Husbandry Guidelines
for
The Freshwater Crocodile

Crocodylus johnstoni

Reptilia : Crocodylidae

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HM Statement

These husbandry guidelines were produced by the compiler/author at TAFE NSW – Western Sydney Institute, Richmond College, N.S.W. Australia as part assessment for completion of Certificate III in Captive Animals, Course number 1068, RUV30204. Since the husbandry guidelines are the result of student project work, care should be taken in the interpretation of information therein, - in effect, all care taken but no responsibility is assumed for any loss or damage that may result from the use of these guidelines. It is offered to the ASZK Husbandry Manuals Register for the benefit of animal welfare and care. Husbandry guidelines are utility documents and are 'works in progress', so enhancements to these guidelines are invited.

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Warnings
Occupational Health and Safety

Caution should always be taken when working with any member of the Crocodylidae. Freshwater crocodiles, *Crocodylus johnstoni*, generally are not aggressive animals and usually not harmful to humans unless provoked (Enc. Australian Wildlife, Parish and Slater), and as a species they could be regarded as a hazardous animal. This is not to say that caution should not be taken when working with this species, as they possess incredibly sharp teeth, have powerful jaws, are surprisingly fast and will quite possibly bite when touched (Parish and Slater). A bite by a freshwater crocodile may cause serious injury through its sharp teeth as well as its strength behind the bite. Using this description *C. johnstoni* could be classed as a relatively dangerous animal as it could be likely to cause serious injury (Bool and West, 1992). It is possible that individuals may be regarded as dangerous or relatively dangerous, but this will need to be determined for each particular animal. All keepers must always consider each animal's full potential, i.e. an animal's strength must never be underestimated.

Enclosures should have clear signs outlining the risk of handling and/or coming into contact with this species so all keepers and staff members understand the risks involved and safety measures needed. Appropriate Personal Protective Equipment (PPE) should be used when handling this species. When working with freshwater crocodiles, various hazards exist and these must be reduced or eliminated wherever possible. There are six groups hazards may fall under: physical; chemical; biological; ergonomical; psychological; and radiation.

Many hazards will depend on the design and access of the enclosure, however there are general hazards that will exist for all freshwater crocodiles kept in a captive institution. These hazards as well as actions to reduce them are summarised in Table 1.0.

Table 1.0: Types of risks encountered when working with freshwater crocodiles and actions to reduce these risks.

Risk Categories	Type of Risks	Actions to Reduce Risks
Physical	sharp teeth, strong jaws – may tear flesh, crush bone; strong tail, immense body strength – may knock person over, may cause lacerations, may crush person; sharp claws – may cause lacerations, cuts.	wear strong protective gloves (elbow length); only experienced keepers should handle crocodiles; have at least 2 keepers present during feeding/cleaning/ capture;
Chemical	exposure to all chemicals used in cleaning - F10SC, virkon, hospital grade disinfectant; medicines used for treatments – betadine, iodine, Flagyl; supplements to diet – calcium powder, vitamins; agents used in maintaining equipment/machinery - WD40.	wear appropriate PPE – gloves, face mask; used correct dilution; ensure labels easily visible and present on all chemicals/medications; always read instructions.
Biological	zoonotic diseases such as *Salmonella spp.*, and *Pseudomonas spp.*, transmitted through bite	always wash hands after handling, cleaning; clean any wounds obtained thoroughly; wear gloves.
Ergonomical	the layout of the enclosure and whether access is awkward or difficult for staff; the height of food preparation areas;	adjustable table heights for food preparation areas; signs indicating difficulty in access, or space; consider modifying enclosure.
Psychological	euthanasia of food animals, administering medicines for sick or injured individuals, as well as the possibility of having to euthanize a freshwater crocodile in your care.	experienced personnel should carry out euthanasia; experienced staff to administer medicines; training of employees.
Radiation	exposed to ultraviolet radiation from the sun; possibility of radiation exposure through ultraviolet lights	wear protective clothing – long sleeves, hat; wear sunscreen.

ANNUAL CYCLE OF MAINTENACE FOR THE FRESHWATER CROCODILE *Crocodylus johnstoni*

JANUARY			3		5	6
FEBUARY			3	4		6
MARCH	1	2	3			6
APRIL			3			6
MAY			3			6
JUNE			3		5	6
JULY			3			6
AUGUST			3	4		6
SEPTEMBER	1	2	3			6
OCTOBER			3	4	5	6
NOVEMBER			3			6
DECEMBER			3			6

1 Drain pond and scrub with chemicals

2 Remove and replace substrate

3 Drain pond and backwash

4 Prune/trim plants and add new plants

5 Ensure temperature and humidity control systems are working correctly

6 Clean and service all feeding and restraint tools and equipment

1 Introduction

The Freshwater Crocodile *Crocodylus johnstoni* is a member of the Crocodilidae, a family of reptiles that includes the largest living reptile, and that have been evolving on earth for the past 250 million years. Crocodilians are well established predators in their respective food chains and are among the most deadly and efficient predators in the world (*Dragons Alive*, 2006). They have incredible strength, stealth and are excellent ambush predators. Crocodilians have adapted many characteristics to suit an aquatic predatory lifestyle including the powerful blade-like tail used for propulsion when swimming, and three webbed toes on its hind limbs (Parish and Slater), water-tight valves in the nostrils which sit high on the head, the possession of nictitating membranes covering the eyes as a third eyelid, and most noticeably an elongated head with sharp teeth (Cogger and Zweifel, 2003).
All crocodilians are ectothermic, and although most comfortable in the water, they spend quite a lot of time on land, usually basking on river banks, logs, rocks etc in the sun in order to raise their body temperature. They are some of the most impressive animals in the world, and often give people an impression of prehistoric dinosaurs.

There are two species of crocodile in Australia, the saltwater crocodile, *Crocodylus porosus*, and the Freshwater Crocodile, *Crocodylus johnstoni*. The Freshwater Crocodile differs in appearance to the Saltwater Crocodile in that they only reach a maximum of three metres, and they have a much narrower snout, and are more likely to consume more fish (Greer, 2006).
The Freshwater Crocodile is a superb predator, of amazing strength and are potentially dangerous to people. It is for this reason that security and safety are two very important issues when considering housing Freshwater Crocodiles. This species is an important part of educating people on conservation and of the amazing, efficient and well adapted crocodilians. They are now a protected species and can no longer be hunted for their skins, something which was unfortunately done by many during the 1950s to 1980. Freshwater Crocodiles are often thought of as being just as aggressive and dangerous as the larger Saltwater Crocodile, therefore the Freshwater Crocodile is important in educating young children.

1.1 ASMP Category

The Freshwater Crocodile is in the Reptile and Amphibian TAG.

1.2 IUCN Category

This species is listed in Appendix II of the CITES.

1.3 EA Category

This does not apply for the species.

1.4 Wild Population Management

Wild populations of Freshwater Crocodiles are somewhat controlled and managed by their only natural predator, the Saltwater Crocodile, *Crocodylus porosus*. It is generally thought that where there are numbers of Saltwater Crocodiles there will be no Freshwater Crocodiles. This is due to the fact that Saltwater Crocodiles are much larger and much more aggressive than the smaller Freshwater Crocodiles.
To prevent any wild Freshwater Crocodiles from being hunted for their skins and meat, there are many Crocodile Farms operating in the Northern Territory and Queensland, Australia. These facilities breed crocodiles specifically for the market.

1.5 Species Coordinator

There is none listed for this species.

1.6 Studbook Holder

There is none listed for this species.

1.7 NZ and PNG Categories and Legislation

This does not apply for this species.

2 Taxonomy

2.1 Nomenclature

Class: Reptilia
Order: Crocodilia
Family: Crocodylidae
Subfamily: Crocodylinae
Genus: *Crocodylus*
Species: *johnstoni*

According to the Florida Museum of Natural History (Britton, 2002), the genus name *Crocodylus* is derived from the Greek *krokodeilos* meaning "pebble worm" (*kroko* = pebble; *deilos* = worm, or man) and thus refers to the crocodile appearance. Britton (2002) also states that the species name of *johnstoni* means "of Johnston" after the first European to discover then report it, however there was an error in the spelling of the name and officially due to the strict rules under the International Commission on Zoological Nomenclature, the name still stands as the error. Therefore, the correct species name should be *johnsoni*, however the majority of technical and non-technical publications uses the name *Crocodylus johnstoni* (Britton, 2002).

2.2 Subspecies

There are no recognised subspecies.

2.3 Recent Synonyms

The only other possible name *Crocodylus johnstoni* goes by is *Crocodylus johnsoni*, however as mentioned above the majority of publications use *C. johnstoni* (Britton, 2002). During my research, I have only located one source that has used the correct name under International Commission on Zoological Nomenclature of *Crocodylus johnsoni*, and that source is Dr. Harold G. Cogger and Dr. Richard G. Zweifel's 2003 publication *Encyclopaedia of Reptiles and Amphibians – A Comprehensive Illustrated Guide by International Experts*.

2.4 Other Common Names

Also known as Johnston's Crocodile; Johnston's Freshwater Crocodile; Fish crocodile; Johnston's river crocodile.

3 Natural History

The Freshwater Crocodile (*C. johnstoni*) is a member of the Crocodylidae family, a group in which there are 23 living species worldwide, and one that includes all crocodile, alligator, caiman and gharial species (Greer, 2006). The distribution of crocodilians is largely confined to the tropical regions, with their distribution ranging from Northern Australia, through Asia, India, Africa and South America to the temperate regions of The United States of America and China (Cogger and Zweifel, 2003). Within the Crocodylidae there are three subfamilies – the Alligatorinae (Alligators and Caimans), the Crocodylinae (Crocodiles, dwarf crocodiles, and false gharials) and the Gavialinae (Indian Gharial) – and of these, only two species are found in Australia – the saltwater crocodile (*Crocodylus porosus*) and the Freshwater Crocodile (*Crocodylus johnstoni*) (Greer, 2006).

Modern crocodiles evolved from prehistoric crocodiles which were quite varied in their body structure – some having long legs and being able to hunt and run on land; and some being much larger and spending a large proportion of time in the water. Professor Roger Seymour from the Discipline of Environmental Biology at The University of Adelaide says that the earliest crocodiles were among a group of animals known as archosaurs which evolved to give rise to dinosaurs along one lineage, which then gave rise to birds; and crocodiles on a separate lineage. It is thought that crocodilians diversified between 200 and 65 million years ago and gave rise to more than 150 genera in all kinds of habitats from land-based to fresh water and the ocean (Seymour, 2005). When the mass extinction occurred 65million years ago, there was a small group of crocodilians that survived and inhabited aquatic environments, evolving into the modern crocodilian species present today.

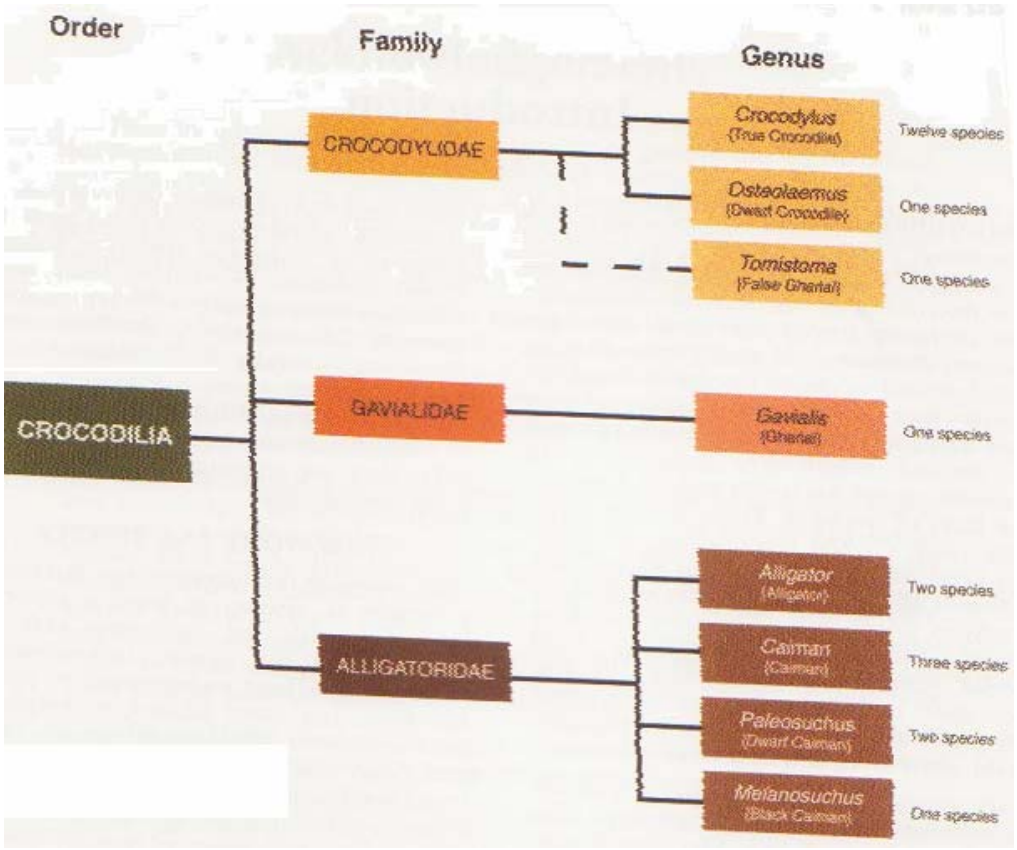

Figure 3.1: Diagram showing the evolutionary lineages and relationships between the crocodilians (Richardson *et al.*, 2002).

Crocodilians are well established predators in their respective food chains and are among the most deadly and efficient predators in the world (*Dragons Alive*, 2006). They have incredible strength, stealth and are excellent ambush predators. Their jaws can close with incredible force and strength (Parish and Slater), and it is this along with their amazing ability to camouflage themselves, that allows them to thrive at the top of food chains (*Dragons Alive*, 2006; Greer, 2006). Crocodilians have many characteristics to suit an aquatic predatory lifestyle including the powerful blade-like tail used for propulsion when swimming, and three webbed toes on its hind limbs (Parish and Slater), water-tight valves in the nostrils which sit high on the head, the possession of nictitating membranes covering the eyes as a third eyelid, and most noticeably an elongated head with sharp teeth (Cogger and Zweifel, 2003). Although locomotion is primarily in the water they are also quite capable of travelling some distance on land. The freshwater crocodile *C. johnstoni* is capable of galloping over short distances, sometimes, as Cogger and Zweifel (2003) mention, with all limbs off the ground at the one time.

Internally, crocodilians have some characteristic features that are unique among the reptilian. The crocodilian heart is four chambered and possesses a foramen of Panizza situated between the two ventricles (Ackerman, 1997; Cogger and Zweifel, 2003). This specialized heart enables crocodilians to direct blood to different organs at different rates depending on their activity. For example when spending a large amount of time underwater, crocodilians are able to slow their heart rate from 40 beats per minute to just three beats per minute and in doing so direct oxygenated

blood to the brain and deoxygenated blood to the other parts of the body, therefore allowing them to remain submerged for a much longer period of time (*Dragons Alive*, 2006; Ackerman, 1997; Cogger and Zweifel, 2003; Parish and Slater).

All crocodilians have specialised salt glands in their tongue which are used to excrete excess salt they may absorb into their skin and therefore maintain the correct salt balance (Cogger and Zweifel, 2003). Although *C. johnstoni* predominantly inhabit freshwater areas, they still possess salt glands, and according to Greer (2006) it is not completely understood why they occur in this species.

