Draft

SOUTH TARAWA

WATER AND SANITATION ROADMAP 2011 – 2030

VOLUME 1: MAIN REPORT

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ADB Asian Development Bank
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South Tarawa Sanitation Improvement Project
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Water and Sanitation Roadmap
2011 to 2030

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Acronyms

ADB	Asian Development Bank
AIDAB	Australian International Development Assistance Bureau (now AusAID)
AusAID	Australian Agency for International Development
BTC	Betio Town Council
CO_2	carbon dioxide
EA	executing agency
EC	electrical conductivity (units µS/cm) – a proxy for salinity of groundwater
EM34	electromagnetic surveying equipment manufactured by Geonics, used to carry out the freshwater lens surveys
EIRR	economic internal rate of return
ENSO	El Niño – Southern Oscillation
EU	European Union
GAP	gender action plan
GCM	global climate model
GLUP	general land use plan
GoK	Government of Kiribati
GW	groundwater
IA	implementing agency
ICI	institutional, commercial and industrial
IDA	International Desalination Association
IHP	International Hydrological Programme (of UNESCO)
IPCC	Intergovernmental Panel on Climate Change
KAP	Kiribati Adaption Project (Phases I, II and III)
KDP	Kiribati Development Plan
KIT	Kiribati Institute of Technology
KMS	Kiribati Meteorological Service
LUP	land use planning
MELAD	Ministry of Environment, Lands and Agricultural Development
MFED	Ministry of Finance and Economic Development
MHMS	Ministry of Health and Medical Services
MIS	management information system
MISA	Ministry of Internal and Social Affairs
NASC	National Adaption Steering Committee
NGO	nongovernment organizations
NSO	National Statistics Office
NZAP	New Zealand Aid Program
MPWU	Ministry of Public Works and Utilities
msl	mean sea level
mth	month
NWSCC	National Water and Sanitation Coordination Committee
PPTA	project preparation technical assistance for the Tarawa sanitation improvement project
OB	Office Te Beretitenti (Office of the President)
O&M	operations and maintenance
PAM	project administration manual (STSISP)
per	person
PIAC	Pacific Infrastructure Advisory Centre
PPP	public private partnership
PRIF	Pacific Region Infrastructure Facility
PUB	Public Utilities Board
RO	reverse osmosis
RRP	report and recommendation to the President of the Board (ADB)
SAPHE	sanitation, public health and environmental improvement project
SD	strategic development
SMF	sustainable maintenance fund

SOE	state owned enterprise
SOPAC	Applied Geoscience and Technology Division, Secretariat of the Pacific Community
STSISP	South Tarawa Sanitation Improvement Sector Project
SWRO	sea water reverse osmosis
TA	technical assistance
TNA	training needs assessment
TOR	terms of reference
TWMP	Tarawa Master Water Plan
TUC	Teinainano Urban Council
UN	United Nations
UNICEF	United Nations Children's Fund
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPC	unit production cost
WB	World Bank
WEU	water engineering unit (within MPWU)
WHO	World Health Organization
WSSW	water, sanitation and solid waste program (Government Task Force)

Note

In this report, $ refers to Australian Dollars unless otherwise stated.

Units of Measurement

ha	hectare (= 10,000 m^2)
kL	kilolitre (= 1,000 L = 1 m^3)
kL/day	kilolitre per day (= 1 m^3/day)
km	kilometer
km^2	square kilometer
L	litre
L/day	litres per day
L/pers/day	litres per person per day (water use)
m	metre
mm	millimeter (one thousand of a metre)
m^2	square metre
m^3	cubic metre
mbgl	metres below ground level
µS/cm	measurement of electric conductivity

EXECUTIVE SUMMARY

1 Background

1.1 The Assignment and Tasks

The assignment has required the development of a water and sanitation roadmap for Tarawa, focusing on the growth centre of South Tarawa, with review of the Tarawa Water Master Plan, an analysis of needs and issues and the presentation of the priority improvements for the period between 2011 and 2030 with an implementation plan and investment strategy.

The analyses for the roadmap have involved an assessment of population growth, land use planning and urban development and the mapping of the urban groundwater lenses on South Tarawa with the estimation of their sustainable capacity and an assessment of water quality. The existing and potential water sources for Tarawa, especially South Tarawa were also investigated.

1.2 The Situation

The findings do not make good reading and raise concern for the circumstances of the South Tarawa communities. All natural water sources are either polluted or at risk of pollution which will deny their use as safe water supplies. The population is growing rapidly and largely unchecked and will more than double in the next twenty years. Development is unstructured and with a lack of adequate regulation and control increasing amounts of scarce land are being denied for residential occupation. The authorities seem powerless to effect management and coordinated use of the land under private ownership and large tracts of land under government ownership will be inundated in the near future through the combined impacts of sea level rise and storm surge, requiring expensive fill and modification for development. Community health is poor and deteriorating.

On every front South Tarawa is facing challenges that will require coordinated policy, and strong management for development and the provision of infrastructure over the next twenty years. The solutions rest within the powers of the Government, its agencies, the town councils, and the communities and will require a cohesive effort and concentrated focus during the coming years.

1.3 The Unpleasant Realities

South Tarawa is facing issues of crucial significance through a burgeoning population which will continue without respite to 2030 and beyond. Population densities will increase with the expectation of average households of 10 to 15 people or more occupying land areas generally of 150m^2 in Betio and Bairiki and between 200 m^2 and 300 m^2 elsewhere. Population densities along South Tarawa will reach the high density level prescribed in the MELAD draft land planning ordinance.

Local food supplies and marine resources will be overtaxed and overcrowded living conditions raise the potential for a continuing deterioration in community health and a substantially increased risk of endemic outbreaks.

Without management and quarantining the existing water resources at Bonriki and Buota are under threat and with pollution, may collapse. Rainwater harvesting may assist overall supplies during “wet” weather but unless operated to higher standards these supplies also

pose a health risk. They will also be inadequate during drought conditions. The secondary lenses under Betio, Bairiki and Bikenibeu are fragile and at risk of saline inversion. These provide necessary water for secondary uses including washing and bathing and will only be preserved with conscientious management.

A poor understanding of health and hygiene and poor sanitary practices contribute disproportionately to poor community health and unnecessary loss of life for both children and adults. Statistics point to the strong probability of more severe water borne diseases such as Typhoid and Cholera. Improved water supplies and sanitation and significantly improved health and hygiene are therefore called for within the period to 2030.

2 The Sector

2.1 Brief Resume

50,402 people, forty-eight percent of Kiribati's population live in South Tarawa where the urban areas of Bairiki, Betio and Bikenibeu have a combined population of 24,171. Rapid urbanization and population pressures have resulted in overcrowding that is putting stress on crucial public infrastructure and the natural environment. High population densities, a lack of potable and secondary water supplies, poor hygiene practices and inadequate sanitation infrastructure are contributing to a high prevalence of waterborne disease among the local population and degradation of the natural environment. With the population forecast to grow at a continuing 3.87% annually the challenge will be to increase the opportunities for economic growth and private sector activity while assisting the government and the community to meet the costs of improved and expanded infrastructure through financial support matched with equitable tariffs and payments for service.

2.2 The Worsening Position

The analysis for this roadmap shows that the secondary and primary groundwater lenses for South Tarawa are at considerable risk and the water abstraction from the galleries at Bonriki and the Bonriki water treatment plant require upgrading and improvement. The distribution system beyond the transmission main and service reservoirs is failing with leaks and high wastage within the household systems. Without improvement the system will deteriorate further and fail and the ability to deliver safe piped water to the communities will be lost.

Of even greater concern is the growing demand for safe water supplies requiring the immediate provision of an additional water supply for South Tarawa. The roadmap has reviewed the Tarawa Water Master Plan (TWMP) and the viable options for additional supplies. The analysis has considered the full impacts on the communities of North Tarawa and their future and livelihoods if the groundwater resources presently available in North Tarawa are diverted to South Tarawa.

The implications for sanitation have also been considered starting with the rehabilitation of the existing sewer systems in Betio, Bairiki and Bikenibeu and the upgrading of the existing outfalls, then extending coverage within the serviced areas to 100% of the population followed by expansion in the form of new systems to villages and communities elsewhere on South Tarawa in line with population densities and increasing urbanisation. Onsite sanitation options will be piloted and their performance monitored for replication through a National Sanitation Guideline for use in the non-sewered urban areas until such times as the urban

densities and site sizes render these approaches unsustainable. The onsite sanitation systems will also be applicable for the rural communities in North Tarawa.

