WATER RESOURCES MANAGEMENT IN KIRIBATI WITH SPECIAL EMPHASIS ON GROUNDWATER DEVELOPMENT USING INFILTRATION GALLERIES

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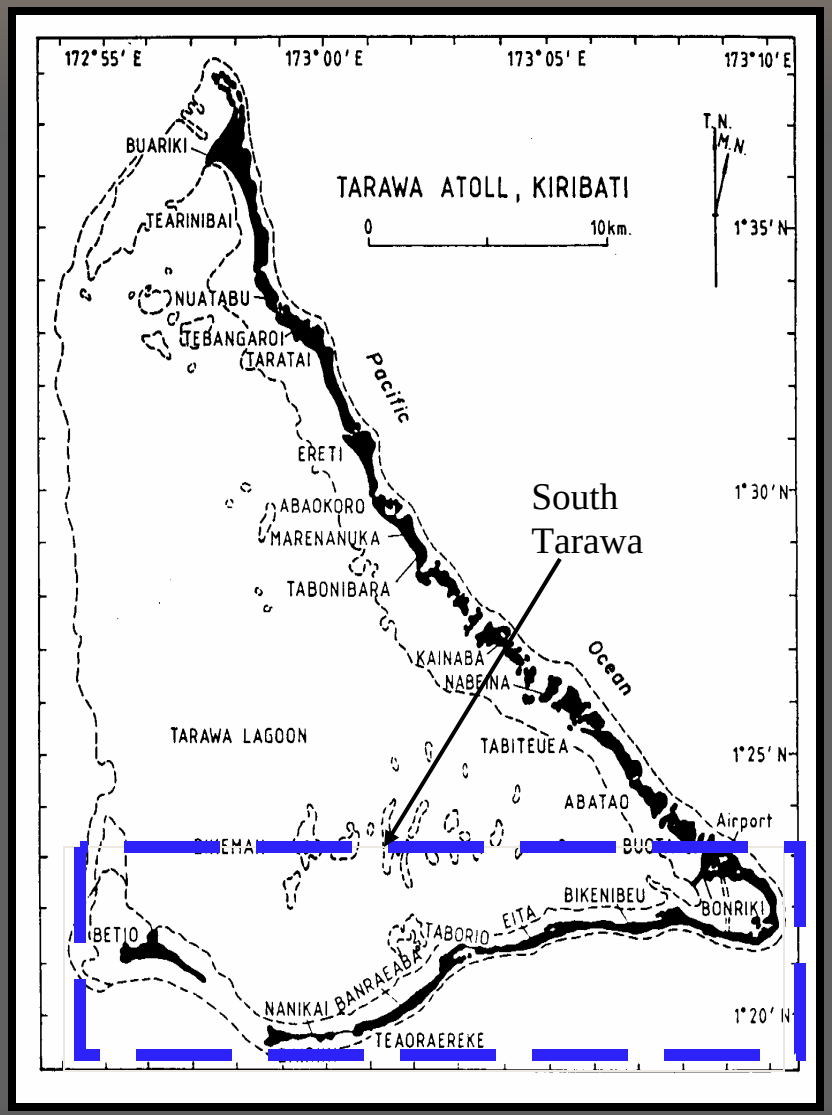
Location of Kiribati

- Located in the Central Pacific.
- Comprised of 33 low lying islands with total land area of 811 sq.km
- Sea area is 3.5 million sq.km
- Population (2000 Census) 84,494

