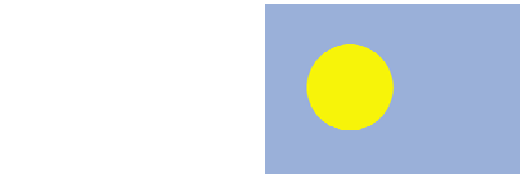
Sustainable Integrated Water Resources and Wastewater Management in Pacific Island Countries

National Integrated Water Resource Management Diagnostic Report

Republic of Palau



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GLOBAL ENVIRONMENT FACILITY

UNDP

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UNEP

Acronyms

BFA	Bureau of Foreign Affairs
BITTA	Bureau of Trade and Technical Assistance
BLS	Bureau of Lands and Survey
BNM	Belau National Museum
BOA	Bureau of Agriculture
BPW	Bureau of Public Works
CIP	Division of Design and Engineering (Formerly Capital Improvement Projects)
DEH	Division of Environmental Health
EA	Environmental Assessment
EIS	Environmental Impact Statement
EQPB	Environmental Quality Protection Board
GEF	Global Environment Facility
IWRM	Integrated Water Resource Management
gpd	Gallons per day
JICA	Japan International Cooperative Agency
MAREPAC	Marine Resources Pacific Consortium - Palau
MCCA	Ministry of Community and Cultural Affairs
MOA	Ministry of Administration
MOE	Ministry of Education
MOH	Ministry of Health
MOS	Ministry of State
MRD	Ministry of Resources and Development
NEMO	National Emergency Management Office
NEPC	National Environmental Protection Council
NGOs	Non Governmental Organisations
NOAA	National Oceanographic and Atmospheric Administration
NRCS	Natural Resources Conservation Services
NSC	National Steering Committee
NWS	National Weather Service
OEK	Olbiil Era Kelulau (National Congress)
OERC	Office of Environmental Response and Coordination
PAN	Protected Areas Network
PALARIS	Palau Automated Lands and Resources Information Systems

PICRC	Palau International Coral Reef Center
PCC	Palau Community College
PCC-CRE	Palau Community College - Cooperative Research & Extension
PCS	Palau Conservation Society
PIC	Pacific Island Country
PNCC	Palau National Communications Corporation
PNRC	Palau Natural Resources Council
PPUC	Palau Public Utilities Corporations
PVA	Palau Visitors Authority
PWSS	Public Water Supply System
ROP	Republic of Palau
SOPAC	Secretariat of the Pacific Islands Applied Science Commission
SPREP	Secretariat of the Pacific Region Environment Programme
TEI	The Environment, Inc.
TNC	The Nature Conservancy
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
USDA	United States Department of Agriculture
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
WHO	World Health Organisation
WSP	Water Safety Plan Program
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

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Executive Summary

Water resources for Pacific islands are under pressure because of increasing populations, urbanisation, development, climate change and other pressures. This is especially true for the Republic of Palau, where water demands are increasing with booming economic development. Sustainable development is necessary for safeguarding the environment while encouraging economic growth. Water resources and wastewater management needs to be properly managed so that community needs with economic development are met without threat to long term health and sustainability of watersheds and coastal environments.

The Republic of Palau consists of moderately elevated islands to flat karsts islands and atolls and therefore faces issues ranging from watershed misuse on the larger island of Babeldaob to saltwater intrusion of freshwater lenses for platform islands and atolls.

With near completion of the Compact Road (around Babeldaob), development is expected in the watersheds of this island. Degradation of the watersheds is a concern. Increasing deforestation, increased pesticide use and inadequate wastewater management due to urbanisation are perceived as potential impacts to the watersheds if management approaches are not properly coordinated and integrated. The connectivity of terrestrial to coastal ecosystems requires connectivity in management approaches. The management of water resources and wastewater sanitation require an integrated approach for proper structuring of policy and technology. However, the current collective management leaves room for improvement. Current management is through sectoral approaches. The agencies and collective committees involved with water resources need to adopt more integrated water resources management approaches.

With an increasing population and higher tourist numbers, water resources and wastewater management issues come to the forefront of priorities. 75% of the 20,000 people that live in Palau reside in the states of Koror and Airai and are dependent on the same water treatment plant. Palau's economy is fuelled by tourism. Each month an estimated 7,000 tourists visit the islands to enjoy the environment and add impact to water resources and increase waste management. Protection of watersheds and coastal environments will ensure healthy ecosystems for locals and tourists alike.

The islands of Palau are vulnerable to natural and manmade disasters. There is room for improvement for disaster response. Potential disasters from human development need to be identified and properly mitigated for.

Because of the linkages between terrestrial, coastal and marine ecosystems, stakeholders range from community groups to the highest levels of the government. With diverse interests among the stakeholders, there is a need for an organised integrated approach to deal with issues revolving around water resources and wastewater management.

This Diagnostic Report reviews national priorities and presents strategies that will improve integrated water resource and sanitation management and move toward sustainability. The National Steering Committee for the Water Safety Program will use this opportunity to expand its responsibilities and will expand its membership to include all relevant stakeholders.

Acknowledgements

This diagnostic report has been prepared, reviewed and amended by the Palauan stakeholders as part of larger watershed and landuse reforms on-going within the country. It was completed under the guidance of the National Steering Committee for the Water Safety Program.

The main facilitator of this project is the Environmental Quality Protection Board, with guidance from the Water Safety Plan Program National Steering Committee. All participating agencies are formally acknowledged for their contribution and pledge of full cooperation and support of this report.

This IWRM diagnostic report has value beyond the GEF pdf-B development process, and the outcomes will be integrated into the ongoing watershed protection and ecosystem.

Introduction

(a) Need for an integrated approach to water resource management

Small Pacific Island countries (PIC) rely heavily on the freshwater resources. However, due to the small land masses of many PICs, most of the freshwater sources are under pressure from overuse and/or pollution leading to deteriorating water quality due to urbanisation, economic development, and population growth. The pollution of freshwater resources also lend a hand to the pollution of marine ecosystems, which many Pacific Islanders rely on heavily for sustenance. Urbanisation and population increases weigh heavily on wastewater disposal, which impact both fresh and marine water resources.

An integrated approach to water and wastewater resource management is essential for small island developing countries because of the limited landmasses. Any activity or development will impact water resources in one way or another. Unsustainable development within a watershed will impact the water supply systems that rely on the rivers within said watershed, increasing cost of water treatment, affecting human health, and impact coastal areas and therefore biodiversity. This impact has a cascading effect that can only be dealt with if the management of such impact is addressed in a sustainable and integrated fashion.

The Pacific Regional Action Plan (RAP) for sustainable water management focuses strongly on six thematic areas: (1) Water resources management, (2) Island vulnerability, (3) Awareness, (4) Technology, (5) Institutional arrangements, and (6) Finance. Linking these thematic areas to landuse, human health, ecosystem health, watershed and coastal management is necessary for an integrated and holistic approach to managing water resources. The "Sustainable Integrated Water Resources and Wastewater Management Project in Pacific Island Countries" will assist the Republic of Palau with integrating these issues and managing them appropriately. Integrated approaches need to take into account sustainability and environmental issues in the planning, design, construction, operation and management of major water projects and other development projects affecting water sources or contributing to the wastewater issues. There is a need to continually restore and protect the quality of surface and ground waters.

In Palau, there are existing legislative bodies, but no proper management schemes towards integrated protection. The underlying principles of integrated water resource management (IWRM) will hopefully help strengthen existing and proposed water resource management for the Republic.

IWRM looks at managing water and land resources through improved collaboration and partnership between the governments, NGOs, and communities.

'IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems[1].'

An integrated approach to water resource and wastewater management will ensure that the future generations of Palau have a healthy economy as well as a healthy environment to enjoy after the current population is long gone.

(b) Objectives and scope

The objectives of this report is to:

- Provide a summary of the water resource management issues, current initiatives, and needs for the Republic of Palau;

[1] Global Water Partnership, Technical Advisory Committee. 2000. No. 4 Integrated water Resource Management.

- Compile existing information related to water and wastewater management in Palau for future use by the IWRM project in Palau
- Provide a reference document on the state of water resources in Palau

The aim of the IWRM project is to assists Pacific Island countries with the implementation of the Pacific Regional Action Plan that addresses sustainable water resource management, to be implemented with applicable and effective integrated water resource management based on best practices and demonstrations of barrier removal.

(c) Scope of the report

This report provides general background information on the water resources and their management in the Republic of Palau. It attempts to link the various sectors as identified under the six themes of the Pacific Regional Action Plan on Sustainable Water Resource Management.

It also describes the constraints with respect to uses and management of water resources in Palau and proposes measures to ensure human well being as well as ecosystem health.

The report will conclude with a discussion on capacity development and an integrated approach to remove barriers.

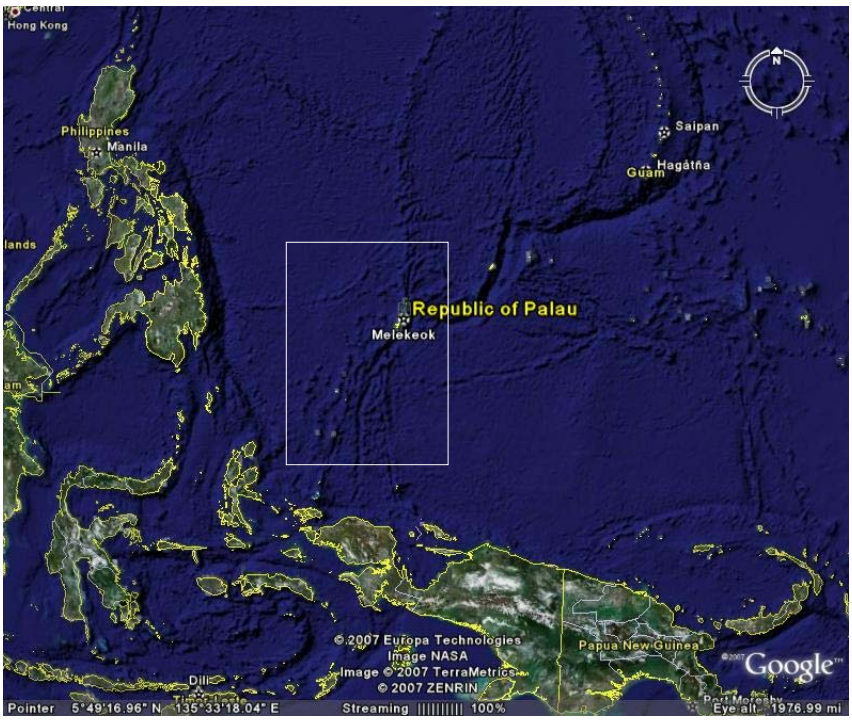
1 GENERAL OVERVIEW

1.1 County Background Information

Location

The Republic of Palau is made up of about 350 islands in the far western Pacific Ocean. It stretches between 2 and 8 degrees north of the equator, with the main island group lying between 6 and 8 degrees north latitude and 134^{o} and 135^{o} east longitude. It is approximately 3220 kilometres south of Tokyo and 1600 km east southeast of Manila. Palau has a total land mass of 487 square kilometres. The largest island is Babeldaob; with an area of 334 sq. km. Ten of Palau's 16 states lie on this island. It contains the capital Ngerelmud, located in Melekeok, on the central east side of Babeldaob. South of Babeldaob is the island of Koror, which is the central commercial site and former capital of the Republic. Stretching south of Koror for 45 km are hundreds of tiny mushroom-shaped islands, the world renown "Rock Islands". At the southern boundary of the Rock Islands is the low island of Peleliu and 11 km south of Peleliu is another inhabited low island, Angaur. 360 km Southwest of Koror are two more of Palau's states, Hatohobei and Sonsorol, which are composed of groups of tiny platform islands and atolls. Though relatively small in total land area, Palau has a coastline of 1,519 km.

Figure 1: Location of Palau in relation to the closest landmasses



Source: Google Earth Imaging

Topography

The islands range in size from small specks of land to the large island of Babeldaob. Elevations range from a few metres above sea level to the highest point in Palau, Mount Ngerchelchuus at

242 metres above mean sea level on the island of Babeldaob. Babeldaob and Koror have rolling uplands with sharp ridges and cliffs, flat alluvial areas, and coastal regions consisting primarily of deans mangrove swamps. The coastlines are comprised of coral and sand beaches and rock along large expanses of mangroves swamp. The swamps are found primarily on the volcanic islands of the north. Rivers and streams are abundant though many are small and dry-up during dry season. The exception to this is Babeldaob, where many large streams flow. The largest river is the Ngerdorch River with a drainage of about 46 sq km. Lake Ngardok, at the upper end of the north fork of the Ngerdorch River, is the largest lake on the islands at a length of 730 metres and a width of 180 metres at the widest part.

Geology

The islands of Palau can be classified as volcanic, high-limestone, low platform and reef or atoll. Babeldaob has old metamorphic-volcanic origins. Angaur and Peleliu low platform islands. Kayangel and Helen reef are atoll. The barrier reef surrounding the main island group averages 2.5 km in width on the west side of the islands. The depths of the lagoon range from a few meters to 40 metres deep.

Babeldaob Island formed from raised volcanic material of tuff and breccia. Limestone from ancient coral reefs and marine terraces are found. The entire island of Babeldaob consists of deeply weathered basaltic and andesitic volcanic breccias and tuffs erupted and deposited between 58 and 22.5 million years ago up to 609.6 metres (2,000 inches) thick (USGS 1984). In areas of low relief, the bedrock is overlain by up to 45.7 metres (150') of Airai clay. This clay originated from highly weathered breccia at higher elevations and deposited between 22.5 and 2 million years ago, at a time of higher sea levels, in estuaries and swamps (U.S. Army 1956). The clay unit consists of interbedded white, light brown and grey clays, silty clays and lignite (i.e. decayed plant material and clay). Inter-tidal mangrove areas are underlain by 150 centimetres or more of peat or highly organic soils, very poorly drained with rapid permeability (SCS 1983).

Soils (main reference source: NRCS Ngerikiil Watershed Resource Assessment)

Soils in the Babeldaob formed primarily in four of the five major parent materials in Palau: bottomlands, marine terraces, volcanic uplands and limestone.

High year-round temperatures combined with abundant rainfall have caused extensive chemical decomposition of rock minerals into soil minerals with the accompanying loss of soil nutrients. The majority of Babeldaob soils formed from highly weathered volcanic bedrock. The Aimeliik, Palau, Babelthuap and Ngardmau soil series are the major soils on volcanic uplands. Soil scientists who have worked in Palau (Smith and Babik 1988) believed these soil series were essentially the same soil before humans arrived in Palau and cleared land of forest. Fire used to clear land has caused loss of organic matter and nutrients and has disrupted the nutrient cycle. Removal of vegetation by fire has also led to erosion on ridge tops, where soils are nutrient poor and vegetation has difficulty becoming established and thriving on them. These soils are the most degraded of the soils. The Palau soil series has a lesser degree of degradation and supports savanna vegetation. Aimeliik soils are forested and most fertile of the volcanic soils in the watershed because the nutrient cycling has been least disrupted.

Marine terraces formed as sediment from upslope accumulated in near-shore environments and formed bedded marine clay. Subsequent emergence of the terraces either by tectonic uplift of the Palau landmass or by lowering of sea level left the terraces high and dry and subject to erosion and soil formation. The terraces are generally slightly sloping planar surfaces but dissected by stream erosion. Ngatpang and Tabecheding soil series are mapped on terraces. Bottomlands are located on valley bottoms where water cannot drain freely into streams or the ocean. The soils developed in bottomlands are generally wet and

saturated for at least part of the year, influencing their formation. Bottomland soils can be mineral soils such as the Dechel and Ngersuul series, which formed from water deposited sediment. Organic soils formed in vegetation that accumulated because saturation inhibited decomposition. The bottomland organic soils are Mesei series in fresh water environs and the Ilachetomel series in brackish water. The Mesei series is mapped as a complex with the Dechel series and occurs in low spots in the landscape where water accumulates.

Small areas of soil developed on limestone occur on hills in the southeast Ngerikiil Watershed on the Oikull Peninsula. Soils on these hills are mapped as the Peleliu series, which is shallow and rocky and is complexed with rock outcrop. These soils are on steep landscapes under forest. At the southern tip of the Oikull Peninsula small areas of sandy soils formed in alluvium from water and wind-deposited coral sand. These soils are mapped as the Ngedebus series. These soils are next to beaches and are vegetated mainly with coconut trees and atoll forest. The majority of soils in Babeldaob watershed formed in highly weathered volcanic materials. The clays remaining after long periods of soil formation in a hot humid climate have a low capacity to retain nutrients and most plant nutrients have been leached from the soil. Low organic matter content results in low nutrient holding capacity.

Smith and Babik (1988) describe in detail how the volcanic upland soils differ. The Aimeliik series has an intact nutrient cycling system (i.e. forest) that maintains a surface layer relatively high in organic matter and nutrients. Clearing forest from upland volcanic soils disrupts the nutrient cycling system and lowers biomass production. Organic matter, which can provide a substantial amount of a soil's ability to hold nutrients, is commonly burned off allowing further topsoil depletion of plant nutrients via leaching or through erosion. The Palau series found under savanna grasses and ferns have lower organic matter and nutrients at the surface. The Babelthuap series represents further degradation of volcanic soil where there is no effective nutrient cycling and low biomass accumulation under the sparse fern vegetation. Sparse vegetation leads to soil erosion and low soil fertility causes difficulty in re-establishing vegetation on these soils.

Loss of topsoil and organic matter lowers soil productivity, but this can be compensated for by using synthetic fertilisers. However, fertilizer application needs to be carefully managed to avoid leaching and runoff. In general, the Volcanic Uplands soils have little capacity to hold nutrients and over-fertilising is likely. Excess fertilizer will either be leached through the soil, and potentially to groundwater, or will be removed from the site by erosion and runoff. Pollution of downstream waters is a distinct possibility in this situation.