2.3 Deteriorating Public Health

Kiribati has an extremely high incidence of water-borne diseases with an infant mortality rate amongst the highest in the Pacific[1] at 46 per 1,000 live births, which is attributed to infantile diarrhoea.[2] The World Health Organization (WHO) and health officials report[3] an average of three outbreaks of diarrhoea annually directly linked to poor water supplies, inadequate sanitation, unsafe practices and poor public hygiene. In 2010, in South Tarawa almost one person in four was affected by diarrhoea or dysentery to the degree that required a visit to a health clinic. For the crowded area of Betio the percentage increased to 54% visiting a clinic. Infants are particularly vulnerable; a reported four infants/children die of diarrhoea every month in South Tarawa. This high incidence of dysentery and diarrhoea results from the pollution of the water lenses from human and animal wastes. Moreover, anecdotal information indicates that the visit to a health clinic only occurs as a last resort after local natural remedies prove unsuitable, indicating that the incidence of dysentery and diarrhoea is significantly higher that the health clinic statistics suggest.

The medical services in South Tarawa have been described as being overburdened with dysentery and diarrhoea[4] with high incidences of non-pneumonia (21,686) and pneumonia (1,485) during 2010 (Betio 10,184 and 415); acute temperature without rash 7,260 (Betio 3,307) and increasing incidents of leprosy, all diseases symptomatic of overcrowded living conditions. In November 2010 the Ministry of Health and Medical Services (MHMS) confirmed an outbreak of fever and vomiting, particularly among children living in Betio and South Tarawa which WHO treated as a typhoid fever outbreak. These poor health statistics underscore the urgent need for water supply and sanitation improvements.

2.4 The Price of Continued Inactivity

The price of continued inactivity or delay in decisions will be to condemn the communities of South Tarawa to an unplanned and uncertain future. The financial demands for Kiribati as a country at the forefront of global climate change and coping with the pressures of population growth are immense. This is doubly difficult for a country of only 103,000 people and lacking a broad economic base.

The financial demands therefore require careful and coordinated commitment to ensure sustainable outcomes from the expenditure. That means either getting the answer correct and avoiding duplication or repetition, or adopting a process where the focus can be reviewed and redirected within the roadmap in the light of changing circumstances.

2.5 The Need for "Home Grown" Commitment and Solutions

The magnitude of the issues call for a whole of sector response and the full cooperation of government, its agencies and its people in the context of the implementation of the Kiribati Development Plan (KDP) 2011 - 2016. Without this there is no sensible way forward. Improvement and change must be matched with the home grown desire and commitment to

[1] Mortality rates in 2005 for children under the age of 15 years in the Pacific and selected countries. Country Health Information Profiles, 2005-WHO.
[2] UNICEF. *Country Profile – Kiribati Maternal, Newborn and Child Survival.* November 2008.
[3] Discussions in October 2009.
[4] Health of Health Services – consultation meeting, August 2011

manage the improved systems and to legislate and regulate for the effective operation of the systems, including their protection from misuse and damage.

2.6 The Immediate Threats

2.6.1 Loss of existing water reserves

Water is presently extracted from the Bonriki freshwater lens through intake galleries sited at the water reserve to the east of the airport. The sustainable yield from the Bonriki reserve is established at 1,660 kL a day. The Buota water reserve to the immediate north which was previously connected to the system has a sustainable yield of a further 350 kL a day. The Buota galleries and pipeline across the new bridge connecting the system to the Bonriki treatment plant were re-established under KAP II, but the reserve is yet to be reconnected although it is understood this will occur shortly.

The present abstraction rate from Bonriki is between 1,980 to 2,050 m^3 a day, about 20% above the sustainable volume. The investigations for the roadmap have confirmed increased salinity levels and evidence of pollution which could, if the trends continue, quickly render this primary water source unfit for potable use. In the absence of actions to protect and quarantine the reserve it is only one short step from the present situation to the loss of the reserve, as has occurred previously with the former water reserve at Teaoraereke. The risks have been reported upon for the past twenty years culminating in a report commissioned by KAP II in 2009.[5] The recommendations of the report, especially those relating to the de-rating of gallery pumps to match the sustainable abstraction rates and the protection of the reserve from encroachment are well founded. Without such actions the safe water needs of South Tarawa are in jeopardy and could be lost virtually overnight. This primary threat now warrants an immediate and effective response, notwithstanding the understandable difficulties of such a response.

2.6.2 Loss of lenses feeding secondary uses

The mapping of the secondary lenses at Betio, Bairiki and Bikenibeu, and along South Tarawa has revealed the fragility of the lenses, where the present abstraction for toilet flushing, washing and bathing requires the remaining capacity of the lens at Betio and exceeds the lens capacities at Bairiki, Bikenibeu and elsewhere. The lens at Betio might survive an extended drought whereas the lenses at Biriki and Bikenibeu will be lost during a shorter-term drought.

The lens mapping and water quality testing have confirmed that all lenses are constrained with increased saline levels in broad borders around their edges and high biological and nitrate loadings, and in some cases evidence of fuel and oil. The lenses are largely unfit for human consumption and the quantities that can be abstracted are too small to warrant treatment by expensive reverse osmosis methods. More significantly, any use for potable supplies will compete with the secondary uses for washing and bathing and will deplete the lenses. The immediate challenge will be to rehabilitate the sewer saltwater flushing systems and to stop the practice of freshwater flushing, thereby allowing greater lens recovery for washing, bathing and general household use. Without this approach the secondary lenses

[5] Report on the Protection and Management of Water Resources, South Tarawa. Kiribati Adaption Project Phase II (KAP II). Dr Ian White, Tony Falkland Fenner School of Environment and Science, Australian national University and Marella Rebgetz KAP II Senior Water Engineer MPWU, 2009

will remain under threat and with increased population and competition for water may be irretrievably damaged and lost.

2.6.3 Impacts of climate change

A study for KAP II in 2008 assumed two possible sea level rises relative to 1980-99 mean levels up to 2095 of 0.49 to 0.79 m and produced possible inundation maps for Tarawa. From these, it was estimated that inundation of Bonriki and Buota could lead to a decrease in the combined sustainable groundwater yield of Bonriki and Buota of about 20% by 2030. For the roadmap this reduction has been applied to all groundwater yields and incorporated into the estimates of the future water balance for the demands of South Tarawa.

2.6.4 Endemic health issues

While the expected decline in groundwater yields of an estimated 20% by 2030 is a significant risk, it needs to be compared with other risks to the water supply. The population projections carried out for this roadmap confirm a doubling of population in South Tarawa by 2030. These large increases will severely stress, if not completely overcome available natural water resources and present supply systems and will greatly increase the risks of death, diseases and illnesses from contaminated groundwater. The requirements for an alternative safe supply and for improved sanitation and hygiene therefore assume crucial importance.

2.6.5 Unfocused political agendas

The economic development of South Tarawa as the centre for economic welfare of the country is fundamental to the position of country and the provision of government services and support to the outer islands. The development of South Tarawa therefore requires a clearly focused political commitment for well planned and coordinated development, and the provision of essential public infrastructure to support economic growth with improved health and lifestyles. Unfocused political commitment represents that greatest threat to any improvement and the management of the major issues faced by South Tarawa.

3 Population Growth, Urban Management and Development

3.1 The Analysis

The preliminary results of the 2010 population Census were reviewed with the support of the National Statistics Office (NSO). Existing land uses and occupation were surveyed with the assistance of MELAD and General Land Use Plans (GLUPs) have been prepared. Development problems and opportunities in South Tarawa have been analysed and the development options for the period 2011 to 2030 have been established.

The population census results between 1995 and 2010 have been used to provide a reliable estimate of long term growth trends of 3.87% per annum. This has been discussed and agreed with NSO.

3.2 The Realities

The three main urban areas have current population densities of, Betio 19,100 Persons per km^2, Bairiki 16,200 Persons per km^2 and Bikenibeu 9,700 Persons per km^2. Only Nanikai exceeds these density levels, although with a small population. The density levels for small areas within the three main urban areas are high in international terms, going as high as 38,200 Persons per km^2 in parts of Bairiki. Betio also includes areas of very high population

density of around 42,000 Persons per km^2. The highest density found in Bikenibeu is around 19,000 Persons per km^2.

3.3 The Growth Projections

As the age structure and fertility rates of the female population of South Tarawa resemble those of the national population it is estimated that natural increase of the South Tarawa population is about 2.26% per annum. This implies that in-migration into South Tarawa accounts for approximately 1.19% per annum of the population growth – averaging just under 600 persons per annum currently. If in-migration from the outer Islands continues at the present rate and the natural increase trend continues a population of some 107,700 persons can be anticipated in South Tarawa in 2030.

