Bates, N. Harvey, S.M. Howden, L. Hughes, J. Salinger and R. Warrick, (2007). Australia and New Zealand. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 507-540.

Huchzermeyer, F.W. (2002). Diseases of farmed crocodiles and ostriches. *Rev. sci. tech. Off. Int. Epiz.* 21, 265-276.

Isberg, S.R., Thomson, P.C., Ncholas, F.W., Gray, E.W., Ahmadi-Esfahani, F., Barker, S.G. and Moran, C. (2004). CrocPLAN: A genetic improvement program for saltwater crocodiles. Pp 344-349. *In*: Crocodiles. Proceedings of the 17th Working Meeting of the Crocodile Specialist Group, IUCN – the World Conservation Union, Gland, Switzerland and Cambridge UK.

Letnic, M., Webb, J.K. and Shine, R. (2008). Invasive cane toads (*Chaunus marinus*) cause mass mortality of freshwater crocodiles (*Crocodylus johnstoni*) in tropical Australia. *Biological Conservation* doi:10.1016/j.biocon.2008.04.031.

Magnusson, W.E. (1980). Habitat required for nesting by *Crocodylus porosus* (Reptilia: Crocodilidae) in northern Australia. *Aust. Wildl. Res*. 7, 149-156.

Magnusson W.E. (1982) .Mortality of eggs of the crocodile Crocodylus porosus in northern Australia. *Journal of Herpetology*: 16, 121-130.

Mawson, P.R. (2004). Crocodile management in Western Australia. Pp 28-37. *In*: Crocodiles. Proceedings of the 17th Working Meeting of the Crocodile Specialist Group, IUCN – the World Conservation Union, Gland, Switzerland and Cambridge UK.

Messel, H., Burbidge, A.A., Vorlicek, G.C., Wells, A.G., Green, W.J., Onley, I.C. and Fuller, P.J. (1987). Surveys of tidal waterways in the Kimberley region, Western Australia, and their crocodile populations. Monograph 20. Pergammon Press: Sydney.

Messel, H., Vorlicek, G.C., Wells, A.G. and Green, W.J. (1981). Surveys of tidal river systems in the Northern Territory of Australia and their crocodile populations. Monograph 1. Pergammon Press: Sydney.

Messel, H. and Vorlicek, G.C. (1985). Population dynamics of *Crocodylus porosus* -a ten year overview. *In*: Biology of Australasian Frogs and Reptiles, (ed. by G. Grigg, R. Shine and H. Ehmann). Surrey Beatty and Sons: Sydney, pp. 71-82.

Messel, H. and Vorlicek, G.C. (1986). Population dynamics and status of Crocodylus porosus in the tidal waterways of northern Australia. *Aust. Wildl. Res*. 13, 71-111.

Molnar, R. (1993). Biogeography and phylogeny of the Crocodylia, *In*: Fauna of Australia Vol. 2A Amphibia and Reptilia, (ed. by C.J. Glasby, G.J.B. Ross and P.L. Beesley) AGPS; Canberra. Pp. 344-48.

Moravec, F., Kay, W.R. and Hobbs, R.P. (2004). *Micropleura australiensis* n. sp. (Nematoda: Micropleuridae) from the body cavity of *Crocodylus johnsoni* in Western Australia. *Journal of Parasitology* 90, 322-326.

Morton, R. (2001). The application of exponentially weighted moving averages to managing crocodile populations. Report Number CMIS 01/106, CSIRO Mathematical and Information Sciences, Canberra.

Stirrat, S.C. Lawson, D. Freeland, W.J and Morton, R. (2001). Monitoring *Crocodylus porosus* populations in the Northern Territory of Australia: a retrospective power analysis. *Wildlife Research* 28, 547-554.

Van Dam, R.A, Walden, D.J and Begg, G.W. (2002). A preliminary risk assessment of cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin, NT.

Webb, G.J.W., Manolis, S.C. & Buckworth, R. (1983a). *Crocodylus johnstoni* in the McKinlay river area, NT. I. Variation in the diet, and a new method of assessing the relative importance of prey. *Australian Journal of Zoology* 30, 877-899.