The Marine Terrace soils and the large majority of the area covered by Volcanic Upland soils have halloysitic mineralogy. Halloysite is a soil mineral commonly formed from volcanic rocks in humid tropical environments. In the wet conditions of Palau, halloysite forms very fine tubes that can hold water. Soils in which halloysite dominates have low bearing strength and can cause severe problems for roads. Pressure applied to the soil by vehicle wheels can cause the release of water held by the mineral and result in muddy conditions and poor traction.

Soils on Volcanic Uplands and Marine Terraces generally have high acidity and potential aluminium toxicity problems. Some volcanic soil layers with large amount of organic matter and deep layers below the active zone of mineral weathering are in the "low" range of aluminium toxicity.

Climate

The climate is tropical with a mean annual rainfall of around 370 centimetres. The heaviest rains are due to monsoonal storms that generally occur between the middle of June through August. The highest daily rainfall occurred in April 1979 with 43 centimetres. There is an annual average of 263 days with rainfall greater than 0.025 centimetres. The average

monthly rainfall for July is 45.8 centimetres. Pre-World War Two Japanese Forestry rainfall records show a slightly higher rainfall amount than the 30 years of Koror records.

Prevailing winds are the northeastern trade winds, with a mean wind speed of 9.65 kilometres per hour. The average annual temperature is 27.6 degrees Celsius. The average annual maximum temperature is 30.9 degrees Celsius and the average annual minimum temperature is 24.2 degrees Celsius. The lowest temperature occurred in January 1998 at 20.6 degrees Celsius and the highest was 35 degrees Celsius in June 1976. There are approximately 72 days where the temperature goes above 32.2 degrees Celsius (90°F). Palau has moderate levels of sunshine. The normal relative humidity averages 85 percent. June is slightly higher with 86 percent and April being the driest with 83 percent.

Natural Disasters

Palau lies outside of the "Typhoon belt" of the northern equatorial Pacific. However, winds pick-up speed during typhoon events that veer close to the islands. Maximum winds recorded were during typhoon events that approached within 150 kilometres of Babeldaob. The major typhoons include: Gelda, December 15, 1959 with 140-knot winds (260 km/h); Louise, November 16, 1964, with 100-knot winds (185 km/h); Opal, December 11, 1964, with 140-knot winds (260 km/h); and Mike, November 10, 1990, with 135 knot winds (250 km/h) (NOAA National Weather Service Guam 2005).

In 2001, Tropical Storm Utor with wind speeds of up to 120 km/hr, caused minor damage to infrastructure, mainly do to minor landslides caused by excessive rains.

El Niño of 1998 bleached 30% of Palau's coral reefs in some areas and in extreme cases 100% of the corals were bleached. During this time, the lowest amount of rainfall was recorded and streams dried up while larger rivers had low flow. Restricted water hours were applied to public water supply systems due to lower intake rates from rivers.

Vegetation

Palauan upland forest is the most diverse vegetative community in Micronesia. The vegetative structure is divided into an upper and lower canopy. Understory communities of plants include *Pinanga insignis*, *Pandanus aimiriikensis*, and *Ixora casei*. Along ravines and streams, *Barringtonia racemosa, Semecarpus venenosus* and the palm *Pinanga insignis* are common.

Coastal swamp forests in Palau are today generally degraded and covered with *Hibiscus tiliaceus*; other suitable habitat has been replaced by taro cultivation. Tree species include *Barringtonia racemosa, Calophyllum soulattri, Cynometra ramiflora, Heritiera littoralis, Horsfieldia irya, Samadera indica* and *Terminalia catappa* (Cole et al. 1987).

Well-developed stands of mangrove forests found along rivers and coastal mudflats can reach 15 to 20 metres in height. On the seaward side, *Rhizophora stylosa* and *Sonneratia alba* dominate; at larger river mouths or bay indentations, *Rhizophora apiculata* and *R. stylosa* can become pure stands or occur with *Sonneratia alba* and *Bruguiera gymnorrhiza*; landward, *Heritiera littoralis*, *Lumnitzera littorea* and *Xylocarpus granatum* are included in the mix; and where the estuary becomes river-like, *Bruguiera, Lumnitzera, Sonneratia* and *Xylocarpus* species are common, but *Rhizophora spp*. becomes uncommon. The palm *Nypa fruticans* is fairly common along the lower portions and mouths of rivers. Other woody species include *Avicennia marina, Ceriops tagal* and *Scyphiphora hydrophyllacea* (Cole et al. 1987).

Limestone forests found on lime outcrops and coralline limestone islands are susceptible to any disturbance. These forests are generally untouched by development because of inaccessibility and landscape characteristics.

Agroforests generally appear along the coasts or near dwellings. They typically contain coconuts, often in extensive plantations, breadfruit, mangos, bananas, betel nut and citrus trees.

On Babeldaob, there are savanna areas that are dominated by herbaceous grasses and sedges. Scattered throughout are woody shrubs and small trees of *Alphitonia carolinensis*, *Decaspermum raymundii*, *Fagraea ksid*, *Pandanus* spp., and *Symplocos racemosa* var. *palauensis*.

On recently disturbed sites, a variety of fast-growing small trees and shrubs quickly fill in. On the islands with volcanic soils, this secondary vegetation commonly consists of *Macaranga carolinensis*, *Bambusa* spp. and *Hibiscus tiliaceus* in wetter sites. On the limestone islands, *Macaranga carolinensis* and *Timonius timon*, an introduced species, are pioneers (Cole et al. 1987).

Agriculture

Agriculture in Palau has been relative small in scale, contributing only 6.2% of the GDP. The produce is locally sold. There are currently over 22 commercial agriculture farms in Palau, and nearly all are located in Babeldaob. Virtually all the farms are located alongside streams, presenting concerns for surface water contamination from the misuse of pesticides and fertilisers, and land degradation. Agriculture activities near streams and associated burning contributes to land degradation through soil erosion and sedimentation, in addition to the release of pollutants in smoke. In addition, nearly all piggeries and poultry farms are located along or near streams and mangroves contributing to land degradation and diminished water quality.

In more recent years, because of the popularity of Noni as the next big health gambit, Noni farms have cropped up around the island.

Modern and foreign-developed methods of agriculture cause a significant amount of land degradation and pollution, in contrast to traditional Palauan methods that used to be more commonly practiced. Native forests have been cleared, sometimes by burning, and converted into vegetable farms, these generally using imported fertilisers and pesticides. The traditional practices of taro patches “mesei” are self-fertilising, relying on mulching of dead leaves and grass while tapioca farms are rotated with sweet potato and other crops.

Geomorphology

The geomorphology (i.e. surface land features including topography, vegetation and hydrology) of the Babeldaob watersheds reveal three distinct zones: upper, middle and lower. The upper zone is characterised by high relief, undisturbed natural forest, and deeply incised tributaries. The middle zone consists of lower relief, river floodplains, and the vast majority of development in the watershed. The lower zone contains mangrove forest at sea level. Successful management of the watersheds should address each zone separately with an understanding of how the use of each affects the other zones.

Kayangel and Helen reef are atolls. North of Kayangel is Ngeruagnel, a submerged volcano with a sand bar. The islands south of Babeldaob are raised limestone platform islands. The hydrogeology of these islands are karst aquifers. Vegetation is similar for most.

Hydrology

Palau produces 300 billion gallons (1.1 billion cubic metres) of water per year from surface water run-off. Gonzales et al. (2001) state that a total of 450 billion gallons (1.7 cubic metres) of internal renewable water is available in Palau.

Comment: Missing in References. Author is checking..

The island of Babeldaob has 5 major watersheds with an additional 11 minor watersheds. The longest river in Palau is Ngerdorch River which is 10 km long and flows out of Lake Ngardok. Lake Ngardok is the largest natural freshwater lake in Micronesia, with a storage capacity of 15

million gallons (56700 cubic metres). Ngermeskang River, on the west side of Babeldaob, is the second largest and drains into the Ngaremeduu bay and is part of the largest watershed on the island.

The Ngerikiil River in Airai supplies 3 million gallons (11000 cubic metres) a day to the Koror/Airai Water Treatment Plant for use by three-fourths of the population of Palau. The same treatment plant extracts 1 million gallons (3700 cubic metres) a day from the Ngerimel Dam. The Ngerimel watershed (which is several times smaller than the adjacent Ngerikiil watershed) drains into the Ngerimel Dam, which has a holding capacity of 20 million gallons (75700 cubic metres).

The rest of the islands of Palau rely on groundwater sources and rainfall. Peleliu has the largest freshwater lens, which is in the south part of the island. It has been estimated to be capable of yielding 1 million gallons (3785 cubic metres) of fresh water per day (Barret 1986.

Demography

Palau has a population of approximately 20,000 people (Palau Census 2005). 24% are aged under 14 years old; 70% between 14-65 years old; and 6% older than 65 years old. The urban population is estimated at 78%. The country as a whole has a population density of 44.6 persons/square kilometre. An estimated two-thirds of the population live in the Koror and Airai states, with a population density of 245 person/square kilometre. The population growth rate is estimated 0.8% per annum. The median age is 32.3 years.

Socio-economic aspects

The two main islands of Koror and Babeldaob are connected by a bridge. Babeldaob has a circumferential road that is near completion. The main international port is Airai. There are three inter-island ferries servicing the islands of Peleliu (twice per week), Angaur (once a week) and the Southwest islands of Sonsorol, Merir, Pulo Anna, and Hatohobei (4 times per year). In 1994 Palau gained independence from its US-administered UN trusteeship. It has tried to develop a modern economy from traditional subsistence agriculture and fishing[2].

Outside of foreign aid, the economy consists primarily of tourism, subsistence agriculture, and fishing. The government is the major employer of the work force, relying heavily on financial assistance from the US. Business and tourist arrivals numbered 63,000 in 2003. The population enjoys a per capita income roughly 50% higher than that of the Philippines and much of Micronesia. Long-run prospects for the key tourist sector have been greatly bolstered by the expansion of air travel in the Pacific, the rising prosperity of leading East Asian countries, and the willingness of foreigners to finance infrastructure development (CIA World Fact Book 2006).

2. Integrated Water Resources Management Situation

2.1 Water Resources Management

2.1.1. Types of freshwater resources

Groundwater

The islands of Peleliu, Angaur and Kayangel rely on freshwater lens aquifers as a water source for their public water supply systems. US Navy geologists (1956) estimated that Peleliu has a lens that is capable of producing 1 million gallons per day of freshwater.

[2] The Compact of Free Association with the US, entered into after the end of the UN trusteeship on 1 October 1994, provides Palau with up to US$700 million in US aid over 15 years in return for furnishing military facilities.

Certain areas in Northern Babeldaob have limestone aquifers overlying volcanic bedrock. Two public water systems, Choll in Ngaraard and the Ngiwal public water system, rely on these aquifers as freshwater sources.

No records have been retained in Palau of well logs or pumping tests of the eight or more test wells that were drilled in Airai in the 1970s and 1980s that would indicate the water bearing properties of the bedrock and overburden. According to the Ministry of Resources and Development - Division of Design and Engineering wells located near surface waters yield as much as 227.1 litres per minute (50 gpm). But due to the naturally high levels of iron and manganese that occur**,** anaerobic bacteria forms in such numbers in the wells that the efficiency of the pumps is reduced by up to eighty percent in just a few months. Therefore, maintenance of pumps and pipe stems becomes costly. Due to the composition and structure of the volcanic bedrock with scattered and concealed joints (U.S. Army 1956), these wells were likely drawing water from the nearby surface sources. Groundwater sources in Babeldaob are not likely significant.

Surface Water

Due to the abundance and largely continuous availability of surface water in Palau, this source has been the more viable and cost effective option for drinking water.

USGS stage-gauging stations averages discharge for the larger tributaries in the Babeldaob watersheds at 0.9 cubic metres per second or 20 million gallons per day. Recurrence intervals show a large resource of water available from these tributaries to the Ngerikiil.

Catchment sizes are small, but the main rivers rarely dry out during drought events. However, during El Nino 1998, after one month of little or no rainfall, low stream flows resulted in water shortages for the Koror/Airai system, forcing the government to declare restricted water hours as a measure for water conservation.

Rainfall

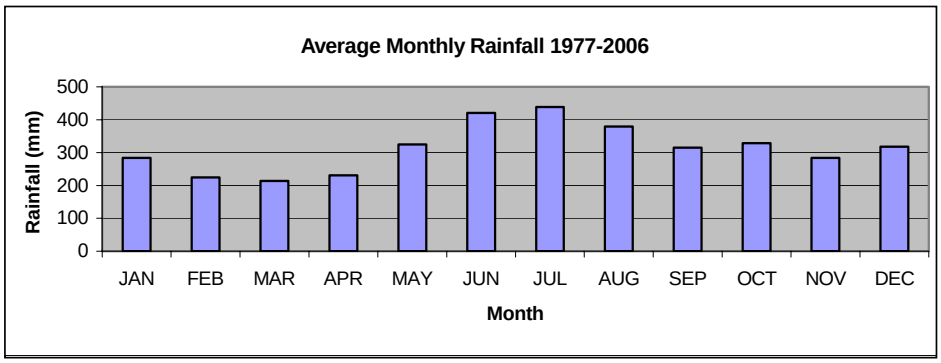
The source of this significant amount of surface water is rainfall. The rainfall averages for Palau is 3700 mm per year, an estimated higher average of 4500 higher rainfall in Aimeliik and Airai. Rainfall in the Southwest islands is only estimated, though anecdotal evidence indicates over 100 inches per year is the norm.

According to data from the National Weather Service, meteorological data for Koror shows that the average annual rainfall for the time period January 1976 through Dec 2006 is 3764 millimetres. The average monthly rainfall for this thirty year period is 316 millimetres. The greatest average monthly rainfall occurs between June and August, with the greatest monthly total occurring June of 1990 (858.5 mm) and July of 1991 (802.1 m). The lowest average monthly rainfall occurs between February and April; the lowest monthly totals for this time-period occurred in February 1983 (16 mm) and March 1998 (12.7 mm). Comparison of data from both islands, where available for the same time periods, indicates that there is not a great difference in rainfall totals between Babeldaob and Koror (USGS 1984). Incomplete monthly total rainfall data is available for a USGS rain gauge in Airai located near the dam on the Ngerikiil River from November 1978 through September 2002. The lowest annual rainfall average for this time period was in 1998 (2905.6 mm) and the highest annual rainfall average was 1991 (4423.7 mm).

Comment: Not in references

Figure 2: Monthly average rainfall in mm (1977-2006)

Comment: Formerly as Fig. 8 in Appendix 4



Data Courtesy: Palau National Weather Service

Data from two major storm events - July/August 1981 and June 1990 was analyzed by the Natural Resources Conservation Services (NRCS) resource assessment in 2003. Analysis of the daily precipitation and discharge for these events indicates the volume of base flow or groundwater contribution of the tributaries, total runoff, and direct runoff or surface flow caused by excess rainfall of the storm event. The total precipitation for the July/August 1981 storm event was 50.42 centimetres over a 31-day period (July 24 to August 21). The discharge data for this period indicates that the average base flow is approximately 0.51 cubic metres per second. The total runoff of this flood period, including base flow, was 58.76 cubic metres per second per day. The direct runoff, determined from subtracting base flow from total runoff, was 43.98 cubic metres per second per or 34.44 centimetres (68 percent of rainfall). The total precipitation for the June 1990 storm event was 42.39 centimetres. The discharge data for this event indicates that the average base flow of the Kmekumel tributary is 0.12 cubic metres per second. The storm event lasted for 15 days from June 23 through July 7.

The total runoff of annual flood during this period, including base flow, was 11.83 cubic metres per second per day. The direct runoff was 9.98 cubic metres per second per day or 23.1 centimetres for this storm event (55 percent of rainfall).

2.1.2. Types of freshwater uses

Drinking Water supply

90% of people living in Palau have access to piped treated water. These public water supply systems water sources are generally surface water and are operated by the National government's Bureau of Public Works. There are currently 15 public water supply systems that rely on surface water intakes, 4 public water supply systems which rely on groundwater and in the northern most inhabited atoll, the old distribution lines are being reconnected to a new well for water supply. The largest treatment plant is in Ngeruobel, Airai State and services the States of Koror and Airai.

Commercial and industrial uses are limited and rely mostly on the Koror/Airai public water supply system.

The states on the island of Babeldaob depend mainly on surface water. There are public water supply systems that rely on groundwater on this island. Koror/Airai system treats 4 million gallons per day (15140 cubic metres, or 15 million litres per day). This is the most advanced system on the island, clarifier – flocculator – sediment beds – AVG filters – wet well. The rural systems have no filtration system and the platform islands and low atolls get their water from the ground and household rain water harvesting systems.

Two local bottle water suppliers are tested monthly by Environmental Quality Protection Board (EQPB) to see if the water meets drinking water quality standards.

Stores import bottled water from the US, Malaysia, Korea, China, Fiji, etc. They are tested annually by EQPB for HPC and coliform and are removed from shelves if tests are positive.

Currently there is a proposal to reuse wastewater from a newly constructed sewage treatment plant, mainly for irrigational purposes. This treatment plant is using a Kubota submerged membrane filter. The re-use of water from this plant has not been approved, pending further testing of the water quality after treatment.

Irrigation
Most irrigation in Palau is small scale. There is minor irrigation in small farms near small streams. The amount of extraction is difficult to estimate.

Irrigation is used in the traditional taro patch "mesei". Here, women divert flow from small perennial streams to supply their wetland taro patches with water. This has been a practice done for centuries to ensure proper moisture content of the taro patches. Very little silt exists in the taro patches.

2.1.3. Major issues and concerns

Extent to which groundwater and surface water resources exploited
The extent to which these water sources are exploited is not known. Estimates are calculated based on the amount of water piped out of the treatment plants.

The Ngerimel Dam, constructed in the early 1950s, decreased water flow into the lower part of its watershed, but the flora and fauna of that area have acclimated to the decreased water levels over the past decades. The amount of water being diverted from the rivers to fulfil the public water supply systems demands does not affect the flow into the coastal areas because enough rain falls in Palau to compensate for the extracted waters. However, during dry season, the dams constructed to increase depth near the intakes cause lower flow out to the reefs, though not significant.

