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# DRINKING WATER SAFETY PLAN KOROR-AIRAI WATER SUPPLY

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This document was compiled by the Palau Water Safety Plan National Steering Committee on behalf of the Ministry of Resources and Development. The Ministry of Resources and Development is responsible for the implementation and oversight of this plan.

This plan is due for revision May 2010.

## Step 1: Flow Chart

### Catchment & Intake

Source: 1. Freshwater stream – Ngerikiil River  
2. Freshwater Dam – Ngerimel Dam

Production (Max): Total of 4 million gallons per day (Ngerikiil River – 3m gallon; Ngerimel Dam – 1m gallons)

### Ngerimel Dam

- The Ngerimel Dam has an estimated storage capacity of 20 m gallons of water, which is estimated based on pump flow rates.
- The catchment consists of forest vegetation dominated by trees, shrubs and grass.
- The intake is located at a dam situated in a valley surrounded by low mountains.
- The catchment is fairly well protected and there is minimal human activity within the catchment area.
- Since the catchment is not fenced off, animals such as chickens, , pigs, and/or humans could access the catchment and/or the intake.

This could have a potential effect on the water quality.



*Ngerimel Dam*



*Ngerikiil River*

Figure 1. Ngerimel Reservoir (left) and Ngerikiil River intake (right)

### Ngerikiil River

- The Ngerikiil River is a freshwater stream running through a catchment that is widely used for residential and/or agricultural purposes.
- The catchment consists mostly of forest vegetation dominated by trees, shrubs and grass. The natural vegetation is disturbed in parts by extensive clearing for cultivation of crops.
- The catchment is not well protected and there is considerable human activity within the catchment area.
- Since the catchment is not fenced off, animals such as pigs and chicken could access the catchment and/or the intake. This could have a potential effect on the water quality.
- Although water levels tend to drop during drought, the Ngerikiil River is known to supply water even during such periods.



*Water from the two sources is collected at the Wet Well.*



*Automatic Gravity Valve-less filters*

Figure 2. Treatment Plant Images

### Treatment

- A total of 4m gallons of water per day are fed into the Koror-Airai water treatment plant located in Airai State. 3 million gallon of water is pumped to the treatment plant from the Ngerikiil River while the remaining 1m gallons is gravity fed into the treatment plant from the Ngerimel Dam.
- Water from both intakes is collected in chamber called the wet well.
- Alum, soda ash and activated Carbon are added at the wet well.
- From the wet well, water is pumped into a series of clarifiers for removal of suspended solids. The sludge from the clarifiers is diverted to a series of drying beds.
- From the clarifiers, water is then diverted into a series of five (5) Automatic Gravity Valve-less (AVG) filters. Filtered water is collected in a separate chamber called the clear well. At the clear well, water is chlorinated before distribution.