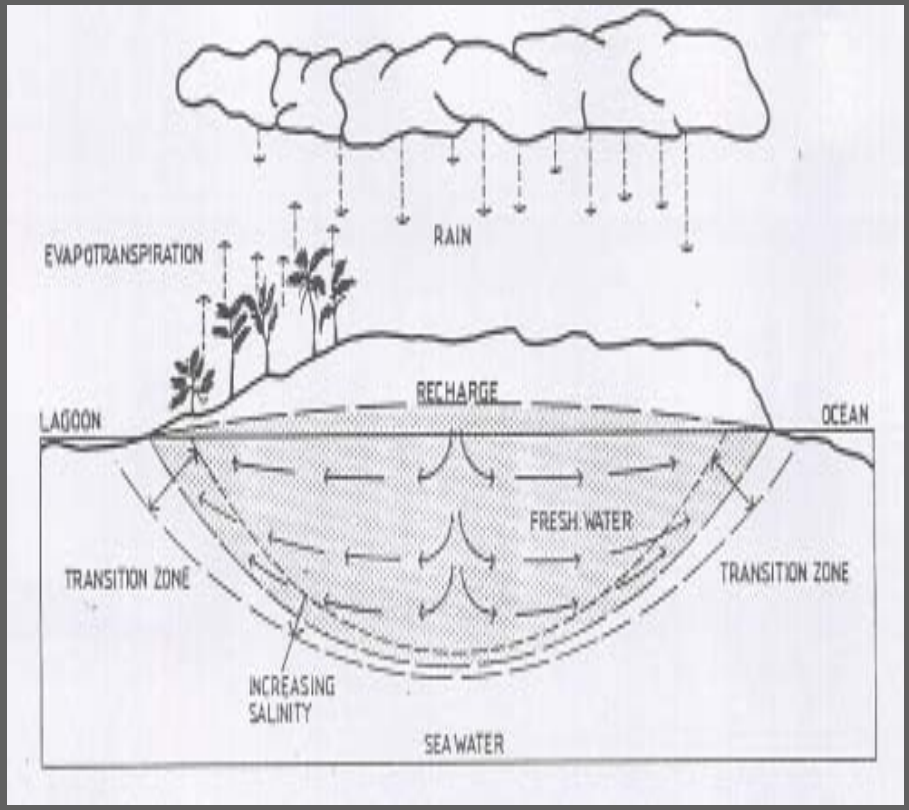
Map of Tarawa

- South Tarawa is the Capital of Kiribati
- South Tarawa is marked on the Map on the right
- Population of South Tarawa is 36227 (2000 census).
- 43% of the total population of Kiribati.



Water Resources

- Water resources of South Tarawa are:
- Groundwater and Rainwater
- Groundwater is the main source for public water supply system.
- Rainwater is supplementary water source.
- Desalination was recently introduced in 1999 and also act as a supplementary source.



Method of Water Extraction

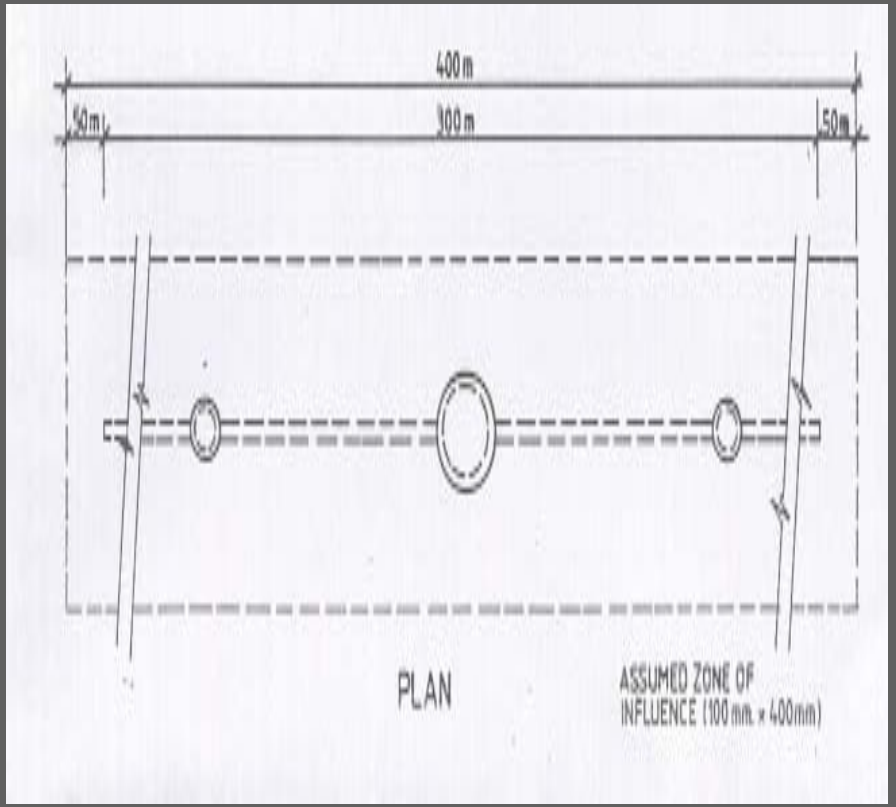
- **Open hand dug well** is the traditional method. This method is suitable for household use and commonly used on all islands including South Tarawa.
- **Infiltration gallery** was introduced in Kiribati in the late 1960 and and was used for large-scale pumping for public water supply system

Infiltration Gallery Design

- There are basically two types of gallery designs:
- Open trench, and
- Buried conduits
- Open trench type of gallery was used on Kiritimati but has been changed to buried conduit under the current AusAid funded water project.
- Buried conduits has been proved to be the most effective type.