In Peleliu, there was saltwater intrusion in one of the wells closer to the shoreline. That well was closed off and a new well was dug at the south end of the island were there is a large freshwater lens. During the dry months of February and March, the Koror/Airai public water supply system issues water conservation warnings. Although there is still a large flow of water, the Ngerimel dam usually gets low water levels, which triggers the reduce usage messages. Only in 1998 was there an extreme need to push for water hours. The water consumption needs to be decreased along with leaks that need to be detected.

Current water usage in Koror/Airai is estimated at 700 litres/day. In the Southwest islands, where they rely heavily on rainwater as a source of drinking water, the water usage is estimated at 150 litres of water per day.

Use of Alternative Sources
Almost every household has some sort of rainwater catchment system, ranging from simple plastic lined 55-gallon steel barrels to imported aluminium 400 gallon tanks to constructed cement tanks. Desalination has been raised in the past though never thoroughly explored.

Two local bottle water suppliers, Aqua-Pure™ and NECO Tabecheding™, sell water purified by filtration, reverse-osmosis and UV-disinfection. These two companies have their water tested monthly by EQPB to see if the water meets drinking water quality standards.

Store bought water bottles are a popular alternative drinking water source. There are 6 water dispensers on the island. Stores import bottled water from the US, Malaysia, Korea, China, Fiji, Hawaii, etc.

The various and relative demands placed on watersheds/water resources
Watersheds are heavily relied upon as water sources. Levels of water extraction from the rivers are unknown at this time. The Koror/Airai treatment plant estimates extraction of 4.5 million gallons per day from the Ngerimel Dam and Ngerikiil River, though these estimations are based on amount processed within the plant, not actual amount of intake.

Outside of water extractions, the lands within the watersheds are developed for a variety of purposes, ranging from private residences to agricultural lands. Because of the small land mass of the islands, virtually any development has impact on the watersheds. Demands on the watersheds are not known as very little development has occurred near or around these areas. However with an expected migration to Babeldaob, increased water usages from the rural public water systems are expected.

Competing uses of water and priority uses
Water priority uses always come down to humans at the forefront. The leading use for water is consumption, meal preparation, and hygiene. Other uses include carwashes, Laundromats, and to a certain extent, swimming pools.

Competing uses on the water supply comes from the tourism industry, where hundreds of thousands of gallons are diverted to tourism-hospitality industry.

How water extraction is impacting the coastal environment is unknown. Mangroves and coral reefs are dependent on certain level of freshwater. The extent to which impounding water has on decreasing fresh water flow to coral reefs is unknown at this time.

Sources of pollution of surface water, groundwater and coastal waters
The main source of pollution is sedimentation. The causes are poor erosion controls, loss of riparian buffers, and poor landuse practices. But with more development expected on the larger islands, other sources of pollution will be inevitable, i.e. sewage, chemical pollution, oil spill, etc. Pollution into the groundwater sources is from poorly maintained septic tanks, leachate from nearby landfills, etc.

The groundwater pollution may be saltwater intrusion. On the platforms and atolls, there is a need to limit the amount of water extracted per day.

Coastal waters are impacted daily from land-based pollution, gasoline and oil from outboard motors and ships.

Trash and solid waste management plans are being put together to deal with the increased generation of human trash.

Information exchange systems on water resources
The Palau Automated Lands and Resources Information System (PALARIS) office is working to collect existing information into a GIS database on water resources along with current landuse data and development projects. The EQPB houses existing data on stream water quality and previous water resources studies done in Palau.

2.1.4. Measures to manage impacts and concerns (IWRM approaches)

The National Hydrological Network for water resources assessment and monitoring
There currently is no National Hydrological Network in Palau. Existing information is from research conducted by the US Geological Survey (USGS). Palau is in the process of obtaining the data from USGS, with assistance from SOPAC and the HYCOS project.[3] Palau is working closely with SOPAC on the HYCOS project to re-establish the stream monitoring stations which were left for Palau's use by the USGS.

[3] Pacific Hydrological Cycle Observing System Project

Meteorological and climatological data is operated and maintained by the Palau National Weather Service. Some government agencies have their own meteorological stations. The Palau International Coral Reef Center (PICRC) has 5 meteorology stations on Babeldaob. The Palau Natural Resources Council (PNRC) has one in Airai.

A groundwater source survey was done in 1996 by an independent consultant[4]. Results from findings of high iron levels shut down the wells in Koror.

The status of water resources quality including existing monitoring programmes and community-based monitoring

- EQPB conducts monthly bacteriological monitoring of all existing public water supply systems. In previous years there was a quarterly river and stream monitoring program. This program is set up to begin again. Marine water quality is also monitored near shores of high traffic or human use.
- The Ministry of Resources and Development water operations has some information of the turbidity levels of the raw water feeding into the treatment plants.
- Palau Conservation Society (PCS) has a community-based watershed awareness approach to watershed protection, mainly in Airai.
- The contractor for the construction of the Compact Road, DAEWOO, sampled streams on a weekly basis for the duration of the construction, although the collected data is limited and tedious to interpret.
- The Division of Environmental Health, of the Ministry of Health, conducts household surveys and when requested, H2S paper strip test checks of household rain catchment tanks.
- The Bureau of Agriculture's Forestry division does inventory of the forested areas in the watersheds of Palau.
- PICRC has sediment monitoring stations on the reef patches outside of the Ngerikiil watershed in Airai and the Ngerdorch watershed in Ngchesar.

All of the above projects are related and there is an attempt to integrate the results. However, there are gaps that need to be addressed. The PCS-led Ecosystems-Based Management project is attempting to address translation of scientific monitoring work to community level understanding.

Water conservation and reuse attitude and applications
Water conservation attitudes have improved somewhat since the water shortages in 1998, although there is a need for continued awareness campaigns. Water usages for the Koror/Airai Area is estimated at 150 gallons per day per person (over 500 litres per person per day).

The Bureau of Public Works is continuing its efforts to identify leaks to address unaccounted-for water and is looking into options for improvement of their leakage detection program. They are also looking into possibly increasing current water use fees. As of now, the current fee is US$0.90 per 1000 gallons (3780 litres).

There is no legislation to limiting water extractions from a water source.

There is an existing proposal for reuse of wastewater treated in the Melekeok Sewage treatment plant, which uses a Kubota submerged membrane filter, although approval for

[4] Winzler & Kelly Consulting Engineers

opening the lines is pending results from further testing. This source will be limited to farm use and watering plants.

Prevention measures of pollution: buffer zones, water reserves, water safety plans
Existing regulations require at least a 50-feet buffer zone (15 metres) from any water source, fresh or marine, although this is hard to regulate. The only enforceable option is to have this buffer zone inserted as a condition of any permit handed out by EQPB. This is enforceable only through notices of violations and fines and has not been very effective in the past.

The Bureau of Public Works is working on regulations to limit development in areas that directly impact the water intakes for all the states, including groundwater sources.

Some states have passed legislation to protect buffer zones, especially in conservation areas. Ngeremlengui, Ngatpang, and Aimeliik States passed legislation in 1999 to protect up to 100 feet (30 metres) as buffer zones for development within the Ngarmeduu Conservation Area, the largest conservation area in Palau. Airai State has limited development near the Ngerikiil River, especially towards the intake for the Koror/Airai public water system. Legislation includes:

- Ngeremlengui Public Law
- Ngatpang Public Law
- Aimeliik Public Law
- Airai- Ngerikiil Watershed Legislation Draft (landuse practices)
- Also in existence is the Ngeremlengui/Melekeok Watershed Alliance in which these two states protect the boundary ridges that impact watersheds in both states.

A Water Safety Plan (WSP) has recently been drafted by the WSP National Steering Committee to ensure safe drinking water for people of Palau. This draft will be introduced to the National Congress for consideration. The WSP calls for limited development upstream of any public water supply intake.

The National Emergency Management Office, under the Office of the Vice President of Palau, was created (Executive Order 166-99 National Disaster Plan.) to coordinate and mitigate for any national emergency.

2.2 Island Vulnerability

2.2.1.Types of disasters

Palau is fortunate to be outside of the main tropical cyclone track of the northwestern Pacific. The natural disasters the country faces rarely involve cyclonal winds or inundating rain. The last storm to directly impact Palau was Tropical Storm Utor in 2001. However, El Nino impacts on Palau are felt heavily when the dry season is extended from its usual 1.5 months to 2-3 months. In the period after this, La Nina, higher than average rainfall is expected along with more intense and more frequent storms.

Palau remains vulnerable to man-made disasters such as fires, marine oil spills, disease outbreaks, and chemical or hazardous pollution to water supplies.

Sea level rise and /or horizontal land movement (subsidence or isostatic rebound)
There is no recent information on sea level rise or land movement. The Intergovernmental Panel on Climate Change (IPCC) in 2001 estimated a rise of between 0.2 and 0.9 m in sea level by 2100.A slight increase in sea level could mean a significant threat to thousands of acres of Palau's lands. Presently, the negative effects of sea level rise can be clearly seen in the

beaches of Angaur to the coastal areas of Babeldaob, even to Kayangel (Office of Environmental Response and Coordination 2002).

Historic data on floods and droughts at the national level
Historically, no flooding has been observed. Anecdotal information indicates that there have been droughts in the past but were never recorded because the water sources never dried up.

Recent El Nino events have contributed to water rationing in the last 10 years. The 1998 El Nino drought was the worst Palau had seen. During the 1998 El Nino event, 75% of the taro patches were damaged due to drought (NEMO/IESL).

Flooding is rarely a problem in Palau, given the natural contours of the land allow for adequate drainage for the maximum average rainfall. Only in areas with man-made changes have there been slight flooding issues. 10% of taro patches were flooded by storm surges during Tropical Storm Utor (MRD 2001).

During the dry season, the rivers are usually shallower, though there is still flow out to the reef. An impact of this low flow is a higher salinity level further upstream, though this has not had a noticeable impact on the natural flora and fauna. However, some research should be done on this to determine any impacts.

People in areas reliant on rainwater harvesting complain of saltwater intrusion during drought periods, although the freshwater lenses replenishes easily during the wet season.

Economic costs of water-related disasters
The collapse of the bridge between Koror and Airai in 1996 destroyed the distribution main to Koror. The cost to rebuild the bridge was in the millions of dollars. The cost to repair and reconnect the mains that collapsed with the bridge was approximately US$1 million.

The cost of repairing or replacing water storage tanks for the public water supply systems is estimated at US$50,000 each. Should there be any damages to these tanks, natural or intentional; Palau does not have the funding to immediately recover the losses. Most of the tanks are in need of repair. There is a proposal to build more tanks as a measure to increase storage capacity of treated water to help during water shortage periods.

In 2001, millions of dollars were spent on repairing infrastructure damage caused by Tropical Storm Utor (NEMO 2001).

Development practices contributing to threats to life and property
Opening up of the Compact Road will expose the entire island of Babeldaob to development. About 10% of the island has infrastructure, 10% is protected, 80% is left to be developed.

Potential of deteriorating water quality, increased water demands on small systems with population shifts, etc. will contribute to impacts on human health and the environment.

Unplanned development contributes to threats to life. For example, the current Ngatpang Landfill site was chosen and used by the DAEWOO Corporation, with approval from EQPB. However, after complaints of trash in the river, EQPB and Bureau of Public Works trekked outflow from the landfill and ended up at the intake of the Ibobang public water supply system. If this landfill continues to operate, leachate from this site may eventually end up in the drinking water supply.

Some foreign farmers (hired by local owners) have in the past, and may still be using, illegal pesticides, which may contribute to health issues if these end up in the water supply systems.

Dredging of coral reefs is still a legal practice in Palau, if proper permits are obtained. Dredging and filling of seagrass patches has led to a loss of fishing grounds for those who rely on the areas for subsistence fishing.

ENSO relationship to climatic disasters
The ENSO has been linked to extended drought periods during the dry season and has had a significant impact on rainfall during La Nina years. It is noted that during El Nino years, storms are more frequent and more intense. The ENSO is blamed for the drought of 1998.

2.2.2. Major issues and concerns

Lack or inundation of water resources
Water demand for Koror/Airai is a major concern during the dry season. Dry seasons also impact water supplies for the Southwest islands, which rely heavily on rainwater catchment systems.

Water quality impacts caused by pollution
Sediments from watersheds are a major issue to the treatment of the water (increasing filtration costs and disinfectant needs). According to the manager of the Koror/Airai Water treatment plant (D. Dengokl oral comm.. 2007), more chemicals are used during and after rain events in order to reduce the increased turbidity caused by runoff.

Sedimentation is also an issue for the coastal areas, where the sediment covered reefs have no live coral. Sedimentation smothers adult corals (Fabricius et al. 2003), blocks coral recruitment (Babcock and Davies 1991), and changes community structures from coral dominated to algal dominated communities thereby affecting coral biodiversity (Edinger et al. 1998). Several studies in Palau (Golbuu et al. 2003, Victor et al. 2004) have shown a rise in sedimentation rates in areas with more terrestrial development.

Land was largely undisturbed in Babeldaob. However, recent construction of the Compact Road and residential developments has caused significant sediment loads into the rivers and the bays. Due to the decline of water quality as a result of increased development and environmentally destructive landuse practices, much of the patch reef in Airai Bay has been smothered, and hence, the fisheries in the bay have collapsed. At present, Palau does not have landuse planning or required controls in place to prevent erosion, sedimentation into riverine systems, and the resulting loss of marine diversity or habitats due to this sedimentation.

The Ngerikiil watershed provides a poignant example of what will happen throughout Babeldaob if landuse controls are not instituted parallel with construction of the Compact Road. Suspended fine sediment into the bay exceeds 1500 mg/l (0.2 oz/gallon); the river sediment plume is about 2 metres thick (6.6') (Golbuu et al. 2003). Should land development and land use practices continue unchecked, sustainability of this drinking water source and suitability of the soils for farming will be jeopardized.

A water quality study by Palau Community College - Cooperative Research and Extension (PCC-CRE) and EQPB (Rengiil 1999) found high levels of faecal bacteria near the intake for the Koror/Airai water treatment plant intake in Ngerikiil. The source was a mismanaged septic system for a pig farm near the area. After the findings, the owner fortunately complied with the request to improve the septic system.

Wastewater pollution is a concern to low platform islands that rely on their freshwater lens as a water source. The flush toilet is a popular type of waste disposal. On low islands in Palau, the septic tank is the most common catchment. Improperly built septic systems will leach down and contaminate the fresh water lens.

Saltwater intrusion and mitigation
Saltwater intrusion has been noted in Peleliu through testing by the Bureau of Public Works in 2000, but that has been rectified by closing down the well closest to the shoreline. It has not been noted in Angaur, Kayangel, or the Southwestern Palau islands. This may be an issue in the near future, with increasing population to the low islands. To mitigate for this, rainwater catchment systems are being promoted and centralised tanks will be built to increase storage of rainwater.

Extreme weather impacts on watersheds
Heavy rainfalls in the watersheds cause immediate sediment loading into the rivers. This in turn, affects coral reefs and seagrass beds on the coast as well as impacting treatment for public water supply systems.

Long dry seasons lead to water supply shortages, dying of crops due to lack of rainfall, and a higher dependence on imported products. During these long dry spells, the coral reefs die off to, not just because of associated increased temperatures, but also the decline in freshwater that is usually received from rivers, which are in low-flow mode.

Impacts of sea level rise or storm surges on aquifers or watersheds
During Tropical Storm Utor in 2001, taro patches in low-lying areas were flooded by the storm surges (MRD 2001). This led to a loss of income for the women who tended these crops. MRD estimated these losses at tens of thousands in income and combined with subsistence farming, the losses were estimated at hundreds of thousands of dollars.

According to the Office of Environmental Response and Coordination if sea levels rise as predicted by the IPCC, thousands of acres of precious habitats, including mangroves forests, beaches, low-lying agricultural sites, and coastal infrastructure will be lost. In addition to this; “there will be enhanced coastal erosion, dislocation of people, reduced resilience of coastal ecosystems, and saltwater intrusion into freshwater sources” (OERC 2002).

2.2.3. Measures to manage impacts and concerns (IWRM approaches)

Measures in place with respect to disaster preparedness and climate change
Because Palau is outside of the typhoon track, the population and the government have become complacent. The heavy rainfall of Utor in 2001 caused damage to infrastructure, power outages and millions of dollars of damage. The National Emergency Management Office (NEMO) is set up to respond to national emergencies and natural disasters. NEMO was created by Executive Order to deal with any national disasters. In terms of water resources, in the course of supplying water to the public, anything posing threat to public health, safety and well-being charges NEMO to warn or alert the general users to take preventive measures to save lives. Potential threats include contamination with chemicals, bacteria, other waterborne pathogens, and incidents of drought. NEMO, with its current staffing and funds, can coordinate and mitigate small scale disasters. However, if any large scale disaster occurs, very little can be done except to warn the public.

Policy needs to change to reflect changing times. The measures in place, which are reactive, need to become more proactive as development and climate change impact Pacific Islands. Further research along the lines of climate change is needed for Palau to determine impacts of such changes, i.e. sea level rise, sea temperature levels, storm intensities and impacts, etc.

Increased awareness of wise water use will reduce consumption levels and decrease the cost of treatment for drinking water supplies so that during drought years, the impact of the decreased rainfall quantity does not severely cripple the social wellbeing of the Republic.

2.3 Awareness

2.3.1. Awareness campaigns, advocacy initiatives currently undertaken in the area of water resources management

Palauans have a culture and history that has surrounded itself with a shroud of water. Water is the central issue of most areas, from freshwater resources to marine water and marine organisms. Earth Day 2003 “Water For Life” continues on today and ties in with the 2007 Earth Day Theme “From Ridge to Reef”.

Water resources are major issues facing Palau. Because of the linkages between terrestrial, coastal and marine ecosystems, stakeholders range from community groups to the highest levels of the government.

“Water Education for Teachers” (WET) is spearheaded by the Ministry of Finance’s Water Utilities Office. The rural water operators have taken it upon themselves to form an association that dedicates itself to keeping up-to-date with the latest technologies and advances in water treatment, even though the national Government lacks the financial ability to upgrade existing treatment plants.

