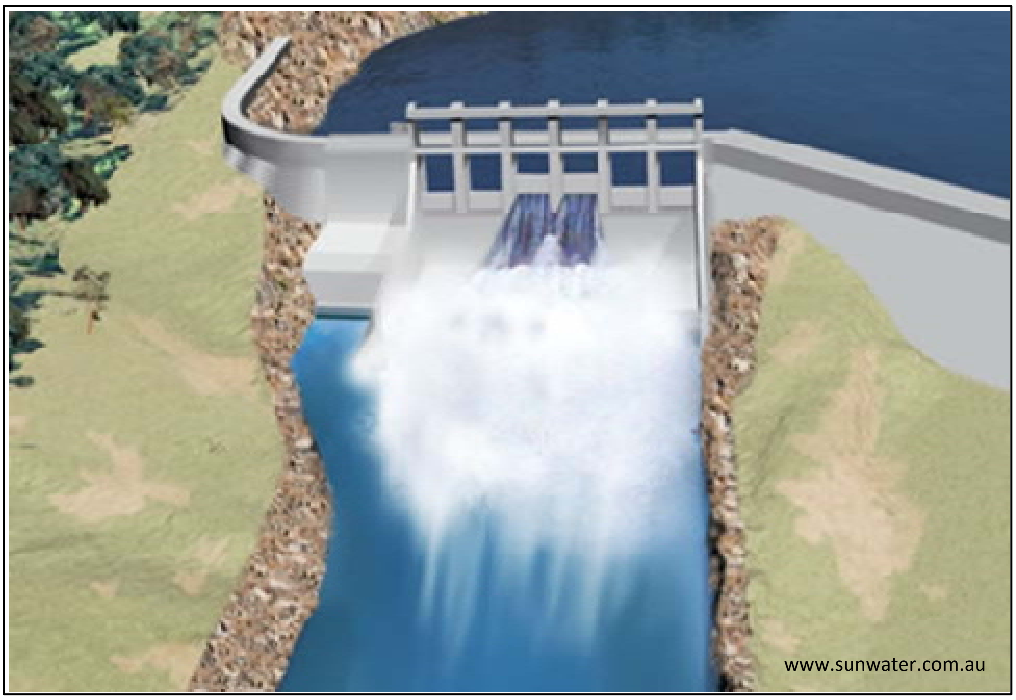
Environmental Impact Statement for Traveston Crossing Dam (Mary River, Queensland): A Review with regard for Species of Concern under the EPBC Act 1999

Report to the
Department of Environment, Water, Heritage and the Arts, Canberra

KF Walker

Consultant in River and Floodplain Ecology
PO Box 331, YANKALILLA 5203

Adjunct Associate Professor
School of Earth and Environmental Sciences, The University of Adelaide



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Executive Summary

Queensland Water Infrastructure (QWI) proposes to construct Traveston Crossing Dam on the Mary River as part of a strategy to meet anticipated water demands in south-eastern Queensland. This is the last high-yield dam site available in the region, according to QWI, but it is also an extremely sensitive site in terms of significance for conservation. An *Environmental Impact Statement* (EIS) has been released for public comment, and a Supplement containing responses to submissions has also been issued. This review is concerned with the implications for a number of species listed under the *Environment Protection and Biodiversity Act 1999* (EPBC Act), including three 'iconic' species, the Australian lungfish, Mary River cod and Mary River turtle.

Context

Ecologically Sustainable Development

In many cases, the EIS makes assumptions on the basis of scant evidence and draws conclusions about impacts with little or no justification. Most of the impact assessments suggest that the dam would have no significant impact or, if there were an impact, it would be compensated by mitigation and offset 'strategies' that are often ill-defined and individually have significant risks of failure. The EIS offsets these claims by indicating that the project includes a number of sustainability 'strategies', the principal one being a Freshwater Species Conservation Centre (FSCC).

The EIS does not view issues in a wider context, although World Heritage and Ramsar sites and migratory species clearly are global issues, by virtue of international conventions. Further, the Mary River harbours flora and fauna that are *nationally* endangered, vulnerable or rare, and the Australian lungfish and Mary River turtle particularly are *internationally* significant. There is substantial literature on the ecology of reservoirs and the environmental effects of dams on rivers, and a substantial part is of Australian origin. Most of this has been overlooked.

QWI proposes to manage the downstream flow environment expressly to maximise the benefits for the lungfish, cod and turtle. There are considerable dangers in this approach because these species are unlikely to be representative of the conditions required by supporting communities of fauna and flora.

Environmental monitoring

The proposal does not incorporate a comprehensive program of monitoring to accompany dam operations, other than to refer this responsibility, in part, to the proposed FSCC. In the absence of a monitoring program, it would not be possible to detect, evaluate and respond to problems other than on an *ad hoc* basis. There are numerous references to problems that may occur, and to actions that might then be taken, but little indication of how these problems would be detected.

The operating authority should be responsible for a monitoring program that would address all of the environmental issues related to dam operations, and continue

indefinitely. These issues would include basic information about the reservoir and its downstream effects on the river. The program should have a wider focus than iconic species, and ideally should consider ecological communities.

Freshwater Species Conservation Centre

The main role of the FSCC would be to address problems related to impacts on iconic species in critical habitats. It is to be constructed near the reservoir and would include research facilities, short-term accommodation and a public education display. It would be administered under a Memorandum of Understanding between QWI and the University of Queensland. A Board and Advisory Committee have been nominated, and a Director is to be appointed. The financial commitment by QWI is $35M for up to 10 years. Beyond this time, it is anticipated that the Centre would become self-supporting.

Several issues arise:

- The need for the Centre is a reflection of how little is known of the biology and ecology of the iconic species. This information should be available *before* a project on the scale of Traveston Crossing Dam is contemplated.
- The tasks for research would require a lead time of several years, perhaps a decade. During this time, impacts associated with the dam may go unrecognised.
- The research agenda for the Centre is not clearly formulated. Although this is properly a task for the Board and Advisory Committee, plans should have been more advanced at this stage in development.
- The financial commitment may not be sufficient to sustain a credible, sustained research effort, as the proposed agenda is very ambitious.
- A limit of 10 years is not appropriate, in the reviewer's opinion, because QWI should retain responsibility for environmental management for the lifespan of the dam. An indefinite commitment is required.
- Griffith University is a national leader in river ecology, with a significant record of research on the Mary River, and should be consulted in planning for the Centre.

Hydrology

The downstream effects of dam operations on seasonal and annual variations in patterns of flow and water levels would be ecologically significant. Some submissions to the EIS raised this issue indirectly, claiming that the EIS does not adequately represent the inherent variability of the flow regime; instead, the emphasis is on daily flows. It is difficult to extract from the EIS a clear synthesis of seasonal and annual flow regimes and the ways in which these would be modified.

The 70-GL annual 'take' from the dam would apply whether discharge in the river is at, above or below the annual mean. Ideally, the take could be indexed to the resources available in any year. In dry years, the environment would bear the cost of a proportionately greater extraction, whereas in wet years part of the flow 'surplus' would be retained for flood mitigation. Mitigation in spring and summer could conflict with the role of floods as cues for breeding and dispersal in flora and fauna. Aside from riparian and floodplain vegetation, flooding is significant mainly for instream communities as there are no major freshwater wetlands on the Mary River floodplain.

Ecology of the reservoir

There is a high likelihood of algal blooms in the reservoir, encouraged by warm temperatures and high nutrient inputs. This would affect water quality, with implications for the flora and fauna in the reservoir and the river downstream, and for human consumption.

Although the reservoir would stratify thermally, QWI has declined to ‘model’ stratification or to indicate how the multi-offtake tower would be operated. In a stratified, eutrophic reservoir, prone to develop dense populations of algae and water plants, the deeper water is likely to become anoxic (without oxygen). This makes the deeper water uninhabitable by fish and most other animals, draws heavy metals into solution and releases hydrogen sulphide. Chemical changes in the bottom water may have adverse consequences for the lake fauna and flora at times of seasonal mixing, when anoxic water is returned to the general circulation.

Aquatic weeds including cabomba, dense waterweed, water hyacinth and salvinia are likely to become established in the reservoir, but the EIS maintains that monitoring and early intervention will prevent the development of nuisance populations. This would need to be continued indefinitely. The methods for intervention have not been described in sufficient detail to evaluate the likelihood of success. If weed infestations do develop, there would be consequences for the aquatic flora and fauna, and for the utility of the reservoir as a water supply. To maintain a potable supply, the emphasis would need to be on biological and physical methods of control rather than herbicides and other chemical treatments.

Establishment of a reservoir encourages a shift away from riverine fish toward lacustrine species, and creates a high potential for invasions by alien species. Native fish would be likely to be stocked in the reservoir for recreational fisheries. Several alien species are already established in the Mary River, and the Traveston reservoir would be a favourable habitat for some, including gambusia and common carp. The Mozambique tilapia, a declared noxious fish that occurs in nearby reservoirs, could also represent a threat. It would be indefensible to introduce alien or exotic fish to a river that supports nationally-threatened aquatic species.

The plan to retain riparian vegetation down to 1.5-m elevation below Full Supply Level, in the riparian zones of tributaries and along the Mary channel in the upper reaches of the reservoir, is intended to provide habitat for littoral fauna. After several decades, trees within this zone will die and fall, to provide snag habitat that is critical for many animals, including the Mary River cod and Mary River turtle. The 1.5-m zone apparently was a compromise between habitat and human safety, but it may offer most value as littoral habitat if it were expanded in areas closed to recreational use. There apparently would be no buffer zone in the main body of the reservoir, and the shoreline in that area would be a comparatively sterile habitat for flora and fauna.

Ecology of the tailwater

The 'tailwater' is the reach below the dam where there are measurable effects on the river environment, albeit decreasing with distance downstream. In this report, the tailwater is taken, conservatively, as the reach from the dam to Fisherman's Pocket (35 km).

The tailwater will experience changes in flows, water levels, water quality and sediment transport, and if these are sufficient to discourage resident and migratory species they will compound the effect of the dam as a barrier to movements, especially upstream movements. The reservoir and tailwater combined would alter the riverine environment over some 70 km, or about 28% of the channel above the tidal barrage. The proposed turtle by-pass channel and fish-transfer device will not be effective unless turtles and fish are able to move freely through the tailwater and through the reservoir.

The Mary River Water Resources Plan has set *Environmental Flow Objectives* (EFOs) for nodes throughout the catchment, but these are planning tools rather than enforceable management requirements and would not be monitored routinely after dam operations commence. The first node downstream of the dam is at Fisherman's Pocket. EFOs therefore are not assessed *within* the tailwater, as defined here, and there is little basis to predict the impacts of dam operations on the environment, flora and fauna in this critical area.

Hydrological effects in the tailwater include:

- A 45% reduction in the median annual flow (24% reduction in mean annual flow) at Dagun Pocket (2 km downstream), compared to the pre-development regime. There appears to be no seasonal variation at Dagun Pocket, but this may be a statistical artefact. At Fisherman's Pocket, median daily flows would be substantially reduced over the year, but seasonality would be preserved.
- Low flows 20-30 cm above the cease-to-flow level are the part of the flow regime most impacted, although the effects are progressively diminished downstream as tributaries join the mainstream.
- Changes in the hydrological regime are of most concern in July-November, when natural flows would be low. The EIS maintains that these flows are already highly impacted, and that dam operations would have only a small additional impact. Again, this needs to be assessed in the tailwater zone, in ecologically-relevant terms. Environmental flows are not included in the modelling, except to recognize that a minimal 100 ML/day would pass without regulation.
- During floods, there would be impacts on river levels at Dagun Pocket because the dam would act to reduce the peak of the flood and extend its duration. Water levels would be lower on 58% of days compared to the present. The flow regime would show more consistent low flows in spring and early summer, but peak summer flows would be little affected. These changes could lead to a deterioration in water quality, owing to the lack of flushing, and could encourage the growth of algae and macrophytes.

Modelling suggests that climate change would have little effect on river flows, but the text indicates that there are likely to be extended periods of lower rainfall and an increased intensity and frequency of extreme rainfall. In a catchment subject to intense cyclonic rainfall, it is difficult to see how these changes would not be significant. Short-lived extreme events are obscured by longer-term averages, but are likely to be ecologically important (e.g. for shallow-water plants and animals).

The EIS estimates that the dam will trap 81% of incoming suspended sediment, and acknowledges that the Mary channel downstream of the dam is highly susceptible to erosion. There would be redistributions of sediment in the tailwater, especially as the channel has sandy, erodible banks and is actively eroding now, in some areas below the dam site. Modelling indicates that there will be significant losses of coarse sediment between Dagun Pocket and Fisherman's Pocket. This would threaten the pool-riffle morphology of the channel, a key attribute of the habitat for lungfish, cod and turtles. There would be potential to scour or smother submerged plant species in the downstream reach, and the time to recovery could be years. Affected plants would include ribbon weed, a favoured spawning and nursery area for lungfish. According to the EIS, the angle of alignment of the spillway discharge will be reviewed to reduce scour below the dam.

Fish and turtle passage

Traveston Crossing Dam is to be a Roller Compacted Concrete construction, like that at Paradise Dam, and consists of many short steps that could be a lethal passage for fish, turtles and other large animals swept over the wall during over-topping flows. The EIS suggests that a monitoring program will be implemented, but there appear to be no plans to install racks, nets or other devices to prevent losses.

The EIS recognizes the need for a fishway. It is an integral part of the design for the dam, and will be modelled on one installed at Paradise Dam, although this has yet to perform effectively. Little information is provided about the nature of the fish fauna, with respect to migrations and movements, other than for the iconic species. Critical questions remain unanswered over the ability of lungfish and Mary River cod to use fishways. The fish-transfer device is expected to operate 96% of the time, but in the event that up- or down-stream passage is not possible, because of environmental conditions or because one or more of the iconic species are unable to use the fishway, QWI proposes to implement a catch-and-carry strategy.

The turtle by-pass channel is a speculative design, as there appears to be no comparable facility elsewhere. It is not known whether turtles in the Mary River (in particular, the Mary River turtle) are able to use such a facility. Again, there are assurances that, if one this species could not use the channel effectively, the catch-and-carry strategy would be employed.

There appears to be no precedent for this strategy as a means to offset population fragmentation, although the EIS points out that the Australian lungfish, the Mary River cod Mary River turtle (or their eggs) have been captured and transported in the past. It clearly is possible to transport small numbers of individuals, but the issue here is the need to maintain connectivity and genetic mixing between sub-populations.

The catch-and-carry strategy targets the iconic species, although the dam is a barrier for other species, including turtles other than the Mary River turtle, fish other than the Mary River cod and Australian lungfish and other vertebrates and invertebrates. It is not clear whether the strategy would be applied to these species, or what would trigger decisions to relocate individuals, or how those individuals would be selected, handled and monitored.

The EIS claims that this method could successfully address the specific issue of genetic isolation, there is no evidence in support. The assertion that success is measurable simply in terms of numbers transported is not consistent with the purpose of the intervention. Indeed, it is conceivable that translocation of a few individuals could have deleterious effects. The situation would need to be monitored at the population level, presumably by monitoring genetic diversity.

Population ecology

The EIS does not distinguish between *reproduction* and *recruitment*, but the difference is critical for maintenance of plant and animal populations. 'Recruitment' here refers to the accession to populations of mature, potentially reproductive individuals, in numbers sufficient to maintain the existing population over the course of time. If recruitment were to fail repeatedly, the population age profile would become progressively skewed toward older individuals and the population would decline and eventually disappear.

It matters little if species like the Australian lungfish, Mary River cod and Mary River turtle can be induced to breed in artificial conditions, including reservoir habitats, unless breeding is on a scale commensurate with maintaining the population over time. From a conservation viewpoint, assurances are needed that recruitment, not merely reproduction, would be maintained in the changed environment.

Connectivity is a vital issue for aquatic and terrestrial flora and fauna. River communities are inherently patchy, and the flowing water in the channel maintains connections between patches. Without connections, the population is fragmented and the isolates, and ultimately the entire population, become vulnerable. The riparian zones of rivers also are, by their nature, corridors for dispersal of plants and animals. It is clear that the dam will intersect existing corridors, but there is no assurance that the planned offsets would be sufficiently continuous to restore the dispersal corridor and maintain connectivity between population elements above and below the dam.

Information about macroinvertebrates is limited to data obtained using methods employed in AUSRIVAS, the Australian RIVer Assessment System. Information about some species, including prawns, crayfish, snails and freshwater mussels, is lacking for the most part. There are no data for freshwater sponges, part of the diet of juvenile Mary River turtles. Freshwater mussels also are part of the diet. Both sponges and mussels are susceptible to smothering by sediment, which would be a hazard in the tailwater.

Although still and flowing waters favour different species of sponges and mussels, they do live in reservoirs provided that there is a stable substratum (typically, rock or wood for sponges; non-compacted sediment for mussels).

The EIS claims that a 'detailed concept' or 'early preliminary design stage' is appropriate for major infrastructure projects. In the reviewer's opinion, the levels of commitment and detail provided, at least in the context of potential environmental impacts, are not commensurate with the risks to the species of most concern, or to their habitats.

Again, there are dangers in tailoring flow management expressly for the iconic species, as they may not represent the flow requirements of other fauna, or flora. There is evidence that the Australian lungfish, Mary River cod and Mary River turtle may not recruit every year, and in that respect their requirements could not be said to represent those of other species with annual recruitment and shorter life spans.

Endangered species

Mary River cod

The stream length occupied by the Mary River cod now is less than 30% of its former range in the Mary system. Cod still occur in the main channel, but are said to be less common than formerly. In the inundation area, the EIS survey recorded more cod from the channel than from any survey in the Mary catchment in the last 10-20 years.

Sub-populations remain in Six Mile Creek, Obi Obi Creek and Tinana-Coondoo Creeks, and in other areas where their status is uncertain. The EIS acknowledges that the survival of cod would be threatened if these habitats were to become isolated. The total population in all core localities in 1996 was estimated at less than 600 adults.

Some tributaries are linked to the Mary channel within the tailwater zone, and the ability of the cod to move in this reach could be prejudiced by environmental changes associated with dam operations.

Whether or not the Mary channel has significant resident populations, or good-quality habitat, it has a key role in connecting the tributary habitats.

Mary River cod prefer deep, shaded, slow-flowing pools. They have a strong affinity for submerged snags, and areas of open water usually are avoided. Little is known of juvenile habitat needs, but adults are often located downstream of riffles, where food is concentrated by the flow.

A striking feature of the population data available for the cod, apart from its paucity, is the lack of information about age profiles (year-class strength). This is a basic requirement in fish biology, used to associate different age/size classes with environmental conditions.

The Gerry Cook Cod Hatchery has reared Mary River cod for stocking purposes for over 20 years. Activities have lapsed in recent years, but QWI proposes to reactivate the hatchery with a grant to support construction of new facilities. Most hatchery-reared fingerlings released before 1999 were not marked, and it may now not be possible to distinguish hatchery stock from wild fish, or to determine the status and dynamics of the wild cod population.

Mary River cod can be induced to spawn in hatchery ponds in the absence of flow stimuli, and judging from studies on related species, probably would be able to breed in the Traveston reservoir. There is a crucial qualification, however, in that they probably would not recruit successfully, even with provision of artificial spawning habitat. The Murray cod (possibly also the eastern freshwater cod) may spawn in impoundments, but for reasons that are not clearly understood by fish biologists, they fail to recruit well in these environments. Successful recruitment is a prerequisite for effective conservation.

The Mary River Cod Recovery Plan commenced in 1996 but has performed poorly. It pre-dates the Traveston Crossing Dam proposal by a decade, and should have been reviewed to determine whether it is adequate to meet the potential impacts of the dam. Doubts over the security of the species would be best served by full, concerted implementation of the recovery plan.

The combined area of inundation, the dam and the tailwater together represent a physical barrier that would fragment the area occupied by Mary River cod, and it would be necessary to ensure connectivity. Adults are territorial, but may move more than 30 km up- or down-stream during high flows, but there are no data to describe the ability of the cod to utilise the proposed fish-transfer device.

The inundation area, dam and tailwater will modify areas of Mary River cod habitat. These areas may provide ‘poor’ quality habitat where cod can survive, but there is no evidence to suggest that they could harbour breeding populations. The reservoir will have little resemblance to the riverine pool-riffle habitats preferred by the cod. Existing pool-riffle habitats in the dam tailwater will be modified by flow changes and consequent erosion and siltation.

It is not possible to state *unequivocally* that the local Mary River cod population would undergo a long-term decline as a result of dam operations. The size of the population is not known with confidence, and there are few data on recruitment and other basic features of biology and ecology. In the reviewer’s opinion, the uncertain status of the cod population and changes to breeding habitat-availability, hence recruitment, and to the scope for free-range movements present an unacceptable risk that the local cod population would decline.

In view of the likely impacts associated with dam construction, and the likely delays before the FSCC research agenda and its findings are implemented, it is recommended that *consideration* be given to a ban on recreational fishing for Mary River cod within the project area. If fishing is permitted, improved methods for monitoring catches would be advantageous for future planning and research.

Mary River turtle

The Mary River turtle is one of the world’s most endangered turtles. It is from an ancient lineage and has no close relatives, and is therefore of extraordinary scientific interest. It lives within a restricted area of the Mary River, and population numbers are commonly believed to have been impacted severely by collecting for the pet trade (now discontinued). The EIS suggests that the main threat to the species now is egg predation.

The absence of a formal Recovery Plan for this species is a major impediment to analysis and management of potential impacts.

Adult Mary River turtles are mainly herbivorous but do eat animals, including sponges and freshwater mussels. The juveniles favour insect larvae, including species from riffle habitats. Favoured habitats include deep pools interspersed by riffles, with overhanging vegetation, snags, beds of water plants and nearby sand banks for nesting. The Traveston Crossing Dam would inundate areas that are now occupied by turtles, and the tailwater flow and sediment regimes also would impact on turtle habitats.

There are 66 potential nesting sites (suitable sand banks) in the vicinity of the dam, and about half of these would be inundated. QWI proposes to relocate some potential sites, either to islands or to more elevated positions, to ensure that they remain above water. This is an untried strategy, unsupported by trials or research.

Water-level fluctuations in the reservoir may not restrict access to nests in the uppermost reaches of the reservoir, where inundation is restricted mainly to the channel, but they could be more significant for nests remaining along the lower reaches.

It is unlikely that the reservoir environment would sustain juvenile turtles. This should be considered alongside the requirements for nesting, in that attempts to relocate and protect nesting areas in some areas may be to no avail if the juveniles did not survive.

The turtles are reported to have bred in the upper reaches of the Mary Barrage impoundment, but this is quite a different environment from a large, deep reservoir with an exposed shoreline and proportionately much less 'edge habitat' than small river channels. It cannot be taken as an assurance that the species would adapt to lacustrine conditions.

In a survey of Mary River turtles undertaken for the EIS, the most densely-populated reach was the 5-km reach downstream of the dam site. This also had a higher proportion of juveniles than the inundation area. It would become part of the dam tailwater.

Although it may be possible to manage downstream flows to enhance the quality of the downstream habitat for turtles, the issue is not whether the dam *could* be managed to benefit turtle populations but whether this would be consistent with routine dam operations.

Without mitigation, the inundation area, dam wall and possibly the tailwater would prevent upstream movements of turtles, and downstream movements would incur some losses due to physical damage to individuals trapped in the offtake or swept over the spillway. In response, QWI proposes to construct a turtle by-pass channel, to consider re-stocking with artificially-reared juveniles and to implement catch-and-carry methods. These strategies are similar to those proposed for Mary River cod.

Design details for the by-pass are not finalised, and development and monitoring would be referred to the FSCC.

Arguments in support of 'catch and carry' and restocking again suggest that there is some confusion about the purpose of transfer. The issue is not whether individual turtles (or fish) can be captured, transported and released at other sites, but whether these methods address the specific issue of genetic isolation. Catch-and-carry is not, as the Supplement says, a technique for which "success is easily measurable in terms of how many individuals moved from one location to another".

If dam construction is to proceed, a formal recovery plan for the Mary River turtle should be made an urgent priority. QWI intends to refer this matter also to the FSCC.

The combined area of inundation, the dam and the tailwater together represent a physical barrier that would fragment the area occupied by Mary River turtles. The turtles undertake small-scale movements within their range and it is necessary to promote these to maintain gene flow between elements of the population. QWI proposes that the fish-transfer device, turtle by-pass channel and catch-and-carry methods will address these issues, but there is little assurance that the situation will be monitored effectively.

Although the turtles can be reared in artificial conditions, this should not be equated with recruitment on a scale sufficient to maintain populations. Artificial stocking is discredited as a solution to declines in wild populations. The arguments against reliance on catch-and-carry are as for Mary River cod.

Adult turtles probably would survive in the reservoir, but there is no evidence that they would breed or form self-sustaining populations in that environment. They might breed in peripheral tributary inflow areas that retain some riverine characteristics. Juveniles may not survive in the reservoir.

Good-quality feeding habitats occur within the inundation area, and it is doubtful that they will be suitable for adults, and particularly juveniles, after inundation. Pool and riffle habitats in the tailwater may be degraded by changes in flow and water quality, and redistributions of sediment through erosion and siltation. Most of the environments created by the project seem likely to have low (or significantly diminished) value as residential habitats, and would be unlike the pool-riffle habitats favoured by the species.

The size of the Mary River turtle population is uncertain, but preliminary estimates suggest 900-3500 within the inundation area. It is likely that this part of the population would decline, and may be lost. In general, there is so little critical knowledge of the ecology and biology of the species that the only responsible conclusion can be that the dam would represent a substantial risk to the integrity of the present population, and the species as a whole. Much would depend on the success of untried mitigation strategies to be implemented, some years after dam construction, by the FSCC.

Southern barred frog

A Recovery Plan exists for several species of stream frogs in south-eastern Queensland, including the southern barred frog. Critical habitats for this species are permanent freshwater streams in rainforest and other forest communities at 0-700 m altitude, including riparian remnants along the Mary River.