The high growth population scenario for which the infrastructure requirements of the roadmap and investment strategy have been developed is summarised in Table E1. The high growth assumes limited management of growth, no migration control, limited land-fill of "at risk" areas including Temaiku, no North Tarawa urbanization, and no rationalization of land-uses or accelerated family planning programs.

Table E1: High Growth Population Forecast

Area	Population Forecasts				
	2010	**2015**	**2020**	**2025**	**2030**
Bonriki	2,607	3,152	3,811	4,609	5,574
Temaiku	3,123	3,776	4,681	6,560	13,985
Nawerewere	2,324	2,810	3,398	4,109	4,969
Bikenibeu	5,940	7,181	8,684	10,501	12,699
Eastern South Tarawa	**13,994**	**16,919**	**20,574**	**25,779**	**37,227**
Abarao	2,431	2,939	3,554	4,298	5,197
Eita	3,153	3,812	4,610	5,575	6,741
Taboria	1,357	1,641	1,984	2,399	2,901
Ambo	2,297	2,777	3,358	4,061	4,911
Antebuka	3,102	3,750	4,535	5,484	6,629
Teaoraereke	4,106	4,964	6,003	7,259	8,777
Central South Tarawa	**16,446**	**19,883**	**24,044**	**29,076**	**35,156**
Nanikai	1,035	1,251	1,409	1,648	1,648
Bairiki	3,281	3,967	4,796	5,798	6,702
Betio	15,646	18,916	22,897	26,830	26,986
Western South Tarawa	**19,962**	**24,134**	**29,102**	**34,276**	**35,336**
Total (rounded)	**52,402**	**60,936**	**73,720**	**89,131**	**107,719**

3.4 Land Availability

The land area potentially available for development is calculated to be lower than is usually assumed at 12.02 km^2 rather than the often quoted 15.76 km^2.[6] The land available for

[6] Consultant measurement of land above the beach embankment delineated on GIS plans of South Tarawa. Confirmed by SOPAC Land Cover Type Mapping of Kiribati using pan sharpened Quickbird

residential use amounts to 8.79 km^2. Moreover not all of this reduced land area is available for development because of complications and disputes with ownership and boundaries. There are also significant areas of land which are regularly inundated or at risk of inundation which would need to be filled before being available for development. These include the large area of undeveloped government land at Temaiku and other areas in Betio, Eita, Abarao and Ambo.

Field surveys confirm that there are large areas of land which could be bought into more appropriate urban use including the areas which are at risk of inundation but which could be in-filled/reclaimed (most notably Temaiku and sites in Betio, Etio-Abarao, Ambo and Eita) and, sites in Betio currently occupied by radio and television transmitting installations, a meteorological station and an area previously used as a construction works depot. The amount of land which could be made available in these ways has been measured and calculated.

3.5 Worsening Environmental Health linked to Over-Population

A review of health statistics and issues has been carried out. This confirms the continuing risks of high levels of diarrhoea and dysentery from an overcrowded urban environment with inadequate water supply and sanitation services. Other significant impacts were also reviewed including communicable diseases risks associated with high density living[7], increasing risk to food security; increasing marine environmental degradation (lagoon pollution, contamination of marine fauna, overfishing); increasing demand for adequate garbage and waste disposal, increasing road traffic accidents and increasing resource abstraction especially sand and gravel.

The anticipated population growth rates will also create high demand for public services and education. The requirements for health, police, manabea, churches, and initiatives for employment creation in the form of commercial and industrial activities have been discussed with MELAD. These requirements have been accommodated within the draft GLUPs prepared.

3.6 Summary of Conclusions

The analysis confirms that the only ways to reduce the rate of the population growth are: in-migration control, planned out-migration to North Tarawa or elsewhere, and accelerated Family Planning programs. However no policies along these lines will be effective (even if formulated) in the early years of the planning period and there has to be doubt about effectiveness of policy implementation, even if any appropriate policies are formulated. With best efforts and effective implementation of policies to constrain growth, the changes are intergenerational and considered unlikely to have much impact in the planning period up to 2030.

Planning for the water and sanitation road map has therefore adopted, as a likely reality, the highest population growth rate supported by efforts to accommodate the population through the planned use of available land, land zoning and regulation, for example:

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and Multi-spectral IKONOS images October 2010, Wolf Forstieuter and Taato Murdoch which gave a land area for South Tarawa of 12.04 km^2.

[7] The Health Section of MHMS referred to the increasing reallocation of essential health resources towards these community diseases in a losing battle for general surgery and improved health services. Leprosy was described as being on the increase – per con August 2011

1. Areas of higher density - multi-storey (two storey) construction;
2. Bringing parts of Temaiku into use along with other filled low-lying sites;
3. Making better use of under-used sites in Betio and elsewhere;
4. Rationalization of government land and buildings;
5. Rationalization of non-residential land uses to limit further alienation of land for residential occupation (i.e. commercial/industrial expansion, and institutional and community buildings (churches and maneaba);
6. To distribute the growth to ensure that pockets of very high density are relieved realizing that the efforts to achieve this will also be significant.

Population growth and the continuing urbanisation of South Tarawa have immediate implications and again warrant recognition in the KDP 2011-2016 and are matters for public debate and consideration by the new government as soon as it convenes in 2012.

3.7 Impact of Population Growth and Land Shortage

While Temaiku is the proverbial “lifeboat” for absorbing the population increase it cannot be assumed the land will be available. Considerable fill material and expenditure is required to raise the land above future sea level rise and storm surges. Quick assessments place the quantity of solid and compacted fill material at 2,100,000m^3 with an indicative cost of more than $42,000,000 for site preparation, winning the material, cartage, placement and consolidation. Some 2,600,000m^3 of loose fill (dredging) will be required to allow for the bulking of the material and compaction and construction losses.

The question of where the fill will come from raises broader issues as approval for the dredging of the lagoon and boat channels as borrow areas for the fill will involve lengthy negotiations and environmental studies. In this context therefore the projections incorporated in the roadmap amount to an argument of a strategy for managing population and urban development and describe the worst case scenario. Given the policy void over past years it is reasonable to use this high growth scenario for infrastructure investment planning. While a maximum density of 200m^2 per household could be adopted and is shown as an alternative strategy with a greater population diverted to Temaiku the risk of not having policies in place for this scenario or the land filled and ready for use, is great.

4 Water Resource Assessment

4.1 Mapping of Lenses

The extent, thickness and capacity of the freshwater underlying Betio, Bairiki and Bikenibeu in South Tarawa have been assessed and the sustainable yields have been estimated. The opportunity was also taken to assess the capacity of groundwater lenses in other locations.

4.2 Assessment of Quantity – Betio, Bairiki and Bikenibeu

Analysis of the data from Betio indicates at significant (average >10m) lens thickness restricted to the very centre of Betio around the sports complex playing field, with contraction of the lens elsewhere due to the level of groundwater abstraction in Betio, and the increased abstraction rate through the use of fast-rate electric pumps. Whilst a proportion of the water will return to ground and recharge the groundwater, a considerable volume is being lost through evaporation, and in greater volumes into the sewerage system where in the absence at present of an operating saltwater flushing system, freshwater is being bailed from wells to

flush toilets connected to the PUB sewerage system and then disposed of through the ocean outfalls.

Analysis of the data from Bairiki also indicates a contraction of the lens due to heavy abstraction rates. The groundwater lens is small and has high salinity rendering it unsuitable for potable use, and marginal for secondary household uses such as personal and clothes washing.

The analysis of the Bikenibeu lens also shows contraction and thinning due to abstraction, again with higher than desired levels of salinity for comfortable potable use. The Bikenibeu lens has very limited capacity. Like Bairiki and to a lesser extent Betio, increasing secondary use from an increasing population will compete for any possible use for potable supplies. Table E2 summarises the data in the hydrogeological report giving the assessed sustainable yield for the lenses.

Table E2: Groundwater Lenses Sustainable Yield

Area/Lens	2010 Yield m3/day	Supply[1] L/pers/day	Abstraction[2] m3/day	2030 Yield m3/day	Supply L/per/day
Betio	258	16	62 - 312	216	6 - 8
Bairiki	23	7	16 - 21	18	3 - 4
Bikenibeu	12	2	22 - 110	10	1

Notes:
1. 2010 population
2. Water abstracted and discharged to outfalls as flushing water

4.3 Summary of Findings

There is the immediate need to protect the secondary groundwater resources from depletion, contamination and over-abstraction. As a first step a reduction of well water used for flushing sewerage is a priority. The saltwater flushing sewerage systems should be rehabilitated as soon as possible and all new sewer systems should rely on saltwater flushing.

