

GUAM

INTRODUCTION

by Gary J. Wiles and Michael W. Ritter

Area: 540 sq.km.

Population: 133,150.

Guam (13°28'N, 144°45'E), a territory of the United States, is the largest and southernmost island of the Mariana Islands in western Micronesia. Northern Guam is characterized by a large uplifted limestone plateau fringed near the ocean by tall cliffs and steep hillsides that descend to narrow terraces or directly into the sea. The southern portion of the island is volcanic in origin, although some hills are capped with limestone, with a tall ridge dissected by deeply eroded ravines running along the southwestern coast. Elevations range from sea level to 180 m in the north and 400 m *in* the south.

The climate is warm and humid throughout the year. Daily temperatures vary from 31-33°C in the daytime to 24-26°C at night. There is a dry season from January to April and a rainy season from July to mid-November. The other months are transitional periods that may be either rainy or dry depending on the nature of the particular year. Mean annual rainfall ranges from 2,100 mm in central Guam to 2,850 mm on the upper slopes of the southern mountains. On average, about 55% of the rainfall occurs in the rainy season and 15% during the dry season, with the remainder falling during transitional months. The prevailing winds blow from the northeast or east for much of the year. The island is regularly affected by typhoons, which bring heavy winds and rains.

Guam shares a large number of plant and animal species with the Commonwealth of the Northern Mariana Islands, which administers the other 14 islands in the archipelago. The native biota of the island chain have strong Australasian affinities. Most of Guam's human population lives in suburban areas in the central and north-central parts of the island. During the last decade, the economy has progressively become based more on tourism and less on military spending and federal and local government programs.

Summary of Wetland Situation

Guam has considerably more wetlands and a wider variety of types than any of the other Mariana Islands. All of its rivers and nearly all wetlands occur in the southern and central parts of the island, where clay or argillaceous limestone soils retard water percolation and permit surface waters to accumulate. Many interior wetlands are located along the upper drainages of rivers and smaller tributaries. In contrast, the northern limestone plateau allows rapid water seepage, and consequently only a few marshy areas and ephemeral streams exist in the vicinity of Mt Santa Rosa. Four basic categories of wetlands are described below, with larger sites often having more than one type.

Freshwater swamps of woody vegetation are the largest category of wetland (Yuen, in press) and may be found on the edges of marshes, along river courses, and in wet depressions in forests. *Hibiscus tiliaceus* is usually the major species involved, although the largest tract of swamp forest on the island, the Talofoto River Valley, is dominated by *Barringtonia racemosa* (Fosberg, 1960). Other trees that may be present are *Pandanus tectorius*, *Cynometra ramiflora* and *Areca catechu*.

Natural freshwater marshes are also common, with individual sites varying in size from the Agana

Swamp (with about 96 ha of marshland) to many that are less than 0.5 ha. Most are dominated by dense, nearly pure stands of *Phragmites karka* that are 2-5 m tall (Fosberg, 1960). Other grasses (e.g. *Panicum muticum*), sedges (e.g. *Eleocharis ochrostachys* and *Cyperus* spp.) and the fern *Acrostichum aureum* are often present but usually less prevalent.

Man-made freshwater wetlands were originally constructed as water impoundments for humans, cattle and crop irrigation, and are found widely through southern Guam. Many are no longer used but they continue to collect water and maintain aquatic ecosystems. The largest is Fena Lake (81 ha), which still functions as an important reservoir for drinking water. Other sites are much smaller and tend to have deeper, more open water than natural marshes. Vegetation is variable, but *Phragmites* and *Hibiscus* are usually minor components. A number of these sites are crucial to the preservation of Common Moorhens (*Gallinula chloropus guami*) (Stinson *et al*, 1991). Ten of the 19 wetlands described in this report are artificial.

Estuarine wetlands occur in areas of tidal intrusion or brackish water, and consist primarily of mangroves and the lower channels of rivers. These habitats are facilitated by a daily tidal variation of about 75-90 cm. The largest concentrations of mangroves exist along the eastern shores of Apra Harbor, with smaller zones present in Merizo and Inarajan. Although they only total about 70 ha (Yuen, in press), Guam's mangroves are the most extensive and diverse in the Mariana Islands. Species include *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Lumnitzera littorea*, *Nypa fruticans*, *Xylocarpus moluccensis*, *Heritiera littoralis*, *Hibiscus tiliaceus* and *Acrostichum aureum* (Fosberg, 1960; Moore *et al*, 1977). Nine of the island's 46 rivers that empty into the ocean have true estuarine zones. The lower channels of these rivers, which are typically only 5-20 m wide and 1-4 m deep, have elevated salinity levels that extend 0.5-1.6 km upstream (Wilder, 1976). *Nypa fruticans* is a common indicator plant of river zones with brackish water regimes. Marshes of bulrushes (*Scirpus littoralis*) are a third estuarine community, and are found at several locations in Apra Harbor. The largest area is the artificial San Luis Ponds.

Significant losses of wetland have occurred historically on Guam, although it is difficult to quantify the extent of the losses. Reclamation of wetlands by the U.S. military was extensive in and around Apra Harbor from 1945 to 1950 during the expansion of port facilities by the Navy. An estimated 500 ha of land area was filled during this period (U.S. Navy, 1978), and involved the destruction of mangrove communities fringing the eastern harbour and freshwater wetlands along the Sasa, Atantano and Namu Rivers and at the present-day Naval Station. Smaller fills have also occurred more recently at several of these sites, one of which was the expansion of a garbage dump into the Naval Station Marsh. At the Agana Swamp, filling along the edges was a chronic problem until about 1980. The original building of a coastal highway around the southern half of Guam by the Spanish, and subsequent improvements, resulted in the laying of a roadbed across wetlands next to river mouths and likely altered natural drainage patterns. From the 1970s to mid-1980s, several sets of aquaculture ponds were constructed in wetlands along the Talofof, Agfayan and Ajayan Rivers, and resulted in vegetation loss. These businesses have not been highly profitable and there has been little desire to build additional facilities. About 20 ha of ponds at four sites are currently in operation.

General land development has accelerated on Guam during the last several decades. Despite the wishes of many developers, regulatory agencies have been successful in greatly reducing the number of wetland fills during the past decade. This has been accompanied by improved enforcement of protective regulations. One well-publicized violation occurred in Yona during the early stages of construction of the huge Manengon Hills resort, which is Japanese owned. Contractors filled 2.5 ha of marshes and diverted several stream channels without approval. Government agencies placed a stop-work order on the project and halted all work for several months at a tremendous loss to the owners, who were eventually fined US\$1.3 million for their violations. The company was also forced to restore the damaged sites to their original condition.

Grassland fires during the dry season have been a serious ecological problem for many years. Many of the fires are deliberately started, and can produce significant soil erosion, resulting in large amounts of sediments being washed into rivers and wetlands. Heavy soil loads have undoubtedly altered many wetland ecosystems by greatly increasing turbidity and sedimentation. Infilling allows the encroachment of new plant species, particularly *Phragmites*, and may eventually result in the shrinkage or loss of wetlands.

Poorly planned developments may affect wetlands adversely in other ways, particularly by increasing erosion through careless construction practices. The owners of several proposed golf courses and resorts have requested that they be allowed to pump water from rivers to meet their irrigation and drinking water needs. Such pumping of large volumes of water may result in reduced seasonal stream-flow and increased saltwater intrusion upstream.

Nearly half of the wetlands (nine of the 19 sites) described in this report suffer from various forms of pollution. The most serious cases have been oil spills in the Atantano and Sasa Bay wetlands, contamination from hazardous wastes and heavy metals at the Shell Oil, Atantano, Namu River and Naval Station sites, and chronic run-off of pollutants from adjoining urban areas at the Agana Swamp and Barrigada Ponding Basin.

Prehistoric cultivation of crops was probably widespread in Guam's wetlands. Rice, taro and vegetables were grown at many sites from the 1800s until World War II (Safford, 1905; Thompson, 1947). Farming of wetlands has declined significantly since the war and is no longer widely practised. Most former fields have reverted to marshy or swampy vegetation, but it is not known how closely these resemble the original floral conditions. It is likely that few undisturbed freshwater swamps remain (Stemmermann, 1981).

As previously noted, many marshes are characterized by dense *Phragmites* growth. Although this reed is indigenous to Micronesia, it is possible that various disturbances to wetlands (e.g. farming) have increased its abundance. It generally provides marginal habitat for most wetland birds, is a severe fire hazard during the dry season and chokes out other wetland plants.

Historically, four species of birds were dependent on Guam's wetlands. Three of these, the Marianas Mallard (*ulnas oustaleti*), White-browed Crake (*Porzana cinerea*) and Nightingale Reed-warbler (*Acrocephalus luscini*), became extirpated between 1945 and 1970. The fourth species, the Common Moorhen, is endangered and has an estimated population of 100-125 birds (U.S. Fish and Wildlife Service, 1991; Stinson *et al.*, 1991). Over-hunting of mallards and loss of habitat for moorhens are thought to be the major reasons for their declines. Recent observations suggest that tilapia (*Oreochromis mossambicus*) may reduce moorhen densities through competition (Stinson *et al.*, 1991). Causes for the losses of the crake and reed-warbler are unclear, but may have included pesticide use, predation by introduced Brown Tree Snakes (*Boiga irregularis*) and marsh fires (Reichel *et al.*, 1992).

Small numbers of migratory shorebirds, ducks and herons annually visit and overwinter in the island's wetlands (see Reichel and Glass, 1991). Yellow Bitterns (*Ixobrychus sinensis*) commonly nest and feed in freshwater marshes (Jenkins, 1983). Guam's native forest birds, which have been almost totally eliminated because of snake predation (Savidge, 1987; Engbring and Fritts, 1988), no longer reside in any of the island's swamp forests. Over-hunting and perhaps snake predation have caused the nearly complete loss of Marianas Fruit Bats (*Pteropus mariannus*) from these same forests (Wiles, 1987).

A variety of native fish and aquatic invertebrates inhabit the island's rivers and larger freshwater wetlands. These include several gobies (*Awaous guamensis*, *Sicyopterus macrostetholepis* and *Stiphodon elegans*), a flagtail (*Kuhlia rupestris*), a sleeper (*Eleotris fusca*), two eels (*Anguilla marmorata* and *A. bicolor*) and a number of shrimp (*Macrobrachium* spp., *Caridina* spp.,

Atya serrata and *Atyoida pilipes*). Many of the fish have pelagic larval stages. Only one, *Awaous guamensis*, is endemic to the Mariana Islands. All are believed to be fairly widespread on Guam. Various gastropods are also present, including members of the genera *Neritina*, *Neritodgas*, *Septaria*, *Clithon*, *Melanoides*, *Thiara* and *Stenomelania* (B.D. Smith, pers. comm.).

The mangroves in Apra Harbor serve as nursery grounds for jacks (Carangidae), barracudas (Sphyraenidae), snappers (Lutjanidae) and groupers (Serranidae) (G. Davis, pers. comm.). Estuarine areas are also inhabited by adult ponyfish (Leiognathidae), rabbitfish (Siganidae), mojarras (Gerreidae), milkfish (*Chanos chanos*), mullets (Mugilidae), mudskippers (*Periophthalmus koelreuteri*), crabs (*Uca* spp., *Cardisoma carnifex* and *Scylla serrata*) and various snails, clams and oysters.

A number of introduced vertebrates have become established in Guam's wetlands. Alien fishes include tilapia (*O. mossambicus* and *Tilapia zilli*), catfish (*Clarius macrocephalus*), tucunare (*Cichla ocellaris*), mosquitofish (*Gambusia affinis*), carp (*Cyprinus carpio*) and guppies (*Poecilia reticulatus*). Several other species are believed to have escaped from aquaculture ponds and started populations in the Ajayan and Agfayan Rivers (R.A. Hensley, pers. comm.). Two species of amphibians, the Marine Toad (*Bufo marinus*) and Dwarf Tree Frog (*Litoria fallax*), breed at many sites, while two types of turtles, the Red-eared Slider (*Trachemys scripta*) and a soft-shelled turtle (*Pelodiscus* sp.), now appear to be reproducing at several locations (MJ. McCoid, pers. comm.). The skink *Carlia fusca* is abundant throughout the island, and is found in many wetlands with seasonally dry substrates.

Wetlands provide little direct economic gain for island residents. A limited amount of fishing and crab hunting takes place, but this is primarily for personal consumption or recreation. The only businesses that are wetland-dependent are four aquaculture facilities and a small tourist boat operation on the Talofofu River. However, Guam's wetlands are more valuable for indirect reasons. They act as natural filters and settling ponds for eroded soils, thereby greatly reducing the amount of sediment dumped on the island's fringing coral reefs. These reefs are a major source of fish for local fishermen and an important tourist attraction. Mangroves serve as important breeding areas for a wide variety of harvestable reef fish. The Agana Swamp has long played a beneficial role by limiting downstream flooding in the city of Agana.

The major criteria for selecting the wetlands listed in this report are size, uniqueness of the site and the presence of moorhens, particularly locations where nesting regularly occurs. Four of the 19 sites contain mangroves and 12 are used by moorhens. Each of the listed sites was field checked in 1990 or 1991. Other important wetlands may be added to the list in the future as more information becomes available.

Wetland Research

A fair amount of research on freshwater and estuarine wetlands was conducted during the 1970s and early 1980s, primarily by staff from the University of Guam (see References). These studies consisted mainly of biological inventories and assessments of basic water quality parameters at several major sites. A largely comprehensive map of the island's wetlands was prepared in 1983 by the U.S. Fish and Wildlife Service. The Division of Aquatic and Wildlife Resources studied the distribution of Common Moorhens at Fena Lake and a number of other locations from 1987 to 1990 (Ritter, 1989; Stinson *et al.*, 1991). Little active field research is currently underway.

Wetland Area Legislation

Regulatory authority for Guam's wetlands rests with the U.S. Federal Government and Government

of Guam (Bureau of Planning, 1991). The U.S. Army Corps of Engineers is the primary federal agency with responsibility for wetlands. Its authority is derived mainly from Section 404 of the Clean Water Act, but two other laws also apply, Section 10 of the Rivers and Harbors Act of 1899, and Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972. The U.S. Fish and Wildlife Service, through the U.S.

Endangered Species Act, reviews all wetland projects that may affect endangered species. Federal Executive Order 119900, Protection of Wetlands, applies to all federal agencies including the military that have projects involving the wetlands.

The Guam Environmental Protection Agency, acting under the authority of the U.S. Environmental Protection Agency, issues Water Quality Certificates through Section 401 of the federal Clean Water Act. In addition, several executive orders apply to wetlands (Bureau of Planning, 1991). These include:

- Executive Order 78-21, which allows the Territorial Land Use Commission to designate wetlands as Areas of Particular Concern and promulgate a set of Wetland Rules and Regulations;
- Executive Order 78-23, which established conservation districts to protect wetlands and other natural resources;
- Executive Order 78-20, which established flood hazard zones;
- Executive Order 90-13, which requires several local agencies to update wetland regulations;
- Executive Order 90-10, which requires that an Environmental Impact Assessment be written for all new development.

Wetland Area Administration

None of Guam's wetlands is specifically designated as a protected area. The Government of Guam owns parcels of land in several wetlands, including the Agana Swamp and Achang Bay mangroves. It has recently begun to consider the acquisition of high priority wetlands from private landowners, with the goal being to protect these areas. All wetlands on U.S. Navy property have been recommended for preservation in a series of recently drafted management plans for natural resources (Biosystems Analysis Inc., 1990; Anon., in press, a, b, c).