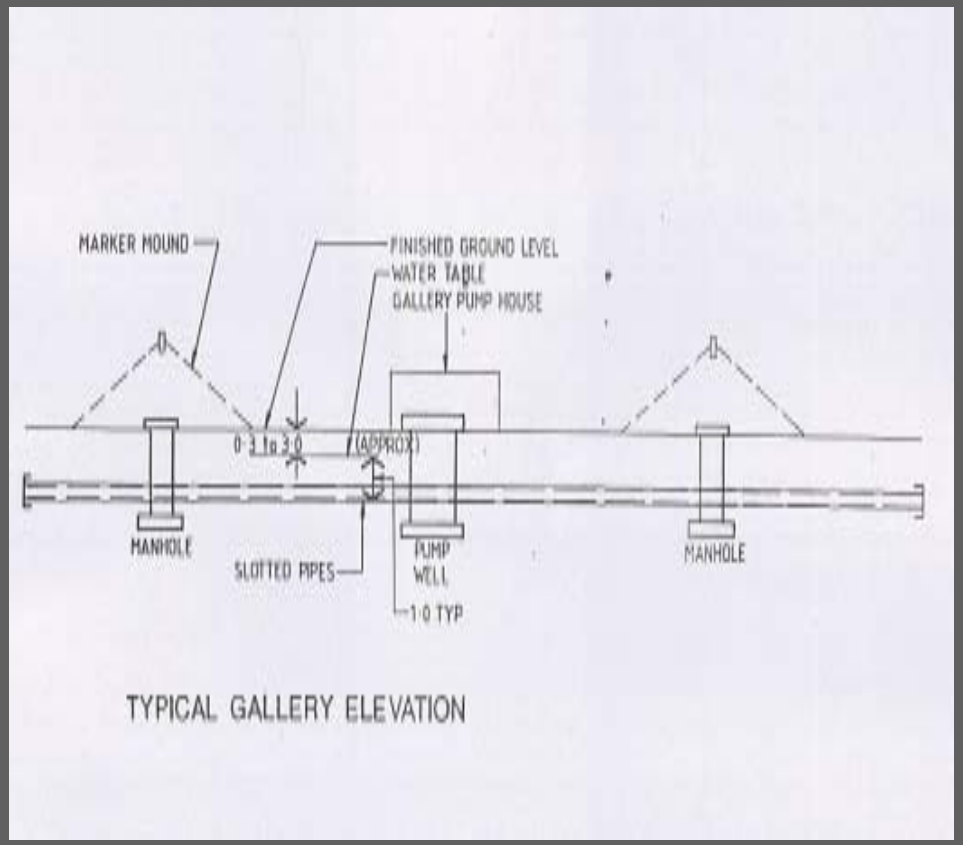
Plan View of Infiltration Gallery (Buried Conduits using PVC Pipe)

- The depth of excavation for the gallery construction is approximately 2-3 m.
- The water table is approximately 1.5-2.0m below ground level.
- The assumed area of influence is 400 x 100 m.



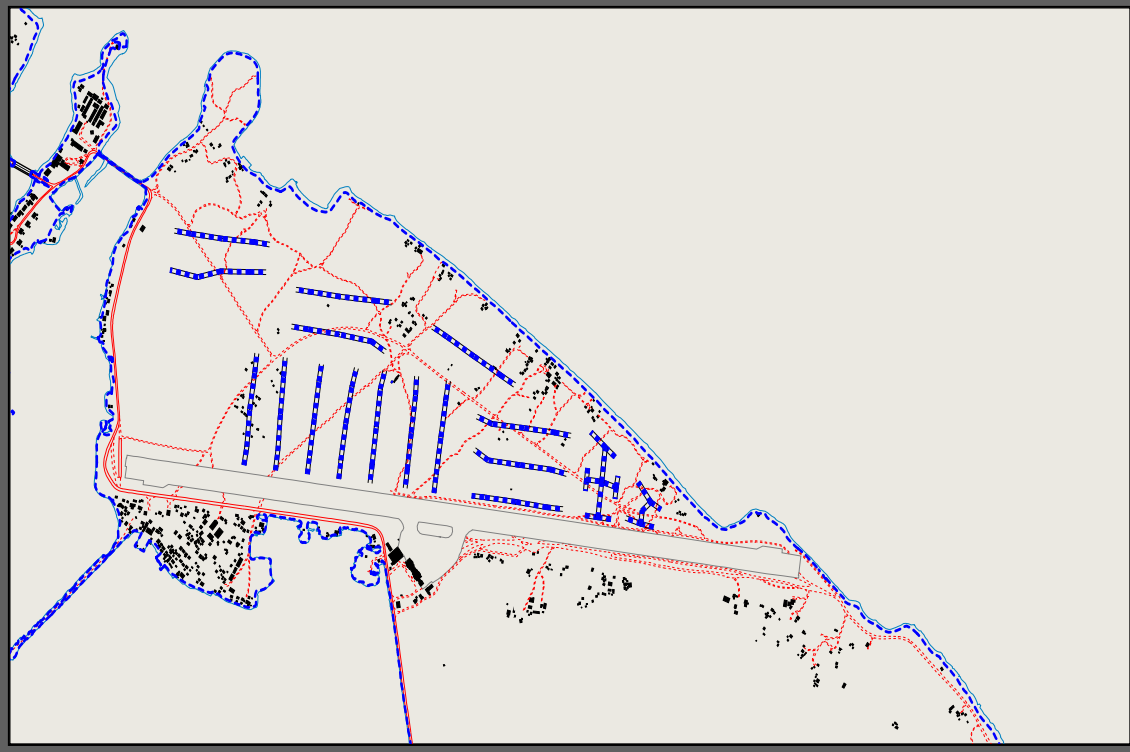
Cross Section of Infiltration Gallery constructed from Horizontal perforated Pipe

- The total length of one gallery is 300m
- The perforated pipe should be buried in a saturated zone.
- One pump per gallery is sufficient.
- On the island of Kiritimati we have installed two pumps on one gallery, a solar pump and windmill pump.