In surveys conducted for the EIS, the southern barred frog was detected at numerous stream sites in lowland vine forest and riparian gallery forest. It occurs mainly upstream of the dam site, and was more often found along tributaries than the Mary channel. The population appears to be concentrated in the eastern tributaries, including Belli Creek. The size of the population is unknown.

Flooding will destroy a substantial area of habitat, or potential habitat, leaving upper Belli Creek as potentially the main refuge for the population. Eastern and western tributary habitats will be isolated from each other, and flooding may also isolate eastern tributary populations unless, as the EIS suggests, the frogs are able to move across sub-catchments by traversing forest habitats. From what is known of the species' movements, and its affinity for stream banks, this seems unlikely.

This is essentially a stream species, and there is no suggestion that it would adapt to new habitats along the reservoir shoreline. Some riparian forest habitats would remain, but lower-elevation areas would be flooded. As a result of the loss of habitat, and the already-fragmented nature of the population, the area of occupancy would decrease and there is a risk that the size of the population would decrease.

Although the project would not intentionally introduce disease, increased access by humans and localisation of the population in Belli Creek and other tributaries could make it more vulnerable to chytridiomycosis, a fungal disease implicated in the decline of frogs elsewhere in Queensland, and in other parts of the world.

It is not clear who would have responsibility for implementing recommendations for mitigation, or whether they represent commitments by QWI. The FSCC is not mentioned, and there is no explicit support for the recovery plan. It seems clear that the project would interfere with implementation of the plan.

The biological and ecological data available to support assessment for the southern barred frog are very sparse. There is a high risk that the population will be adversely affected by the direct and indirect effects of dam construction. The proposed mitigation and offsets are framed in very general terms and it would be difficult to measure compliance, post dam construction.

Coxen's fig-parrot

In the case of highly mobile species, with habitats extending beyond the Mary River catchment, it is difficult to identify direct impacts. The project may contribute to the overall fragmentation of habitat for the fig-parrot, and may deplete a significant winter food source. This does not appear to be adequately addressed in the proposed mitigation and offsets. The project would not assist in implementation of the existing Recovery Plan for this species.

Spotted-tailed quoll

The destruction and fragmentation of potential habitat would discourage quolls (and other species), but in the absence of confirmation that the species does occur locally, and a formal recovery plan, a cautious response is indicated. The best course would be to implement a survey and monitoring program before and after dam construction.

Vulnerable species

Australian lungfish

The Australian lungfish is the world's most primitive survivor of a 400-million year old lineage, and is internationally renowned. Its natural range is the Mary and Burnett Rivers, although it has been translocated to other rivers in south-eastern Queensland.

There is not a formal recovery plan for the lungfish, although a draft was near completion near the time that the Traveston Crossing Dam EIS was released. It is not known why the plan was not issued for incorporation into the proposal.

Lungfish are reasonably common in the Mary channel, including the inundation area, and several tributary streams. The species' *vulnerable* status reflects its small geographic range and threats to habitat and recruitment rather than its population size.

The EIS points to the Brisbane River, where lungfish have been translocated and now live above and below Wivenhoe Dam, as evidence that the species can live in regulated-flow environments. Comparisons are deceptive, however, because daily flows below Wivenhoe Dam are 5-10 fold greater than those likely to prevail downstream of Traveston Crossing Dam. There will not be equivalent habitats in the Mary below the dam, and diminished flows during the breeding season (July-December) could threaten spawning and recruitment. The EIS concedes that it is doubtful that lungfish would recruit successfully in the Traveston reservoir, and there is no evidence that they do so in other impoundments. Lungfish may lay eggs in still or flowing water but this is not, as the EIS implies, an affirmation that they could breed in a large reservoir.

The EIS likens parts of the reservoir to the pool-riffle environments inhabited by lungfish. Although the reservoir would provide a variety of habitats, most of the physical diversity will be in the uppermost reaches, a relatively small area that retains some riverine characteristics, where the banks are likely to be steep and there may be few shallow areas where water plants can grow. These are the limits of a much larger expanse of water that is very different in character. It may accommodate adult lungfish, but the critical issue is whether the reservoir and its upper reaches could sustain lungfish populations. In this respect, it is misleading to compare small and large impoundments.

Adult lungfish favour shallow, flowing reaches with overhanging riparian vegetation, submerged snags, dense beds of ribbon weed and other plants. The reservoir would flood 36.5 km of this habitat upstream of Gympie, and would extend into several tributaries. The EIS argues that, as adults would live in the reservoir, and the inundation area is only a small part of the available habitat, and if breeding is improved in the tailwater (as the EIS suggests), a long-term decrease in the size of the population is not expected.

If breeding did *not* occur in the tailwater, the impact zone would cover twice as much (70 km) of the available habitat as the reservoir alone.

The EIS acknowledges that the dam would fragment the area occupied by the lungfish, but maintains that "multi-tiered transfer strategies" will allow lungfish to access habitats upstream and downstream of the dam and ensure genetic mixing.

Lungfish are naturally sedentary, but do undertake regular, small-scale movements and may move further afield. Accordingly, QWI proposes a fish-transfer device and, if necessary, a catch-and-carry program.

There is scant information on the use of fishways by lungfish, including the Paradise Dam fishway, and no evidence that the fish are able to use existing facilities in numbers sufficient to offset the genetic effects of fragmentation. In addition, there are no records to account for injuries or death of lungfish swept over the dam wall during high flows.

References to "the apparently highly successful" catch-and-carry in the 19th Century merely affirm that lungfish (and Mary River cod) can be captured and transported to new habitats. The issue of genetic isolation is treated superficially in the EIS, and it is unclear how the need for mixing will be determined, or how success would be measured. As lungfish recruitment is not necessarily annual, the need for catch-and-carry presumably would arise only after the fish-transfer device had been inoperative over several years.

This issue is accentuated because lungfish populations in the Mary and Burnett Rivers may not be genetically diverse. There is evidence of low variability across the genome, typical of 'endangered' species and implying a low potential for evolutionary adaptation to change. This, combined with sporadic recruitment, slow growth and long generation times would limit the species' capacity to adapt to changes in environmental conditions associated with the dam.

The EIS states that consideration will be given to the translocation of artificially-reared lungfish into areas where natural and man-made barriers prevent access to potentially useable habitat. Hatchery releases should be considered a last resort in restoration of declining natural populations.

Hatchling lungfish favour dense beds of vegetation, in shallow, flowing water. They are cryptic and notoriously difficult to observe or sample, and may remain in these habitats as juveniles for months or years. Failures to detect juvenile lungfish in surveys for the EIS cannot be explained simply by saying that they are cryptic and difficult to observe. This is a *critical* issue, and the EIS should have expended more effort to reinforce the proponent's claims in this respect. It is possible that failure to locate juveniles means failed recruitment. If that is correct, and if it were to persist, a catastrophic population decline is inevitable.

Information about year-class strength is conspicuously lacking, but it is known that recruitment in the Burnett River has been poor for over a decade because macrophyte beds were stripped by floods in 1997-1999 and took a long time to recover. Periodic scouring is likely to limit the development of ribbon weed, and pool-riffle macro-invertebrate communities, downstream of Traveston Crossing Dam.

It is likely that in lungfish successful recruitment does not occur every year, due to variations in spawning conditions and food resources, and that some years produce stronger age classes than others. This is significant for conservation, as failed recruitment over several years may go un-noticed, so that while adults remain common and the population seemingly is secure, the population may decline catastrophically as the older individuals die.

Most of the proposed mitigation 'strategies' for lungfish are directed also at the Mary River cod and Mary River turtle. None guarantees that the net loss of breeding opportunity for lungfish in the reservoir will be compensated. In general, the proposal is not greatly strengthened by listing mitigation 'recommendations' (it is not clear to whom) that, taken individually, may not succeed.

In the absence of detailed knowledge about lungfish in critical areas, the prudent course is to be conservative. It is *possible* that the lungfish population is already in decline, due to failed recruitment, and in that respect the new dam presents an unacceptable risk that the population would be severely impacted.

Traveston Crossing Dam would mean that 26% of core lungfish habitat in the Mary River is impounded and, at the very least, the dam would reduce the *quality* of habitat for the species. This offers little security for a *vulnerable* species, under the EPBC Act, and conceivably could be sufficient to have the species nominated for consideration as an *endangered* species.

Black-breasted button quail

This species is not recorded from the project area. It does occur in the region, however, and the project could contribute to the fragmentation of its former habitat.

Green turtle

The EIS outlines the natural history of the green turtle, and other marine turtles that frequent the Great Sandy Strait, at the mouth of the Mary River, but offers no assessment of impacts. It is not possible to identify likely changes to the population or its habitat that could confidently be ascribed to dam operations.

Grey-headed flying fox

Some 300 ha of remnant forest would be flooded, reducing the foraging area for a flying-fox colony that occurs immediately outside the inundation area. The EIS acknowledges that this could increase the severity of seasonal food shortages, causing starvation and high infant mortality, leading to reductions in the size of the colony and the area of occupancy. The EIS also concedes that clearing of foraging habitat in the project area would conflict with the recovery of the species.

Roosting habitat would be protected, and measures would be taken to reduce construction noise disturbance. The EIS suggests that with these measures the breeding cycle of the grey-headed flying-fox colony would not be disrupted.

This is insufficient assurance, in the reviewer's opinion, and a monitoring program should be invoked to monitor noise and disturbance and daily impacts on the colony, and to make adjustments to work practices as necessary.

Red goshawk

Dam construction will remove patches of open forest, woodlands and riparian vine forests that are part of the habitat for this species, although it is not formally recorded from the project area. As it ranges widely and is highly mobile, it would be difficult to relate particular features of dam construction and operation to the overall decline of the species. If nesting pairs are discovered in the project area, they should be monitored closely to ensure that they are not disturbed.

Slender milkvine

Clearing for the project would remove about 7.4 ha of potential habitat for slender milkvine. One of two known plants in the area will be lost and, according to the EIS, the formation of new edges on the periphery of habitats is likely to adversely affect any undetected individuals in those areas by increasing exposure to sun and wind.

Potential habitats for this species are mainly on hill-slopes and foot-slopes above the inundation area, but small portions would be flooded. Most impact to potential habitats would be along roads, especially the proposed Bruce Highway realignment in the north-eastern area (although no plants are reported from that area).

The EIS acknowledges that there is potential for weed invasion, particular in newly-created edge-habitats, and potential also for introduction of the root-rot fungus *Phytophthora cinnamomi*.

The EIS cites 'expert opinion' suggesting that this taxon probably is more common than distribution records show, and concludes that clearing of small areas of potential habitat for this species is unlikely to interfere with its recovery. Better justification is required.

Mitigation measures proposed for this species include protection and management of existing populations, in part, translocation of propagated stock and development of management and monitoring programs. Methods for propagation apparently have not yet been developed, so that early implementation is not assured. The threat of root-rot fungus could be significant, and may best be managed by propagating and distributing large numbers of plants and limiting human traffic between habitats, especially in the event of an outbreak.

Without more information about the *regional* status of the slender milkvine, and ideally a formal recovery plan, it is difficult to accept uncritically the assurances given in the EIS that the effects would be small and adequately compensated by offsets.

Rainforest Assemblage

In the EIS, a group of species recorded near, but not in, the project area are treated collectively as a 'rainforest plant assemblage'. Flooding would cover about 67 ha of habitat for these species, and any (undetected) individuals within this area would be lost. Most potential habitat is in riparian fragments of notophyll vine forest along the Mary River and its tributaries, in the inundation area, and small patches of araucarian vine forest on hill-slopes and foot-slopes.

Some existing fragments will be reduced by inundation or clearing, and possibly by road construction, increasing the vulnerability of resident species to local extirpation. Reduced patches could become non-viable habitats for some species. Edge-effects also become more significant for small patches, and may facilitate invasions by weed species.

The root-rot fungus *Phytophthora cinnamomi* could become a threat as its spread is enhanced in areas frequented by people.

The EIS indicates that, if any of the named species are encountered, the goal would be to ensure that there is no net loss of individuals from the project area. Suitable sites for translocation would be fenced, monitored and managed to reduce the threats from fire, weeds, pests, grazing stock and drought.

Although the likelihood of an impact cannot be assessed, as these species are not recorded from the project area, the project apparently will do nothing to encourage them to become established locally. It is not clear who would be responsible for surveys, monitoring and management.

Migratory species

Dugong

There are unlikely to be discernible effects from reduced annual flows on the dugong population or seagrass meadows in the Great Sandy Strait. There may be more concern for the influences that dam operations could have on extreme events, including floods and droughts, or flow reductions caused by a long-term change in climate. Water quality also may be an occasional issue. Although the dugong population in the Great Sandy Strait may not be secure, it is difficult to identify likely changes that would be 'substantial', as indicated in the Significant Impact Guidelines, or could confidently be ascribed to dam operations.

Shorebirds

The Great Sandy Strait supports estuarine shorebirds that are *migratory*, *marine* species under the EPBC Act. The effects of the dam could contribute in minor ways to the *degrade* the wetland habitats occupied by these species, but terms like "substantially modify" and "seriously disrupt" in the Significant Impact Guidelines preclude minor effects. As before, it is difficult to identify likely changes in the bird populations or their wetland habitats that could confidently be related to dam operations.

Contents

1. Introduction

1.1 Background

Queensland Water Infrastructure (QWI) proposes to construct Traveston Crossing Dam on the Mary River, 27 km upstream of Gympie, as part of a strategy to meet anticipated water demands in south-eastern Queensland.

The proposal is in two stages. At Stage 1, due for completion in 2011, the reservoir would have a full supply level (FSL) at EL 71.0 m Australian Height Datum (AHD), capacity 153.7 GL, mean depth 5.02 m and surface area 3039 ha, and it would flood 36.5 km of the river channel. The annual diversion from the reservoir would be 70 GL. The estimated cost is $1.7 billion (http://www.qldwi.com.au).

Stage 2 is not considered here. A proposal for an extension is not expected before 2035 and, if it is approved, the spillway, gates and intake tower would be modified. The reservoir then would have FSL at EL 79.5 m AHD, capacity 570 GL, mean depth 8.0 m and surface area 7135 ha, and it would flood 50.7 km of the channel. The annual diversion would increase to 110 GL.

In October 2006, the Traveston Crossing Dam proposal was declared a 'significant project' by the Queensland Coordinator-General, under the S*tate Development and Public Works Organisation Act*. This obliges QWI to prepare an *Environmental Impact Statement* (EIS).

In November 2006, the Federal Minister for Environment and Heritage declared that the project should be a 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), with potential impacts on *Matters of National Environmental Significance*. The controlling provisions under the EPBC Act are:

Sections 12 and 15A (*World Heritage*),
Sections 16 and 17B (*Ramsar Wetlands*),
Sections 18 and 18A (*Listed Threatened Species and Communities*) and
Sections 20 and 20A (*Listed Migratory Species*).

Under these provisions, QWI is required to recognize and assess the likely impacts and, where appropriate, to describe ways to avoid, minimise or mitigate them.

Terms of Reference for the EIS were determined by the Coordinator-General in August 2007. The EIS was released for public comment in October 2007, and a supplementary report (hereafter the 'Supplement') containing updates and responses to submissions was issued in August 2008.

This review is concerned with listed threatened and migratory 'species of concern' under the EPBC Act, and does not consider World Heritage or Ramsar Wetland values. The review was commissioned by the Department of Environment, Water, Heritage and the Arts (DEWHA), and prepared by a river ecologist with no prior association with the Traveston Crossing Dam project.

1.2 Preparations

The reviewer has read the EIS and Supplement, and comments and documentation supplied by DEWHA, agency reports, scientific publications and internet sites. It was necessary to consider most of the EIS to establish an appropriate context, but chapters of special significance were:

4: Description of the project
5: Land
6: Water resources and water quality
7: Terrestrial environments
8: Aquatic environments
9: Matters of National Environmental Significance
17: Cumulative impacts
18: Environmental Management Plan and
Appendices: Final Terms of Reference, F2.1: Geomorphology, F4.1: Flora report, F4.3: Fauna report, F5: Aquatic specialist studies and F6: MNES specialist studies.

The Supplement was also considered, with particular regard for the chapters providing updates to those listed above.

As part of the review process, meetings were held with DEWHA staff in July 2008, before the review was commenced, and in November 2008, after the review was completed. In August, a field inspection was made of sites along the Mary River, including the proposed dam site, in company with personnel from DEWHA and QWI. The fish-transfer device at Paradise Dam on the Burnett River was also inspected, with personnel from SunWater, as it resembles the one proposed for Traveston Crossing Dam.

1.3 Terms of reference

The reviewer's tasks were:

- To evaluate the rigour of information in the EIS relating to species of concern under the EPBC Act,
- To evaluate the accuracy of judgements about the likely nature and extent of impacts and operation of the dam on these species, relative to their status prior to dam construction,
- To suggest amendments to improve the rigour of the information or associated interpretations, or to offer alternative judgements/interpretations with justification, if information and/or judgements in the EIS are found to be deficient,

- To evaluate the likely success of measures proposed for protecting or mitigating impacts on the species,
- To describe possible alternative measures where appropriate, and
- To consider relevant issues raised in public submissions and the Supplement.

2. Documentation

2.1 Presentation

The EIS, Supplement and associated papers contain several thousand pages of information that is detailed, often repetitive and distributed piecemeal. The binders used for the printed documentation also make access difficult. The CD versions contain numbered PDF files that are not cross-linked, and it is difficult to locate specific data. It is a formidable task to assimilate complex data presented in this manner. Nevertheless, the proposal has received close scrutiny from the Mary Valley community.

2.2 Responses to submissions

The EIS attracted 11,261 public submissions. These are listed by type and location in the Supplement (Appendix A) and key points, as perceived by the proponent, are noted. In the main text, the lack of numbering or cross-referencing for submissions makes it difficult to ascertain whether all issues have been fairly represented. In general, points made in submissions are dealt with selectively. Factual errors, on the part of either the correspondent or the proponent, are corrected. Some issues are left unresolved because unsubstantiated opinions and statements are met merely by contrary opinions. Other issues, such as the nature of variability in patterns of river flow, or the potential role of Population Viability Analysis, appear not to have been fully understood.

3. Context

From an ecological viewpoint, the Mary River is the most significant, least regulated river in coastal south-eastern Queensland. It is by no means pristine, but nevertheless is a standard for assessing the health of other regional rivers and their responses to water resource management. It is also of immense scientific importance as the home of the Australian lungfish, the Mary River cod, the Mary River turtle and other species of national and global significance. Although QWI regards Traveston Crossing as the last 'high-yield' dam site available in south-eastern Queensland, it is also an extremely sensitive site in terms of its significance for conservation.

With this in mind, it is necessary to establish some background on wider issues before considering the EPBC 'species of concern'.

3.1 Ecologically Sustainable Development

The principles of *Ecologically Sustainable Development,* defined by the EPBC Act, include the following:

> "If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".

This is a statement of *The Precautionary Principle*, and essentially means that doubt over a threat should not be used to discount measures to avert the threat. There are numerous examples in the EIS where doubts are glossed over, assumptions made and conclusions proffered without full justification. Evidence that would inform decisions has often been overlooked. Most of the 'significant impact' assessments suggest that the dam would have no significant impact or, if there was an impact, it would be compensated by mitigation and offset 'strategies' that are sometimes ill-defined and individually would carry high risks of failure.

The EIS often evades these issues by responding that the project includes a number of sustainability 'strategies' in accord with guidelines developed by CSIRO (17). The primary one of these is the proposed Freshwater Species Conservation Centre (FSCC), which will address threats to the Mary River cod, the Mary River turtle and the Australian lungfish, and monitor their welfare once dam operations commence. The FSCC is considered in Section 3.3, p6.

Although the EIS refers to Endangered, Vulnerable and Rare (EVR) species, including those above, this notation applies to *state* legislation for threatened species. The EPBC Act classifies threatened species as *extinct*, *extinct in the wild*, *critically endangered*, *endangered*, *vulnerable* or *conservation-dependent*. The EVR label is used here to maintain parity with the EIS. It is synonymous with 'species of concern'.

A second issue, not explicitly recognized in the EPBC Act, is that the global dimensions of impacts should be recognized as part of Ecologically Sustainable Development (e.g. http://www.environment.gov.au/esd/). The EIS does not view issues in this context, although World Heritage and Ramsar sites and migratory species clearly are global issues by virtue of international conventions. Further, the Mary River harbours flora and fauna that are *nationally* endangered, vulnerable or rare, and the Australian lungfish and Mary River turtle particularly are *internationally* significant and of inestimable scientific importance. It is not clear that the proponent is aware of the significance of EVR species, apart from the necessity to consider them in assessments.

EVR designations may have shortcomings as a focus for management. As a policy, QWI proposes to manage the downstream flow environment expressly to maximise the benefits to the Australian lungfish, Mary River cod and Mary River turtle. There are dangers in this approach because these EVR species are not selected as indicators of community needs. If they are not representative, the managed regime could be hostile to non-EVR species and cause the supporting communities, and populations of EVR species, to collapse. EVR species should be seen in the context of the ecosystems of which they are part.

There is an immense global literature on the ecology of reservoirs and the environmental effects of dams on rivers, and a substantial part is of Australian origin (e.g. Bunn and Arthington 2002, Arthington et al. 2006). In Europe and North America, where the (long-term) environmental costs of river regulation sometimes have outweighed the (short-term) economic benefits, proposals for new dams receive intense scrutiny (see, for example, http://www.friendsoftheriver.org).

In general, the EIS makes extensive use of agency reports and little use of the scientific literature. EIS chapter 8 (Aquatic Environments) overlooks research papers on the Mary River by ecologists at Griffith University. This group is a national leader in river ecology, and has contributed research on environmental flow management and the ecology of riverine flora and fauna. For example, the habitat and flow requirements of fish and flow-habitat-plant-fish response models are described by Pusey et al. (1993, 2000, 2004), Pusey and Arthington (2003), Kennard et al. (2000, 2005, 2006a,b,c, 2007), Mackay et al. (2003) and Stewart-Koster et al. (2007). These omissions suggest that QWI has failed to recognize the wider context for issues evoked by the dam proposal.

3.2 Environmental monitoring

A salient weakness of the Traveston Crossing Dam proposal is that it does not incorporate a detailed, comprehensive program of monitoring to accompany dam operations, other than to refer this responsibility, in part, to the FSCC. In the absence of a monitoring program, it would not be possible to detect, evaluate and respond to problems except on an *ad hoc* basis. Similarly, there is no indication of a commitment to evaluate the actions taken by management to address problems. The documentation conveys an impression that environmental issues will be dealt with on a casual basis.

There are numerous references to problems that may occur, and to actions that might then be taken, but little indication of how these problems will be detected. If problems are left unchecked until the consequences become apparent, solutions may be difficult.

QWI offers no assurance of funding expressly for monitoring. The primary role of the FSCC would be to undertake research on the Australian lungfish, Mary River turtle and Mary River cod. It may also have some responsibility for research on the southern barred frog (Section 4.4, p41), but this is not clear. The FSCC would have monitoring responsibilities in respect to these iconic species, but it is not clear who would be responsible for wider monitoring issues (e.g. non-EVR species, water quality, weed problems). Monitoring and research are complementary but separate undertakings with different purposes, methods and outcomes. The FSCC is unlikely to be able to do both comprehensively.

Funding for the FSCC nominally is for up to 10 years, when it is suggested that the Centre would become self-supporting through research grants. Again, however, these grants would not cover the costs of comprehensive monitoring. Some responsibilities (e.g. the performance of the fish-transfer device and turtle by-pass channel) could be met by other agencies (e.g. Department of Primary Industries and Fisheries: DPIF, Environmental Protection Agency: EPA), provided that there is adequate communication with those responsible for dam operations. Much of this work should be undertaken by trained personnel on site, as monitoring ideally is part of, rather than incidental to, routine operations.

The operating authority should be responsible for a monitoring program that would address all of the environmental issues related to dam operations, and continue indefinitely. These issues would include basic information about the reservoir (e.g. water quality, stratification, weed problems, fauna and flora) and downstream effects (e.g. erosion, fauna and flora, water quality). The program should have a wider focus than EVR species, and ideally should consider ecological communities. Significantly, the *Mary River Catchment Coordinating Committee* (http://www.mrccc.org.au/) has nominated the riffle-pool-sandbank community as a *Threatened Ecological Community* under the EPBC Act.

3.3 Freshwater Species Conservation Centre

A Freshwater Species Conservation Centre (FSCC) is a key element of the Traveston Crossing Dam proposal. It is part of the EIS' claim to have met ESD criteria (Section 3.1, p4), because it would contribute to mitigation of impacts.

The role of the FSCC is to solve problems related to impacts on EVR species, specifically the Mary River cod, Mary River turtle and Australian lungfish. It apparently would not be required to monitor the costs and benefits of modified flow regimes and other impacts of dam operations on the environment generally, although it is not clear who would fulfil this role. Several unresolved questions about likely impacts, and some issues arising from public submissions (e.g. the potential impact of recreational boating on lungfish in the reservoir: 20-106) are referred to the Centre.

The Centre is to be constructed on the shore of the reservoir, near the dam. Its facilities would include laboratory and office space, short-term accommodation for staff or visitors, outdoor tanks and sheds, boats and vehicles. It will also include a public education display. It is to be administered under a Memorandum of Understanding between QWI and the University of Queensland, and led by a Director who is yet to be appointed. A Board and Advisory Committee have been nominated. Those who have agreed to be involved, in principle, include scientists with expertise on lungfish (Prof Jean Joss), lungfish and frogs (E/Prof Gordon Grigg), turtles (Dr Col Limpus) and fish (Dr Peter Jackson).

The financial commitment by QWI is $35M over a period of “10 years or less”. Beyond this time, it is anticipated that the Centre would become self-supporting through grants from research agencies and other sources.

QWI has committed to an annual audit of the Centre's operations, to be undertaken by CSIRO. The nature of this audit is unclear, but CSIRO's involvement suggests that it would have an environmental rather than financial context.