Webb, G.J.W. and Manolis, S.C. (1989). Crocodiles of Australia. Reed Books: Sydney.

Webb, G.J.W. and Manolis, S.C. (1992). Monitoring saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory of Australia. In: *Wildlife 2001: Populations* (ed. by D.R. McCullough and R. Barrett). Elsevier Applied Science: London and New York, pp. 404-18

Webb, G.J.W. and Manolis, S.C. (1993). Conserving Australia's crocodiles through commercial incentives, In: Herpetology in Australia, (ed. by D. Lunney and D. Ayers) Surrey Beatty, Sydney, pp. 250-6.

Webb G.J.W., Manolis S.C. and Buckworth R (1983c). *Crocodylus johnstoni* in the McKinlay River Area N.T. VI.* Nesting Biology. *Wildlife Research* 10: 607-637.

Webb, G.J.W., Manolis, S.C. and Whitehead, P.J. (eds.) (1987). The management of crocodiles in the Northern Territory of Australia. *In*: Wildlife Management: Crocodiles and Alligators. (ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead). Surrey Beatty and Sons Pty. Ltd. in association with the Conservation Commission of the Northern Territory: Sydney.

Webb, G.J.W., Manolis, S.C., Whitehead, P.J. and Letts, G.A. (1984). A proposal for the transfer of the Australian population of *Crocodylus porosus* Schneider (1801), from Appendix I to Appendix II of C.I.T.E.S. Conservation Commission of the Northern Territory, Tech. Report No. 21.

Webb, G.J.W., Messel, H. and Magnusson, W.E. (1977). The nesting biology of *Crocodylus porosus* in Arnhem Land, northern Australia. *Copeia* 1977: 238-249.

Webb, G.J.W., Sack, G.C., Buckworth, R., and Manolis, S.C. (1983b). An examination of *C. porosus* nests in two northern Australian freshwater swamps, with analysis of embryo mortality. Aust. Wildl. Res. 10, 571-605.

Webb, G.J.W. and Smith, A.M.A. (1984). Sex ratio and survivorship in the Australian Freshwater Crocodile *Crocodylus johnstoni*. *Symp. Zool. Soc. Lond*. 52, 319-355.

Webb, G.J.W. and Smith, A.M.A. (1987). Life history parameters, population dynamics and the management of crocodilians. *In*: Wildlife Management: Crocodiles and Alligators. (ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead). Surrey Beatty and Sons Pty. Ltd. in association with the Conservation Commission of the Northern Territory: Sydney, pp. 199-210.

Yoshikane, M., Kay, W.R., Shabata, Y., Inoue, M., Yanai, T., Kamata, R., Edmonds, J.S. and Morita, M. (2006). Very high concentrations of DDE and toxaphene residues in crocodiles from the Ord River, Western Australia: an investigation into possible endocrine disruption. *Journal of Environmental Monitoring* 8, 649-661.

APPENDIX 1: Draft Code of practice on the humane treatment of captive and wild Australian Crocodiles is available at:

http://www.environment.gov.au/biodiversity/trade-use/publications/crocodile/index.html

This Appendix will be updated with any nationally endorsed Code of Practice developed during the life of this management plan.

APPENDIX 2: Survey areas for salt and freshwater crocodiles in Western Australia.

Helicopter Surveys

1. Lake Kununurra: Sections 12-18 (64.5 km) (see Figure 3).

2 Lake Argyle: Sections 2, 5, 8-15, 17, 19, 21-23, 26 (299.5 km) (see Figure 4).

3. Ord River: Non - tidal mainstream (5 sections, both banks; Diversion Dam - Ford Beach Rapids, Ford Beach Rapids - Ivanhoe Crossing, Ivanhoe Crossing - Bullocks Crossing, Bullocks Crossing - Tararra Bar, Tararra Bar (at km 87.5) - House Roof Crossing (see Figure 5).

4. Ord River: Tidal mainstream (east bank; km 20 - 87.5) (see Figure 6).

5. West Arm: Parry's Creek, King River, Pentacost River, Durack River, Forrest River, Patrick River, West Arm Mainstream (east bank, km 0-40), West Arm Mainstream (south bank, km 40-62) (see Figure 7).