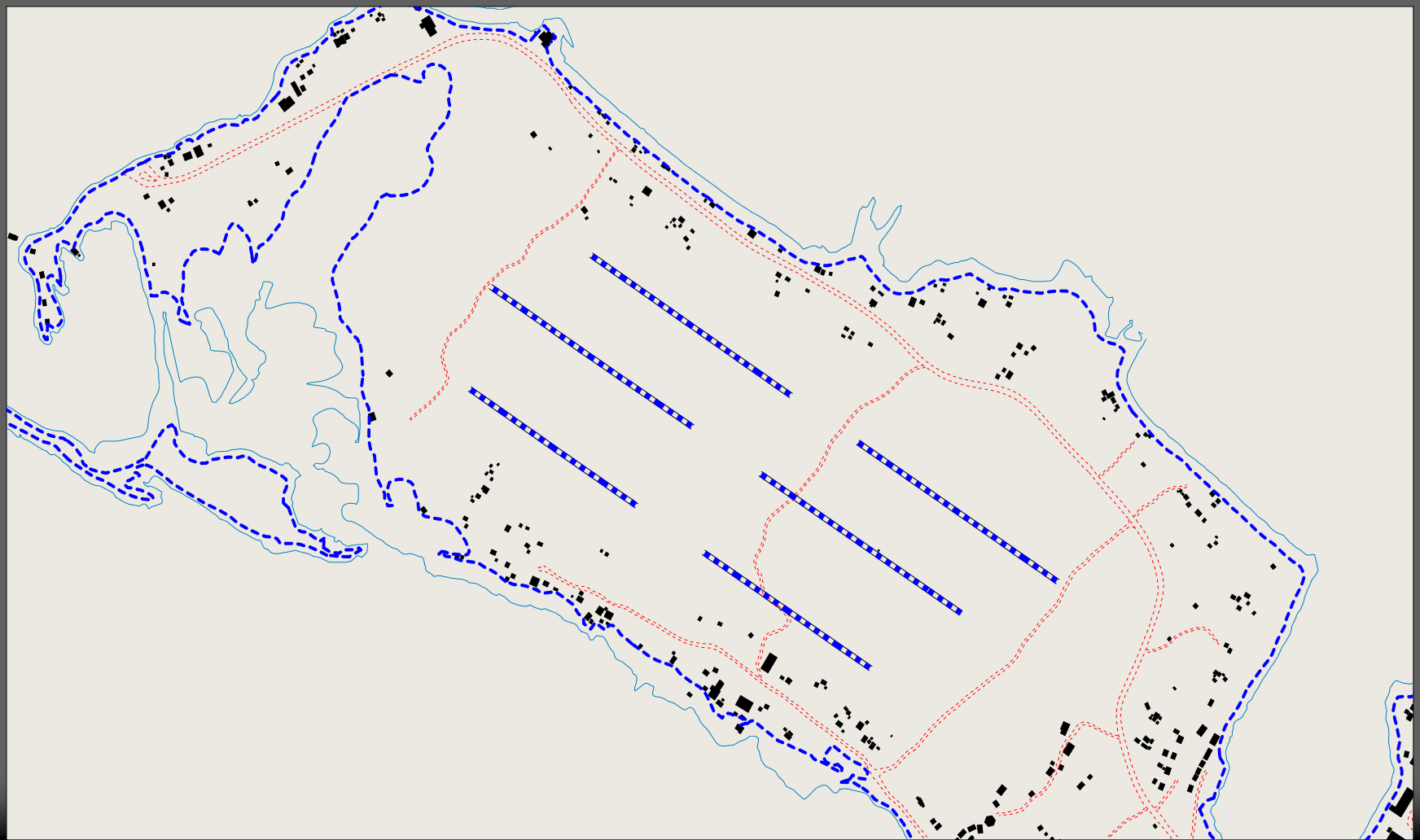


Bonriki Galleries Layout

- Gallery layout should be parallel to the edge of the lens.
- At the centre of the lens the layout can be at any direction.
- Bonriki is a typical example of where the galleries are generally located.
- Galleries should be located in an open area or adjacent to open areas such as airfields.
- The Bonriki airport acts as a catchments to recharge the freshwater lens.
- Bonriki freshwater lens is relatively thick compared with other atolls.



Buota Galleries Layout



Infiltration galleries and Sustainable Yields

- Earlier sustainable yield estimates based on the old design gallery layout.
- Note the other lenses at Temaiku and Teaoraereke cannot be used during the drought.