*Clarifiers*



*Sludge drying bed*

Figure 3. Water Treatment plant barriers

# Multiple Barrier Concept

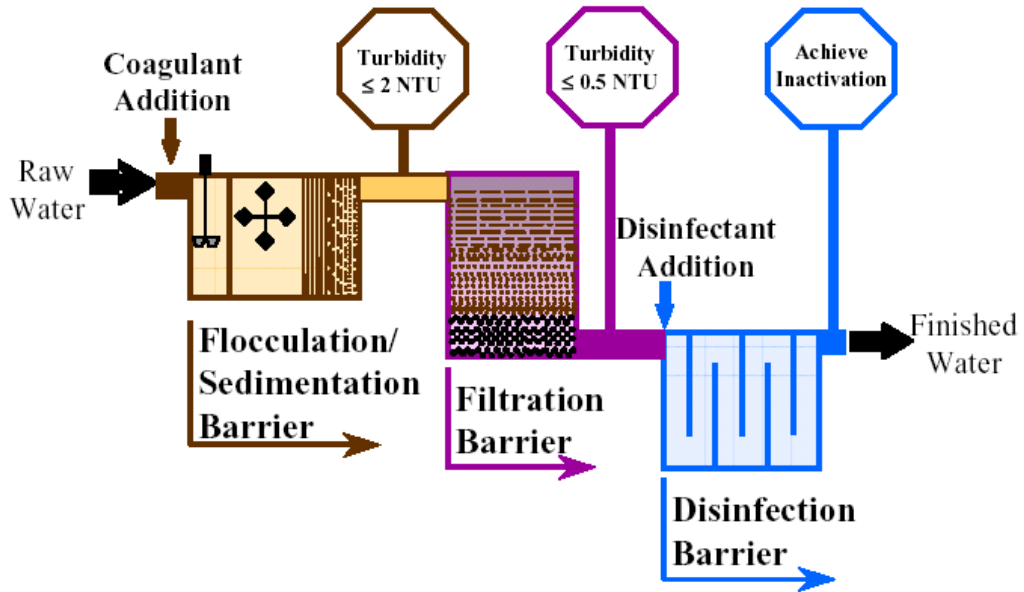


Figure 4. Multiple Barrier Concepts for Koror/Airai Water Treatment Plant

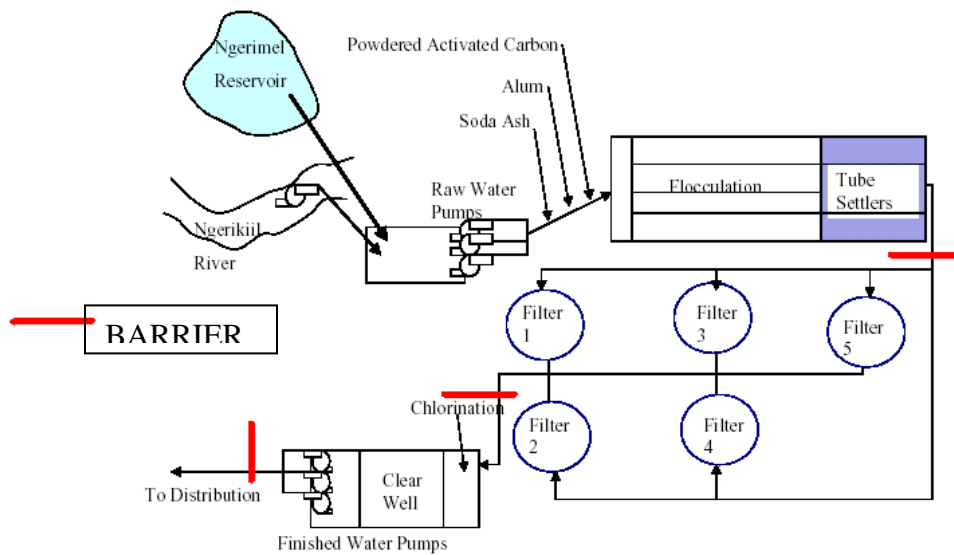
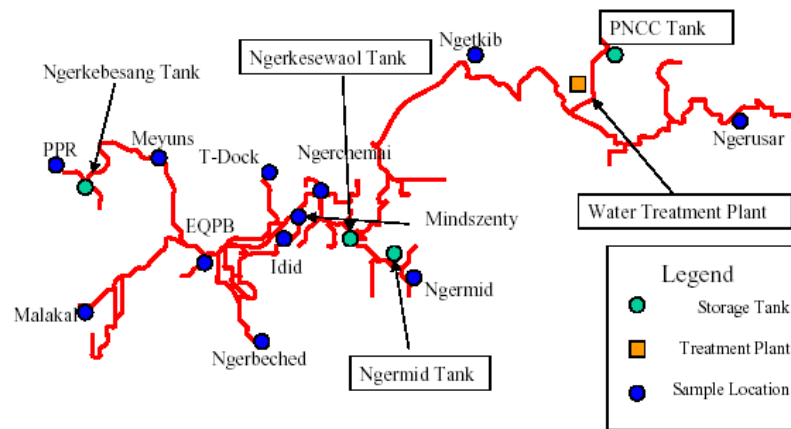


Figure 5. Koror/Airai Water Treatment Plant Barrier Schematic

## Distribution

- The Koror-Airai system supplies water to Koror and Airai states.
- Water is pumped to storage tanks and gravity fed into the distribution network.
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated (treated) water and maintain open/cross-connection sometimes leading to backflow  
Some households have illegal connections



Koror/Airai Distribution System Schematic

## Source of Drinking Water aside from the K/A WTP

- rainwater catchment tanks
- Dispensed water
- Bottled water

## Population Served

- The Koror-Airai water supply serves:
  - a population of 12,676 (2005 census)
  - 7 x pre-school facilities
  - 9 x schools
  - 1 x Hospital