Several issues arise:

- The need for the Centre is a reflection of how little is known of the biology and ecology of EVR species in the Mary River catchment. This information should be available *before* a project on this scale is contemplated, and especially so in regard to species of major significance for conservation.
- The financial commitment may not be enough to sustain a credible research effort, given that the Centre would have an ambitious agenda. Staffing levels and deployments (research, technical, maintenance, administration) are not specified. If a nominal $5M were put aside for construction and equipment costs, there would be about $3M available annually to fund salaries, operating costs, public education activities, monitoring and research. Conceivably, the research budget would be of the order of $1-2M. In comparison, the 5-year *Mary River Cod Recovery Program* (proposed in 1996 but not fully implemented) was predicted to cost $1.994 million (Simpson and Jackson 2000).
- A limit of 10 years is not appropriate, in the reviewer's opinion, because QWI should retain responsibility for environmental management for the lifespan of the dam. An indefinite commitment is required, with the FSCC remaining as an integral part of dam operations.
- The research agenda for the Centre has not been clearly formulated and prioritised, but appears very ambitious. In the EIS, unresolved issues or recommendations regarding EVR species are referred to the Centre for action, and it is frequently cited in place of a response to issues concerning the status of populations and habitats. For example, the EIS concedes that the Mary River cod population would be impacted, but claims that it would recover through the activities of the Centre. Whilst a refined agenda properly is a task for the Board and Advisory Committee, these are critical issues and plans should have been more advanced at this stage in development.
- The tasks recommended for research on Mary River cod alone could occupy a team of researchers and would require a lead time of several years, possibly a decade or more. Within this time, the FSCC is expected to identify problems and implement strategic solutions, either by itself or through relevant agencies. During this time, impacts associated with the dam may go unrecognised and unaddressed. This is not in the interests of EVR species in critical habitats.
- The University of Queensland is not a premier research institution in the specific area of river ecology, whereas nearby Griffith University is a national leader in this field. It is not clear why scientists from Griffith have not become consulted in planning for the Centre. They include experts in the ecology of fish, environmental flow management and ecosystem health assessment.

The central point here is that the activities of the FSCC, and indicative budgets for its operations and research programs, should have been presented in more detail. The proposal lacks a clear agenda, staffing profiles, operating guidelines and costings. Without this information, it is not possible to be confident that the security of EVR species would be protected.

3.4 Hydrology

3.4.1 Role of the dam

Traveston Crossing Dam is to be a water-supply dam, providing a pondage from which 70 GL of water can be withdrawn annually, regardless of changes in seasonal or inter-annual conditions or long-term trends in climate. Evaporative losses from the reservoir would be roughly 9 GL annually (assuming 300 mm annual net evaporation: Bewsher 2008), and there would be comparable losses to seepage. An incidental benefit of the dam, according to the EIS, would be to ameliorate downstream flooding, particularly near Gympie.

The description in the Supplement (15-1):

> "The role of a water supply dam is to store water in times of surplus (floods) for use in times of scarcity (droughts) thus increasing the certainty and availability of water independent of climatic conditions at a point in time…"

would be better applied to an irrigation storage dam, like many in the Murray-Darling Basin. In the EIS, the rate of water extraction from the Traveston reservoir has been modelled as a constant, apparently insensitive to seasonal changes in demand. If there is a seasonal component, this needs to be incorporated into assessments of environmental impact. At face value, it appears that seasonal changes in the reservoir level could occur in association with floods or droughts, but not as a result of extraction.

It is important that the design, purpose and mode of operation of the dam are clearly understood because these factors, imposed on the pre-existing pattern of flow in the river, govern the nature and extent of its environmental impacts. They also limit the comparisons that can be drawn between Traveston Crossing Dam and dams elsewhere in Australia.

3.4.2 Flow regime

In terms of gross hydrological statistics, the predicted effects of Traveston Crossing Dam on the Mary River appear small, equivalent to a 4% reduction in the mean annual discharge (6% of the median) at the river mouth. From an ecological viewpoint, however, the localised effects of dam operations on seasonal and inter-annual variations in the *patterns* of flow and water levels are much more likely to be significant. In other words, animals and plants may not respond to a small reduction in the average annual flow, but many would be sensitive to changes in the seasonal flow pattern, especially at critical times for breeding or migration. The EIS places more emphasis on mean daily or monthly flows. In addition, inter-annual variation in flows would be ecologically significant, particularly for species that do not recruit annually.

From the EIS, the pre-development median annual inflow at the dam site is 415.405 GL, and the corresponding mean is 668.261 GL. The mean therefore is about 1.6 times the median, indicating a skewed flow distribution. To illustrate the sensitivities of these statistics, the numbers 1, 3 and 5 have an identical mean and median of 3, but if 135 is added to the series, the mean and median become 36 and 4, respectively. In general, a mean is more sensitive to extreme values (floods and droughts) than a median. In these circumstances, it is reasonable to ask whether mean statistics alone are an adequate basis for annual projections of dam performance and the ecological consequences. In a variable series of annual flows, the median, rather than the mean, is the more typical value. In effect, the mean in this case overstates the magnitude of typical flows and understates the volume of water extracted for use.

Some submissions to the EIS raised this issue indirectly, questioning the use of the mean rather than median and claiming that the EIS did not adequately represent the inherent variability of the flow regime. It is true, as the Supplement says (15-12), that no single statistic is adequate to represent complex data, or to describe variability, but the respondents appear not to have understood the implicit issue, which is to provide a clear, ecologically-relevant characterisation of the flow regime. The issue is not that data are missing but that, from an ecological rather than hydrological perspective, it is difficult to arrive at a clear understanding of the seasonal and annual flow regimes and the ways in which these would be modified by the dam.

The effect of the dam may be obscured by the fact that the flow time series used in the IQQM model used to simulate flows in the Mary River ends in June 1999, and includes the flood in 1999, but does not include the last eight years of drought. This was partly addressed in later modelling. If climate-change projections are accurate, the flow regimes of the 20th century probably are not good indicators of future conditions.

The 70-GL annual ‘take’ from the dam will apply whether discharge in the river is at, above or below the annual mean. In dry years, the environment will bear the cost of a proportionately greater extraction, whereas in wet years part of the flow ‘surplus’ will be retained for flood mitigation, protecting roads, farms and towns. Flood mitigation at particular times of year, especially in spring and summer, could conflict with the role of floods as cues for breeding and dispersal in flora and fauna. The ‘floods’ referred to the EIS and Supplement have durations of hours and days rather than the more protracted flooding associated with the gently sloping, lowland reaches of inland rivers. There are no major freshwater wetlands on the Mary floodplain and, aside from riparian and floodplain vegetation, it appears that flooding is significant mainly for instream communities.

Changes in the flow regime are potentially of most concern in the ‘tailwater’, or the section of the river below the dam. This is considered in Section 3.6, p**Error! Bookmark not defined.**.

3.5 Ecology of the reservoir

3.5.1 Eutrophication

There is a high likelihood of algal blooms in the reservoir, encouraged by warm temperatures and high nutrient inputs (*eutrophication*). This will affect water quality, with implications for flora and fauna in the reservoir and the tailwater, and for human consumption. Under calm, still conditions, algal blooms deplete levels of dissolved oxygen in the surface waters, threatening fish and other animals. Some algal species produce toxins, under bloom conditions, that threaten aquatic animals and may affect livestock and humans. Eutrophication will also modify the consequences of thermal stratification (Section 3.5.3, p11). The EIS says little of these potential problems.

3.5.2 Aquatic plants

A survey of aquatic and semi-aquatic plants (macrophytes) in the vicinity of the Traveston Crossing Dam site, undertaken for the EIS, showed that the common native species include *Vallisneria nana, Hydrilla verticillata*, *Spirodela* spp*., Myriophyllum verrucosum, Potamogeton perfoliatus*, *Azolla pinnata, Ceratophyllum demersum, Nymphoides indica* and *Persicaria decipiens*. None is problematic in local water supplies, and none is listed under the EPBC Act.

A complementary study of the abundance and distribution of submerged macrophytes in the Mary River has identified four groups of species, characterized by differing abundances of *M*. *verrucosum*, *V*. *nana* and *Potamogeton crispus* (Mackay et al. 2003). These groups were associated with the intensity and variability of discharge, riparian canopy cover, substrate composition and nutrient levels.

In the EIS survey, alien plants (species originating outside Australia) were present at nearly all river sites. These include dense waterweed (*Egeria densa*), water hyacinth (*Eichhornia crassipes*) and salvinia (*Salvinia molesta*). In addition, cabomba (*Cabomba caroliniana*) occurs in Lake MacDonald on Six Mile Creek, a tributary to the Mary River below the dam site. Each potentially is a nuisance species in the Traveston reservoir, although dense waterweed is less so and is not a declared plant under the Queensland *Land Protection (Pest & Stock Route Management) Act 2002*.

The EIS acknowledges that weed species are likely to become established in the reservoir, but maintains that monitoring and early intervention will prevent the establishment of nuisance populations, especially in protected embayments where they are likely to develop. Management interventions will need to be continued indefinitely.

Shallow embayments (< 2 m), suitable for aquatic and semi-aquatic plants, will occupy 24% of the reservoir surface area at FSL, or 36% when the dam is half full. The reservoir is expected to be more than half full for 92% of the time. There would be substantial areas available for plants, subject to changes associated with floods and droughts.

If weed infestations do develop, there would be consequences for other aquatic flora and fauna, and for the utility of the reservoir as a water supply. To maintain a potable supply for humans, the emphasis would need to be on biological and physical methods of control rather than herbicides and other chemical treatments. According to the EIS, bio-control agents have been only partly effective in limiting water hyacinth populations in the Mary River, and mechanical harvesting has been used with some success to control cabomba in Lake Macdonald.

Black plastic sheeting is proposed as one means of control, intended for small rather than large infestations, presumably using floating rafts. This method is labour intensive, but potentially effective in small areas (< 1 ha: Kriwoken and Hedge 2000). There may be difficulties in anchoring the plastic in exposed areas and maintaining it for sufficiently long (perhaps several months). This is a non-selective method that would kill all associated plants and affect fish and other animals that feed, breed or take refuge among plants.

Rapid drawdown could also be used to control excessive growth, although this would affect other littoral and riparian fauna and flora, and the downstream environment, and may not be compatible with routine dam operations.

In general, the proposed methods have not been described in sufficient detail to evaluate the likelihood of success. The claims that there would be no problems must be regarded as optimistic because it appears that no other reservoir in the region has a record of more than partial success.

Dam construction will mobilise sediment, with potential to scour or smother submerged plant species in the downstream reach. Under normal operating conditions, but not in times of flood, the scouring effect may be partly offset by reduced flows, encouraging plant growth. If scouring does occur to the extent that macrophyte beds are removed, the time to recovery may be considerable. Affected plants could include ribbon weed (*Vallisneria nana*), a shallow-water plant which, although listed under Queensland's *Nature Conservation Act 1992*, occurs throughout the study area. It is a favoured spawning site and nursery area for Australian lungfish in the Mary and Burnett rivers. Duivenvoorden (2008) showed that high flows have scoured shallow-water *Vallisneria* populations in the Burnett River, that recovery takes at least a year and may be prejudiced by even small changes in water level. He recommended that stable water levels are needed for at least five months prior to the lungfish spawning season if submerged plants are to reach the density (90% cover) preferred for spawning.

The EIS maintains that scouring will have minimal effects, except below the dam, and no mitigation measures are recommended. This may need reconsideration with regard for *Vallisneria* and its significance for lungfish, and for the pool-riffle communities that sustain lungfish, Mary River cod, Mary River turtle and other fauna and flora.

3.5.3 Stratification

Although the reservoir undoubtedly will stratify thermally, QWI has declined to 'model' stratification on the grounds that it would be too complex a problem. This is difficult to understand, as the circulation behaviour of the reservoir has implications for dam operations, including the multi-offtake tower, and for potential management problems in the reservoir and tailwater. The depth of the thermocline, the temperature differential between surface and bottom water and other broad features of the stratification cycle could be inferred from observations of other reservoirs in the region.

In a stratified, eutrophic reservoir, prone to develop dense populations of algae and water plants, the water below the thermocline (hypolimnion) is likely to become hypoxic (low oxygen), or anoxic (no oxygen), as a result of decomposition of organic matter. Anoxia draws heavy metals into solution, releases hydrogen sulphide and makes the bottom water uninhabitable by fish and most other animals. Ideally, under these conditions water extracted for human use, and water discharged to the river, would be drawn from above the thermocline, although this could be compromised by algal blooms. Chemical changes in the hypolimnion may also have adverse consequences for the fauna and flora in the reservoir (and tailwater) at times of complete mixing ('overturn'), when anoxic water is returned to the general circulation, especially if surface water quality is affected by algal growth, weed growth or low inflows.

The limitations imposed during stratification, on water use and downstream release, can be minimised by appropriate use of a multi-offtake tower, allowing water to be drawn from selected depths and avoiding potential problems with releases of cold, de-oxygenated water (e.g. Todd et al. 2005). No information is provided on how the tower at Traveston Crossing Dam would be operated. A similar tower is installed at Paradise Dam, but it was not clear, from the field inspection in August, whether it has been used.

3.5.4 Alien fish

Reservoir environments encourage a shift from riverine fish toward lacustrine species, and creates a high potential for invasions by alien species. Native species likely to form self-sustaining populations in the Traveston reservoir, as in other regional impoundments, include bony herring (*Nematalosa erebi*), spangled perch (*Leiopotherapon unicolor*), crimson-spotted rainbowfish (*Melanotaenia duboulayi*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), purple-spotted gudgeon (*Mogurnda adspersa*), firetailed gudgeon (*Hypseleotris galii*), western carp gudgeon (*Hypseleotris* spp.), eel-tailed catfish (*Tandanus tandanus*) and mouth almighty (*Glossamia aprion*). Eels (*Anguilla* spp.) would live in the reservoir, given access to the sea for breeding.

It is not known whether Mary River cod (*Maccullochella peelii mariensis*) can develop self-sustaining populations in impoundments, but hatchery stocks have been introduced to reservoirs in the Mary catchment, and several other reservoirs in south-eastern Queensland, and there is little doubt that the adults survive in these environments (e.g. Simpson and Jackson 1996, 2000). Cod presumably would be stocked in the Traveston reservoir, although their success could depend, in part, on provision of littoral snag habitats and interactions with other fish species. Exotic species (native to other parts of Australia) including golden perch (*Macquaria ambigua*), silver perch (*Bidyanus bidyanus*) and saratoga (*Scleropages leichardtii*) have been translocated to the Mary River (Simpson and Jackson 1996, 2000). Other species likely to be translocated, but unlikely to form self-sustaining populations, are barramundi (*Lates calcarifer*) and Australian bass

(*Macquaria novemaculeata*). Some of these species are large ambush predators, like cod, and there is likely to be overlap in their preferences for food and space.

Several alien species of fish are established in the Mary River. The Traveston reservoir and its margins would favour the common carp (*Cyprinus carpio*) and gambusia (*Gambusia holbrooki*). It is also likely that the Mozambique tilapia (*Oreochromis mossambicus*), a declared noxious fish in Queensland, would become established. There are already tilapia infestations in Boondooma (Boyne River), North Pine (North Pine River) and Wivenhoe (Brisbane River) reservoirs. These alien species generally have adverse effects on native fish and other fauna (e.g. Arthington et al. 1984, Koehn et al. 2000, Canonico et al. 2005).

It is likely that applications would be made to stock native fish into Traveston reservoir to establish recreational fisheries and boost regional tourism. A decision to allow the introduction of alien or exotic fish into a river that supports nationally-threatened aquatic species would be indefensible.

3.5.5 Riparian buffer

QWI proposes to clear all vegetation within the inundation area to FSL, except in the riparian zones of tributaries and the Mary River upstream. The exceptions will be cleared to within approximately 1.5 m of FSL because, according to the EIS (7-64), "there is a chance that riparian vegetation within these zones may survive, depending on inundation frequency and duration".

The EIS often refers to the proposed riparian buffer, but it should be stressed that the buffer will remain only in upstream and tributary areas, and only if the existing vegetation survives in those areas.

The riparian buffer is intended to preserve complex habitat for littoral and riparian fauna and flora. In comparison, the main reservoir shoreline would be comparatively bare and sterile as a habitat. Trees within the buffer zone will die and fall, after several decades, to provide snag habitat that is critical for many animals, including the Mary River cod and Mary River turtle.

The 1.5-m limit apparently was a compromise between the need to maintain water quality, bank integrity and safety for recreational users and the need to maintain habitat for aquatic and terrestrial flora and fauna. Its habitat value would depend on several factors including its width, slope and integrity (as opposed to fragmentation). Although the EIS records areas of vegetation that would be lost (Chapter 7), it is difficult to judge how well-vegetated and continuous the buffer zone would be, and what its value may be in terms of connectivity (Section 3.8.3, p213.8.3). Water-level fluctuations will ensure that the fringe is often exposed, and in areas closed to recreational users an extended band, consistent with safety issues, may offer more value as littoral habitat. The buffer will have some value for terrestrial fauna when exposed, although the reservoir is expected to be within 2 m of FSL about 82% of the time.

3.6 Ecology of the tailwater

3.6.1 Nature of the environment

In this review, the term 'tailwater' represents the reach below the dam where there would be measurable, significant effects on the river environment, including changes in flows and water levels, although these would decrease progressively with distance downstream. A conservative approximation is to regard the tailwater as the reach from the dam past Dagun Pocket (2 km downstream) and Gympie (27 km) to Fisherman's Pocket (35 km). This estimate is based partly on hydrological data from the EIS. The zone could be shorter for some variables, and longer for others, and the most practical measure of its extent would become clear from the effects of the dam on downstream flora and fauna communities, once it is in operation.

The tailwater could be defined more precisely as the distance over which the values of significant environmental variables are different from those that would have prevailed in the absence of the dam, but there are too few data for variables other than hydrological variables (cf. Ward and Stanford 1983). It is reasonable to assume, as the EIS does, that the major effects of dam construction and operations will be apparent in the reach between the dam and Fisherman's Pocket.

The tailwater will experience changes in flows, water quality and sediment transport, among other changes, and if these are sufficient to discourage resident and migratory species they would compound the effect of the dam as a barrier to upstream movements. The reservoir and tailwater combined would change the riverine environment over some 70 km (about 28% of the length of the Mary channel above the tidal barrage). The proposed turtle by-pass channel and fish-transfer device would not be effective unless turtles and fish are able to move freely through the tailwater and through the reservoir.

3.6.2 Environmental Flow Objectives

The Mary River Water Resources Plan has set *Environmental Flow Objectives* (EFOs) for nodes throughout the catchment (Bunn and Arthington 2002; Brizga et al. 2004; Kennard 2004). These are targets based on studies of fish assemblages and aquatic vegetation (Pusey et al. 1993; Mackay et al. 2003) and other sources. They include specifications for low flows (and constraints on low flow spells), instream flows and floods to maintain habitat, food resources and the passage and breeding requirements of aquatic flora and fauna.

EFOs are planning tools rather than enforceable management requirements. The EIS conveys the impression that they are mandatory or non-mandatory criteria for environmental management, but they would not be monitored routinely after dam operations commence. In fact, some EFOs refer to long-term statistical parameters (e.g. frequency of low flows) that could not be used to measure the immediate impact of the Traveston Crossing Dam.

The first node for measuring compliance downstream of the dam is at Fisherman's Pocket. EFOs therefore are not assessed within the tailwater, as defined above, and there is little basis to assess the impacts of dam operations on the environment, flora and fauna in this reach.

3.6.3 Hydrology

Hydrological changes in the tailwater would include the following:

- There would be a 45% reduction in the median annual flow (24% reduction in mean annual flow) at Dagun Pocket, compared to the pre-development regime. For example, EIS Figures 6.21 and 6.29 show changes to monthly variations in median daily flows. At Dagun Pocket, with the dam in place, the median daily flow is virtually fixed at up to 100 ML/day throughout the year. There appears to be no seasonal variation, although this could be an artefact because the data are median rather than mean flows, and infrequent high flows over-topping the dam would be obscured. Peak seasonal flows in February-April are 456-625 ML/day under the existing regime and 681-874 ML/day under the pre-development regime. At Fisherman's Pocket median daily flows would be substantially reduced over the year, although the seasonality of changes would be preserved. Modelled peak flows in March are 1328 ML/day under the pre-development regime, 1040 ML/day under the existing regime and 637 ML/day with the dam in place.
- Flushing flows, or small, brief flows to purge poor quality water, would be little affected. In the 109-year simulation period, flows of water deeper than 2 m occur 5.4% of the time under existing conditions and 4.7% of the time with the dam in place.
- At Dagun Pocket, with the dam in place, the 109-year flow simulation includes 35-40 periods of no flow, and the longest no-flow period is increased, relative to present conditions, from 6 to 42 days. The Supplement argues that this is desirable because it approaches pre-development conditions, where the longest no-flow period is 37 days. At Fisherman's Pocket, there are 56 no-flow periods under existing conditions and 58 such periods with the dam in place. The longest period of no flow is 34 days under both scenarios.
- Low flows 20-30 cm above the cease-to-flow level are the part of the flow regime most impacted in the tailwater, although the effects are diminished downstream as tributaries join the mainstream.
- Changes in the hydrological regime are of most concern during the JASON months (July-November), when flows are naturally low. The EIS maintains that these flows are already highly-impacted by water resources development in the Mary catchment, and that dam operations will have only a small additional impact. For example, the median flow in July at Home Park (116 km below the dam) will decline by 13%, from 155 to 135 ML/day. Again, this impact needs to be assessed in the tailwater zone, and in ecologically-relevant terms.
- During floods, there would be impacts on river levels at Dagun Pocket because the flood gates would reduce the peak of the flood and extend its duration.

There will be no change to levels on 40% of days, increased levels on 2% of days and decreased levels on 58% of days. The flow regime will show more consistent low flows in spring and early summer, particularly in periods of low river flows, but peak summer flows would be little affected. These changes could lead to a deterioration in water quality, owing to the lack of flushing, and could encourage growths of algae and macrophytes. The EIS claims that they would also provide better conditions for reproduction in turtles and lungfish, but this is not well-justified. QWI intends to undertake further optimisation studies to discover ways to reduce the chances of water-quality problems in the tailwater.

- The Supplement suggests that the dam operating rules can be modified to meet all EFOs and improve system performance relative to current conditions. This would change the situation at Dagun Pocket towards pre-development conditions rather than existing conditions. Thus, the frequency of flows <100 ML/day would be brought nearer the natural (pre-development) level, and flows >100 ML/day would occur 20-40 percent of the time. Further, the revised scenario would cause post-winter (July-October) flows to be more nearly 'natural'. It is not clear whether this 'preliminary optimisation scenario' would have positive or negative impacts on the tailwater environment. It does not necessarily follow that, in a highly-modified river environment, a return to pre-development conditions is beneficial.
- Environmental flows are not included in the IQQM modelling, save that the first 100 ML/day of inflow would pass through the dam without regulation. As mentioned, there are assurances that releases from the dam would be sufficient to meet all mandatory and non-mandatory EFOs prescribed in the Water Resource (Mary Basin) Plan 2006, Schedule 6.
- The modelling suggests that climate change will have no significant effect, but the text (15-36) indicates that there are likely to be extended periods of lower rainfall and an increased intensity and frequency of extreme rainfall. In a catchment subject to intense cyclonic rainfall, it is difficult to accept that these changes would not have significant effects, although the effects of short-lived extreme events could be obscured by longer-term averages. The potential effects of climate change on rivers are described by Gibson et al. (2005).

3.6.4 Sediment transport

River water surrenders part of its suspended sediment load as particles settle in deep, comparatively still water. Water released downstream then has a renewed capacity to entrain particles, manifest as local erosion of the banks and bed and deposition downstream, particularly as sills across the mouths of tributaries. Depending on the degree of main-channel deepening, tributary channels also may deepen. The extent of changes depends mainly on the flow regime and the nature of the river bank material.

The Mary channel below the dam site is incised, with a variable gradient, and floodplain development is limited by terracing (Brizga 2003, Brizga et al. 2006). The planform varies from confined reaches to alluvial flats in active reaches, with frequent alternate bars and point bars, occasional snags and other in-channel habitat features. The bed material is mainly sand and gravel. Bank erosion is widespread, reflecting natural processes, sand and gravel extraction, clearance of riparian vegetation and uncontrolled stock access. There are few connected wetlands, permanent pools or other off-stream water bodies, but there are abandoned channels and flood runners on the alluvial flats and lower terrace levels. The lower section of this reach includes the town of Gympie, and receives its effluent discharge.

It is certain that there will be redistributions of sediment in the dam tailwater. The banks and in-channel benches in areas like Dagun Pocket would tend to become more unstable, and there is a significant risk to the pool-riffle morphology of the channel in the tailwater. According to the EIS, the angle of alignment of the spillway discharge will be reviewed to reduce the 'scour effect' below the dam (5-106).

The EIS estimates that the dam will trap 81% of incoming suspended sediment (5-105), and acknowledges that site HB3, downstream of the dam, is highly susceptible to erosion (5-74). SedNet modelling for fine and coarse sediment balances shows big differences under pre-development and existing conditions, confirming that the channel in some areas is highly unstable (e.g. Brizga et al. 2006). The model also indicates losses of coarse sediment between Dagun Pocket and Fisherman's Pocket (Fig. 5-39, p5-102).

The Mary River Rehabilitation Plan assigned a low 'condition' score to this section of river, indicating little chance of natural recovery. The reach nevertheless does represent part of the main channel of the river and, as the Supplement acknowledges, the channel plays important roles in linking habitats and in the transport of sediment and nutrients. QWI regards the main potential impact in this reach as reduced flows that could exacerbate existing problems of water quality and macrophyte growth, and for this reason dam operations would emphasize flushing flows to maintain water movement. The proposed mitigation strategies concentrate mainly on the area from the dam to 5 km downstream of the junction with Amamoor Creek, which supports Mary River cod. The emphasis in management is on providing a suitable flow regime for EVR species, in the belief that this will satisfy the needs of the wider community (cf. Section 3.1, p4).