Organizations involved with Wetlands

a) Government of Guam

- Department of Agriculture
 - The Division of Aquatic and Wildlife Resources conducts research on wildlife and fisheries, and assesses proposed developments that affect wetlands.
- Guam Environmental Protection Agency
 - Reviews proposed development projects and issues Water Quality Certificates under the authority of Section 401 of the U.S. Clean Water Act. Investigates wetland violations.
- Bureau of Planning
 - The Coastal Zone Management Program reviews permit applications for development, including those in wetlands, and determines that projects are consistent with federal regulations.
- Department of Land Management
 - The Planning Division processes development permits to be examined by the

Territorial Land Use Commission.

- Department of Commerce
 - Responsible for the planning of aquaculture activities.

b) U.S. Government

- Army Corps of Engineers
 - Reviews and issues Section 404 permits, and investigates wetland violations.
- Environmental Protection Agency
 - Reviews Section 404 permits; however, much of this agency's responsibility has been delegated to the Guam Environmental Protection Agency.
- Fish and Wildlife Service
 - Reviews wetland development projects that are authorized by federal permits, occur on federal lands, or receive federal funding and affect endangered species. Has prepared a recovery plan for moorhens.
- Soil Conservation Service
 - Provides technical assistance to other government agencies on the delineation of wetlands.

c) Universities

- University of Guam
 - Biology Department
 - Maintains a herbarium and has staff familiar with wetland ecology and plant identification.
 - Marine Laboratory
 - Conducted various wetland research projects in the 1970s and early 1980s. Staff are knowledgeable of estuarine and freshwater fauna.
 - Water and Energy Resources Institute
 - Conducts research on surface and groundwater quality, including studies on pesticide and heavy metal contamination and soil run-off.
 - College of Agriculture and Life Sciences
 - Administers extension programs relating to aquaculture.

d) Non-Governmental Organizations

- Marianas Audubon Society
 - Conducts bird counts at several wetlands and promotes conservation of natural resources on the island.

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WETLANDS

Site descriptions compiled by Gary J. Wiles and Michael W. Ritter of the Division of Aquatic and Wildlife Resources, Guam.

Wetland Name: Agana Swamp

Country: Guam

Coordinates: 13°28'N, 144°45'E

Location: the marsh is located in west-central Guam in the municipalities of Agana, Sinajana and Mongmong-Toto-Maite. It is found 250 m southeast of the intersection of Highway 4 and O'Brien Street (Highway 7).

Area: 112 ha.

Altitude: 1-3 m.

Overview: Long referred to as the Agana Swamp, this is Guam's largest natural freshwater marsh. It is vegetated primarily with dense stands of *Phragmites karka*. Common Moorhens (*Gallinula chloropus guami*) nest here. The site is largely surrounded by urban and suburban development.

Physical features: Randall and Tsuda (1974) described the physiography and geology of the Agana Swamp and its surrounding environment. The main body of the marsh lies in a broad low-lying basin along the Agana River, with several narrow fingers of marshland extending up to 1.5 km to the north, east, and south. Important sources of water for the wetland are run-off from surrounding hills, rainfall, several springs (including the Agana Springs) and the Chaot River, which enters from the south. Drainage occurs via a channelized section of the Agana River, 800 m long, which empties into Agana Bay. Inside the marsh, the Agana River channel is poorly defined and silted in. The marsh's water level ranges from 5-30 cm in the rainy season, but only depressions and the river channel retain standing water during the dry season (Randall and Tsuda, 1974). Soils consist of deep poorly drained muck derived from decomposed organic matter (Randall and Tsuda, 1974; Young, 1988).

The Agana Springs are located on the south side of the marsh at the base of a limestone ridge. A pair of retaining walls and a low dam are present, and were once part of a municipal water pumping station (Smalley and Zolan, 1981). Maximum depth at this site is 2-3 m. Water quality characteristics and hydrology of the marsh and Agana Springs are described and discussed by several authors (Smalley and Zolan, 1981; Ayers and Clayshulte, 1983; U.S. Army Corps of Engineers, 1985).

Low limestone hills and ridges border the marsh and project inward at a number of locations. Isolated limestone hills and hummocks occur inside the marsh and are 6-12 m high. The entire Agana-Chaot river basin covers 2,700 ha (U.S. Army Corps of Engineers, 1985).

Ecological features: The wetland is dominated by dense stands of *Phragmites karka*, with *Hibiscus tiliaceus* common along the edges and scattered throughout (Randall and Tsuda, 1974; Moore *et al.*, 1977; Smith & Hedlund, 1978). A fairly large bed of *Eleocharis ochrostachys* is present in the northeast (Wiles, pers. obs.). A few small openings in the *Phragmites* exist, but only several have open water. The opening at the Agana Springs is choked with *Eichhornia crassipes*, while the channel for the Agana River at the O'Brien Street bridge is covered by *Pistia stratiotes*, *Panicum muticum* and a small amount of *E. crassipes*. Two small plots on the north and northwest sides of the wetland have been cleared of *Phragmites* and planted with taro (*Cyrtosperma chamissonis* and *Colocasia esculenta*). Other plants in the marsh include *Acrostichum aureum*, *Thelypteris interrupta*, *Eleocharis geniculata*, *Polygonum minus*, *Cyperus polystachyos*, *Lemna perpusilla* and *Ipomoea aquatica*. The habitat classification of the marsh is PEM1F, PFO3C, PEM1Ff, R2EM1Hx and R2AB4Hx (Cowardin *et al.*, 1979).

Dryland vegetation on the boundaries of the marsh is variable and highly disturbed (Randall and Tsuda, 1974). *Momordica charantia*, *Passiflora foetida*, *Mikania scandans*, *Chromolaena odorata* and *Antigonon leptopus* are common in weedy openings. Scrubby forests contain *Leucaena leucocephala*, *Heterospathe elata*, *Cocos nucifera*, *Pandanus tectorius*, *Triphasia trifolia* and *Morinda citrifolia*.

Land tenure: Most of the wetland is privately owned. The Government of Guam owns two tracts of property in the marsh totalling about 17 ha. Surrounding areas are mostly private.

Conservation measures taken: A small area around the Agana Springs was declared a conservation preserve in the 1970s by the Guam Department of Parks and Recreation, and developed as a park for nature education (Belk *et al.*, 1971), but the facilities have fallen into disrepair in recent years. The entire marsh is considered a wetland of primary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991). In order to protect moorhen habitat, the U.S. Fish and Wildlife Service issued a "jeopardy opinion" on a filling and construction project that was proposed for a corner of the marsh in 1987. Conservation measures proposed: A recovery plan for moorhens also lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to the marsh include: (1) the development and implementation of a habitat management plan through a cooperative management agreement among the landowners, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; (3) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats; and (4) the periodic monitoring of the site for toxic substances.

A proposal to designate land owned by the Government of Guam in the marsh and along the Chaot River as conservation reserves was submitted by the Guam Department of Agriculture to the Guam Departments of Land Management and Parks and Recreation in 1989. Recent consideration has also been given by the government to acquire privately owned land in the marsh for conservation purposes.

Land use: Colonial administrations dating back to at least the 1850s regularly considered or attempted to drain the marsh to encourage farming and for public health reasons (Safford, 1905; E.G. Johnston in Randall and Tsuda, 1974). The Spanish built a set of dikes in the marsh in the 1800s in an apparently unsuccessful effort to grow rice. In 1933-1934, a channel six metres wide was cut from the north side of the marsh to the Agana Springs, a distance of 1,750 m (Seabury, 1934; Randall and Tsuda, 1974). This resulted in two-thirds of the marsh being drained of standing water and allowed corn to be planted. Safford (1905) and Thompson (1947) both reported that some of the marsh was used for taro and vegetable gardening. The Agana Springs was used as a municipal water source from 1937 to 1957, with 3.8-9.5 million litres of water pumped daily (Smalley and Zolan, 1981). During the last 20-30 years, most of the marsh has been unused. Currently, taro is cultivated on two small plots.

The Agana Swamp occurs in a large urban centre. Land surrounding the marsh is occupied by a number of businesses and homes. Only the hills on the southeast side of the marsh remain relatively undeveloped.

Possible changes in land use: No development of the marsh is currently planned. However, continued commercial and residential growth on adjacent lands is expected in the future.

Disturbances and threats: Over the years, drainage patterns have undoubtedly been modified by development in and around the marsh. Two important factors in this process have been small- and large-scale filling along the edges (Stinson *et al.*, 1991) and siltation caused by human activity and the deposition of decaying wetland vegetation. An electrical powerline and gravel access road bisect the north end and have reduced drainage except through one depression. The Agana Shopping Center was built in 1978 on a four-hectare fill in the northwest corner of the marsh. Proposals were put forth in the 1970s and again in the 1980s to construct large flood control projects inside the marsh and along the lower Agana River (U.S. Army Corps of Engineers, 1985). The projects would have resulted in the building of several levees along the northern boundaries of the marsh. Neither project was initiated but the plans could be revived in the future.

Thick beds of *Phragmites* clog the wetland and prevent other more favourable emergent plants from becoming established. This probably reduces the attractiveness of the wetland for moorhens and other wildlife. Intense dry season fires occasionally burn off large areas of *Phragmites*. Four major fires (in 1983, 1987, 1988 and 1990) occurred between 1981 and 1991. Fires during the 1960s may have played a role in the decline of the Nightingale Reed-warbler (*Acrocephalus luscini*) at this site (Reichel *et al.*, 1992).

The Chaot River has been chronically polluted with raw sewage since at least 1981. Other probable sources of pollution are run-off from adjacent urban areas and illegal dumping of garbage. A military fuel pipeline crosses two upper sections of the wetland and is a pollution threat should a leak occur.

In 1989, the Public Utility Agency of Guam installed two new water wells near the Agana Springs. A total of 5.7 million litres/day is removed from the wells. This could have some affect on the amount of water entering the marsh.

Hydrological and biophysical values: The marsh is valuable for a number of reasons including sediment trapping, flood control and maintenance of water quality. **Social and cultural values:** The dikes dating from the Spanish era remain in the marsh, but are heavily overgrown with *Phragmites*. The dikes are listed on the National Register of Historic Places. Potsherds and shell artifacts have been found on hummocks in the swamp, suggesting prehistoric use by Chamorros.

Noteworthy fauna: Common Moorhens were commonly recorded in the Agana Swamp in 1945 (Baker, 1951), but the population has been relatively small during the last 20-30 years. This may result from the presence of large *Phragmites* stands. Regular nesting occurred in one of the taro plots in the 1980s. The marsh is believed to be an important roosting site for significant numbers of Yellow Bitterns (*Ixobrychus sinensis*). It is the only recorded location for the White-browed Crake on Guam (*Porzana cinerea*) (Baker, 1951), which disappeared sometime after World War II. It is also the last site inhabited by the Nightingale Reed-warbler, which became extirpated in about 1969 (Reichel *et al.*, 1992). The preservation of the marsh would assist in reintroductions of these species from other islands, should such efforts ever be attempted. Feral pigs (*Sus scrofa*) were a nuisance to taro farmers in 1991 and may be fairly common in parts of the marsh.

Randall and Tsuda (1974) and Smith and Hedlund (1978) describe the aquatic fauna of the marsh. Native species include shrimp (*Macrobrachium lar*), freshwater eels (*Anguilla marmorata* and *A. bicolor*), two gobies (*Awaous guamensis* and *Stiphodon elegans*) and a sleeper (*Eleotris fusca*). Introduced fish include tilapia (*Oreochromis mossambicus* and *Tilapia zilli*), catfish (*Chlarius macrocephalus*), mosquitofish (*Gambusia affinis*) and a guppy (*Poecilia reticulatus*).

Noteworthy flora: Checklists of plants are given by Randall and Tsuda (1974), Moore *et al.* (1977) and Smith and Hedlund (1978).

Scientific research and facilities: Limnological, hydrological and biological surveys were made by Randall and Tsuda (1974), Moore *et al.* (1977), Smith and Hedlund (1978), Smalley and Zolan (1981) and Ayers and Clayshulte (1983).

Conservation education: Efforts were made in the 1970s to use the Agana Springs Nature Preserve as a teaching site for conservation education (Belk *et al.*, 1971), but the program was abandoned by 1980. The marsh's location in the population centre of Guam makes it an ideal site for future education efforts.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional jurisdiction: Division of Aquatic and Wildlife Resources

References: Ayers & Clayshulte (1983); Baker (1951); Belk *et al.* (1971); Moore *et al.* (1977); Randall & Tsuda (1974); Reichel *et al.* (1992); Safford (1905); Seabury (1934); Smalley & Zolan (1981); Smith & Hedlund (1978); Stinson *et al.* (1991); Thompson (1947); U.S. Army Corps of Engineers (1985); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 1a, 2a, 2b. This is the largest freshwater marsh on Guam. It contains habitat for Common Moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Barrigada Ponding Basin

Country: Guam

Coordinates: 13°28'N, 144°48'E

Location: this site is located in central Guam in the village and municipality of Barrigada. It occurs about 75-100 m southeast of the intersection of Highways 8 and 10.

Area: 0.3 ha.

Altitude: 61 m.

Overview: A wetland created to eliminate flooding in the surrounding residential and commercial area. It is used nearly year-round for nesting by Common Moorhens (*Gallinula chloropus guami*).

Physical features: This man-made site is comprised of an excavated basin ten metres deep that occupies about one ha of land. The bottom of the basin holds water throughout most years. Water comes from surface run-off from surrounding lands after heavy rainfall. Drainage occurs by slow percolation into the ground. The water level fluctuates about one metre between the wet and dry seasons. The upper perimeter of the basin is surrounded by a dilapidated chain link fence. Soils in the area are derived from argillaceous limestone and are shallow and well drained (Young, 1988).

Ecological features: The flooded bottom of the ponding basin has developed into a true wetland. It contains about 75% open water, all of which is covered by *Lemna perpusilla*. *Panicum muticum*, *Alocasia macrorrhiza* and *Cassia alata* grow along the fringes of the water. The site is classified as PAB4Hx and PEM1Fx (Cowardin *et al.*, 1979). The slopes of the basin are covered by dense secondary scrub, particularly *Leucaena leucocephala* and several species of weedy vines.

Land tenure: The wetland is owned by the Government of Guam; surrounding areas are privately owned with both residential and commercial areas.

Conservation measures taken: The ponding basin is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens lists the activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to the ponding basin include: (1) the development and implementation of habitat management plans through cooperative management agreements between the Government of Guam and the U.S. Fish and Wildlife Service; (2) the periodic monitoring of the site for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: The site was built in the mid-1970s. It functions as a ponding basin to collect surface water run-off and prevent flooding. During the late 1970s, the Guam Department of Public Health reared mosquitofish in the basin, then distributed the fish to other bodies of water around the island. The basin is bordered by homes on the east and south, a gasoline station on the north, and a busy seven-lane highway on the west.

Possible changes in land use: No major changes are expected to occur in the near future, although further residential development will probably continue.

Disturbances and threats: The main threat appears to be polluted run-off water entering the basin, particularly from the gasoline station. Some illegal dumping of garbage from neighbouring houses and the gasoline station occurs on the slopes above the water. Predation by pet or stray cats may occur on moorhens.

Hydrological and biophysical values: The site helps prevent flooding.

Social and cultural values: None known.

Noteworthy fauna: The ponding basin is large enough to support a breeding pair of Common Moorhens during most of the year. Up to three clutches of chicks are raised per year, making it one of the most productive sites currently known. Mosquitofish (*Gambusia affinis*) are present.

Noteworthy flora: None known.

Conservation education: The site has much potential for educating the public about moorhens.

Management authority and jurisdiction: Management Authority: Division of Aquatic and Wildlife Resources and the Department of Public Works. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources. References: U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Masso Reservoir

Country: Guam

Coordinates: 13°27'N, 144°42'E

Location: this pond is located in central Guam in the municipality of Piti. It lies about 600 m east of the intersection of Highways 1 and 6, or about 300 m east of the Guam Veterans Cemetery in Piti village.

Area: 2 ha.

Altitude: 12 m.