There is an immediate need to provide additional safe water supplies for potable use in South Tarawa. Reconnection of Buota Water Reserve should occur followed quickly by the development of an additional, reliable supply.

Support needs to be provided to households to prevent groundwater contamination, improve well protection and advise households on the suitability of well water for secondary uses, and the high risks of consumption of the contaminated groundwater. Management of the groundwater resource is required.

4.4 Assessment for Remainder of South Tarawa

Twenty-one measurements were taken, in Nanikai village (5), Teaoraereke village (4), Eita village (9) and Nawerewere (3). Wells were selected in a line across each village; two lines in Nanikai village, one line in Teaoraereke village, three lines in Eita village and one line in Nawerewere village. The locations of the wells and the EC measurements were used to estimate the fresh groundwater lens width for each village as presented in Table E3.

Table E3: Estimated Freshwater Lens Widths at Selected Villages, South Tarawa

Village	Line no.	Wells	Estimated Fresh Groundwater Width (m)
Nanikai	1	1-3	0
Nanikai	2	4-5	<50
Teaoraereke	1	1-4	>230
Eita	1	1-4	50
Eita	2	5-6	70
Eita	3	7-9	<110
Nawerewere	1	1-3	<180

The data confirms that at edges of the islets where the fresh groundwater lens is thin, the lens is brackish, in part due to excessive pumping using electric pumps. This observation, along with the estimated fresh groundwater widths in Table E3 confirm that the freshwater lenses at the selected villages are also fragile due to the limited islet widths and existing high abstraction rates.

4.5 Water Quality Testing

Water quality has been assessed to determine the basic chemistry, biological indicators and possible chemical contamination (hydrocarbons, heavy metals and agricultural chemicals) and to assess suitable cost-effective options to treat groundwater for potable or non-potable use.

A sampling plan for Betio, Bairiki and Bikenibeu was prepared collaboratively with MHMS and MPWU. Potential pollution hot-spots were identified and these together with a number of sites for random sampling formed the basis of the sampling program. The field measurements for each site involved testing for dissolved oxygen, pH, electrical conductivity and temperature and oxidation reduction potential. Forty samples were collected and sent to an internationally certified laboratory in New Zealand for comprehensive analysis including volatile organics, hydrocarbons, PCBs and general analysis depending on the risk profile of each site. Separate samples were taken for microbiological analysis (Presence /Absence and in some cases enumeration and for a limited range of analysis for sulphides, nitrates and ammonia using project resources in Tarawa. In conjunction with the sampling program a water user survey/ interview was carried out to obtain background information on usage patterns, numbers of users for the wells sampled, owner observations and comments.

4.6 Rainwater Tank Quality

Samples were collected at random from rain-water tanks, most from household tanks but some from maneaba tanks including well designed systems set up under development projects. Household rain water tanks were mostly commercially available tanks constructed of polyethylene, but in some cases comprised a collection of informal drums and containers ranging the full spectrum from large aluminium basins, 20 litre buckets and 200 litre steel or polyethylene drums.

The microbiology results from 49 samples show little relationship with the quality of the tank installation. Very high readings > 2419.6 E coli per 100ml sample were detected in very

poorly set up household systems and at one state of the art installation at the maneaba in Taboria Village.

Rainwater catchments are an 'at risk' type supply[8] and it is only excellent management of the rainwater systems and boiling of water that ensures the rain water is safe. Ultra violet disinfection systems are widely used in Australasia to disinfect tap water just prior to use but this is not an appropriate system for Kiribati and MHMS is presently conducting tests of a locally imported instant microbiological filter (life-straw) which may have application for the filtering of rainwater to avoid the requirement for boiling.

The management of rainwater tanks involves different parties with varying standards of operation. In the absence of formal arrangements for monitoring and the regulation the water quality its safety will always be of doubt. Considerable improvement is required in training and building community and household capacity to maintain the tanks. Guidelines have been prepared under KAP II and through the work of the other projects and the promulgation, acceptance and adherence to these guidelines for rainwater harvesting is urgently required.

4.7 PUB Water Quality

The treatment process at the Bonriki plant consists of aeration to remove the sulphides and post-chlorination as the water leaves the plant to the transmission main. The aerator is operating effectively but requires replacement and upgrading to a capacity adequate for the combined abstraction rates from Bonriki and Buota, plus improvement to the abstraction from Bonriki. The steel frame supporting the aerator to reservoir pipeline also needs to be replaced.

Gas chlorine is dosed post-reservoir. This is a concern as White and Falkland in their KAP II report confirmed that some galleries were contaminated by coliforms and the thermo tolerant E. coli. Given the absence of proactive watershed management it is only a matter of time before microscopic parasites such as *Giardia* and *Cryptosporidium* become endemic in the community. To provide more robust public health protection chlorine dosing must be changed to pre-reservoir dosing.

It is an expensive and difficult exercise to identify whether these microscopic pathogens (*Giardia and Cryptosporidium*) are endemic in the community or whether at least some of the time they are the causative agents of the high incidence of diarrhoeal disease in South Tarawa. The conventional protection is to provide public health protection barriers via a multi-barrier treatment approach to prevent these parasites reaching the consumer. If correctly managed, the Bonriki and Buota water reserves could be considered protected catchments (acting as the first line of defence) but evidence confirms that they are not protected catchments and that it may take some shift in government agency and community attitudes for this to occur.

Pre-reservoir chlorination will provide better protection against bacteria and *Giardia* but no protection against *Cryptopsporidium*. If water reserve protection measures are not

[8] Pers Comm. Stan Abbott, Director, and a Senior lecturer in Microbiology and Communicable Diseases in the Institute of Food Nutrition and Human Health.Massey University, New Zealand. Speciality - Rainwater harvesting

introduced in the medium term to prevent further degradation of the gallery water it is inevitable there will be *Giardia* and *Cryptosporidium* contamination. While the normal requirement for boiling will destroy *Giardia* if the boiling is prolonged, neither the existing post-treatment or boiling water at the consumer end of the system will destroy *Cryptosporidium* nor will it assist with the reduction of nitrates which become more concentrated with boiling. Expensive conventional treatment such as optimised flocculation and sand filtration will then be required to effectively remove *Cryptosporidium* as will membrane treatment, for example reverse osmosis.

The Betio re-chlorination system has failed and despite a new head unit installed last year on the 70kg cylinder the chlorination system is in need of replacement. Replacement equipment should occur quickly and be the same brand as that at Bonriki (Acromet brand) because this brand is recognised internationally as being robust and relatively maintenance free. Sampling for chlorine residuals throughout the pipe network identified that a free chlorine residual (less than about 0.8mg/l) was maintained as far as the elevated storage tanks used for distribution of treated water to communities. Apart from one occasion at Bairiki, no coliform or thermo-tolerant bacteria were isolated from the reservoirs during the sampling program. This fits with the irregular MHMS survey data which records the occasional coliform or thermo-tolerant bacteria in PUB reservoirs and a typically low (less than 0.4-0.5mg/l free chlorine residual) in the reservoirs.

In South Tarawa people rely on three sources of water: PUB piped supply, well water and rain water. Project survey data consistently showed that of these three sources, well water and rain water were microbiologically contaminated and PUB supplied water was not. As consumers have limited awareness of the risk of drinking contaminated well water and rainwater and a low appreciation of related hygiene and poverty is an issue that restricts their choice as to preferred water supply, improved chlorination and quality of PUB water must be supported by the planned comprehensive community awareness programs.

The recommended strategy therefore is to adopt an integrated approach of improved treatment and management i.e. an improved, reliable and well managed PUB network and a comprehensive and focussed community awareness program.

4.8 The Realities for Water Supply

All tests of the groundwater have confirmed the unsuitability of the water for human consumption. Increasing competition for secondary use and the population growth predicted will eventually place the lenses under pressure and compromise their ability to provide water in managed quantities for bathing and washing. The overriding conclusion is that a new additional safe water source (supply) is urgently required for potable consumption.

4.9 The Realities for Sanitation

The options for the design of the future sanitation systems for South Tarawa depend upon water quality and the sustainable yields of the groundwater lenses. For the use of septic tanks as a component of decentralised sewerage system there must be sufficient freshwater or brackish water with acceptable saline levels, as the septic tanks and irrigation fields will not function with saltwater of or water of high saline content. For freshwater bucket flushing the available lenses must be capable of supporting this draw off and loss by discharge through the ocean outfalls, without compromising the other secondary uses.