Local schools include field trips to the water treatment plants to help students understand the complex workings of the plants. They also invite speakers from EQPB, PCS, the Bureau of Agriculture (BOA) etc. to the schools to discuss the need for watershed protection with the students.

PCS has dedicated an entire section of its offices to the promotion of watershed protection. With the assistance of PNRC, researchers have been brought in to study and survey the best management practices for watersheds.

State governments are dedicating a majority of their limited land to the protection of the upper watersheds. The longstanding traditions of protecting natural resources are alive and booming in Palau, even though assistance and technical expertise is limited.

The Ministry of Health’s Community Advocacy Program (CAP) can be used as a model to create closer ties with the community. Individuals within the local rural communities are hired as liaisons for the Ministry of Health to each respective community and vice versa. These tend to be individuals respected within the community.

PCS utilises a similar campaign, with one minor exception. They hire respected, retired community members to work at PCS and are the main drivers of PCS’ programmes within their communities.

• *Relevant stakeholder participation in water resource and management outside of the government or statutory body responsibilities.*
Private stakeholders voluntarily participate in national or state workshops that deal with water resources. There are private citizens that are active members of several environmental bodies, including the National Environmental Protection Council (NEPC), the PNRC, and the WSP National Steering Committee. For major community projects or policy planning; meetings and public hearings are held for the communities to voice any concerns and add their input. Individuals who are considerably expressive are often invited to become members of committees (if any are formed for projects). Given the small population of Palau, much of the community level input is provided through the state governments and representatives.

Some community members have formed unified groups to push and support their concerns. Several small community groups have applied for and received small grants from the GEF Small Grants Program. A list of grantees is in this document.

Comment: Find it and list it here for ref.

The Rural Operators Association is an association of water operators for the rural states of Palau. They formed to present a united front to negotiate for training and workshops and a voice in the national environmental bodies.

The Rotary Club of Palau, is very active with communities, and with Rotary International, is supporting the *Water for People* (WFP) programme, which is purchasing and installing Solar Pasteurisation Units for two schools in Palau. The installation of these units will provide a source of safe, clean drinking water to the students.

2.3.2. Major issues and concerns

• *Social or cultural issue associated with water resource and wastewater management*
Water is seen as abundant and a resource that should not have to be bought. The social stigma of having to pay for water is slowly fading away as people get more information on the cost of treatment and lack of cost recovery. Nowadays people are paying US$0.85 for a 500 ml water bottle so paying the same price for 1000 gallons seems reasonable.

Wastewater discharge into any body of water is socially, environmentally, and economically unacceptable because of the heavy reliance on the streams as a water source and the oceans as a source of food and tourist attraction. When the Malakal wastewater treatment plant (WWTP) was in the planning process, Palauans realized that sewage would be discharged into coastal areas and the public outcry was loud. Government agencies were swamped with angry phone calls, letters of outrage were sent to the Olbiil Era Kelulau (OEK, National Congress) and the President, and the local radio talk shows had irate callers calling about the situation. Only when proper awareness campaigns about how the plant would work to remove most of the contaminants commenced did the public outcry die down. Still, a majority of the population refuse to fish in the waters near the outfall of the WWTP.

The composting toilet is seen by the government as an alternative to flush toilets. It would decrease the use of water and decrease the amount of wastewater entering sewer systems and septic tanks. However, flush toilets are seen as a sign of luxury and therefore installed in most new homes. There needs to be a stronger push for composting toilets, especially in areas reliant on groundwater sources, as a measure to protect water supplies and increase organic fertilising material for agricultural purposes.

• *Community participation and consultation*
Community participation has always been an important aspect of environmental work in Palau because the community level activities generally determine the success or failure of a project. With large projects, communities are involved in public hearings, consultations, workshops, and meetings. Negative community reactions tend to lead to failure of projects. Because of miscommunications in the past with regional and international environmental projects, communities are hesitant to embrace new projects. In order to have receptive community participation, any project must clearly state its goals and objectives, as well as the funding and allocation of funds.

• *Political will*
Water resources are a priority for the national government, from safe drinking water for the people of Palau to clean coasts and shores for marine life. The national master plan calls for 24-hour potable running water by the year 2020. Even though the master plan is in place, Palau is still a long way away from meeting this goal. The policy makers are aware that water is a priority, but they have yet to increase funding towards meeting this goal. The political will does exist. It just needs a little push. The platform that the current President of the Republic ran on was the environment and has, during his two terms initiated and endorsed proposals and policies for environmental protection. However, some projects are seen as political pushes because of limited local involvement. This needs to be recognised by local involvement from the beginning.

• *Gender Issues*
The majority of public offices are held by men. In the democratic political sense, the country is run by the male gender. There are currently no women in the OEK nor in ministerial positions, though in the past there was a female minister who became a senator and eventually Vice President of the Republic of Palau. In other parts of the government, there are female heads of agencies.

The traditions and cultures of Palau are still highly regarded. Though the Council of Chiefs (traditional leaders) act only in an advisory role to the President, they are socially respected and recognised as the leaders of social and cultural values. Traditionally, the feminine presence is strong. The female counterpart to the Council of Chiefs is the *Mechesil Belau,* comprised of the highest ranking female leaders of each State. In Palau, chiefly titles are inherited or attained through maternal lineages. Moreover women have the power to bestow and rescind chiefly titles. Women also define cultural practices and act as educators, thereby cultivating and preserving cultural practices.

The role of women in Palauan culture has been one of active participation and involvement with most programmes and projects in Palau. The traditional women's groups are far more active with community work than the men's groups. The *Ekei Women's Group* is one of the most active women's groups in Palau. This group consists of socially prominent women and are very active in cultural and social affairs.

2.3.3. Measures to manage impacts and concerns (IWRM approaches)

• *Community based monitoring programmes*
Community based monitoring programmes for forest transects have been done with the assistance of PNRC. Seagrass programmes are conducted with assistance from PICRC. Marine invertebrate studies are done by a private stakeholder with the assistance of local community members who harvest these for a living. The same goes for rabbit fish counts. Though not entirely scientific, the involvement of the local communities increases their awareness and interest in their environment. Water quality monitoring is slightly harder to involve the communities in, but with the IWRM, Palau would like to begin some community based monitoring programmes. There have been attempts in the past to involve local schools with water quality monitoring. The students expressed great interest, but the technical people must keep updating information each year.

The participation of community members can be tracked with surveys. Community groups, such as the *Ekei Women's Group*, can be utilised to conduct community surveys and questionnaires.

• *Targeted campaigns geared towards a certain demographic group.*
Because everyone has an interest in, and is impacted one way or another by water, it may be hard to narrow down the educational and awareness campaign to a specific demographic.

As mentioned above, the water sectors have targeted schools, with the "WET" Project and including water quality monitoring in the local school curriculum. School children have always been a target group because they are seen as the future active stakeholders and ingraining in them the will to protect the environment becomes helpful in the future. The "*Uel A Sechelid*" (turtles are our friend) campaign, one of the most successful environmental campaigns, had targeted elementary school children.

• *High level advocacy initiatives*
Water is a priority for the government of Palau. The WSP National Steering Committee is comprised of individuals that are very active when it comes to water safety. Tying in the WSP with the IWRM takes the group to the next level of integration.

The IWRM committee can, with the assistance of the Ministry of Health develop ties to the community, similar to the Ministry's CAP program. This program can then be used by the entire environmental sector of the government, which usually goes directly to the communities whenever a project, issue or meeting take place. The direct approach is generally uncoordinated and there can be several agencies approaching the communities with similar projects or workshops. At the community level, there is a feeling of redundancy and scepticism at this lack of coordination. Having an environmental liaison between the community and water resource agencies can lead to less confusion and more cooperation.

2.4 Technology

2.4.1. Types of water supply systems

Table 1: Number of connections in each state and water source

State	Source of water per household by state			
	PWS only	PWS + rain	Rain Only	Other
Kayangel	2	6	38	2
Ngarchelong	138	4	0	8
Ngaraard	96	20	3	1
Ngiwal	54	2	0	0
Melekeok	69	26	4	4
Ngchesar	58	9	2	6
Airai	418	104	4	3
Aimeliik	9	50	18	1
Ngatpang	22	68	6	0
Ngardmau	43	2	2	0
Ngaremlengui	70	3	4	1
Angaur	52	32	0	2
Peleliu	4	181	6	0
Koror	2416	544	11	22
Sonsorol	1	0	36	0
Hatohobei	0	0	18	2
Total (% of total households)	**3452 (73.4%)**	**1051 (22.3%)**	**152 (3.2%)**	**52 (1.1%)**

Source: Palau Census 2005

• *Rural and urban (reticulated/non-reticulated)*

The Bureau of Public Works (BPW) under the Ministry of Resources and Development is responsible for ensuring that treated piped water reaches every household. There are 17 public water supply systems operated by BPW. The largest and most advanced treatment plant is the Ngeruobel water treatment plant, which services approximately 75% of the population. There are 13 other public water systems on the island of Babeldaob, one each in Kayangel, Angaur, and Peleliu.

Households using rainwater catchment tanks are always informed to disinfect their tanks or boil the water before consumption.

• *Water treatment systems*

According to the 2005 census, 95% of Palau's population receives treated water. The Koror/Airai treatment plant treats approximately 17000 m^3/day.

Water from the Ngerikiil River is pumped into the Ngerimel Reservoir and water flows by gravity to a raw water collection basin at the plant. At the raw water basin, the water is blended and pumped towards the flocculation basin. In the line to the flocculation basin, soda ash, then alum then powdered activated carbon is added to the water and the water proceeds through a static mixing arrangement. After flow splitting, the water goes to one of

four treatment trains and into the flocculation basins. After 2-stage flocculation the water flows up through tube settlers, is collected and split again to five valveless filters. After filtration the water is collected and mixed with a chlorine solution just after it enters a clear well. From the clear well high service pumps pump the water to distribution. Finished water flow meters are located on the high service pump discharge.

In 2005-2006, the Koror/Airai systems generally met drinking water quality standards (set forth by the EQPB public water supply system regulations) for absence of coliform bacteria, though it failed to meet turbidity standards (25% of the time) and residual disinfectant levels 4% of the time.

The rural water supply systems are simple sand filtration into holding tanks where chlorine tablets are added. During times of high natural turbidity, these systems generally fail to meet turbidity standards. In 2005-2006, the rural state did not meet standards for coliform 29% of the time, turbidity 73%, and disinfectant residual 30% of the time.

2.4.2. Types of wastewater/sanitation systems

• Rural and urban (onsite and reticulated)
Only Koror has a fully operational wastewater system. The Koror plant, the Malakal WWTP services 2218 households in Koror, 75% of total households. The only other state with a treatment plant is Melekeok, where the capital of Palau is located. This plant began operation in 2006. The rest of the nation uses septic tanks, cesspools, or latrines.

Table 2. Type of sewage disposal for households

State	Sewage Disposal (by household)		
	Public Sewer	Septic Tank/Cesspool	Other Means
Kayangel	-	20	28
Ngarchelong	-	124	26
Ngaraard	-	67	53
Ngiwal	-	40	16
Melekeok	?	103	-
Ngchesar	-	49	26
Airai	-	483	46
Aimeliik	-	67	11
Ngatpang	-	88	8
Ngardmau	-	41	6
Ngaremlengui	-	37	41
Angaur	-	74	12
Peleliu	-	121	80
Koror	2218	623	152
Sonsorol	-	3	34
Hatohobei	-	4	16
Total (% of total households)	**2218 (47.1%)**	**1934 (41.1%)**	**555 (11.8%)**

Source: Palau Census 2005

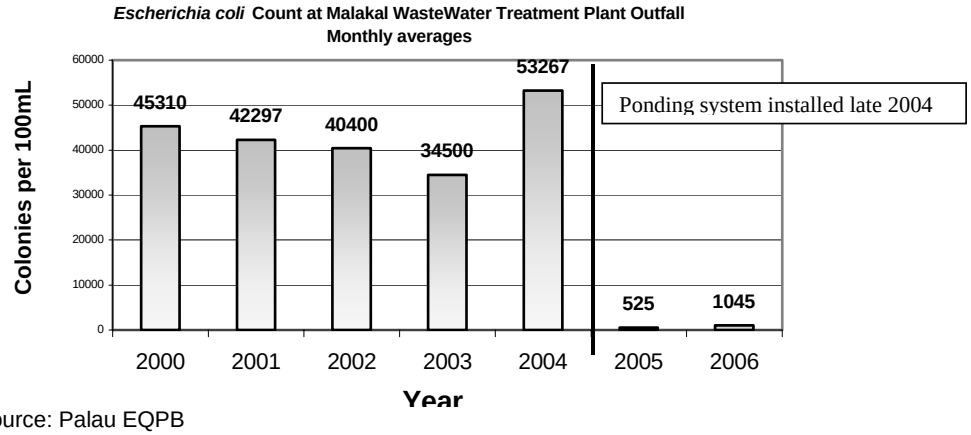
Most septic systems are new and when properly constructed, can last a fairly long time, especially if the tank sludge build-up is pumped out routinely. The previous method of latrine sewers has become less utilised, though are still in existence. Old latrine and improperly

constructed septic tanks are often abandoned for newer systems. These abandoned facilities will be an issue in the near future, with increasing development on the island.

The building of latrines and septic tanks above water intakes is discouraged. The proximity of the piggery and farm near the Koror/Airai system water intake existed before the intake was built and was overlooked during the building process. When high levels of faecal bacteria was detected near the piggery (Rengiil 1999), the owner was asked to remove the pig farm, or install a proper septic system. A septic tank and leach field was constructed and the levels of faecal bacteria near the intake decreased, though if the system is not properly maintained, the government may ask the owner to shut down the system.

• *Is there any medium to large-scale collection and treatment?*
In Koror, 2 million gallons (7500 cubic metres) of raw wastewater is treated per day at the Malakal WWTP. The plant was newly renovated to include an aerated settlement pond before the activated carbon filters and a wetland filter to remove nutrients from the water before release into the ocean. Since installation of the new ponds, *E.coli* counts at the outfall in the Malakal channel have decreased significantly. This plant is operated by BPW.

Figure 3: Faecal Coliform indicator counts, Malakal WWTP outfall, Malakal Channel



Source: Palau EQPB

A new wastewater treatment plant was set up in the new capital in Melekeok, using a Kubota submerged membrane filter. The proposed plan is to re-use water treated through this plant to irrigate the lawns of the new capital building and some agricultural use. The permit approval is pending on further testing. This new plant is capable of processing 1,500 cubic metres per day.

• *Available mechanisms for handling and managing wastewater?*
Three pump trucks, operated by the Malakal WWTP pump sludge from private septic tanks and transport this to the treatment ponds to be processed. Sludge from the settlement pond is disposed at the Koror Landfill. Though this option is available, most households do not get their septic system sludge pumped, due to cost and/or lack of awareness. Instead, there is a tendency to build new septic systems when the old ones overflow.

2.4.3. Major issues and concerns

• *Does demand meet supply?*
Water demand is readily met by the surface and groundwater sources, although it will not be properly treated 100% of the time.

The estimates for Koror/Airai area is 500 litres per day per capita. There is no metering for the rural areas therefore no estimations can be given. The Southwest Islands water usage is estimated at 180 litres per day per capita based on availability and activities. They rely on mainly on rainwater, therefore when there is a lack of rain, they turn to the dug wells.

The demand can now be met with current supplies. However, any increases in the population will necessitate increased production of reticulated water. The current water usage per capita in the Koror and Airai areas still needs to decrease, or too much strain will be put on existing systems in the future.

• *Water shortages*
Water shortages occur only when there has been little or no rain for three consecutive weeks. A dry spell of this duration happens only during moderate to heavy El Nino years. BPW is investigating the possibility of increasing the size of the Ngerimel Dam (currently 75,000 cubic metre capacity) and building larger reservoirs. During such periods, BPW imposes water hours. Bottled water had to be shipped to the Southwest Islands for drinking water supplies. The Southwest Islanders were encouraged to move to Koror until the rains resumed.

Water shortages impact Koror harder than the rest of the states because of the higher population. In 1998, the ground wells which were closed with the installation of the K/A reticulated system, were re-opened, but this water was used for hygiene and laundry only. The rest of the states had readier access to fresh water supplies.

• *Human/financial resources*
The water treatment plants and the WWTP have trained staff to operate the plants. The largest water treatment plant has 15 staff that runs the plant 24 hours a day. There are a total of 42 operators for the 16 rural water treatment plants. The Malakal WWTP has a staff of 20 people to ensure the system is running around the clock.

Palau has no hydrologist, geologist, or hydro-geologist and relies heavily upon US based researchers who are interested in studying the islands. Existing hydrogeological studies are over a decade old. There is a United States Department of Agriculture NRCS office on island that assists with many field studies (soil, vegetation) and conservation measures.

Financial resources are limited. Funding is received from the national congress, outside aid from Japan, Taiwan and Australia. The water usage fee is US$0.85 per 1000 gallons which does not recover the costs of treatment and distribution of water.

•*Level of threat wastewater management or its absence represent to water resources, to human health and to ecosystem welfare*
Wastewater management is needed in the low islands as they are dependent on their freshwater lens for primary supply and must not contaminate it with faecal coliforms. There is a need for promoting the use of composting toilets and to move away from the water-using flush toilets, which speeds up the permeation of wastewater into the ground.

There is also a need for wastewater management on the larger island, especially if the effluent discharge will be to the coastal areas, as was the case with the Malakal WWTP. Potential impacts from sewage effluents on coastal ecosystems include, but are not limited to, nutrient loading, sedimentation, benthic community shifts due to nutrient loading, and increased faecal bacteria contamination.

Some issues have recently arisen from poorly managed/designed septic tanks. Septic tanks in a housing development in Casabelau, Airai have overflowed into neighbouring yards, creating a human health situation by exposing raw sewage. This situation came from the fact that the soil in the area was not porous enough for proper leaching.