	Yield	
Lenses	Good Season	Drought Period
	m^3/day	m^3/day
Buota	91	91
Bonriki	91	91
Temaiku	45	Nil
Teaoraereke	68	Nil
Totals	295	182

Source: Operation and Maintenance Manual for the South Tarawa Piped Water Supply System (AGDHC, 1975)

Sustainable Yield Estimates

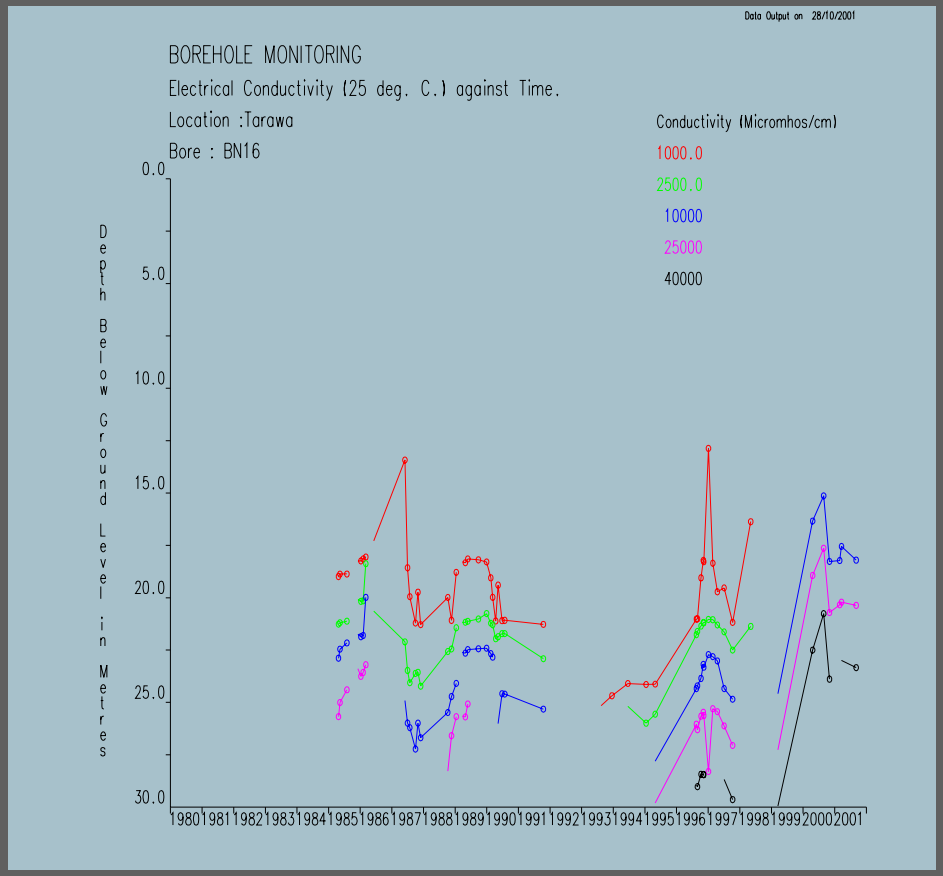
- The 1981 estimates based on limited data using a sharp interface model.
- The 1992 estimates done using a sharp interface model, based on more than ten years of monitoring data.
- The 2002 estimates done using a dispersion type model SUTRA backed with more than ten years of monitoring data.

Water Lens	1981 Estimated Safe Yield (m^3/day)	1992 Estimated Safe Yield (m^3/day)	2002 Estimated Safe Yield (m^3/day)
Bonriki	750	1000	**1350**
Buota	**200**	**300**	**350**
TOTAL	**950**	**1300**	**1700**

Sources: AGDHC 1982, Falkland 1992, Alam et al 2002.