These requirements cannot be met and Table E4 summarises information from the assessment of the groundwater lenses along South Tarawa and the implications for the development of sustainable sanitation systems.

Table E4: Lens Capacity, Water Quality and Implications for Sanitation

Lens	Lens Capacity	Water Quality	Implications
Betio	258 m3/day	Poor	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Bairiki	23 m3/day	Poor/saline	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Bikenibeu	12 m3/day	Poor/saline	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Nanikai	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Teaoraereke	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Eita	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Nawerewere	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)

5 Water Supply

5.1 Presently Available Resources

The available resources are limited and inadequate to meet present demand without the additional needs of the future population. The well water throughout South Tarawa is becoming increasingly saline as abstraction rates increase and is polluted and unfit for human consumption, yet adequate for secondary uses. Rainwater harvesting provides, and will continue to provide a useful buffer for the shortfall between demand and supply during normal “wet” periods, but will not provide sufficient volumes for the dryer times and periods of extended drought particularly as household occupancies increase. The challenge therefore is the best and most economic use of existing natural water resources from Bonriki and Buota and rainwater harvesting matched with the provision of an additional reliable supply at least cost to the community and government.

5.2 Assessed Water Demand and Shortfall

The following criteria have been used to estimate the average water demand per capita.

1. Household wells in South Tarawa have groundwater that is too polluted for use;

2. Strong management will be necessary to preserve these degraded lenses for secondary uses such as washing clothes, household cleaning and bathing;
3. Institutional, commercial and industrial (ICI) sectors will require 10% of the per capita domestic consumption in South Tarawa and 5% in North Tarawa;
4. No piped freshwater will be allocated for toilet flushing. No systems will take groundwater for flushing and discharge this to the ocean. All systems, unless saltwater flushed, will return the treated effluent to the lenses;
5. No piped freshwater will be allocated for irrigation in South Tarawa. Grey water, washing, bathing and kitchen waste water shall be recycled to the lenses;
6. Toilet flushing requirements for sewer systems shall be met from seawater;
7. The reduction from groundwater resources at Bonriki and Buota as a result of climate change will be adopted for calculations of supply and demand;
8. A provision of 2L/pers/day will be allowed for increased water use due to increasing temperatures from 2020;
9. All households on South Tarawa will be supplied with piped, treated freshwater;
10. Pipeline water loss rates and wastage will receive vigorous attention and will be reduced to 25% by 2015, 20% by 2020 and 15% by 2030.

A per capita demand of 50L/pers/day has been adopted for the water demand in South Tarawa and 45L/pers/day for North Tarawa. The population projections provided earlier in Table E1 have been combined with the required per capita water demand of 50L/pers/day to give estimates of the total daily amount of safe, treated water required to satisfy the future demand. This is displayed in Table E5. The deficit illustrates the additional water resources required.

Table E5: Estimated Water Balance for South Tarawa – 50L/pers/day

Description	2011	2015	2020	2025	2030
High population growth	50,402	60,936	73,721	89,130	107,719
Medium population growth	50,402	60,940	68,133	75,992	83,929
Low population growth	50,402	60,940	68,133	75,437	82,038
Water Loss	67%	25%	20%	20%	15%
High growth demand	4,209	3,809	4,423	5,348	6,194
Medium growth demand	4,209	3,809	4,088	4,560	4,826
Low growth demand	4,209	3,809	4,088	4,520	4,717
Safe yield[1]	1,660	2,010	2,010	2,010	2,010
Increased production[2]	0	500	500	500	500
Decrease due to climate change[3]			166	333	500
Total water available	1,934	2,510	2,344	2,177	2,010
Water distributed[4]	705	1,868	1,872	1,738	1,705
Deficit (high demand less distribution)	-3,504	-1,931	-2,552	-3,611	-4,489

Notes:
1. Safe yield initially from Bonriki with Buota coming into production in 2012
2. Bonriki clearing palms 2012, infill of borrow pits 2013
3. Loss of 20% of groundwater capacity by 2030
4. Distribution after allowing for losses

An alternative source of safe water is required from 2011 forward with progressive increases to balance supplies with demand. The roadmap analyses give attention to the provision of future resources to meet the deficits between demand and supply.

5.3 The Viable Options

5.3.1 Leak detection and control of wastage

The first priority needs to be given to reducing the losses through leak detection and loss management. PUB currently places unaccounted for water losses at around 67%.[9] There are no structured leak detection programs, nor are systematic processes followed to monitor and limit water losses. The situation is not helped by the view within PUB that its responsibility for water supply stops at the outlets from the service reservoirs. Despite featuring strongly as a capacity building component in the first part of the SAPHE project the activity receives little attention in the daily activities of PUB. Presently there is one flow meter installed on the 30 km long transmission main, reportedly at the Bagantebure reservoir. Other flow meters and pressure tapping points are required, with easily accessed and lockable manholes for improved loss management.

The leak detection programs do not require high technology but will require planning, commitment and continued effort. TA support through KAPIII and the ADB South Tarawa Sanitation Improvement Sector Project (STSISP) with funding allocated for leak detection under KAP III will advance this work. Any additional water supplies must be conditional upon significant progress with the leak detection program bringing unaccounted for water to 25%. This work should start immediately.

There are long-standing cultural and social customs in Kiribati that make leak control and demand management difficult issues. These have led to a situation in water supply where the distribution of water in South Tarawa is inequitable, where wastage is not discouraged, where anti-social and even illegal actions are condoned, where the water supply system is not financially sustainable, and where the very survival of the community into the future has been placed at risk. If these problems are to be addressed then difficult decisions regarding demand management must be made. They represent the key issues to be addressed in the longer-term campaigns to promote behavioural change and will require underpinning by the necessary legal framework.

5.3.2 Rainwater harvesting

Although an important source of freshwater, and one that should be supported, rainwater harvesting cannot be relied on as a continuous source of water because of the frequent, severe ENSO-related droughts in Tarawa, the limited roof catchment areas, the rain tank volumes available and the large number of people per household. There is the potential to increase rainwater harvesting, especially from large public buildings but this will not provide the answer to water supply through prolonged droughts. A water balance model prepared for the roadmap analysis confirms this situation where over an three month dry period the tank water for an average household would only deliver 5L/pers/day if marshalled well over the full period.

[9] Report to NWSCC stating “The current water transportation loss through the rising main stands now at 29% of total Bonriki production. Hence the quantity available for storage and distribution to the whole of South Tarawa is 1,410 kL per day of which 50% estimated/assumed is lost in the reticulation systems.” So of a production of some 2100 kL at Bonriki only around one third or 705 kL is delivered to customers

5.3.3 Option 1 – removal of trees from Bonriki

The option for the removal of 1,700 deep rooted coconut palms from the central portion of Bonriki will increase the sustainable yield of Bonriki by 250 kL/day. At $272,000 it is a relatively low-cost and low-risk option but will require negotiations with landowners over tree removal and compensation payments. Only minor modification of the existing infrastructure is required. The advantages are a quick improvement to the sustainable capacity of the Bonriki reserve which will partially offset the loss due to the climate change impacts on the reserve from 2020 onwards. The unit production cost of this option is $3.97/kL.

5.3.4 Option 2 – infill of borrow pits

During construction of the airport runway at Bonriki, borrow pits were excavated at the western, lagoon end of Bonriki. These become brackish during drier periods and contribute salinity to the freshwater lens. The option provides for the cleaning of organic matter and infilling the ponds with clean, dredged sand. The area sustainable yield of Bonriki reserve would be increased by a further 250 kL/day and will again offset the loss due to the climate change impacts on the reserve. The option will require negotiations with landowners and the Bonriki community who use the ponds for soaking pandanus fronds for thatching, the installation of three new galleries in the reclaimed area and may involve increased land rental payments. At a cost of $2,500,000 the option has a higher unit production cost ($7.65/kL) than other options but this is outweighed by the ability to action the option quickly.

5.3.5 Freshwater resources from North Tarawa

The main freshwater sources in North Tarawa identified in TWMP are the shallow groundwater lenses in the major islands. Rainwater harvesting can contribute to potable household use but because North Tarawa is a rural area, the number of buildings with suitable roofs for rainwater collection is limited. TWMP identifies previous suggestions for providing adequate water supply for South Tarawa including the progressive use of groundwater from islands north of Buota with the pumped groundwater being pumped across the channel between Abatao and Buota. The gradual development of all of the islands in North Tarawa will be a lengthy process and will only satisfy the demands of South Tarawa until around 2020. The option will also irrevocably change the sustainable lifestyles of the North Tarawa communities, lead to extensive consultation over years and require large lease and compensation payments in perpetuity. The approach adopted by the roadmap is to retain the resources for community use on North Tarawa and over time accept a natural shift of part of the population of South Tarawa to North Tarawa as an outer growth centre in its own right, with acceptance of the communities there and its own sustainable resources.