The respiratory system in crocodilians is completely separated from the mouth by a fleshy valve positioned at the base of the tongue in the throat, which is of high importance during prey capture as it allows the mouth to be opened underwater (Ackerman, 1997; Cogger and Zweifel, 2003).
The crocodilian metabolism is interesting to discuss; its stomach is the most acidic of any vertebrate, allowing the digestion of all bone consumed; and about 60% of all energy contained in the food is stored as fat in the tail, along the back in mesenteric organs and anywhere else it may be stored (Garnett, 1989). This allows crocodilians to go some time without access to food, which is often the case in some wild populations of crocodilians where there can be a dry season of almost drought like conditions (*Dragons Alive*, 2006).

For further information on characteristics, biology, the anatomy and the specific physiological functions of *Crocodylus johnstoni* please refer to Richardson, Webb and Manolis' book *Crocodiles: Inside Out – A Guide to the Crocodilians and their Functional Morphology (2002).*

3.1 Morphometrics

3.1.1 Mass And Basic Body Measurements

C. johnstoni is a relatively small crocodile, in comparison to the other well known species such as the saltwater crocodile (*C. porosus*) and the Nile crocodile (*C.niloticas*), and rarely exceeds three metres in length (Britton, 2002; Parish and Slater). Generally, adult freshwater crocodiles range in size from 2.0 metres to 3.0 metres for total length, and Greer (2006) states that the largest reliable specimen reported has been recorded to measure 3.05m in total length and 91kg in weight.
Hatchlings are and remain relatively small for quite a few months. Greer (2006) provides information on the average snout-vent length, total length and weight of hatchlings and lists these as 113.7mm, 246.7mm and 44.6g respectively. At eight weeks old two *C. johnstoni* hatchlings measured approximately 30 cm total length (*Pers. Obs,* Oceanworld Manly, 2007).

3.1.2 Sexual Dimorphism

Female freshwater crocodiles are generally smaller than males, measuring between 2.0 and 2.1 metres in total length whereas males can reach 3.0 metres as mentioned above (Britton, 2002).

3.1.3 Distinguishing Features

The freshwater crocodile *C. johnstoni* can be distinguished from other crocodilian species in various ways. Firstly, it can be easily determined that it is a member of the subfamily Crocodylinae as all members of this family have a notch on each side of their upper jaw in which the fourth tooth in the lower jaw sits when the jaws are closed, effectively making this tooth visible when the mouth is shut (Cogger and Zweifel, 2003). This is the major diagnostic difference between the Crocodiles and Alligators, as the latter do not have a notch in the upper jaw, but instead have pits in which the fourth tooth on the lower jaw fits, making none of the teeth being visible when the mouth is closed (Cogger and Zweifel, 2003). Secondly, being a member of the Crocodylinae, *C. johnstoni* has small sensory pits in the middle of each scale on the underside of the body whereas other crocodylians such as alligators lack these (Cogger and Zweifel, 2003).

Within the subfamily of Crocodylinae, *C. johnstoni* can be determined as this species firstly by looking at the distribution, and noticing that there is only one other crocodilian species that occurs in across a similar range, that being the Saltwater crocodile (*Crocodylus porosus*), however, the freshwater crocodile is not found in estuarine rivers where there are saltwater crocodiles present (Swan, 2001). Both *C. johnstoni* and *C. porosus* occur in the northern parts of the Northern Territory, Cape York Peninsula and the northern parts of Western Australia, however physical diagnostic features exist between the two species (EPA Queensland, 2007). The freshwater crocodile has a long, slender and smooth snout with needle-sharp teeth (Britton, 2002; Parish and Slater). The body colour varies but is predominantly grey to green-brown or light brown, with darker bands on the body and tail (Britton, 2002; Parish and Slater; Swan, 2001). *C. johnstoni* possesses a total of 68-72 teeth, with

five pre-maxillary; 14-16 maxillary; 15 mandibular teeth (Britton 2002) and the teeth are noticeably sharp and pointed.

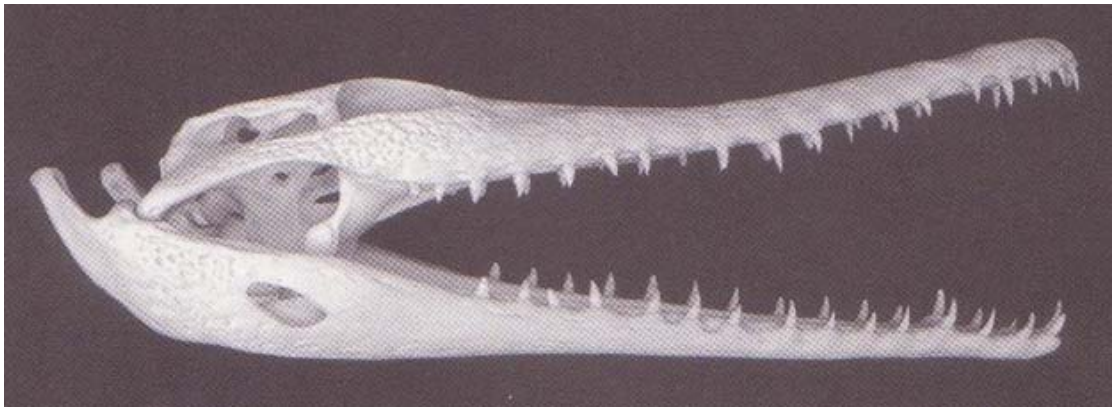

Figure 3.2: Skull of an adult Freshwater Crocodile, showing its sharp pointed teeth. The fourth tooth on the lower jaw and the notch on the upper jaw are visible in this photo (Richardson *et al*., 2002).

Hatchlings appear to have a large head relative to total body length, and they have much more vivid markings such as speckled pattern on the snout than do adults (*Pers. Obs*., 2007), as can be seen in the photo below. Once hatched, the mother carries the hatchlings to the water and here they remain in crèches guarded by the mother for safety (Greer, 2006).

Figure 3.3: Photo of two four week old Freshwater crocodiles (*C. johnstoni*) in holding tank at Oceanworld, Manly. Taken 24th, March, 2007.

There is some information on the differences in growth rates and therefore weights of individuals of the same age in different areas across the *C. johnstoni* distribution. It is noted that in the wild during the dry season, growth rate is slowest, and in the wet season it is most rapid (Greer, 2006). In the dry season where water sources disappear, individuals may not gain weight and live off fat reserves due to the lack of prey in the area (Greer, 2006). It is noted in Greer (2006) that juvenile freshwater

crocodiles in a captive environment seem to grow heavier and longer that wild juveniles of the same age, and this is thought to be due to the fact that the captive juveniles do not have to forage for their own food.

3.2 Distribution and Habitat

The freshwater crocodile (*C. johnstoni)* has a distribution in the northern parts of Western Australia, the Northern Territory and Queensland in Australia (Britton, 2002; EPA Queensland, 2007; Parish and Slater; Swan, 2001), and can be seen in figure 3.3. It is endemic to this region and is found to inhabit inland waterways such as lakes, billabongs, rivers, swamps and streams, occasionally venturing into more saline waterways (Britton, 2002; EPA Queensland, 2007; Greer, 2006; Parish and Salter; Swan, 2001).

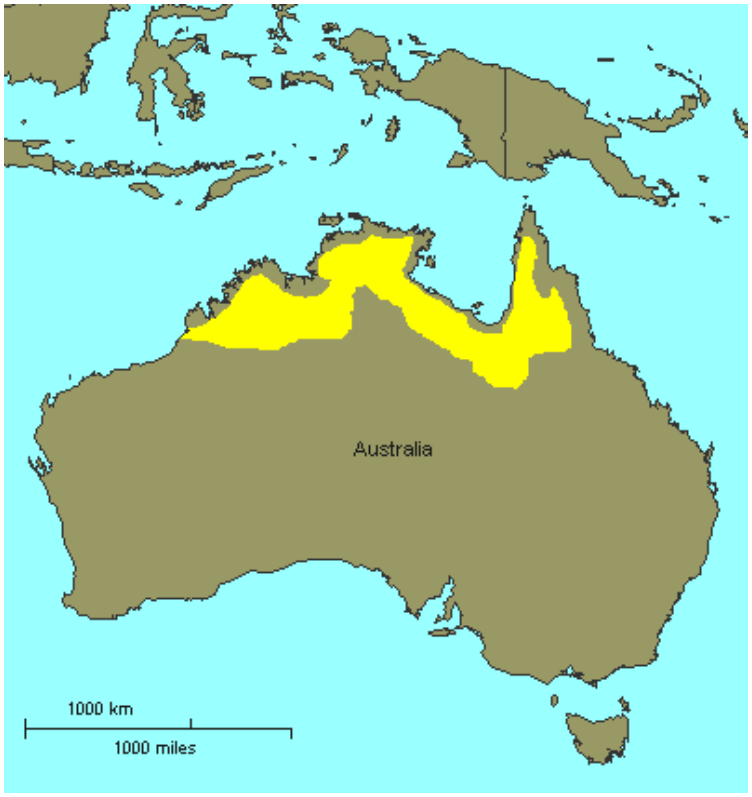

Figure 3.4: The distribution of *Crocodylus johnstoni*. Taken from the Florida Museum of Natural History website compiled by Britton, 2002.

3.3 Conservation Status

The Freshwater Crocodile *(Crocodylus johnstoni)* is listed in Appendix II on the CITES Appendices, and this indicates that the species is not endangered at present. However, both the freshwater crocodile and the saltwater crocodile are protected species in Australia.

3.4 Diet in the Wild

The natural diet of Freshwater Crocodiles varies during different seasons and different stages of a Freshwater Crocodile's life. Generally, hatchling and yearling Freshwater crocodiles consume a large proportion of invertebrates – insects, spiders, freshwater shrimp, small crabs and yabbies – but as they grow larger their diet includes fish, birds and small mammals.

3.5 Longevity

3.5.1 In the Wild

Determining the longevity of freshwater crocodiles poses quite a problem. It is known by determining the growth rates of juvenile, sub-adult and adult *C. johnstoni* that the growth rate is more rapid when the individual is young, and as the individual becomes older the growth rate slows (Greer, 2006). However, it is often very difficult to accurately determine the longevity of freshwater crocodiles or any Crocodilian species, and this is because they live for such a long time (Britton, 2002). It is thought that many of the medium to large species can live for 70-80 years, however much of the data is only estimated based on using one of two or both methods (Britton, 2002). Britton (2002) mentions a study that was conducted on freshwater crocodiles over 22 years, using a capture-marking-recapture method that had dated from the 1970s. This estimated that the longevity of freshwater crocodiles in the wild may be at least 50 to 60 years old, fairly typical of medium sized species (Britton, 2002).

3.5.2 In Captivity

In captivity, longevity can be determined by keeping accurate records of when the individual hatched or the age of it when it was obtained. This is still not a reliable method that would be able to give accurate age or longevity figures; however Britton (2002) states that estimated ages for captive crocodilians may be an underestimate for longevity. He also states that the average age and longevity in captive animals may be higher than in wild populations, however, that the maximum age or longevity may be higher in the wild due to the optimal conditions.

3.5.3 Techniques Used to Determine Age in Adults

There are several methods that may be used to determine the age of adult *C. johnstoni*, however none of them is regarded as being reliable and/or accurate (Britton, 2002). The most common method used is skeletochronology – a technique that measures the growth rings present in the bones and teeth of individuals, as every time there is a change in growth rate for the individual a ring is laid down in the bone, usually occurring once a year (Britton, 2002). However, there are some problems associated with this method. Firstly, for those species inhabiting tropical areas, growth rates may vary much less and so a growth ring may not be deposited (Britton, 2002). Secondly, the innermost rings tend to deteriorate or erode over time (Britton, 2002; Hutton, 1986). Also, to carry out this technique it is necessary to cut a cross section of the animals femur (Wikipedia, accessed 24th March, 2007), which is an invasive procedure and would be a good method to used if the animal had already died.

Another method is to simply mark an individual when young of a known age, and then determine age when the same animal is recaptured (Britton, 2002). This method would work quite well in a wild population.

In a captive institution, the easiest method to use would be to keep accurate records of the date of hatching or the age of the juvenile when it was acquired, then determine the age of adults by recovery old records.

4 Housing Requirements

4.1 Exhibit/Enclosure Design

There are general requirements needed in a captive reptile institution to ensure the care and husbandry of all reptiles is of a high standard. It is of absolute necessity that all staff working with reptiles possess a basic understanding of several important factors. The Exhibited Animals Protection Act (amended, 2004) states that these include:

a) basic knowledge of biological, nutritional and environmental requirements;
b) understanding of particular temperature requirements and thermoregulation in crocodilians;
c) familiarity with correct and appropriate handling techniques;
d) experience in applying current first aid for snake bites;
e) awareness of dietary balance and continued health in captive reptiles – in crocodilians the avoidance of thiamine deficiency;
f) understanding the dangers of overcrowding and stress related problems that may occur in captive situations.

In addition to this essential staff knowledge and understanding there are some other aspects that required in order to exhibit and house reptiles in an acceptable manner. Under no circumstances must reptiles be kept in conditions that do not allow normal physiological function, for example temperature, humidity, light cycles; or should they be exposed to areas with excessive noise and vibration or temperature fluctuation (EAPA, amended, 2004).
Successful captive management of reptiles relies upon good husbandry that addresses the species biological, nutritional and environmental requirements as it is known that the majority of diseases seen in captive reptiles arise from environmental stress and/or poor animal husbandry (EAPA, amended, 2004).

4.2 Holding Area Design

All reptiles kept for exhibition need to be moved to holding facilities at various times in order for maintenance and extensive cleaning of exhibits to be carried out. It is in these circumstances that it is necessary to move all freshwater crocodiles into a holding enclosure. The design of holding enclosures can be quite different to that of display or permanent enclosures. This is due to the fact that this housing is only temporary and the animals should only remain in the holding enclosure for limited period of time. However, the Exhibited Animals Protection Act (EAPA) states minimum requirements for the holding area. For all crocodilians, the EAPA (amended, 2004) states that the minimum floor area of temporary enclosures constructed to accommodate 2 individuals is 1.5L x 1.5L, where L is the extended length of the longest specimen. So for example, if the longest freshwater crocodile measured 1.0 metres, the minimum floor area required would be 1.5m x 1.5m. This may appear to be incredibly small if there were two individuals being held in the same enclosure.

Even in holding or temporary enclosures, there are still minimum requirements that need to be met regarding heating, light, shelter, basking space, ventilation, humidity, and clean water. Providing a form of shelter may be as simple as a wooden box turned upside down, as this is adequate for temporary use. Ensuring the temperature of the water is of high importance as freshwater crocodiles require a certain water temperature and for most tropical species 26-32° is appropriate (EAPA, amended 2004). The provision of light is important as it provides a cycle in which the crocodile can carry out normal physiological and behavioural functions (EAPA, amended 2004).

Holding enclosures need to be secure enough to prevent the crocodile escaping or causing injury to keepers, however do not need to meet the same requirements for security as do exhibit design. Other requirements include a filtration system to allow the water to be kept clean during the animals time spent in the holding or temporary enclosure.

The photo below (Figure 4.1) shows a holding enclosure for a juvenile freshwater crocodile of approximately 55cm in total length. The enclosure has an Ultraviolet light and basking light, as well as an up-side-down wooden box to act as a hide. There is a water filtration system in place to keep the water flowing slightly at all times, and the water is completely changed twice a week.

Figure 4.1: Photo of holding enclosure for freshwater crocodile of approximately 55cm in length at Oceanworld, Manly, taken on 24th March, 2007.

4.3 Spatial Requirements

The standards outlined by the EAPA (amended, 2004) give general guidelines as to the spatial requirements for all species. These include: a) sufficient vertical and horizontal space to meet activity needs of the species; b) the space must be large enough for a temperature gradient to be provided; and c) for each additional individual, the floor space of the enclosure must increase by 20% (EAPA, amended 2004).