Overview: A small man-made pond built as a potable water reservoir. Common Moorhens (*Gallinula chloropus guami*) occur on the site.

Physical features: The reservoir was created by damming the Masso River. A dike and spillway, 65 m long, are present on the west bank. Water depth in the pond is about 4 m (Biosystems Analysis, Inc. 1989a) and falls slightly during the dry season. Hosmer (1982) reported on a variety of water analyses conducted here. The reservoir's watershed covers approximately 200 ha. Soils in the area are derived from argillaceous limestone and are shallow and well drained (Young, 1988).

Ecological features: This wetland has 75% open water, with large aquatic beds of *Hygrophila difformis* common. Dense stands of *Phragmites karka* grow along the southeastern and northeastern shores. The site is classified as PAB2Hh, PEM1F and POWHh (Cowardin *et al.*, 1979). Small to medium-sized trees were planted on the dike in the late 1970s. Extensive grasslands grow on the east and south sides, while secondary forest occurs to the north and west.

Land tenure: The wetland and surrounding property are owned by the U.S. Navy but have been pending transfer to the Government of Guam for several years. Conservation measures taken: The Navy and Government of Guam signed a perpetual use agreement in 1976, allowing the Guam Department of Agriculture to manage the reservoir and immediate area (2.2 ha) for public use. The reservoir is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991). Conservation measures proposed: A recovery plan for moorhens lists the activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that particularly apply to this wetland include: (1) the development and implementation of habitat management plans through cooperative management agreements between the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; (3) the periodic monitoring of the site for toxic substances; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: The Masso Reservoir was constructed by the U.S. Navy in about 1945 for the storage of drinking water, however, excessive siltation caused it to be abandoned in 1951 (Tucker and Kock, 1979). In 1978, the Guam Division of Aquatic and Wildlife Resources renovated the site with the goal of turning it into a public park and fishing area (Tucker and Kock, 1979). This involved the removal of one ha of *Phragmites*, the repair of the spillway and the planting of exotic trees and shrubs on the banks of the reservoir. In 1980 and 1981, the Division stocked the pond with hybrid tilapia (*Oreochromis mossambicus* x *O. niloticus*), mosquitofish (*Gambusia affinis*) and tucunare (*Cichla ocellaris*) (Hosmer 1982). However, vandalism and illegal fishing with chlorine caused the management program to be terminated in 1983 (Molina, 1983). The reservoir and surrounding grasslands are currently unused.

Possible changes in land use: No changes in land use are foreseen at the reservoir, but a condominium complex is proposed for construction 1.3 km upstream of the reservoir.

Disturbances and threats: Siltation of the reservoir is a chronic problem and is worsened by grassland fires that cause increased erosion in the catchment area. Proposed development is likely to worsen soil run-off. Illegal fishing with chlorine occurs infrequently in the pond and threatens aquatic animal life.

Hydrological and biophysical values: Useful in holding eroded soil sediments.

Social and cultural values: None known.

Noteworthy fauna: Common Moorhens are seen occasionally at the reservoir. Further observations may find that nesting occurs here. In 1978, the aquatic fauna of the reservoir included two species of eel (*Anguilla marmorata* and *A. bicolor*), three gobies (*Awaous guamensis*, *Stiphodon elegans* and *Sicyopterus macrostetholepis*), a sleeper (*Eleotris fusca*) and several shrimp (*Macrobrachium lar*, *Atya* sp. and *Caridina* sp.) (Tucker and Kock, 1978). In 1980 and 1981, the pond was stocked with hybrid tilapia, mosquitofish and tucunare (Hosmer, 1982). Some of these species may have since disappeared from the reservoir because of poisoning with chlorine.

Noteworthy flora: None known.

Scientific research and facilities: Limnological and faunal surveys were made by Tucker and Kock (1978) and Hosmer (1982).

Conservation education: There is little potential for education purposes under present conditions.

Recreation and tourism: A minor amount of recreational fishing still occurs at the reservoir.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Biosystems Analysis, Inc. (1989a); Hosmer (1982); Molina (1983); Tucker and Kock (1979); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Sasa Bay Wetland

Country: Guam

Coordinates: 13°27'N, 144°41'E

Location: this wetland is found along the eastern shore of Apra Harbor in west-central Guam. It occurs in the municipality of Piti and lies about 0.75 km southwest of Piti village.

Area: 102 ha.

Altitude: Sea level to 6 m.

Overview: A large coastal wetland with estuarine and freshwater habitats present. The largest stand of mangroves in the Mariana Islands is found here.

Physical features: This is a large natural wetland that fringes about 4 km of the northern, eastern and part of the southern shorelines of Sasa Bay in eastern Apra Harbor. The wetland occurs on flat low-lying ground and generally extends 50-500 m inland, where portions of it abut a series of hills to the east. Highway 1 divides the wetland into two areas and acts as a dike by altering drainage patterns. The largest portion of the wetland, about 65 ha, occurs west of the highway. Mucky clay soils that are deep and poorly drained characterize the mangrove zone along the shore (Young, 1988). The surface is hummocky in many areas. Further inland, a second band of wetland soils is also comprised of poorly drained clay but has a higher sand content (Young, 1988). Wetlands east of the road occur primarily along the drainages of the Sasa, Laguas and Aguada Rivers, which flow westward from the neighbouring hills to Sasa Bay. Two narrow fingers of wetland penetrate 1.0-1.3 km inland along the Sasa and Aguada Rivers. Both rivers are about 4-8 m wide and appear to be channelized (Moore *et al.*, 1977). The Sasa has banks that are 1-2 m high and stops flowing during the dry season. Mean water quality parameters of the Sasa River are reported in Biosystems Analysis, Inc. (1989a). The Aguada River has lower banks and overflows during the wetter parts of the year, which helps to maintain the adjacent swamp forest. The soils of these areas are predominantly deep and poorly drained clays (Young, 1988).

The total catchment area for the wetland is about 550 ha. The wetland is bounded by volcanic and limestone hills to the east, significant areas of man-made fill to the north and south, and Sasa Bay to the west, which is a shallow coastal lagoon containing a number of patchy coral reefs.

Ecological features: This wetland contains a variety of plant communities. Mangroves grow in a strip, 30-175 m wide, along the edge of the bay, and occupy almost 30% of the entire wetland. *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, *Avicennia marina* and *Lumnitzera littorea* are the dominant species (Moore *et al.*, 1977). The mangroves consist primarily of scrubby immature growth although patches of large trees also exist (Moore *et al.*, 1977). Mud sediments are generally 10-60 cm deep. A few *Heritiera littoralis*, *Terminalia catappa* and *Hernandia sonora* grow along the back edges of the mangroves, as does a small grove of *Nypa fruticans* near the Laguas River.

Much of the remaining area west of the highway is occupied by dense disturbed secondary forest with *Hibiscus tiliaceus*, *Cocos nucifera*, *Leucaena leucocephala*, *Pandanus tectorius*, *Thespesia populnea*, *Bambusa vulgaris*, *Pithecellobium dulce*, grasses and weeds present. This forest floods seasonally, then dries out for much of the year. Other habitats in this area

include beds of *Phragmites karka*, *Panicum muticum* and *Eleocharis ochrostachys*, and an intertidal mudflat generally lacking in vegetation. The western part of the wetland is classified as E2SS3N, PF03C and PEM1F (Cowardin *et al.*, 1979).

East of Highway 1, wetlands along the Sasa and Aguada Rivers are comprised primarily of short-statured palustrine forests of *Hibiscus tiliaceus* and *Bambusa vulgaris*. The Laguas River wetlands are well-zoned and reflect the salinity regime of the area (Moore *et al.*, 1977). The centre of the site contains a bed of *Scirpus littoralis* edged with *Acrostichum aureum* and a few *R. apiculata* (Moore *et al.*, 1977). Outward from this is a zone of *Phragmites*, with a band of *Hibiscus* behind this at the rear edge of the wetland. This eastern side is classified as PF03C, PEM1C, E2EM1N and E2SS3N.

Adjacent uplands are covered largely by disturbed secondary forest with *Leucaena leucocephala*, *Spathodea campanulata*, *Cocos nucifera*, *Pithecellobium duke*, *Casuarina equisetifolia* and herbaceous weeds.

Land tenure: Ownership of the wetland lies predominantly with the U.S. Navy (Naval Supply Depot and U.S. Naval Station). Private landowners hold a small area of wetland along the upper reaches of the Aguada River. Surrounding areas are also largely owned by the U.S. Navy (Naval Supply Depot and U.S. Naval Station). The Government of Guam and private landowners own some of the neighbouring lands.

Conservation measures taken: The eastern portion of the marsh is listed as a wetland of secondary importance for Common Moorhens (*Gallinula chloropus guami*) because of its potential for being managed as suitable habitat for this species (U.S. Fish and Wildlife Service, 1991). In 1980, a project was initiated to restore several hectares of mangroves at the mouth of the Laguas drainage that were killed by an oil spill (Pacific Basin Environmental Consultants, 1981). Several thousand hypocotyls, seeds and seedlings of mainly *R. mucronata* and *Avicennia* were planted. The seedlings, especially *Rhizophora*, have shown good survival. They are now 2-3 m tall and cover most of the damaged area.

Conservation measures proposed: Two natural resource management plans drafted by the Navy call for the prohibition of all activities in and adjacent to the wetland that might cause significant alterations or damage (Anon., in press, a, b). Other management recommendations are: (1) the rehabilitation and enhancement of areas with dense *Phragmites* growth; (2) the designation of two small areas east of Highway 1 as Common Moorhen sanctuaries; (3) the maintaining of a buffer zone 30 metres wide around the perimeter of the wetland, in which no development will be permitted; (4) the posting of signs around the wetland to note its protected status; and (5) assisting the Government of Guam and the U.S. Fish and Wildlife Service in moorhen censuses. A recovery plan for moorhens lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to the Sasa Bay Wetland include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the U.S. Navy, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the periodic monitoring of the site for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Dolga irregularis*) and feral dogs and cats.

Land use: Before World War II, portions of the wetland were used for growing rice and vegetables (Thompson, 1947). Currently, crab hunters and fishermen occasionally visit the wetland. A variety of commercial, industrial and military developments exist in or near the wetland. Highway 1 passes through the centre and has about two active oil pipelines and four old pipelines buried under the shoulder of the road. The Navy manages a large fuel storage area with a number of storage tanks in the Sasa River watershed east of Highway 1. Two other Navy installations operate adjacent to the wetland. A service base for submarines, known as Polaris Point, occurs to the south, and a ship repair facility on Dry Dock Island is found to the west. The Government of Guam and the Navy have several electrical power plants about 0.5 km northeast of the wetland. Other developments include a small private marina on Dry Dock Peninsula and a petroleum pipeline and pump house in the northeast corner of the wetland.

Possible changes in land use: The Government of Guam is considering the building of a large incinerator to burn municipal trash in the northeast portion of the wetland.

Disturbances and threats: The wetland has undergone considerable alteration over the years (Biosystems Analysis, Inc., 1988). The mangroves and associated wetlands were once much larger, but filling has reduced their size and divided them from neighbouring wetlands. The construction of Highway 1 probably modified parts of the wetland by blocking the natural flow of saline water upstream and impounding the palustrine wetlands east of the road (Biosystems Analysis, Inc., 1989a). Other major fills and road building, which occurred during the construction of Dry Dock Peninsula and Polaris Point in the late 1940s, cut across mangrove forests. The Laguas River has been completely dammed and the lower river channel no longer reaches Sasa Bay, passing instead into a reed marsh which eventually drains into the bay.

An oil spill involving an estimated 38,000 litres of diesel fuel occurred at the mouth of the Laguas drainage in June 1980 (Pacific Basin Environmental Consultants, 1981). The oil leaked from one of the pipelines buried along Highway 1 and killed or damaged about 1.8 ha of mangroves. Approximately 4,000 mangrove trees were lost (Pacific Basin Environmental Consultants, 1981). Oil saturated several centimetres of sediments in the worst areas of the spill. Clean up operations were sufficiently successful to allow the replanting of mangrove trees on the site. Biosystems Analysis, Inc. (1989a) observed a visible sheen of oil in the *Scirpus* marsh east of the highway near the Laguas River in 1987. They speculated that the oil emanated from a leak in one of the pipelines along the road, although it was possibly left over from the 1980 spill.

Thick *Phragmites* stands are common in the marsh and probably prevent other more favourable emergent plant species from becoming established. This may reduce the attractiveness of the wetland for wildlife.

During much of the year, the wetland is downwind from several power plants, which represent potential polluting sources. The building of an incinerator could similarly lead to additional contamination of downwind sites, including the wetland.

Hydrological and biophysical values: Valuable in sediment trapping and support of food chains.

Social and cultural values: The area contains a significant prehistoric or early historic Chamorro site, with about a dozen fish weirs made of stacked coral rocks lying on the reef flat near the edge of the mangroves at the Laguas River (Anon., 1990). The traps form a chain, 100 m long, of roughly rectangular enclosures, the largest of which is about 20 x 30 m in size. The site also has an abundance of broken pottery lying exposed in the wetland and at least three partial sets of latte stones. The central portion of the wetland also contains what appears to be the remains of a historic fishing camp dating back to the 1940s (Anon., 1990).

Noteworthy fauna: This area is important for a number of aquatic organisms that are specific to mangroves, including molluscs, bivalves, crustaceans and fish. Common species include several gastropods (*Littorina scabra* and *Cerithium* sp.), a clam (*Gafrarium tumidum*) and an oyster (*Crassostrea cucullata*) (Amesbury *et al.*, 1977; Pacific Basin Environmental Consultants, 1981). Fiddler crabs (*Uca chlorophthalmus* and *U. volans*), land crabs (*Cardisoma carnifex*) and mangrove crabs (*Scylla serrata*) inhabit mud substrates. The mangroves act as nursery grounds for jacks (Carangidae), barracudas (Sphyraenidae), snappers (Lutjanidae) and groupers (Serranidae) (G. Davis, pers. comm). They are also used by adult ponyfish (Leiognathidae), rabbitfish (Siganidae), mojarras (Gerreidae), milkfish (*Chanos chanos*) and mudskippers (*Periophthalmus koelreuteri*). An undescribed species of *Siganus* is restricted to the mangroves here and at the Atantano Wetland (Site 5). Hawksbill Turtles (*Eretmochelys imbricata*) occasionally approach the edges of the mangroves to feed on certain species of sponges (G. Davis, pers. comm).

Biosystems Analysis, Inc. (1989a) provides a partial list of the aquatic animals inhabiting the Aguada, Laguas and Sasa Rivers. The fauna includes three species of shrimp (*Caridina* sp., *Ayoida pilipes* and *Macrobrachium lar*), two tilapia (*Oreochromis mossambicus* and *Tilapia zilli*), two gobies (*Awaous guamensis* and *Sicyopterus macrostetholepis*) and a flagtail (*Kuhlia rupestris*). Small numbers of migrant shorebirds forage on nearby tidal mudflats and roost on exposed coral rocks in the mangroves. There are no records of Common Moorhens in the freshwater emergent portions of the wetland, but they are likely to use these areas seasonally.

Noteworthy flora: The wetland contains the largest area of mangroves on Guam. Moore *et al.* (1977) compiled a list of plants for the site. Scientific research and facilities: Preliminary plant and

animal lists were compiled by Amesbury *et al.* (1977), Moore *et al.* (1977), and Biosystems Analysis, Inc. (1989a). Pacific Basin Environmental Consultants (1981) discussed rehabilitation of the mangroves.

Conservation education: The mangroves have high potential for conservation education. The site is well-suited for the construction of a boardwalk and other visitor facilities (Anon., 1990).