Spotlight Surveys

6. King River: Both banks, from mouth (km 0) to km 41 upstream. (see Figure 7).

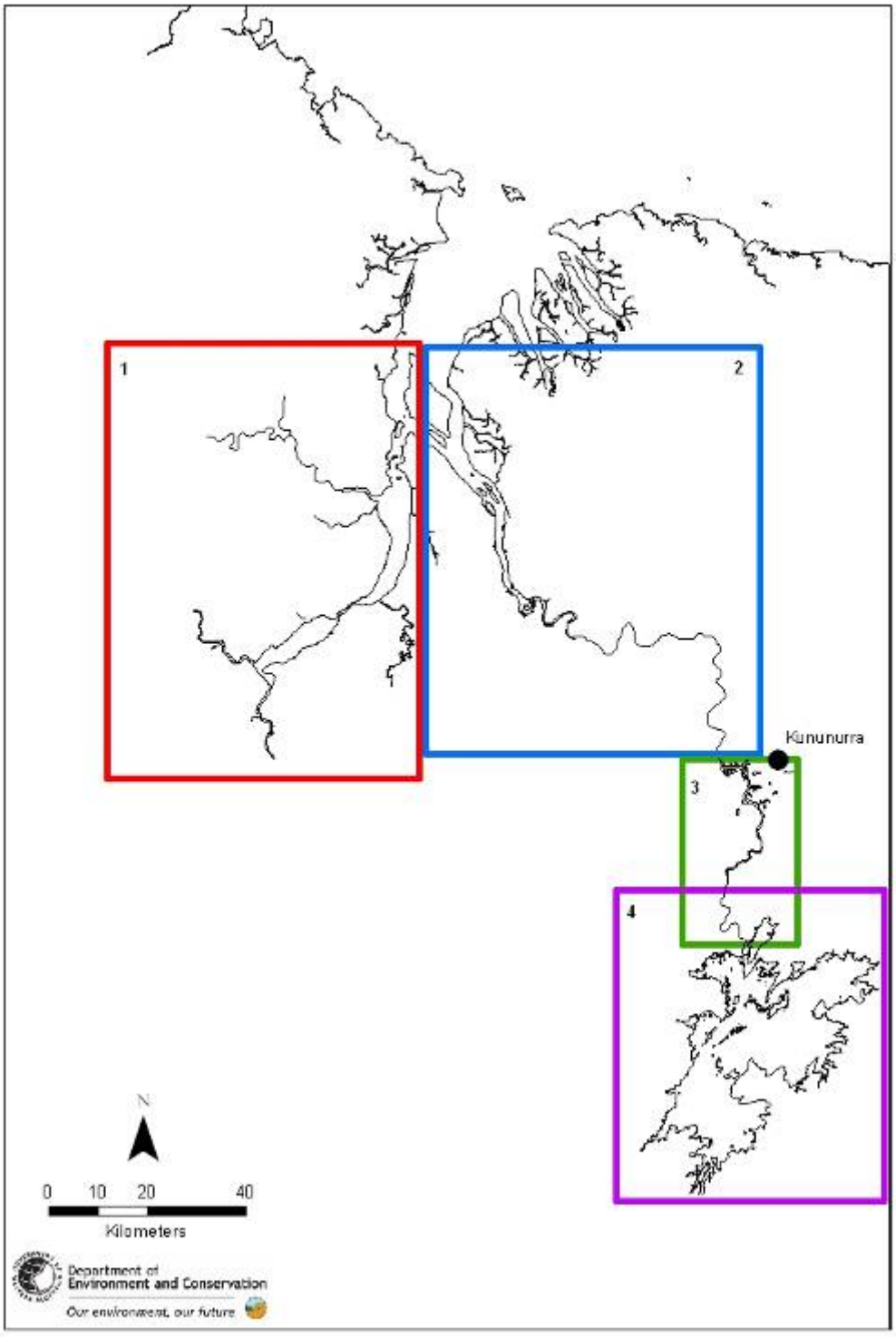

Figure 3. Map showing the relative location of sections of the Ord River and Cambridge Gulf that are subject to annual survey (aerial and boat) for salt and freshwater crocodiles. Inset 1 Cambridge Gulf (see Figure 6); inset 2 Ord River (see Figure 7); inset 3 Lake Kununurra (see Figure 4); and inset 4 Lake Argyle (see Figure 5).