2.4.4. Measures to manage impacts and concerns (IWRM approaches)

• *Measures in place to prevent pollution from poorly managed wastewater treatment and/or discharges*

No septic tanks are allowed near rivers or close to the aquifer wells. Any discharges into the water require a Pollutant Discharge permit from EQPB and the water quality of the discharges have to meet certain standards, depending on location of outfall. Large scale discharges are routinely monitored.

Wetlands and sensitive habitats are protected and mitigated for with legislation. However, enforcement of such legislation is an issue. Another issue is that such legislation can be changed. Most mangrove areas are protected by classification and zoning. If a state decides to change classification of zoned areas, these areas are no longer protected by existing laws. There should be laws or regulations limiting the total area of mangrove that can be reclassified.

In 2005, pump stations for the Koror area WWTP overflowed into surrounding areas, some of which were residential, wetlands and coast waters. Untreated sewage poses a threat to human health and ecosystem health. The government agencies (EQPB, BPW, and the Division of Environmental Health) worked together to resolve the issues as well as raise public awareness of posed dangers. EQPB issued MRD a timetable to fix the pump stations. When this timetable was not met, a suit was filed against MRD for a monetary fine. Immediately following this suit, to avoid payment of the fine MRD proposed a new timeline and fixed the pump stations.

As of now, measures are in place, but for large scale pollution, the tendency is to be more reactive than proactive.

• *Water conservation measures*

During dry season, water hours are put in place. Other than that, several awareness programmes through various agencies go on year round. The Bureau of Public Works and the WSP are looking into promoting low-flush toilets.

The government is contemplating an increase in water tariff as a water conservation measure. The local power supplier, Palau Public Utilities Corporations (PPUC), has experienced a decrease in wattage use since it hiked its fees due to rising gas prices. BPW is expecting the same to happen with water usage if the water tariffs are increased.

• *Appropriate technologies and method*

Water shortages can be addressed by increasing the reservoir size to hold more water. Hydrological monitoring is needed. Rivers still have flows during dry season and can still be utilised. Flow meters are needed in all the treatment plants to address water usage needs. Water fees need to be increased to help alleviate the strain on the government as well as promote water conservation. Palau needs to implement low-flush toilets to conserve water as well as decrease wastewater.

Wastewater treatment facilities and management must have consultation with various sectors of the government and general population so that issues that arose with the Malakal WWTP can be prevented or avoided. A prime example of wastewater management without integrated approach is the new ponding system for the Koror sewage treatment. Test results show that since installation of the new ponding system for the Malakal WWTP, the *E.coli* count at the outfall in the Malakal Channel has decreased significantly. On the other hand, the number of mosquitoes has increased in that area (DEH Vector Control and Prevention Program, oral comm. 2007). In order to control the mosquito population in the area, the WWTP staff scoop the mosquito larvae out of the ponds. The ponds are working as expected, decreasing the faecal bacteria and nutrient levels in the effluent, but the related

increase in the number of mosquitoes was not accounted for during the planning process. Now the increased population poses a threat to the community because mosquitoes are vectors for dengue and other diseases. When the larval counts in the pond increase beyond the threshold, larvacides (such as Altosid) are applied to control the population. The effects of such chemicals on the surrounding ecosystems need to be determined.

• *Existing Geographical Information Systems (GIS) where water resources or catchment management information are being stored*
The office of PALARIS holds resource and landuse information for the entire Republic, including water resources and watershed catchments. They hold most of their data on the ArcGIS program. This office holds training workshops for employees from other government agencies to use the ArcGIS program so that they are capable of accessing and using the data.

GIS as a tool can be used to provide an effective interface between landuse change, watershed management and development proposals and impacts on water resources. In the past, PALARIS has used GIS to assist the national government with planning major infrastructure. It is underutilised as a tool for decision making.

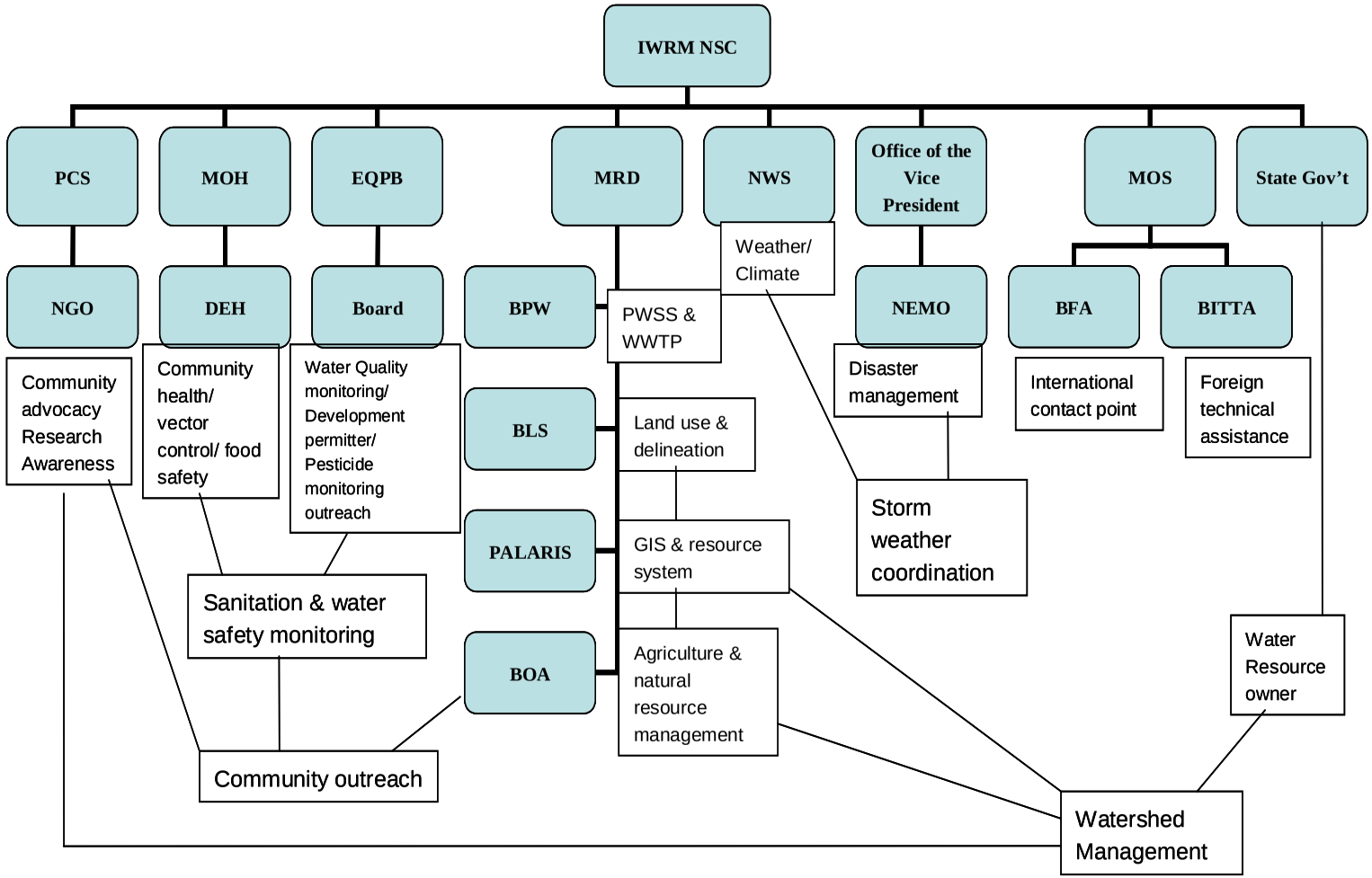
2.5 Institutional Arrangements

2.5.1. Types of institutional arrangements

• *National Water Vision*
The national Master Development Plan calls for 24-hour access to potable water by the year 2020. High priority is placed on a clean water supply, and proper water and wastewater management.

Palau currently does not have a National Water Committee. The organisations involved with the Water Safety Program will be involved with the IWRM and work on formalising a recognised National Water Committee. The WSP National Steering Committee includes consists of active department heads with a vested interest in water resources including, but not limited to: Bureau of Public Works; Bureau of Agriculture, PALARIS, Bureau of Lands and Survey; Bureau of Foreign Affairs; Bureau of Trade and Technical Assistance, EQPB, Division of Environmental Health; PCS, National Weather Service and the National Emergency Management Office.

The roles and responsibilities of the following National Steering Committee members with relation to water resources are listed in Section IV Stakeholder engagement. Figure 3 gives an overview of the overlapping roles of these agencies.



Research partners: NRCS, PICRC, BNM Other potential partners: OERC, BMR, MOA, more community groups.

Figure 3. Relationship between IWRM committee members

• *Water related Legislation*

- The Palau National Code (PNC) has a mixture of laws passed by Congress, old Trust Territory Codes plus some US laws (i.e. Clean Water Act), which have been applied to Palau.

-Constitution of Palau gives the State Government oversight of fresh and marine water resources out to 12 miles at sea. The states have the right to change classification of waters within their boundaries.

State level legislation:

Airai- Ngerikiil Watershed Legislation Draft (landuse practices)

Ngeremlengui/Melekeok Watershed Alliance

-Environmental Quality Protection Act (ROP Law No 1-58) PNCA Title 24, is the legislative framework for the Environmental Quality Protection Board and of Wildlife Protection, includes an Endangered Species Act, administered under the Ministry of Resources and Development.

-The Natural Heritage Reserves System Act (ROP Law 3-51) creates a system of reserves and refuges of terrestrial, freshwater and marine areas suitable for inclusion in the Republic's Natural Heritage Reserves System.

• *Legislative and policy documents that provide the appropriate mandates for the institutions responsible for water resource and wastewater management.*

Executive Order 166-99 National Disaster Plan created the National Emergency Management Office to deal with natural disasters, including disasters that affect water and water supplies.

Bureau of Public Works Regulations for water uses are under review at the Attorney Generals' Office

Best Management Practices, recommendations only, have been used by EQPB as permit conditions.

EQPB Regulations, Title 24 under the Palau National Code, promulgates and enforces primary and secondary drinking water standards, permit and monitor discharges in the air, land, and water, and enforcement of environmental quality protection.

- The Environmental Quality Protection Act : Palau National Code
- EQPB Regulations Chapter 2401- enforceable by law
- Environmental Assessments and Impact Statements (EA & EIS) – permit conditions are enforceable
- Best Management Practices for Agriculture – an integrated plan which is mainly recommendations, though EQPB uses it to enforce certain permit conditions.

Public Water Supply System Regulations**:** The purpose of these regulations, technical provisions and specifications is to establish certain minimum standards and requirements as determined by the Republic of Palau Environmental Quality Protection Board to be necessary for the public health and safety to insure that public water supply systems are protected against contamination and do not constitute a health hazard.

• *Monitoring, enforcement and compliance arrangements*
EQPB's enforcement arrangements are limited to compliance of permit conditions or pursuant of non-permitted activities involving the above-stated regulations. There is a need for more manpower to monitor all development activities ongoing within the Republic.

The Bureau of Public Works and Bureau of Agriculture currently have no enforceable regulations, though they do have Best Management Practices in place.

The Division of Fish and Wildlife Protection (DFWP) enforces conservation laws and, when no state level enforcement is available, enforces entry restrictions to reserves and preserves.

As with all other agencies as well as other Pacific islands, the lack of funding translates into a lack of enforcement for the most part. When there is enforcement, the mitigation arrangements are somewhat limited, with monetary fines usually below levels necessary to make a statement.

This lack of funding can sometimes be seen as a lack of interest from decision-makers towards activities of each agency. Regulatory capacity should be increased so that staff and enforcement agents see legitimacy of their responsibilities in order for regulatory agencies to maintain accountability and acceptability to the public.

• *Multilateral and environmental agreements (MEAs)*
Palau is party to the conventions on Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Law of the Sea, Ozone Layer Protection, and Wetlands.

Existing legislation supports the objectives of most conventions but the need to strengthen ground level support still exists.

The National Invasive Species project has been one of the most active parts of the National Biodiversity Strategic Action Plan (Convention on Biodiversity) and has achieved most of its goals. The four primary goals to address invasive species issues in Palau are:

The Micronesia Challenge is a commitment by Palau and its regional partners to effectively conserve, within each country, 30% of near-shore marine and 20% of terrestrial resources by the year 2020. Through this challenge, Palau aims to become the first nation in the world to establish a Protected Areas Network (PAN) that is totally self-supporting. The goal is to establish a US$12 million fund that will provide annual funding for the management of our protected areas.

2.5.2. Major issues and concerns

What are the capacity shortfalls in the context of the absence of appropriate institutional arrangements/bodies, human resources, equipment, etc
There is a need for more information on stream flow and discharges, amount of water being extracted on a daily basis from treatment plants to determine the impact that water extraction is having on the water sources.

In every case, there is a lack of manpower, vehicles, and funding for continuous monitoring.

Palau needs to increase its monitoring capabilities for discharges. Full chemical analysis should be done annually for each water system. This has been accomplished only once, for the Koror/Airai system, at an off-island lab. Local laboratory capabilities must increase to monitoring current and future development and their impacts on the watershed and coastal ecosystems.

Further research must be done on the freshwater lenses of the platform and atolls of Palau.

2.5.3. Measures to manage impacts and concerns (IWRM approaches)

• *Institutional, policy and legislative*
Legislation for watershed protection exists at all levels of government. A National Water Resources Policy needs to set goals and objectives for the management of water resources at the national scale and include policies for regions, catchments, and shared water resources all within an IWRM framework. The Watershed Alliance is a good start for management of shared catchments.

Comment: First mention

The existing institutions that implement such policies need to be strengthened and expanded to accommodate the existing level of legislation and future ones.

Agencies with related mandates need to coordinate and assist rather than compete for existing funding. They need to identify the overlapping confusion of roles and responsibilities through integrated working relationships.

• *Capacity building*
Capacity building is necessary at every level. Existing capacity is adequate for current activities within the government structure. However, further development of knowledge base is required to ensure sustainable growth and development of the Republic.

Palau currently has limited technical capacity to address proper watershed policy implementation. While basic capacity exists at the national, state, and local levels additional training is required in the areas monitoring etc. Specifically, Palau needs the knowledge and expertise to assess pollutant sources, implement best management practices, etc.

Regulatory capacity building is also need for the development and implementation of new and existing regulations. The regulatory staff need to see the legitimacy of their responsibilities in order for regulatory agencies to maintain legitimacy too. This will lead to acceptability and compliance by the communities and business.

2.6 Financing

2.6.1. Types of financing arrangements

• *Identify the funding/revenue sources for water supply and wastewater management.*
Primary source of funding for water supply and wastewater management is budget appropriated by Olbiil Era Kelulau (National Congress). The amount allocated for Water and Sewer Operations (US$2.3 million) has been increased for FY2006-2007 mainly to cover increasing electricity rates for the past several years and leaves little for improvement of the rural water treatment plants. There are a total of 57 water operators, 15 of which work at the Koror/Airai treatment plant. About 20 people work at the Malakal WWTP and 4 at the Melekeok WWTP.

Water fees are collected through the Ministry of Finance's Water Utilities Division and deposited into the National Treasury. Water fees apply only to piped water. There are no charges for private or commercial use of the existing sewer systems.

EQPB monitors water supplies and wastewater effluents. The laboratory section for this office takes up 25% of the annual US$400,000 budget allocated by Olbiil Era Kelulau. The engineering and compliance enforcement sections of EQPB also monitor construction of and compliance to permit conditions of wastewater treatment facilities. External grants and small on-island projects help EQPB purchase needed equipment and supplies.

Assets investment

The BPW is still developing an assets management system for the water and wastewater treatment plants. This will be necessary when the plants are turned over to the private sector.

Table 3: Assets inventory for the EQPB Water Quality Laboratory

Assets	**#**	**Replacement Value (US$)**
Incubator	3	20,000
Ovens	2	3,000
pH meters	2	2,000
Spectrophotometer	2	15,000
Distillers	2	15,000
Fume hood	2	10,000
DO meter	1	2,000
Multi-probe meters	2	30,000
Microbiological supplies	Annual restock	10,000
Chemical supplies	Annual restock	10,000
Descicator	2	5,000
Refrigerator	3	2,000
Computer w/software (ArcGIS, Trimble, YSI, etc)	3	15,000
River Sediment Stations	5	75,000
Boat w/ outboard motor	2	30,000
4x4 vehicle	2	30,000
Dishwasher	1	1000
Water heater	1	1000
Staff	4	80,000 (annual)

• *Economic instruments and sources of external/ international funding (past, present and intended).*

External funding has always been a major source of funds for infrastructure. The main sources have been from the US, through the Compact funding and technical assistance from the United States Environmental Protect Agency (USEPA), JICA with technical assistance and Republic of China – Taiwan with monetary assistance.

•*Tariffs and cost recovery*

Water meters are being put in place and the water usage fee is US$0.85 per/1000 gallons. In areas with no meters, a flat rate is imposed on all connections. The Water Utilities Collection Office collects approximately US$650,000 annually.

The cost of operations of the water treatment plants in Palau is approximately US$1.6 million. The water fees cover only 37.5% of the costs of the treatment plant.

There is no fee for use of the public sewage system.

There is no limit to water extraction by any company and individual, from either surface or ground water. This is an issue that needs to be dealt with before it arises, which is most likely in the near future, given the number of developers interested in Palau. Recently, a large corporation had negotiated with one of the state governors to develop a large resort/residential type complex. The project was stopped for several reasons. However, no one considered that the amount of water they planned to extract from the aquifer daily could

result in saltwater intrusion, or how the amount of sewage that would be produced from such a large resort impact the surrounding area.

• *Subsidies*
The water treatment plants are owned and operated by the national government who shoulders the US$1.0 million loss from this operation. The Malakal WWTP is owned and operated by the national government. The Melekeok WWTP is owned by the national government and operated by FreeAir Corporation. The national government has plans to turn the water operations over to a semi-government corporation after it ensures that all homes and future homes will have access to potable water. Two utilities corporations exist in Palau: PPUC (electricity) and PNCC (communications). These two corporations are subsidised by the government, but to a minimal extent and rely heavily on consumer fees; therefore rates are reflective of increasing charges. The same is expected if the water operations become privatized. The water utilities will be transferred to PPUC, along with current employees. The government understands the importance of water and plans to subsidise the corporation once it takes over.