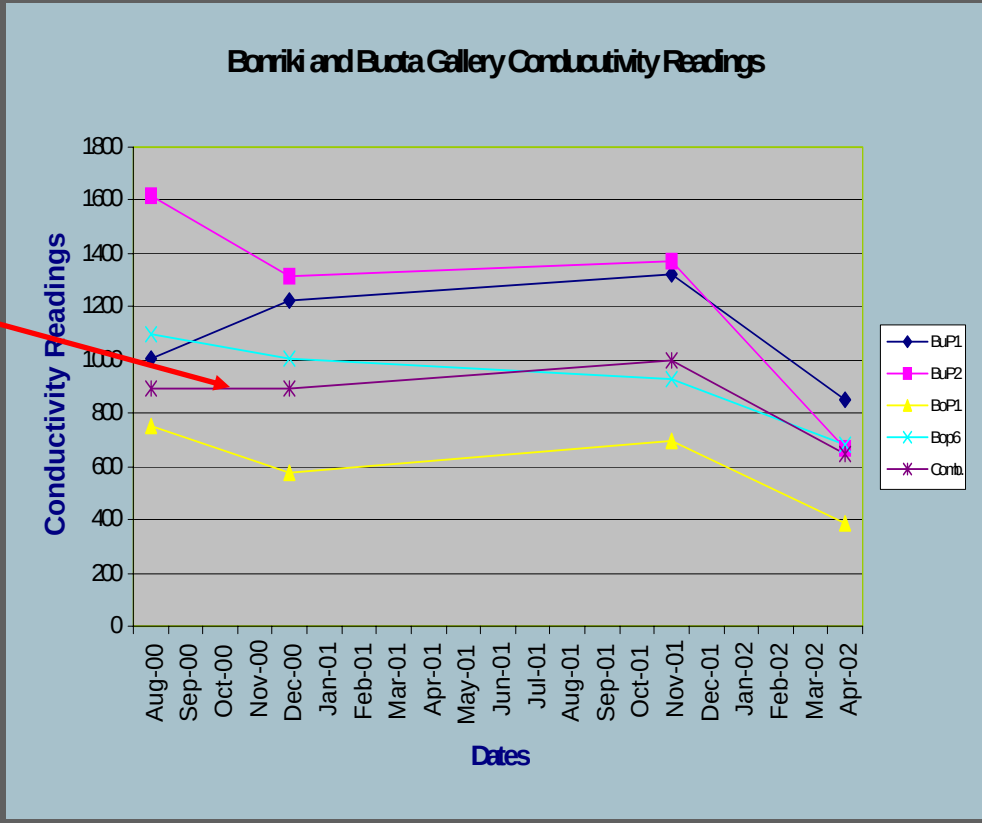
Boreholes Monitoring Data

- The figure on the right is the result of boreholes monitoring on one borehole located on Bonriki.
- The green colour line show the base of the freshwater lens with 2,500 µs/cm.
- It can be seen that the depth of the water lens can go down to about 27 m below ground level during el nino.
- During the drought, nearby boreholes at the centre of Bonriki showed the depth of about 10m.
- This particular borehole does not show the exact freshwater depth during the 1998-2000 drought due to effect of vandalism of some monitoring tubes.



Conductivity (EC) Readings from Galleries

- The figure on the right show the conductivity readings of galleries on Buota and Bonriki.
- This line show the conductivity reading of the blended water.
- The blended water is the combined water from Bonriki and Buota.
- The conductivity reading of the blended water never went above 1000 µs/cm during the drought but dropped to 650 µs/cm after a heavy rain.



Other Water Sources for South Tarawa: Rainwater

- Rainwater is used only as a supplementary water source.
- This is because of the marked unevenness of rainfall, frequently manifested in months long drought.
- Affordable rainwater tanks by individuals do not have sufficient volume to store and supply water during prolonged drought periods.

Other Water Sources for South Tarawa: Desalination

- Introduced in the country at the height of the 1998-2000 droughts.
- The reverse osmosis type of desalination was used.
- The 110-m^3/day capacity plant was installed on Betio to help alleviate water shortage problem on the island. This was financed by the Government of Kiribati.
- Another two plants (50-m^3/day capacity) were donated by the Government of the People's Republic of China and installed at the Central Hospital and the government owned Otintaai Hotel.

Kiribati Experience with Desalination

- Desalination plants are quite simple to operate, provided spare parts are always available.
- Desalination plants should be installed on the ocean side where clean seawater intake can be obtain to feed the plant. The lagoon water is always dirty and would require pre-treatment which can cause more complications.
- Desalination is a viable option on small islands where adequate funding and appropriate expertise is available.
- One should purchase the desalination from a reliable manufacturer.