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy (U.S. Naval Supply Depot and U.S. Naval Station). Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Amesbury *et al.* (1977); Anon. (1990); Anon. (in press, a, b); Biosystems Analysis, Inc. (1988, 1989a); Moore *et al.* (1977); Pacific Basin Environmental Consultants (1981); Thompson (1947); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 1a, 2b, 2c. This is one of Guam's largest wetlands. It contains a significant area of mangroves and an important cultural site, and is potential habitat for Common Moorhens.

Source: Gary J. Wiles.

Wetland Name: Atantano Wetland

Country: Guam

Coordinates: 13°25'N, 144°41'E

Location: this wetland lies 2.2 km west of Mt Tenjo in west-central Guam. It occurs along the boundary of the municipalities of Santa Rita and Piti, and is found about 2.9 km north of the village of Santa Rita.

Area: 130 ha.

Altitude: Sea level to 4 m.

Overview: One of Guam's largest wetlands, with both freshwater and estuarine areas present. It contains the most developed mangrove forest in the Mariana Islands. Common Moorhens (*Gallinula chloropus guami*) nest here.

Physical features: This is a large natural coastal wetland located on the southeast side of Apra Harbor. The wetland is comprised of two distinct subdivisions that are separated by Highway 1. The area east of the road is a large freshwater marsh formed at the confluence of the Atantano, Tenjo, Aplacho, Big Gautali and Gautali Rivers. This portion of the wetland is about 1.5 km long and up to 750 m wide. Water depths reach an estimated 0.5-1.0 m, but probably fall considerably in most areas during the dry season. Drainage occurs primarily through the Atantano River channel and a smaller creek, both of which pass under the highway. Clay soils in the marsh are mucky, deep and poorly drained (Young 1988).

The area west of the highway is smaller, about 1.2 km long and 500 m wide, and comprised largely of an estuarine mangrove swamp. Soils in the swamp are comprised of alluvial clays, with the sand content highest on the south side of the river channel (Moore *et al.*, 1977).

A distinct channel for the Atantano river forms several hundred metres east of the highway and flows northwestward through the centre of the mangrove swamp. Between the road and the harbour, the channel is distinctly banked and about 12-18 m wide. Moore *et al.* (1977) report a range in the river's discharge flow of 0.001-0.06 cubic metres per second. The channel is 0.6-1.2 m deep and has water temperatures of 27.4-29.2°C (Wilder, 1976). Water salinity is variable, depending on depth and distance from the river mouth. Salinity measurements of bottom water declined from 34 to 30 parts per thousand in the first 600 m of the channel, then fell to 10 parts per thousand in the next 300 m (Wilder, 1976). Biosystems Analysis, Inc. (1988) report on other water quality parameters in the Atantano and Big Gautali Rivers.

The total catchment area for the Atantano Wetland is about 1,490 ha. The site is surrounded by limestone and volcanic uplands. A number of small limestone hills border the wetland, while Mt Tenjo and other steep hills of volcanic soil occur 0.5-1.0 km to the east.

Ecological features: The freshwater marsh is dominated by monotypic stands of *Phragmites karka* and thickets of *Hibiscus tiliaceus*. *Panicum muticum* and various species of sedges are also present (Moore *et al.*, 1977; M. Ritter, pers. obs.). This section of the wetland is classified as PEM1F and

PF03C (Cowardin *et al.*, 1979).

The mangrove forest is 3-12 m tall. *Avicennia marina* and *Rhizophora apiculata* are dominant, with *Bruguiera gymnorrhiza* and *R. mucronata* also present (Moore *et al.*, 1977). A large pure grove of *A. marina* grows south of the river. Other common species west of the road include *Hibiscus tiliaceus*, *Dalbergia candenatensis*, *Barringtonia racemosa* and *Acrostichum aureum* (Wiles, pers. obs.). A small bed of *Scirpus littoralis* occurs near the Naval Supply Depot. The section of the Atantano channel that flows through this area is lined primarily with *H. tiliaceus*, *Casuarina equisetifolia*, *P. karka*, *Pandanus tectorius*, *Scaevola taccada*, *Scleria polycarpa* and some *Nypa fruticans*. Overall, the western portion of the wetland is classified as E2SS3N, E2F03N, R1 OWL, and PF03C.

Land tenure: The eastern portion of the wetland is privately owned. The U.S. Navy controls the area west of the highway. Surrounding areas are partly under private ownership and partly owned by the U.S. Navy.

Conservation measures taken: The freshwater portion of the marsh is listed as a wetland of primary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this site are: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the Government of Guam, The U.S. Navy and the U.S. Fish and Wildlife Service; (2) the periodic monitoring of the site for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Two natural resource management plans drafted by the Navy call for the prohibition of all activities that might significantly alter or damage the wetlands west of Highway 1 (Anon., in press, a, b). The plans also propose that a buffer zone, 30 m wide, with no development be maintained around that section of the wetland.

Land use: Before World War II, portions of the wetland were used for farming rice and vegetables (Thompson, 1947). Currently, several hectares on the west side (near the intersection of Highways 1 and 2A) are cleared annually during the dry season for vegetable crops. A minor amount of crab hunting occurs in the mangroves.

Various types of commercial, industrial and military development exist in a few areas next to the wetland. The largest of these is the Shell Oil refinery, which is a 45 ha complex located about 100 m east of the wetland. The military operates installations on each side of the mangrove forest. These consist of the Naval Supply Depot, which has a large set of docks and warehouses, and a U.S. Army Reserve facility to the south and a submarine port at Polaris Point to the north. Other developments include several small businesses and homes along the west side of the marsh. Highways 1 and 2A pass through the wetland and along the west of it, respectively.

Possible changes in land use: Several developments are proposed for construction near the southern end of the wetland along Highway 2A.

Disturbances and threats: The Atantano Wetland has experienced considerable disturbance over the years. The mangroves and freshwater marsh were probably continuous before the first road (now Highway 1) was built about 200 years ago. The roadbed functions as a dike and has likely caused significant changes in drainage patterns and salinity characteristics (Moore *et al.*, 1977; Biosystems Analysis, Inc., 1988). In the 1930s, ditches were dug to increase drainage (Eckburg, 1935). The site was probably once connected to other marshes that bordered Apra Harbor, such as the present-day Namo River and Naval Station Marshes, but became separated from them by filling for military and civilian development.

Filling has reduced the original size of this site. In addition to the construction of the highway, major fills preceded the building of naval facilities to the north and south of the mangroves in the mid to late 1940s. Further encroachment occurred with the building of a few homes and businesses along the margins of the wetland. Recently, one developer was required to alter his project and remove an illegal fill at the southern end of the wetland.

In September 1983, a major oil spill involving an estimated 3.8 million litres was discovered in the

wetland. The oil emanated from a pipeline on a nearby hillside that had been leaking for an unknown period of time. The oil flowed into the Gautali River and travelled downstream into the marsh. It eventually seeped outward to the channel of the Atantano River and washed into Apra Harbor. Cleanup efforts lasted two and a half years, during which time an estimated 2.8 million litres of oil were recovered from the wetland. The oil's presence had no apparent harmful effects on the *Phragmites*, which continued to persist even in areas with 15-30 cm of standing oil. Also, no die-offs of mangroves occurred. The effect of the spill on the wetland's fauna was never determined; however, cleanup workers failed to observe any aquatic animal life in the immediate area of the spill.

Parts of the wetland may be contaminated with heavy metals and other toxic substances originating from the nearby Shell Oil refinery, which is known to have pollution problems. It is likely that toxic materials have seeped from the refinery downhill into the Atantano marsh.

Soil erosion from hillsides east of the wetland is a continual problem (Eckburg, 1935) exacerbated by annual grassland fires. Soils are washed down the streams of the watershed and deposited in the wetland. Such sedimentation is probably slowly reducing the water capacity of the marsh.

Sedimentation and disturbed conditions resulting from past and present farming may aid the invasion of *Phragmites*, which clogs the marsh. Large fires burn through the *Phragmites* beds on rare occasions.

Hydrological and biophysical values: The wetland has a number of important values including flood control, sediment and pollutant trapping, and support of food chains.

Social and cultural values: A historic monument known as the Atantano Shrine is located on an area of fill in the centre of the wetland a short distance from Highway 1. The shrine commemorates the completion of the road from Piti to Agat, which was originally built in 1784-1785 and further improved in 1832-1834 and again in 1908-1909. The shrine is listed on the Guam Register of Historic Places and is now owned by the Government of Guam.

Noteworthy fauna: Common Moorhens nest in the freshwater marsh, but their abundance and seasonal occurrence are poorly known. Yellow Bitterns (*Ixobrychus sinensis*) also make use of the area. The Nightingale Reed-warbler (*Acrocephalus luscini*), an endangered species now extinct on Guam, inhabited the wetland until 1968 (Reichel *et al.*, 1992). Introduced catfish (*Clarius macrocephalus*) occur in the marsh.

Biosystems Analysis, Inc. (1988) provided a preliminary list of aquatic animals found in the Atantano River channel between Highway 1 and Apra Harbor. The list includes three species of shrimp (*Caridina* sp., *Atyoida pilipes* and *Macrobrachium lar*), a halfbeak (*Zenarchopterus dispar*), tilapia (*Oreochromis mossambicus*), a goby (*Awaous guamensis*), a flagtail (*Kuhlia rupestris*) and a mullet (*Liza vaigiensis*).

The Atantano mangroves provide important habitat for a number of aquatic organisms, including sponges, molluscs, bivalves, crustaceans and fish (G. Davis, pers. comm. The area is particularly well-suited for molluscs because of its location in inner Apra Harbor, where water turbidity is higher and water circulation is lower than in other mangroves on the island. The mangroves are an important nursery ground for jacks (Carangidae), barracudas (Sphyraenidae), snappers (Lutjanidae) and groupers (Serranidae). They are also used extensively by adult ponyfish (Leiognathidae), rabbitfish (Siganidae), mojarras (Gerreidae) and milkfish (*Chanos chanos*). An undescribed species of *Siganus* is restricted to the mangroves here and at Sasa Bay (Site 4). Fiddler crabs (*Uca* spp.), land crabs (*Cardisoma carnifex*) and mangrove crabs (*Scylla serrata*) inhabit mud substrates. The native skink *Emoia caeruleocauda* is also common in the mangrove (Wiles, pers. obs.). Noteworthy flora: The wetland contains the best developed and most mature stand of mangroves in the Mariana Islands (Moore *et al.*, 1977). Guam's largest grove of *Avicennia marina* occurs here. Moore *et al.* (1977) list the plants found in the wetland.

Scientific research and facilities: Plant and animal lists were compiled by Moore *et al.* (1977) and Biosystems Analysis, Inc. (1988).

Conservation education: The wetland has moderate potential for conservation education, particularly for showing the characteristics of mangroves to the public.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and the U.S. Navy (U.S. Naval Supply Depot and U.S. Naval Station). Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction:

Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Anon. (in press, a, b); Biosystems Analysis, Inc. (1988); Eckburg (1935); Moore *et al.* (1977); Reichel *et al.* (1992); Thompson (1947); U.S. Fish & Wildlife Service (1991); Wilder (1976); Young (1988).

Reasons for inclusion: 1a, 2a, 2b, 2c. One of the island's largest wetlands, with a significant stand of mangroves. Common Moorhens use the site.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Shell Oil Wetlands

Country: Guam

Coordinates: 13°25'N, 144°41'E

Location: this site occurs in west-central Guam in the municipality of Piti. The wetlands are found about 3.3 km northeast of the village of Santa Rita and 1.0 km west of Mt Tenjo.

Area: A total of 2.3 ha for four separate ponds.

Altitude: 10-30 m.

Overview: A group of four small ponds located on the grounds of an oil refinery. Common Moorhens (*Gallinula chloropus guami*) nest in several of the ponds throughout the year.

Physical features: The four ponds lie in the drainages of the Big Gautali and Tenjo Rivers and were created during the construction of the Shell Oil refinery (formerly known as the GORCO refinery) in the mid-1960s. Two ponds in the northwest corner of the facility are shallow depressions adjoining each other, and are rimmed by diking one metre high. The western pond is larger, about 125 m by 80 m. The eastern pond is 125 m by 50 m. Both have gently sloping bottoms, with the deepest areas occurring on the north. Water depths reach about one metre during the rainy season, when some overflow of the dikes occurs. The ponds usually retain up to 50% of their water in the dry season. A third pond measuring 125 m by 35 m lies on the southwest side of the refinery, while a fourth pond in the centre of the facility is about 80 m by 40 m in size. Both are diked and have steep sides. Water depths are fairly constant during the year, ranging from about one to two metres. The silty clay soils in the refinery are deep and well drained but were greatly disturbed during construction (Young, 1988).

Ecological features: Although the northwestern ponds lie next to each other, they vary considerably in vegetation. Little plant growth is present in the eastern pond, except for *Panicum muticum* on the dikes and mats of algae in the water. During the wet season, open water comprises about 80-90% of its surface area. The western pond has luxuriant plant growth, with *P. muticum*, *Saccharum spontaneum*, *Fuirena umbellata*, *Eleocharis geniculata*, *Fimbristylis* sp. and other species present. The amount of open water in the pond varies from 10-50% during the year. These sites are classified as POWHh and PEM1Fh (Cowardin *et al.*, 1979).

The southwestern pond has approximately 75% open water. *P. muticum* is the dominant plant present, while *Phragmites karka* grows on the edges. The pond is classified as POWHh and PEM1Hh. The central pond is also ringed by *Phragmites*, with *Hydrilla verticillata* and *P. muticum* growing in deeper water. The amount of open water is estimated at 50%. The pond is classified as POWHh, PEM1Hh and PAB2Hh. Savanna and secondary forest with *Leucaena leucocephala*, *Hibiscus tiliaceus*, *Vitex parviflora*, *Cocos nucifera* and *Casuarina equisetifolia* border the refinery.

Land tenure: The wetlands are privately owned by the Shell Oil Company; surrounding areas are also privately owned.

Conservation measures taken: The ponds are listed as wetlands of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for Common Moorhens lists the activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this site include: (1) the development and implementation of habitat management plans through cooperative management agreements between the landowner, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the periodic monitoring of the sites for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: The ponds occur in a 45 ha petroleum refinery with a number of large storage tanks. The two northwestern ponds function to separate minor amounts of oil from storm water run-off coming from the entire refinery facility. The southwestern pond was originally built to aerate oily water discharged during oil refining processes, but has been unused since about 1983. The central pond was created to hold water for fighting fires, although no water has been withdrawn for this purpose in at least 10 years. Public entry into the refinery is generally prohibited. Most adjoining lands are currently idle.

Disturbances and threats: The ponds generally receive little disturbance aside from occasional grass mowing and other refinery maintenance work. The northwestern ponds may contain a variety of toxic substances. Testing is underway to determine the extent of contamination. If severe, both ponds may have to be decontaminated and capped, which will destroy their functional role as wetlands.

The presence of tilapia (*Oreochromis mossambicus*) in at least one of the ponds may be harmful to moorhens by reducing food sources. Two large uncovered sludge ponds near the northwest ponds may also threaten moorhens and shorebirds that occasionally visit them.

Hydrological and biophysical values: Important in trapping refinery pollutants.

Social and cultural values: None known.

Noteworthy fauna: These wetlands are used extensively by Common Moorhens. Pairs of moorhens inhabit each pond for part or all of the year, with regular nesting occurring in at least three ponds. A variety of migratory ducks, shorebirds and egrets visit the site in small numbers. Tilapia occur in the central pond.

Noteworthy flora: None known.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Important nesting habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Naval Station Marsh

Country: Guam

Coordinates: 13°25'N, 144°40'E

Location: this wetland occurs in west-central Guam at the base of Orote Peninsula. It is in the municipality of Santa Rita about 3 km north of the village of Santa Rita. It is located on the U.S. Navy Public Works Center.

Area: 40 ha.

Altitude: 1-3 m.