2.6.2. Major issues and concerns

• *What are the difficulties faced with the current financing arrangements?*
Current revenues from water fees do not meet the operation and maintenance costs of the supply systems.

Water meters need to be installed to determine daily water use per capita.

The government needs to increase the water fees, but law-makers hesitate to do so because of voter ire. Because of this, the water treatment plant is operating at a very significant loss. Water revenue needs to be directed at infrastructures, to truly improve the water systems and stop water leaks, thus gaining the necessity of water fee increases as well as public trust.

Large business, such as hotels and restaurants, use more water than private customers and put more strain on the sewer systems and environment. Yet there are no tariffs levied against such entities. The government must recognise the strains such businesses are putting on the environment and determine the appropriate financial measurement to outweigh the cost of doing business.

2.6.3. Measures to manage impacts and concerns (IWRM approaches)

• *Funding and cost recovery systems*
Though it may not be a popular option, the water fees need to be increased. Volumetric tariffs can provide incentives for careful use of water. Any fees collected for water and wastewater tariffs should be redirected to the improvement of water treatment. Only with a coupled service improvement will an increase in water fees be acceptable to the public.

There should be a fee for the use of the wastewater treatment plant, especially from big business (hotels, restaurants, etc) to put more pressure on the plant.

• *Public Private Partnerships*
The private sector in Palau is very under-developed. The government of Palau has slowly handed out utilities management to corporations that remain semi-government. If the government can move the water supply service to the private sector, it may support the growth of the local economy as well as relieve the government of the pressures of providing such service. Private companies may have an easier time raising prices.

Should such services become private, regulatory oversight must be in place to ensure that quality remains high and that costs do not overwhelm the individual.

Regulatory oversight
There needs to be regulations regarding water extraction, especially on groundwater resources and during low-flow periods. These regulations should apply to the government as well as the public, as the government is the main water extractor.

There should be severe fines to any corporation, individual, or government agency that abuses water resources.

3. Linkages to other areas

3.1 Landuse and agriculture

•*Existing land-use policy with special emphasis on water resources, wastewater management and water source protection*
70% of the land is public land (State determines use). Land Planning legislation exists under Title 31 PNC division 3 and 4 enact Zoning and Subdivision Laws for Koror. Other legislation deals with special purpose wildlife, natural heritage, and historical preservation reserves.

The existing laws in Palau for environmental protection were enacted to ensure protection of water resources and wastewater pollution. These laws, however, need to be updated and enforcement and implementation need to be strengthened with the proper capacity and funding.

Palau recently received funding from GEF for capacity building to develop sound landuse planning policies. The project, "Capacity building for sustainable land management for mitigation of land degradation", helps with water source protection and wastewater management of future development.

• *Conflicts that exist in relation to land use within watersheds*
Current conflicts are boundary issues. Landuse issues within the watersheds have been limited due to lack of access. With the completion of the Compact Road, there will be issues from private landowners with the use of their own lands.

There should be awareness raising campaigns targeting states and private landowners with access to or ownership of watersheds.

• *Land use impact on source protection*
Main impacts in the lower watersheds have been increased sedimentation due to improper buffer zone applications, and faecal contamination by improper wastewater management.

Suspended soil particles are not travelling alone. Other pollutants such as pesticides and nutrients are attached to the soil particles and are thus carried into the water along with them. The fine clay and silt particles in the soils have a high nutrient holding capacity, which means that very large amounts of nutrients and other chemical pollutants can stay absorbed in the particles and thus be carried into the surface water. A study comparing two sites on Palau with different levels of development showed that the more developed watershed had significantly higher sediment loading to adjacent coral reefs (Victor et al. 2003).

Increasing sedimentation in the rivers increases the need to use more chemicals to reduce turbidity levels to drinking water standards and also increases the use of disinfectants to ensure safe drinking water. This translates to an increase in expenditures on chemical supplies. Simple filtration systems do not remove enough turbidity and this causes reticulated water from such systems to be unpotable regardless of disinfectant levels. In such instances, human health is at risk if public water systems are the main drinking water sources.

• *Describe the relative importance of irrigation with respect to water use at the national level*
Irrigation has not been an issue at the national level.

• *Land-based pollution affects on watershed management*
Pollution sources are hard to identify. Sediment from natural and human development activity is hard to separate. There are some dumpsites that may be affecting water quality at intakes. The Ibobang water intake lies downstream of the current Ngatpang landfill. Future management of these intakes need to ensure that development upstream will not contaminate their water source.

• *Main sources of land-based pollution of watersheds*
The major land-based pollution sources are development of the circumferential road in Babeldaob, poor agricultural practices, and residential developments. Solid waste is a big issue for the island, though mainly on the coastal fringes because most landfill areas are in or near mangrove forests.

In the NRCS Soils study in 2003, the calculated erosion rates indicate that modern farming practices increase sediment loads into the rivers.

Traditional and sustainable farming practices in the watershed produce erosion at rates between 0.2 and 9.9 metric tons per hectare per year (0.1 and 4.4 tons /acre/year). In addition, unsustainable techniques cause erosion at rates of over 515.7 and 728.7 metric tons per hectare per year (230 and 325 tons/acre/year). With 140.4 hectares (347 acres) of agricultural land currently existing in the watershed, annual erosion could reach upwards of 102,330 metric tons (112,800 tons) annually. This is over 10 times the amount of erosion produced by forested lands that cover 16 times more land area than agriculture.

The traditional Palauan farming method of agroforestry has proven to be sustainable, causing insignificant soil erosion. This method involves planting of multi-storied crops – fruit trees, medicinal plants or shrubs, and food crops – intermixed or in small patches. Agroforestry involves minimal disturbance of the soil and maximum input of organic matter into the soil. Using leaves from trees for mulching around crops is a valuable technique that is traditionally used in Palau. Mulching minimises soil erosion, decreases the temperature of the farm fields by providing shade to underlying roots, holds or stores nutrients, as well as adds nutrients to the soil. These are great examples of how maintaining soil cover reduces soil erosion well below current rates. These techniques will have important application for most agriculture systems in Palau.

• *Impacts of deforestation and sedimentation on watersheds*
Clearing forest for development purposes and agricultural farming have caused higher sediment loads into the rivers and out to the coral reefs. Research by PICRC has indicated higher sedimentation rates in the past few years (Victor 2007; Golbuu et al. 2003). Victor et. Al. (2004) found higher sediment rates on coral reefs near watersheds with larger deforestation (for development and agricultural purposes) than near watershed with relatively pristine forests. Soil erosion is affecting water quality, decreasing depth of the rivers, and covering seagrass beds and coral reef patches. This is impacting the flora and fauna of the rivers and adjacent coastal areas.

3.2 Habitats and Ecosystems

• *Identify the critical habitat types and associated threatened, endangered, charismatic and/or endemic species.*
Palau's watershed areas are vital not only as a source for freshwater, but also for their ecological value. These watersheds are home to numerous species of vegetation, freshwater fish and invertebrates, nesting birds, and crocodiles. The two longest rivers in

Palau are the Ngerdorch and the Ngermeskang Rivers. The Ngerdorch River drains from

Lake Ngardok, meandering around Babeldaob for 10 kilometres before it flows to the ocean in Ngchesar State on the east coast of Babeldaob. On the west coast of Babeldaob the Ngermeskang River flows into Ngaremeduu, the largest watershed in Palau. Both

Ngardok and Ngaremeduu are protected areas.

Palau is home to the greatest area of continuous native forest in Micronesia. There are 303.51 km^2 of forest cover throughout the islands. With more than 1200 species of plants, of which over 860 are native and 109 are endemic, Palau's forests are the most species-diverse in Micronesia.

Upland forest is on volcanic soils in the hilly interior of the watershed and consists of a species rich mixed broadleaf forest that occupies flat or sloping sites as well as river and stream banks. Aside from these upland forests, there are coastal swamp forests, limestone forests on limestone outcrops and coralline limestone islands. These native forests are home to endemic trees and birds. Savannas dominated by grasses and sedges can be found on Babeldaob.

The mangrove swamps are home to the saltwater crocodile (*Crocodylus porosus)* and serve as fish nurseries. Seagrass beds are feeding grounds for the Dugong and macroinvertebrates such as sea cucumbers, which are local delicacies. Coral reef and patches reefs are home to endemic fish, giant clams (*Tridacna* spp) etc.

Coral reef degradation is of major concern in Palau. Excess sediment and nutrients are typically the main culprits when it comes to the killing of any coral reef. Under natural circumstances coastal mangroves do the job of intercepting sediment and nutrients that runoff the watershed. Palau supports the highest coral (>400 species) and fish (1,450 species) diversity of any island group in Micronesia.

The Rock Islands house the most marine lakes in the world, which are home to the stingless jellyfish. Palau is home to one endemic Nautilus, *Nautilus belauensis*, the world's largest Nautilus species. Palau is home to seven of the nine known giant clam species in the world.

In 2006, Fanna Island was recognised as an 'Important Bird Area' by Birdlife International. It is estimated to have a density of 675-853 birds per hectare, with a total population of 23,000 to 31,000 birds.

Table 4: Number of species for Palau

Species Lists	Approximate Total	Endemics
Plants	1260	109
Insects	5000	500
Birds	141	16
Freshwater fish	40	3
Terrestrial snails	301	300
Amphibians/reptiles	46	12
Soft corals	200	
Stony corals	385	
Mangrove tree species	18	
Marine fishes	1387	11+
Seagrass	9	
Macro-invertebrates	>600	1

Turtles	5	
Saltwater crocodile	1	
Dugon dugon	1	

Source: Office of Environmental Response and Coordination 2002

List of Endemics Birds and reptiles (Engbrin 1988; Otobe 1997; Crombie and Pregill 1999):

Anas superciliosa, grey duck

Pyrroglaux podargina Palau scops owl

Gallicolumba conifrons Palauan ground dove

Cettia annae Palau bush warbler

Myiagra erythrops Palau fly catcher

Rhipidura lepida Palau fantail

Colluricinla tenebrosa Palau morningbird

Artamus leucothynchus White-breasted wood swallow

Megazosterops palauensis Palau Greater white-eye

Erythrura trichroa Blue-face Parrotfinch

Ptilinopus pelewensis Palauan fruit dove

Platymantis pelewensis Palau Frog

Dendrelaphis lineolatus Palau Tree snake

Aulacoplax leptosoma Pandanus skink

Gekko sp Rock island gecko

Lepidodactulus spp Gekko spp. (2)

Pteropus mariannus pelewensis (Micronesian Fruit bat)

Pteropus pilosus Palau Fruit bat (possibly extinct)

Emballonura semicaudata palauensis (Palau Sheath-Tailed bat)

Impacts to any of the above-mentioned ecosystems impacts species that rely on those ecosystems and biodiversity becomes an issue. Several monitoring programmes are in place for ecosystems (i.e. Reef Check, Ecosystem based management) or species (i.e. Birdlife).

•*Watershed and coastal areas currently included in any protective area system*

In previous years, the focus of conservation was marine-based. Palau has 28 Marine Protected Areas, 2 with national legislation.

Two terrestrial conservation areas were passed by state legislation. Ngardok Lake Reserve is a designated Ramsar Wetlands site and the Ngaremeduu Conservation Area is recognised as Biosphere Reserve.

The Protected Areas Network office is currently assisting states with designating areas for reserves or conservation areas. This office was set up to coordinate projects and search for funding to support these protected zones.

• *Primary threats to these habitats/ecosystems?*

- Sedimentation to coral reefs caused by deforestation, improper landuse (no buffer zone), development
- Overexploitation of natural resources
- Destruction of natural habitats for development
- Shifts in population (movement from Koror to Babeldaob)

Irresponsible land development includes:

• Not controlling erosion and sedimentation

• Not containing excess nutrients

• Removing upland forests, riparian buffers, and mangrove forests

Irresponsible land development leads to a greater amount of pollutants reaching the reefs. Sediment from deforestation, construction and farming activities flows past the mangroves as their capacity is exceeded (especially if they are being cut down) and collects on the corals instead. This gathering of sediment shades and smothers the corals causing death of the reef.

3.3 Health and hygiene

• *What are the major health concerns related to watershed and wastewater management?*
Waterborne illness may be associated with drinking water from both public and private supplies and with recreational water.

Drinking water sources (surface and ground), face contamination from various sources. Animal wastes pose serious health and environmental hazards when they are allowed to reach the water system. Excess nutrients in the rivers can be very toxic to aquatic wildlife and stimulate algae growth and lead to eutrophication. There is also the potential for a major human health hazard if farms develop upstream of intake stations for water treatment plants and local wells used for drinking water. Animal manure also contains large amounts of disease-causing pathogens that can injure humans, livestock and other animals if allowed to contaminate crops and/or drinking water.

Some common agents that can cause a wide range of problems—from mild diarrhoea to fatal illnesses—are: bacteria such as *Salmonella*, *Shigellae*, *Cholerae*, *E. coli*, *Leptosporidia*, *Encephalitis*, *Chlamydia*, *Gangrene* and those causing botulism; Protozoa such as *Giardia*, *Cryptosporidia* and *Balantidium coli*; and *Helminths* such as large roundworms. Disease outbreaks happen often all over the world due to improper containment of animal manure and human sewage. In Palau, most of the outbreaks of water-borne illness come in cluster outbreaks, usually from campers in the forests using rivers directly as a drinking water source. However, the danger can be greatly reduced through proper waste management practices.

Dengue fever is a water related issue because of the large number of mosquitoes and larvae at the ponding systems of the Malakal treatment plant. Carrier mosquitoes may breed in the water thereby causing a dengue outbreak. When this occurs, it costs the government to subsidise medical treatment and services. According to the Division of Environmental Health, small dengue outbreaks occur at least once a year, with larger outbreaks happening every 2 to 3 years.

• *Comment on water borne, water-washed, and water-related diseases.*
Water-borne illnesses are under-reported, as infected persons tend to recover at home rather than facing the hospital and high associated costs. The number of gastro-enteric diseases reported by the Ministry of Health is inclusive of all types and it is hard to determine which are water-borne.

Gastroenteritis includes waterborne issues. Many pathogens occur naturally in aquatic environments. Water may also become contaminated by sewage overflows, deliberate discharges, leaching from failing septic disposal fields and surface runoff from land. Adequate treatment of water supplies may be a factor with this low number of cases. Gastroenteritis is a reportable illness in Palau. According to the Division of Environmental Health, gastroenteritis occurs mainly as cluster outbreaks, usually a group of people with a bad meal or without a proper water source (i.e. campers). The only major gastro-enteric outbreak in 10 years was in late 2006 to early 2007, with over 400 reported cases. The Ministry of Health was unable to determine if this outbreak was food-borne or water-borne. The Community Advocacy Program set up reminders to wash hands with soap and water. Table 5 shows the list of gastroenteritis outbreaks in Palau from 2003-2005. As can be noted, the sources are mainly food-borne. However, it is hard distinguish between water-borne and food-borne due to limited laboratory capability, but most are believed to be food-related.

Table 5: Gastroenteritis outbreaks in Palau 2003-2005

Month	Location	Pathogen Implicated	Implicated source	Comments	No. of people affected
Sept. 2003	Birthday Party - Home	Unknown	Belsiich (pounded taro) suspected	Several cases confirmed as Amebiasis.	20
May 2005	Tour Group – various	Unknown	Bento Meal suspected	Incomplete investigation – group returned home overseas.	8
May 2005	"Custom" (Funeral)	Suspected Bacterial toxin	Food vehicle not identified	Meal held all day with no temperature control. Not all attendees interviewed/identified	4
Sept. 2005	"Custom" (Funeral)	Bacillus cereus suspected	Fried Rice	Meal held all day with no temperature control.	6
Nov. 2005	Home (Farm)	Scombroid fish poisoning suspected	Fish (Tuna)	Repeated freezing and thawing of fish before eating.	3

Source: Carter et al. 2006

Because most of the water supply systems are treated, the number of water related diseases caused by public water supply systems is low. The highest concern is individual catchment tanks. The Division of Environmental Health is currently using the hydrogen sulphide test to conduct bacteriological tests for household catchments. Before the H^2S paper strip test was introduced in 2006 by WHO, EQPB tested individual tanks by request. Up to 75% of the tanks tested by EQPB were positive for total coliform bacteria. A catchment maintenance document was produced by PCC-CRE with assistance from DEH and EQPB and funded by USDA. The WSP committee plans on reproducing copies of this document and distributing it to the general public for use.

The EQPB Water Quality Lab conducts routine monitoring of public water supply systems and marine recreational areas. The following table is a report for FY2005/2006, which shows the number of tests done per year and quality of water for public water supply systems, marine recreational areas, and water quality in the Malakal channel around the outfall of the wastewater treatment plant.

Table 6: Water Quality Results for October 2005-September 2006 for PWSS, Marine Recreational Areas and the Malakal Wastewater Treatment Plant outfall in the Malakal Channel.