5.3.6 Option 3 – groundwater production from Abatao and Tibituea

This option identified in TWMP with a cost of $4,952,560 contemplates the construction of 8 infiltration galleries in already surveyed areas in Abatao and Tabiteuea (Falkland et al., 2003) together with a water treatment plant for each island, a cross-channel pipeline to connect with South Tarawa and reticulation systems in each island to supply local household needs. This would increase the sustainable water supply by a modest 220 kL/day. Under this option, lengthy negotiations with landowners together with compensation payments and continuing land-rental payments will be required. New legislation may also be needed for the declaration of water reserves in Abatao and Tabiteuea. After allowance for production and distribution losses at say 25% the net gain would be 160 kL per day and a very high unit

production cost of $10.10/kL. It represents one of the highest priced options and is not recommended.

5.3.7 Option 4 – groundwater production from Buariki and Taratai

In this option, again identified in TWMP, estimated to costs $21,125,000 or more, a total of 18 infiltration galleries would be constructed in the northern islands of Buariki and Taratai together with a power station to supply energy for pumping for the galleries and cross-lagoon transfer, one major water treatment plant, a major water storage tank, a 16.5 km long cross-lagoon maritime pipeline to connect with the South Tarawa reticulation system at Ambo and reticulation systems for the islands in North Tarawa to supply local household needs. This could increase the sustainable water supply by an upper yield of 1,524 kL/day. Again under this option, lengthy negotiations with landowners together with compensation payments and continuing, expensive land-rental payments will be required. New legislation will also be needed for the declaration of water reserves in Buariki and Taratai. This option would substantially change the character of North Tarawa and may be resisted by the North Tarawa communities. The option has a high unit production cost of $9.58/kL assuming 25% production and distribution losses.

5.3.8 Option 5 – seawater RO desalination

Nauru has successfully run SWRO plants for 10 years, supplying a major proportion of its potable water needs, especially in droughts with maintenance and technical services being contracted out to the manufacturer/supplier. The strengths of the SWRO systems are that they can be installed and started quickly, are of small size and can be modularized, do not require lengthy negotiations with communities or excessive land rental payments, and can be installed close to areas of most need. In addition, new modular units can be added as demand increases. The TWMP observes that it does however represent a technological fix, diverting attention from fundamentally important aspects of protection of water sources, water conservation, community engagement and demand management. Table E6 shows the water balance using 50L/pers/day with the provision of initial desalination in 2014, and the progressive increase of desalination capacity.

Table E6: Estimated Water Balance for South Tarawa – 50L/pers/day with Desalination

Description	2011	2015	2020	2025	2030
High population growth	50,402	60,936	73,721	89,130	107,719
Medium population growth	50,402	60,940	68,133	75,992	83,929
Low population growth	50,402	60,940	68,133	75,437	82,038
Water Loss	67%	25%	20%	20%	15%
High growth demand	4,209	3,809	4,423	5,348	6,194
Medium growth demand	4,209	3,809	4,088	4,560	4,826
Low growth demand	4,209	3,809	4,088	4,520	4,717
Safe yield[1]	1,660	2,010	2,010	2,010	2,010
Increased production[2]	0	500	500	500	500
Decrease due to climate change[3]			166	333	500
With desalination[4]	0	2,211	3,364	4,278	4,955
Total water available	1,934	4,721	5,708	6,455	6,965
Water distributed[5]	705	3,535	4,522	5,160	5,918

Deficit (demand - production)	-3,504	-274	+139	-188	-276

Notes:
1. Safe yield initially from Bonriki with Buota coming into production in 2012
2. Bonriki clearing palms 2012, infill of borrow pits 2013
3. Loss of 20% of groundwater capacity by 2030
4. Introduction of desalination plants by 2014 and progressively thereafter
5. Distribution after allowing for losses

The cost of the initial SWRO units allowing for manufacture, delivery, onsite civil and related works and commissioning is estimated at $8,483,800 with a unit production cost of $3.88/kL allowing for electricity, consumables (RO antiscalant, chemicals and replacement micron filter cartridges), chemicals (for membrane cleaning) and membrane replacement at five years (the Nauru membrane has lasted 10 years), and for a manufacturer's service warranty (three or four year contract with six visits per year at an inbuilt cost of $110,000 for each bank of three units producing 528m^3/day). Provision is also made for spare parts amounting to $65,000 annually again for each bank of three units).

The greatest risk of the desalination option is the ability to effectively maintain and operate the plants for at least ten years or more. The risk will be minimised by procurement that focuses on a selection process involving world leaders in the field with proven and extensive operational experience and the ability to back up and support their equipment well into the future. The worst possible situation will be to take the lowest price from a supplier without these attributes who is unable to provide technical and parts backup, and has a high risk of financial and business failure. Ease of support would favour a supplier from the Australasian and Pacific region. The supply arrangement must provide for a maintenance contract with the supplier, with provision for guaranteed payment to ensure the longer term maintenance and operations support.

The roadmap outlines the various options for the management and maintenance of the desalination plants ranging from PUB operation with a maintenance contract with the manufacturer/supplier to a Build, Operate, Lease and Transfer arrangement with the manufacturer/supplier through to a Build, Own, Operate and Maintain contract with the supplier. This last option would require PUB to "take or pay" for the desalinated water produced It has the advantages of limiting the Government/PUB risk and also providing scope for private investment for expansion, but would come at a higher cost for the water produced as the risks are largely transferred to the plant operator.

5.4 Desalination (SWRO), the Future Option

The comparison of unit production costs confirms that Seawater Reverse Osmosis (SWRO) desalination is the most cost effective option, after the present Bonriki supply. Recent technological advances and development have improved the operations, costs and longevity of SWRO plants. Contracting out the training of operators, maintenance of units and the provision of technical advice to system manufacturers will significantly increase their lifetime.

The situation in South Tarawa requires an alternative source of water that can be established quickly, at an affordable capital cost, and with the ability to be expanded as the population increases. The supply must also be capable of providing a twenty-four hour pressurised service for the efficient operation of the piped water supply system. These considerations have led to the choice of SWRO desalination over the groundwater options in that: they can be installed and operated rapidly and produce pathogen-free water. It is also unlikely an environmental impact assessment will be required, and there will be no issues of excavation across the lagoon, or negotiation for abstraction rights.

The SWRO desalination units can be manufactured in various combinations and installed into 20 foot and 40 foot containers depending upon the size of the unit. Presently shipping requirements would limit the units imported into Kiribati to a size fitting within a 20 foot container.

While the manufacturing costs are higher for the banks of multiple smaller units this additional cost comes with the advantage of maximum flexibility in operations and the ability to take units out of operation for maintenance and to maintain production in the advent of the outage of one unit. There will also be the advantage of uniform sparing and the training of operators for one unit and specification. The roadmap provides initially for four banks of multiple units (three desalination units in each bank of units) with each multiple installation capable of producing 528 kL of freshwater daily and the four multiple groupings giving a total production of 2,112 kL daily. The Brine discharge and backwash from the plant can be directed back to the ocean. The Brine is about twice the salinity of sea water (depending on m/c recoveries) and this disperses quickly without issue to the environment. This is the worldwide practice.

The units (banks of three) would be sited in Betio (2), Bairiki and Nanikai (1), Teaoraereke and Antebuka (1). From their fresh water reservoirs they would be connected to the existing transmission main, thence the service reservoirs and the network. The present system on South Tarawa can be divided into service areas for the operations and management of loss control, with the areas balanced to the capacity of the desalination plants. The remainder of South Tarawa would continue to be supplied from the Bonriki and Buota water reserves.

6 Tungaru Central Hospital

The water supply and sanitation systems in the hospital require urgent upgrade, including the reestablishment of saltwater flushing for sanitation and water pumps and storage for rainwater and groundwater plus water treatment and disinfection arrangements and the treatment of sewerage before discharge to the ocean outfall at the hospital. KAP II funded a draft consultant's report of the requirements and this placed the cost for all improvements and upgrading at $3,378,537. Allowing for price escalation since the preliminary costs were prepared and for a robust contingency the work has now been reassessed at $3,700,000. Provisions for these improvements and associated costs have been included in the roadmap and investment plan.