Overview: A large marsh suffering from infilling and overgrowth of *Phragmites karka* and *Panicum muticum*. Common Moorhens (*Gallinula chloropus guami*) probably nest here.

Physical features: This natural wetland is located near the coast in Apra Harbor. It is bordered on the east, south and west by buildings, open lawns, a large landfill and stands of scrubby secondary forest. A natural limestone berm and highway occur on the north side. Several small mounds of high ground occur inside the marsh. The water level of the marsh varies considerably during the year. Maximum water depth is probably never more than one metre. Most of the site dries out during the dry season. Only a few pockets of standing water are retained during this time. Water at the north end of the marsh is slightly brackish. The clay soils in the area are deep, mucky and poorly drained (Young, 1988).

Ecological features: The wetland is dominated by dense beds of *Phragmites karka* and *Panicum muticum*. Several small areas of open water occur near the north end of the marsh and cover 1-2% of the total area. One of these openings is surrounded by *Ipomoea aquatica*. A few scattered mangrove trees (*Rhizophora apiculata*) also grow in the northern end, which is nearest the sea coast. The habitat classification of this wetland is PEM1F (Cowardin *et al*, 1979). *Leucaena kucocephala*,

Casuarina equisetifolia, *Cocos nucifera*, *Bambusa vulgaris*, a grass (*Saccharum spontaneum*) and weeds grow on areas of higher ground in and around the marsh.

Land tenure: The wetland and surrounding areas are under the control of the U.S. Navy. Conservation measures taken: The marsh is listed as a wetland of primary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A drafted natural resources management plan for the U.S. Navy Public Works Center, Guam, proposes that active management of this wetland be initiated (Anon., in press, c). The major recommendations of the plan are to designate most of the marsh as a Common Moorhen Sanctuary, rehabilitate the marsh by deepening it and controlling *Phragmites* growth, and reestablish appropriate emergent vegetation. The plan proposes that these actions be started in the northwest corner and then enlarged to the remainder of the wetland at a later date. A public education campaign would also be conducted.

A recovery plan for moorhens also lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this marsh include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the Navy, Government of Guam and U.S. Fish and Wildlife Service; (2) the periodic monitoring of the site for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: A small amount of *Ipomoea aquatica* is collected in the marsh. The surrounding upland areas are used by the Navy for various military functions, including administrative and housing purposes. The Navy-operated landfill southeast of the marsh continues to be used as a disposal site for most of the garbage produced by the Navy on Guam.

Possible changes in land use: No changes in land use in or around the marsh are foreseen. Additional construction of new buildings at Camp Covington, located east of the marsh, could occur but is not expected to have a direct impact on the wetland.

Disturbances and threats: Historically, this wetland was probably much larger in size, but some of it was probably filled after World War II to make room for military facilities. Slow infilling from siltation over the years has allowed the invasion of *Phragmites* and *Panicum*, which occupy most of the site. Both plants tend to choke off the wetland, and prevent other more favourable emergent plant species from becoming established. The possible leaching of hazardous materials from the landfill represents a significant threat to the area that the Navy is currently investigating.

Hydrological and biophysical values: Important for trapping sediments and pollutants. Social and cultural values: None known.

Noteworthy fauna: Small numbers of Common Moorhens were regularly seen here in the past, but increasingly dense reed beds resulted in few sightings from 1988-1990. Nesting has undoubtedly occurred here. Small migratory flocks of Cattle Egrets (*Bubulcus ibis*) roost in the mangrove trees during the fall and winter months of most years. A few migratory waterfowl are also sometimes observed. Catfish (*Clarius macrocephalus*) are present.

Noteworthy flora: Moore *et al.* (1977) list the plants found on the site.

Scientific research and facilities: Moore *et al.* (1977) conducted a floral survey.

Conservation education: In its current condition, the wetland has little value for conservation education. However, if the program to enhance the marsh is carried out, the site will have significant value for educating the public about wetlands.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Anon. (in press, c); Moore *et al.* (1977); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 1a, 2a, 2b. One of the largest marshes on Guam. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: San Luis Ponds

Country: Guam

Coordinates: 13°26'N, 144°39'E

Location: these marshes are located on the north side of Orote Peninsula adjacent to Apra Harbor in west-central Guam. They occur on the U.S. Naval Station and in the municipality of Santa Rita. They lie 3.5 km east of Orote Point. Area: A total of 7.5 ha for the two marshes.

Altitude: Sea level.

Overview: Two man-made estuarine ponds. Common Moorhens (*Gallinula chloropus guami*) are present for at least part of the year.

Physical features: A narrow artificial dike with an asphalt road separates the marsh from Apra Harbor. The dike also divides the marsh, creating two ponds that are 7.0 ha and 0.6 ha in size. The east pond is the largest and is triangular in shape. Both were probably created by the U.S. military during the late 1940s. Standing water in the large pond is generally about one metre deep although a moat on the inner edge, from which materials were obtained to construct the dike, has depths of up to two metres. The water level is fairly constant throughout the year. The ponds are primarily supported by freshwater runoff from nearby uplands, although there is some tidal influence (Biosystems Analysis, Inc., 1988). Thus, both are somewhat brackish. The southern sides of the marshes are bordered by limestone uplands that comprise San Luis Point. The soils in the vicinity of the ponds are quarried fill consisting primarily of limestone gravel (Young, 1988).

Ecological features: Both impoundments support lush beds of *Scirpus littoralis*, with *Acrostichum aureum* growing along many of the edges. There is about 20% open water in the larger pond and about 10% open water in the smaller pond. The habitat classification of the ponds is E1EM1Lh and E1OWLh (Cowardin *et al.*, 1979). The shorelines of both ponds support dense weedy growth (*Wollastonia biflora* and *Pluchea x fosbergii*) and some woody vegetation, primarily *Casuarina equisetifolia*, *Leucaena leucocephala* and *Thespesia populnea*. Mature limestone forest grows on the hillside to the south.

Land tenure: The wetland and surrounding areas are under the control of the U.S. Navy.

Conservation measures taken: The marsh is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A drafted natural resources management plan for the Naval Station proposes that active management of this wetland be started (Anon., in press, a). Major recommendations of the plan are to designate both ponds as a Common Moorhen Sanctuary, limit human activities in and around the ponds, and make structural modifications to the ponds that would enhance moorhen production. A public education campaign would also be initiated as part of the program.

A recovery plan for moorhens also lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this site include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the Navy, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; and (3) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: The ponds are not used for any purpose. The road encircling the wetland is used recreationally to a minor extent, and the Navy maintains a small picnic and swimming area at NSD Beach on the west end of the small pond. The Navy also runs a small marina east of the large pond.

Possible changes in land use: No changes in land use are foreseen for this area.

Disturbances and threats: The omnivorous habits of tilapia in the ponds may prevent other types of aquatic vegetation from becoming established, and may reduce some populations of invertebrates. These effects may limit moorhen numbers below their potential carrying capacity.

Hydrological and biophysical values: None known.

Social and cultural values: None known.

Noteworthy fauna: Common Moorhens have been recorded at both ponds (Biosystems Analysis, Inc., 1988), but their occurrence is not well documented and historic sightings have been few. Nesting may occur here. Yellow Bitterns (*Ixobrychus sinensis*) also use the ponds. The ponds support dense

populations of two species of tilapia (*Oreochromis mossambicus* and *Tilapia* and flagtails (*Kuhlia rupestris*) (Biosystems Analysis, Inc., 1988).

Noteworthy flora: None known.

Conservation education: The ponds have moderate potential for conservation education.

Recreation and tourism: A little fishing occurs in the ponds. The surrounding areas also receive some recreational use.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Anon. (in press, a); Biosystems Analysis, Inc. (1988); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Namo River Marsh

Country: Guam

Coordinates: 13°24'N, 144°40'E

Location: the marsh is located in west-central Guam in the municipality of Santa Rita. It lies about 1.4 km north of the village of Agat and just east of the intersection of Highways 2 and 2A. Most of the site is found on the U.S. Naval Station.

Area: 33 ha.

Altitude: 1-3 m.

Overview: A moderately-sized wetland that is heavily overgrown with *Phragmites karka*. Common Moorhens (*Gallinula chloropus guami*) probably reside in the area.

Physical features: This is a natural marsh found along the eastern bank of the lower Namo River. The lower 600 m of this river was channelized for flood control purposes in the late 1970s by the U.S. Army Corps of Engineers. A low dike, 50 m wide, was built next to the river channel at that time, along with a second similar dike across a central portion of the wetland. Water depths in the marsh reach at least one metre. They vary somewhat during the year, being lowest in the dry season. Biosystems Analysis, Inc. (1988) report on water quality parameters for the Namo River. The clay soils in the area are deep and poorly drained (Young, 1988).

The drainage area of the Namo River is about 500 ha (Best and Davidson, 1981). The eastern side of the wetland is bounded by low hills, several of which jut into the site. A large residential area is located on the tops of several of these hills, while smaller areas of homes occur on the south and west. The wetland is bordered by Highway 2A on the northwest and a large concrete parking lot on the north.

Ecological features: The wetland consists predominantly of dense beds of *Phragmites karka* and woody stands of *Hibiscus tiliaceus*. An area of one hectare of *Panicum muticum* grows in the northwest corner on a site that was apparently cleared for farming about 8-10 years ago. Several pools of open water occur in the north-central portion of the marsh and cover an estimated 5% of the total area. The wetland is classified as PEM1F and PF03C (Cowardin *et al.*, 1979). Scrubby secondary forest, with *Hibiscus tiliaceus*, *Leucaena leucocephala*, *Casuarina equisetifolia*, *Pandanus tectorius* and a variety of other species, is the major vegetation type surrounding the wetland.

The Namo River Wetland was probably once part of a much larger interconnected complex of marshes that bordered inner Apra Harbor. However, these wetlands have been severely fragmented over the years by filling for military activities, civilian development and road construction. The present-day Naval Station and Atantano Marshes were part of this complex.

Land tenure: The wetland and surrounding areas are partly under the control of the U.S. Navy and partly in private ownership.

Conservation measures taken: The marsh is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this site

include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the Navy, Government of Guam and U.S. Fish and Wildlife Service; (2) the periodic monitoring of the site for toxic substances; (3) the conducting of regular censuses for moorhens; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

The northern portion of the marsh is located on the Naval Station and is one of a number of wetlands noted in a recently drafted natural resources management plan for the base (Anon., in press, a). Although the plan does not make specific management recommendations for this area, it does provide a list of general recommendations regarding the base's wetlands. Recommendations that apply to the marsh include: (1) protecting the site from development; (2) maintaining a buffer zone 30 m wide around the site; (3) posting of signs around the site to note its protected status; and (4) assisting the Government of Guam and the U.S. Fish and Wildlife Service in moorhen censuses.

Land use: Before World War II, portions of the marsh were used for farming rice and vegetables (Thompson, 1947). From the late 1940s to the mid-1970s, an area immediately north of the wetland known as Camp Busanda provided housing for about 10,000 contract workers and military personnel. An adjacent area bordering the east side of the wetlands was a disposal site for solid wastes and contained several underground storage tanks. At present, the wetland is not used. A large residential area occurs about 300-400 m to the east on adjacent lands, while smaller areas of homes are also present to the south and west. The parking lot on the north side of the marsh is used by the Guam Department of Education for parking school buses.

Possible changes in land use: The Government of Guam is proposing to construct a municipal sewage treatment facility on the north side of the marsh on land that is now partially occupied by the parking lot. The facility will include primary and secondary treatment facilities and a pump station, and will cover about 8-10 ha.

Disturbances and threats: This site suffers from a number of problems, making it one of the more threatened wetlands on Guam. Thick beds of *Phragmites* cover large areas and prevent the establishment of other more favourable wetland plants. The heavy growth of *Phragmites* is probably enhanced by the long-term deposition of eroded soils into the marsh from neighbouring lands. The channelization of the lower Namu River has probably increased drainage and lowered seasonal water levels (Biosystems Analysis, Inc., 1988). Tests for hazardous wastes in the vicinity of the parking lot found oil in the ground and higher than expected levels of heavy metals. These materials probably originated from a vehicle maintenance yard that the Navy operated at the site for about 30 years. The Navy also believes that underground storage tanks east of the marsh are still in place and may be leaking hazardous substances. The building of the sewage treatment plant may result in additional filling and contamination of the wetland.

Hydrological and biophysical values: Valuable in flood control and sediment trapping.

Social and cultural values: None known.

Noteworthy fauna: Wildlife use of the marsh is not well documented. Common Moorhens probably reside here, particularly in the pools of open water at the north end.

Noteworthy flora: A list of plants in the wetland is given in Moore *et al.* (1977).

Scientific research and facilities: Moore *et al.* (1977) conducted a floral survey of the site.

Conservation education: The wetland has moderate potential for conservation education.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Anon. (in press, a); Biosystems Analysis, Inc. (1988); Moore *et al.* (1977); U.S. Fish and Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Pulantat Marshes

Country: Guam

Coordinates: 13°25'N, 144°44'E

Location: these wetlands are located in central Guam in the municipality of Yona. The smaller eastern marsh occurs 3.7 km west of Yona village, with the larger marsh found 0.5 km further west.

Area: A total of 2 ha for two marshes. The western site covers 1.2 ha.

Altitude: 133 m.

Overview: Two artificial marshes located in savanna along the edge of a large resort currently under construction. Common Moorhens (*Gallinula chloropus guami*) nest seasonally at both sites.

Physical features: The Pulantat Marshes are comprised of two man-made impoundments located near the edge of a high plateau overlooking the Sigua River valley. Both wetlands have small dikes two metres high at their eastern ends and were built in about 1966 by the landowner (H.D. Look, pers. comm.). They are filled by run-off water from somewhat higher ground to the south and west, and have water depths of 0.6-0.8 m during the rainy season. In the dry season, the eastern pond dries out completely while the western marsh retains only one small pool at the east end. The marshes are bounded by gently sloping uplands to the south and west, and by the Sigua River valley to the north. Soils in the marshes have not been classified but are probably derived from the clay soils that occur throughout the area.

Ecological features: Both marshes are comprised primarily of uniform beds of *Eleocharis ochrostachys*. A small stand of *Phragmites karka* occurs at the western end of the larger pond. Depending on the time of year and amount of water present, relatively open water covers between 0-30% of the marshes. Both are classified as PEM1Fh (Cowardin *et al.*, 1979). The savanna grasslands surrounding the marshes are comprised of *Miscanthus floridulus*, *Gleichenia linearis*, a variety of other herbaceous plants and scattered *Casuarina equisetifolia*. Numerous erosional scars of exposed earth exist in the vicinity of both ponds.

Land tenure: The wetlands and surrounding areas are privately owned.

Conservation measures taken: The marshes are listed as wetlands of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991). In 1989, in response to the impending building of a resort immediately south of the marshes, federal and territorial government agencies prevailed upon the resort's developer to redesign the project to preserve both sites. The developer is being required to protect the marshes during construction by using silt fences and other methods to control soil run-off. Other practices have also been instituted to protect any Common Moorhens in the western marsh. These include maintaining buffer zones of no activity that are 10-90 m wide around the marsh, and keeping the area free of dogs and pollutants.

Conservation measures proposed: A recovery plan for moorhens lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to the marshes include: (1) the development and implementation of a habitat management plan through a cooperative management agreement among the landowners, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; (3) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats; and (4) the periodic monitoring of the site for toxic substances.

The developer of the resort will be required to continue some erosion control practices to protect the marshes after the completion of the resort. For the benefit of moorhens, the U.S. Fish and Wildlife Service will also require that the developer: (1) maintain a suitable water level throughout the year in the western marsh by piping or trucking water to the site; (2) construct or plant a visual barrier of some form around the site to reduce human-related disturbances to the birds; and (3) monitor water quality for pollutants.