Cost of Water Resources Development

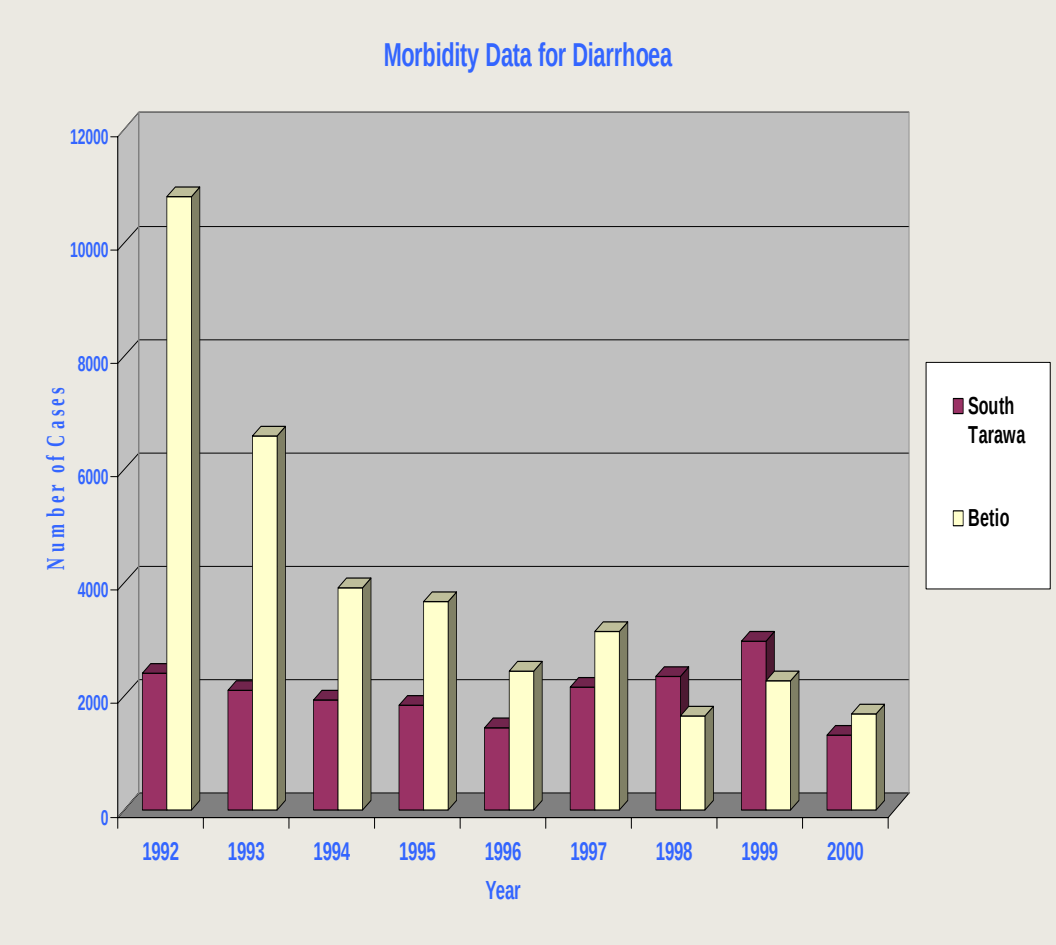
- Desalination can be used for public water supply but its energy cost is very high, sixteen (16) times higher than groundwater.
- The unit electricity cost of running the desalination plant is AUD$2.81/$m^3$.
- The unit electricity cost of running water pumps at Bonriki and Buota is only AUD$0.17/$m^3$.

Cost of Water Resources Development

- Groundwater is the cheapest option of the three water sources (rainwater, desalination and groundwater).
- Rainwater cannot be used for the public water supply as it is only applicable for supplementary domestic use during rainy seasons.
- Running a central rainwater collection system utilising roof area of government buildings for public water supply entails a rather complicated and costly operation

Diarrhea Cases on South Tarawa

- The number of diarrhea cases was high in the early 1990's but has reduced in recent years.
- This shows that most people are now boiling water before drinking.
- The number of diarrhea cases on Betio, the most populated islet on South Tarawa has been reduced from 10,810 in 1992 to 1684 in the year 2000.
- This is quite an achievement toward the WHO target of health for all – 2000.



Constant Flow Method of Water Distribution (CFMWD).

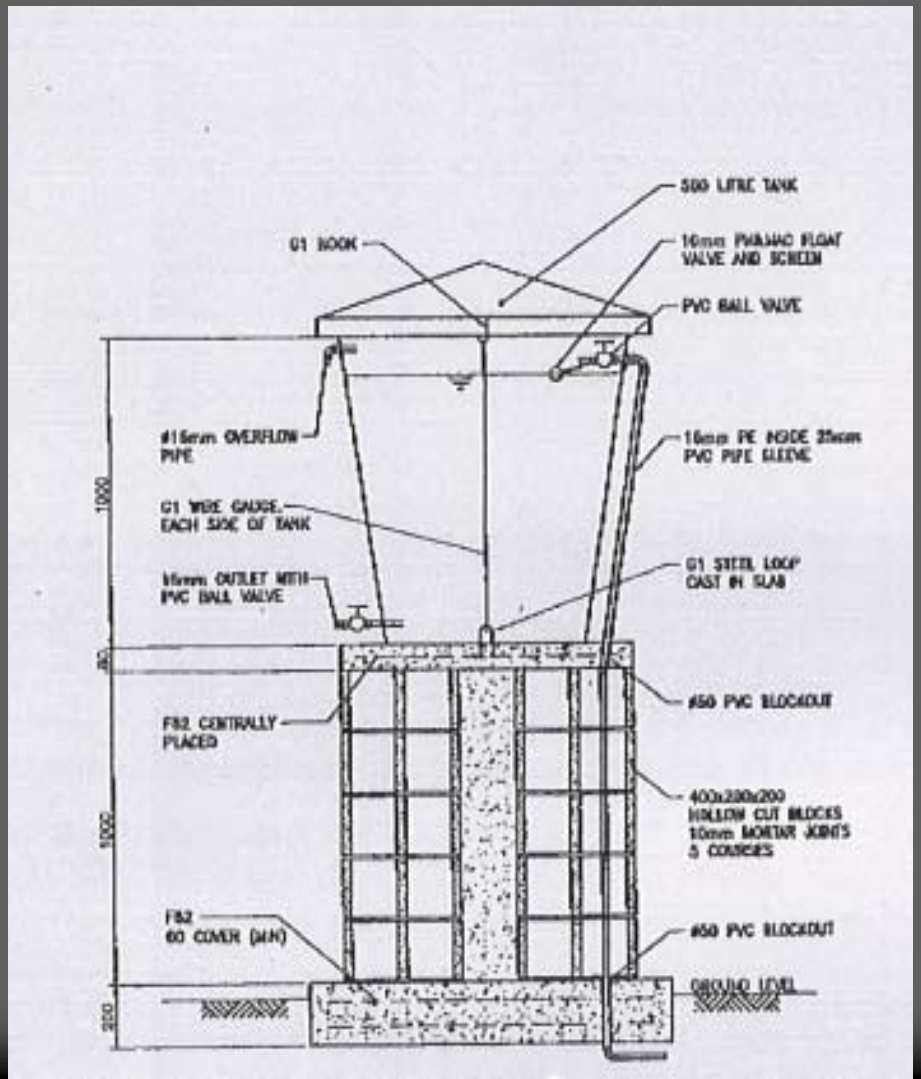
- Objective of public water supply is to provide an equitable supply of water to all consumers.
- Equitable distribution cannot be achieved with limited water.
- On South Tarawa we can not run the water supply 24 hours because of limited water.
- Running water supply 24 hours will lead to excessive water usage and wastage, due to high leakages.