7 Sanitation

7.1 Evaluation of Existing Systems

The three urban sewer systems in Betio, Bairiki and Bikenibeu originally constructed in the early 1980's by the Australian Government in response to an outbreak of cholera in 1977 were rehabilitated between 2003 to 2004 by the SAPHE project. By 2010 due to an absence of maintenance and funding for routine operations and repairs the systems had deteriorated to a state of near collapse. The rehabilitation of these systems and the reconstruction of their outfalls therefore became the focus of the core sub-projects for The South Tarawa Sanitation Improvement Sector Project (STSISP).

The return submitted by PUB to the Pacific Water and Waste Water Association for the benchmarking of Pacific Authorities in 2011 shows 2,679 sewer connections, against the 2010 Census which confirms a total of 1,654 households connected to the PUB system. A

detailed count conducted by the TA 7359-KIR PPTA consultants from permit records aligned to the 2010 Census gives the number of 1,833 connections and 2,115 pans.

7.2 Sewerage Loadings

Average daily per capita loading, for the existing and likely future sewerage networks in South Tarawa have been assessed and wastewater load forecasts have been made based on the population growth projections, including average daily per capita loads for the period 2010 to 2030, assuming 100% access to improved sanitation in South Tarawa. The enumeration areas of the 2010 census have been adopted for this calculation. The high population growth scenario for 2030 and related sanitation flows and loadings have been adopted for the design of the future extensions and the options for new Sewer systems.

7.3 Calculations of Design Sewerage Flow

A daily water demand/use of 80L/pers/day has been adopted for preliminary design purposes. This reflects a total potable demand of 50L/pers/day and sewer flushing of 30L/pers/day. In South Tarawa few kitchens and washing areas are connected to the sewer and grey water has a productive use for watering plants. The flow to the sewers is limited to direct toilet discharge and flushing. The design calculations using the above consumption are therefore conservative given that the discharge of potable waters to the sewer will be less than 60% of the potable water intake to a household.

For the new sewerage options the design peak hourly flow has been estimated to determine the cross section of sewers and the capacity of pumps and rising mains. For the purposes of the preliminary assessment the commonly used value of 1.8 times the average daily sewerage has been adopted to give a design peak hourly flow of 120L/pers. For the design of the new area sewer systems a flow of 5 times the dry weather flow has been used for the estimates of Design Peak Wet Weather Flow.

The capacities of the existing systems for Betio, Bairiki and Bikenibeu have been checked and using the design parameters of the original SAPHE design plus the new discharge figures have been found to be adequate for 100% of the population in each area through to 2030. The dimensions of the upgraded outfalls have been sized to accommodate the flows from Betio, Bairiki and Bikenibeu respectively and the new areas to be connected to the outfalls following extension of sewer systems throughout South Tarawa.

7.4 Urban Growth and Densification

The population growth and displacement in South Tarawa is predicated on household land area of 150 m^2 for Betio, Bairiki and central Bikenibeu and between 200m^2 and 300m^2 elsewhere. Even if the low-lying land in the Temaiku area is raised for managed occupation by population overflows the land area per household will still be within the 200 m^2 to 300m^3 range. With an average household occupancy of 10 and 15 people the area around each house will be limited and hard pressed to accommodate buildings, vegetation, well(s) and toilets. Space will be limited for conventional septic tanks and irrigation fields, or for the separation required for latrines and other onsite sanitation systems relative to houses (10m separation) and wells with a similar clearance. The roadmap therefore assumes that conventional saltwater flushed sewerage systems will become necessary as the population densities peak in each area. This places an idealised need for a sewer system for Nanikai around 2018, Nawerewere and Bikenibeu east by 2020, Bikenibeu west and Abarao by 2023, and Taboria and the remainder of South Tarawa from Teaoraereke and Eita between 2025 and 2031.

7.5 Onsite Sanitation – Piloting and Possibilities

At MPWU's request TA 7359-KIR PPTA has prepared a sub-project for the piloting of on-site sanitation systems, for implementation early in STSISP as a candidate sub-project. This will develop onsite sanitation options for replication in national sanitation guidelines prepared by MPWU as a practical approach for the non-sewered areas. The design of the on-site systems has been developed in collaboration with MPWU staff and includes a monitoring and reporting program for an assessment of performance and effluent quality under operating conditions. Full consultation has occurred with the land owners and occupiers with their direct involvement in discussions on onsite requirements and suitable options.

The pilot sub-project will determine affordable onsite systems using locally available materials for the national sanitation guidelines for effective sanitation for the medium term until the permanent centralised systems become necessary. Depending upon their performance the onsite systems could provide an effective approach for sanitation into the future and could lead to some deferral in the timing proposed for the installation of area sewer systems along South Tarawa.

The PRIF Kiribati Infrastructure Sectors Review of August 2009 identified the high cost of centralised sewer systems and suggested a focus on onsite systems as a more affordable solution. This could well be the case provided the type of onsite systems proposed are accepted by the community and their performance is proven. At the same time however this roadmap has identified the fragility of the groundwater lenses, the high water tables which are predicted to increase with rises in sea level and the high population densities which are poised to double in the next twenty years. It is inevitable therefore that with densities equating to intense inner city levels centralised sewerage will gradually become necessary, requiring a planned and progressive response. In summary therefore onsite sanitation has a considerable part to play over the next twenty years but will eventually, and gradually give way to centralised systems.

7.6 Decentralised Systems

With the assessment of the urban lenses and their fragility the option of using either fresh or brackish water for toilet flushing and primary treatment in the septic tanks where the filtered effluent is conveyed off-site and disposed of through the ocean outfalls is no longer an option. The design options within the roadmap therefore make no provision for decentralised systems.

7.7 Area Systems

For the same reason all future area systems identified in the roadmap rely totally on saltwater flushing.

7.8 Future Priorities

7.8.1 Rehabilitation of existing systems

The initial priority is for the rehabilitation of the existing sanitation systems in Betio, Bairiki and central Bikenibeu and to consolidate the systems serving some 50% of the South Tarawa population.

7.8.2 Extended coverage

The present sewerage systems were originally designed to deliver sewerage services to 80% of the urban population within the service areas but in reality presently serve less than

this number of people. It is desirable that those households that can be connected, be connected and that the systems be extended over the next ten years to service 100% of the population in each area, including squatter communities on government land where occupation rights will need to be approved to give security to the “landless” as an incentive for investment in household sanitary facilities and sewer connections. The areas where the extensions and additional communal toilets are required due to the lack of space for separate household cubicles have been mapped and the work estimated to cost $4,679,550 has been scheduled for gradual implementation, subject to development partner support between 2011 and 2020.

7.8.3 Temaiku development

The off-site infrastructure for the model urban subdivision at Temaiku support by NZAP is included in the roadmap. The sanitation component provides for a rising main from the development to link with an upgraded outfall at the Tungaru Central Hospital. The rising main has been designed for a population of 10,000 on the greater Temaiku area. The outfall at the hospital is being designed for the same population, plus the flows from the Bikenibeu east and Nawerewere areas in the anticipation of centralised sewerage to the areas at a later date. The implementation of the Temaiku off-site infrastructure will start during 2012.

7.8.4 Expansion outwards from existing systems

The roadmap recommends the gradual installation of area sewer systems in stages developing outwards from the existing systems, discharging initially on the upgraded outfalls at Bairiki, Bikenibeu, and Tungaru Hospital, then for the central villages connecting to a new outfall to be located at Taboria. Table E7 summaries the details of the proposed sub-systems and the initial timing selected for their implementation. Provision has been included in the estimates for all engineering costs and physical contingencies and for engineering appraisal of the new Taboria outfall with bathometric studies and the preparation of an EIA.