Land use: The marshes were constructed in 1966 as a water source for cattle. The animals were removed from the area in 1975 and since then, both sites have remained essentially unused. The surrounding grasslands also received little use until 1988, when work began on the huge 525 ha resort. When completed in about 1994, the resort will comprise 3,000 housing units, a hotel and commercial centre, two and a half golf courses, several artificial lakes and a number of service roads.

Possible changes in land use: In September 1991, a second group of developers presented

the Government of Guam with plans for the building of another large resort in the Sigua River valley and immediately south of the marshes. Thus, both marshes may be surrounded by urban growth by the end of the decade.

Disturbances and threats: Both marshes suffer from chronic siltation caused by soil runoff from adjoining lands. The grasslands in the area are prone to dry season fires, which are often set by people and result in erosion. Despite the safeguards taken during the construction of the resort, there is still some possibility that the project will lead to further erosion and disturb resident moorhens. During the dry season, feral pigs (*Sus scrofa*) commonly visit both wetlands to feed on *Eleocharis* tubers. The pigs may root up 10-20% of each marsh while feeding.

Hydrological and biophysical values: Useful in trapping soil sediments.

Social and cultural values: None known.

Noteworthy fauna: Common Moorhens inhabit both marshes during the wet season. Breeding has been recorded at both locations.

Noteworthy flora: None known.

Conservation education: The marshes will have moderate value for education purposes, once the resort is completed and public access into the area is improved.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: U.S. Fish & Wildlife Service (1991).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Naval Magazine Pond

Country: Guam

Coordinates: 13°23'N, 144°41'E

Location: this pond is located in south-central Guam in the municipality of Santa Rita. It lies about 20-30 m off the south side of Highway 12, approximately 0.9 km east of the village of Santa Rita. It occurs entirely within the boundaries of the U.S. Naval Magazine.

Area: 0.5 ha.

Altitude: 85 m.

Overview: A small marsh found on the U.S. Naval Magazine. Common Moorhens (*Gallinula chloropus guami*) are periodically recorded here.

Physical features: This man-made wetland was probably created when Highway 12 and an adjacent berm were constructed, blocking water flow along a small seasonal stream. The site is bordered by forest to the south and by Highway 12, mowed openings and a chainlink fence to the north. A small culvert under the road drains the pond and prevents flooding. The site holds water year-round, but the level may decline to a depth of 0.5-1.0 m in the dry season. Soils are deep, well-drained, contain a silt and clay mixture, and are volcanic based (Young 1988).

Ecological features: This wetland is 50-75% open water and dominated by an unidentified submergent algae. Emergent vegetation, mainly *Phragmites karka* and *Panicum muticum*, grows along the edges in several shallow areas. Some *Hibiscus tiliaceus* is also present. The site is classified as PAB1Hh and PEM1Hh (Cowardin *et al.*, 1979). The marsh is bounded by secondary limestone forest to the south.

Land tenure: The wetland and surrounding areas are under the control of the U.S. Navy.

Conservation measures taken: The Navy has generally prohibited the entry of civilians into Naval Magazine for the purposes of military security since the base was established in the early 1950s. Although not a deliberate conservation action, this limitation has indirectly protected the base's wildlife and natural habitats. The pond is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991), and the forest bordering the south side has been declared essential habitat for Marianas Fruit Bats (*Pteropus mariannus*) (Wiles, 1990).

Conservation measures proposed: A recovery plan for moorhens lists the actions needed to protect this species at this site (U.S. Fish and Wildlife Service, 1991). These include the development and implementation of habitat management plans, the conducting of regular censuses, the control of

introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats, and the control of introduced ungulates. A new natural resources management plan for Naval Magazine also calls for the protection of natural habitats and the improvement of moorhen habitat (Biosystems Analysis, Inc., 1990). A proposal to establish Critical Habitat for fruit bats and endangered forest birds throughout Naval Magazine, which would give protection to the forests surrounding this wetland, is now being considered by the U.S. Fish and Wildlife Service.

Land use: Naval Magazine serves as a munitions storage site and public access is completely restricted. The area surrounding the pond is not actively used for any purpose.

Disturbances and threats: Soil run-off from nearby hills into the pond may be a minor problem. Erosion is caused primarily by rooting, trampling and overgrazing by feral pigs (*Sus scrota*) and Philippine Deer (*Cervus mariannus*) in adjoining forests.

Hydrological and biophysical values: None known.

Social and cultural values: None known.

Noteworthy fauna: Moorhens are periodically observed at this marsh but their occurrence, which appears to be seasonal, has not been well studied. The species may breed here. Deer and feral pigs are common in the forests adjacent to the marshes.

Noteworthy flora: None known.

Conservation education: The pond has limited potential for conservation education.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Biosystems Analysis, Inc. (1990); U.S. Fish & Wildlife Service (1991); Wiles (1990); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Fena Valley Reservoir

Country: Guam

Coordinates: 13°21'N, 144°42'E

Location: the reservoir occurs in south-central Guam in the municipalities of Santa Rita, Agat and Talofof. It is located entirely within the boundaries of the U.S. Naval Magazine.

Area: 81 ha.

Altitude: 33 m.

Overview: The largest open body of fresh water on Guam. The reservoir was built by the Navy in 1951 as a source of drinking water. It holds the largest dry season concentration of Common Moorhens (*Gallinula chloropus guami*) on Guam.

Physical features: The reservoir was formed by the damming of the Mahlac River and is 3 km long and up to 600 m wide. A large dike about 400 m long and 12 m high and a spillway occur on the northeast side of the reservoir. The Maulep, Almagosa, Sadog Gaso and Imong Rivers flow into the reservoir. The areas drained by these rivers occupy approximately 1,500 ha. The reservoir has a stored water capacity of about 9.7 million cubic meters when full (Biosystems Analysis, Inc., 1989b). Maximum water depth in the reservoir is 20 m during the rainy season, but the water level drops 2-9 m during the dry season. The predominant soil types of the area are deep, well-drained volcanic clays (Young, 1988). Average water temperatures range from 27-31°C (Kennedy Engineers, 1974; Biosystems Analysis, Inc., 1989b). Levels of dissolved oxygen are very low at the bottom of the reservoir but increase near the surface. The stratification of oxygen is typical of tropical lakes and is a result of decomposition of organic matter in deeper water (Biosystems Analysis, Inc. 1989b). Nutrient concentrations are reported by Kennedy Engineers (1974). Average outflow of water from the reservoir is about 62 million litres per day (Ward *et al.*, 1965).

Ecological features: The reservoir is an open-water lake surrounded primarily by steep slopes vegetated with ravine forest, grassland and limestone forest. The reservoir contains extensive beds of

Hydrilla verticillata. Narrow bands of emergent vegetation (*Phragmites karka*, *Panicum muticum* and *Cyperus difformis*) grow along the shoreline. The main body of the reservoir is classified as LI OWHh and its edges as PEMIF and PEMIC (Cowardin *et al.*, 1979).

Land tenure: The wetland and surrounding areas are under the control of the U.S. Navy.

Conservation measures taken: The Navy has generally prohibited the entry of civilians into Naval Magazine and the Fena Valley Reservoir for the purposes of military security since the base was established in the early 1950s. Although not a deliberate conservation action, this limitation has served indirectly to protect the base's natural habitats and wildlife. All hunting and most fishing in and around the reservoir is prohibited because of entry restrictions, although these activities occur illegally at low to moderate levels. The reservoir is listed as a primary wetland for Common Moorhens (U.S. Fish and Wildlife Service, 1991), and the entire watershed has been declared essential habitat for Marianas Fruit Bats (*Pteropus mariannus*) Wiles, 1990). Both species are endangered. A program is ongoing to revegetate a small hillside on the northwest side of the reservoir, thereby reducing soil erosion caused by trampling and overgrazing by feral water buffalo *Wubalus bubalis*).

Conservation measures proposed: Recovery plans for moorhens and fruit bats list a number of actions that need to be taken to protect these species in the Fena Valley (U.S. Fish and Wildlife Service, 1991; Wiles, 1990). These include the development and implementation of habitat management plans, the conducting of regular censuses, the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats, and the control of introduced ungulates. A new natural resources management plan for Naval Magazine also calls for the active management of natural resources on the base (Biosystems Analysis, Inc., 1990). This includes the protection of natural habitats in the Fena Valley watershed, the reduction of soil erosion through reforestation, the establishment of a water quality monitoring program for the reservoir, and the improvement of moorhen habitat. A proposal to establish Critical Habitat for fruit bats and endangered forest birds throughout the watershed is under consideration by the U.S. Fish and Wildlife Service. Recent discussions between the Navy and the Guam Division of Aquatic and Wildlife Resources may lead to the establishment of a protected area for Common Moorhens in the southern half of the reservoir if greater public entry to the base is allowed in the future.

Land use: Naval Magazine serves as a munitions storage site and public access is completely restricted. The reservoir serves as an important source of drinking water for Navy bases and civilian communities in southern Guam. There is little human use of the reservoir and surrounding areas. Currently, fishing is limited to only a few employees of the base and all hunting is prohibited. However, some illegal hunting and fishing does occur.

Possible changes in land use: Recent discussions have been held regarding the opening of Naval Magazine and the Fena Valley Reservoir to the public for managed fishing, hunting and recreational programs.

Disturbances and threats: Soil sediments are gradually filling the reservoir due to erosion from nearby hills. Soil run-off is increased by grassland fires, which are deliberately set by illegal hunters and other trespassers, and heavy amounts of rooting, trampling and overgrazing by feral water buffalo and pigs in the watershed area. Overgrazing of aquatic vegetation and invertebrates by introduced fish may be affecting the abundance and reproductive success of moorhens.

Hydrological and biophysical values: The reservoir has some value in trapping sediments and preventing their transport down the Mahlac and Talofofu Rivers.

Social and cultural values: Because of restricted entry to civilians, there is currently little social value associated with the reservoir.

Noteworthy fauna: Common Moorhens inhabit the reservoir throughout the year, but numbers increase during the dry season when birds immigrate here as other wetlands on the island dry up (Stinson *et al.*, 1991). Thus, the reservoir is the most important dry season refuge for this species on Guam. Moorhen numbers observed during censuses average about 30-60 birds in the dry season and 10-30 birds in the rainy season (Beck *et al.*, 1988). Breeding commonly occurs on the reservoir. Yellow Bitterns (*Ixobrychus sinensis*) are also common. A small population of Marianas Fruit Bats occurs in the forest surrounding the southern half of the reservoir (Wiles, unpubl. data). Philippine Deer (*Cervus mariannus*), feral pigs (*Sus scrofa*) and feral water buffalo are

common in forests adjoining the reservoir. Aquatic organisms are listed by Biosystems Analysis, Inc. (1989b). They include eels (*Anguilla marmorata* and *A. bicolor*), tilapia (*Oreochromis mossambicus* and *Tilapia zilli*), tucunare (*Cichla ocellaris*), catfish (*Clarius macrocephalus*), sleepers (*Eleotris fusca*), gobies (*Awaous guamensis* and *Sicyopterus macrostetholepis*), flagtails (*Kuhlia rupestris*), mosquitofish (*Gambusia affinis*) and shrimp (*Macrobrachium lar*, *A0vida pilipes* and *Caridina* sp.) (Kennedy Engineers, 1974; Biosystems Analysis, Inc., 1989b).

Noteworthy flora: Biosystems Analysis, Inc. (1989b) list the aquatic plants and phytoplankton in the reservoir.

Scientific research and facilities: Limnological, plankton, floral and faunal surveys were made by Kennedy Engineers (1974) and Biosystems Analysis, Inc. (1989b). The Division of Aquatic and Wildlife Resources conducted monthly censuses of moorhens in 1987-1988 (Beck *et al.*, 1988).

Conservation education: The reservoir and surrounding watershed is visited several times a year for ecological field trips by university students. There is great potential for increasing the amount of this activity.

Recreation and tourism: A small amount of recreational fishing occurs at the reservoir. Swimming is not allowed. If well-managed programs are adopted, there is significant potential for increasing the amount of public recreation on the reservoir.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. **Functional Jurisdiction:** Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Beck *et al.* (1988); Biosystems Analysis, Inc. (1989b, 1990); Kennedy Engineers (1974); Stinson *et al.* (1991); U.S. Fish & Wildlife Service (1991); Ward *et al.* (1965); Wiles (1990).

Reasons for inclusion: 2a. Major dry season refuge for Common Moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Naval Magazine Marshes

Country: Guam

Coordinates: 13°22'N, 144°42'E

Location: the marshes occur in south-central Guam in the municipality of Talofofo. They are located approximately 4.3 km west of the village of Talofofo. They are found entirely within the boundaries of the U.S. Naval Magazine. Area: A total of 2.4 ha for the three marshes.

Altitude: 20-25 m.

Overview: These three small marshes occur on the east side of Naval Magazine in the Talofofo River watershed. Because of their distinct habitat and occurrence on military land, they are discussed as a separate site rather than as part of the Talofofo River Valley. Common Moorhens (*Gallinula chloropus guami*) inhabit two of the marshes for most of the year.

Physical features: These three natural sites are located near the Mahlac Stream, which is a tributary of the Talofofo River. They are orientated on a north-south axis over a distance of 1 km. The northern marsh (0.2 ha) is surrounded entirely by knolls of limestone karst and is filled by water run-off from these hills. The central (0.6 ha) and southern (1.6 ha) marshes are bounded by forested limestone hills on three sides and lowland swamp forest on one side. Drainage of the marshes occurs through seepage into the ground. Only the central and southern sites are believed to hold water throughout most years. Water level in the central marsh is about 1 m deep during the wet season. The marshes occur on deep, clay soils that are poorly drained (Young, 1988).

Ecological features: The southern marsh has about 30% open water. The eastern and northern portions are thickly vegetated with *Phragmites karka*, while the western and southern ends are more open with *Potamogeton* sp. and *Chara corallina* present. The central marsh is oval-shaped and about 30% open water. Most of it is occupied by dense *Phragmites* growing inward from the edges. A large opening in the centre is vegetated with *Eleocharis ochrostachys*, *Potamogeton* sp. and *C. corallina*. Vegetation in the northern marsh has not been determined. Water levels fluctuate between the dry and wet seasons, with an increase in vegetative growth in the dry season. The habitat classification of the marshes is PEM1F and PAB2 (Cowardin *et al.*, 1979).

Land tenure: The wetland and surrounding areas are under the control of the U.S. Navy.

Conservation measures taken: The Navy has generally prohibited the entry of civilians into Naval Magazine for the purposes of military security since the base was established in the early 1950s. Although not a deliberate conservation action, this limitation has served indirectly to protect the base's natural habitats and wildlife. All hunting around these marshes is prohibited because of entry restrictions, although some poaching still occurs. The marshes are listed as secondary wetlands for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens list a number of actions needed to protect these species in the Naval Magazine marshes (U.S. Fish and Wildlife Service, 1988). These include the development and implementation of habitat management plans, the conducting of regular censuses, the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats, and the control of introduced ungulates. A new natural resources management plan for Naval Magazine also calls for the active management of natural resources on the base (Biosystems Analysis, Inc., 1990). This includes the protection of natural habitats on the base and the improvement of moorhen habitat. A proposal to establish Critical Habitat for endangered Marianas Fruit Bats (*Pteropus mariannus*) and forest birds on Naval Magazine, which would give protection to the forest habitat surrounding these marshes, is under consideration by the U.S. Fish and Wildlife Service.

Land use: The Naval Magazine serves as a munitions storage site, and public access is completely restricted. The area surrounding these marshes is not actively used for any purpose but does serve as an important watershed area.

Possible changes in land use: Recent discussions have been held regarding the opening of Naval Magazine to the public for managed hunting and recreational programs. Disturbances and threats: Soil run-off from nearby hills may be gradually filling in these marshes. Erosion is caused primarily by heavy amounts of rooting, trampling and overgrazing by feral pigs (*Sus scrofa*) and deer in the adjoining forests.