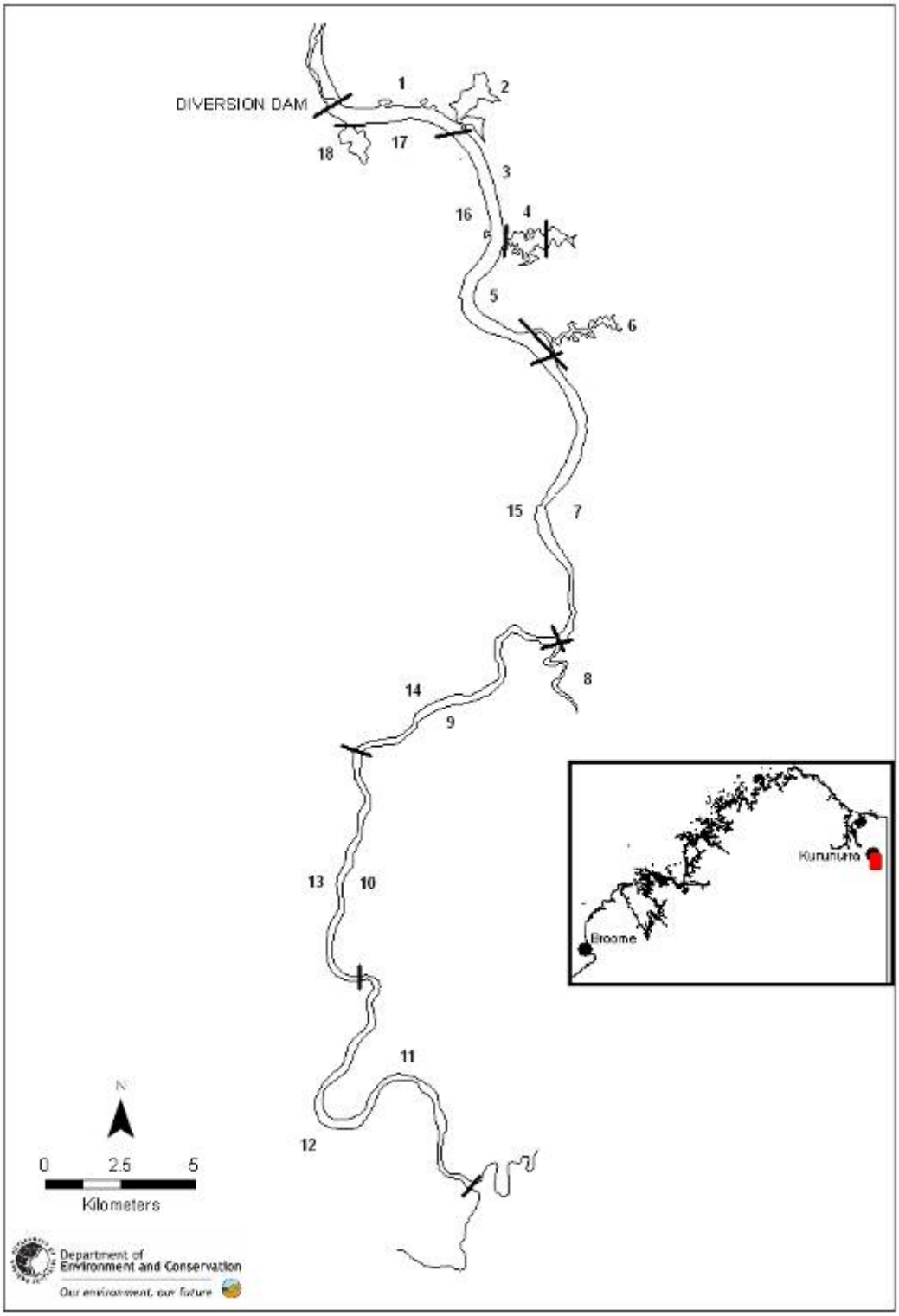

Figure 4. Map showing sections of Lake Kununurra subject to survey (refer to text at start of Appendix 2 for additional information).