## Catchment & Intake

### Risk Assessment Worksheets

	Risks to Water Quality	Control Measures	Risk Priority
c1	Drying up of the Ngerimel Dam due to drought events	None	<i>High-</i> Although not frequent the loss of water has a high impact on the system and population.
c2	Contamination from Agricultural Chemicals	None (Ngerikiil River Intake)	<i>Medium-</i> Risk has potential but currently not quantified.
c3	Increased turbidity due to deforestation e.g. for agriculture or wild fires or clearing for development	None	<i>High-</i> Not likely to occur on a regular basis. However, the impact of such an event would have a devastating affect on the water supply and population.
c4	Contamination from road runoff e.g. from oil and petrol leaks/spills	None	<i>Medium-</i> Not likely to occur on a regular basis. Therefore urgent action is probably not warranted, however, a emergency/contingency plan should be prepared to deal with this risk in the long-term especially with the new Compact Road opening soon
c5	High Sediment load from flooding during periods of heavy rainfall	None	<i>Medium-</i> Occurs over a great period of time.
c6	Contamination from human and animal feces due to open access to Intake for people and animals especially at Ngerikiil River	None	<i>Medium-</i> it is a risk but one that is not so significant, therefore urgent action is probably not warranted, however, an emergency/contingency plan should be established to deal with the risk in the long-term.
c7	Damage to dam infrastructure	None	<i>High-</i> Structural integrity of the dam is a cause of concern and related pipework age.
c8	Fecal Coliform contamination from residential / recreational activities within the catchment and intake areas	None	<i>Low-</i> Restricted access to catchment areas.
c9	Power Outage	Yes back-up generator on-site to continue operations during power outage.	<i>Low</i>

## Treatment & Storage

### Risk Assessment Worksheets

Risks to Water Quality		Control Measures	Risk Priority
T1	Monitoring equipment	None	<i>High</i> - monitoring equipment is old and not calibrated.
T2	Increased turbidity loading from source	Partially Routine tests to ensure correct dosing.	<i>High</i> - plant unable to perform with high turbidity levels
T3	Increased Coli-forms levels due to inadequate dosing and monitoring of chemicals such as Chlorine	Partially Chlorine is dosed and FAC tested- accuracy variable	<i>Medium</i> - Procedures in place, but monitoring equipment upgrade required
T4	Insufficient funds to buy relevant equipment, carry out repairs and maintenance etc	None	<i>High</i> - ineffective preventative maintenance programme.
T5	Not enough chemicals in stock (running out of chemicals such as Chlorine etc)	Yes. Proper stock control procedures in place to avoid the problem of running out of chemicals	<i>Low</i>
T6	Contamination or damage to infrastructure due to Sabotage and/or vandalism	Yes. The treatment area is well fenced and there are water operators onsite at all times.	<i>Low</i>
T7	Damage to storage tanks due to aging Infrastructure	Yes. Regular monitoring of infrastructure conditions and maintenance when needed	<i>Low</i>
T8	Damage to Storage tanks due to vandalism	None	<i>High</i> - Access to needs to be restricted
T9	Power Outage	Yes. A back-up generator on-site to continue operations during power outage.	<i>Low</i>

## Distribution

### Risk Assessment Worksheets

Risks to Water Quality		Control Measures	Risk Priority
D1	Loss of water due to water wastage	None	<i>High</i>
D2	Increase in water loss from pipe breakages due to aging pipes	None, lack of equipment	<i>High</i>
D3	High water loss due to unattended and/or unreported leakages in the distribution lines	None	<i>Medium</i>
D4	Backflow contamination and/or cross contamination from household/rainwater storage tanks connected to water mains	Partially- regulations exist but not enforced.	<i>High</i>
D5	Incorrect analysis data due to un-calibrated laboratory equipment	Regular calibration of analytical equipment; cross-check /validation of data by EQPB	<i>High</i>
D6	Point of use contamination due to improper hygiene practices	None	<i>High</i> - Mitigation of some of this risk can be achieve through actions of D4



## General

### Risk Assessment Worksheets

Risks to Water Quality		Control Measures	Risk Priority
G1	Unforeseen or out of the ordinary events	No	High

### Catchment Risk Management Plan- High Risks

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
c1	Drying up of the Ngerimel Dam due to drought events	Establish / identify a back-up Intake and/or storage system for drought events	IS1	<ul style="list-style-type: none"> <li>- Visuals Inspections</li> <li>- Monitoring of dam Levels</li> </ul>		Water restrictions	
c3	Increased turbidity due to deforestation e.g. for agriculture or wild fires or clearing for development	Improved land use management/ planning within the catchment Sanitary survey BMP Agricultural practices around watersheds	IS8	<ul style="list-style-type: none"> <li>- Visual Inspections</li> <li>- Sanitary Inspections</li> </ul>		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	
c7	Damage to dam infrastructure	Investigation and survey of dam assets	IS3	<ul style="list-style-type: none"> <li>- Visual Inspections</li> </ul>		<ul style="list-style-type: none"> <li>- Water restrictions</li> <li>- Implantation of emergency plan</li> </ul>	