Hydrological and biophysical values: None known.

Social and cultural values: None known.

Noteworthy fauna: Moorhens inhabit the southern and central marshes for most of the year, but may depart during the height of the dry season (Ritter and Wiles, unpubl. data). Breeding probably occurs. Island Swiftlets (*Aerodramus vanikorensis*) have a nesting colony close to the central marsh, and forage extensively over the southern and central marshes. Yellow Bitterns (*Ixobrychus sinensis*) are also common. Philippine Deer (*Cervus mariannus*) and feral pigs are common in the surrounding forests.

Noteworthy flora: None known.

Conservation education: The marshes have little value for conservation education because of their remote locations.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Biosystems Analysis, Inc. (1990); U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens and swiftlets.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Talofofu River Valley

Country: Guam

Coordinates: 13°20'N, 144°45'E

Location: the wetland extends westward from Talofofu Bay almost to Fena Reservoir, following the basin of the Talofofu River in southern Guam. The valley is located in the municipalities of Talofofu, Inarajan and Santa Rita, with the headwaters found on the U.S. Naval Magazine. The mouth of the valley lies 1.3 km southeast of Talofofu village.

Area: 279 ha.

Altitude: Sea level to 30 m.

Overview: The largest contiguous wetland on Guam, occupying riparian areas along the valley of the

Talofofu and lower Ugum Rivers. Most of the wetland is forested but a variety of other habitats are also present. Large stands of *Barringtonia racemosa* occur here. The island's only large population of Island Swiftlets (*Aerodramus vanikorensis*) forages exclusively over the wetland and surrounding watershed.

Physical features: This large natural wetland occupies most of the broad alluvial plain along the Talofofu River and its major tributaries, the Ugum, Maagas, Mahlac, Sarasa and Tinechong Rivers. The river system drains much of southern Guam and has a watershed of 7,300 ha (Best and Davidson, 1981). The wetland is about six km long and varies in width from 100-500 m. Drainage patterns in the wetland probably remain mostly intact. Only one road, located in the Acapulco area, crosses the wetland. The road is raised up about 0.5 m and causes some water to back up behind it. Soil is a deep and poorly drained clay derived from both volcanic rock and limestone (Moore *et al.*, 1977; Young, 1988). A group of 11 fish ponds occurs near the mouth of the Talofofu River and occupies 3.5 ha. The ponds are about 1.2 m deep, have steep sides and level bottoms, and are permanently flooded.

The Talofofu River meanders through the valley and is joined by the Ugum River about 1.2 km from Talofofu Bay. The lower Talofofu River is 10 m wide and 2-6 m deep (Wilder, 1976). Brackish waters extend about 1.6 km upstream (Wilder, 1976). Flow rates, water quality parameters and sediment discharge rates in the Talofofu and Ugum Rivers are described by Randall (1974), Moore *et al.* (1977) and Shade (1983). Water temperatures in the lower Talofofu River range from 26-28°C (Wilder, 1976).

The wetland is bordered by ridge lines and rolling hills. Areas of volcanic soils occur primarily on the south side of the valley, while limestone-based soils are present on the east, north and west (Young, 1988).

Ecological features: Swamp forest with *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Areca catechu*, *Cocos nucifera* and *Cynometra ramiflora* occupies large sections of the wetland. Relatively pure stands of *Barringtonia* and *Hibiscus* occur at some locations (Fosberg, 1960). *Barringtonia* reaches heights of 10-15 m, with trees often growing on low hummocks surrounded by small muddy channels (Fosberg, 1960). Standing water in these forests is usually present only in the rainy season, with the ground being muddy to relatively dry during the rest of the year. The banks of the Talofofu and lower Ugum Rivers are lined with *H. tiliaceus*, *C. nucifera*, *Bambusa vulgaris* and *Pennis etum* sp., while *Nypa fruticans* extends about 900 m upstream from the river mouth, being limited by the range of brackish water (Wilder, 1976; Wiles, pers. obs.). *Pistia stratiotes* covers portions of the lower Talofofu River channel.

Stands of *Phragmites karka* grow on some sites that are probably old agricultural fields. A few newer fields are scattered throughout the valley and are sometimes cultivated during the late dry season and early wet season. After harvesting, the fields quickly become overgrown with a variety of grasses and weeds. Other plants in the wetland include *Ipomoea aquatica*, *Panicum muticum*, *P. maximum*, *Acrostichum aureum* and *Cyperus* sp. Aside from the river channels, the only open water in the entire wetland occurs in the fish ponds and at two pools in the centre of the valley. Various wetland habitats in the valley are classified as PF03C, PEM1F, PEM1C, R10WH and POWHKx (Cowardin *et al.*, 1979).

Upland vegetation in the valley is greatly influenced by soil type. Mixed limestone forest occurs on limestone soils. Ravine forest and savanna grasslands with *Miscanthus floridulus* are found on sites with volcanic soils.

Land tenure: All of the wetland is privately owned except for about 45 ha at the western end which is located on the U.S. Naval Magazine. Most of the watershed is privately owned, with the Government of Guam and Navy owning smaller sections.

Conservation measures taken: Few active measures have been taken to manage this wetland. The Navy has prohibited the entry of civilians into the western end of the valley on Naval Magazine for military security reasons since the early 1950s. Although not a deliberate conservation action, this limitation has indirectly protected the area and its wildlife. The upper portion of the Talofofu watershed, which is found on the base and includes the swamp, has been declared essential habitat for Marianas Fruit Bats (*Pteropus mariannus*) (Wiles, 1990). An area of eight ha near the Talofofu River mouth is designated as a secondary wetland for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: Recovery plans for Common Moorhens (*Gallinula chloropus*

guami) and Marianas Fruit Bats list a number of actions needed to protect these species in the wetland and its watershed (U.S. Fish and Wildlife Service, 1991; Wiles, 1990). These include the development and implementation of habitat management plans, the conducting of regular censuses, the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats, and the control of introduced ungulates. A new natural resources management plan for Naval Magazine also calls for the active management and protection of natural habitats on the base (Biosystems Analysis, Inc., 1990). A proposal to establish Critical Habitat for fruit bats and endangered forest birds throughout Naval Magazine, which would give protection to the western swamp forest and its watershed, is now being considered by the U.S. Fish and Wildlife Service. The entire Talofofo Valley should be declared essential habitat for Island Swiftlets.

The owner of the fish ponds is being required by the U.S. Army Corps of Engineers to enhance three of his ponds for moorhens and manage them as a wildlife area, as part of a mitigation plan for his unauthorized building of five ponds from 1985-1987.

Land use: Safford (1905) reported that corn was grown in the bottomlands of the valley. Thompson (1947) indicated that some areas were used for garden crops before World War II. Most of the wetland and surrounding watershed has been unused for at least several decades. *Ipomoea aquatica* was cultivated in several areas in the 1970s (Moore et al., 1977). Currently, vegetable farming occurs seasonally at a few small fields. The aquaculture ponds near the mouth of the Talofofo River produce hybrid tilapia (*Oreochromis mossambicus* x *O. niloticus*). Half of the ponds were built in the early 1970s, with the remainder made in the mid-1980s. A few homes exist in the valley. In early 1991, construction began on a new golf course on the north-central slopes of the valley.

Possible changes in land use: Several additional golf courses and resorts are proposed for the valley. However, none will be built in the wetland.

Disturbances and threats: Soil erosion from hillsides is one of the most severe threats to the wetland. Fires annually burn large amounts of grassland in the watershed, causing a significant soil loss into streams and the wetland after heavy rains. Turbidity of the Talofofo River increases greatly after heavy rains. Deposits of volcanic soil are noticeable in parts of the swamp below some hills. Further erosion will probably result from the careless construction of new golf courses. Feral pigs (*Sus scrota*) are abundant in the area; their rooting is another cause of erosion on hillsides. Pigs also damage the wetland by disturbing soils and feeding on plant seedlings.

Sedimentation and past farming activities have probably aided the establishment of thick *Phragmites* reed beds, which choke portions of the wetland. The dense beds are largely unsuitable for most wetland birds and prevent other wetland plants from becoming established.

The Public Utility Agency of Guam will install a water diversion structure in the lower Ugum River in 1992. Expected rates of water withdrawal are 7-11 million litres per day. There have also been requests from golf course developers and farmers to pump water from the Talofofo River for irrigation. In the late 1970s, a proposal to build a dam on the upper Ugum River as a municipal water source was considered but eventually scrapped (U.S. Army Corps of Engineers, 1980). The removal of significant amounts of stream water will probably reduce stream flow and increase saltwater intrusion up the Talofofo and Ugum Rivers.

The few farmers in the valley apply pesticides to their fields, which are often located in seasonally flooded areas next to water courses. Under some circumstances, pesticides could easily leach into the adjacent wetland or streams.

The development of fish ponds at the mouth of the valley altered about 3.5 ha of the wetland, and resulted in the flooding of an adjacent one hectare grove of *Barringtonia* and *Hibiscus* forest, which is now mostly dead. Water for the ponds is obtained from the river, with waste water discharged back into the river. High nutrient loads in the waste water undoubtedly affect the river's ecology downstream.

Hydrological and biophysical values: Valuable in sediment trapping and support of food chains.

Social and cultural values: A number of archaeological sites are present, suggesting that a large human population once lived in the valley. Perhaps the most important site is the remains of an

ancient village located about one km upstream along the Talofofo River.

It contains about 10 sets of latte stones. Radio carbon dating shows that it was inhabited back to at least 300 A.D. (R. Davis, pers. comm.). Other latte sets and cultural deposits are scattered throughout the valley. Some hunting, fishing, shrimping and gathering of betel nut occurs in the valley.

Noteworthy fauna: Guam's only remaining large colony of Island Swiftlets, which contains about 400-500 birds, forages almost exclusively along the entire length of the Talofofo valley from eastern Naval Magazine to Talofofo Bay and the lower Ugum valley (Beck and Wiles, 1989). Feeding occurs over the swamp and hillsides. Preservation of habitat in the valley is extremely important in maintaining the current swiftlet population. Common Moorhens have been recorded sporadically at a flooded field in the Acapulco area and at the fish ponds, but nesting has never been noted. They may reside elsewhere in the valley, but in general the small amount of marshland limits the population. Feral pigs and Philippine Deer (*Cervus mariannus*) are common in the swamp.

A number of aquatic animals have been recorded in the streams and rivers of the wetland. Invertebrates include various shrimp (*Macrobrachium lar*, *M. latimus*, *Atya serrata*, *Caridina Opus*, *C. niloticus* and *C. serratirostris*), a limpet-like snail (*Neritina pulligera*) and snails of the family Thiaridae (U.S. Fish and Wildlife Service, 1978). Mangrove crabs (*Scylla serrata*) inhabit the *Nypa* communities. Freshwater and estuarine fish include gobies (*Awaous guamensis*, *Stiphodon elegans* and *Periophthalmus koelreuteri*), *Eleotris fusca*, *Kuhlia rupestris*, *Gambusia affinis*, an eel (*Anguilla marmorata*), rabbitfishes (*Siganus argenteus*, *S. punctatus* and *S. spinus*), *Liza fulvus* and other mullets, snappers (*Lutjanus fulvus* and *L. argentimaculatus*), a barracuda (*Sphyaena barracuda*), tilapia (*Oreochromis mossambicus*) and a catfish (*Clarius macrocephalus*) (Randall, 1974; U.S. Fish and Wildlife Service, 1978; R.F. Myers, pers. comm.).

Noteworthy flora: The valley contains the largest stand of *Barringtonia racemosa* swamp forest in the Mariana Islands. A checklist of plants found in the lower Talofofo River valley is provided by Moore *et al.* (1977).

Scientific research and facilities: Limnological and biological studies were made by Randall (1974), Moore *et al.* (1977) and Shade (1983). Swiftlet distribution in the valley was mapped by Beck and Wiles (1989).

Conservation education: The swamp forest in the valley has some potential for conservation education. It might be possible to include some form of wetland education as part of the riverboat tour.

Recreation and tourism: A small riverboat operation takes tourists about one km up the river once or twice a day to the ancient village site. The jungle atmosphere of the river is an important part of the trip's attraction.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources and U.S. Navy. Territorial jurisdiction: Territory of Guam and U.S. Navy. Functional Jurisdiction: Division of Aquatic and Wildlife Resources and U.S. Navy.

References: Beck & Davidson (1981); Beck & Wiles (1989); Biosystems Analysis, Inc. (1990); Fosberg (1960); Moore *et al.* (1977); Randall (1974); Safford (1905); Shade (1983); Thompson (1947); U.S. Army Corps of Engineers (1980); U.S. Fish & Wildlife Service (1978, 1991); Wilder (1976); Wiles (1990); Young (1988).

Reasons for inclusion: 1 a, 2b. This is the largest wetland on Guam. It contains extensive swamp forest and foraging habitat for Island Swiftlets, and has a small amount of habitat for Common Moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Sarasa Marsh

Country: Guam

Coordinates: 13°19'N, 144°43'E

Location: the site is found in south-central Guam in the municipality of Talofofo. It lies along the Sarasa River, 3.7 km southwest of Talofofo village.

Area: 2.5 ha.

Altitude: 80 m.

Overview: A small freshwater marsh flowing into a man-made pond. Common Moorhens (*Gallinula chloropus guami*) occur at the site.

Physical features: This site consists of a natural marsh along the Sarasa River, with the eastern lower end being dammed to create a shallow pond. The wetland is dog-legged in shape and about 250 m long by 50-125 m wide. The dam is 100 m long and 5 m wide, and also functions as a road. Water depth varies from about 0.5-2.5 m, with depths greatest near the dam. Water level is fairly constant during the year. Soils in and around the wetland are deep and well-drained volcanic clays (Young 1988). The site is surrounded by low rolling hills.

Ecological features: The wetland is characterized by four distinct zones. Open water exists next to the dam and occupies about 30% of the entire site. A large bed of *Eleocharis ochrostachys* grows in a band across the centre of the marsh. As the water becomes shallower further to the west, the *Eleocharis* is replaced by a bed of *Fimbristylis triskichya* and finally a small stand of *Phragmites karka* at the far west end. A species of sedge, *Rhynchospora corymbosa*, grows sparingly throughout the marsh. The site is classified as PEM1H and POWHKh (Cowardin *et al.*, 1979). The marsh is bordered on all sides by extensive grasslands except for a narrow tract of ravine forest that grows below the dam along the Sarasa River.

Land tenure: The wetland and surrounding areas are privately owned.

Conservation measures taken: None.

Conservation measures proposed: The site should be declared a wetland of secondary importance for moorhens, as defined by the U.S. Fish and Wildlife Service (1991), and appropriately managed. Fencing to prevent access by feral water buffalo (*Bubalus bubalis*) would probably allow the growth of aquatic vegetation in the area of the dam, thus making the site more suitable for moorhens.

Land use: The dam was probably built as a watering pond for cattle several decades ago. Cattle are no longer raised by the landowner, and the wetland is now little used and infrequently visited by people. Most of the surrounding area is vacant, although plots of vegetables are occasionally grown nearby.

Possible changes in land use: The wetland is part of a large piece of property that was recently put up for sale. If purchased by a foreign developer, it is likely that a resort will be built on the land.

Disturbances and threats: Feral water buffalo regularly wallow in the open water near the dam. Their presence prevents the establishment of aquatic vegetation along the edges of this area and greatly reduces water clarity. Grassland fires during the dry season on adjacent land result in soil erosion and increased siltation of the marsh.

Hydrological and biophysical values: Useful in trapping sediments.

Social and cultural values: None known.

Noteworthy fauna: Moorhens have been observed in the marsh during the wet season, but nesting has not yet been recorded. A herd of 70-100 feral water buffalo lives in the general vicinity of the wetland and often visits to drink and wallow.