3.7 Fish and turtle passage

3.7.1 Spillway and multi-offtake tower

Traveston Crossing Dam is to have a fixed crest spillway with six flood gates. The crest will be at 67 m AHD, 4 m below FSL, so that water can be released over the spillway whenever the storage is above 40% of full capacity (i.e. 96% of the time). Other options for releasing water to the tailwater are *via* the multi-level offtake (operational above 10% capacity) or the fish-transfer device (operational above 30% capacity).

The spillway would be a Roller Compacted Concrete (RCC) construction, like that at Paradise Dam, and would consist of a series of many short steps that could be a lethal passage for fish, turtles and other large animals swept over the wall during over-topping flows. The EIS suggests that a monitoring program will be implemented, presumably by the Department of Primary Industries and Fisheries (DPIF), who have a similar program underway at Paradise Dam. The program will include radiotelemetry observations of tagged fish as they approach and pass over the spillway. In the meantime, there appear to be no plans to install racks, nets or other devices to prevent injuries or losses.

The EIS makes only passing reference to damage to the shells of turtles drawn into multi-level offtakes (cf. Latta 2007).

3.7.2 Fish-transfer device

Evaluations of fishway performance are complex, as the criteria vary with species and environmental conditions. Certainly, they require more than counts of passing fish.

Virtually all riverine fish need to move within their habitat. They may do so to access food resources, to explore and colonise new habitats or to move to and from refuges during floods or droughts. Larger-scale, purposeful movements or *migrations* generally lead to or from spawning habitats. There are mainly spawning migrations by *potamodromous* species that remain in fresh water and *diadromous* species that move from the sea to fresh water, or *vice versa*. Migrations are triggered by seasonal or diurnal cues, particularly changes in flow and temperature.

An incidental benefit of the movements and migrations undertaken by fish is to maintain the genetic diversity and integrity of populations through breeding and gene flow. This is a critical issue in evaluation of fishway performance because large dams, like Traveston Crossing Dam, are potentially a barrier to all forms of fish movements.

The EIS recognizes the need for a fishway, and it is an integral part of the design for the dam. Design details are not provided, but the facility apparently will be modelled on one installed at Paradise Dam on the Burnett River (inspected by the reviewer in August 2008). One difference is that the latter does not have a lock, so that fish swim directly into the reservoir from the lift hopper. Little information is provided about the nature of the fish fauna, other than for EVR species, with respect to migrations and movements.

The fish-transfer device is expected to operate 96% of the time, whenever the storage level is above the spillway crest (67 m AHD). In the event that up- or down-stream passage is not possible, because of environmental conditions or because one or more migratory species are unable to use the fishway, QWI proposes to implement a catch-and-carry strategy (Section 3.7.4, p19). This would counter one of the drawbacks of the fish-transfer device and turtle by-pass channel, in that individuals could be released into favourable riverine habitats rather than into reservoir or tailwater environments.

Construction of the upstream lift at Paradise Dam was completed in late 2005, but monitoring did not commence until February 2007 and no data are publicly available. An audit by DEWR (2007) has rated the device as ‘partially compliant’ with requirements, mainly because the downstream passage (the first in Australia) has not yet operated due to persistent low-water levels.

Critical questions remain unanswered over the ability of lungfish and Mary River cod to use fishways. It might be presumed that the cod will behave as Murray cod, which are able to use certain kinds of fishways (e.g. Barrett and Mallen-Cooper 2006, Barrett 2008; cf. Baumgartner et al. 2006), but there appears to be no formal evidence that lungfish can use fishways effectively (cf. Edward 2006).

3.7.3 Turtle by-pass channel

The turtle by-pass channel is a speculative design, as there appears to be no other comparable facility. It is not known whether turtles in the Mary River (in particular, the Mary River turtle, *Elusor macrurus*) would be able to use such a facility. The design has not been finalised, and will be developed in consultation with the Environment Protection Authority. It will include a long, gently-sloping channel by-passing the dam wall, with pools and riffles and planted vegetation to simulate a natural environment.

There are no details to indicate how the performance of the turtle by-pass channel would be assessed, but a proper evaluation would draw upon criteria comparable to those applied to a fishway (Section 3.7.2, p18). Again, there are assurances that a 'catch-and-carry' strategy would be employed in the event of problems.

3.7.4 Catch and carry strategy

The EIS recognizes that, because the dam is a barrier to genetic mixing between populations of fauna (and flora), there is a risk that population fragments would become isolated and more vulnerable to extirpation. This applies to sedentary as well as mobile species.

If the fish-transfer device or turtle by-pass channel were inoperative for extended periods, or if one or more species were unable to use them, QWI proposes a catch-and-carry strategy whereby selected individuals (e.g. adult lungfish or male turtles) would be captured, transported up- or down-stream and released.

There appears to be no precedent for this as a strategy to offset population fragmentation, although the EIS points out that the Australian lungfish, the Mary River cod and Mary River turtle (or their eggs) have been amenable to capture and transport in the past. The possibility of transporting small numbers of individuals is not disputed, but the goal here is not translocation but connectivity between population fragments.

Difficulties with this strategy are:

- It appears to be targeted at EVR species, although the dam is a barrier for other species, including turtles other than the Mary River turtle and fish other than the Mary River cod and Australian lungfish, and other vertebrates (including the frogs) and invertebrates.
- It is not clear what will trigger decisions to catch-and-carry individuals, or how those individuals will be selected, handled and monitored.
- Although the Supplement claims (19-22) that "there is no doubt" that catch-and-carry can successfully address the specific issue of genetic isolation, there is no persuasive evidence in support.

The Supplement further states (19-23) that:

> "Catch and carry is a physically simple technique for which success is easily measurable in terms of how many individuals moved from one location to another. It is well suited to turtles (or their eggs), lungfish and to a lesser extent cod because they are easy to capture and transport and because only low numbers of them probably need to move…"

The assertion that success is measurable in terms of numbers transported is not consistent with the purpose of the intervention, which is to offset genetic isolation. In addition, the assumption that only low numbers may be required is not substantiated. The effects would need to be monitored at the population level, presumably by monitoring genetic diversity.

3.8 Population ecology

3.8.1 Hatcheries

It is well understood, particularly by fish biologists, that hatcheries are not a solution for declines in natural populations. Rather, they are 'a last resort', and there is a lot of technical literature to demonstrate that stocking may be ineffective and may even have adverse effects on wild stocks. One of the obvious dangers is 'genetic swamping', referring to the genetic effects of releasing large numbers of progeny from few parents (e.g. Allendorf and Ryman 1987). In general, protection and restoration of wild stocks and their habitats should be promoted above stocking as a management strategy.

Too little information is available about the status of the Gerry Cook Cod Hatchery to assess its potential future role, although it apparently would work in concert with the FSCC. QWI has committed $664K toward repair and construction works at the hatchery, but the more substantive issues of how it would operate are not explained. Re-commendations in the Mary River Cod Recovery Plan (Simpson and Jackson 1996, pp. 56-57) are pertinent, but are more than 10 years' old and in need of review.

The same applies, in principle, to the Australian lungfish and the turtles (e.g. Williams and Osentoski 2007). Lungfish have been reared successfully in captivity, and the EIS mentions a small commercial hatchery operation. A small hatchery at Paradise Dam hatched 717 turtles for release into the Burnett River in 2006-2007, and a similar number is planned for release in 2008 (Supplement, 8-7). The species are not named, but the Mary River turtle does not occur in the Burnett.

3.8.2 Recruitment

The EIS does not distinguish between *reproduction* and *recruitment*, but the difference is critical for maintenance of animal and plant populations. 'Recruitment' here refers to the accession to populations of mature, potentially reproductive individuals, in numbers sufficient to maintain the existing population over the course of time. If recruitment were to fail repeatedly, the age profile would progressively become skewed toward older individuals and, when these died, the population would become locally extinct.

In this sense it matters little if EVR species like the Australian lungfish, Mary River cod and Mary River turtle can be induced to breed in artificial conditions, including reservoir habitats, unless breeding is on a scale commensurate with maintaining the population age profile. From a conservation viewpoint, assurances are needed that sustainable recruitment, not merely reproduction, will occur in the changed environment.

Recruitment is a particular issue for long-lived organisms like trees, turtles and fish, including the cod and lungfish, because the effects of failures may not be apparent until shortly before the population disappears. As recruitment in these species is not necessarily an annual event, even under natural conditions, failures may occur over extended periods of a few decades before the consequences become clear. Even large populations of mature individuals may appear secure, but are bound for extinction if recruitment is not sufficient to offset mortality.

3.8.3 Connectivity

Connectivity is a critical issue for aquatic and terrestrial flora and fauna. River communities are inherently patchy, and it is the flowing water in the channel that maintains connections between patches. Numbers of Mary River cod, for example, are concentrated in tributary sites, and comparatively few inhabit the channel, but the channel enables links between the elements of the population. Without this connection, the population is fragmented and the isolates, and ultimately the entire population, become vulnerable to extirpation.

Although the Traveston Crossing Dam is to have a fishway, there is no assurance that the cod or lungfish will use it in numbers sufficient to offset fragmentation and isolation. As noted above, the barrier represented by the dam includes not merely the dam wall and the impounded water upstream, but the tailwater, where there will be changed flow and sediment regimes. If the tailwater is hostile to fish, they are unlikely to approach the fishway or to make effective use of it. The barrier effect of the tailwater is problematic also for lungfish and for turtles.

The riparian zones of rivers are, by their nature, corridors for dispersal of plants and animals. It is clear that the dam will intersect existing corridors (7-61), and this is recognized to the extent that *Vegetation Management Offsets* are planned. From the information provided, there is no assurance that these offsets will be sufficiently continuous to restore the dispersal corridor, and so maintain connectivity between population elements above and below the dam (see further Section 3.5.5, p13).

3.8.4 Macroinvertebrates

Information about macroinvertebrates is limited to data obtained using methods employed in AUSRIVAS, the Australian River Assessment System. These typically employ a combination of dip netting and stick/rock baskets in sampling, and do not adequately represent many of the crustaceans and molluscs that are typical of lowland rivers. Information about prawns, crayfish, snails and freshwater mussels therefore is lacking, for the most part. The results make no reference to freshwater sponges (Spongillidae), although these are 21% of the diet of juvenile Mary River turtles, according to Flakus (2002). Freshwater mussels (Hyriidae) also are part of the turtle diet, but they were not sampled although they are reported to be common. Both sponges and freshwater mussels are susceptible to smothering by sediment, which may be significant in the tailwater (Section 3.6, p14). Still and flowing waters accommodate different species of sponges and mussels, but both groups live in reservoirs provided that there is a stable substratum (typically, rock or wood for sponges; non-compacted sediment for mussels). For example, the freshwater mussel *Velesunio ambiguus*, a species that favours lentic habitats, could be expected to become established in Traveston reservoir (cf. Walker et al. 2001).

Identifications in AUSRIVAS generally are carried out to family level rather than species level. In some places (e.g. 19-27), the Supplement appears to confuse species-level diversity and family-level diversity, despite claiming to be aware of the distinction, stating that few macroinvertebrate species are restricted to riffle habitats, when there are no data in support. Even if family diversity was unaffected by the loss of riffle habitat, species diversity could be reduced. This is noteworthy because riffle habitats are utilised, directly or indirectly, by the Australian lungfish, Mary River cod, Mary River turtle and many non-EVR species. Riffles are a critical part of the tailwater environment.

The only EPBC-listed aquatic invertebrate reported from the Mary catchment is a *threatened* species, the spiny crayfish *Euastacus hystricosus* (e.g. Smith et al. 1998). It is not mentioned in the EIS as it occurs in the uppermost reaches (Conondale Ranges, above 550 m) and would not be affected directly by the dam.

3.9 Management for 'species of concern'

The Supplement maintains (19.2.1) that the EIS is at a level of design ('detailed concept' or 'early preliminary design stage') that is appropriate for major infrastructure projects. This applies to operating procedures for the dam and presumably also to accessory structures like the fish-transfer device and turtle by-pass channel. It also claims that sufficient detail was developed to support impact assessment, and to develop mitigation strategies, in keeping with the 'commensurate to risk' philosophy of the Terms of Reference. Interactions between design and impact assessment are to continue as designs are finalised and approvals are received.

In the reviewer's opinion, the levels of commitment and detail provided are not commensurate with the risks to EVR species and the river ecosystem generally. Unless the assurances offered in the EIS are accepted uncritically, it is clear that there are significant risks involved.

Another issue is that there are dangers in tailoring flow management expressly for EVR species. The Supplement (19-17) says:

> "… the emphasis is on providing a suitable flow regime for species of national environmental significance as this will also largely satisfy the needs of the greater community".

There is no evidence in support. EVR species probably do not adequately represent the flow requirements of other fauna, as they are selected using different criteria. Indeed, there is evidence that three long-lived EVR species, the Australian lungfish, Mary River cod and Mary River turtle, may not recruit every year. In that respect, the requirements of these species could not be said to represent those of other species with shorter life spans and annual recruitment. Nor could the flow requirements of EVR fauna be said to represent the needs of the flora.

4. Endangered species

4.1 Significant Impact Guidelines

Following DEH (2006), an action is likely to have a significant impact on a *critically endangered* or *endangered* species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

In the following analyses, the format is to describe (1) the current regional status of the species, (2) the likely impacts of the dam (following the Significant Impact Guidelines, as above), (3) the proposed mitigation and offset measures and (4) impacts not covered by mitigation and offsets and finally to provide (5) a summary assessment.

4.2 Mary River cod, *Maccullochella peelii mariensis*

4.2.1 Status

The Mary River cod (Percichthyidae) is an *endangered* 'species' under the EPBC Act. It is conspecific with the Murray cod (*M. p. peelii*), and was first described as a subspecies by Rowland (1993). According to Native Fish Australia (http://www.nativefish.asn.au), un-published genetic analyses suggest that the Mary River cod is a sub-species of the eastern freshwater cod (*M. ikei*). This awaits confirmation.

A synthesis of biological and ecological data is provided in the Mary River Cod Recovery Plan (Simpson and Jackson 1996, updated 2000).

There is technical literature for the Murray cod that could be consulted in support of questions about movements, recruitment and fishway performance, population dynamics and ecology. Similarly, there is a Recovery Plan and other data for the eastern cod (NSW Fisheries Threatened Species Recovery Planning Program 2004).

Distribution and habitat

Abundance, distribution and population data for the Mary River cod are patchy and often anecdotal. The principal data sources are from a decade or more ago (Simpson 1994; Simpson and Jackson 1996, 2000; Pickersgill 1998). The survey undertaken for the EIS (8.6.51, Appendix F5) is the first since Simpson's (1994) survey, despite the intentions of the *Mary River Cod Recovery Plan.* In the Supplement, these data are augmented by extended survey data and records from DPIF, but the picture remains the same.

The total stream length occupied by the Mary River cod now is 51 km, or less than 30% of its former range in the Mary system (Simpson and Jackson 2000). Brizga et al. (2006) estimated that cod habitats are distributed discontinuously over 170 km, or about 68% of the river above the tidal barrage (250 km). Cod still occur in the Mary channel, including the proposed inundation area, although they are less common than formerly. Indeed, the EIS survey reported more cod from the channel than other formal surveys in the last 10-20 years. Natural sub-populations remain in Six Mile Creek (Lake Macdonald), Obi Obi Creek and Tinana-Coondoo Creek upstream of Tinana Barrage (Simpson and Jackson 1996, 2000). The latter tributary is separated from the Mary channel by tidal barrages, and the cod population is isolated. Cod are known from other areas (e.g. Amamoor, Kandanga, Yabba Creeks), but their status there is uncertain. The total population in all core localities was estimated by Simpson and Jackson (1996) as less than 600 adults.

Mary River cod prefer deep, shaded, slow-flowing pools with abundant snags, although they may also occur in fast-flowing upland streams (Simpson 1994, Simpson and Mapleston 2002). Radio-tagging has shown that they have a strong affinity for sub-merged woody debris, and that areas of open water usually are avoided. The snags provide cover from which to ambush prey, sites for resting, spawning and nesting and a habitat for invertebrate prey. These studies also show that cod are often located downstream of riffles, where food is concentrated by the flow.

Little is known of larval and juvenile habitat needs. The larvae of the closely-related Murray cod drift for 1-2 weeks in the main river channel, particularly at night, rather than sheltering in shallow backwaters (Humphries 2005, King et al. 2005, Koehn and Harrington 2005). Preliminary observations of Mary River cod suggest that 1-2 year old fish use shallow, flowing reaches more than adults do (Simpson and Mapleston 2002).

In Simpson's (1994) survey, Tinana-Coondoo, Six Mile and Obi Obi Creeks all had significant areas of 'good' or 'very good' habitat, whereas Widgee Creek had patches of 'very good' habitat within poorer patches. Most habitats rated as 'very good' were flanked by state forest and would have had abundant submerged snags, favoured by the cod as refuges, spawning and feeding areas. In contrast, the Mary channel was rated as 'poor' habitat, with small numbers of cod. This is supported by later reports (e.g. Pickersgill 1998), although recreational anglers suggest that numbers in the main channel are more substantial than the surveys suggest. As noted above, the EIS survey recorded more cod in the channel than other surveys in the recent past.

Population data

Mary River cod were common in the Mary River channel until around 1920-30, but are now less common. The decline may have been in response to land clearing and agriculture, leading to siltation of pool habitats (Simpson and Jackson 1996).

The pattern of distribution appears to be of sub-populations, or population fragments, in a number of tributaries, linked by the Mary channel. The channel in the inundation area no longer provides good-quality instream habitat, according to the EIS, but it nonetheless has a vital role in connecting the tributary habitats. The presence of inferior habitats within a reach appears not to matter as most of the cod's 40-km range in Six Mile Creek does not include pools deep enough to support them. The EIS acknowledges that the survival of cod would be threatened if their tributary habitats were to become isolated.

Some tributaries, including Amamoor and Six Mile Creeks, are linked to the Mary channel within the tailwater (Section 3.6, p14), and the ability of the cod to move further afield could be prejudiced by environmental changes associated with dam operations.

Remarkably, knowledge of the reproductive biology and early life history of Mary River cod is from observations in hatcheries (Simpson and Jackson 1996, 2000) rather than nature. There are no recorded observations of the spawning behaviour of wild fish, and no studies of reproductive physiology or recruitment.

Under hatchery conditions, female Mary River cod produce about 2000 eggs per kilogram of body weight, and some may spawn more than once in a season (Simpson and Jackson 1996). Spawning is in spring, after the water temperature reaches 20°C, in a nest site that in nature probably is a submerged hollow log. The eggs are adhesive and hatch in 7 days; the brood is guarded by the male cod for another 7-9 days. The fry grow rapidly and become predators in less than 10 weeks, at 30-50 mm length. They attain maturity at 300-380 mm (Merrick and Schmida 1984, Simpson and Jackson 2000), when they would be about 4-5 years old. Cod longer than 500 mm and weighing more than 2 kg generally are sexually mature (Simpson and Mapleston 2002). Cod larger than 700 mm and 5 kg are now uncommon, although the adults may attain 23.5 kg and, from anecdotal accounts, may reach 38 kg (Simpson and Jackson 2000). The adults feed mainly on other fish, yabbies and shrimp.

A striking feature of the population data, apart from its paucity, is the lack of information about age profiles. In the absence of validated methods for age determination, such as exist for Murray cod (Anderson et al. 1992, Rowland 1998a), size (total length) might be used as a surrogate. With this information, it may be possible to associate age/size classes with environmental conditions—to determine, for example, if spawning and recruitment occur annually or less often, perhaps in association with flooding. Information about year-class strength is a basic requirement in fish biology, although the situation for Mary River cod has been confounded somewhat by past hatchery operations.

Hatchery stocking

A comprehensive population study is needed to demonstrate that localised populations of fish are breeding, and that the juveniles attain maturity in sufficient numbers to replace the adult population. A self-sustaining population would contain a range of age (or size) classes, allowing for the likelihood that the cod do not breed successfully every year. Determinations of sustainability have been made difficult, however, by haphazard stocking with fish reared at the Gerry Cook Cod Hatchery, using broodstock from the Mary River. Most of the hatchery-reared fingerlings released before 1999 were not marked, and it may now not be possible to distinguish the hatchery stock from wild fish, or to determine the status and dynamics of the wild cod population. Methods for tagging fingerlings include Visual Implanted Elastomer (VIE) tags (Simpson and Jackson 2000) and microsatellite markers (Loughnan et al. 2004, Rourke et al. 2007).

According to the Mary River Cod Recovery Plan (Simpson and Jackson 1996, pp. 56-57), captive-breeding of cod at the hatchery continued for 15 years without guidelines to ensure long-term genetic integrity. With release of the Recovery Plan, the emphasis changed from recreational fisheries to conservation and recovery and guidelines were developed based on those used for trout cod (*M. macquariensis*) in Victoria and New South Wales (Douglas et al. 1994).

Since 1983, and particularly after the advent of the Recovery Plan, fingerlings have been released to riverine and impounded sites in and beyond the Mary catchment. According to the Supplement (20), 182,642 fingerlings were released into the Mary River and tributaries from 1998-2005, generally at sites where there was suitable habitat, and where cod once did occur but were thought now to be absent. Sites in the Mary channel received 85,673 fingerlings. Tributary release-sites included Obi Obi (Baroon Pocket Dam), Kandanga, Amamoor, Six Mile (Lake Macdonald), Widgee and Yabba (Borumba Dam) Creeks, among others, but not the isolated Tinana-Coondoo Creek system, where the wild stock may have retained its genetic integrity. Assuming 5% survival (Simpson 2000), for immature 2-y old fish, this would represent over 9000 cod added to the system. The number of mature fish (> 4 y) would be less.

The genetic integrity of Mary River cod could have been prejudiced by the reported translocation of Murray cod (*M. p. peelii*) to the Mary River in the 1970s. Although it is believed that the Murray cod did not survive (Rowland in Simpson and Jackson 2000), they may have left a genetic 'signature' and an investigation is needed to resolve any doubt.

The Supplement states that most cod reported recently by recreational anglers are of a size and age (<65 cm, < 8 y) that are consistent with stocked fish, and occasional larger captures could represent remnant populations or the progeny of earlier stocking. Increased numbers of small fish, reported by anglers, could be either from natural spawning or stocked fingerlings.

The Supplement states also that cod in Obi Obi Creek are remnant wild populations but, confusingly, the same stream is listed as a site where fingerlings have been released. As mentioned, the most likely genetic remnants of the original wild cod population are in the Tinana-Coondoo Creek system.

It is true that cod can be induced to spawn in hatchery ponds in the absence of flow stimuli (8.6.5.1). This cannot be taken as confirmation that cod will breed in the reservoir (8.8.2.2), as hatchery conditions are quite unlike those in natural environments. For example, the fertilized eggs are removed from the ponds, after spawning, and reared in aerated troughs, protected from fungal disease and the larvae are supplied with abundant food. In nature, many factors intervene to determine hatching success and, of course, survival to maturity.

It seems likely that the Mary River cod could breed in reservoirs, because the related Murray cod does so, but with the very important caveat that spawning and recruitment are not synonymous (Section 3.8.1, p20). For reasons that are not understood, Murray cod do not recruit well in impoundments (http:// www.nativefish.asn.au) (see Rowland 1998b; Humphries 2005; Koehn and Harrington 2005, 2006). Similarly, there is no evidence that Mary River cod successfully recruit in Queensland impoundments, despite the provision of artificial spawning habitat, and the same is true for the closely-related eastern cod (*M. ikei*) (e.g. Pollard and Wooden 2002). In general, recruitment to populations of percichthyid fish species in impoundments is low or non-existent (Barlow 1991 in Simpson and Jackson 1996).

Movements

Radio-tracking studies (Simpson 1994, Simpson and Mapleston 2002) show that adult cod are territorial, but may move more than 30 km up- or down-stream during high flows. It has been suggested that the cod tended to move to upstream tributaries in spring and summer, and to return in autumn, but Simpson and Mapleston (2002) found no evidence in support. The mean distance moved each month apparently is correlated with stream discharge, but the directions of movements vary between individuals and appear to be unrelated to their body size. Some fish are more sedentary, and may stay within a 'home reach' of up to a kilometre for several years. Home ranges usually include two to four 'core areas' where a fish spends most time. Homing behaviour is common, and fish may return to a previous home reach after an absence of several months. Comparable patterns of movement are shown by Murray cod (Koehn 1997).

Radio-tagged Mary River cod monitored by Simpson and Mapleston (2002) did not move within 15 km of barriers at Lake Macdonald and Tallegalla Weir.

Fish-transfer device

There are no empirical data to describe the ability of Mary River cod to utilise the fish-transfer device proposed for Traveston Crossing Dam. It is likely, however, that they have a similar swimming capacity to Murray cod (e.g. Barrett and Mallen-Cooper 2006, Barrett 2008), and may be able to traverse vertical-slot fishways, as used in the Murray-Darling Basin (Simpson and Jackson 2000). The ability of juveniles is likely to be more limited (e.g. Baumgartner et al. 2006).

Recovery plan

Given the shortcomings in basic biological and ecological information for Mary River cod, the failure to properly monitor the fate of hatchery-reared stock and the omission of a review set for 2006, it is clear that the Mary River Cod Recovery Plan (Simpson and Jackson 1996, 2000) has performed poorly. Indeed, the plan pre-dates the Traveston Crossing Dam proposal by a decade, and should have been reviewed to determine whether it is now adequate to meet the potential impacts of the dam. Large-scale rehabilitation, long-term monitoring and research on the cod have seen no progress in 18 years. The Supplement explains that the lack of progress reflects a loss of focus by the Recovery Team, which has not met since 2003, and a lack of funding. This was part of the rationale for proposed Freshwater Species Conservation Centre (FSCC), intended to re-focus research on the cod and to establish similar programs for the Australian lungfish and Mary River turtle.

Numerous questions remain over the sustainability, genetic integrity and recruitment dynamics of the remnant sub-populations, and formal investigations are needed. These unresolved issues would be best served by full implementation of the Mary River Cod Recovery Plan (Simpson and Jackson 1996, 2000), particularly recommendations by Dr Peter Jackson, listed in the EIS as a possible agenda for the FSCC.