Specific to crocodilians, and therefore the standards that must be used when constructing housing for freshwater crocodiles, there are minimum floor area formulas that must be used. For an enclosure used for display or permanent housing the minimum floor area for two individuals must be: 2.5L x 2.5L, where L is the length of the longest specimen (EAPA, amended, 2004).

Within the enclosure there must be an appropriate sized pond available, as well as sufficient land for the crocodiles to stretch out and bask under. There are four requirements that must be met when constructing the pond within the freshwater crocodile enclosure – pond length, pond width, pond depth and overall size:

a) the length of the pond must be at least two times as long as the longest individual's SVL (snout-vent length);
b) the crocodiles must be able to turn around in the water without being impeded;
c) when completely submerged, the largest crocodile must have at least 15cm of water covering it and so the depth must allow this;
d) the pond must be sufficient in length, width and depth to allow all crocodiles in the enclosure to submerge at the same time and without touching each other (EAPA, amended 2004).

When designing the land area within the enclosure, there are two requirements that must be met by the institution:

a) the largest crocodile must be able to lie its full length and width without any physical obstructions on the land area;
b) the land must be of sufficient size to allow all individuals to bask/rest on the land at the same time without touching each other (EAPA, amended 2004).

4.4 Position of Enclosures

Crocodilian enclosures can be indoor or outdoor; however, indoor enclosures are usually a more reliable option when housing species that originate from differing climatic regions than those of the location of the exhibit (EAPA, amended 2004). In the case of the freshwater crocodile, a tropical species, it may be advisable to establish an indoor housing exhibit in those regions of the world that are of a more temperate climate. By constructing indoor exhibits for this species, a greater degree of environmental control is gained (EAPA, amended 2004) and it may be easier to provide good husbandry and care for the species.

Indoor and outdoor enclosures should be positioned in ways in which keepers can gain easy access to all areas of the enclosure, but prevent members of the public from accessing the enclosure directly. Exhibition enclosures need to have a large proportion of it available for visibility by the public, as it is the animal inside they have come to see.

4.5 Weather Protection

If housing *C. johnstoni* in outdoor enclosures, it must be ensured there is adequate security to avoid all possibility of escape or entry of people other that trained staff (EAPA, amended, 2004). Outdoor enclosures require some form of shelter from the direct sun, for example the provision of vegetation or a man made roof could be constructed, in case the temperature is too high; adequate hiding areas; and areas that are permanently covered and dry (EAPA, amended, 2004). This may include the construction of a solid roof over a certain area of the enclosure or incorporating an indoor section of the enclosure with a passageway between the two options. Although if housing freshwater crocodiles indoors there is no need for weather protection as it is possible to create a mircoclimate within the enclosure.

4.6 Temperature Requirements

As freshwater crocodiles, like most crocodilians, are tropical reptiles it is necessary to provide individuals with appropriate heating, especially in institutions where the climate of the area is cooler. Like all reptiles, crocodiles need to regulate their body temperature by positioning themselves in warmer or cooler areas in order to maintain their preferred body temperature (EAPA, amended 2004). Heating devices such as heat lamps as well as water heaters should be positioned so that not all of the floor area is exposed to the heat source, therefore creating a temperature gradient in which individuals may choose whether to spend time in near the heat source or further from it (EAPA, amended, 2004). For *C. johnstoni* the water temperature of the pond in the exhibit needs to meet requirements also.
It is stated in the EAPA (amended, 2004) that the water temperature for tropical crocodilians should be between 26°C and 32°C, and both this heating system and the terrestrial heating system should be controlled thermostatically.

4.7 Substrate

It is recommended that natural substrates be provided where this is possible for the purpose of reflecting the natural habitat of the freshwater crocodile (EAPA, amended, 2004). As the freshwater crocodile spends time both in the water and on land, there must be adequate and suitable substrate in the enclosure to allow the individual to bask and keep dry if desired (EAPA, amended, 2004). In the enclosure includes a pool or pond, the EAPA (amended, 2004) states that the edges must be non-abrasive and rounded so as to prevent any injuries to their ventral surface, and that the bottom of the ponds must not allow the possibility of a crocodile catching its claws or toes. As the freshwater crocodile nests or rests on sandy banks in the wild it would be recommended to use a sandy substrate in exhibition enclosures if possible to enhance the natural appearance for the public and for the purpose of minimising behavioural or environment stress in the individuals (*Pers. Obs*, 2007).

4.8 Nestboxes and/or Bedding Material

The freshwater crocodile does not require extra materials for nesting or bedding as in their natural habitat this species nests or sleeps on sandy river banks or lake banks. Therefore, to provide adequate material for nesting the enclosure should include a sufficient amount of sandy or sand-like substrate necessary to enable all individuals to stretch out and dig if necessary to accommodate them for nesting. During breeding, the female freshwater crocodile lays eggs in a nest that is dug into the sand as opposed to building a nest using vegetation and debris.

4.9 Enclosure Furnishings

Enclosure furnishings are an important aspect of housing in exhibited animals. Exhibition housing for *C. johnstoni* should be greatly considered when designing the enclosure. In addition to assisting the natural appearance of the enclosure, furnishings provide an opportunity for keepers to allow *C. johnstoni* to portray natural behaviour (EAPA, amended, 2004). The requirements listed in the EAPA (amended, 2004) discuss the need for basking furniture such as rocks and logs, however, specific to the freshwater crocodile a basking site would simply be a sandy bank or substrate. For freshwater crocodiles, it may perhaps be advantageous to include aquatic vegetation and/or logs sitting in the pond as this would provide individuals with the opportunity the exhibit natural camouflage behaviour. It may also help act as visual barrier, something in which the EAPA (amended, 2004) lists as a requirement to minimise stress.

Some examples of furnishings for a freshwater crocodile enclosure include tropical plants such as palms, paper barks, and aquatic plants and reeds and/or grasses; logs; rocks; and sandy or grassy basking areas. Shown below is an example of an indoor enclosure using several of the enclosure furnishings mentioned previously.

Figure 4. : Image of Freshwater Crocodile exhibit showing a range of furnishings including plants, logs and rocks. (Taken at Sydney Aquarium, 2008).

5 General Husbandry

5.1 Hygiene and Cleaning

The EAPA (amended, 2004) lists specific hygiene and cleaning requirements that need to be met in order to provide adequate housing for crocodilians. However, Oceanworld, Manly also carry out a cleaning regime to ensure the health and well being of their freshwater crocodiles. The EAPA states that ponds must have regular water changes, and that faecal, urine and uneaten food must be removed daily. The Act however does not go into detail.

Freshwater Crocodile holding enclosures may have the ponds as well as the terrestrial areas of the enclosures spot cleaned daily where any debris, faeces or discarded food is removed, and perform a complete or 80% change of pond water twice weekly (*Pers. Obs*, 2007). The exhibit enclosures should also be spot cleaned regularly, daily or alternate days. Exhibit ponds should be emptied and the pond scrubbed about once a week to remove excess algae, debris, and any microorganisms.

When scrubbing the ponds it may be appropriate to use a light chemical agent such as F10, which may help in disinfecting the pond and also does not cause harm to the animals. Major cleaning using stronger chemicals and removing enclosure furniture could be carried out bi-monthly.

For keeper hygiene, gloves and sinks must be provided as reptiles can carry bacteria and other pathogens that may be ingested by any person who touches a reptile and these pathogens may be harmful to humans also (EAPA, amended, 2004).

Please see the husbandry maintenance schedule detailed in the appendix.

5.2 Record Keeping

Keeping accurate records for all animals is of great importance, for many reasons. Records are an excellent database for health problems, veterinary procedures, treatments administered, growth and development, feeding patterns among many more aspects of animal husbandry. The EAPA (amended, 2004) lists the requirements necessary for keeping records for all reptiles, but these can be directly applied to the husbandry of freshwater crocodiles. It is listed that:

a) feeding records including the feed date, amount and type of food offered and eaten;
b) occurrence of skin shedding;
c) measurements of weight and length and date on which taken;
d) any adverse health conditions and treatments;
e) breeding details and offspring details;

should all be recorded and kept as permanent records.

One method of keeping records which appears to be quite common across captive institutions is the use of identification cards which have numerous columns designated to record specific information such as feed records, measurements and

observations of changing behaviour or injury (*Pers. Obs*, 2007). The information kept as records in each institution must accompany the particular animal when it is, if ever, transferred to another facility (EAPA, amended, 2004).

5.3 Methods of Identification

A common method used in the identification of crocodilians and could be used in assisting identification among captive freshwater crocodile individuals is the procedure of cutting scutes in a unique pattern (Isberg *et al.*, 2006). Scutes are chitinous or bony external plates (Wikipedia, accessed March, 2007), and in crocodilians are the triangular vertical plates positioned along the midline of the tail (Isberg *et al.*, 2006). This method is usually done on the first day of hatching (Isberg *et al.*, 2006) and is probably easier to do at this age and less painful to the hatchling. There is however some problems which may arise from this method. Although it is a permanent form of identification, care must be taken to ensure each scute is cut properly so as to avoid regrowth of the scute that could obscure identification (Isberg *et al.*, 2006).
Other identification methods include microchipping which would be a valuable and permanent form of identification, may also be used, however may result in higher costs.
One further identification technique may be as simple as using photographs of distinguishing features on each of the individuals and writing descriptions on care cards for all staff and keepers. This is an easy method which can be applied to most animals, however it must be ensured that as growth and development continues the photographs are updated with new ones and the old one stored in a file. This will help with record keeping also.

Figure 5. : Photo showing the individual markings on the scutes of the tail, which can be used to identify individual freshwater crocodiles. (Richardson *et al.*, 2002).

5.4 Routine Data Collection

The collection of data should be a routine in the workplace. Any data collected provides a written record of any notable events or other comments about each animal. Records are an excellent database for health problems, veterinary procedures, treatments administered, growth and development, breeding, feeding patterns among many more aspects of animal husbandry.

A routine should be established of when observations are taken or data collected. For example, it is recommended that each animal should be checked for any changes or problems daily, and if any notable events have been observed these should then be recorded. It is of great value if the type and amount of food offered to and taken by the individual is always recorded so that if any illnesses or problems occur keepers and veterinarians are able to use the feeding records to help determine the cause of the problem. Similarly, weight, snout-vent length and total length data is invaluable to determine growth and development.

Data collection cards could be developed to allow all keepers to understand what and how to record observations and data. A general example is shown below, however between institutions the layout of the cards may differ, and symbols or abbreviations may be used. Examples of these symbols or abbreviations are:

- AM – *adult mouse*
- FM – *fuzzy rat*
- √ – *food item was taken*
- X – *food item was refused*

Species:		Common Name:	
ID/Specimen No.:		Sex:	
Distinguishing Marks:		Enclosure No.:	
Date	Observations/Comments	Weight/SVL	Initial
15/10/07	*Weight taken;*	*1.72kg*	*LM*
17/10/07	*Offered 1x AM; taken*		*LM*

Figure 5. : Example of a Specimen Data Sheet or Species Card, showing where and how to record particular data. (Example of data recorded is in italics).

6 Feeding Requirements

6.1 Captive Diet

The natural diet of Freshwater Crocodiles can not be replicated precisely in captivity. However, the basic nutritional requirements must be met for all freshwater crocodiles kept in captive environments. The nutritional requirements and captive diet differs depending on the age of the crocodile, and so this must be addressed when preparing diets.

Hatchling and yearling freshwater crocodiles should be fed a range of insects and aquatic invertebrates, and as they grow larger, small fish and worms may be added to the diet (Moran and Malone, 2003). In captivity, crickets are often supplied as the main or sometimes only source of diet for smaller crocodiles, but caution must be taken when this is done (Moran and Malone, 2003) as a varied diet allows the crocodiles to be in better condition and health.

Larger juvenile and adult freshwater crocodiles are suggested to be fed a diet consisting primarily of fish, however small mice, day-old chicks (*Pers. Obs*, 2007), and other small mammals may be offered (Beynon, 1992). They may be fed rats, mice, rabbits and chickens but it is recommended to only feed animals or parts of animals that will be easily swallowed in one gulp (Moran and Malone, 2003). The table below (table 6.1) shows the recommended food types for freshwater crocodiles of varying ages.

Table 6.1: Recommendations of food types to be offered to Freshwater Crocodiles of varying ages or sizes.

	Hatchlings	Juveniles	Adults
Food Offered	Crickets; roaches; prawns; whitebait; worms; pinky or fuzzy mice and rats.	Adult mice; weaner rats; yabbies; red spot whiting; pilchards; day-old chicks.	Adult rats; rabbits; chickens; larger fish e.g. yellow tail; yabbies; crabs.
Supplements	Calcium dusted on crickets (1x week); UVB light; exposure to sunlight (at least 4 hrs weekly)	Calcium powder on food items (1x fortnight); UVB light; exposure to sunlight (at least 4 hrs weekly)	Calcium powder on food items (1x fortnight); UVB light; exposure to sunlight (at least 4 hrs weekly)
Amount offered	Invertebrates: 2-3 times weekly offer ~20 inverts each time. Fish, pinky rodents: one item once per week.	Small to medium meals (mice, fish): one item once per week. Larger meals: once per fortnight.	One food item cut into several pieces once per week.

Generally most captive freshwater crocodiles are fed once each week (*Pers. Obs.*, 2007). It seems to be known in the herpetological departments of institutions that the more frequently you feed a young freshwater crocodile the faster it will grow. However, it is generally something that does not seem to be done in many institutions and would be more common in commercial crocodile farm.
Hatchling freshwater crocodiles may not eat immediately, however after a few weeks they should be offered crickets (usually by scattering them on the water surface or in the enclosures) at different times each day usually once a day or every second day.

6.2 Supplements

It is recommended that Calcium supplements are provided for young, growing animals or those individuals whose diet does not consist of whole animals (Moran and Malone, 2003). The Rural Industries Research and Development Corporation suggest that young, hatchling crocodiles be given vitamin and mineral supplements. Moran and Malone (2003) state that when using crickets as a large part of the crocodile's diet these crickets should be kept on a high vitamin, calcium rich diet, therefore ensuring the crickets have a good supply of calcium and vitamins which can then be passed on to the crocodile during digestion.
Supplying an adequate source of UV is essential to ensure growth and development of the bones and muscles and so provision of a UV light or exposure to direct sunlight is required. Exposure to sunlight provides vitamin D to the individual, which is also required to ensure growth and development.

6.3 Presentation of Food

When feeding hatchling and juvenile freshwater crocodiles, live invertebrates and insects can be given and scattered in the enclosure (*Pers. Obs,* 2007). Feeding hatchlings and juveniles live invertebrates allows individuals to exhibit natural hunting behaviours such as using camouflage to sit and wait for prey, and snapping sidewards. It also simulates the natural diet, as juvenile freshwater crocodiles are known to eat a large range of aquatic and terrestrial invertebrates (Greer, 2006). From personal experience, hatchlings are scatter-fed approximately 10-15 crickets twice weekly (at Oceanworld, Manly). Small fish such as whitebait are defrosted in freshwater and one or two are placed in the water; rodents can be tong fed to the crocodile and they may snap and take the prey item immediately, if not the rodent can be left in the water (*Pers. Obs*, 2007).
For larger juveniles, sub-adults and adult freshwater crocodiles, feeding parts of dead animals can be presented in various ways to maximise the behavioural advantages during feeding. Many parks, zoos and aquaria provide a crocodile feeding show (Pers. Res., 2007), and so it would benefit the public as well as the crocodile to present food in a manner in which behavioural enrichment is provided for the freshwater crocodile as well as entertainment for the public. This often involves a keeper holding parts of dead feed animals with long tongs and either slaps it on the water (*Pers. Obs., (see photo 6.2),* Australian Reptile Park, 2007), or waves the food item in the air enticing the crocodile to come out of the water to catch its prey (*Pers. Obs.,* Oceanworld, 2007).