Noteworthy flora: A fairly rare reed *Philydrum lanuginosum* was recorded in 1989.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Assupian Marsh

Country: Guam

Coordinates: 13°18'N, 144°45'E

Location: this marsh occurs in southern Guam in the municipality of Inarajan. It lies 1.5 km west of Malojloj village.

Area: 0.5 ha.

Altitude: 80 m.

Overview: A small wetland in southern Guam. It dries out almost entirely during most dry seasons. Common Moorhens (*Gallinula chloropus guami*) nest here in the wet season.

Physical features: This man-made site is located in gently rolling topography near the headwaters of an unnamed tributary of the Aslinget River. The marsh is rectangular in shape and is found at the base of several sloping grass fields. A dike exists along the eastern end. The marsh receives run-off from the adjacent fields, and drainage occurs through seepage into the ground or through an outlet in the dike when water levels are highest. Soils are deep, clayey and derived from volcanic residuum (Young, 1988).

Ecological features: In 1981, the marsh was composed primarily of *Eleocharis ochrostachys*; however, by 1991 it was dominated by *Paspalum* sp. with a small amount of *Fuirena umbellate* also present. *Eleocharis* is no longer present. The amount of open water ranges from 2-50% and varies with season and year. Water depth is 0.6-1.0 m in the wet season, but the site usually dries out except for a few small pockets of standing water during the dry season. The marsh is classified as PEM1Fh and POWFh (Cowardin *et al.*, 1979). It is surrounded by savanna grassland dominated by *Pennisetum* and several small patches of secondary forest.

Land tenure: The wetland and surrounding areas are privately owned.

Conservation measures taken: The site is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens lists the activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that particularly apply to this wetland include: (1) the development and implementation of habitat management plans through cooperative management agreements between the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; (3) the periodic monitoring of the site for toxic substances; and (4) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: The marsh was probably constructed originally as a source of water for livestock or irrigation, but there are no current uses. Some of the surrounding fields are occasionally cleared and planted with crops for one or two seasons.

Disturbances and threats: Run-off of pesticides and fertilizer residues into the wetland may occur. Grassland fires occasionally burn into the marsh. A fire in 1991 burned about a quarter of the site. Feral pigs (*Sus scrofa*) occasionally root up wetland plants during the dry season.

Hydrological and biophysical values: Probably useful in trapping soil run-off.

Social and cultural values: None known.

Noteworthy fauna: Common Moorhens inhabit the marsh during the wet season and breeding has been recorded. Yellow Bitterns (*Ixobrychus sinensis*) regularly forage here. Small numbers of migratory ducks (*Arras acuta* and *Aythya fuligula*) and shorebirds (e.g. *Gallinago* sp. and *Tringa glareola*) are sometimes present.

Noteworthy flora: None known.

Conservation education: The site has limited potential for conservation education.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Yabai Wetland

Country: Guam

Coordinates: 13°17'N, 144°45'E

Location: this wetland is found in southern Guam in the municipality of Inarajan. It lies 1.3 km northeast of Inarajan Village on the west side of Highway 4, and 0.6 km northwest of Paulilac

Bay. It occurs in an area known locally as Yabai. Area: 1 ha.

Altitude: 5 m.

Overview: A seasonal man-made wetland. Common Moorhens (*Gallinula chloropus guami*) use the site for part of the year and probably nest here.

Physical features: This wetland is essentially a low-lying pasture that is flooded for 4-8 months of the year. It was apparently created inadvertently a number of years ago after the construction of Highway 4 blocked water drainage into the nearby Paulilac River. The bed of the road acts as a dike to hold water on the site. During the wet season, the water depth reaches one metre in a few spots. However, the area dries out completely in the dry season. The clay soils are deep and poorly drained (Young, 1988). The wetland is bordered by the highway on the east, several homes on the north, and low hills on the remaining sides.

Ecological features: The wetland has 0-25% open water, depending on the time of year and amount of water present. The most common plants are *Panicum muticum*, *Eichhornia crassipes* and *Paspalum* sp. Other species include *Echinochloa colonum*, *Ludwigia octovalvis* and *Lemna perpusilla*. The wetland is classified as PEM1Fh (Cowardin *et al.*, 1979). The hills on the northwest, west and south are covered with disturbed secondary forest composed largely of *Leucaena leucocephala*, *Cocos nucifera* and *Hibiscus tiliaceus*.

Land tenure: The wetland and surrounding areas are privately owned.

Conservation measures taken: The marsh is listed as a wetland of secondary importance for Common Moorhens (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens also lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply to this wetland include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between the private landowners, the Government of Guam and the U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; and (3) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: Residents of the area regularly pasture several water buffalo in the wetland. These animals graze on the site and form muddy wallows. Several homes occur on the north edge of the wetland.

Possible changes in land use: No changes in land use are currently predicted.

Disturbances and threats: Human activity and the presence of domestic water buffalo may disturb moorhens using the wetland. Water hyacinth is thick late in the wet season. Grazing, trampling and wallowing by water buffalo may disturb wetland vegetation.

Hydrological and biophysical values: None known.

Social and cultural values: None known.

Noteworthy fauna: Common Moorhens inhabit the wetland on a seasonal basis when sufficient water is present, and the species probably nests here. The area also attracts small numbers of Yellow Bitterns (*Ixobrychus sinensis*) and occasionally migratory ducks (*Anas acuta* and other species) and egrets (*Bubulcus ibis* and *Egretta intermedia*).

Noteworthy flora: None known.

Conservation education: The site currently has little potential for conservation education.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: U.S. Fish & Wildlife Service (1991); Young (1988).

Reasons for inclusion: 2a. Habitat for moorhens.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Agfayan River Valley

Country: Guam

Coordinates: 13°16'N, 144°44'E

Location: this area occurs in southern Guam in the municipality of Inarajan. It lies along the

Agfayan River 1.2 km southwest of Inarajan village.

Area: 28 ha.

Altitude: Sea level to 5 m.

Overview: A remnant stand of estuarine swamp forest bordered by aquaculture ponds on two sides. The forest has a high diversity of tree species.

Physical features: This natural wetland lies along the lower floodplain of the Agfayan River. Most of the site is located immediately behind Agfayan Bay; however, a narrow strip of habitat continues up the river about 1.2 km inland. The wetland is about 300 m wide at its greatest point. Soils consist of a deep and poorly drained mucky clay (Young, 1988). The original drainage patterns of the wetland were probably changed by the building of the first road around the edge of the bay, and were further altered by the construction of fish ponds. The channel of the Agfayan River is about 10 m wide and 0.3-1.8 m deep near its mouth (Wilder, 1976). A second smaller channel formerly occurred near the existing river mouth (Wilder, 1976), but is no longer present. Data from a monitoring site just above the river mouth indicate average discharge rates ranging from 0.004-0.012 cubic metres per second (Moore *et al.*, 1977). Temperature and salinity profiles for the Agfayan River are described by Wilder (1976).

Almost half of the site is occupied by commercial fish ponds. One group of 10 ponds (8 ha) occurs north of the river and is made entirely of earthen dikes. A second smaller group of 12 ponds (5 ha), most of which are lined by concrete block walls, lies south of the river. The ponds are steep sided, about 1.2 m deep, and flooded year-round. The river valley is bordered by low sprawling hills on all sides except the east, where Agfayan Bay occurs. The drainage area of the valley is 575 ha (Best and Davidson, 1981).

Ecological features: The original wetland was probably composed almost entirely of swamp forest. This forest is relatively short, 5-10 m tall, and contains a variety of trees including *Nypa fruticans*, *Hibiscus tiliaceus*, *Cocos nucifera*, *Thespesia populnea*, *Xylocarpus moluccensis*, *Heritiera littoralis*, *Rhizophora apiculata* and *Bruguiera gymnorrhiza*. Tidal inundation of portions of the lower floodplain allows *Nypa* and mangroves to grow inland from the river channel. *Nypa* extends at least 700 m up the river to the limit of brackish waters (Wilder, 1976; Wiles, pers. obs.). The vine *Derris trifoliata* is abundant in the swamp, while the introduced tree *Leucaena leucocephala* occurs on slightly higher ground at some locations. *Panicum muticum* is common on the berms of the fish ponds and in other disturbed openings. Various wetland habitats in the valley are classified as PFO3C, POWHKx and R1SB3 (Cowardin *et al.*, 1979). On lands adjacent to the valley, grasslands exist on volcanic soils to the north and west and secondary forest grows on limestone substrates along the south.

Land tenure: The wetland is privately owned. Adjacent areas are private, but much of the upper watershed above the wetland is owned by the Government of Guam. Conservation measures taken: The site is listed as a wetland of secondary importance for Common Moorhens (*Gallinula chloropus guami*) (U.S. Fish and Wildlife Service, 1991).

Conservation measures proposed: A recovery plan for moorhens lists a variety of activities needed to protect this species on Guam (U.S. Fish and Wildlife Service, 1991). Actions that apply here include: (1) the development and implementation of a habitat management plan through a cooperative management agreement between private landowners, Government of Guam and U.S. Fish and Wildlife Service; (2) the conducting of regular censuses for moorhens; and (3) the control of introduced predators such as Brown Tree Snakes (*Boiga irregularis*) and feral dogs and cats.

Land use: Parts of the wetland may have been farmed for vegetables before World War II (Thompson, 1947). Subsistence farming probably continued after the war. Aerial photos from 1975 show several fields along the edges of the wetland that were probably once farmland or pasture. Aquaculture facilities were built on the south and north sides of the valley in the late 1970s and mid-1980s, respectively. The ponds are used to raise hybrid tilapia (*Oreochromis mossambicus* x *O. niloticus*), milkfish (*Chanos chanos*), mullet (*Mugil cephalus*) and catfish (*Clarius batrachus*). The surrounding land is largely unused, with a few homes and small scale farming present.

Possible changes in land use: A few additional homes are likely to be built near the wetland.

Disturbances and threats: Up to half of the swamp forest has been lost to human activity over the years. Farming caused initial losses, with fish pond construction also a factor. It appears that some clearing of swamp forest occurred to make the southern ponds and that a small side channel of the river was filled in the process. More recently, several additional hectares of forest were cut without the proper permits to build the northern set of ponds. The U.S. Army Corps of Engineers required the owner to remove the fill in one area and replant it with *Hibiscus tiliaceus*. Water for both sets of ponds is obtained from the river, with waste water discharged back into the river. High nutrient loads in the waste water undoubtedly affect the ecology of the river downstream. Other management practices at the ponds, such as maintaining high fish densities and the removal of dense emergent vegetation, generally render the ponds unsuitable for moorhens.

Grassland fires occur annually in the upper watershed and result in heavy soil erosion and greatly increased river turbidity following heavy rains. High surf and winds from Typhoon Russ caused considerable damage to the swamp forest and southern fish ponds in December 1990.

Hydrological and biophysical values: None known.

Social and cultural values: A minor amount of crab harvesting occurs at the site.

Noteworthy fauna: The fish ponds are occasionally drained, leaving shallow pools of water and exposed mudflats. This produces good habitat for small numbers of various migratory shorebirds and other waterbirds. Common Moorhens may visit the ponds rarely but sightings are lacking. Mudskippers (*Periophthalmus koelreuteri*), fiddler crabs (*Uca* sp.) and land crabs (*Cardisoma carniflex*) occur along the lower banks of the river. **Noteworthy flora:** The swamp forest is almost unique in southern Guam. Plant species found in the wetland are listed by Moore *et al.* (1977).

Scientific research and facilities: Moore *et al.* (1977) described the plants of the area. Conservation education: The site has moderate potential for nature education.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: Best & Davidson (1981); Moore *et al.* (1977); Thompson (1947); U.S. Fish & Wildlife Service (1991); Wilder (1976); Young (1988).

Reasons for inclusion: 1d, 2b. Presence of estuarine swamp forest.

Source: Gary J. Wiles and Michael W. Ritter.

Wetland Name: Achang Bay Mangroves

Country: Guam

Coordinates: 13°15'N, 144°41'E

Location: this site is centred around Achang Bay in the municipality of Merizo at the southern end of Guam. It lies 12 km east of Merizo village. Area: 10 ha.

Altitude: Sea level.

Overview: The only sizeable area of mangrove forest in southern Guam. Four species of mangroves and several other coastal tree species are present.

Physical features: The mangroves in this area extend about 2.3 km along the shoreline from Jaotan Point to the mouth of the Suyafe River, with Achang Bay in the middle of the site. The Manell and Achang Streams run through the area and empty into Achang Bay and Manell Channel, which form the eastern boundary of Cocos Lagoon. The streams are narrow and shallow, being only a few metres wide at their mouths. Mangrove soils consist of silty sands and muds (Wilder, 1976).

Several small stone jetties and a dredged boat channel project out through the mangroves in Achang Bay. The site is bordered by a wide, shallow reef flat to the south and a narrow coastal plain and steep hills to the north. Highway 4 runs 50-400 m inland of the mangroves.

Ecological features: The site consists of a strip of mangrove forest, 20-60 m wide, lining the shore. The trees are relatively short, 4-8 m tall, with *Rhizophora mucronata* and *Bruguiera gymnorrhiza* being the most common species (Wilder, 1976; Moore *et al.*, 1977; Wiles, pers. obs.). *R.*

mucronata grows throughout but particularly along the seaward edge, while *Bruguiera* occurs closer to shore. *Avicennia marina* is also fairly common. *R. apiculata*, *Heritiera littoralis* and *Xylocarpus moluccensis* are rare. *Hibiscus tiliaceus*, *Thespesia populnea* and a few *Hernandia sonora* grow on the inland edge of the site. The site is classified as E2SS3N and E2FO3N (Cowardin *et al.*, 1979). Beds of seagrass (*Enhalus acoroides*) occupy large areas of the adjacent reef flat. Shrubby secondary forest with *Cocos nucifera* appears on firm ground behind the mangroves.

Land tenure: The wetland is owned by the Government of Guam. Surrounding areas are mostly private, but some parts are owned by the Government of Guam.

Conservation measures taken: None.

Conservation measures proposed: None.

Land use: The mangroves are unused, but a small marina and restaurant operate in Achang Bay. A few homes and vegetable plots exist nearby.

Possible changes in land use: Further development is expected to occur. A small municipal park will be made next to the marina. The new owners of the marina have discussed the possibility of making a hotel and an apartment building across from the marina.

Disturbances and threats: A small area of mangrove forest was cleared during the building of the marina in the early 1970s (Moore *et al.*, 1977). Two other small clearings of mangroves, both illegal, were made by adjacent landowners at the western end of the site.

Hydrological and biophysical values: The mangroves probably help prevent coastal erosion.

Social and cultural values: None known.

Noteworthy fauna: Yellow Bitterns (*Ixobrychus sinensis*) and migratory shorebirds forage in small numbers in the mangroves or on the nearby reef flat. Mudskippers (*Periophthalmus koelreuteri*), fiddler crabs (*Uca* sp.) and land crabs (*Cardisoma carnifex*) are present. The snail (*Littorina scabra*) has been found on mangrove foliage and prop roots, while the clam *Quidnipagus palatum* is common on adjacent sandflats.

Noteworthy flora: This is the only location on Guam where *Bruguiera* is common (Wilder, 1976). A checklist of plants is given by Moore *et al.* (1977).

Scientific research and facilities: Plant surveys were made by Wilder (1976) and Moore *et al.* (1977).

Conservation education: The site has good potential for nature education.

Recreation and tourism: Visitors and boat owners use the marina.

Management authority and jurisdiction: Management authority: Division of Aquatic and Wildlife Resources. Territorial jurisdiction: Territory of Guam. Functional Jurisdiction: Division of Aquatic and Wildlife Resources.

References: Moore *et al.* (1977); Wilder (1976).

Reasons for inclusion: 1 a, 2b. A moderate-sized area of mangroves.

Source: Gary J. Wiles.

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