### Catchment Risk Management Plan- Medium Risks

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
C2	Contamination from Agricultural Chemicals	Establish buffers (vegetation) between agricultural land and intake areas (river/stream) Create legislation	IS2	<ul style="list-style-type: none"> <li>- Water chemistry monitoring programme</li> <li>- Sanitary Survey</li> </ul>		Shut off the system, flush the system out; place public messages over local media advising consumers to take precautionary measures	
C4	Contamination from road runoff e.g. from oil and petrol leaks/spills	Improve drainage around roads to divert runoff away from the intake areas	IS2	<ul style="list-style-type: none"> <li>- Water chemistry monitoring programme</li> <li>- Sanitary Survey</li> </ul>		Shut off the system, flush the system out; place public messages over local media advising consumers to take precautionary measures	
C5	High Sediment load from flooding during periods of heavy rainfall	Increase reservoir capacity Better filtration system in place to remove suspended solids	IS3	<ul style="list-style-type: none"> <li>- Monitoring programme</li> <li>- Sanitary Survey</li> </ul>		Public Notices to collect water will be broadcasted over the media during heavy rainfall;	

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
C6	Contamination from human and animal feces due to open access to Intake for people and animals especially at Ngerikiil River	Fencing off the intake area; place warning signs for the public Assess alternative locations and existing intakes	IS2	<ul style="list-style-type: none"> <li>- Water chemistry monitoring programme</li> <li>- Maintenance and monitoring of Cl levels in distribution system</li> <li>- Sanitary Survey</li> </ul>		Place public messages over local media advising consumers to take precautionary measure.	

### Treatment & Storage Risk Management Plan- High Risks

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
T1	Monitoring equipment	Purchase and training of reliable monitoring equipment for operators	IS4	- EQPB Monitoring for verification			
T2	Increased turbidity loading from source	Create Contingency Plan for an event. Auditing process for WTP SOPs Investigate alternate source water Investigate extra finished water storage	IS1 IS5 IS6 IS8	- Water chemistry monitoring - Sanitary Survey		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	
T4	Insufficient funds to buy relevant equipment, carry out repairs and maintenance etc	Provide justification through design of asset management/sustainability plan for funding	IS9	- Monitoring Programme - Verification EQPB		If an event occurs- Place public messages over local media advising consumers to take precautionary measure e.g. boiling	
T8	Damage to Storage tanks due to vandalism	Construction of fences around the storage tanks	IS10	- Visual Inspections		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	

**Treatment & Storage Risk Management Plan- Medium Risks**

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
T3	Increased Coli-forms levels due to inadequate dosing and monitoring of chemicals such as Chlorine	Create Standard Operating Procedures (SPO) Auditing process for WTP SOPs	IS6	<ul style="list-style-type: none"> <li>- Monitoring Programme</li> <li>- Verification EQPB</li> </ul>		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	

**Distribution Risk Management Plan- High Risks**

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
D1	Loss of water due to water wastage	Increase public awareness of water conservation, water shed protection Proposed legislation on water saving plumbing fixtures	IS11	- Flow monitoring		Decrease water pressure	
D2	Increase in water loss from pipe breakages due to aging pipes	Regular checks and maintenance/ replacement of pipes and/or fittings. Asset Management Plan development. SOP for Mains disinfection	IS9	- Demand and Pressure Surveys		Decrease water pressure	
D4	Backflow contamination and/or cross contamination from household/rainwater storage tanks connected to water mains	Strengthen existing regulations and enforce. Disconnect illegal and unpermitted connections; discourage connection of private tanks to water mains.	IS12	- Inspection Programme		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	
D5	Incorrect analysis data due to un-calibrated laboratory equipment	Purchase and training of reliable monitoring equipment for operators	IS4	Regular calibration of analytical equipment; cross-check /validation of data by EQPB		Public Messages	

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
D6	Point of use contamination due to improper hygiene practices	Public education/awareness about proper hygiene practices programme	IS11	- Property Surveys		Place public messages over local media advising consumers to take precautionary measure e.g. boiling	



**Distribution Risk Management Plan- Medium Risks**

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
D3	High water loss due to unattended and/or un-reported leakages in the distribution lines	Leak detection programme Investigation and design of asset replacement/renewal programme	IS11	<ul style="list-style-type: none"> <li>- Repairs sheets</li> <li>- Distribution procedures</li> <li>- Pressure testing programme</li> </ul>		Place public messages over local media advising consumers to take precautionary measure and conserve water.	

**General Risk Management Plan- High Risks**

Worksheet N°	Identified Risk	Improvement Identified	I/Schedule N°	Monitoring and Management Activity	Procedure N°	Contingency/ Emergency Plan	Plan N°
G1	Unforeseen or out of the ordinary events	Design of Disaster Management Plan with NEMO	IS13	- Monitoring and Management by NEMO/EQPB/PW		Assistance from outside Palau	