	Turbidity (not >1.0 NTU)			Coliform Bacteria (not > 0 per 100 mL Sample)			Marine water tested by Palau EQPB	Faecal Coliform (not>200 per 100ml Sample)		
	Total # of tests done	Agree with Standard		Total # of tests done	Agree with Standard			Total # of test done	Agree with Standard	
		#	%		#	%			#	%
Koror-Airai	753	599	79.5%	156	156	100.0%	Koror-Airai	174	160	92%
Hospital	252	248	98.4%	12	12	100.0%	Ngerchelong	5	5	100%
Ollei	9	0	0.0%	9	3	33.3%	Ngaraard	6	6	100%
Mengellang	12	5	41.7%	12	10	83.3%	Ngiwal	6	6	100%
Ngaraard	10	0	0.0%	10	8	80.0%	Melekeok	5	5	100%
Choll (ground)	11	11	100.0%	11	4	36.4%	Ngchesar	6	6	100%
Ngkeklau	12	0	0.0%	12	11	91.7%	Ngatpang	7	7	100%
Ngiwal (ground)	12	11	91.7%	12	12	100.0%	Ngardmau	7	7	100%
Melekeok	12	0	0.0%	12	7	58.3%	Ngeremlengui	7	7	100%
Ngchesar	12	0	0.0%	12	11	91.7%	Aimeliik	7	7	100%
Ngatpang	12	0	0.0%	12	10	83.3%	Peleliu	8	8	100%
Ibobang	12	0	0.0%	12	10	83.3%	Angaur	2	2	100%
Ngardmau	12	3	25.0%	12	12	100.0%	Koror Waste Water Treatment Plant (Faecal Coliform (not >400 per 100ml Sample)			
Ngermetengel	12	1	8.3%	12	9	75.0%				
Imeong	12	0	0.0%	12	11	91.7%				
Ngchemiangel	12	0	0.0%	12	5	41.7%	A	9	9	100%
Mongami	12	0	0.0%	12	9	75.0%	B	9	9	100%
Peleliu (Ground)	10	10	100.0%	10	1	10.0%	C (Sewer Outfall)	9	7	78%
Angaur (Ground)	3	3	100.0%	3	2	66.7%	D	9	9	100%
Totals	**1192**	**891**	**74.7%**	**355**	**303**	**85.4%**		**276**	**260**	**94%**

• *Major tourism concerns related to watershed and wastewater management*
In 2006, a total of 82,397 tourists (Palau Visitors Authority Visitor Study 2006) visited Palau. This number of tourist is four times the population of Palau. This number averages out to an extra 6,000 people each month relying on the water resources that serves over 15,000.

Increasing numbers of tourist visit waterfalls, lakes and forests for bird watching. The main impacts directly from these activities are potential wastewater and solid waste issues.

Projects are in place to develop more hotels on the larger island to attract tourists. Most of these proposed developments are high-end boutique cottages that cater to a limited number of people per year. For the most part, the entrepreneur has a vested interest in protecting

the environments their customers come to enjoy. However, there is the potential for larger-scale hotels to develop within the watersheds, thus creating more wastewater.

• *Significant tourism impacts on watershed and wastewater management*
The increasing number of tourists to the islands is putting a strain on the existing wastewater treatment systems. Hotels are required to have their own wastewater treatment facilities, but most rely on the public system, thus pushing the system beyond its maximum capacity.

Tourists have an unintentional tendency to be environmentally destructive i.e. coral damage, congestion, increased use of personal watercrafts (Eledui and Olkeriil 2007). Because of this, the State of Koror passed legislation delineating tourist activity areas. A tour guide certification program for the Rock Islands tour companies was developed to certify tour guides to ensure an awareness of history and culture, environmental awareness, and safety and regulations.

3.4 Watershed and coastal management

• *Need to integrate watershed and coastal management in the context of IWRM*
There is a clear linkage between development within watershed and coastal areas. Sediment, nutrients and pollutants that end up in rivers and streams eventually find themselves in the marine environments. Previously in Palau, legislation focused on protecting coastal areas. Now, there is recognition that watershed management is necessary to ensure the health, not just of the watershed and river, but also for the near shore environment.

There are existing committees composed of government agencies and community members attempting to deal with integrating watershed and coastal issues. However, there are no defined tools used to smooth out the process. Many gaps exist in linking the terrestrial based studies to the marine studies.

Capacity building within government agencies is needed so that heads of agency are aware and attempt to look at the holistic approach to management rather than looking at their own roles and responsibilities.

With development expected to increase, there will be a higher demand for water, which current systems can not supply. There is still more work to be done to protect the watershed from overdevelopment and promote conservative water use.

Existing policies need to be reviewed in the context of the IWRM approach to ensure that every section of the Pacific RAP is integrated and that there are linkages to ecosystem protection and human health/hygiene issues with watershed and coastal management and landuse policies.

• *Existing sectoral linkages and the requirements for a more integrated/coordinated management approach.*

National Environmental Protection Council (NEPC)
Created by President Remengesau, the NEPC is composed of government and non-government agencies and organisations and is responsible for prioritising national environmental issues facing Palau. The strengths of the NEPC is that it has the Presidents support for most of their programmes. However, the focus of this group is mainly policy. It has very little community awareness and initiative.

Marine Resources Pacific Consortium Palau (MAREPAC Palau)
MAREPAC-Palau is a group of government and non-government organisations who hold interest in marine resources research. Members are interested organisations and persons

and generally conduct scientific and community research for the understanding and protection of the marine environment. MAREPAC has been very active at the community and agency level. However, most of its funding depends on the Regional MAREPAC group, which has been inactive recently in grant-seeking, and has limited interaction with the executive level of government.

Palau Natural Resources Council (PNRC)
PNRC is another group of government and non-government agencies who have a specific interest in the terrestrial resources of Palau. Its main focuses are forestry resources, invasive species, and watershed protection. PNRC horizontally links agencies and NGOs, and has several on-the-ground programmes with active participation from partners. However, community involvement can be increased and the Council is still seeking legal recognition from the Executive level.

Water Safety Plan National Steering Committee (WSP NSC)
The National Steering Committee for the Water Safety Plan includes government and non-government organisations. It was formed to oversee the development and implementation of the Water Safety Plan (with assistance from SOPAC), and has expanded its range to oversee implementation of the IWRM project in Palau. To clearly have linkage with all sectors, horizontally and vertically, the NSC needs to invite more members to successfully integrate the project.

These groups meet to discuss a number of issues relating specifically to the interest of the committees, and each have common issues and require more community involvement.

5. Stakeholder Engagement

Table 7: Stakeholders involved with IWRM

Institution	**Stakeholders/Interests and Responsibility**	**Relevance to IWRM and reason for inclusion**	**Role in the consultation Process**
Bureau of Public Works (BPW)	performance of the duties and functions of the public utilities for the health and wellbeing of the people and the community.	responsible for the identification and zoning of water resources, design and construction, maintenance, operation, of public utilities and related matters.	IWRM Committee member
Ministry of Health (DEH)	to protect the health of the people in the republic by ensuring clean, safe and healthy living environments.	Reportable Disease Surveillance System (RDSS) that includes gastroenteritis food-borne and waterborne diseases and investigate all food-borne and water-borne disease outbreaks	IWRM Committee member
EQPB	to ensure for all persons in Palau safe, healthful, productive, and aesthetically and culturally pleasing surroundings, and to attain the widest range of beneficial uses of the environment without degradation, risk of health and safety	Water quality monitoring; pesticide monitoring; pollution monitoring; issuance earthmoving, building and discharge permits	IWRM Focal point
Palau Conservation	To preserve the nation's unique natural environment and perpetuate	Most active conservation NGO in Palau. PCS's current	IWRM Committee

Society	its conservation ethic for the economic and social benefit of present and future generations of all Palauans and for the enjoyment and education of all.	programmes focus on working with local communities, states and other partners to designate and manage marine and terrestrial protected areas, to protect watersheds and to build local capacity for land and resource use planning.	member
PALARIS	responsible for the development of a centralised land and resource system to inventory and support the management of natural, economic, and human resources of Palau. The system will unify and integrate information in support of decision making and enhance the formulation of policies for the development of the NWSP.	National GIS office, database on water resources, watershed, utilities, etc.	IWRM Committee member
Bureau of Agriculture (BOA)	to promote, develop, protect, and conserve the Republic's land-based natural resources and to assist families to have the skills, resources and opportunity to ensure sustained food production, nutrition, food security, and wise stewardship of ecosystems.	Tree nursery and reforestation, revegetation of buffer zones	IWRM Committee member
Palau National Weather Service	The National Weather Service is the collection and storage site for national and regional weather data, which includes rainfall and weather patterns.	Climate logging and rainfall collection	IWRM Committee member
National Emergency Management Office (NEMO)	National focus during natural disasters. Such events include contamination with chemicals, bacteria, other waterborne pathogens, and incidents of drought.	Disaster management, water supply.	IWRM Committee member
Ministry of State (BFA & BITTA)	Responsible for regional/international relations and communications	National focal point and conduit for all communication between Palau and regional/international organisations.	IWRM Committee member
Natural Resources Conservation Services (NRCS)	Very active with natural resource inventory and most recently, watershed inventory which included updating the soil inventory for the Ngerikiil Watershed.	Research assistance	IWRM Committee member
Palau International Coral Reef Center (PICRC)	Conducting research and education activities which will contribute to the management, use and conservation of Palau's marine environment.	Coral reef research, including sedimentation rates on coral reef patches	Possible member

Governor's Association	Water resources are owned by the State and care for these resources falls under the charge of these leaders.	State level involvement	IWRM Committee member
Belau National Museum	BNM's objective is to identify and record Palau's past and present thru collections, identification, documentation, preservation, research and exhibition of cultural and natural property for the people of Palau.	Active research in watersheds	Possible member
The Nature Conservancy	Preserve the natural communities that represent the biodiversity on earth by protecting the lands and waters they need to survive.	Research and development of conservation programmes to protect both marine and terrestrial environments	Technical assistance offered
Office of Environmental Response and Coordination (OERC)	National environmental planning and secretariat to NEPC	GEF Operational Focal Point	GEF Operational Focal Point
Ministry of Finance – Water Utilities Branch	Water fee collectors, WET project office	Check water meters and issues out water bills. Water conservation campaign	Possible member
Rural Water Operators Association	Rural water suppliers	Water suppliers for rural areas	Possible Member
Private stakeholders	interest in water resources	Local community involvement	Consultations

Consultation process and institution involved

The IWRM project was introduced to the National Steering Committee for the Drinking Water Safety Plan, which is composed of government agencies that deal with water and water-related issues, such as watershed management and human hygiene and health. The WSP NSC is a multi-faceted stakeholders group that have a vested interested in water resources. The WSP NSC agreed to extend its responsibilities to encompass the IWRM program.

The following persons were contacted for this project.

- Minister of Resources and Development
- Director of Bureau of Public Works
- Director of Bureau of Foreign Affairs
- Director of Bureau of Agriculture
- Chief, Division of Environmental Health
- Epidemiologist, DEH
- Executive Officer, Environmental Quality Protection Board
- Airai State Governor and Legislators
- Assistant EO, EQPB
- Compliance Specialist, EQPB
- Palau National Weather Service
- NEMO
- PALARIS
- Rural Water Operators Coordinator

- PNRC
- The Environment, Inc.
- PCC
- Koror/Airai Drinking Water Treatment Plant Operators
- PCS
- TNC
- OERC
- Community members

6. Other programmes, projects and activities related to IWRM

Table 8: Project/activity that provides a contribution to the implementation of IWRM in the country

Donor	Implementing Agency	Project name	IWRM sector	Objective	Duration
AusAID/ NZAID	SOPAC	Water safety Plan	Water resources/Water Use	Ensuring safe drinking water	2006-ongoing
GEF	MRD - BLS	Capacity Building for Sustainable Land Management	Water resources Land degradation	Capacity building for sustainable land use	2007-2012
JICA	MRD – BPW	Solid Waste Management	Water resources	Decreasing/limiting leachate from landfill	2006-2011
Packard Foundation	PCS	Eco-system based management	Watershed protection	Science to the community	2006-2009
SPREP	SPREP	Database Management	Institutional linkage	Resource database management and linkage	2005-ongoing
EU	SOPAC	HYCOS	Watershed and water Resource management	Hydrological cycling observation system	2006-2009
GEF/TNC/Conservation International	For Palau-OERC	Micronesian Challenge	Watershed and water resources protection	Protecting land and water	2005-ongoing
State Govt.s	State Govt.s	Watershed Alliance	Watershed Protection	Protecting watershed and water resources	2004-ongoing
Palau National government	MRD	Protected Areas Network	Watershed/water resource protection	Assist local states with setting aside and find funding for protected areas	2002-ongoing
Airai State Government	Airai State	Watershed Protection Act	Watershed Protection	Ngerikiil watershed from over-development, sedimentation	2004-ongoing
USDA	USDA-NRCS	Ngerikiil Assessment	Watershed planning	Assessment of Ngerikiil watershed	2007-2009
USDA	US Forestry Service	Mangrove nutrient assessment	Water resources	Study impact of nutrient loading in mangrove forests	2007 - 2008
USDA	US Forestry Service	Mangrove forest study	Climate change, ecosystem assessment	Study impact of sea level rise in mangrove forests	2007-2008
USEPA	EQPB	Capacity Building	Capacity Building	To improve understanding of various environmental impacts and enforcement of EQPB regulations	Ongoing
TNC	TNC	Ngerdorch Watershed	Watershed	Assessment of Ngerdorch	2006-

		Assessment	planning	watershed in Ngchesar	2009
Asia Pacific Science Congress	PNRC	Pacific Biodiversity Transect	Watershed assessment	Integrated watershed assessment of flora, fauna, and water quality	2006-ongoing
USDA	PCC-CRE	Water Quality study	Water resources	Water quality	2006-ongoing
FAO	EQPB	Land-use awareness	Land degradation water resources	Impact of improper land use/planning on water resources	2007-2008
FAO	TEI				2007-2008
FAO	BOA	Invasive Weeds Eradication	Biodiversity, watershed protection	Program to control invasive weeds in Palau	2007-2008
NFWF	PCS	Watershed	Watershed protection		2006-ongoing
PACKARD	PCS	Modelling Tools	Water resources watershed protection	Using modelling tools to identify and control impacts	2008-2010
Rotary International	Water For People	Solar Water Pasteurisation	Water Resources	Safe drinking water for schools	2006-ongoing
GEF – Small Grants Fund	Ngara-Telok	Ngechsar State Invasive Species Removal	Biodiversity	Invasive species removal	2007 – 2008
GEF – Small Grants Fund	Ngarailulk	Restoration of traditional assets and removal of invasive plants and trash to protect wetlands and water sources in Ngchesar Village	Water quality, water resources, biodiversity		2007 – 2008
GEF – Small Grants Fund	Belau Cares Inc.	Tree Planting Program - Designation of Arbor Day	Land Degradation	Tree Planting	2007-2008
GEF – Small Grants Fund	Belau Modekngei School	Development of Landscaping: Land Degradation and Erosion Prevention	Land Degradation	Erosion control	2007 – 2008
GEF – Small Grants Fund	Dini Faruya (Women's Group)	Community mobilisation to address resource management, conservation and promotion of biodiversity	Watershed protection; Capacity building	Resource management and promotion of biodiversity	2007 – ongoing
GEF – Small Grants Fund	PCS	Empowering local communities to catalyse partnerships for achieving community sustainable development goals	Capacity building	Community participation and empowerment	2007 – ongoing

Existing or planned water and wastewater management plans or strategies
Ngeremlengui-Melekeok Watershed Alliance

Airai Watershed Protection Act – looking to designate the upper part of the Ngerikiil watershed as a protected area to safeguard it against unsustainable development.

Water Safety Plan – provide safe water to public

UNDP administered**:** Capacity Building for Sustainable Land Management for Mitigation of Land Degradation

7. Capacity Development Needs for Removing the Barriers

Training is needed in a variety of disciplines, hydrology, hydrogeology, civil engineering, etc. Capacity needs to improve in various sectors of the government and the community to remove barriers to the IWRM process.

Water Resource Management

- Capacity building is needed for hydrological assessments of water resources. Capacity building for hydrology, hydrogeology and water resource planning and management is required.
- A National Hydrological Network needs to be developed.
- Technical capacity is needed to implement existing regulations and regulate development specifically near intake.
- Existing monitoring programmes need to be strengthened.
- Laboratory capacity needs to be expanded to support policies standards and guidelines and enforcement of regulations.
- Over the past few years, funding for PALARIS has decreased, and along with it the support for Palau's information analysis.

Island Vulnerability

- The level of disaster preparedness is low. There is complacency because of Palau's location outside of the cyclone track. Awareness raising for disaster preparedness is necessary. There should be capacity building to develop a drought management plan and for proactive disaster management.
- Man-made disasters are an issue where ever there is a human presence.
- Saltwater intrusion becomes an issue when there is over-extraction of the freshwater lens

Awareness

- There are too many awareness programmes from too many agencies, sometimes overwhelming local communities and leading to confusion of roles and messages.
- Previous regional and international funded projects have left some negative impressions on communities (i.e. lack of funding after or even during project period, false promises, etc.)
- More community involvement is needed.
- Increased support at the decision-making level is needed.

Technology

- Sanitation technology needs to be increased in rural areas
- Capacity building is needed to address:
    - effective use of available resources
    - ineffective leakage detection
    - infrastructure and capacity development to deal with increasing demands
- Sometimes inappropriate technologies utilised because of limited input from all stakeholders. This does not require much capacity building, just a more integrated approach to identifying proper technology.

- An asset management system for the public water supply and wastewater treatment plants needs to be developed.

Institutional framework

- There is no national water committee
- There is limited coordination between agencies and organised committees
- There is a lack of resources and resolve to conduct enforcement. Generally enforcement of policies are lacklustre, or limited by resources.
- Regulations need to be updated to reflect changes in lifestyle, research, and climate.
- Capacity building for regulatory enforcement should be increased so that staff and enforcement agents see legitimacy of their responsibilities in order for regulatory agencies to maintain accountability and acceptability to the public.

Financing

- There is high dependency on outside donors (Japan, Taiwan, United States)
- Water tariffs not enough to cover costs of water treatment and there are no tariffs for sewer treatment plant use. Capacity building will be required to improve operations and management of systems and billing structures before fees can be increased with public support.
- There are no tariffs for water extractions or discharge. Studies must be done to assess impacts of extractions or discharges and to impose proper fees.

Land use and agriculture

- Capacity building is needed for proper landuse to reduce impacts to watersheds, water sources and coastal environments.
- Capacity building is also needed for sectoral integration of data and information.
- Increased enforcement of existing regulations is needed.

Habitat and ecosystem

- Increase capacity for monitoring of ecosystem health by physical indicators as well as indicator species.
- Community capacity building on importance of ecosystems and habitats to continued human health.