4.2.2 Potential impacts

Will the proposal lead to a long-term decrease in the size of the population?

The size of the cod population is not known with any confidence. Simpson and Jackson (1996) estimated that there were less than 600 individuals in core tributary habitats, and whilst the total population would be larger, partly because of stocking, the numbers are speculative. As there are uncertainties about the size, status and dynamics of the existing population, it is not possible to state unequivocally that there would be a long-term decrease in the size of the population. There is no surety that a decrease would *not* occur, and it therefore would be wise to assume that there is a significant risk of a population decline. This conclusion is reinforced by the likelihood that the Mary River cod would not recruit successfully in the reservoir, and by the fact that most environments created by the project, above and below the dam, will be of low value compared to the preferred pool-riffle habitat.

If a decline occurs, it could be party compensated by a properly-managed program of releasing hatchery-reared fingerlings, provided that this was expressly for conservation purposes rather than stocking for recreational fisheries. It would not be appropriate to continue past stocking practices.

Will the proposal reduce the area of occupancy of the species?

The fate of cod now within the inundation area is uncertain. They are likely to be disturbed by construction, retreat and recolonise the area after the environment becomes more stable. Although adult cod probably would live in the reservoir, and may breed there, the available evidence strongly suggests that they would not recruit successfully in that environment (that is, they would not form self-sustaining populations). Rather, they may favour peripheral tributary inflow areas that retain some riverine characteristics. The total area of occupancy may not be greatly reduced, but most environments created by the project would have low value as residential habitats, and would therefore accommodate relatively low numbers of cod. The modified environment would restrict the free movements of cod up- and down-stream.

Will the proposal fragment an existing population into two or more populations?

The combined area of inundation, dam and tailwater together represent a physical barrier that would fragment the area occupied by Mary River cod. It is not clear which, if any, of the cod sub-populations in tributaries are self-sustaining. Regardless, connectivity between these sub-populations is needed to preserve genetic diversity.

The dam will isolate some known habitats and change the flow regime in the tailwater reach, fed by Six Mile Creek and Amamoor Creek, which are both known habitats. This could affect the ability of the cod from these habitats to move up- and down-stream.

Will the proposal adversely affect habitat critical to the survival of a species?

The dam will occupy a river reach that provides a corridor for dispersal of cod and connections between sub-populations. The inundation area in particular will cover a significant length (36.5 km) of riverine habitat. The EIS claims that as deep pools are favoured by Mary River cod, the deep-water habitat in the reservoir may be beneficial (8.8.2.2). Yet pools in the river generally are < 5 m deep, whereas roughly half of the reservoir will be deeper than 5 m. Pools in the Mary River are not like open water in a reservoir, but are associated with flowing water, riffles, undercut banks, roots and submerged logs and overhanging riparian vegetation. Pool-riffle habitats in the dam tailwater would be modified by flow changes and consequent erosion and siltation, and corresponding changes would occur in tributary reaches. In general, cod habitats in the reservoir and tailwater would be of significantly lower quality than those that now exist.

Will the proposal disrupt the breeding cycle of a population?

Mary River cod may breed in the impoundment, but probably not recruit successfully. There is no evidence that they have recruited well in other reservoirs. This is true also of related species, including the eastern freshwater cod and Murray cod.

Like the Murray cod, the Mary River cod may respond to seasonal temperature changes as a primary cue for spawning (Koehn and Harrington 2006). Temperature changes in the tailwater environment are not likely to be significant, and although there would be changes in the thermal regime in the reservoir, in shallow and deep water, other environmental factors would intervene to limit recruitment. Spawning does not require a flow stimulus, nor is there a spawning migration.

Recruitment is likely to be substantially better in years when there is overbank flooding, probably because floods entrain plankton and other food resources that promote juvenile survival (cf. Humphries 1995). This effect would be muted in the reservoir and possibly also the tailwater.

Will the proposal modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The inundation area, dam and tailwater would modify areas of Mary River cod habitat. These areas now provide few, if any, areas of high-quality habitat, but habitat quality probably would be diminished further after dam construction. Cod may survive in these modified areas, or traverse them, but there is no evidence that they would support breeding populations. The reservoir would have little resemblance to the riverine pool-riffle habitats preferred by the cod, and the tailwater also would be modified.

In the reviewer's opinion, the uncertain status of the present cod population and changes to habitat quality, free-range movements and breeding-habitat availability, hence recruitment, and represent a significant risk that the local cod population would decline further after dam construction.

Will the proposal result in invasive species that are harmful to a species becoming established in the species' habitat?

The reservoir will create a favourable habitat for a variety of native and alien species, including fish. Whilst the proposal itself does not advocate stocking with other fish species, experience elsewhere in south-eastern Queensland and Australia generally suggests that other species, including noxious species, are likely to become established. Species like common carp and Mozambique tilapia would change the environment to the detriment of Mary River cod.

Populations of water weeds, including cabomba, salvinia and water hyacinth, are likely to develop in sheltered areas of the reservoir. Floating rafts of these plants may accumulate near the dam wall.

Will the proposal introduce disease that may cause the species to decline?

This is not anticipated.

Will the proposal interfere with the recovery of the species?

The Mary River Cod Recovery Plan (Simpson and Jackson 1996, 2000) has had serious shortcomings in execution and is in need of review. QWI's intention is to refer the recovery plan to the FSCC.

4.2.3 Mitigation and offsets

The EIS proposes to maximise utilisation of the reservoir by cod, by creating suitable habitat in areas closed to recreational use by humans and rehabilitating areas, especially in the upper inundation areas and local tributaries, to offset residual impacts by compensatory offsets, to overcome the barrier effect of the dam and to support research at the FSCC. Proposals include:

- Retention of vegetation (within 1.5 m elevation of FSL in riparian areas); when this dies, it will be allowed to stand as habitat for fish and roosting birds
- Re-vegetating targeted fringing margins of the dam, particularly riparian zones upstream of FSL, with species native to the area and tolerant of periodic flooding
- Introducing artificial snag habitat to the impoundment, drawn initially from trees removed prior to inundation
- Introducing artificial surfaces that may act as suitable shelter habitat for fish (e.g. rocks or concrete pipes)
- Compensating for the loss of habitat in the impounded area by re-vegetating and re-snagging other parts of the catchment (particularly where Mary River cod are known to occur). Habitat values and Mary River cod conservation would be enhanced if re-vegetation efforts were also centred on the degraded reach between the dam wall and Amamoor Creek, but should be directed by existing knowledge and programs
- Regular monitoring of the efficacy of the fish-transfer device and turtle by-pass and, if they are not achieving a target success rate, adjust their operation. If necessary, instigate catch-and-carry techniques or release hatchery-bred stock
- Regular and intense PIT tagging of Mary River cod prior to the fish transfer device becoming operational (procedure to be confirmed with DPIF)
- Enhance captive breeding knowledge and capacity through support of the Gerry Cook Cod Hatchery
- Request that the by-pass strategy include fish-barrier assessments and rehabilitation of weirs in major tributaries upstream of the dam (Yabba Creek, Kandanga Creek) and
- To implement the findings of the Freshwater Species Conservation Centre.

The vegetation retention zone would be broadest in areas where bank slope is least, and narrowest where it is steep. According to the EIS, the figure of 1.5 m is a compromise between a larger, ecologically more useful margin and one that is safe for human recreation. Trees within this zone could take a century to fall and provide snag habitat for Mary River cod, and it would be necessary to introduce artificial snag habitat. This would encourage other fish and invertebrates. It may be possible to extend the zone in protected areas and increase its habitat value, consistent with safety issues.

Restoration of the reach between the dam and Amamoor Creek would promote the local cod sub-population. It is unclear what scope there may be for riparian revegetation in this area, consistent with dam operations. A statement in the EIS indicating that the Amamoor Creek habitat is "not currently well linked to the Mary River" could mean that habitat restoration is warranted.

Offsets would include support for the Mary River Cod Recovery Plan and the Mary River and Tributaries Rehabilitation Strategy, through funding specific works that relate to the acknowledged or potential impacts of the dam in riparian areas, or to fish passage or improvements in water quality. As noted, the recovery plan is outdated, has made little progress and is in need of review. It would be referred to the FSCC.

Hatchery releases are not a substitute for wild, self-sustaining populations but, properly managed, they may have some value in conservation. The FSCC and Gerry Cook Cod Hatchery would need to liaise closely to ensure that releases of hatchery-bred fingerlings were consistent with conservation goals, given that these may not always be compatible with stocking for recreational fisheries. Releases should not proceed except under strict control by fish biologists, using marked fingerlings.

There is considerable momentum in small-scale, community-driven habitat rehabilitation projects, although it has been difficult to procure funding for on-ground projects, and QWI proposes to support these projects. Monitoring the impacts of rehabilitation works on fish communities is a specialised task, however, requiring money, equipment and expertise. The nature of support proposed by QWI is not clear.

The target success rate for the fish-transfer device is not defined, but presumably would vary for each species and would rely on PIT tagging to establish movements above and below the dam.

There is a need for research, and the proposed agenda for investigations of Mary River cod by the FSCC is sound, although ambitious. It is not clear who would implement the findings. Even so, there would be a lead time of some years before findings could be implemented, and local cod populations could decline within that period.

4.2.4 Residual impacts

Issues of recruitment, habitat quality, the ability of cod to use fishways and mortalities and injuries to fish swept over the spillway are not adequately considered. There are so few basic ecological data that it is not possible properly to assess the extent of these impacts or to evaluate the strategies proposed for mitigation.

4.2.5 Impact assessment

The dam project may not *directly* impact the tributary habitats where cod reside, but it will affect connectivity between these habitats. The inundation area may be 5% of the length of the river, as the EIS says, but if the tailwater is included, and if it is hostile to cod movements for significant periods, this proportion would double. The Supplement claims that “changes to the downstream flow regime that may impact on cod were specifically addressed in the EIS and shown to be not impacted”, but in the reviewer’s opinion this is not proven.

Information about the biology and ecology of Mary River cod is sparse. Doubts remain in regard to population size and age profiles, breeding and recruitment, habitat quality, distribution and movements, genetic integrity and the sustainability of populations. The basis for addressing the potential impacts of the dam is further weakened by the perceived failure of the Mary River Cod Recovery Plan and past activities at the Gerry Cook Cod Hatchery.

It is likely that adult cod would live in the Traveston reservoir, and may breed, but it is unlikely that the reservoir would provide habitat conducive to recruitment. Similarly, if cod proved capable of using the fishway, doubts remain over whether they would do so in numbers sufficient to counter the genetic and other effects of the dam as a barrier. To offset doubts, QWI refers problems to the FSCC and offers a variety of other offsets, including a re-financed, re-focused cod hatchery and a catch-and-carry strategy. Even if the Centre has appropriate support (Section 3.3, p6), there may be issues over adequate monitoring of the cod population. In addition, the lead time for research is likely to be several years, and the delay between recognising a problem and implementing a research-based solution could be regarded as a form of impact. The cod population may not be sufficiently robust to withstand more years of inaction over critical issues.

In view of the likely impacts associated with dam construction, and the uncertain delays before FSCC research and its findings are implemented, it is recommended that *consideration* be given to a ban on recreational fishing for Mary River cod within the project area (inundation area, tailwater and tributaries).

The EIS offers assurances using a combination of sparse data, offsets framed in very general terms and, in many cases, the opinions of unidentified authors. In this reviewer’s own opinion, the dam project presents significant risks to the integrity of the Mary River cod population in its original habitat, and there are reasonable grounds to doubt that the proposed strategies would succeed.

4.3 Mary River turtle, *Elusor macrurus*

4.3.1 Status

The Mary River turtle (Chelidae) is an *endangered* species under the EPBC Act. It is also listed as *endangered* on the IUCN *Red List*, and as one of the world’s 25 most en-dangered turtles by the Turtle Conservation Fund (http://www.chelonia.org/).

This is one of six turtle species in the Mary River, but the others are not EVR species and are not considered in detail in the EIS. They are the southern snapping turtle (*Elseya albagula*), saw-shelled turtle (*E. latisternum*), Krefft's turtle (*Emydura macquarii krefftii*), the eastern snake-turtle (*Chelodina longicollis*) and the broad-shelled turtle (*C. expansa*).

The Mary River turtle is confined to the Mary River and has no close relatives. It was first described by Cann and Legler (1994) and is one of Australia's largest turtles (> 50 cm carapace length), a fast swimmer with long barbells, a short neck and a long tail, and is capable of cloacal ventilation as well as breathing air. Mary River turtles were popular in pet stores until 1974, when the breeding population had been reduced by an estimated 95% due to harvesting. As maturity is attained after 25-30 years, turtles hatched in 1974 will only recently have become potential breeders. According to the EIS, the main threat to the present population is egg predation by dogs, foxes and other animals.

The absence of a formal recovery plan for the Mary River turtle is a serious impediment to any planning development. Taylor and Booth (2008) listed this as one of the EPBC-listed species least well-protected by reserves, and pointed to Queensland as the state with the highest proportion of poorly-protected threatened animals.

The EIS is supported by two turtle surveys. One was a 9-month survey by Ecotone Environmental Services (EES), commissioned by QWI and focussed mainly on the inundation area. The other was a substantial study of the ecology of the Mary River turtle is provided in a thesis by Flakus (2002). The EIS refers to a 10-year database maintained by the EPA (Limpus et al. 2007), including mark-recapture studies, field site assessments and nest investigations, but nearly all of this information was drawn from Flakus (2002) and an earlier report by Tucker (2000) (see also Tucker et al. 2000). The latter is often cited in submissions to the EIS.

Habitat

The Traveston Crossing Dam would inundate areas that are now occupied by Mary River turtles, and changes in the tailwater also would impact on turtle habitats. Their favoured habitats include deep pools (1-5 m) interspersed by riffles, with overhanging vegetation, exposed roots and undercut banks, submerged and emergent snags and beds of water plants, with proximity to sandy banks for nesting.

The Supplement indicates that there were high proportions (42-44%) of juvenile turtles in the inundation and tailwater areas. It claims that the inundation area is not more critical than the downstream area, but the data nevertheless demonstrate that a significant breeding population extends through the area to be influenced by the dam. According to the EPA report (Limpus et al. 2007), nesting occurs within the inundation area, but with less intensity than downstream near Tiaro.

Mary River turtles are reported to have bred in the upper reaches of the Mary Barrage impoundment (Flakus 2002), and the Imbil Weir impoundment on Yabba Creek, and turtles of unspecified age are recorded from the Tallegalla Weir impoundment on Tinana Creek. These observations support suggestions that the turtles could breed in the uppermost reaches of the Traveston reservoir, and may inhabit the shallow margins of the reservoir. The Mary Barrage impoundment is quite a different environment, however, from a large, deep lake with an exposed shoreline.

Tucker (2000) suggested that the Mary River turtle would not survive or breed in impoundments. Among the reasons advanced were that fluctuating water levels would discourage the plants that provide food and shelter for juveniles, and that the loss of riparian trees would eliminate a food source (windfall fruits) and structural habitat (submerged roots). Tucker pointed out that the food webs of turtles in lakes differ from those in rivers, a claim mirrored by studies of fish (e.g. Pusey et al. 2004).

The Supplement argues that the impacts referred to by Tucker relate mainly to the deeper parts of storages, or to storages that do not support macrophytes. The Traveston reservoir would support macrophytes, although not all species are likely to be suitable as habitat or food for turtles. No information is provided about the suitability of nuisance plants like cabomba, salvinia or water hyacinth as turtle habitat, although the turtles reportedly will eat cabomba.

It is widely believed that the Mary River turtle prefers riffle habitats, and that the juveniles feed on riffle-dwelling invertebrates. This is significant because there would be no riffle habitats in the main body of the reservoir, and riffles in the tailwater would be subject to changed flows, erosion and siltation. The Supplement points out that adult and juvenile turtles are often found in pools. Whilst this may be partly an artefact of sampling (they may be easier to observe in pools), it does seem that adults reside in pools except during the breeding season (about two months), when the females move closer to their nesting bank. The home range of adult turtles, other than in the breeding season, is reported as 200-650 m, although they can move further (Flakus 2002).

In the reviewer’s opinion, the cardinal point is that pool-riffle sequences are a conspicuous feature of the preferred habitat, and in the present context there is no value in arguing for the merits of one part of the environment over another. The turtles’ habitat is a mosaic of patches, including deep pools and shallow riffles, all of which are likely to contribute resources at different times of day, or in different seasons. Many stream-dwelling animals, notably fish, occupy pools downstream of riffles (e.g. Simpson and Mapleston 2002), where there is a ready supply of invertebrate food dislodged by the turbulent water, and in that context the pools and riffles offer complementary resources. The reservoir would be a fundamentally different environment, lacking pools and riffles and with proportionately much less ‘edge habitat’ than in river channels.

Management interventions would be required to meet other habitat requirements:

- Snags will be introduced in strategic locations,
- Riparian zones within 1.5-m elevation below FSL will not be cleared, leaving roots and snags for basking and a substratum for food (sponges, algae), and
- Selected riparian zone areas will be enhanced by planting of native species, particularly those that supply windfall fruits or are tolerant of flooding.

The Supplement acknowledges that much of the value of the riparian plantings (e.g. for windfall fruit) would not be realised for decades.

Nesting

Nests are sparsely distributed throughout most of the species' range, but are concentrated in areas downstream of the dam site, particularly around Tiaro. According to the EIS, there are 66 potential nesting sites (suitable sand banks) in the vicinity of the dam, and about half would be inundated (although three would be exposed for some time during the normally dry breeding season). Most nest sites are within 6 m of the water.

Water-level fluctuations are not likely to restrict access to nests in the uppermost reaches of the reservoir, where inundation is restricted mainly to the channel, but they could be significant for nests along the lower reaches.

QWI proposes to relocate some potential nesting banks, either to islands or to more elevated positions, to ensure that they remain above water. This is because the female turtles are believed to return to the same nesting bank each season, and because conditions in the reservoir would not favour formation of sand banks (cf. Tucker 2000). Relocation is an untried strategy, apparently without precedent.

There may be some disturbance to turtle nesting areas during dam construction. QWI has committed to consult with the EPA if problems were to arise.

Unprotected nest sites are highly vulnerable. The survival of clutches laid in the wild is low, although estimates vary widely (Flakus 2002). Wild dogs, dingoes, foxes and goannas are significant predators, and illegal egg-collecting by humans persists. In response, QWI would control access by grazing and feral animals to nesting sites within the project area, and establish and support other nest-protection activities. This would be referred to the FSCC for monitoring and management.

There is considerable doubt that the reservoir environment would sustain juvenile turtles. They appear to favour flowing water, particularly riffles, and this is reflected in their diet. They may survive in upstream areas of the reservoir, near tributary inflows, but their fate in more open areas of the reservoir is uncertain. This needs to be considered alongside the requirements for nesting, in that attempts to relocate and protect nesting areas in some areas may be to no avail if the juveniles are unlikely to survive.

Diet

Adult Mary River turtles are mainly, but not exclusively, herbivorous. According to Flakus (2002), aquatic plants make up 79% of the diet by weight. Key plants are filamentous algae (43% of samples by mass, eaten by 53% of turtles sampled), *Vallisneria* (17%, 50%), and *Myriophyllum* (11%, 22%), and less significant species include *Cabomba*. Another 20% of the diet is insect larvae, particularly caddis (Trichoptera), mosquitoes and midges (Diptera) and moth larvae (Lepidoptera). The turtles may also eat freshwater mussels (*Velesunio ambiguus*). Aside perhaps from (some) caddis, these invertebrate taxa would not be from riffle habitats. Windfall fruit was a small part of the diet (2%). The proportions of dietary components would vary widely with seasonal and other factors, and the quoted data are merely indicative.

Juvenile turtles eat mainly insect larvae (53% by mass), plants (25%) and freshwater sponges (21%) (Flakus 2002). The insect larvae include caddis families (Trichoptera: Helicopsychidae, Hydropsychidae) which do occur in riffle habitats.

Tailwater habitat

In the EES survey, the most densely-populated area was the 5-km reach downstream of the dam site. This also had a higher proportion of juveniles than the inundation area. This reach would become part of the dam tailwater.

Limpus et al. (2007) pointed out that dam construction may not necessarily cause the loss of downstream turtle populations, and that it is "theoretically possible" to manage the downstream flow regime to enhance the quality of the habitat for turtles. The issue here, however, is not whether the dam *could* be managed to benefit turtle populations but whether this would be consistent with routine dam operations.

The same report stated that:

> "Within the regime of current impoundments within the Mary River there is no indication that the existence of impoundments threatens the survival of these species further downstream from impoundment structures."

Again, this is arguable because no existing impoundment on the Mary River is of a size comparable to the proposed Traveston Crossing Dam.

The EIS suggests that the tailwater would be suitable for Mary River turtles as it will support the growth of *Vallisneria* and other plants, pools will be maintained through scouring and flood flows during the nesting season will be reduced. Support for nest-protection programs will be focused on this reach (and reaches near the upper reaches of the storage).

In general, the EIS maintains that the tailwater environment will be enhanced for Mary River turtles. In the reviewer's opinion, the argument is not persuasive. As stated above, the central issue is not that the environment could be maintained, or even improved in some respects, but whether these initiatives would be consistent with dam operations.

Movements

Radio-tracking data suggest that adult Mary River turtles do not move further than a few kilometres in the course of a year (Flakus 2002), and there is no evidence of migratory movements. The movements of juveniles, however, are unknown.

Without mitigation, the inundation area, dam wall and possibly also the tailwater would prevent upstream movements of turtles, and downstream movements would incur losses due to physical damage to individuals trapped in the offtake or swept over the spillway (see Latta 2007). In response, QWI proposes to construct a turtle by-pass channel (Limpus et al. 2007), to consider re-stocking with artificially-reared juveniles and to implement catch-and-carry methods. These strategies are comparable to those proposed for Mary River cod (Section 4.2.3, p31), and open to the same arguments.

Although the fish-transfer device would have some capacity to transport turtles, judging from the reviewer's observations at Paradise Dam, it is deemed by QWI not to be a complete solution, for reasons that are not explained. The EIS states that physical damage to shells and mortality of turtles will be minimised by design changes, in consultation with the EPA and FSCC. In the wider environment, physical damage due to trampling by cattle appears to be significant (Limpus et al. 2007), and might be overcome by providing offstream watering points. It is not clear whose responsibility this would become, once dam operations commence.

QWI proposes to build a turtle by-pass channel (aka 'turtle ramp' or 'biopass'). Following recommendations from the EPA, this will consist of a stream channel containing pools with a variety of depths, substrates and flows, bordered by planted riparian vegetation. Design details are not finalised, and would be referred to the FSCC.

The arguments presented in support of catch-and-carry and restocking suggest some confusion about the purpose of transfer. The question is not whether individual turtles (or fish) can be captured, transported and released at other sites, but whether these methods address the specific issue of genetic isolation. Catch-and-carry is not, as the EIS says, a technique for which "success is easily measurable in terms of how many individuals moved from one location to another". Genetic diversity is the focus, rather than numbers of individuals. The EIS suggests that only low numbers of transfers would be required to ensure genetic mixing, but without substantiation. As for cod, translocations of small numbers of turtles could have deleterious effects. Translocated individuals would be mature males or juveniles rather than females, in deference to their apparent fidelity for nesting areas.

Recovery

In the absence of a recovery plan for the Mary River turtle, recommendations by Flakus (2002) and the EPA are the basis for research proposed for the FSCC. These include identification and protection of critical habitat, identification of nesting sites, determination of population dynamics, demography and nesting success, predator control and a program to artificially incubate eggs and protect them from predators.

If dam construction is to proceed, preparation of a formal recovery plan for the Mary River turtle should be made an urgent priority.

4.3.2 Potential impacts

Will the proposal lead to a long-term decrease in the size of the population?

The size of the Mary River turtle population is uncertain, but preliminary estimates suggest that there are 900-3500 in the inundation area. As there are doubts about the size and dynamics of the population, and other major deficiencies in biological and ecological knowledge, the risk of a long-term decrease in the size of the population must be considered real, but not quantifiable.

Will the proposal reduce the area of occupancy of the species?

The reservoir and tailwater would occupy some 70 km, a large part of the range of the species. It is possible that parts of this area, notably the tailwater and the uppermost reaches of the reservoir, would retain some good-quality habitat, but there is little doubt that there would be adverse effects on overall habitat quality.

Will the proposal fragment an existing population into two or more populations?

The inundation area, dam and tailwater together represent a physical barrier that will fragment the occupied area. Although Mary River turtles are not known to be migratory, they do undertake small-scale movements within their range and it is imperative to maintain gene flow between all elements of the population. QWI proposes that the fish-transfer device, turtle by-pass channel and catch-and-carry methods would address these issues, but there is little assurance that they would do so, or that the situation would be monitored effectively.

Will the proposal adversely affect habitat critical to the survival of a species?

The EIS maintains that the inundation area is not 'critical' habitat, but it is a substantial part of the core range of the species, and the effect would be substantially greater if part or all of the tailwater proves to be unfavourable.

Good-quality feeding and nesting habitats occur within the inundation area, and there is reasonable doubt that they will be suitable for adults, and particularly juveniles, after inundation. About half of the potential nesting habitat within the project area will be impacted or lost, and remaining potential nesting habitat within the storage will be relocated. The principal nesting area near Tiaro should not be affected although management may be needed there to promote recruitment.

Pool and riffle habitats in the tailwater region may be degraded by changes in flow and water quality, and redistributions of sediment through erosion and siltation.

Although the Mary River turtle may live and breed in some storages, this generally is in the upstream, riverine areas of small impoundments like the Mary Barrage, and these should not be likened to a large reservoir. It seems unlikely that the main body of the Traveston reservoir would sustain juveniles.

Will the proposal disrupt the breeding cycle of a population?

Although adult turtles may be able to survive in some parts of the Traveston reservoir, there is no evidence that they would breed or form self-sustaining populations there, although they might breed in tributary inflow areas that retain some riverine characteristics. Juveniles may not survive in the reservoir. Nesting banks near the reservoir would need to be artificially maintained and protected. The environments created by the project probably would have low (or significantly diminished) value as residential habitats, and are quite unlike the pool-riffle habitats favoured by the species under natural conditions.