Figure 6.2: Photo of crocodile feeding show at The Australian Reptile Park showing one of the methods used by keepers when feeding large crocodiles. Note: Although this photo shows a saltwater crocodile, feeding large adult Freshwater Crocodiles can be performed in the same way.

Figure 6.3: Photo of a wild Freshwater Crocodile eating a yabbie. Taken from ABCs Wild Australasia website, at www.abc.net.au/nature/australasia, accessed: January, 2008.

7 Handling and Transport

7.1 Timing of Capture and Handling

It is preferable to arrange capture and handling of freshwater crocodiles in the early part of the day, as this would allow the crocodiles less time to have warmed their body temperature, thus the crocodiles may be more docile. The duration of the capture procedure should not be unnecessarily long, and there should be limited hesitation between gathering and preparing for the capture and actually performing the capture (*Pers. Comm.,* Brims, 2007).

7.2 Catching Bags

Depending on the size of the freshwater crocodile, a catching bag may or may not be used. Generally for juvenile animals with a snout-vent length of less than 60cm a bag may be used as temporary transport between enclosures or enclosure and transport box. In all cases where a bag is to be used it must be made of a breathable material such as cotton, with the seams on the outside to prevent the crocodile from becoming tangled in any way (*Pers. Obs.,* 2007).

7.3 Capture and Restraint Techniques

The technique used to capture and restrain freshwater crocodiles varies depending on the size and aggressive nature of the individual. For hatchlings, capture and restraint is quite like that of lizards – firmly place one hand around the neck region in front of the forelegs and support the hind legs and tail with the other hand (*Pers. Obs.,* 2007). For larger juvenile crocodiles, a similar technique can be used; however, caution must be taken as they are fast and can inflict a painful bite. A thick glove should be worn, and the less time the crocodile has to see the gloved hand the easier it is to capture and restrain the crocodile. One hand is used to firmly hold around the jaws to prevent the possibility of a bite from the side, and as this hand is holding down the head, the other hand can be brought in to hold the base of the tail. Once the keeper has a firm hold the crocodile can be brought out of the water and either placed into an inside-out bag or restrained for examination or show. Once the crocodile has been restrained and is calm, the glove can be removed, ensuring there is a constant grip around the jaws. The photo below (Figure 7.1) shows the method which should be used to restrain a juvenile freshwater crocodile. The grip around the jaws should be firm, but not tight, ensuring the jaws remain closed but the neck and throat is not squeezed (*Pers. Comm.,* Brims, 2007). The grip used can be seen in Figure 7.2.

Figure 7.1: Restraint of juvenile freshwater crocodile (Taken at Oceanworld, Manly, 2007)

Figure 7.2: Correct grip used to restrain a juvenile freshwater crocodile's jaws (Taken at Oceanworld, Manly, 2007)

For capture and restraint of larger freshwater crocodiles, a similar method is to be used, however it must involve at least two experienced keepers, ensuring the mouth is secured first (Moran and Malone, 2003). The use of a catch pole is recommended when catching a medium-sized or adult freshwater crocodile, and this technique can been seen if Figure 7.3. Once the catch pole has successfully caught the crocodile, and experienced keeper is to grip from behind the crocodile just in front of the forelegs (Moran and Malone, 2003), then the mouth can either be taped or bound to prevent biting.

Figure 7.3: Restraint of a large crocodilian. Note: Although this photo shows a saltwater crocodile, restraining a large adult Freshwater Crocodile can be performed in the same way. (Taken from website http://www.crocodilian.com)

7.4 Weighing and Examination

Weighing and examination of any freshwater crocodile involves first the capture and restraint of the animal using the methods described previously. Weighing juvenile animals is relatively easy, as they can be placed in an appropriate sized inside-out bag, and then placed on scales. The bag can either be pre-weighed or weighed after the crocodile has been weighed. Weighing sub-adult or adult Freshwater Crocodiles the use of suspended scales may be necessary as can be seen in figure 7.5.

To perform a brief examination, two keepers are required – one to restrain the crocodile, and the other to carry out the examination. Once restrained, a cloth can be placed over the eyes to help prevent stress, and this will also calm the crocodile (Salkeld, TAFE 2007). The second person can examine the tail, body and limbs for any abnormalities, then when ready can examine the eyes and nictitating eyelid, mouth and snout (*Pers. Obs.*, 2007). For larger animals, it may be necessary to have more than two keepers in order to restrain and examine the individual.

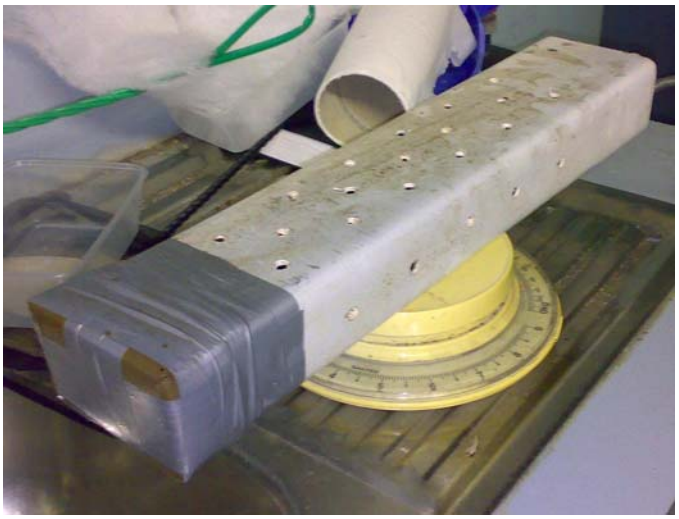

Figure 7.4: Weighing an adult Freshwater Crocodile at Sydney Wildlife World.

7.5 Release

The release of a juvenile freshwater crocodile is similar to the capture, where the same grip round the jaws is to be used. If the juvenile is in a bag, the snout must be found from outside the bag and the mouth restrained before the other hand is to be placed in the bag. Once this grip round the jaws is secure, the other hand can be brought inside the bag and take the grip round the jaws from the first hand (*Pers. Comm.*, Brims, 2007). The crocodile can then be removed from the bag and be placed back into its enclosure.

When placing a juvenile crocodile back into its enclosure, it is best to place it in the water. Using the same grip as described previously, place the crocodile gently in the water (see Figure 7.6) and release the hand that is holding the base of the tail first, ensuring there is still a firm grip round the jaws (*Pers. Comm.*, Brims, 2007). Once the hand holding the tail is clear the hand holding the jaws can be released and that hand should then be taken out of the enclosure quickly (*Pers. Comm.*, Brims, 2007).

Releasing an adult freshwater crocodile back into its enclosure is quite different to the method used for juveniles. Again it will require at least two keepers. One keeper should remain behind the crocodile and keep a firm grip round the neck. Before the tape around the snout is removed the catch pole can be slipped back onto the snout and held by a keeper at a distance from themselves. The tape can then be removed, then as the keeper holding the crocodile down releases their restraint and backs away, the keeper holding the catch pole can remove it once all staff are in safety (*Pers. Obs.*, 2007).

Figure 7.5: Photo showing method of placing juvenile crocodile back into its enclosure (Taken at Oceanworld, Manly, 2007).

7.6 Transport Requirements

The International Air Transport Association (IATA) is the governing body that dictates the standards required involving the transport of any animal using member airline services. The standards and regulations cover all container requirements necessary for the transport of all animals as well as the accompanying permits and documentation that apply. For the transportation of freshwater crocodiles, general container requirements for reptiles as well as the specific crocodile requirements must be followed. An individual freshwater crocodile must be measured by snout-vent length (SVL) in order to determine the correct dimensions for the transport box.
General requirements state that the box must prevent the animal from escaping and prevent the handlers from being bitten (IATA, 2006). The transport container must be adequately ventilated, and the size of ventilation holes depends on the ambient temperature. However, the ventilation holes must be small enough to prevent escape (IATA, 2006). Accompanying the transport box and animal must be the appropriate labelling and marking, and documentation – names, addresses, and phone numbers of the person shipping the crocodile/s and the person receiving them. All boxes must have labels stating “THIS WAY UP” and “LIVE ANIMAL” affixed to all four sides, and reptiles/amphibians must be indicated on the live animal label (IATA, 2006). Further information on the general container requirements can be found in the appendix.

7.6.1 Box Design

The container requirements and box design for crocodiles can be found in the appendix or in the IATA handbook from 2006, however a brief summary is provided here. For freshwater crocodiles measuring 60cm or more in SVL the transport container must be constructed so in a manner that restricts the crocodile's freedom of movement. IATA (2006) states that there should be no more than 10cm of space between the wall and the widest part of the crocodile's abdomen; and there should be no more than 30cm greater than the total length of the crocodile. The direction the head of the crocodile is facing must be indicated on the transport box. The box must have smooth edges and without sharp protrusions to prevent injury to the animal. Given below are the IATA box designs for crocodiles.

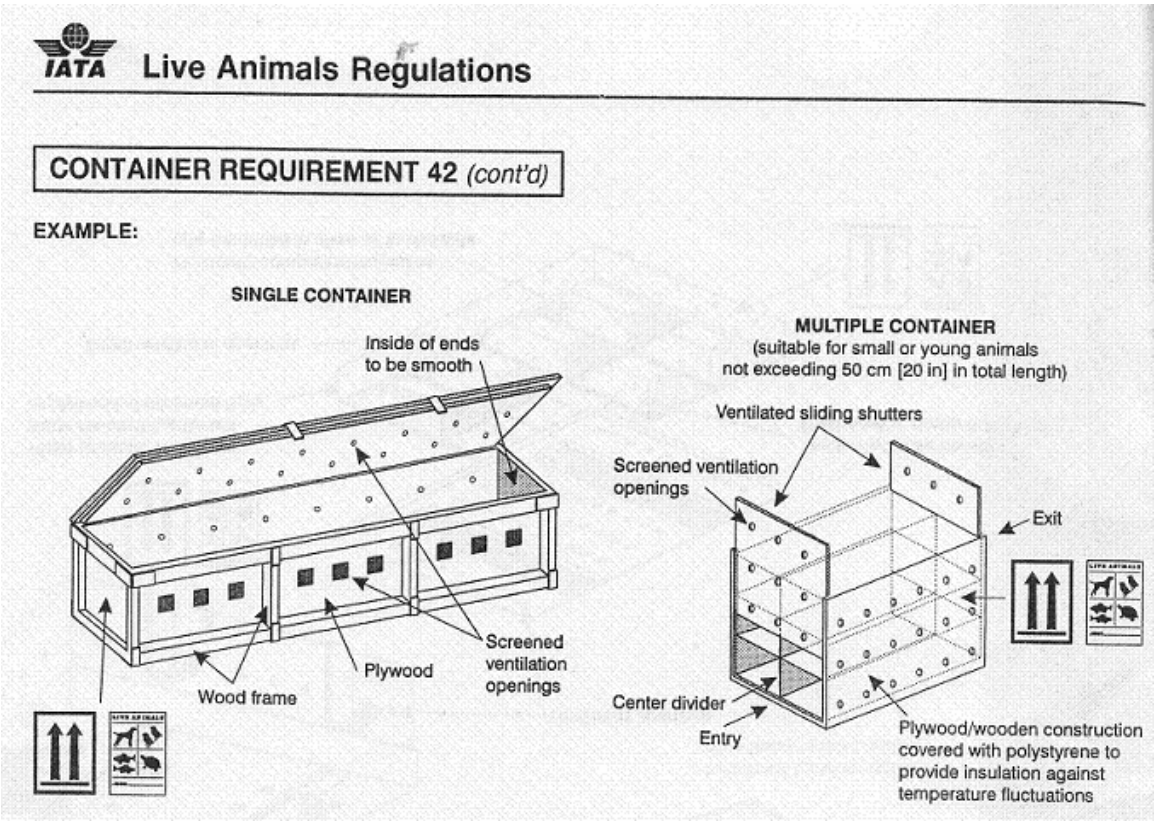

Figure 7.6: Diagram of a suitable transport container meeting all requirements from the IATA handbook.

Figure 7.7: The transport containers used to transport 1.2m freshwater crocodiles at Sydney Wildlife World.

7.6.2 Furnishings

It is not necessary to provide any furnishings in the transportation box. This may actually cause the individual to injury itself.

7.6.3 Water and Food

Water and food is not to be provided during transportation, unless there is a severe delay (IATA, 2006). Food should not be given to freshwater crocodiles for at least a few days before transportation. This helps prevent regurgitation or vomiting of food during transport and also helps prevent food decaying in the stomachs of the animals (Salkeld, TAFE discussion, 2007). Water should be offered immediately prior to transportation in order to help prevent dehydration during transport.

7.6.4 Animals per Box

For all freshwater crocodiles greater than 20cm in SVL only one individual is to be transported per box. For crocodiles between 12.5cm and 20cm in SVL, two individuals can be transported together; and crocodiles measuring less than 12.5cm SVL can have a maximum of three individuals per box (IATA, 2006).

7.6.5 Timing of Transportation

Transportation should be arranged to assist ease of capture and restraint, suggesting early morning as this would not allow the crocodile time to raise its body temperature and be more active.

7.6.6 Release from Box

When releasing a freshwater crocodile from its transportation box, care should be taken to minimise stress and the possibility of the crocodile injuring itself. It would be advised to place the transportation crate into the enclosure where the door can still be reached or accessed by keepers, for example, they may be behind a fence, but the door of the transportation box can still be accessed. The door of the transport box can slowly be raised opened, allowing the crocodile to view its new enclosure before venturing out into it. The transportation box should be positioned so that there are no fences or obstructions too near the door; this would help prevent the crocodile charging out of the box and injuring itself on the enclosure boundaries (Salkeld, TAFE, 2007).

8 Health Requirements

8.1 Daily Health Checks

When servicing freshwater crocodile enclosures on a daily basis, the general physical condition of each individual should be checked to ensure each crocodile has no signs of stress, physical injury, or ill health (*Pers. Obs.,* 2007). General observation of behaviour checking for abnormalities or changes can be done from a non-invasive distance, and can be done continually throughout the day.

It is incredibly important to check the temperature of the water; the ambient temperature; and the heating and/or filtration systems. If one of these factors is unusual or not functioning it could potentially cause the environmental conditions to fall outside of the optimum.

It may even be possible on some occasions to perform a general physical examination quickly whilst the crocodile is being handled for certain tasks such as in shows, training, moving exhibits. This would allow the keeper to test the crocodile's strength and check the skin.

8.2 Detailed Physical Examination

In order to carry out a detailed physical examination it will almost always be required to restraint the individual using one or more of various methods. On hatchling freshwater crocodiles, performing general physical examination can be relatively easy. Usually very little, restraint is necessary on hatchlings that are captive bred, often only requiring a light hold similar to that used when holding small lizards. They can generally be held in one hand with the forearm helping support the hatchling. This then allows the other hand to be used to check the feet, tail, dorsal (back) and ventral (underside) surfaces and the head, including the eyes, nostrils, snout, inside mouth, teeth, vent area, and close examination of any wounds or injuries (Pers. Obs., 2007). For larger juveniles, approximately 60cm in total length, some degree of restraint is needed, predominantly for the safety of staff. For safety reasons, it may be necessary to use a pair of thick gloves while restraining the crocodile (Pers. Obs., 2007). One staff member should restraint the crocodile while another staff member performs the examination (Pers. Obs., 2007). Procedures such as drawing blood can be performed by one keeper while other staff members restrain the crocodile.