Human health and hygiene

- Capacity building for integrating health and hygiene issues with development projects is necessary. The current way this issue is address is by having input during EQPB permitting processes from the health sector. There needs to be a way to increase the health sector involvement.
- Capacity building to prevent water related illnesses is needed, as well as laboratory capability to identify if cases are food-borne or water-borne.
- Impacts of high numbers of tourists on water supplies and habitats must be studied.

Watershed and coastal management

- Capacity to review existing policy is needed in order for appropriate measures to be taken to strengthen and expand policy to reflect changes since policies were enacted and incorporate current needs/issues.
- Capacity building for sustainable development of the civil and government sector.
- Increased involvement from the civil sector with protection and management of watersheds and coastal areas needs to be addressed.

And finally to include some lessons learned from the IWP project, “to fully understand the root causes of environmental degradation requires a much more detailed understanding of the social and economic factors: income, population density, unemployment, education levels, legal and economic structures, etc., through which the environmental problems arise”

(IWP Terminal Report 2007). If such is the case, then capacity building for socio-economic analysis tools is a definite must for successful implementation of the IWRM project in Palau.

8. Introducing an Integrated Approach towards Barrier Removal

The impacts and concerns are stated throughout this document along with the capacity building areas needed for removal of barriers for IWRM. IWRM tools are applied in Palau, through different sectors of the government and civil society. The need now is to incorporate all the tools together and work towards a coordinated management strategy to ensure the success of a sustainable management approach.

National Water Resources Committee
Though a committee does exist to deal with water safety issues, a larger committee is needed to address deficiencies in water resource management, water quality and quantity monitoring, health and environmental impacts, socio-economic impacts of developments, and effectiveness of policy and regulations. The current committee has worked well together, and through meetings and informal networking can effectively implement the integrated water resource management of Palau.

Through this national committee, reviews of existing policies, technical limitations, identification of appropriate technologies, information-sharing, and other agendas related to water resource and wastewater management can be accomplished.

Awareness Raising and Community Advocacy groups
The government has in the past been successful at introducing projects to the communities but needs to incorporate dissemination of project statuses and results to the public. Involvement of more local community groups is essential, maybe more so than some government agencies, to ensure sustainable management of water resources. These communities deal directly with the issues that policy makers debate on. The increased networking with policy makers and community advocacy groups with assistance from the National Water Committee will ensure political sustainability of water resource projects.

There is a need to continually promote decreased water consumption levels as this will alleviate the demands on public water supply systems and decrease burdens on wastewater treatment plants.

Integrated Land use planning/water resource information
Palau is currently implementing a project for capacity building for sustainable landuse planning. This can be integrated into the IWRM approach for improved effectiveness. In order for IWRM to be effective, landuse planning must be entertained with water flow, quality and quantity, use and discharge. PALARIS was set up to deal with such issues. However, with decreased funding, this office has had limited capability to carry-out their functions. Increased support is needed to ensure effective information management for the IWRM.

Research
Research is needed to further understand capacity to regulate service providers', and the private sector option for water supply and sanitation services.

Ecological research is necessary, especially in the fields of hydrology, hydrogeology, water resource management, ecosystem values and sanitation issues. Existing water quality and quantity programmes can be used to promote the IWRM tools, however they do need strengthening and improved technical capacity.

Capacity building
Strategic thinking is needed (especially for policy makers). There is a need for translation of research and monitoring information to meaningful format.

Increased capacity building on understanding linkages is necessary.

- Physical linkage between landuse and surface/groundwater quality and coastal ecosystem health.
- Economic links between various agencies (decrease cost of water treatment, decrease cases of water borne illnesses, decrease in water usage)
- Social linkages – people, culture, urbanisation vs. traditional lifestyle
- Institutional linkages – horizontal and vertical, among various stake-holders (government, NGOs, community)

Inter-linking these various sectors to each other is in a sense the main approach that the IWRM is hoping to achieve. There are several IWRM tools utilised in these various areas and now needs strengthening and connections to properly approach integrated management.

With everything mentioned above, an ecosystem valuation is necessary for local communities and government officials alike to fully understand and appreciate the importance of proper watershed management. The value of a hotel or a golf course is easily seen, but it takes a little more to understand and appreciate the priceless value of having a protected and well-managed environment that ensures a continued high quality of life to be enjoyed for years to come.

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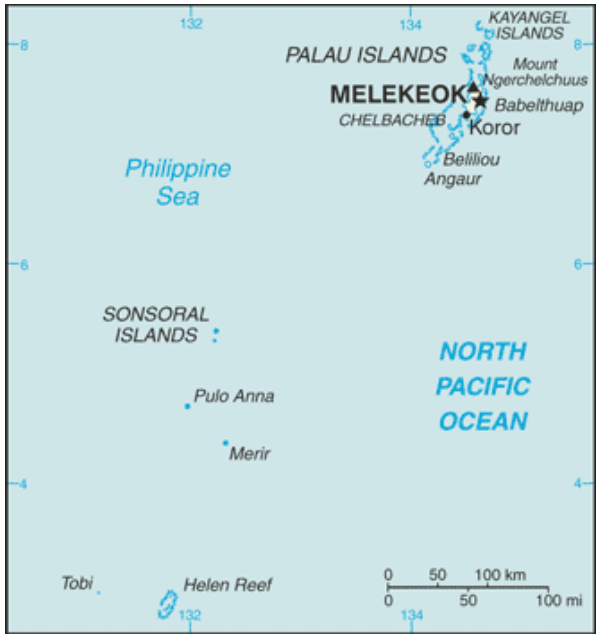
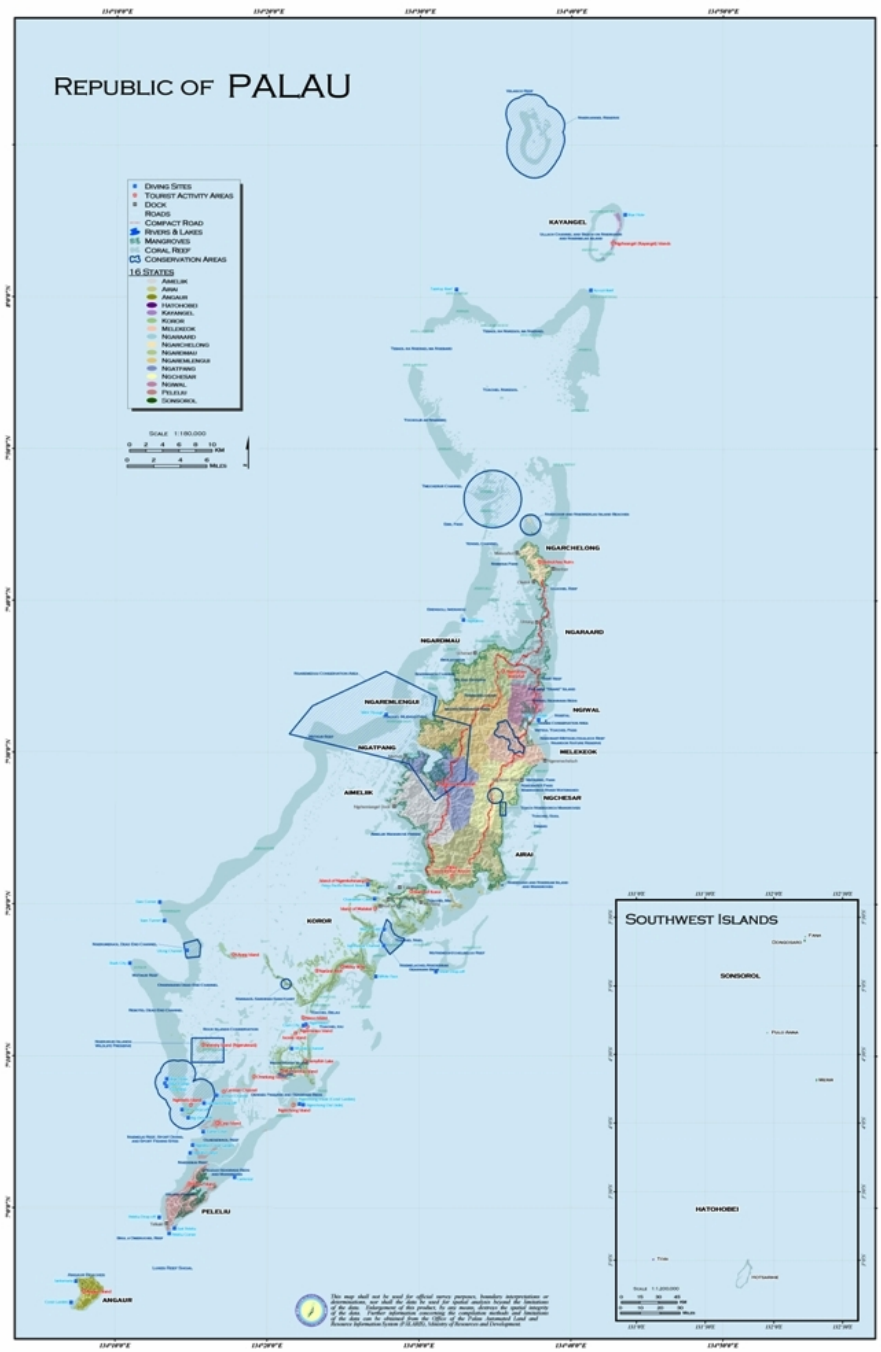
Reference is missing for Gonzales et al. (2001): I'll have to get the Gonzales reference from the person that assisted us with the DR.

Appendix 1: Map of Palau Islands with State boundaries indicated



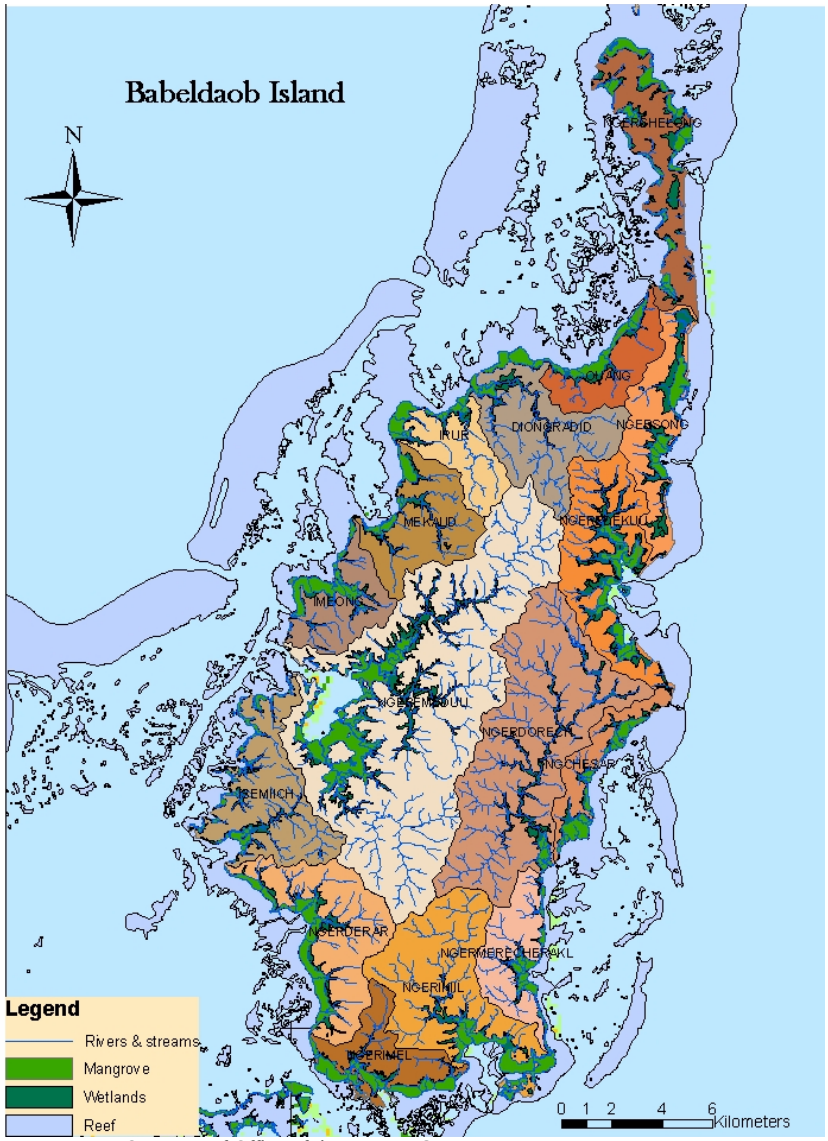
Source: CIA World Fact Book 2006

Appendix 2: Conservation and Protected Areas in Palau



Map Courtesy of Office of the PALARIS

Appendix 3: Babeldaob watersheds and wetlands with river contours



Map Courtesy of Office of the PALARIS

Appendix 4: Annual Rainfall 1977 to 2006

PRECIPITATION (in inches) 1977-2006

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1977	5.18	5.30	3.60	4.48	11.36	11.15	20.72	19.20	12.65	10.63	7.38	7.79	119.44
1978	10.34	22.46	6.02	8.98	12.52	16.04	9.13	20.36	10.85	20.06	17.66	10.33	164.75
1979	6.98	6.47	7.96	27.69	11.26	22.84	17.79	11.69	12.29	11.97	11.57	11.57	160.08
1980	8.72	16.01	5.53	18.80	10.02	19.50	12.40	15.26	13.60	17.11	12.17	19.95	169.07
1981	11.32	15.00	4.49	3.00	9.66	29.17	21.14	6.89	16.70	14.30	11.37	9.81	152.85
1982	5.79	6.81	9.90	9.45	19.12	22.41	19.40	10.94	1.04	8.82	9.92	13.71	137.31
1983	3.44	0.64	1.71	3.12	5.73	18.48	21.20	17.96	11.73	14.23	11.40	10.48	120.12
1984	18.57	10.81	13.58	7.23	10.85	16.49	12.82	17.47	10.39	15.94	9.19	9.42	152.76
1985	13.22	13.88	5.38	11.82	10.41	25.25	17.55	14.32	23.16	8.64	13.61	6.28	163.52
1986	11.10	16.60	8.33	3.49	12.24	17.16	26.15	13.09	10.21	15.92	17.97	9.06	161.32
1987	9.12	5.94	6.10	4.74	15.32	19.60	28.23	33.11	4.21	12.75	10.88	8.72	158.72
1988	7.14	7.83	6.22	6.18	14.30	21.88	14.90	14.39	12.34	20.05	15.05	21.04	161.32
1989	12.99	12.66	11.31	7.41	16.39	17.33	21.97	17.81	5.54	13.07	9.54	5.96	151.98
1990	5.09	3.83	11.74	7.00	11.72	33.83	19.84	10.34	15.18	11.96	20.71	1.49	152.73
1991	24.16	5.46	17.72	10.34	9.37	12.79	31.58	13.73	21.16	7.81	7.79	12.25	174.16
1992	8.28	2.74	4.88	2.46	9.76	15.73	14.94	17.46	8.15	15.48	5.34	17.25	122.47
1993	9.25	10.49	9.46	14.67	6.72	18.47	11.85	8.61	11.81	8.68	9.24	9.63	128.88
1994	7.29	5.08	13.41	7.83	12.34	19.94	16.98	16.48	4.75	3.72	7.22	7.08	122.12
1995	15.10	15.22	10.75	2.59	16.71	11.39	10.13	13.43	15.57	15.16	15.87	18.32	160.24
1996	12.06	9.20	5.57	18.49	16.85	11.05	15.10	7.33	15.85	10.91	9.32	14.99	146.72
1997	8.34	27.13	9.10	6.44	4.61	18.14	9.18	4.59	10.33	11.56	4.17	11.35	124.94
1998	4.72	2.40	0.50	2.17	9.16	17.62	7.52	10.16	10.09	19.05	17.43	13.57	114.39
1999	24.83	6.44	19.24	14.70	10.66	11.93	18.33	26.00	8.00	5.88	9.51	16.37	171.89
2000	13.16	20.17	6.63	12.71	9.32	11.95	20.38	17.16	3.10	13.49	14.27	18.87	161.21
2001	6.21	11.93	7.15	13.27	13.86	22.53	21.77	20.38	9.30	14.48	11.69	15.76	168.33
2002	12.57	4.50	9.60	6.04	14.13	27.39	8.09	11.97	8.73	8.70	13.01	6.07	130.80
2003	8.88	13.48	7.65	8.82	17.52	13.90	25.03	13.57	23.67	11.82	13.38	19.53	177.25
2004	7.02	16.94	6.49	3.33	17.21	20.73	18.73	3.94	7.68	7.92	8.59	6.47	125.05
2005	11.39	1.03	7.23	8.56	19.51	15.02	25.70	13.16	18.16	11.87	17.58	17.54	166.75
2006	21.44	7.93	10.73	8.85	10.27	16.49	19.62	17.14	17.46	10.73	5.41	10.97	157.04
30 YRS ave inches	11.20	8.85	8.41	9.10	12.79	16.59	17.28	14.92	12.43	12.92	11.20	12.51	148.20
(mm)	**284.5**	**224.8**	**213.6**	**231.1**	**324.9**	**421.4**	**438.9**	**379.0**	**315.7**	**328.2**	**284.5**	**317.8**	**3764.3**

Data Courtesy: Palau National Weather Service

Appendix 5: Monthly water usage by area

Monthly water usage by area (estimated)

Area	Population (local population + tourists)	Gallons per month (estimates)
Koror/Airai	20,000+	130 million
Southwest islands	30	50,000
Kayangel	188	800,000
Ngarchelong	488	2.2 million
Ngaraard	581	2.6 million
Ngiwal	223	1.0 million
Melekeok	391	1.8 million
Ngchesar	254	1.1million
Aimeliik	270	1.2 million
Ngatpang	464	2.1 million
Ngardmau	166	750,000
Ngaremlengui	317	1.4 million
Angaur	320	1.4 million
Peleliu	702	3.6 million
Total	**24,500 people**	**150 million gallons per month**

These estimates are given based on the average water consumption per person calculated for Koror/Airai (150gpd), except for the Southwest islands, which is estimated at 50 gallons per person per day.