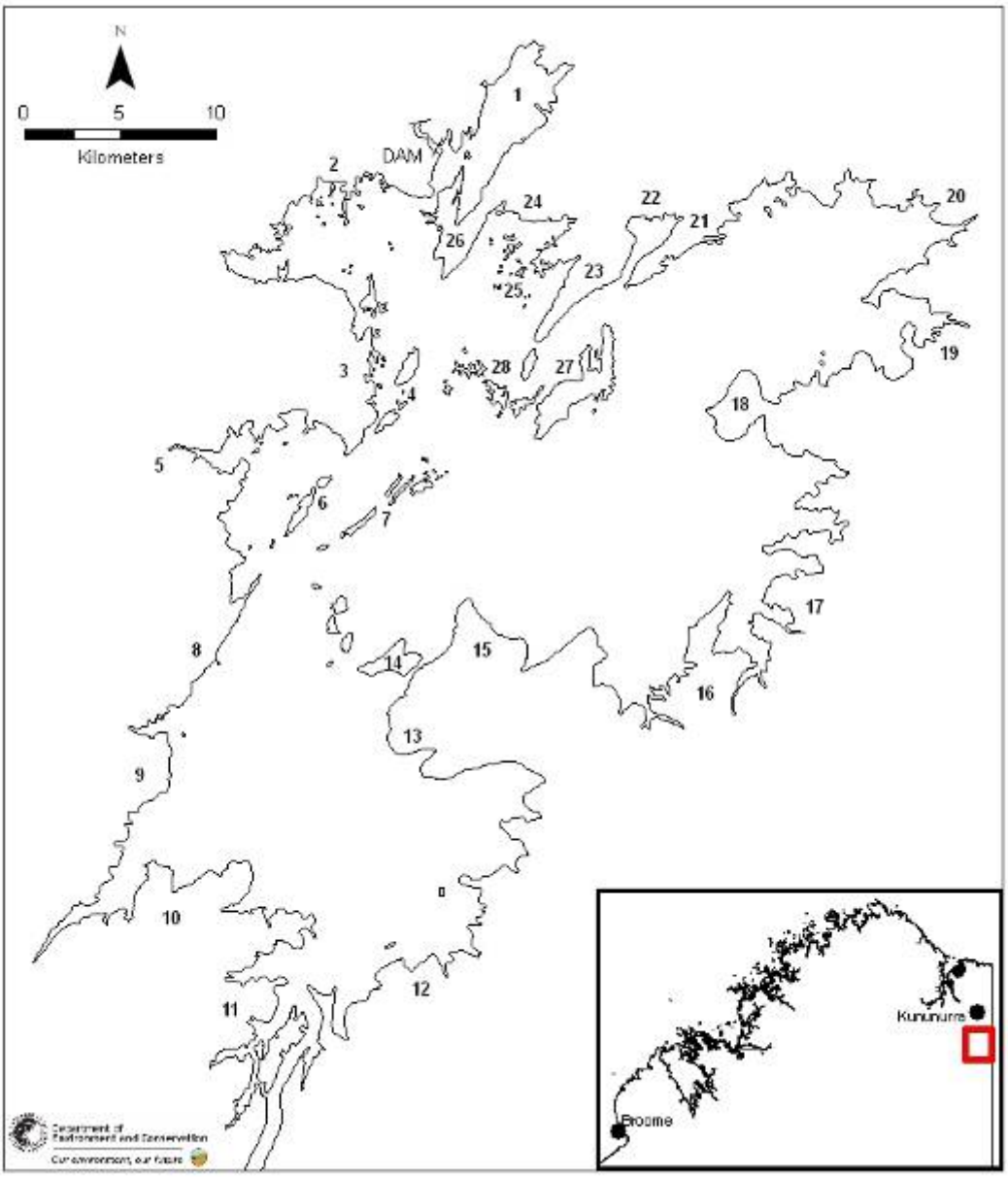

Figure 5. Map showing sections of Lake Argyle subject to survey (refer to text at start of Appendix 2 for additional information).