Constant Flow Method of Water Distribution

- Due to unlimited water source, water has been rationed by supplying each area intermittently for one hour each day.
- The main problem with this system of operation are that:
- There is a risk of contamination from backflow into the empty pipes during the periods when water is not being supplied.
- Equitable distribution is difficult with most water going to customers close to service reservoirs and more remote customers receiving little or no water

Constant Flow Method of Water Distribution.

- meters will not operate effectively because of the large amounts of air in the pipes; and
- water stored in the home in informal containers is at risk of contamination.
- A promising alternative is to have a constant flow method with flow restricting devices on each house connection.
- The system ensures that each household receives a constant but low flow of water that is fed into a small tanks and store until required.



CFMWD (Continuation)

- To test the viability of the CFMWD, a pilot trial was conducted on Nanikai village on South Tarawa.
- The trial was run for about four months.
- It was found that all household tanks receive water at a very slow flow rate: Small size households receive 250 litres per day while large households receive 430 litres per day.
- 58% of households are happy with the quantity of water received.

CFMWD (Continuation)

- The remaining 42% of households are not satisfied with the quantity of water received daily.
- With our on-going public awareness campaign people should start to realise that they should learn to live with limited water.

Future water resources and water demand

- The high population projection uses 5% as an annual growth rate based on the 2000 census results.
- The low population projection uses 3% as a growth rate bases on average over the past census for South Tarawa.
- The water demand is 40 litres per head per day.
- The unaccounted for water is assumed to be 30%
- It assumes coverage of 80% of South Tarawa population.
- 20% of South Tarawa population relies on rainwater and groundwater.
- Major water users use desalination.

High Population Projection	Current Population				
Year	2000	2005	2010	2015	2020
Population	36227	46516	59728	76693	98475
Water Demand (m^3/day)	1478	1935	2485	3190	4097
Low Population Projection					
Population	36227	42090	48901	56815	66010
Water Demand (m^3/day)	1478	1751	2034	2364	2746

Potential Water Sources for South Tarawa Water Supply

- There is a need to develop water lens further into North Tarawa, as current water resources are inadequate to meet the current water demand.
- A major issue regarding development of groundwater resources is landowners consent. This is a necessary but time consuming planning component.

Water Source	Estimated Sustainable Yield (m^3/day)
Abatao	300
Tabiteuea	250
Marenanuka	150
Abaokoro	50
Nooto	200
Taratai	600
Tearinibai	250
Nuatabu	150
Buariki	1500
Total	3,450

Groundwater Resources in North Tarawa. (Based on Falkland 1992)

Landownership and water reserve Issues

- Landowners demand more compensation and increases in land lease payments.
- Limited land in Kiribati and South Tarawa with the population of almost 40,000 puts pressure on existing and potential water reserve areas.
- Some landowners on Bonriki and Buota water reserve area have no lands elsewhere, making resettlement difficult.

Conclusions

- The use of Infiltration Galleries are an effective method for water extraction on islands with limited water resources.
- The constant flow method of water distribution is an answer for equitable water distribution on islands with limited water resources.

Conclusions

- The landownership issues with water reserves require careful management.
- The use of groundwater as the main water source remains the cheapest option.
- However, the limited land problem will mean that desalination may be a viable option for future generations of South Tarawa.

Conclusions

- If sea level rise causes loss of land, this will result in the depletion of groundwater lenses and this will require other water sources, including desalination.

End of Presentation

Thank you all for your attention

KAM RABWA