The statement that 'breeding in the impacted area is known to occur but is expected to be at a low level' is unsubstantiated. On the other hand, the EIS states that nesting sites near Tiaro, 'a critical breeding area', should not be affected.

Although the turtles can be reared in artificial conditions, this should not be equated with recruitment (reproduction and survival to maturity) on a scale sufficient to maintain populations. Further, artificial stocking is generally discredited as a solution to declines in wild populations (cf. Allendorf and Ryman 1987, Williams and Osentoki 2007). A small hatchery at Paradise Dam has released hatchling turtles to the Burnett River in 2006-2008, but the species involved are not known (Supplement, 8-7) (Section 3.8.1, p20).

Will the proposal modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The inundation area, dam and tailwater will surely degrade areas inhabited by Mary River turtles. There is no evidence that the reservoir could harbour breeding populations, except possibly in upstream riverine areas. Most of the impacted area would provide poor-quality habitat where turtles may be able to survive or traverse, but this would not be like the riverine pool-riffle habitats favoured by the species.

There is a significant risk that the species would decline, as so much depends on the success of untried mitigation strategies to be implemented by the Freshwater Species Conservation Centre.

Will the proposal result in invasive species that are harmful to a species becoming established in the species' habitat?

The reservoir would create a favourable habitat for a variety of native and alien species, including fish. Alien species like common carp and Mozambique tilapia could change the environment to the detriment of Mary River turtles.

Populations of water weeds including cabomba, salvinia and water hyacinth would develop. It is unclear how these would affect the turtles.

Will the proposal introduce disease that may cause the species to decline?

This is not anticipated.

Will the proposal interfere with the recovery of the species?

There is not a formal recovery plan in place for the species, and this issue should be addressed as a high priority. QWI proposes that work of this nature would be undertaken by the FSCC. It would concentrate on methods to promote turtle habitats in the reservoir and to counter egg predation.

4.3.3 Mitigation and offsets

Community-based recovery activities are underway at the nesting banks near Tiaro. These areas will not be affected directly by the project, but QWI intends to expand the activities to the dam and nearby areas, particularly through protection of nesting sites and rehabilitation of habitat.

Other proposed mitigation measures include retention of fringing vegetation, re-planting in targeted areas, rehabilitating riparian and instream habitats in the upper section of the tailwater (to Amamoor Creek), introducing snags to littoral areas of the reservoir, relocating nesting sites to islands and areas above FSL, controlling access to nesting areas by grazing and feral animals, monitoring the fish-transfer device and turtle by-pass channel and, if necessary, using catch-and-carry methods. The FSCC would address most of these practical issues.

4.3.4 Residual impacts

QWI has endeavoured to address all likely issues and covered shortcomings by referring them to the FSCC. The methods to be used are in most cases unproven, and it is doubtful whether the Centre will be adequately prepared and supported to undertake this work.

4.3.5 Impact assessment

There is so little critical knowledge of the ecology and biology of the Mary River turtle that the only responsible conclusion can be that the project represents a significant risk to the integrity of the present population, and tto he species as a whole. In that respect, the circumstances for the Mary River turtle are like those for the Mary River cod.

The inundation area and tailwater are a substantial part of the species' range. There are doubts that the tailwater would preserve the pool-riffle habitats favoured by the species in its natural environment, that the reservoir will support a self-sustaining population, that the turtles will be able to negotiate the by-pass channel and fish-transfer device and that mortalities/damage caused by the offtake structure and spillway will be low. The assurances offered by QWI rest heavily on untried methods and the proposed FSCC.

4.4 Southern barred frog, *Mixophyes iteratus*

4.4.1 Status

The southern barred frog (Leptodactylidae) (aka giant barred frog) is *endangered* under the EPBC Act and the Queensland *Nature Conservation (Wildlife) Regulation 1994*. It is also listed as *endangered* on the IUCN *Red List*.

This is a large species (to 115 mm) with conspicuously-barred hind legs. It occurs in coastal ranges and lowlands from the Mary catchment south to mid-coastal New South Wales, but has declined greatly in the southern part of its range (Covacevich and McDonald 1993, Hines et al. 1999).

The southern barred frog is a nocturnal, terrestrial, stream-breeding species, with an altitudinal limit of 520-1000 m (EIS, Hines et al. 2002), found along shallow, rocky streams in rainforest, wet sclerophyll forest and farmland, or deep, slow-flowing lowland streams with steep banks. The frogs bury themselves in litter and are difficult to detect other than by the calls of the males at night, in September-April, from under rocks or overhanging banks. The female may carry more than 4000 eggs (Hero and Fickling 1996), laid under over-hanging banks and rock ledges. The tadpoles can exceed 100 mm and probably over-winter, so that they are present throughout the year. In the breeding season, the frogs may move hundreds of metres along the stream, but they generally remain within 50 m of the water (cf. Streatfeild 1999, Lemckert and Brassil 2000). They are most active at temperatures above 18°C (Koch and Hero 2007).

A 5-year, $1.3 million Recovery Plan for seven threatened species of stream frogs in south-eastern Queensland, including the southern barred frog, is provided by Hines et al. (2002). The plan describes the declines of these species, critical habitats, threats, current and proposed monitoring and necessary research and management actions. Recovery actions, including population monitoring and habitat assessments, have been underway since 1998.

The southern barred frog is regarded as the least well-protected of the seven species (Hines et al. 2002), as its most significant populations, in the lower catchments of the Stanley and Mary Rivers, are almost entirely on private land (cf. Taylor and Booth 2008). Local community groups are facilitating recovery efforts in these areas. Otherwise, the species occurs in several national parks and state forests, including Conondale, Lamington and Main Range National Parks and Ingelbar, Kenilworth, Spicer's Gap and Blackall State Forests (Tyler 1997).

It is difficult to assess the extent of the species' decline in Queensland because there are no historical data, but it persists in scattered locations in the Mary catchment downstream to about Kenilworth, and in the Maroochy River, Upper Stanley River, Caboolture River, Burpengary Creek and Coomera River. Factors in the decline may include urban development, clearing and timber harvesting, changed flow regimes, trampling by stock in riparian areas, weed invasion and fungal disease (chytridiomycosis, caused by *Batrachochytridium dendrobatidis*) (Campbell 1999, Hines et al. 2002). Strict hygiene protocols have been developed to minimise the spread of chytrid infection in New South Wales (NPWS 2001).

The recovery plan describes habitats critical to the survival of the species in terms of an arbitrary 40-m corridor centred on the middle of the stream. The authors acknowledge that this may be inadequate for protecting water quality, hydrological processes and non-breeding habitat for the frogs. Critical breeding habitat for the southern barred frog is regarded as permanent freshwater streams from 0-700 m altitude, in forest communities that include the narrow riparian rainforest remnants along the Mary River.

In surveys conducted for the EIS, the southern barred frog was detected at numerous stream sites in lowland vine forest and riparian gallery forest. It was most often found along tributaries, but also occurred at two locations on the Mary River, albeit near tributary inflows. It appears to be concentrated in the eastern tributaries (Belli, Happy

Jack and Skyring Creeks). The only western tributary where the species was found was Coonoon Gibber Creek.

4.4.2 Potential impacts

Will the proposal lead to a long-term decrease in the size of the population?

The EIS acknowledges that flooding will have a significant impact on the occurrence of the southern barred frog at the northern limit of its range, and will reduce its distribution within the Mary River catchment (e.g. 7-79).

The size of the population, or sub-populations, in the Mary catchment is unknown, but the distribution obviously is fragmented. The frogs along Belli Creek and other tributaries are essentially remnant groups that have survived despite clearing, grazing and other disturbances.

The southern barred frog is a stream species and there is no suggestion that it would occupy new habitats along the reservoir shoreline, except perhaps in upstream areas, provided there is a riparian buffer (Section 3.5.5, p13). Although riparian gallery-forest habitats would remain along Belli Creek, above FSL, lowland habitats along the Mary River, Skyring Creek and Belli Creek would be flooded.

The EIS suggests that the proposed 1.5-m riparian buffer zone may allow some individuals to move upstream along Belli Creek into riparian gallery forest outside of the inundation area, “as flooding occurs gradually”. Elsewhere, it is suggested that the reservoir should fill within one year. Much depends on the rate of rise, the continuity of habitats and the frogs’ capacity to move to new environments.

As a result of the loss of habitat, and the already-fragmented nature of the population, it is probable that the local population would decrease.

Will the proposal reduce the area of occupancy of the species?

Flooding along the Mary River, Belli Creek (in part) and Skyring Creek will significantly reduce the area of occupancy. Upper parts of Belli Creek may remain as a refuge, if the riparian zone is preserved.

Will the proposal fragment an existing population into two or more populations?

In the Mary catchment, the species occurs mainly upstream of the dam site, so that eastern and western tributary habitats in that region would be isolated. Flooding may also isolate eastern tributary populations unless, as the EIS suggests, the frogs are able to move across sub-catchments by traversing forest habitats. From what is known of the species’ capacity for movements, and its affinity for stream banks, this seems unlikely. Tracking studies (Streatfeild 1999, Lemckert and Brassil 2000) refer only to movements during the breeding season, but it appears that individuals make daily movements along and across the stream, and rarely move further than 50 m from the stream. At other times, activity may be hampered by low temperatures (Koch and Hero 2007).

Will the proposal adversely affect habitat critical to the survival of a species?

Flooding will destroy a substantial area of habitat, or potential habitat, in riparian areas of the Mary channel and lowland areas of Belli and Skyring Creeks. This will include areas of 'critical' habitat, as defined in the recovery plan (Hines et al. 2002).

Will the proposal disrupt the breeding cycle of a population?

This is a stream-breeding species, incapable (so far as known) of breeding in a reservoir environment. It is possible that the species would breed in upstream areas, particularly along tributaries, where riparian zones are preserved.

Will the proposal modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Riparian habitats below FSL, along the Mary River, Belli Creek and Skyring Creek will be flooded. As noted above, upper Belli Creek may remain as a primary refuge.

Will the proposal result in invasive species that are harmful to a species becoming established in the species' habitat?

Predation on eggs and tadpoles by gambusia (*Gambusia holbrooki*) is a threatening process, acknowledged in the Recovery Plan (Hines et al. 2002). Common carp and tilapia would be significant predators if they became established in areas occupied by the frogs, but they would be more likely to occupy littoral areas in the main body of the reservoir.

Will the proposal introduce disease that may cause the species to decline?

Although the project would not deliberately introduce disease, increased access by humans and the localisation of the population in Belli Creek would make it more vulnerable to chytridiomycosis. The fungus is implicated in the declines of several frog species (Campbell 1999), but is not known to have played a role in the decline of the southern barred frog.

Will the proposal interfere with the recovery of the species?

Although some present and potential habitat would remain, the project will destroy areas of existing habitat and will therefore interfere with the Recovery Plan (Hines et al. 2002).

4.4.3 Mitigation and offsets

The following strategies are recommended in the EIS:

- Vegetation will not be cleared within riparian zones within approximately 1.5 m elevation of FSL. Depending on inundation frequency and duration, this habitat will remain 'for some time' in the upper reaches of the dam along Belli Creek and Skyring Creek.

- Habitat immediately upstream from known populations will be quarantined for relocation and rehabilitation purposes. In this way, as the habitat near FSL that was not cleared dies (*sic*), the fauna can move into the quarantined and rehabilitated habitat. The habitat in several locations is already suitable but can be improved through targeted rehabilitation and protection.
- Environmental Management Plans must be developed for all works adjacent to the Mary River and tributaries to prevent increased sedimentation, erosion, weed invasion and nutrient and chemical pollution.
- Pre-construction monitoring should be completed to determine existing frog population size along Belli Creek and Skyring Creek, both within the inundation area and upstream of FSL. The population should be monitored during and post-construction.

It is not clear who would have responsibility for implementing these recommendations, or whether they represent commitments by QWI. The EIS suggests that rehabilitation will be carried out on Happy Jack Creek, subject to monitoring and evaluation of community-led projects in this area, but this is not mentioned under ‘mitigation’. The FSCC is not mentioned in this context, and there is no explicit support for the Recovery Plan (Hines et al. 2002).

Frogs were recorded in riparian gallery forest along upper Belli Creek, above the level of the reservoir, and this would remain, as potentially the main refuge for the species in the Mary catchment.

4.4.4 Residual impacts

The proposed mitigation and offsets are framed in very general terms and it would be difficult to measure compliance after dam construction. If, as appears, frog populations in tributaries will become further isolated, it may be useful to consider declarations of stream reserves protected from cattle and other disturbances related to land use. It would be useful also to establish and maintain continuous riparian habitats to ensure connectivity along and, where possible, between stream habitats. Some of these activities, however, are not under the control of the proponent.

4.4.5 Impact assessment

The biological and ecological data available to support assessment are sparse. The proposed mitigation and offsets do not appear to represent a clear commitment on the part of the proponent. They do not include a research agenda, but do support monitoring underway by local community groups (e.g. Mary River Catchment Coordinating Committee).

There is a very high risk that the southern barred frog population would be adversely affected by the effects of the proposed dam. This would contribute to the overall fragmentation and degradation of habitat throughout the range of the species.

4.5 Coxen's fig-parrot, *Cyclopsitta diophthalma coxeni*

4.5.1 Status

Coxen's fig-parrot (Psittacidae) is an *endangered* species under the EPBC Act. It is the largest subspecies of Australia's smallest parrot, the double-eyed fig-parrot, with another seven subspecies ranging from north-eastern Queensland to New Guinea and the Aru Islands. Coxen's fig-parrot could warrant separate-species status, but genetic analyses are needed for confirmation.

A summary of knowledge is provided by the Coxen's Fig-Parrot Recovery Team (2001). This includes a comprehensive Recovery Plan that was due for review in 2006.

Coxen's fig-parrot is among the rarest of Australian birds, with about 60 recorded sightings in south-eastern Queensland since 1970. It was once widespread from north-eastern New South Wales north to the Mary Valley, but has declined due to land clearance and habitat fragmentation. It is not formally recorded from the Mary Valley, but is known from adjacent areas, and there seems little doubt that it did and probably still does occur locally, as a seasonal visitor.

An important caveat is that surveys carried out for the EIS did not coincide with the seasonal fruiting period of local fig trees and very few mature fruits were present. The absence of sightings therefore is to be expected.

Fig-parrots are cryptic and difficult to observe in nature. They are highly mobile and may inhabit lowland rainforest in winter and disperse at other times to feed on native fruits, especially figs (*Ficus* spp.), in lowland and upland areas. They may also visit isolated trees in grazing land, parks and gardens.

4.5.2 Potential impacts

Native figs are abundant in the Mary Valley, and occur in several areas marked for clearing as part of the project (7-71). The Coxen's Fig-Parrot Recovery Plan notes that lowland forests, like those along the Mary River, may be a significant food source for this species during the critical winter period. It also identifies intermittent gaps in food availability during the year as a threat to the species.

The EIS estimates that 10% of mature fig trees located in the survey would be lost (28 among 277 identified trees). This would under-estimate the likely total impact, as figs occur in other parts of the project area.

Vegetation clearance associated with the project could therefore affect the regional food reserves available to the fig-parrot.

4.5.3 Mitigation and offsets

The revegetation strategy for the project area would include plantings of at least 56 native figs and other native fruiting trees in targeted areas, although it is not clear how this number was arrived at. Ideally, these plantings should augment existing stands of figs. Other *Vegetation Management Offsets* (VMOs) are described (e.g. 7-88), but these relate mainly to riparian revegetation and retention of buffer areas to compensate for the loss of riparian vegetation and about 144 ha of 'significant regional ecosystems'.

4.5.4 Residual impacts

There would be a delay of some years after destruction of existing fig-tree stands before the new plantings bear fruit.

4.5.5 Impact assessment

It is difficult to apportion effects, but it appears that the project would contribute to the overall fragmentation of habitat for the subspecies, and would deplete a winter food-source. The proposed mitigation and offsets offer little to counter the loss of fruit trees, and consideration might be given to a much-expanded program of plantings.

4.6 Spotted-tailed quoll, *Dasyurus maculatus maculatus*

4.6.1 Status

The spotted-tailed quoll (Dasyuridae) (aka spot-tailed quoll, spotted-tail quoll, tiger quoll) is a small carnivorous marsupial with two subspecies: *D*. *m*. *gracilis* in northern Queensland and *D*. *m*. *maculatus* in coastal areas from south-eastern Queensland to Tasmania. It is an *endangered* species under the EPBC Act, and is *vulnerable* in Queensland (*Nature Conservation (Wildlife) Regulation 1994*).

This is a forest-dependent species, recorded from rainforest, wet and dry sclerophyll forest and woodland habitats where it favours rocky outcrops, gullies and riparian areas, but not highly disturbed areas and plantations. The species was once more widespread, but is now isolated in areas that may be too small to sustain viable populations (Edgar and Belcher 1995). Land clearing has reduced the area of habitat and caused declines and local extinctions. Secondary threats include poisoning from 1080 baiting (DEH 2004), hunting, vehicle mortality, predation and competition from cats, dogs, foxes and other feral animals, poisoning by cane toads and eradication as a threat to domestic poultry. Recent ecological studies include Belcher (2003), Belcher and Darrant (2004, 2006) and Claridge et al. (2006).

The spotted-tailed quoll is not recorded from the study area, but it may occasionally visit the inundation area, particularly riparian areas. It is highly mobile and estimates of the home range vary from thousands of hectares to 20 km^2 (e.g. Edgar and Belcher 1995).

There is no recovery plan for the species in Queensland or at the national level.

4.6.2 Potential impacts

The project will remove existing, discontinuous tracts of riparian forests along the Mary River and its tributaries, within a mosaic of cleared agricultural and rural land, and will therefore contribute to habitat fragmentation over the range of the species.

Cats, dogs and foxes pose a threat, and increased human visitations, particularly with dogs, could have an impact. Cats may transmit protozoan parasites to quolls (Edgar and Belcher 1995). Baiting with 1080 also is a threat.

4.6.3 Mitigation and offsets

None proposed.

4.6.4 Residual impacts

Not applicable.

4.6.5 Impact assessment

The destruction and fragmentation of potential habitat would discourage quolls (and other species), but in the absence of confirmation that the species does occur locally, and a formal recovery plan, it is difficult to recommend a course of action other than to implement a survey and monitoring program before and after dam construction.

4.7 Plectranthus, *Plectranthus torrenticola*

4.7.1 Status

The genus *Plectranthus* (Lamiaceae) is widespread in tropical Africa and Asia, and includes about 40 Australian species of herbs and herbaceous shrubs. According to Halford (1998), *P. torrenticola* occurs on rocky outcrops in heathland and rainforest margins, at altitudes of 250-450 m, and is restricted to a 500-km^2 area between Kenilworth and Bli Bli in south-eastern Queensland. Little is known of its biology and ecology. It is an *endangered* species under the EPBC Act, and is listed as 'endangered wildlife' under the Queensland *Nature Conservation Act 1992*. It is affected by pedestrian traffic at Kondallila Falls National Park (Forster in Halford 1998).

In the EIS, *P. torrenticola* is considered as part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus*, *Bosistoa transversa*, *Cossinia australiana*, *Floydia praealta*, *Fontainea rostrata*, *Macadamia integrifolia*, *M. ternifolia*, *Pouteria eerwah*, *Sophora fraseri*, *Romnalda strobilacea* and *Xanthostemon oppositifolius*. None is recorded from the project area.

4.7.2 Impacts

This species is treated as part of the *Rainforest Assemblage* (Section 6, p69).

4.8 Triunia, *Triunia robusta*

4.8.1 Status

The glossy spice bush (Protaceae), is an *endangered* species under the EPBC Act. It is an understorey shrub presumed extinct until rediscovered in 1989, in pockets of subtropical rainforest on the Sunshine Coast (Shapcott 2002). The species is not recorded from the project area, but habitat-modelling suggests that it could have occurred there prior to land clearing (Powell et al. 2005).

4.8.2 Potential impacts

If present in the project area, this species would be extirpated by flooding, and may also be vulnerable to weed invasion and root-rot fungus.

4.8.3 Mitigation and offsets

None proposed.

4.8.4 Residual impacts

Not applicable.

4.8.5 Impact assessment

The likelihood of an impact cannot be assessed as the species is not recorded from the project area. It is not clear who would be responsible for surveys, monitoring and management.

5. Vulnerable species

5.1 Significant Impact Guidelines

Following DEH (2006), an action is likely to have a significant impact on a *vulnerable* species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population of a species;
- reduce the area of occupancy of an important population;
- fragment an existing important population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- introduce disease that may cause the species to decline; or
- interfere substantially with the recovery of the species.

5.2 Australian lungfish, *Neoceratodus forsteri*

5.2.1 Status

The Australian lungfish (Ceratodontidae) (aka the Queensland lungfish) is a *vulnerable* species under the EPBC Act. It has been protected by the Queensland *Fish and Oyster Act* since 1914, and listed under the C*onvention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) since 1977.

The Traveston Crossing Dam proposal is widely perceived as a threat to the lungfish, and has attracted global attention in this respect (e.g. Nature 2006, Arthington 2008).

The Australian lungfish is the most primitive survivor of a 400-million year old lineage that otherwise is represented by one species in South America and four in Africa. It ranged more widely in Australia until the Pleistocene, 1.6 million years ago (Kemp 1991, 1997), but now persists as remnant natural populations in the Mary and Burnett Rivers, and as translocated populations in the Brisbane, Coomera and North Pine rivers.

Lungfish habitats have been degraded by agriculture, forestry, river regulation and alien species (Arthington et al. 1983, 2000, 2008; Kemp 1995; Pusey et al. 1993, 2004; Mackay et al. 2003; Kennard et al. 2005; Duivenvoorden 2008). Like the Mary River cod and Mary River turtle, the lungfish is slow-growing and long-lived. The age of first breeding is 15-17 years for males and 20-22 years for females (e.g. Pusey et al. 2004). Individuals may live for more than 60 years under the most favourable conditions.

There is not a Recovery Plan for the Australian lungfish, although a draft was near completion near the time that the Traveston Crossing Dam EIS was released. The *Annual Report* of the Mary River Catchment Coordinating Committee in 2007 included the following:

> "The Lungfish Recovery Plan is in its final stages with the last meeting of the Recovery Plan Team held in September 2007 before the Plan goes out for stakeholder comment. After this process it is submitted to the Federal Department of Environment and Water for approval and is open for public comment for three months. The Plan was to be ready for Federal submission by February 2007 however forced changes to the priorities of some team members held up progress. It is envisaged that the Plan will be finalised by early 2008. It will be a useful tool for research and planning generating opportunities for projects that assist this unique fish to persist long into the future. As flow regulation and barriers to movement are the highest priority threats it is hoped that the Plan will provide information and direction for decision makers who influence the future of the Mary and other rivers."

It is not clear why the plan has not been released for comment, or for incorporation into the Traveston Crossing Dam proposal. The lack of a formal plan for this species, as for the Mary River turtle, is a serious impediment to the EIS process.

5.2.2 Potential impacts

Will the proposal lead to a long-term decrease in the size of the population?

A survey of lungfish in the Mary River was made for the EIS (Hydrobiology 2007) (8.6.5.2, Appendix F-5), and later supplemented by data from the Queensland DPIF *Long Term Monitoring Program*. The evidence shows that lungfish are reasonably common in the Mary channel and several tributary streams, and common also in the Burnett River. The species' *vulnerable* status under the EPBC Act reflects its small geographic range and threats to habitat and recruitment rather than its population size.

The population in the Mary River depends on the integrity of the habitat and sustained recruitment. These issues are considered below.

The EIS (8.6.5.2) and Supplement point to the Brisbane River, where lungfish have been translocated and now live above and below Wivenhoe Dam, as evidence that lungfish can survive in regulated-flow environments. Comparisons are deceptive, however, as daily flows below Wivenhoe Dam are 5-10 fold greater than those likely to prevail downstream of Traveston Crossing Dam (100-200 ML/day). There will not be equivalent habitats below Traveston Crossing Dam, and the diminution of flows during the lungfish breeding season (July-December) threatens spawning and recruitment. There is also substantial doubt that lungfish would recruit successfully in the Traveston reservoir; this is conceded in the EIS.

The EIS argues that as the inundation area is only a small part of the available habitat for lungfish, and as adults would live in the reservoir and because (according to the EIS) breeding is likely to be improved in the tailwater, a long-term decrease in the size of the population is not expected. It is not established that breeding would occur in the tailwater, but if it does not, the impact zone would cover twice as much of the available habitat as the reservoir itself.

Will the proposal reduce the area of occupancy of the species?

Lungfish are common in the Mary channel above the tidal barrage (59 km from the mouth) (Brooks and Kind 2002), and they occur also in Amamoor, Six Mile, Obi Obi and Yabba Creeks, in western tributaries like Widgee Creek, and in the Tinana-Coondoo Creek system.

The EIS claims that the project will not reduce the area occupied by lungfish because they are known to occupy reservoirs. In fact, adults occupy (some) reservoirs, but there are doubts over the suitability of both reservoir and tailwater environments for breeding and the survival of juveniles. It is also likely that the proposal will reduce the *quality* of habitat for the species.

Although impoundments do provide habitat and foraging areas for adult lungfish, they favour upper reaches that retain some riverine characteristics (Brooks and Kind 2002). It is potentially misleading to claim that lungfish breed in reservoirs and weir pools.

Adult lungfish favour shallow, flowing reaches with overhanging riparian vegetation, submerged snags, dense beds of ribbon weed (*Vallisneria nana*), hydrilla (*Hydrilla verticillata*) and floating species (e.g. water primrose, *Ludwigia peploides*; water lilies, *Nymphaea*; marshwort, *Nymphoides*) (Kind 2000). The Traveston reservoir inundation area will cover 36.5 km (about 22%) of this habitat upstream of Gympie, and will extend into several tributaries. Within the reservoir, these kinds of habitats are likely to occur only in the uppermost, riverine reaches.