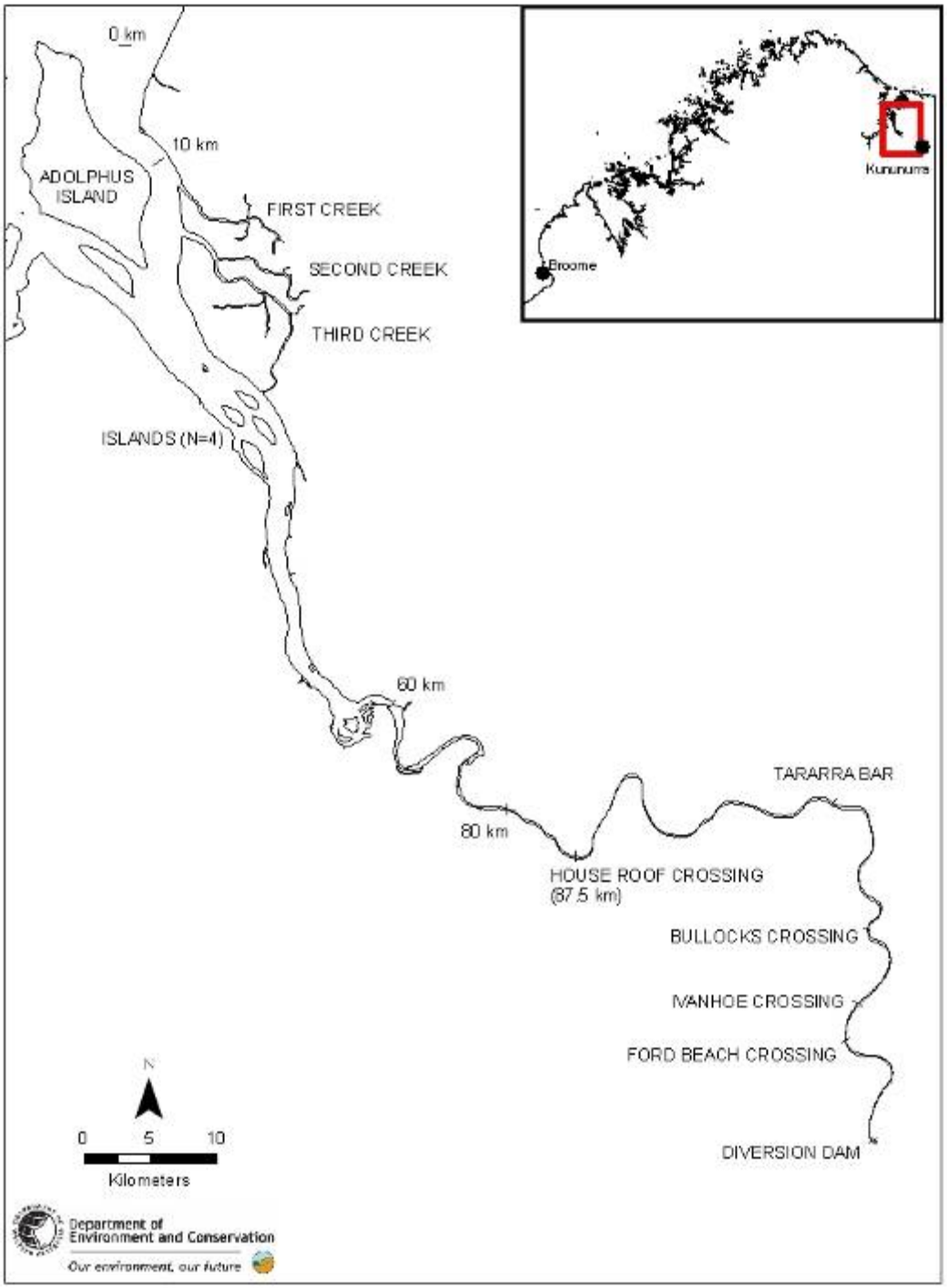

Figure 6. Map showing sections of the Ord River subject to survey (refer to text at start of Appendix 2 for additional information).