The examination described above can be applied to all ages and sizes, with only the level of restraint differing.

Diagrams and photos of specific procedures such as drawing blood, as well as musculature and skeletal features of crocodiles can be found in the Appendix.

8.2.1 Chemical Restraint

There are several methods in which chemical restraint can be achieved. As all crocodilians are potentially dangerous, the chemical used in restraint should contain some kind of immobilisation chemical (Mader, 2006). A range of different chemicals can be used but they include gallamine, succinylcholine, benzodiazepines and

ketamine (Mader, 2006). Some form of physical restraint should still be provided. The drug should only be administered by qualified veterinarians.

8.2.2 Physical Examination Restraint

Physical restraint and examination for juveniles or sub-adults is carried out very similarly. Firmly and quickly place one hand around the neck region in front of the forelegs and support the hind legs and tail with the other hand (*Pers. Obs.*, 2007). Caution must be taken for sub-adult crocodiles as they are fast and can inflict a painful bite. A thick glove should be worn, and the less time the crocodile has to see the gloved hand the easier it is to capture and restrain the crocodile. One hand is used to firmly hold around the jaws to prevent the possibility of a bite from the side, and as this hand is holding down the head, the other hand can be brought in to hold the base of the tail. Once the keeper has a firm hold the crocodile can be brought out of the water and be restrained for examination. Once the crocodile has been restrained and is calm, the glove can be removed, ensuring there is a constant grip around the jaws. The photo below (Figure 1.0) shows the method which should be used to restrain a juvenile freshwater crocodile. The grip around the jaws should be firm, but not tight, ensuring the jaws remain closed but the neck and throat is not squeezed (*Pers. Comm.*, Brims, 2007). The grip used can be seen in Figure 8.1.

Figure 8.1: Restraint of juvenile freshwater crocodile (Taken at Oceanworld, Manly, 2007)

Figure 8.2: Correct grip used to restrain a juvenile freshwater crocodile's jaws (Taken at Oceanworld, Manly, 2007)

To restrain larger freshwater crocodiles the use of a hoop net may be necessary in order to restrain the jaws and/or upper body with the addition of strong tape wound around the jaws for extra restraint (figure 1.2). Once the animal has been captured and restrained, a physical examination can be performed. Physical examination can be carried out as described previously but should always been done methodically.

Figure 8.3: The use of a hoop net pole to secure an adult saltwater crocodile's jaws and upper body (Taken from www.crocodilian.com).

8.3 Routine Treatments

All freshwater crocodiles kept in captivity should be regularly checked and treated for any diseases or conditions that could potential cause illness or injury to the crocodile. Crocodiles in captivity consume food items that have already been killed. This may expose them to microorganisms that may be potentially harmful. It may be suggested that freshwater crocodiles like other reptiles be administered regular "worming" medications to help prevent disease by endoparasites.
Routine faecal analysis should be carried out to ensure there are no signs of endoparasitic infection.

8.4 Known Health Problems

The table below lists the known infectious and non-infectious diseases that can occur in the freshwater crocodile *(Crocodylus johnstoni)*.

Infectious Diseases

Bacteria	*Salmonella sp.*; bacterial dermatitis (*Dermatophilus spp.)*; *Mycoplasma crocodyli*; respiratory infection
Viruses	Adenoviruses; Parapoxvirus
Fungi	fungal dermatitis; respiratory infection
Endoparasites	Trematodes; Nematodes;
Ectoparasites	Mites; ticks
Protozoans	Coccidia;

Bacterial Disease
Bacterial diseases are quite common in captive freshwater crocodiles due to the smaller amount of space and greater numbers living together. Generally, many bacterial diseases can be prevented, controlled or treated by means of ensuring high quality hygiene is practised.
Probably the most common infectious disease seen in captive crocodilians is respiratory infection, usually caused by either bacteria or fungi. Treatment is based on the type of pathogen causing infection (Mader, 2006).
Some species of crocodile are susceptible to *Dermatophilus spp.*, a bacterium which causes brown to red lesions between the scales, and is sometimes associated with ulcerative lesions (Mader, 2006). This disease is difficult to treat with medications as it has limited response to antibiotic drugs; therefore strict hygiene procedures are necessary to prevent and control this disease (Mader, 2006).
Samonella sp. is common in normal body flora, however, at low concentrations. If the numbers of cells increases too greatly infestation will occur (Mader, 2006). This disease is zoonotic and can be easily passed on to humans even if the individual is not showing signs of infection. Treatment can be with antimicrobial medications such as metronidazole, a medication used for the treatment of many diseases (Mader, 2006).
Mycoplasma crocodyli is quite prevalent too in captive populations, and signs of infection are rather general – lethargy; weakness; anorexia; white discharge from the eyes – however, these signs must not be overlooked as pneumonia and other conditions can develop and cause death (Mader, 2006). Again treatment should include the use of antimicrobial medications.

Viruses

Freshwater crocodiles have been known to suffer from parapoxvirus, and usually show signs of lesions forming on the skin. These lesions can be yellow to brown, wart-like nodules that can either be raised or unraised, and can be found on the head, nostrils, mouth, oral cavity, ventral neck among other sites (Mader, 2006). The only treatment for this virus is to improve husbandry and maintain to a high standard, and all signs of the virus may subside in 3-4 weeks (Mader, 2006).

Fungal

Many fungal infections can be treated with specialised antifungal medications; however, it is often improvement in husbandry practices and a high level of hygiene that can effectively treat these conditions (Mader, 2006; *Pers. Obs.*, 2007).

Endoparasites and Ectoparasites

There is little information specific to the freshwater crocodile; however, generalised information has been gathered on reptile ecto- and endo-parasites.

Freshwater crocodiles are susceptible to both endo- and ecto-parasites. As captive crocodiles may be fed rodents, they may be exposed to *Cryptosporidium* from the gut of the rodent. Many mites and ticks exist as reptile parasites, and this may be similar for the freshwater crocodiles. Some ticks can spend their whole life cycle on the skin whereas some change hosts, but all are usually difficult to see. Mites are also difficult to see but infestations can be quite visible (Mader, 2006). In general for other reptile species, medications such as Ivermectin and Flagyl can be administered to treat both internal and external parasites, however, information is lacking on specific treatment for freshwater crocodiles (Mader, 2006; *Pers. Obs.*, 2007).

Protozoans

The most common of these is *Coccidia sp.*, a pathogen which can cause infection and disease in many reptiles. It is known to often infect young animals and there has been important in captive crocodile rearing in Zimbabwe (Mader, 2006), and so may be a problem in freshwater crocodiles also. In young animals it can cause stunted growth, and Mader (2006) states that the disease is slightly different in the Zimbabwe captive crocodiles. Clinical signs here included hemorrhagic enteritis and swelling and congestion of the small intestine (Mader, 2006).

Non Infectious Diseases

Nutritional	Anorexia; obesity; malnutrition; growth deformities;
Neoplastic	None known
Physical Trauma	Integumentary disease (from lacerations etc. due to fighting); Capture Myopathy
Chemical Toxicities	None known
Allergies	None known
Genetic/Metabolic	Growth deformities;
Environmental	Hypothermia; Hyperthermia; Respiratory discomfort or infection, Thyamine deficiency

Nutritional diseases are of concern, but if records are kept correctly changes in feeding habits should be identified promptly. It should be recorded every time a

crocodile refuses its food item. This way a keeper would be able to be aware of the crocodile's loss of appetite. However, if for some reason there are no records, it should be quite noticeable when a crocodile is showing signs of anorexia. This is often most noticeable around the neck and head area (*Pers. Obs.*, 2007). Malnutrition will present very similar to anorexia. Similarly dangerous to the crocodile's health is consuming too much food. This can evidently lead to obesity as well as a huge amount of secondary illnesses. Any abnormalities in the nutritional diet have the potential to cause, in the long run, growth abnormalities or deformities.

Secondary disease can arise due to physical trauma injuries becoming infected. An example of this is Integumentary disease. This disease is caused by lacerations from fighting, which are then exposed to bacteria and fungi in the water, causing infection (Mader, 2006). If integumentary disease is suspected, treatment with antimicrobial medication should be instigated immediately. Although there are medical treatments available ensuring good hygiene and water treatments using disinfectants are recommended (Mader, 2006).

Although Freshwater crocodiles do survive well in temperate regions with an appropriately heated environment, one the most serious risks to their health are through sudden changes in the environmental conditions. For example, if the heating systems fail or malfunction and this problem is not resolved, the temperature of the water in the exhibit will decrease. If the temperature is too low for too long the crocodile can develop hypothermia, and possibly respiratory discomfort or infection, both conditions of which are potentially fatal (*Pers. Obs.*, 2007; *Pers. Comm.*, 2007). Similarly, freshwater crocodiles may become distressed if environmental conditions are too warm; with the crocodiles suffering from hyperthermia. Treatment of these conditions requires gradual re-adjustment of the environmental temperature – it should be gradual so as to eliminate the risk of further complications caused by too fast a variation in environmental conditions (*Pers. Obs.*, 2007).

8.5 Quarantine Requirements

As is the case with all new animal acquisitions, when the new animal arrives it must spend a specified time in an isolated quarantine facility, freshwater crocodiles must do the same. The area necessary to house an adult freshwater crocodile in quarantine would be quite extensive, however, if juvenile or hatchling crocodiles are acquired the quarantine space required would be far less (*Pers., Obs.*, 2007). Animals must stay in quarantine for a period of at least 40 days.

Before a freshwater crocodile can be released from quarantine, extensive health checks must be carried out. Faecal samples must be taken on several occasions as well as blood samples and identification makings. All equipment and instruments used for each individual animal must be kept separate and clean, in order to prevent disease. Once all test results are satisfactory the freshwater crocodile is allowed to be moved to its enclosure.

9 Behaviour

9.1 Activity

In areas where there is a permanent water source, freshwater crocodiles are active throughout the year; however in areas where the water source disappears during the dry seasons, crocodiles may aestivate, i.e. become dormant, until the rains return (Greer, 2006).

The daytime is usually spent between basking on the river banks and sitting in the water hiding in amongst the murky water and reeds. The water offers many methods of predator avoidance such as water plants, reeds, algae, murky water, logs, and branches. When basking, freshwater crocodiles often sit with their mouths open, which may help them to prevent overheating and regulate their body temperature.

They tend to be more active at night, when there is a lesser threat of being attacked or being eaten by predators. It is at night when freshwater crocodiles hunt for food, taking invertebrates, fish, frogs and other reptiles. It is also at night when females come to land to dig their nests and lay their eggs.

9.2 Social Behaviour

In general, social behaviour in crocodilians is relatively complex compared to most other reptiles (Cogger and Zweifel, 2003). Freshwater crocodiles may inhabit the same water hole or river as one another; however, they do not live in family groups like many mammals. Due to overlapping territories, freshwater crocodiles may have contact with the larger saltwater crocodiles. For the majority of the year freshwater crocodiles do not really interact socially with each other, however in the breeding season males and females spend quite a large proportion of time displaying to and vocalising with one another. Unfortunately, most crocodilian research is carried out using American Alligators (name) or Nile Crocodiles (*Crocodylus nilotus)*, so the social behaviour of freshwater crocodiles is relatively unknown.

9.3 Reproductive Behaviour

Crocodilians generally have relatively long courtship rituals and behaviours, whereas mating and actual intercourse is completed in minutes (Grenard, 1991). Little is known of the reproductive behaviour specific to the Freshwater Crocodile; however, males will come to gather at water sources at the beginning of the dry seasons where they will compete against one another for the right to mate with a female. The stimulus for breeding and courtship is unknown for the freshwater crocodile, (Webb and Manolis, 1989), but it may be related to a period of cooler temperatures and lack of rainfall. Males may mate with several females, however, females will only mate with a single males. Males then have no further role in the reproductive cycle.

The female will often dig several test holes first before choosing her nest site (Greer, 2006; Parish and Slater). Once the nest site is chosen and prepared the female will prepare to lay her eggs, usually six weeks after mating. Egg-laying usually occurs at night (Webb and Manolis, 1989; Grenard, 1991). It is quite unusual but the

freshwater crocodile has been known to often "pulse nest", where all the females in a specific population lay their eggs within a period of three weeks (Grenard, 1991).
During incubation, the mother will usually not guard the nest and will show little interest in her clutch; however, once hatching is near females become more active around their nest. Once the hatchlings start calling, the female then starts to excavate the nest and carries her young to the water, where she protects them in a crèche for a period of time that is not yet known for this species.

9.4 Bathing

Freshwater Crocodiles spend a large amount of their time in water, but they do come to land to bask, nest and defend their territory. Hatchlings and juvenile crocodiles probably spend more time in water than other adults, as there is more safety in amongst reeds and murky water.

9.5 Behavioural Problems

In captivity, Freshwater Crocodiles can be very aggressive toward each other, with juveniles up to six months biting each other on the head, body and legs (Greer, 2006). Freshwater Crocodiles are generally considered hazardous but not dangerous as they are only likely to attack humans is they are provoked (Caldicott et al, 2005). In captivity, unusually aggressive behaviour may prevent or hinder keepers from performing their duties due to the risks involved. In this case, plans to manage this animal would need to be implemented and action taken to reduce or eliminate the risks to keepers.

9.6 Signs of Stress

All crocodilians are unfortunately prone to suffering capture myopathy during capture, restraint and relocation procedures, i.e. where the animals' muscles begin to breakdown due to a lack of blood supply. Being kept in undesirable conditions can lead Freshwater Crocodiles to display different behaviours.
Signs of stress may include:

- a lack of or decrease in appetite,
- reduced activity,
- stereotypic behaviour, e.g. pacing up and down enclosure
- trying to escape
- suffering from illness or infections frequently,
- hatchlings or juveniles only a few years old may still vocalise when stressed (*Pers. Obs.*, 2007)
- injuries caused by enclosure furnishings
- lack of activity
- change in behaviour

9.7 Behavioural Enrichment

There are several different elements that can be used to enrich Freshwater Crocodiles. The following are some options that have been tried or suggested based on personal observation or communication. For all the suggestions listed below, the behaviour of all individuals should be observed before, during and after the enrichment to determine whether the enrichment is successful or unsuccessful.

- Scatter feed juveniles and hatchlings crickets, roaches and other invertebrates/
- Larger juveniles and adults could be fed a variety of food types – fish, day-old chicks, other birds, rodents and possibly reptiles. Alternate the types of food being offered as well as varying the time and day of feeding. This would come close to replicating their natural diet and feeding.
- Move crocodile/s to outdoor enclosure (if housed indoors) – allows natural sunlight, natural scents and sounds to be experience or investigated.
- The natural environmental conditions can be replicated – e.g. simulating the wet season by providing periods of heavy rainfall through the use of sprinklers or hoses to saturate the enclosure.
- The provision of different water plants and branches can provide alternative hiding places and different scents.

9.8 Introductions and Removals

When introducing a new Freshwater Crocodile to an enclosure, care should be taken with not only the new animal but also the other individuals already on exhibit. Relocating a Freshwater Crocodile can cause a large amount of stress to the animal, possibly leading to capture myopathy. As it has been previously discussed in the transportation section, when introducing a new animal to an exhibit the transport box should be placed in a position so that the crocodile will not injure itself as it emerges from the box. To prevent further stress, other individuals should be moved to a separated area within the enclosure or to one end of the enclosure. This would allow a higher degree of safety for all animals and all staff. After introduction to the enclosure, the behaviour of all individuals should be observed and recorded to determine whether there are any problems between all the Freshwater Crocodiles.