In 2002, 41% of the range of lungfish in the channel of the Burnett River (128 km) was occupied by impoundments (Brooks and Kind 2002), and if the Paradise reservoir fills completely the proportion will increase to 55% (173 km) (Arthington 2008). Traveston Crossing Dam Stage 1 will mean that 26% of core lungfish habitat in the Mary River is impounded, and if Stage 2 is constructed the proportion would approach 40% (Arthington 2008). This offers little security for a *vulnerable* species, under the EPBC Act, and may evoke nominations that the species should be declared *endangered*.

Will the proposal fragment an existing population into two or more populations?

Genetic consequences

The EIS acknowledges that the dam would fragment the area occupied by the lungfish in the Mary catchment, but maintains that “multi-tiered transfer strategies” would allow them to access habitats up- and down-stream of the dam, and so ensure genetic mixing.

An incidental argument that “fragmentation over a long period has apparently not impacted the population in the Brisbane River as the barriers on that system have no fish transfer devices” cannot be accepted in the absence of genetic evidence. Frentiu et al. (2001) do not address this issue.

Lungfish populations in the Mary and Burnett Rivers are not genetically diverse (Frentiu et al. 2001). Low variation at two classes of neutral, independent markers suggests that there is low variability across the genome, probably including loci linked to fitness and resistance to disease. Low genetic variation is typical of ‘endangered’ species, and is often associated with inbreeding depression, population declines, lower evolutionary potential and a high risk of extinction (Frankel and Soulé 1981, Frankham 1996). Indeed, reduced variability may be a symptom as well as a cause of extinction (Dunham et al. 1999). Low genetic diversity implies a low potential for evolutionary adaptation to change, and this combined with other attributes of the lungfish, including sporadic recruitment, slow growth and long generation times, could limit the species’ capacity to adapt to changes in environmental conditions associated with the new dam.

The significance of the apparently low genetic diversity is illustrated, for example, by the Comparative Genome Evolution Committee’s (2006) recommendation for genetic sequencing studies on the lungfish as part of the *Human Genome Project*. This will contribute to understanding of the transition to life on land, reflecting the lungfish’s Devonian origins and close relationship to the first tetrapods (Daeschler et al. 2006).

Movements

Lungfish are naturally sedentary but do undertake regular, small-scale movements and may move further afield (Pusey et al. 2004). In free-flowing reaches, adults usually move around one or two pools at night, and may cross riffle areas, but then return each day to a resting retreat (submerged log, rock or plant bed). Their fidelity for a daytime retreat may last for years. In a radio-tagging study by Kind (2002), however, four (20%) of 20 radio-tagged fish moved more than 5 km from their original location.

In impounded reaches of the Burnett channel, lungfish movements are variable and may extend for tens of kilometres (Kind 2002), and there appears to be an annual cycle of movements in search of spawning habitat (Brooks and Kind 2002). These migrations apparently do not occur in the free-flowing channel of the Mary River.

The Supplement’s assertion that the lungfish “probably has limited need of substantial movement past the dam site” could be interpreted in a number of ways, but appears to accept the need for movements while downplaying their significance. Accordingly, QWI proposes a fish-transfer device and, if necessary, a catch-and-carry program.

The movements of lungfish are restricted, of course, by waterfalls and other natural barriers, as well as dams, weirs, barrages and culverts. They have been stranded downstream of the tidal barrage on the lower Burnett River, being too large to enter the vertical-slot fishway (Brooks and Kind 2002; Stuart and Berghuis 2002). Similar strandings have occurred at the Mary Barrage and North Pine Dam (Johnson 2001).

Fishways and catch-and-carry transfers

Scant information is available on the use of fish-transfer devices by lungfish, and there is no persuasive evidence that the fish are able to use existing facilities in numbers sufficient to offset the genetic effects of fragmentation.

There are few data on lungfish injured or killed when swept over dams and barrages during high flows, although they would be expected to be vulnerable. During a field inspection at Paradise Dam (Section 1.2, p2), there appeared to be no devices in place to rescue fish from being swept over the spillway, although DPIF is known to have a monitoring program in place, in preparation for higher flows. The EIS for Traveston Crossing Dam makes brief reference to a similar monitoring program to be established for lungfish and turtles, and presumably other species. The downstream passage included in the fish-transfer device at Paradise Dam has not operated during prolonged low-flow conditions (e.g. DEWR 2007).

References to “the apparently highly successful” catch-and-carry in the 19th Century merely affirm that lungfish (and Mary River cod) can be captured and transported to new habitats. The fundamental issue of genetic isolation was not considered then, and it is treated superficially in the EIS.

Will the proposal adversely affect habitat critical to the survival of a species?

It is likely that the overall *quality* of lungfish habitat in the Mary River will be adversely affected. There presently is breeding habitat for lungfish in the area marked for inundation, and in the tailwater. These areas together represent a substantial part (about 70 km) of the range of the species in the Mary River.

Adult lungfish occur in dam and weir impoundments (Kemp 1984, Brooks and Kind 2002, Hydrobiology 2007), including the Mary Barrage pool, and are often in good physical condition, indicating that food resources are not limiting. This could be misleading because small (weir) and large (dam) impoundments are physically and ecologically different environments, and it needs to be confirmed that the lungfish are breeding in the pools or reservoirs and not in the riverine areas in the upstream reaches. There appears to be no evidence that lungfish are able to form self-sustaining populations strictly within reservoir environments.

The EIS suggests that lungfish breeding may be enhanced in the regulated flow environments below dams, following observations in the Brisbane River (Hydrobiology 2007) and the Burnett River (Brooks and Kind 2002). Much depends on whether the tailwater regimes will favour beds of macrophytes in shallow water.

The EIS suggests that

> "it is highly likely that an increase in *Vallisneria* will occur downstream of the Project as it is currently present but frequently stripped by high stream flows",

and

> "…clear water scouring would be expected to increase and/or maintain pool depth immediately downstream of the dam wall and, notwithstanding other potential impacts, this may benefit larger fish species, including Mary River Cod and Lungfish. The effects of clear water scouring will decrease with distance downstream from the dam wall",

and

> "As negative impacts of clear water scouring on the general aquatic fauna community are relatively localised and minor, the potential positive benefits … will be capitalised on by strategic riparian re-vegetation and rehabilitation of instream habitat complexity (i.e. re-snagging) within the affected reach. [This] will stimulate macroinvertebrate production in riffles that will then filter through to pools containing fish further downstream."

On the contrary, there is reason to expect that scouring will limit the development of *Vallisneria* beds, and pool-riffle macroinvertebrate communities, downstream of the dam. These effects are typical of dam tailwaters around the world (e.g. Petts 1984).

If flows cease completely, and pools dry, the lungfish can survive if the skin surface is constantly moist, but for only a few days. Unlike its African relatives (*Protopterus* spp.), the Australian lungfish is not capable of forming a cocoon to aestivate in dry sediments (e.g. Grigg 1965).

Will the proposal disrupt the breeding cycle of a population?

Lungfish are selective in choice of spawning sites (Kemp 1986a,b, 1995; Pusey et al. 2004). Between 50-100 eggs are laid in dense beds of water plants, at 400-600 mm depth, in clear, well-oxygenated, moderately-flowing water (0.2 m/s), at temperatures up to 36^{o}C (Brooks and Kind 2002). Occasionally, they will spawn among the submerged roots of riparian trees or partly-submerged grasses (Brooks and Kind 2002). They may lay eggs in still and flowing water (Brooks and Kind 2002) but this is not, as the EIS implies, confirmation that they could breed, or recruit, in a reservoir.

The EIS suggests that flow may not be a cue for breeding, contrary to some submissions. If lungfish commence to breed 11 weeks after the shortest day of the year, according to Kemp (1984), this does not mean that day length (or temperature) is the trigger. Photoperiod, temperature and flow, and other factors, are all likely to change at that that time of year, and it is not possible to attempt to isolate one factor without appropriate experimentation. It is likely that lungfish respond to a suite of seasonal changes rather than any one factor.

Most knowledge of spawning behaviour comes from studies in the Burnett River (Brooks and Kind 2002). Spawning has been observed in a 7-km riffle-and-glide section of the Burnett above the Burnett Barrage (Kind 2002), but there is no evidence that spawning occurs in impoundments on the Burnett River (Arthington 2008). Paradise Dam has steep banks and fluctuating water levels, and there are limited opportunities for macrophyte beds to develop. A rapid 250-mm reduction in water level is reported to have killed many eggs in *Vallisneria* beds in Bingera Weir on the lower Burnett River (Brooks 1995).

Impoundments on the Burnett River have removed 26% of the core distribution of the lungfish, and there has been a marked decline in the quality and extent of breeding habitat (Brooks and Kind 2002). This may also have occurred in recent drought conditions. While impoundments provide habitat and feeding grounds for adults, the conditions needed for spawning would rarely occur in impounded areas (Pusey et al. 2004). The preferred spawning habitat, and also the habitat for juvenile fish, is dense beds of water plants in shallow water, whereas impoundments tend to have steep banks, deep water and fluctuating levels.

Information about spawning in Mary River habitats is very limited. Suitable macrophyte beds were rare in the Mary River in 1999-2002, following a flood that scoured the river banks, and lungfish recruitment was reduced (Brooks and Kind 2002). Spawning habitats in the Mary channel and some tributaries upstream of Traveston Crossing Dam would be inundated, and shallow embayments with or without aquatic and riparian vegetation, limited water movement and large expanses of open water would present few options for spawning.

Lungfish eggs hatch about three weeks after spawning. The hatchlings favour dense beds of vegetation, in shallow water, where they feed on small crustaceans, molluscs and worms. Juveniles are cryptic (< 300 mm) and notoriously difficult to observe or sample. They remain in these habitats for months or years after hatching, before moving into deeper water (Brooks and Kind 2002).

In reservoirs, the main threats to survival of eggs and hatchlings would be stranding and desiccation caused by declining water levels, either through reduced inflows or extraction for human use. Although Traveston Crossing Dam is intended to supply a constant level of withdrawal, the water level will fall when extraction and downstream flows exceed inflows. The Supplement suggests that it is the rate of change of water level, rather than the actual change in depth, that is most relevant to the survival of eggs and larvae. Allowing for some variation between wet and dry years, the reservoir level will fall (say, 1.5 m) at a rate of about 200 mm per month from July to December, during the lungfish breeding season. At this rate, eggs and larvae in the shallow water could be stranded.

In general, it is likely that successful recruitment does not occur every year, due to variations in spawning conditions and food resources, and likely also that some years produce stronger age classes than others (e.g. Boardman 1995, Johnston 2001, Brooks and Kind 2002). This is an important caveat for conservation, in that failed recruitment over several years may easily go un-noticed, so that adults remain common and the population seemingly secure for a few decades, only to decline catastrophically as the older individuals die. In this species, recovery from a catastrophic decline is likely to be very protracted.

Failures to detect juvenile lungfish cannot be explained simply by saying that they are cryptic and difficult to observe. This is a *critical* issue, and the EIS proponents should have expended a greater effort to reinforce their claims in this respect. It is possible that failure to locate juveniles means failed recruitment. If that is correct, and if it were to persist, a catastrophic population decline is inevitable.

Where there are no satisfactory methods for age determination, length and weight can be used as surrogates. It is surprising that there are no indications of which years, historically, have produced strong age classes in the lungfish, although it is known that recruitment in the Burnett River population has been poor for over a decade because macrophyte beds were stripped by floods in 1997-1999 and took a long time to recover (Brooks and Kind 2002). Under these conditions, the mere presence of many mature fish does not necessarily mean that the lungfish population is 'healthy'. If recruitment has indeed been poor for a decade or more, the evidence is to the contrary.

Although the Supplement dismisses submissions pointing to the need for Population Viability Analysis (e.g. Beissenger and McCulloch 2002), modelling could be a means to assess the responses of populations to environmental changes that could affect parameters like hatching success, juvenile survival, recruitment and emigration or immigration. The fact that such models do not yet exist for lungfish, or other EVR species in the Mary River, could be seen as an affirmation that biological and ecological knowledge is very limited. In keeping with the Precautionary Principle, areas of doubt should be respected rather than met by assumptions.

Will the proposal modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The Supplement states that:

> "The EIS noted that adult lungfish reportedly favour submerged logs, dense banks of aquatic vegetation and their preferred habitats are pools of 3-10 m depth. In habitats such as these, they can often live in large groups (Kemp 1986). All lungfish under 500 mm in length collected by Brooks and Kind (2002) were caught in still water in the sort of dense macrophyte growth favoured for spawning, suggesting that juveniles prefer the same habitat. All of these conditions will be mirrored in the majority of the Traveston Crossing Dam."

In fact, most of the reservoir environment will have no similarity to these conditions. The EIS and Supplement consistently liken the reservoir, or parts of the reservoir, to the pool-riffle environments inhabited by lungfish. Although it is true that the reservoir will provide a variety of habitats, most of the physical diversity will be in the uppermost reaches, in a relatively small area where the banks are likely to be steep and there may be few shallow areas where macrophyte beds can develop. These are the limits of a much larger expanse of water that is very different in character. It may accommodate adult lungfish, but the more important issue is whether the reservoir and its fringe areas could sustain lungfish populations. In this respect it is misleading to compare small and large impoundments—the Mary Barrage pool, for example, is a different environment from a large, deep reservoir.

Will the proposal result in invasive species that are harmful to a species becoming established in the species' habitat?

The Supplement states that

> "The Project in itself will not introduce invasive species to the Mary River catchment. Consequently, invasive species will not reduce the habitat available to the lungfish."

It is true that the project does not necessitate the establishment of invasive species, but reservoirs generally do facilitate the establishment and spread of alien species of plants and fish (Bunn and Arthington 2002). In the Traveston reservoir, areas of still, shallow, eutrophic water would be colonized by plants (Duivenvoorden 1998, Mackay et al. 2001), and alien weeds (e.g. *Cabomba caroliniana, Egeria densa, Eichhornia crassipes, Salvinia molesta)* would dominate. These provide different habitats from those in natural riverine areas (Pusey and Arthington 2003) and may not attract lungfish, although they may spawn on the roots of water hyacinth (e.g. Brooks and Kind 2002).

There are also concerns that the lungfish could be threatened by alien and translocated fishes already present in the Burnett and Mary catchments (Pusey et al. 1993, Kennard 2004). For example, the ubiquitous gambusia ('mosquitofish': *Gambusia holbrooki*) preys on the eggs and juveniles of native fish and competes with other small species for food and habitat (Arthington and Lloyd 1989, Arthington and Marshall 1998). The Mozambique tilapia (*Oreochromis mossambicus*), a declared noxious species in Queensland, is present in Boondooma Dam on the Burnett River and other impoundments in south-eastern Queensland, and could be introduced to the Mary. Tilapia is an aggressive competitor with potentially devastating impacts on native fish and their habitats (Arthington and Blühdorn 1994; Arthington et al. 1994; Canonico et al. 2005).

Will the proposal introduce disease that may cause the species to decline?

This is not anticipated.

Will the proposal interfere with the recovery of the species?

Recovery plans generally are designed to restore and maintain habitats. A plan for the lungfish apparently is in an advanced stage of preparation, but has not yet been released (Section 5.2.1, p49). Traveston Crossing Dam will reduce and fragment larval, juvenile and adult habitats along the Mary River, and while the reservoir may support mature lungfish, they appear unlikely to breed or recruit there with the intensity that they do in their present riverine habitat. The proposal therefore is likely to interfere with recovery.

5.2.3 Mitigation and offsets

Acknowledging the potential for a net loss of breeding opportunity caused by the dam, the EIS states that:

> "It is a practical approach to mitigation that if an impact of the dam is the reduction of breeding potential of lungfish in that location, then that should be compensated by increased potential in the regulated flow regime downstream."

The following 'strategies' are recommended for the lungfish:

- Retention of vegetation (i.e. areas within 1.5 m elevation of FSL in riparian areas);
- When this vegetation dies, it will allowed to stand and offer habitat to fish and roosting birds;
- Re-vegetating targeted fringing margins of the dam, particularly riparian zones upstream from FSL, with species native to the area that are tolerant of periodic inundation, such as *Melaleuca quinquenervia* and *Waterhousea floribunda*;
- Artificially introducing snag habitat to the impoundment, drawn initially from trees removed prior to inundation;
- Manage dam levels, as far as practicable, to minimise impacts on macrophyte health;
- Compensating for the loss of snag habitat in the impounded area, by re-vegetating and re-snagging other parts of the catchment (particularly where lungfish are known to occur);
- Regular monitoring of the efficacy of the fishway and by-pass channel and, if they are not achieving a target success rate, adjust operation. If still not achieving the target, instigate catch and carry techniques;
- Undertaking regular and intense PIT tagging of lungfish in the Mary River prior to the fish transfer device becoming operational;
- Enhance knowledge and management capacity through support of the FSCC;
- Request DPIF undertake fish barrier assessments and rehabilitation of weirs in major tributaries upstream of the dam (Yabba Creek and Kandanga Creek);
- Manage the downstream flow regime as far as practicable to suit lungfish habitat requirements;
- Implement relevant actions identified in the Lungfish Recovery Plan (not yet released);
- Chapter 9.5.3.4 of the EIS noted several actions related to threats to the species, to be referred to the FSCC; and
- Implement the findings of the FSCC.

There are no assurances that lungfish would use the fish-transfer device proposed for Traveston Crossing Dam, and neither the up- or down-stream passages would be likely to provide lungfish with the level of connectivity that prevailed prior to dam construction. The device will be similar to that at Paradise Dam on the Burnett River, but there are no publicly-available data to demonstrate the efficacy of that facility for lungfish. The facility has been rated as only partially compliant, so far, with requirements under the EPBC Act (DEWR 2007).

If the Traveston fish-transfer device is inoperable, QWI will consider catch-and-carry methods as a means to ensure genetic mixing. It is unclear how the need for genetic mixing will be determined, or that it has been achieved. As lungfish recruitment under natural conditions is sporadic, and not necessarily annual, the need for catch-and-carry presumably would arise only when the fish-transfer device was inoperative over several years. Catch-and-carry should not be completely dismissed, but it does not appear to have been properly considered.

The EIS states that consideration will be given to the translocation of artificially-reared lungfish into areas where natural and man-made barriers prevent access to potentially useable habitat. Hatchery releases are considered a last resort in restoration of declining natural populations, and there are attendant dangers with 'genetic swamping'. The legacy of confusion introduced by the Gerry Cook Cod Hatchery, releasing unmarked Mary River cod fingerlings into wild populations, is another illustration of the inherent dangers in this approach (Sections 3.8.1, p20; 4.2.1, p23). In particular, Frentiu et al. (2001) recommended an evaluation of the genetic implications of lungfish population enhancement, including the effects of establishing gene flow among naturally-fragmented populations, before further translocations are considered.

5.2.4 Residual impacts

Most of the proposed mitigation 'strategies' for the Australian lungfish are directed broadly at other EVR species, including the Mary River cod and Mary River turtle. None guarantees that the net loss of breeding opportunity for lungfish in the reservoir will be compensated. In general, the proposal is not greatly strengthened by listing mitigation 'recommendations' (it is not clear to whom) that, taken individually, may not succeed for lungfish or other target species. The risk of failure must be considered high.

No measures are described to prevent injury and death of lungfish swept over the dam spillway during high flows, although a monitoring program is planned.

5.2.5 Impact assessment

Under the EPBC Act (DEH 2006), an *important* population is one that is necessary for the species' long-term survival and recovery, and may include key source populations for breeding or dispersal, populations that are necessary for maintaining genetic diversity and/or populations that are near the limit of the species' range (DEH 2006). The Burnett River (420 km) and the Mary River (250 km, above the tidal barrage) are the northern and southern limits, respectively, of the lungfish's natural range. Genetic diversity is low, indicating ‘bottlenecks’ associated with contractions of the former geographic range (Frentiu et al. 2001). The reduced range of the species, and the low diversity in the genome, suggest that the species has little capacity to adjust to environmental changes on the scale suggested by the Traveston Crossing Dam. These considerations satisfy the criteria for ‘importance’ under the EPBC Act, and indicate that the continued well-being of the lungfish population(s) in the Mary River is necessary for the species’ long-term survival and recovery.

In the absence of detailed knowledge about lungfish, in critical areas like adaptability, recruitment and dispersal, the prudent course is to be conservative. It is possible that the lungfish population is already in decline, due to failed recruitment, and in that respect the construction of a new dam and alienation of existing lungfish habitats represent an unacceptably high risk that the population would be severely impacted.

Principal concerns are:

- There are scant population data for the lungfish and little understanding of historical patterns of recruitment. Assessments in the EIS often are speculative.
- The inundation area (36.5 km) would destroy existing habitats and would be unlikely to sustain breeding and/or juveniles. It is imperative to know whether lungfish spawn, and juveniles can survive, in the conditions likely to prevail in Traveston reservoir (comparisons with smaller impoundments are spurious).
- Habitats in the tailwater (35 km) may be degraded or lost, and may not support breeding and juveniles. The inundation area and tailwater combined represent 29% of the length of the Mary River above the tidal barrage.
- The dam will impede movements of lungfish up- and down-stream. This includes normal movements and those that serve to offset genetic isolation. There is no evidence that lungfish will use the fish-transfer device, and there appear to be no measures to rescue fish from being swept over the dam wall in overtopping flows. The catch-and-carry strategy is not properly considered.
- The lungfish genome appears to allow little margin for adaptations to environmental change.
- The mitigation proposals are framed as general recommendations rather than commitments. In particular, the role of the FSCC is not clearly defined.

5.3 Black-breasted button quail, *Turnix melanogaster*

5.3.1 Status

The black-breasted button-quail (Turnicidae) is *vulnerable* under the EPBC Act. The species is cryptic, and less often seen than revealed by characteristic saucer-shaped feeding depressions (‘platelets’). It lives in vine forest habitats with a dense canopy and deep leaf litter, often adjacent to open forest. Its range has contracted greatly due to land clearing, but it remains in small areas of south-eastern Queensland and, to a lesser extent, north-eastern New South Wales (Hamley et al. 1997). It is listed as *threatened* on the IUCN *Red List*, and is listed also by CITES and the Queensland *Nature Conservation Act (Regulations) 1994.*

In south-eastern Queensland there are known 14 areas where the button-quail occurs (Hamley et al. 1997), and its sedentary nature suggests that there is little interchange between the isolates. The estimated home range is up to 6.2 ha (Smith et al. 1998, Lees and Smith 2000), being larger in rainforest fragments in agricultural landscapes than in undisturbed forest. The species is well-known in aviculture, but there is little information about natural populations (Smyth and Young 1996). The total wild population may be less than 2500 mature individuals, with no population exceeding 250 mature individuals (Collar et al. in Smyth and Young 1996).

Reported threats to the species include land clearing, tree-felling and urban development, fire, grazing and trampling by cattle, horses and feral pigs, and predation by cats, foxes and pigs.

In the EIS and Supplement, the occurrence of this species in the project area is assessed as 'not likely', on the slender basis that there is no 'optimal habitat' in the project area, and it was not detected in the most likely areas during the fauna survey.

According to DEWHA's SPRAT database, a draft national recovery plan in preparation.

5.3.2 Potential impacts

Not applicable.

5.3.3 Mitigation and offsets

None proposed.

5.3.4 Residual impacts

Not applicable.

5.3.5 Impact assessment

An assessment is not made in view of the absence of records for this species in the project area. The species does occur in the area of Paradise Dam on the Burnett River, however, and was an issue prior to dam construction:
(http://www.environment.gov.au/epbc/publications/pubs/burnett-audit-report.pdf).

5.4 Green turtle, *Chelonia mydas*

5.4.1 Status

The green turtle (Cheloniidae) is a *vulnerable*, *marine*, *migratory* species under the EPBC Act. It occurs in tropical and subtropical waters worldwide, and the Great Sandy Strait region, at the mouth of the Mary River, provides their main food resources, seagrass (*Halodule uninervis*, *Halophila ovalis and H. spinulosa*), algae and grey mangrove propagules. Their association with seagrass meadows exposes them to threats similar to those for dugongs (Section 7.2, p71).

5.4.2 Impacts

The EIS includes notes on the natural history of the green turtle, and other marine turtles that frequent the Great Sandy Strait, but offers no direct assessment of impacts. The implication is that the turtles occur outside the zone of influence of the dam. As with dugongs, it is difficult to identify likely changes that could confidently be ascribed to dam operations.

5.5 Grey-headed flying fox, *Pteropus poliocephalus*

5.5.1 Status

The grey-headed flying fox (Pteropodidae) is a *vulnerable* species under the EPBC Act. It occurs along the eastern coast of Australia, from Melbourne to Bundaberg (formerly to Rockhampton). Individuals form breeding camps during summer and then either disperse or join juveniles in winter camps. They feed on the fruits, nectar, pollen and blossoms of more than 80 plant species in rainforest, eucalypt forest and woodland, mangroves, *Melaleuca* wetlands and cultivated areas. They are highly mobile, and may travel long distances to exploit seasonal food resources.

In the EIS, the grey-headed flying fox is rated as having a 'moderate likelihood' of occurrence in the project area, but a colony was subsequently found in lowland vine forest on Hynes Estate Road, just outside the inundation area. The colony was estimated to be 90% grey-headed flying foxes and 10% black flying foxes (*P. alecto*).

According to the EIS, the main threat to the grey-headed flying fox is the loss of foraging and roosting habitats, as winter resources are limited to coastal areas that are subject to intensive development. Other threats include disturbance of roosting sites, especially near orchards, competition with other species (e.g. *P. alecto*) and electrocution on powerlines.

There is no formal recovery plan for the species in Queensland, or at the national level, but there are EPBC guidelines for protection of fruit crops and roosting sites. *The Action Plan for Australian Bats* (DEWHA 1999) also includes specific recommendations. In New South Wales, the Department of Environment and Climate Change has formulated priority actions for recovery of the species

5.5.2 Potential impacts

The colony and roosting habitat are outside the inundation area, but about 302 ha of remnant forest in the project area would be lost, reducing the foraging area for the colony. The EIS claims that grey-headed flying foxes can travel up to 50 km to forage, but does not indicate whether suitable alternative foraging areas exist within this range. The EIS acknowledges that loss of local habitat could increase the severity of seasonal food shortages, causing starvation, spontaneous abortion and high infant mortality, leading to a decline in the colony size and a reduction in the area of occupancy.