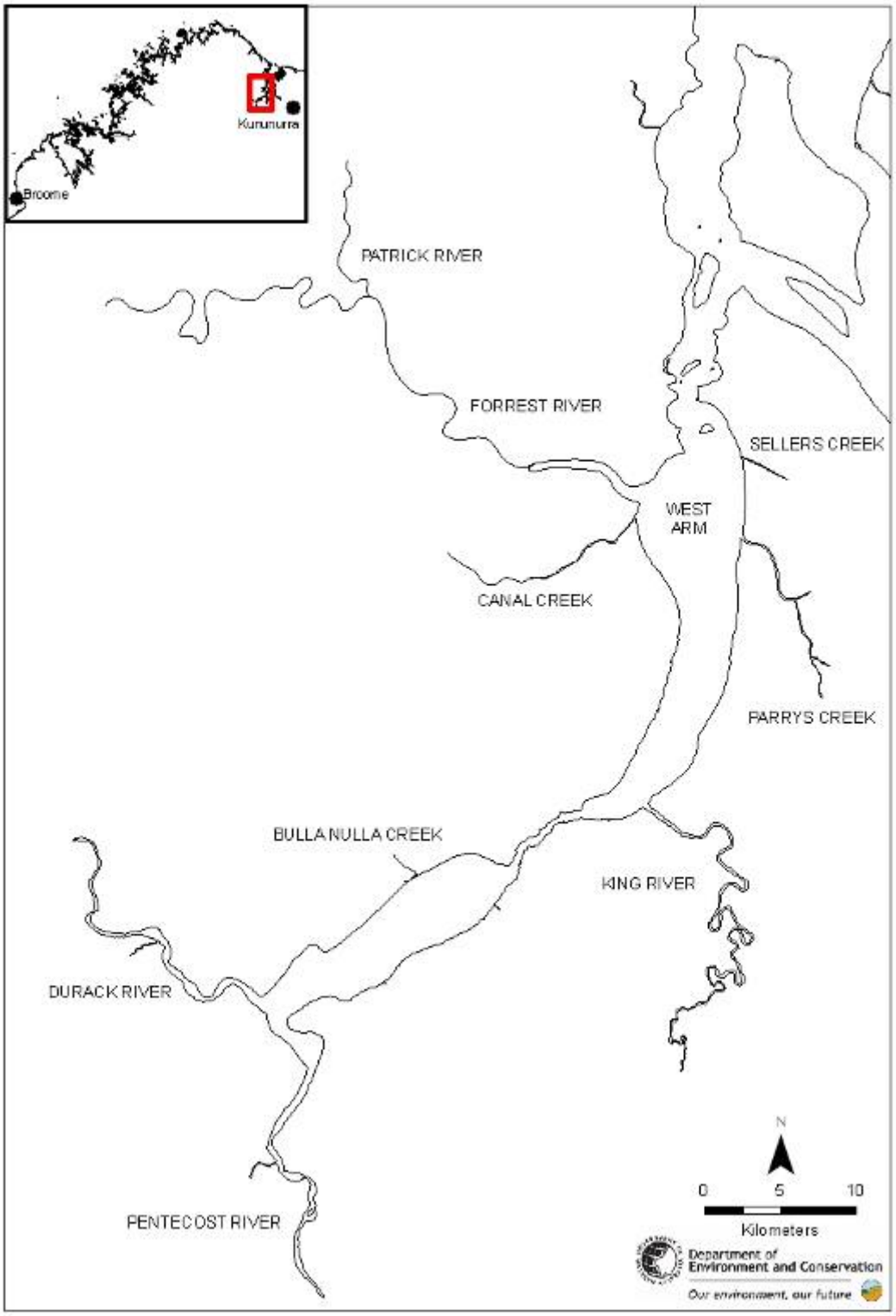

Figure 7. Map showing sections of Cambridge Gulf subject to survey (refer to text at start of Appendix 2 for additional information).