When removing an animal, similar practices should be employed. The other animals should be separated from the targeted individual for the safety of all animals and keepers. Several staff should be required to observe the behaviour of the crocodile to prevent any accidents or injuries.

Ideally all movements or transportation of Freshwater Crocodiles should be carried out early in the morning, to minimise the risk of overheating in the crocodile as well as for safety reasons – the crocodile will be less active before the opportunity for it to increase its body temperature.

9.9 Intraspecific Compatibility

In the wild, several Freshwater Crocodiles may live within the same water hole or river but will have their own individual territories. Fighting between males is common during the breeding season. In captivity, however, it is known that hatchlings and juveniles up to about six months old will bite each other on the head, body and legs if they are housed together (Greer, 2006). It is possible to house several adult or sub-adult Freshwater Crocodiles together, however observation should be recorded to ensure there is no aggression and dominance toward one or more individuals.

9.10 Interspecific Compatibility

As mentioned above, Freshwater Crocodiles may have contact with the larger Saltwater Crocodile (*Crocodylus porosus*) due to the overlapping territories. Even though this is the case, the two species are not really compatible. The larger Saltwater Crocodiles are known to attack and bully the smaller Freshwater Crocodiles, and sometimes to the extent that the Freshwater Crocodiles may be forced to leave the area (Greer, 2006).

9.11 Suitability to Captivity

Providing there are several key requirements in a Freshwater Crocodile enclosure, the species can be quite suitable to captivity. It is of vital importance that the enclosure offers large enough areas of both land and water; temperature gradient with basking place at one end of the enclosure; the water temperature must resemble water temperature of tropical water sources and must be maintained at this temperature. As they area smaller species than the Saltwater Crocodile, it would be easier for institutions to develop and exhibit for the Freshwater Crocodile; however Saltwater Crocodiles tend to be quite impressive due to their size. There is also the addition of Freshwater Crocodiles being more suitable than Saltwater Crocodiles due to the risks and hazards associated with both species – Freshwater Crocodiles are considered hazardous whereas Saltwater Crocodiles are considered dangerous.

10 Breeding

10.1 Mating System

The mating system of freshwater crocodiles is quite advanced, and involves various courtship behavioural displays by both the males and females. The mating season generally commences in June/July at the beginning of the dry season, when ambient temperatures are quite cool. The stimulus for breeding and courtship is unknown for the freshwater crocodile. (Webb and Manolis, 1989).

Generally, crocodilians have relatively long courtship rituals and behaviours, whereas mating and actual intercourse is completed in minutes (Grenard, 1991). After mating the males play no role in the nesting process and may even mate with another female. It is unknown whether or not male freshwater crocodiles play a role in nesting processes (Webb and Manolis, 1989).

About three weeks after mating, the female freshwater crocodile will stat to search for an appropriate nest site and begin to excavate her nest. The female will often dig several test holes first before choosing her nest site (Greer, 2006; Parish and Slater). Once the nest site is chosen and the nest prepared the female will prepare to lay her eggs, usually six weeks after mating. Egg-laying usually occurs at night (Webb and Manolis, 1989; Grenard, 1991). It is quite unusual but the freshwater crocodile has been known to often "pulse nest", where all the females in a specific population lay their eggs within a period of three weeks (Grenard, 1991).

During incubation, the mother will usually not guard the nest and show little interest in her clutch; however, once hatching is near females become more active around their nest. Once the hatchlings start calling, the female then starts to excavate the nest and carries her young to the water, where she protects them in a crèche for a period of time that is not yet known (Webb and Manolis, 1989).

10.2 Ease of Breeding

In captivity, it is relatively difficult to successfully breed freshwater crocodiles without the facility being in a tropical location (*Pers. Comm.*, 2007). This is due to the high but constant ambient and water temperature (*Pers. Comm.*, 2007). It is very demanding and costly to maintain an exhibit large enough to house at least two adult freshwater crocodiles at the optimal environmental conditions. Further more, it is very difficult to provide substrate of the appropriate temperature and humidity requirements in a temperate or colder climate.

10.3 Reproductive Condition

10.3.1 Females

Before females can reproduce they must reach maturity which is both age and size dependant. Females are required to be healthy and strong in order to produce healthy and strong young. They must be healthy in order to produce enough nutrients and calcium to protect the eggs and allow them to develop. In captivity, it is the responsibility of the keepers to ensure all animals but particularly breeding animals are kept in their optimal condition.

10.3.2 Males

Before males can reproduce they too must reach maturity. Males will also require to be healthy and strong, more so for the reason of competing for females with other males. All across the animal kingdom, males compete to impress females. Males want to display how strong and healthy they are, with good genes to pass onto the next generation. If male freshwater crocodiles are not in their peak condition it may mean they lose the chance to breed for that season. In captivity, it is the responsibility of the keepers to ensure all any but particularly breeding animals are kept in their optimal condition.

10.4 Techniques Used to Control Breeding

The most obvious and easiest method to control breeding is to house males and females separately until breeding is desired. This is by far the most effective method. It would not really be desirable to house several adult males and females together with sub-adult and juvenile crocodiles as this may cause fighting between small and large animals and between males. It would be more advisable to house a small female group together and a small male group together. Once a male has been selected for breeding with a female the two can then be introduced to the same enclosure, effectively controlling the breeding.

10.5 Occurrence of Hybrids

Although freshwater crocodiles sometimes share their environment with the saltwater crocodiles, hybrids don't occur. If saltwater crocodiles are found in the same areas as freshwater crocodiles, they are generally aggressive towards the smaller freshwater crocodile and can drive them out of that area.

10.6 Timing of Breeding

The Freshwater Crocodile reproduces in the dry season, opposite to that of its close relative the Saltwater Crocodile. Breeding in the dry season allows the freshwater crocodiles to nest when there is low risk of flooding, and to have their young hatch when the wet season is approaching, allowing the hatchlings to have the maximum amount of time to grow during the prosperous wet season before the next dry season.

10.7 Age at First Breeding and Last Breeding

As freshwater crocodiles are relatively long lived animals, the time it takes for hatchlings to reach maturity and breed is much greater than animals whose lifespan is quite short. On average, female freshwater crocodiles mature first at about 12 years, but this does vary; males mature at about 17 years and also vary (Webb and Manolis, 1989). It is unclear as to when freshwater crocodiles last breed. It may be that the older males may be unable to compete for a mate due to old age, however it is not certain.

10.8 Ability to Breed Every Year

The freshwater crocodile like most crocodilians breed once every year. Breeding begins each year at the end of the wet season in June or July. Once the female has laid her eggs she then needs to regain all her energy spent on developing her clutch, as developing the eggs uses a large amount of nutrients and calcium which the female must regain before breeding again the following dry season (Grenard, 1991; Webb and Manolis, 1989).

10.9 Ability to Breed More than Once Per Year

Freshwater crocodiles do not have the ability to breed more than once each year. There is only one species of Crocodilian that has the ability to breed more than once a year – the Mugger Crocodile, *Crocodylus palustris*. The female Mugger may mate twice a year (Grenard, 1991). Male freshwater crocodiles will sometimes mate with more than one female in the season, however females will not.

10.10 Nesting, Hollow or Other Requirements

Unlike the saltwater crocodile, the female freshwater crocodile does not build a mound nest but rather excavates a suitable nest hole (Greer, 2006; Parish and Slater; Grenard, 1991; Webb and Manolis, 1989). About three weeks before nesting, females will dig test holes at night in and around prospective nesting sites, usually not far from the water (Grenard, 1991; Webb and Manolis, 1989). The nest sites are generally in sandy banks most within 10m to the water source (Webb and Manolis, 1989). If breeding in captivity, an area that allows females ample space to have a choice of nest site and space for test holes to be dug may be necessary (*Pers. Obs.*, 2007).

10.11 Breeding Diet

There is no specialised breeding diet; however, females may increase the amount of food they consume prior to the breeding season. If breeding this species in captivity, the amount of food given may need to be increased also.

10.12 Incubation Period

The incubation period for freshwater crocodile eggs varies markedly some hatching after as little as 65 days incubation, to as great as 95 days incubation (Grenard, 1991). The longer incubation periods are generally for nests in which the temperature is at the lower end of the spectrum, therefore requiring a longer incubation time. Nests with a higher temperature require less incubation time (Webb and Manolis, 1989; Grenard, 1991).

It is interesting to note that the temperature at which the eggs are incubated determines the sex of the hatchlings (Ackerman, 1997; Britton, 2002; Cogger and Zweifel, 2003; Greer, 2006; Parish and Slater). In the freshwater crocodile incubation temperatures of 32°C will produce male hatchlings whereas incubation temperatures of only one or two degrees above or below this will produce female hatchlings (Britton, 2002).

10.13 Clutch Size

Freshwater crocodiles generally lay only one clutch a season with the average number of eggs in a clutch being 12-13 (Parish and Slater; Swan, 2001; Webb, 1989), but there can be between 4 and 21 eggs laid (Britton, 2002; Greer, 2006; Webb, 1989).

10.14 Age at Weaning

As freshwater crocodiles are reptiles there is little maternal care and no foods are given by the mother. There is no weaning in this species.

10.15 Age of Removal from Parents

Once hatchling freshwater crocodiles have been helped from their nests by their mother, the female provides little maternal care. The female may protect her young by carrying them carefully in her mouth from the nest to the safety of the water. It is unknown just how long the female stays protecting her crèche (Webb and Manolis, 1989).

10.16 Growth and Development

Freshwater crocodiles, like all crocodilians are relatively slow growing animals, and may take up to 15 or 20 years to reach maturity. In the wild growth rates vary greatly between populations, regions and even between seasons. Some years may have provided individuals with ample food where their growth rate would have increased; and in years that provided less food and resources their growth rate would have decreased.

Like all oviparous animals, freshwater crocodiles spend a certain time developing within the egg while it is being incubated, before the hatchlings break the shell and emerge. Development in the egg is aided by several membranes – the amnion; the chorion; the allantois; the yolk; and the albumen. The amnion acts as protection for the developing embryo; the chorion allows gas exchange to occur; the allantois is a receptacle for metabolic wastes; and the yolk and the albumen provide nutrition to the developing embryo (Grenard, 1991).

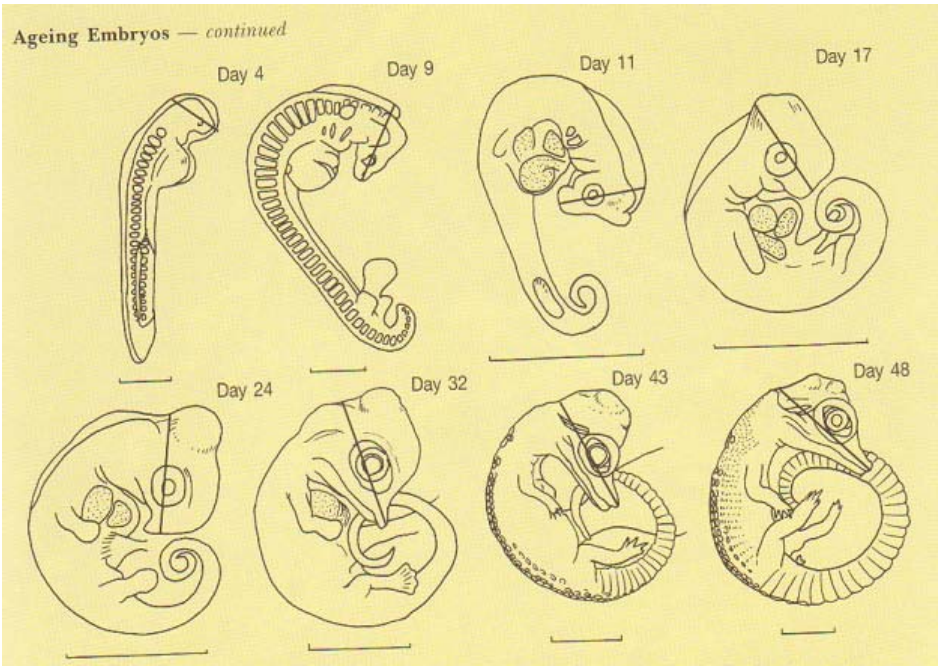

Figure 10.1: Diagram showing the different stages of embryonic development within the egg in Freshwater Crocodiles (Richardson *et al*., 2002).

After incubating for 65-95 days, the small hatchling will use the egg tooth to crack the shell and emerge from the nest. The egg tooth is a small raised pointed lump on the snout specifically to break the egg (Greer, 2006; Parish and Slater; Grenard, 1991). Once in the safety of the water, the hatchling crocodiles grow slowly. It may take young crocodiles five years to reach a total length of one metre, or it may take ten years. This variation is due to the unpredictability of available food and environmental conditions.

Freshwater crocodiles continually grow throughout their lives, with their growth patterns imprinted in their bones. As a crocodile grows, rings develop in their bones indicating growth (Webb and Manolis, 1989). It is not until the crocodile is dead it is possible to determine the exact age, unless its birth date is known.

The average maximum size of male freshwater crocodiles is about 2.0m long whereas for females it is 1.8m long (Webb and Manolis, 1989), although freshwater crocodiles are known to reach 3.0m.

Growth in captivity is often at a greater rate than that in the wild. In captivity it depends on abundance of appropriate food, optimal ambient temperatures, and sufficient space (Grenard, 1991).

11 Artificial Rearing

11.1 Incubator Type

Several different types of incubator may be used, and this can be from as simple as a large Styrofoam container, sealed and fitted with heat mats and temperature and humidity gages set at the desired temperature (*Pers. Obs.*, Oceanworld, Manly, 2007); to highly specialised incubators with the temperature and humidity controlled electronically from a computer. To adequately incubate Freshwater Crocodile eggs, they must be placed on suitable medium before being put in the incubator, for example, a mix of 50% vermiculite to 50% water (Oceanworld, 2007; TAFE, 2007). When the eggs are removed from the mother's nest site extreme care must be taken not to roll or turn the eggs, as this may disrupt the allentoic membrane (which small air-pocket that forms at the uppermost part of the shell to allow embryo to receive adequate air).

11.2 Incubation Temperature and Humidity

The incubation period for freshwater crocodile eggs varies markedly some hatching after as little as 65 days incubation, to as great as 95 days incubation (Grenard, 1991). It is interesting to note that the temperature at which the eggs are incubated determines the sex of the hatchlings (Ackerman, 1997; Britton, 2002; Cogger and Zweifel, 2003; Greer, 2006; Parish and Slater). In the freshwater crocodile incubation temperatures of 32°C will produce male hatchlings whereas incubation temperatures of only 31°C or 33°C will produce female hatchlings (Britton, 2002).

11.3 Desired % Egg Mass Loss

In general, reptile eggs do not lose weight bt actually gain weight during the incubation period.

11.4 Hatching Temperature and Humidity

The hatching temperature and humidity would be the same as the incubation temperature, however, once the hatchlings are removed from the incubator box they should be housed in a tub of water with at least some dry area accessible, with a hide and/or visual barrier to prevent stress. The water temperature should be between 26 C and 32C (EAPA, 2004); there must be a basking area that is dry and provides a source of heat; and there must be the provision of UV light, through UVB light bulbs or exposure to natural sunlight. Basking temperature should be between 28C and 35C.

11.5 Normal Pip to Hatch Interval

This information has not been located at this time.