Roosting habitat would be protected, and measures would be taken to reduce construction noise disturbance. Road works east of the colony could affect the colony, although roosting camps elsewhere are reported to show some ability to cope with some traffic disturbance. The EIS includes assurances that no road works or stockpile areas would be in the patch of vine forest occupied by the colony, and that this would be mandated to ensure that roosting and breeding habitat is protected. Road works would be restricted during the breeding season, and noisy activities would be restricted to evenings and limited to 55 dB(A) (about the noise level of conversation at 1-m distance). The EIS suggests that with these measures the breeding cycle of the grey-headed flying-fox colony would not be disrupted.

This is insufficient assurance, in the reviewer's opinion, and a monitoring program should be invoked to monitor noise and disturbance and impacts on the colony, and to make daily adjustments to work practices as necessary.

Problems are not anticipated with invasive species or disease.

The EIS concedes that clearing of foraging habitat in the project area would conflict with the recovery of the species.

5.5.3 Mitigation and offsets

From the EIS, proposed mitigation measures are that:

- The habitat patch occupied by the colony would be protected from clearing associated with road works,
- Road construction would be restricted during the breeding season (Sep-Nov) to avoid disturbances to pregnant females and young,
- Noisy activities would be restricted to night time, after the bats have left the roost, and
- Construction sites and stockpile areas would be located away from the colony.

5.5.4 Residual impacts

The loss of foraging habitat would be a persistent problem. Proposed revegetation in the vicinity would take many years before it replaces the area lost, and by then the colony could have declined or disappeared.

5.5.5 Impact assessment

Dam construction and subsequent habitat loss are likely to have detrimental effects on the colony, and probably would cause it to disappear. The tenor of discussion in the EIS is that protection of the colony would, at the least, be difficult and some negative effects are anticipated. The degree of protection afforded the colony may possibly be improved by instituting a program of frequent monitoring of the colony, and adjusting work practices as necessary.

5.6 Red goshawk, *Erythrotriorchis radiatus*

5.6.1 Status

The red goshawk (Accipitridae) is a declared *vulnerable* species under the EPBC Act, and receives protection from the Queensland *Nature Conservation Act 1992* and the

Vegetation Management Act 1999. It ranges from northern Australia through eastern Queensland to north-eastern New South Wales. It once extended to Sydney but it is now rare in New South Wales.

The home range of individuals can be 50-220 km^2, and may include tall open forest, woodland, lightly treed savannah and rainforest edges. Nest sites are in exposed forks of trees 10-20 m tall, often in hill-slope country, and are re-used each year. In winter, the goshawks migrate to coastal plains, where they prey upon waterbirds.

The red goshawk is not confirmed from the project area, although breeding pairs do occur elsewhere in the Mary Valley. They may use riparian forest and wetland areas in the inundation area.

The species is threatened by land clearing and other factors that reduce the available prey. Illegal shooting and egg collecting are also threats. A Recovery Plan was prepared by the New South Wales National Parks and Wildlife Service in 2002, but there are no formal plans in Queensland or at the national level.

5.6.2 Impacts

Dam construction will remove patches of open forests, woodlands and riparian vine forests that are part of the habitat for the red goshawk. It is a highly mobile species, however, and ranges widely over tall open forests, woodlands and rainforest edges. It would be difficult to relate particular features of dam construction and operation to the overall decline of the species. If nesting pairs are discovered in the project area, they should be monitored.

5.7 Ball nut, *Floydia praealta*

5.7.1 Status

The ball nut (Protaceae) (aka possum nut) is *vulnerable* under the EPBC Act. It is a tree related to the Macadamia nut, and is superficially similar. It has a scattered distribution in riparian rainforest and vine forest from Gympie, on the Mary River, to north-eastern New South Wales. The known populations are small and sparsely distributed.

In the EIS, this species is considered as part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus*, *Bosistoa transversa*, *Cossinia australiana*, *Fontainea rostrata*, *Macadamia integrifolia*, *M. ternifolia*, *Plectranthus torrenticola*, *Pouteria eerwah*, *Sophora fraseri*, *Romnalda strobilacea* and *Xanthostemon oppositifolius*. After the EIS was prepared, ball nut was discovered in vine forest on hill-slopes along Frayne Road, just outside the north-western boundary of the survey area, and an assessment is included in the Supplement. The species generally occurs in notophyll vine forest with *Waterhousea floribunda* or with or without *Araucaria cunninghamii*.

Ball nut is threatened by clearing and fragmentation of habitat, burning, weed invasion and grazing and trampling of seedlings by stock.

There is no recovery plan in place in Queensland, or at the national level, but strategies have been developed by the New South Wales Department of Environment and Climate

Change, including fencing to exclude stock, weed removal, identification and protection of plants and habitats and re-connection of habitat remnants.

5.7.2 Impacts

This species is considered further as part of the *Rainforest Assemblage* (Section 6, p69).

5.8 Slender milkvine, *Marsdenia coronata*

5.8.1 Status

The slender milkvine (Asclepiadaceae) is a *vulnerable* species under the EPBC Act, and is protected by the Queensland *Nature Conservation Act 1992* and the *Vegetation Management Act 1999*. It occurs in rainforest margins and open eucalypt forest or woodland and grasslands. It ranges from Gunalda Range, north of Gympie, to Killarney, and has been recorded from Imbil State Forest and atop Mt Kandanga. It occurs also in scattered sites on the northern coast of New South Wales.

The species is known at two locations in the project area, one being in the inundation area (3D Environmental 2007). Potential habitats include the understorey associated with tall open forests of small-fruited grey gum (*Eucalyptus propinqua*) and northern grey ironbark (*E. siderophloia*) on hill-slopes and foot-slopes, with minor incursions into the inundation area.

Threats to the slender milkvine include fragmentation and loss of habitat through land clearing, weed invasion, grazing stock and herbicide use. The risks are amplified because populations are small and isolated.

Priority actions to help recover the species have been identified in New South Wales, but there are no plans in Queensland or at the national level.

5.8.2 Potential impacts

Vegetation clearance for the project will remove about 7.4 ha of potential habitat for slender milkvine. One of two known plants in the area will be lost and, according to the EIS, the formation of new edges on the periphery of habitats would adversely affect any undetected individuals, or potential habitats, by increasing exposure to sun and wind.

Inundation would reduce the area of occupancy, as above. Potential habitats are mainly on hill-slopes and foot-slopes, above the inundation area, but small portions would be flooded. Most impact to potential habitats would be along the proposed Bruce Highway corridor in the north-eastern area, although no plants are reported from that area.

The potential habitat is fragmented, leaving isolated patches of remnant vegetation in agricultural and rural land. The project would destroy some known and potential habitat in the inundation area, and the highway realignment would fragment potential habitats in the north-eastern area.

Populations of slender milkvine are fragmented throughout its range. In the absence of a formal recovery plan, or data describing the abundance and distribution of existing individuals, it is not possible to accept the EIS' conclusion that the project would not affect an area of critical habitat, nor affect the breeding cycle of an 'important' population, nor decrease the availability of habitat to the extent that the species is likely to decline.

The EIS acknowledges that there is potential for weed invasion, particularly in new edge-habitats, and for introduction of root-rot fungus, *Phytophthora cinnamomi*.

Finally, the EIS cites a Flora Expert Panel Report (EPA 2004) suggesting that this taxon "is probably more common than the distribution record shows, and therefore clearing of small areas of potential habitat for this species is unlikely to interfere with its recovery." This may be true, if the Panel's judgement is correct, but better justification is required.

5.8.3 Mitigation and offsets

Mitigation measures proposed for this species include protection and management of existing populations, in part, translocation of propagated stock and development of management and monitoring programs.

The known habitat in the inundation area would not be cleared during construction works. A plan would be developed to identify several translocation sites above FSL, specify methods for propagation and translocation and provide a framework for ongoing management (e.g. weed removal, fire protection). Monitoring programs would be developed to determine the size and health of *in situ* and translocated populations.

The EIS cites examples of apparently successful translocation of threatened flora (*Acacia bynoeana*, *Allocasuarina emuina*, *Cryptocarya foetida*), but no documentation is cited.

5.8.4 Residual impacts

The local population of slender milkvine consists of two known individuals, one of which would be lost. Methods for propagation apparently have not yet been developed, so that early implementation of the mitigation strategy is not assured. The threat of root-rot fungus could be significant, and may best be managed by propagating many plants and limiting human traffic between them, especially in the event of an outbreak.

5.8.5 Impact assessment

Without more information about the *regional* status of the slender milkvine, and a formal recovery plan, it is not possible to accept uncritically the assurances given in the EIS that the effects would be small and adequately compensated by offsets. There is a significant risk to the local population, but whether this is significant for the species as a whole is a judgement that cannot be made without more information. The Precautionary Principle usually is invoked in these circumstances.

5.9 Fontainea, *Fontainea rostrata*

5.9.1 Status

Fontainea (Euphorbiaceae) is a small rainforest tree declared *vulnerable* under the EPBC Act. In the EIS, it is part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus, Bosistoa transversa, Cossinia australiana, Floydia praealta, Macadamia integri-*

folia, M. ternifolia, Plectranthus torrenticola, Pouteria eerwah, Sophora fraseri, Romnalda strobilacea and Xanthostemon oppositifolius. All are recorded near, but not in, the project area.

According to the EIS, *F. rostrata* is restricted to Teddington Weir in the Tinana Creek area, and to State Forest 15 km north and east of Gympie, where it occurs in riparian rainforest and araucarian vine forest. The likelihood of its occurrence in the project area is rated 'low'.

5.9.2 Impacts

This species is considered further as part of the *Rainforest Assemblage* (Section 6, p69).

5.10 Hairy-joint grass, *Arthraxon hispidus*

5.10.1 Status

Hairy-joint grass (Poaceae) is *vulnerable* under the EPBC Act. It is a creeping perennial grass that occurs from Japan to central Eurasia and is widespread, but never common, in south-eastern Queensland and north-eastern New South Wales (NPWS 2002). It typically occurs near the edges of rainforest and in wet eucalypt forest, often near wetlands. It is not known from the project area but, according to the EIS, was recorded in 1939 in the Kenilworth area and along Boolumba Creek. It is rated as having a 'low likelihood' of occurrence. Threats to this species include land clearing for agriculture and development, burning, grazing by stock and competition from alien grasses.

In the EIS, this species is considered as part of a 'rainforest plant assemblage' that includes *Bosistoa transversa*, *Cossinia australiana*, *Floydia praealta*, *Fontainea rostrata*, *Macadamia integrifolia*, *M. ternifolia*, *Plectranthus torrenticola*, *Pouteria eerwah*, *Sophora fraseri*, *Romnalda strobilacea* and *Xanthostemon oppositifolius*.

5.10.2 Impacts

This species is considered further as part of the *Rainforest Assemblage* (Section 6, p69).

5.11 Small-fruited Queensland nut, *Macadamia ternifolia*

5.11.1 Status

The small-fruited Queensland nut (Proteaceae) is a medium-sized (10 m) tree growing in riparian forest and araucarian vine forest. It is a *vulnerable* species under the EPBC Act, and is listed as *vulnerable* under the Queensland *Nature Conservation Act 1992*. It occurs north from the Coomera River to Kin Kin, south-east of Gympie. It is related to the commercial macadamia (*M. integrifolia*), but produces an inedible nut containing poisonous cyanogenic glycosides.

This species is not recorded within the project area, and the EIS rates its potential occurrence as 'low likelihood'. A cultivar of *M. integrifolia* is reported, however, from within the realignment proposed for the Bruce Highway.

In the EIS, this species is considered as part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus*, *Bosistoa transversa*, *Cossinia australiana*, *Floydia praealta*, *Fontainea rostrata*, *Macadamia integrifolia*, *Plectranthus torrenticola*, *Pouteria eerwah*, *Sophora fraseri*, *Romnalda strobilacea* and *Xanthostemon oppositifolius*.

5.11.2 Impacts

This species is considered further as part of the *Rainforest Assemblage* (Section 6, p69).

5.12 Southern penda, *Xanthostemon oppositifolius*

5.12.1 Status

The southern penda (Myrtaceae) (aka penda, Luya's hardwood) is a tall, rainforest tree. It occurs in three areas in south-eastern Queensland, including Teddington Weir, in the Mary catchment south of Maryborough. It is a *vulnerable* species under the EPBC Act, and is listed as *vulnerable* under the Queensland *Nature Conservation Act 1992*.

The species occurs mainly on sandy clays along watercourses, in vine forest with emergent *Araucaria cunninghamii*, or where rainforest species are part of a developing understorey or mid-storey (Barry and Thomas 1994). Threats include land clearing, timber harvesting, weed invasion, fire and grazing by stock.

There is no formal recovery plan for this species, but priority actions are included in *Approved Conservation Advice* on the DEWHA SPRAT database.

In the EIS, this species is considered as part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus*, *Bosistoa transversa*, *Cossinia australiana*, *Floydia praealta*, *Fontainea rostrata*, *Macadamia integrifolia*, *M*. *ternifolia*, *Plectranthus torrenticola*, *Pouteria eerwah*, *Sophora fraseri* and *Romnalda strobilacea*.

5.12.2 Impacts

This species is considered further as part of the *Rainforest Assemblage* (Section 6, p69).

5.13 Three-leaved bosistoa, *Bosistoa transversa*

5.13.1 Status

The three-leaved bosistoa (Rutaceace) (aka heart-leaved bosistoa, yellow satinheart, heart-leaved bonewood) is a tree, and a *vulnerable* species under the EPBC Act. It occurs in rainforest below 300 m altitude, and on alluvial flats, from Maryborough, on the Mary River, south to north-eastern New South Wales (NPWS 2002). It is threatened by land clearance, grazing by stock, fire, forestry activities and weed invasion.

Priority actions have been identified by the NSW Department of Environment and Conservation, but there are no formal recovery plans for the species in Queensland, or at a national level.

In the EIS, this species is considered as part of a 'rainforest plant assemblage' that includes *Arthraxon hispidus*, *Cossinia australiana*, *Floydia praealta*, *Fontainea rostrata*, *Macadamia integrifolia*, *M*. *ternifolia*, *Plectranthus torrenticola*, *Pouteria eerwah*, *Sophora fraseri*, *Romnalda strobilacea* and *Xanthostemon oppositifolius*.

5.13.2 Impacts

This species is considered further as part of the *Rainforest Assemblage*.

6. Rainforest Assemblage

6.1 Status

In the EIS, a group of species found near, but not in, the project area (3D Environmental 2007) is treated collectively as a 'rainforest plant assemblage'. These are *Arthraxon hispidus, Bosistoa transversa, Cossinia australiana, Floydia praealta, Fontainea rostrata, Macadamia integrifolia, M. ternifolia, Plectranthus torrenticola, Pouteria eerwah, Sophora fraseri, Romnalda strobilacea and Xanthostemon oppositifolius*.

The ball nut *F. praealta* received additional attention in the Supplement, owing to the later discovery of individuals near the north-western project boundary.

These are listed *endangered* or *vulnerable* species under the EPBC Act. Although protective measures have been identified in New South Wales for hairy-joint grass, three-leaved bosistoa and ball nut, there are no formal plans for any of the species in Queensland or at the national level. They are protected, however, by the Queensland *Nature Conservation Act (1992)* and the *Vegetation Management Act (1999)*.

The term 'assemblage' could be inappropriate here, as it has various connotations in ecology. In the present context it is used as a collective term for species that occupy the same kind of habitat and are members of the group due to their *endangered* or *vulnerable* status under the EPBC Act.

The individual characteristics of these species are considered in other sections. Here, impacts on the assemblage as a whole are considered.

6.2 Potential impacts

Flooding would cover about 67 ha of habitat for these species, and any individuals within this area would be lost. Most *potential* habitat is in fragments of notophyll vine forest along riparian corridors of the Mary River and its tributaries, in the inundation area, and small patches of araucarian vine forest on hill-slopes and foot-slopes.

Some existing fragments will be reduced by inundation or clearing, and possibly by road construction, increasing the vulnerability of resident species to local extirpation. Reduced patches could become non-viable habitats for some species. Edge-effects, for example, become more significant for small remnant patches, and one consequence may be to facilitate invasions by weed species.

The root-rot fungus *Phytophthora cinnamomi* is well-established in coastal Queensland and although there have been no reports of local infestations, it could become a threat as its spread is enhanced in areas frequented by people. The threat posed by *Phytophthora* to rainforests in northern Queensland is described by Gladek (1999).

6.3 Mitigation and offsets

The EIS indicates that, if any of the named species are encountered, the goal would be to ensure no net loss of individuals from the project area. This would involve "protection (in part) and management of existing populations, establishment of an *ex situ* population prior to any site disturbance, translocation of propagated stock and development of management and monitoring programs".

Suitable sites would be identified in Vegetation Management Offset (VMO) and re-vegetation areas, and these would be fenced and monitored and managed to reduce the threat from weeds, pests, grazing stock, fire and drought.

The translocation strategy requires minor clarification. According to the Supplement, propagated rather than translocated individuals will be planted. This is confusing because the term 'translocation' often refers to moving individual plants rather than planting seeds (cf. Vallee et al. 2004). Methods for propagation are not necessarily available for all species, and may require research and development. The Supplement states that "pilot propagation and planting trials should be initiated as soon as practicable to determine the translocation potential of these species", but this appears to be a recommendation rather than a commitment, and presumably would not be implemented unless individuals were encountered in the project area.

The EIS also suggests that, if necessary, the mitigation strategy proposed for slender milkvine (Section 5.7, p64) could be adapted for other threatened flora.

6.4 Residual impacts

The proposed mitigation framework is sufficiently general to cover most likely impacts.

The project alone could not be held responsible for the threat represented by *Phytophthora*, but the threat is real and requires a plan for prevention and management.

6.5 Impact assessment

The likelihood of an impact cannot be assessed as these species are not recorded from the project area, but it is clear that the project would not encourage them to become established locally. Further, it is not clear who would be responsible for surveys, monitoring and management.

7. Migratory species

7.1 Significant Impact Guidelines

Following DEH (2006), an action is likely to have a significant impact on a *migratory* species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;

- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

7.2 Dugong, *Dugong dugon*

7.2.1 Status

The dugong (Dugongidae) is one of several mammal species that inhabit the Great Sandy Strait Ramsar Site, near the Mary River mouth. It is listed as a *migratory*, *marine* species under the EPBC Act and as a *vulnerable* species under the IUCN *Red List* and the Queensland *Nature Conservation (Wildlife) Regulation*. The species inhabits near-coastal waters, and its security is linked closely to that of its exclusive food resource, seagrass (especially *Halodule uninervis*, *Halophila ovalis and H. spinulosa*). Numbers in the region have declined drastically in recent decades (e.g. Marsh et al. 1999). The number in the region in 2001 was estimated at 1708 ± 392, or about 30% of the total population south of Innisfail (McKenzie and Campbell 2002).

7.2.2 Potential impacts

The EIS asserts that dam operations will not have a significant impact on seagrass beds, either through changes in flow or water quality, but there are few substantive data.

Traveston Crossing Dam is predicted to reduce the existing mean annual flow in the Mary River by 3-4%. At that scale, there are unlikely to be discernible effects from reduced flows on the dugongs or seagrass meadows (FRC Environmental 2007).

There may be more concern for the influences that dam operations could have on floods and droughts, seasonal flow reductions (JASON months) and sustained reductions caused by a long-term change in climate. For example, there were catastrophic losses of seagrass (*Zostera capricorni*) during floods from the Mary River in 1999, and turbidity and nutrient levels increased 2-3 fold in the following six months. Recovery took three years (Campbell and McKenzie 2004).

In the event of large-scale seagrass dieback, dugongs have some capacity to relocate to areas further afield, but it appears that only some members of the population are likely to move (Sheppard et al. 2006).

Dugongs are sensitive to poor water quality, which can lead to physiological disorders (Greenland and Limpus 2006) and may also affect seagrass. Changes in water quality related to dam operations potentially could include increased nutrient loads, causing algal blooms (for example, the cyanobacterium *Lyngbya majuscule* is a problem in Queensland coastal waters) (McKenzie and Campbell 2002; McMahon et al. 2003).

The water quality assessment in the Supplement (16) suggests that, most of the time, nutrient and sediment loads in water released from Traveston Crossing Dam will be reduced due to increased holding times. It is true that the reservoir will retain nutrients in the short-term, but these inevitably would be released in pulses following seasonal overturn. The reservoir therefore will not cause a sustained reduction in nutrient loads, as the EIS suggests. Pulsed releases of high-nutrient water, at times when there is potential for algal growth, could cause problems.

An Ecological Character Description (ECD) exists for the Great Sandy Strait Ramsar site (Lee Long and O'Reilly 2007). Public submissions pointed out that this was not considered in the EIS, and the omission was partly redressed in the Supplement (20.2.2.1). According to the Supplement, the ECD is a benchmark tool that managers can use for planning and assessments of potential impacts. It is not clear that it has been used in this way in the EIS or Supplement.

The ECD specifies ecosystem services, components and processes in the Ramsar site, and key threats to those services. The Supplement distinguishes between those considered 'critical' and those that are merely 'important', and states that the critical elements are the focus for management. In reference to maintenance of dugong populations, the Supplement identifies critical components as habitat condition, extent and diversity, energy and nutrient dynamics, water quality and hydrology. Key threats include accidental mortality (net entanglements, boat strikes), eutrophication and other pollution, algal blooms and aquaculture.

The Supplement also contains the following:

> "One submission claimed that the assessment of the dugong was flawed and made many false statements. In particular, the submission suggested using Population Viability Analysis (PVA).
>
> Section 9.5.3 of the EIS discusses the habitat and threats to the dugong. This discussion was based on a number of studies undertaken since 1995. Section 19.2.2 of the Supplementary Report discusses the use of PVA which finds that PVA is neither standard nor necessary for determining the risk of extinction."

Neither of these responses is satisfactory. It is not clear what false statements are referred to, and the dismissal of Population Viability Analysis suggests that the respondent has not understood the basis for the question (e.g. Section 5.2.2), and the elements of such an analysis already exist (e.g. Marsh et al. 1999). The real issue is to determine what capacity the dugong population may have to endure further environmental changes.

7.2.3 Mitigation and offsets

A desktop review by FRC Environmental (2007) for QWI claims that effects of the Traveston Crossing Dam on dugongs and seagrass meadows will be negligible. Instead, the report recommends that mitigation measures for estuarine and marine receiving waters should focus on potential impacts to fishery productivity. No mitigation is proposed.

7.2.4 Residual impacts

Not applicable.

7.2.5 Impact assessment

Although the dugong population in the Great Sandy Strait is not secure, it is difficult to identify likely changes that could confidently be ascribed to dam operations. The changes are unlikely to be 'substantial', as indicated in the Significant Impact Guidelines (Section 7.1, p70).

7.3 Green turtle, *Chelonia mydas*

This species is a *marine*, *migratory* species under the EPBC Act. It is also a *vulnerable* species, and is considered in Section 5.4, p61.

7.4 Coxen's fig-parrot, *Cyclopsitta diophthalma coxeni*

This species is a *migratory* species under the EPBC Act by virtue of its seasonal movements seeking fruit. It is also *endangered*, and is considered in Section 4.5, p46.

7.5 Shorebirds

7.5.1 Status

The Great Sandy Strait supports a number of estuarine shorebirds that are declared *marine*, *migratory* species under the EPBC Act. They include the bar-tailed godwit (*Limosa lapponica*), eastern curlew (*Numenius madagascariensis*), greenshank (*Tringa nebularia*), grey plover (*Pluvialis squatarola*), grey-tailed tattler (*Heteroscelus brevipes*), lesser sand plover (*Charadrius mongolus*), terek sandpiper (*Xenus cinereus*) and whimbrel (*Numenius phaeopus*).

The area includes 'important' habitats for migratory species (DEH 2006). These are:

- utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species; and/or
- of critical importance to the species at particular life-cycle stages; and/or
- utilised by a migratory species which is at the limit of the species range; and/or
- within an area where the species is declining.

These criteria are intended for particular species and are difficult to apply collectively. Although the wetlands of the Great Sandy Strait are outside the project area and may not be impacted directly, these kinds of environments are sensitive to freshwater inflows (e.g. Ravenscroft and Beardall 2003; Gobler et al. 2005) and the impact of the dam on the discharge regime in the Mary River should be monitored.

7.5.2 Impacts

The hydrological and water quality changes described for dugongs (Section 7.2, p71) would apply also to the wetland habitats for shorebirds. In addition, the inundation area will cover vegetation which is habitat for the white-bellied sea eagle and other migratory non-wetland species named in the EIS (9-87).

A case might be made to show that dam could *degrade* the wetland habitats, and thereby affect the migratory species, but the inclusion of terms like “substantially modify”, “important habitat” and “seriously disrupt” in the Significant Impact Guidelines (Section 7.1, p70) exclude all but major disruptions. As noted above, it is difficult to identify likely changes that could confidently be ascribed to dam operations, and none is likely to be on a scale to match the specifications in the guidelines.

8. Postscript

The Traveston Crossing Dam proposal spotlights an extremely sensitive site for river conservation in Australia. Any new dam warrants careful analysis, given our national legacy of degraded rivers and declining biodiversity, but the present proposal deserves the closest scrutiny because it could decide the fate of a number of imperilled species.

Among them, the Mary River turtle and the Australian lungfish are survivors of lineages that began hundreds of millions of years ago. They are *internationally* significant, and no less symbolic than the giant panda.

We know little of the biology of these species, and other fauna and flora of the Mary River, and the threats they face are compounded by our ignorance. Research is properly part of a *proactive* strategy, however, and should not be invoked as a means to repair damage *after* the environment is changed.

We have often taken refuge in the belief that there are many steps on the road to extinction, and no single action could be held responsible. For some of these species, including the turtle and lungfish, we are near the end of that road.

9. References

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