11.6 Diet and Feeding Routine

Once first hatched, Freshwater Crocodiles will most likely be very cautious and hide in the enclosure. It may be difficult to observe feeding however records can determine how often and how much the hatchlings are eating. During the first few weeks to months, a hatchling's diet should comprise mostly of invertebrates, crickets being the most commonly used (*Pers. Experience,* 2007). It can be recommended to offer a crickets 3-4 times each week, then gradually add other food item such as worms, small fish e.g. whitebait, eventually adding in rodents of appropriate sizes – (usually pinky to fuzzy rats or mice (*Pers. Experience,* 2007). Once the young crocodiles are a few months old, feeding can be decreased to once or twice each week. However, do not be alarmed if some individuals refuse and do not eat for a few weeks; freshwater crocodiles are able to survive for some time without food.

Each time hatchlings are offered food it should be recorded as well as details of whether the item was taken or refused, and what the food item was. By recording these details, keepers are able to monitor the feeding and the growth and development of each hatchling, and these records are invaluable.

11.7 Specific Requirements

As mentioned previously in Housing Requirements, the Exhibited Animals Protection Act (2004) lists the requirements necessary to house reptiles in captivity. All reptiles and therefore the Freshwater Crocodile must be provided with adequate space in order to display natural behaviours. There must a source of heat such as a basking heat lamp, as well as providing UV light, by way of either specialised UVB light bulbs or by exposure to natural sunlight. A hide and/or visual barrier must be provided to minimise the risk of stress the hatchling crocodiles. The temperature of the water should be between 28C and 32C, and the basking temperature should be

11.8 Data Recording

As mentioned previously, record keeping and data collection are extremely important in the captive husbandry of all animals. The EAPA (amended, 2004) lists the requirements necessary for keeping records for all reptiles, but these can be directly applied to the freshwater crocodile. It is listed that:

a) measurements of weight and length and date on which taken;
b) breeding details and offspring details;

should be recorded and kept as permanent records.

It is important that data is recorded from the earliest stages possible, for example once the eggs have been laid. Once the eggs have been removed from the mother's enclosure they must be place into an incubator immediately, on appropriate medium such as the vermiculite mix mentioned previously. Care must be taken not to roll or turn the eggs.

The weight, length and width of each egg should be taken and recorded upon being laid, then each week after (Sydney Wildlife World, 2007). This allows there to be an accurate record of all the eggs and helps keepers determine important statistics such as the average weight and size of Freshwater Crocodile eggs; by how much the weight of the embryo increases during the incubation; the percentage of egg mass lost during

incubation; and the weights and lengths of the hatchlings upon hatching (*Pers. Obs.*, 2008).
Records are an excellent database for growth and development, health problems, veterinary procedures, feeding patterns and treatments among many more aspects of animal husbandry.

11.9 Identification Methods

The ability to identify each individual hatchling Freshwater Crocodile is extremely important in order to deliver high quality husbandry to each animal. There are several methods of identification used in Freshwater Crocodiles and probably the easiest for hatchlings is the use of separate tubs for each crocodile and individual photos of distinguishing marks (*Pers. Obs.*, 2008).

Figure 11.1 Photos of specific head and back markings taken for identification purposes of juvenile freshwater crocodiles at Sydney Wildlife World (*Pers. Obs.*, 2008).

A common method used in the identification of crocodilians and could be used in assisting identification among captive freshwater crocodile individuals is the procedure of cutting scutes in a unique pattern (Isberg *et al.*, 2006). Scutes are chitinous or bony external plates (Wikipedia, accessed March, 2007), and in crocodilians are the triangular vertical plates positioned along the midline of the tail (Isberg *et al.*, 2006). This method is usually done on the first day of hatching (Isberg

et al., 2006) and is probably easier to do at this age and less painful to the hatchling. There is however some problems which may arise from this method. Although it is a permanent form of identification, care must be taken to ensure each scute is cut properly so as to avoid regrowth of the scute that could obscure identification (Isberg *et al.*, 2006).

11.10 Hygiene

Hygiene is extremely important for hatchling Freshwater Crocodiles, both to prevent disease transfer between animals as well as to keepers. The EAPA (amended, 2004) lists specific hygiene and cleaning requirements that need to be met in order to provide adequate housing for crocodilians. Hatchling Freshwater Crocodile holding enclosures may have the ponds as well as the terrestrial areas of the enclosures spot cleaned daily where any debris, faeces or discarded food is removed, and perform a complete change of pond water twice weekly (*Pers. Obs*, 2007). Each of the enclosure furnishings should be sprayed and scrubbed with a light chemical agent such as F10, which may help in disinfecting the furnishings and also does not cause harm to the animals.

For keeper hygiene, gloves and sinks must be provided as reptiles can carry bacteria and other pathogens that may be ingested by any person who touches a reptile and these pathogens may be harmful to humans also (EAPA, amended, 2004). Gloves should also be worn and changed between handling each individual hatchling to minimise the spread of disease (*Pers. Obs.*, 2007).

11.11 Behavioural Considerations

It is during the breeding season when Freshwater Crocodiles may become more aggressive. This is particularly leading up to mating and then again up to the hatching of the eggs. The female Freshwater Crocodile will usually not guard the nest and show little interest in her clutch; however, once hatching is near females become more active around their nest. Once the hatchlings start calling, the female then starts to excavate the nest and carries her young to the water, where she protects them in a crèche for a period of time that is not yet known (Webb and Manolis, 1989). In captivity, this potential aggression can be avoided as the eggs will be removed from the nest and placed in an incubator, therefore when the hatchlings start calling from the eggs the female will not be in the vicinity.

Care and caution must always be taken with this species, even at just a few weeks old. Freshwater Crocodiles exhibit several innate behaviours that may pose a risk to keepers' safety. This includes their incredibly quick biting or snapping behaviour, which could put keepers at risk of bites, and although not severe the bite is still capable of inflicting a small wound (*Pers. Obs.*, 2007). If considering housing several hatchlings together they can be very aggressive toward each other, with juveniles up to six months biting each other on the head, body and legs (Greer, 2006). Hatchlings should be housed individually.

11.12 Weaning

This species does not wean their young. The female may protect her young by carrying them carefully in her mouth from the nest to the safety of the water. It is unknown just how long the female stays protecting her crèche (Webb and Manolis, 1989).

In a captive situation this protection is not required and so the hatchlings must fend for themselves.

12 Acknowledgements

- Brimms, Victoria, Senior Aquarist, Oceanworld Manly, Sydney, NSW, Australia, for training and personal instruction on restraint, handling and feeding techniques for juvenile freshwater crocodiles.

- Hainke, Jason, Invertebrate Keeper, Sydney Wildlife World, Sydney, NSW, Australia, for personal communications on feeding and health.

- Jensen, Matthew, Senior Aquarist, Oceanworld Manly, Sydney, NSW, Australia, for training and personal instruction on restraint, handling and feeding techniques for juvenile freshwater crocodiles.

- Mostyn, John, Senior Reptile Keeper, Sydney Wildlife World, Sydney, NSW, Australia for personal communications on husbandry of freshwater crocodiles and behaviour.

- Phipps, Graeme, TAFE Teacher, Certificate III Captive Animals, TAFE NSW, Richmond Campus, Sydney, NSW, Australia, for endless information on husbandry for all species and for encouraging students to focus on animals with which they have an interest.

- Salkeld, Jacki, TAFE Teacher, Certificate III Captive Animals, TAFE NSW, Richmond Campus, Sydney, NSW, Australia for personal communication and practical experience in handling reptiles, personal communication on specific aspects of behaviour of freshwater crocodiles.

- Townsend, Robert, Life Sciences Manager, Oceanworld, Manly, Sydney, NSW, Australia, for training and personal instruction on restraint, handling and feeding techniques for juvenile freshwater crocodiles.

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15 Glossary

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Appendix

ANNUAL CYCLE OF MAINTENACE FOR THE FRESHWATER CROCODILE *Crocodylus johnstoni*

JANUARY			3		5	6
FEBUARY			3	4		6
MARCH	1	2	3			6
APRIL			3			6
MAY			3			6
JUNE			3		5	6
JULY			3			6
AUGUST			3	4		6
SEPTEMBER	1	2	3			6
OCTOBER			3	4	5	6
NOVEMBER			3			6
DECEMBER			3			6

Drain pond and scrub with chemicals

Remove and replace substrate

Drain pond and backwash

Prune/trim plants and add new plants

Ensure temperature and humidity control systems are working correctly

Clean and service all feeding and restraint tools and equipment

MATERIAL SAFETY DATA SHEET

COMPANY DETAILS
AUSTRALIAN DISTRIBUTOR:
COMPANY: Chemical Essentials (Pty) Ltd
Address: 13 Abelia Str, Doncaster East,
Victoria 3111
Emergency Telephone number:+03 9841 9901
Fax: +03 9841 9909

MANUFACTURER:
Health and Hygiene (Pty) Ltd
P O Box 347. Sunninghill 2157,
South Africa.
Tel:+27 11 474-1668
Fax: +27 11 474-1670
e-mail: info@healthandhygiene.co.za

IDENTIFICATION

PRODUCT NAME: **F10SC VETERINARY DISINFECTANT**
OTHER NAMES: **F10 SUPER CONCENTRATE DISINFECTANT**

UN Number: None
D G Class: None
Hazchem code: None
Poisons Schedule: 5

HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA IN THE PACK CONCENTRATE ONLY (eyes and skin irritant)

USE: Biodegradable multi purpose Disinfectant for all hard surfaces, equipment and airspaces

PHYSICAL DESCRIPTION/PROPERTIES

Appearance:	Clear, colourless liquid, with a slight natural odour.
Boiling Point:	110°C
Vapour Pressure:	Not known
Specific Gravity:	1.00
Flash Point:	Not flammable
Flammability Limits:	Not flammable
Solubility in water:	Soluble

INGREDIENTS

	CAS Number	Quantity (w/w)
Benzalkonium Chloride	68424-85-1	5.4%
Biguanide	27083-27-8	0.4%
Ingredients not determined to be hazardous		to 100%

HEALTH HAZARD INFORMATION

HEALTH EFFECTS:
Acute

SWALLOWED: Low. Substantial ingestion may cause irritation to mouth, throat and digestive tract.

EYE: Low. Will cause irritation but not serious damage.

SKIN: Low. Concentrate may act as mild degreasant to sensitive skin.

INHALED: Low. No significant hazard.

Chronic

INHALED: Low. No significant hazard

FIRST AID

SWALLOWED: DO NOT induce vomiting. Give milk or water to drink. Seek medical advice where necessary.

EYE: Rinse eyes with water. Seek medical advice where necessary.

SKIN: Wash affected area with soap and water.

INHALED: Non-toxic. Avoid long term inhalation of neat liquid. Remove to fresh air.

FIRST AID FACILITIES: Contact a doctor or Poison Information Centre (phone 131126)

ADVICE TO DOCTOR: Treat symptomatically

F10SC VETERINARY DISINFECTANT
F10 SUPER CONCENTRATE DISINFECTANT

PRECAUTIONS FOR USE

EXPOSURE LIMITS:	No data found
Engineering controls:	None required
PERSONAL PROTECTION:	Not required
FLAMMABILITY:	Not Flammable

SAFE HANDLING INFORMATION

Storage and Transport:	Store below 30^{0}C in dry conditions
SPILLS AND DISPOSAL:	Soak up on an inert material e.g. dry earth and dispose of in an area approved by local authority by-laws. Flush small spills with copious amounts of water
FIRE/EXPLOSION HAZARD:	The product is not flammable or explosive.
OTHER INFORMATION:	Ensure good industrial hygiene. DO NOT mix with soaps or other chemicals.

CONTACT POINT: Managing Director, +03 9841 9901
Chemical Essentials Pty Ltd

KEEP OUT OF THE REACH OF CHILDREN

Issue number: **2**

Issue Date: **August 2004**

MATERIAL SAFETY DATA SHEET – BLEACH

STATEMENT OF HAZARDOUS NATURE

Not classified as hazardous according to criteria of WorkSafe Australia.

COMPANY DETAILS

Company:	CHEMICAL FORMULATORS PTY. LTD.
A.C.N.	008 905 119
Address	7 Kirke Street, Balcatta, WA 6021.
Phone	(08) 9344 2455
Fax	(08) 9344 4360

IDENTIFICATION

Product Name	: **BLEACH**
Other Names:	: Hypochlorite Solution
UN Number	: None allocated
Dangerous Goods Class	: None allocated
Subsidiary Risk	: None allocated
Hazchem Code	: None allocated
Poisons Schedule	: None allocated
Use	: Bleach

Physical Description / Properties

Appearance	: Clear liquid (chlorine odour)
Boiling Point	: Above 100°C
Vapour Pressure	: Not Available
Specific Gravity	: 1.05
Flashpoint	: Not Relevant
Flammability Limits	Not Relevant
Solubility Limits	: Miscible in all proportions.

Other Properties:

Corrosiveness	: Corrosive to non-ferrous metals & fabric
pH (undiluted)	: 12.5

Ingredients

All hazardous substances as defined by the NOHSC Code are listed by chemical name and CAS No. Other ingredients which are determined to be non-hazardous are listed by generic name or as non hazardous ingredients.

Chemical Name:	CAS No:	Proportion:
Sodium Hypochlorite	7681-52-9	Less than 10%
Water		Up to 100%

HEALTH HAZARD INFORMATION

Health effects

Acute:

Swallowed	: Corrosive. Causes burns to mouth, throat and gastro-intestinal tract.
Eye	: Very corrosive. Causes severe burns. Risk of serious damage to eyes.
Skin	: Corrosive. Causes severe burns.
Inhaled:	: Corrosive mist.

Chronic:
Prolonged exposure to low concentration solutions may cause skin irritation to skin, eyes and mucous membranes.

First Aid

Swallowed:
Contact a Doctor or Poisons Information Centre. Do NOT induce vomiting. Give a glass of water. Repeat if vomiting occurs. If the patient is not fully conscious do not give anything by mouth.

Eye:
In case of contact with eyes, rinse immediately with plenty of water and contact a doctor or Poisons Information Centre. Get urgent medical attention.

Skin:
Remove contaminated clothing immediately and wash skin thoroughly with water.

Inhaled:
Leave contaminated area.

First Aid Facilities:
Eye wash. Fresh water.

Advice to Doctor:
Corrosive product. Treat chemical burns if present.

PRECAUTIONS FOR USE

Exposure Standards:
No value assigned for hypochlorite solution by Worksafe Australia

Engineering Controls:
Avoid generating and inhaling mists without appropriate ventilation.

Personal Protection:
Avoid contact with the skin and eyes. Avoid breathing mist. Wear face shield, overalls or apron, protective footwear and natural rubber or PVC gloves when using undiluted product.

Flammability:
Not flammable or combustible.

SAFE HANDLING INFORMATION

Storage and Transport:
Store in a cool, well ventilated area away from all other chemicals, keep containers closed at all times.

Spills and Disposal:
May be flushed to sewer with water but prevent larger spillages from entering stormwater drains or water courses. To contain spillages, absorb on sand or similar absorbing material, such as Attapulgite, and collect in drums. Residues may be flushed away with water.

Fire/Explosion Hazard
Not applicable as product is non-combustible.

Other Information
Do not mix with acids as toxic chlorine gas may be liberated.

This MSDS is valid for five years from date of issue but readers should contact Chemform to ensure that this is the latest issue. As per the Worksafe Guidance Note NOHSC 3017, each user should review the information in the specific context of the intended application.

Contact Point: Technical Manager (08) 9344 2455

ISSUE DATE: APRIL 2001

Purdue Products L.P.

Material Safety Data Sheet

Betadine® Solution
(10% povidone iodine) **Version: 14-July-05**

1. CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification: Betadine® Solution (10% povidone iodine)

Chemical Name

1-ethyenyl-2-pyrrolidinone homopolymer compound with iodine

Synonyms
PVP-I

Molecular Formula: $(C_6H_9I_2NO)_n \cdot I_x$ **Molecular Weight:** not available

CAS Number: 25655-41-8

Product Use: topical microbiocide

Company Identification

Manufacturer
Purdue Products L.P.
One Stamford Forum
201 Tresser Boulevard
Stamford, CT 06901-3431
Telephone: (888) 726-7535

EMERGENCY CONTACT
Chemtrec (800) 424- 9300. For all international transportation emergencies call Chemtrec collect at (703) 527-3887.

2. HAZARDOUS COMPONENTS

Material	CAS Number	%
1-ethenyl-2-pyrrolidinone homopolymer compound with iodine	25655-41-8	5.0-5.5
contains either of the following:		
glycerin	56-81-5	
pareth 25-0	68131-39-5	

3. Hazards Identification

Purdue Products L.P.

Emergency Overview
Normal handling should not constitute a hazard. The following information is provided for those circumstances where uncontrolled exposure may occur.

Reddish-brown, clear liquid
Characteristic odor
Harmful by inhalation, skin contact, or ingestion
May cause eye irritation and mild skin irritation
Target organs: respiratory system, gastrointestinal tract, skin, eyes, kidneys, thyroid.

Potential Health Effects
Betadine® Solution is a topical microbiocide. Its active ingredient is povidone iodine.

Betadine® Solution is generally non-irritating to skin. However, prolonged exposure to wet solution may cause irritation or, rarely, severe skin reactions. Povidone iodine may cause skin sensitization. Betadine® Solution may cause eye irritation.

Prolonged contact of large skin areas with Betadine® Solution may lead to excessive absorption of iodine and should be avoided.

Overexposure from breathing aerosols and/or iodine vapors may cause irritation to the respiratory tract, bronchitis and absorption through the lungs.

High concentrations of iodine in the blood from inhalation or ingestion may cause thyroid disorder (hyperthyroidism), renal disturbances, acidosis, and electrolyte disturbances such as increased iodine levels and severe hyponatremia.

Conditions that may be aggravated by exposure to povidone iodine: asthma, chronic bronchitis, and thyroid disorders.

Carcinogenicity Information
None of the components of Betadine® Solution are listed by IARC, NTP, OSHA, or ACGIH as a carcinogen.

4. First Aid Measures

First Aid
INHALATION
If aerosols or iodine vapor are inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

SKIN CONTACT

Remove contaminated clothing. Flush skin with plenty of water and wash thoroughly with soap and water. If irritation (redness, itching, swelling) develops, seek medical attention. Wash contaminated clothing before reuse.

EYE CONTACT
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Get medical attention.

INGESTION
If swallowed, do not induce vomiting. Drink several glasses of milk or water. Never give anything by mouth to an unconscious person. Get medical attention.

Notes to Physicians
No special first aid. Provide supportive measures.

5. Fire Fighting Measures

Flammable Properties
Non-flammable.

Extinguishing Media
Water spray, carbon dioxide, dry chemical powder, or foam as appropriate for the surrounding material.

Fire Fighting Instructions
Evacuate personnel to a safe area. Move containers from area if it can be done without risk. Wear protective clothing and positive-pressure, self-contained breathing apparatus with full protective gear.

6. Accidental Release Measures

Safeguards (Personnel)
NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up to minimize exposure to this material. Evacuate personnel from the area.

Initial Containment
Prevent material from entering sewers, waterways, or low areas. Dike area for later disposal.

Spill Clean-up
Wear suitable protective clothing and equipment. Vacuum or mop up liquid and place in a container suitable for chemical waste; avoid generation of aerosols. Place collected material into a suitable container for disposal. Thoroughly wash

area with detergent and water. Dispose of all solid waste and wash and rinse water in accordance with federal, state, and local regulations.

7. Handling and Storage

Handling (Personnel)
Avoid procedures that will generate aerosols. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Wash contaminated clothing after use. Use with adequate ventilation.

Handling (Physical Aspects)
Close container after each use. Do not generate aerosols.

Storage
Store in an airtight container. Keep container closed. Store at room temperature. Keep from contact with oxidizing materials.

8. Exposure Controls/Personal Protection

Engineering Controls
Handle material under adequate ventilation. Keep container tightly closed.

Personal Protective Equipment
Wear safety glasses with side shields. Wear full-face protection when judged that the possibility exists for eye and face contact.

Wear an appropriate NIOSH-approved air purifying respirator or positive pressure air-supplied respiratory in situations where a respirator is judged appropriate to prevent inhalation.

Wear impervious clothing such as gloves, lab coat, shoe covers, apron, or jumpsuit, as appropriate, to prevent skin contact. Consult the site safety professional for additional guidance, as needed.

Exposure Guidelines

Exposure Limits
None established for Betadine® Solution.
None established for Povidone iodine.
None established for Pareth 25-9.

For Iodine:
PEL (OSHA): 0.1 ppm
TLV (ACGIH): 0.1 ppm

For Glycerin:

PEL (OSHA): 15 mg/m^3, total dust
5 mg/m^3, respirable fraction
TLV (ACGIH): 10 mg/m^3 (mist)

Exposure Guideline Comments
none

9. Physical and Chemical Properties

Physical Data
Odor: slight characteristic
Form: liquid
Color: reddish brown
Vapor Pressure: no information available
Melting Point: no information available
Solubility: soluble in water and in alcohol

10. Stability and Reactivity

Chemical Stability
Low stability hazard expected at normal operating temperatures.

Reactivity
A mixture of equal parts of a 10% povidone iodine solution and hydrogen peroxide 3% exploded about 100 minutes after mixing.

Incompatibility with Other Materials
Strong alkalis or reducing agents

Decomposition
Will not decompose under conditions of usual handling.

Polymerization
Material will not polymerize.

11. Toxicological Information

Animal Data
Betadine® Solution has not undergone toxicity testing in animals. The information presented below is for povidone iodine, glycerin and pareth 25-9.

Skin/Eyes
Povidone iodine
Povidone iodine has been reported to be a mild skin and eye irritant in animals.

Glycerin
Glycerin has been reported to produce mild skin and eye irritation in rabbits.

Pareth 25-9
No information available.

Acute
Povidone iodine
Oral LD_{50}: rat: >8 g/kg
Oral LD_{50}: mouse: 8.1 g/kg
Intravenous LD_{50}: rat: 640 mg/kg
Intravenous LD_{50}: mouse: 480 mg/kg
Intravenous LD_{50}:rabbit 110 mg/kg

Glycerin
Oral LD_{50}: rat: 12.6 g/kg
Oral LD_{50}: mouse: 4.1 g/kg
Intravenous LD_{50}: rat: 5.6 mg/kg
Intravenous LD_{50}: mouse: 4.2 mg/kg
Dermal LD_{50}: rabbit: >10 g/kg

Pareth 25-9
No information available. Pareths are ethoxylated long-chain alcohols and are expected to have low acute oral toxicity; e.g., the acute oral LD_{50} for Pareth 25-7 is 2000 mg/kg.

Subchronic
Subchronic Toxicity
Povidone iodine
In a 12-week dietary study in rats, ingestion of povidone iodine at an average povidone iodine dosage of approximately 75 to 750 mg/kg/day produced a dose-dependent increase in serum protein-bound iodine and nonspecific, reversible microscopic changes in the thyroid. No other gross or microscopic povidone iodine-induced cahnges were observed. At equivalent iodine dosages, dietary potassium iodide produced similar thyroid changes of equal or greater severity.

Glycerin
No information available.

Pareth 25-9
No information available.

Chronic
Chronic Toxicity
Povidone iodine
No information available.

Glycerin
No information available.

Pareth 25-9
No information available.

Carcinogenicity
Povidone iodine
No information available.

Glycerin
No information available.

Pareth 25-9
No information available.

Mutagenicity/Genotoxicity:
Povidone iodine
Bacterial mutagenicity: negative
Bone marrow (hamster): negative
Dominant lethal assay (mouse): negative
Mouse lymphoma: negative
Mouse micronucleus: negative

Glycerin
Bacterial mutagenicity: negative

Pareth 25-9
No information available.

Developmental/Reproductive Toxicity
Povidone iodine
No information available.

Glycerin
No information available.

Pareth 25-9
No information available.

12. Ecological Information

Ecotoxicological Information
No information available

Chemical Fate Information

No information available

13. Disposal Considerations

Disposal
This material is not listed under US RCRA. Disposal of this material must be in accordance with federal, state/provincial, and local regulations.

14. Transportation Information

Shipping Information
This material is non-hazardous under US DOT.

15. Regulatory/Statutory Information

US Federal: none
International: none
EC Labeling: none
FDA: The Approved Drug Products with Therapeutic Equivalence Evaluations List identifies currently marketed drug products, including povidone-iodine, approved on the basis of safety and effectiveness by FDA under Sections 505 and 507 of the Federal Food, Drug, and Cosmetic Act.

16. Other Information

The information contained in this Material Safety Data Sheet is believed to be accurate and represents the best information available at the time of preparation. However, no warranty, express or implied, with respect to such information, is made. The data in this Material Safety Data Sheet relate only to the specific material designated herein and does not relate to use in combination with any other material. The data in this Material Safety Data Sheet are subject to revision as additional knowledge and experience are gained.

This MSDS was prepared for Purdue Products L.P. by the Occupational and Environmental Assessment Section of Purdue Pharma L.P.

TRU CLEAN MATERIAL SAFETY DATA SHEET

Kitchen Hygiene Specialists

IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Company: Truclean (Qld) Pty Ltd
Address: 101 Jijaw Street, Sumner Park, QLD, 4074 Email: service@truclean.com.au
Phone: (07) 3279 1274 Fax:(07) 3279 1079 Web: www.truclean.com.au
Emergency Telephone Number: Poisons Information Centre 131126 or company (07) 3279 1274

Product Name: METHYLATED SPIRITS

Other Names: None
Manufacturer's Product Code: metho
Recommended Use: Solvent Cleaner.

HAZARDS IDENTIFICATION

CLASSIFIED AS HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA
CLASSIFIED DANGEROUS GOODS ACCORDING TO THE CRITERIA OF THE ADG CODE FOR TRANSPORT.
Risk Phrases: *R 10*
Safety Phrases: *S 2 – 16 – 23 - 45*

COMPOSITION / INFORMATION ON INGREDIENTS

INGREDIENTS

Chemical Entity	*CAS Number*	*Proportion (%)*
Denatured Alcohol	64 – 17 – 5	95
Water	7732 – 18 - 5	to 100

FIRST AID MEASURES

FIRST AID TREATMENT
Swallowed: If swallowed, **DO NOT** induce vomiting. Give a glass of water and seek medical advice.
Eye: If in eyes, hold eyes open, flood with water for at least 15 minutes and see a doctor urgently.
Skin: If skin contact occurs, remove contaminated clothing and wash skin thoroughly. Wash clothing before reuse.
Inhaled: Remove victim from exposure if safe to do so. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume a comfortable position and keep warm. Seek medical assistance if symptoms persist.
First Aid facilities: Potable water should be available to rinse eyes or skin. Provide eye baths and safety showers.
Advice to Doctor: Treat symptomatically.
Additional Information: None available.

FIRE FIGHTING MEASURES

Fire/Explosion Hazard: This product is flammable. Fire fighters to wear self-contained breathing apparatus in the event of a fire. Use foam, water fog, or fine spray mist to extinguish.
Additional Information: class 3 Hazchem 2 [Y] E

ACCIDENTAL RELEASE MEASURES

Spills and Disposal: Spills and vapours will be flammable. Remove non-essential personnel from the area. Ensure that other products of incompatible classes near the spill are removed. Remove all ignition sources. Dam and recover. Prevent entry into drainage systems, sewers and waterways. Consult Local Authority on disposal

HANDLING AND STORAGE

Precautions for Safe Handling and Storage: Classified Dangerous Goods for storage. When not being used, the product containers should be stored upright, and secured with the original closure. If transfer to another container becomes necessary, ensure that all ignition sources are removed, static earth lines are used, the container is clearly labelled, the container is of a type suitable for the product, and is clean and free of other materials. Do not smoke in contaminated areas. Before eating, drinking or smoking, remove contaminated clothing and wash hands.
Dispensing: Always use clean and dry equipment to dispense the product. Containers should be cleaned before and after use. All dispensers should be washed out after use.
Flammability: Flammable liquid.

EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Standards: There are no exposure standards available for this product
Personal Protective Equipment: Use sensible work practices that reduce operator exposure to the product. Protective clothing and equipment should be worn: chemically impervious gloves, safety glasses, overalls, waterproof apron and rubber boots. Respiratory protection should be used if there is a risk of exposure to high vapour concentrations. Respirators should comply with AS1716 or an equivalent approved by a state/territory authority.
Engineering Controls: Ensure that adequate ventilation provided is flame proof. Maintain air concentrations below recommended exposure standards. Avoid generating and inhaling mists. Keep containers closed when not in use.

IDENTIFICATION

PHYSICAL DESCRIPTION / CHEMICAL PROPERTIES

Appearance	Clear liquid
Odour	Alcoholic
Boiling Point (°C):	78.3
Vapour Pressure (mmHg @ 20°C):	58.1 mbar @20 o C
Specific Gravity (g/ml @ 25°C):	Approx 0.8
Flashpoint (°C):	13
Flammability Limits (%):	U.E.L. – L.E.L.
Solubility in Water	Soluble in water
pH:	

STABILITY AND REACTIVITY

Reactivity Hazards: Store in a cool dry place away from heat, naked flames, ignition sources.

TOXOCOLOGICAL INFORMATION

HEALTH EFFECTS
Acute:
Swallowed: May cause headaches, dizziness, and symptoms of central nervous system.
Eye: May cause irritation, reddening of eyes.
Skin: Moderately irritating. Prolonged contact with concentrated product may cause dermatitis.
Inhaled: Inhalation of vapour may cause irritation to the respiratory tract and nasal passages and may cause dizziness.
Chronic: prolonged or repeated exposure to high concentrations of alcohol may lead to skin dryness and addiction.
First Aid:
Swallowed: If swallowed, **DO NOT** induce vomiting. Give a glass of water and seek medical advice.
Eye: If in eyes, hold eyes open, flood with water for at least 15 minutes and see a doctor urgently.
Skin: If skin contact occurs, remove contaminated clothing and wash skin thoroughly. Wash clothing before reuse.
Inhaled: Remove victim from exposure if safe to do so. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume a comfortable position and keep warm. Seek medical assistance if symptoms persist.

Product: METHYLATED SPIRITS

ECOLOGICAL INFORMATION

Ecotoxicity: Concentrated product will harm environment. Can be used as a fuel under special conditions. Dispose of as per Local Authority regulations.

DISPOSAL CONSIDERATIONS

Disposal Methods: In accordance with Local, State and Federal regulations. Fuel [burning] is preferred method of disposal.

TRANSPORT INFORMATION

UN Number:	1170	Proper Shipping Name:	Ethanol
Class:	3	Subsidiary Risk:	Nil
Packing Group:	II	Hazchem Code:	2 [Y] E

REGULATORY INFORMATION

Poisons Schedule: Sch 5

Hazardous substances

R 10 Flammable liquid
S 2 Keep out of reach of children
S 16 Keep away from sources of ignition
S 23 Do not breathe vapour
S 45 In case of accident or if you feel unwell, seek medical advice immediately [show label if possible

OTHER INFORMATION

Further Information may be obtained by contacting the company on (07) 3279 1274.

The information sourced for the preparation of this document was correct and complete at the time or writing to the best of the writer's knowledge. The document represents the commitment to the company's responsibilities surrounding the supply of this product, undertaken in good faith. This document should be taken as a safety guide for the product and its recommended uses but is in no way an absolute authority. Please consult the relevant legislation and regulations governing the use and storage of this type of product.