Table E7: Description, Scheduling and Estimated Cost of Centralised Sewerage

Sub System	Description	Schedule	Estimate
Nanikai to Teaoraereke West	Sub system connecting Nanikai and Teaoraereke in vicinity of the Catholic Headquarters to Bairiki outfall through a rising main – with provision for leachate discharge from the Nanikai landfill.	2018	$3,021,000
Bikenibeu East (Abarao to Temaiku)	One sub-system connecting the Temaiku ocean side area (east of the airport turnoff) and Nawerewere through local gravity sewers connecting to a rising main which discharges through the upgraded Tungaru hospital outfall Second sub-system connecting Abarao east and intervening area through a second rising main to the hospital outfall Hospital outfall to be upgraded to accommodate flows as a component of NZAP offsite sanitation works for Temaiku model urban subdivision	2020	$3,417,000

Bikenibeu West	Sub system connecting the eastern end of Abarao to west Bikenibeu and servicing the intervening lands through local gravity systems connecting to a rising main brought to and discharging through the Bikenibeu ocean outfall	2023	$4,010,000
Teaoraereke to Eita Stage 1: Ambo to Taboria (East)	Provision of a centralised sewer system for the central villages of South Tarawa. This will be approached in the following stages Providing for the construction of the new centrally located ocean outfall at Taboria and the installation of sewers to service the area from the vicinity of the Catholic church in Ambo in the west to and including Taboria in the east. Local gravity pipelines connecting to a common rising main discharging at the new ocean outfall	2025	$3,907,000
Stage 2: Ambo and Antebuka in the west and Taboria to central Eita in the east	Extended systems moving outwards from the stage 1 improvements with local gravity systems connecting to the common rising main linking to the ocean outfall at Taboria	2027	$4,420,000
Stage 3: Teaoraereke East and the bulk of Eita	Further extension from the sewer network established in stages 1 and 2 with local gravity networks connecting to the common rising main linking to the ocean outfall at Taboria.	2029	$4,750,000
Stage 4: The remaining section of Teaoraereke in the west and the remaining section of Eita in the east (Tebikenikora)	The completion of the remaining sections of central South Tarawa extending outwards from stages 1, 2 and 3 again with local gravity networks connecting to the common rising main linking to the ocean outfall at Taboria.	2031	$2,435,000
TOTAL			**$25,960,000**

7.8.5 Operations and maintenance – new systems

The O& M costs for the new sewer extensions have been calculated based on estimates of cost prepared under TA 7359-KIR. The O&M costs average $11.33 per household/mth.

7.8.6 Systematic and least cost approach

The approach taken has been to spread the costs over time and therefore bring a systematic and more affordable approach to the provision of sanitation. The gradual approach also allows deferral or advancement of subsequent stages depending upon final population growth and the effectiveness or otherwise of the on-site sanitation systems.

8 Road Map Recommendations

8.1 Elements

The roadmap brings together the requirements for water supply and sanitation and displays

the respective priorities for each. The priorities build upon population growth and densities on South Tarawa. These create an undeniable need for immediate additional safe water supplies to relieve critical shortages, and improved sanitation and hygiene and health practices to head off a surge in waterborne diseases that will otherwise occur from overcrowding coupled with inadequate provision of basic infrastructure services.

The analysis highlights South Tarawa's limited safe water resources, the need to protect the available resources at the Bonriki and Buota reserves from pollution and the high risk of the loss of these essential resources. The water resource assessment conducted during the assignment has also confirmed the fragility of the groundwater lenses elsewhere in South Tarawa, their limited ability to survive an extended drought and the high rate of abstraction for secondary use for bucket flushing of toilets, bathing and washing. Water quality throughout is poor with high bacteriological contamination, high nitrate levels and in locations the presence of oils and fuels.

The conclusion is that the degraded urban lens should remain for secondary use. The fresh water bucket flushing of toilets where freshwater is lost by discharge through the ocean outfalls should cease. The circumstances provide three clear messages, the first being the critical shortage of safe water supplies and the vulnerability of the secondary water resources the community presently depends upon for washing and bathing, the second being the unacceptable loss of scarce potable water in the distribution systems, and the third being that future sanitation systems will, of necessity, have to be predicated on the use of saltwater for flushing.

Long-term community awareness programs and capacity building programs for PUB and MPWU are being provided through KAP III, ADB's STSISP, NZAP's Urban Development programs with harmonized activities. With these programs in place the priorities in overall terms become:

Water Supplies:

1. Immediate restoration of the Buota water supply connection;
2. Leak detection and demand management of PUB's systems for efficient water supply services. Here the roadmap identifies the continuing need for long-term leak detection programs as a normal component of PUB operations;
3. Contingent upon item 2 above the urgent provision of additional water supplies for South Tarawa, through the provision of desalination plants;
4. Immediate protection and quarantining of the Bonriki and Buota water reserves;
5. Improvement of the Bonriki reserve capacity through the selective culling of coconut and pandanus palms, and the clearing and infilling of the borrow pits on the reserve;
6. Continued Rainwater Harvesting;
7. Improvement of the Tungaru Central Hospital water supply system;
8. The sparing of pumps and valves for the Bonriki galleries, improvements to the Bonriki treatment plant, replacement of the Betio rechlorination unit and the cleansing/repair of service reservoirs;
9. Offsite infrastructure (water supply) for the Temaiku model urban subdivision;

Sanitation

1. The rehabilitation of the existing sewer systems with the restoration of the saltwater flushing systems and the upgrading of the ocean outfalls;
2. The pilot onsite sanitation sub-project and monitoring and alignment of the National Sanitation Guidelines;
3. Extension of the existing sewerage systems at Betio, Bairiki and Bikenibeu to provide for the connection of 100% of the population within the service areas;
4. Improvement of the Tungaru Central Hospital sanitation systems;
5. Continuing provision of sanitation to the sections of South Tarawa without sewerage through a combination of extended sewer systems and onsite sanitation;
6. Offsite infrastructure (sanitation) for the Temaiku model urban subdivision.

All actions indentified by the roadmap are closely intertwined and for sustainability require a whole of sector approach between government and its communities. Institutional alignment will be necessary to strengthen sector policy and regulatory frameworks and the actioning of obligations flowing from these leading to more effective utility operations. Equitable cost recovery for operations and maintenance will be crucial for sustainability. Least cost options will take precedent over more costly and possibly desirable alternatives, where these least cost options are shown to be effective with acceptable longer-term operating and maintenance costs.

8.2 Investment Plan

The investment required over the twenty years to 2030 is substantial amounting to $20,904,039 for water supply improvements and $45,022,389 for sanitation infrastructure. Existing development partner commitments amount to $3,691,000 for water supply and $13,511,000 for sanitation, leaving balances of $17,213,039 and $31,511,389 respectively for which future funding will be required. The investment plan in the roadmap shows the funds required annually on the basis of a proposed implementation plan and the assumptions upon which this is based.

8.3 Overarching Requirements

The roadmap recognises the need for fundamental shifts in the past approaches for identifying infrastructure needs and their maintenance and operations into the future. The initial provisions to give impetus to these changes are largely in place within the designs for KAP III and STSISP. These existing commitments and their intended outcomes are covered in the roadmap and the related implementation plan. In summary the proposed activities will provide for:

1. Sector Regulation and Institutional Strengthening and Capacity Building
2. PUB assistance for Institutional Strengthening and Capacity Building
3. PUB support for Operations and Maintenance
4. PUB support for Financial Systems and setting of Fees and Charges - Sustainability
5. Asset Management for Water and Sanitation
6. Community Awareness Program – harmonised and long-term

8.4 Operations and Maintenance Costs

Inadequate revenues and cash resources have led to poor maintenance of the water supply and sanitation infrastructure with declining standards of services and failing infrastructure. Rehabilitation is required in advance expected useful life. PUB customers have signalled their discontent with the services by withholding payment for services.

PUB's accounts do not provide an accurate breakdown of the total costs for providing water supply and sanitation. In the past there has been a considerable cross-subsidy from the electricity activities to water supply and sanitation. Likewise shared operations and maintenance, staffing and administration functions have not been apportioned. The roadmap therefore reallocates these costs and provides for electricity meters on all electrical equipment to properly account accurately for these costs.

PUB continues to be constrained by its weak financial position for the maintenance of infrastructure. Capital expenditure for remains dependent on development partner funding. This situation has lead to deteriorated assets, unreliable services, default on the part of customers and a downwards spiral of infrastructure and service failure. To overcome the present circumstances PUB needs government and development partner support to enable it to improve its operations.

PUB's operations and maintenance costs have been established including those costs associated with future water sources and sewerage for South Tarawa. The O&M costs have been captured and developed. The O&M costs have been developed and used to assess equitable fees and charges for water supply and sanitation. The O&M costs align with the respective costs established from the financial assessment for STSISP and the draft PUB Asset Management Plan prepared by TA 7359-KIR.

The roadmap also considers and discusses the opportunities for PUB to focus on core activities out-source tasks with a potential for reduced overheads and direct saving in operations and maintenance.

8.5 Fees and Charges – Sustainability

Water and sewerage services in South Tarawa have been dependent on government subsidies. Water service operating losses were approximately $513,000 in 2010. Annual government subsidies for sewerage services were $480,000 in 2010, Water and sewerage operating costs have previously been understated with costs for electricity being bundled into the electricity operations.

Domestic water supply is not metered. PUB achieved revenue collection rates in 2010 of 84.5%% and 70% for domestic and non-domestic customers respectively (inclusive of arrears). No sewerage tariffs are charged.

Consultations occurred with accommodation providers, business services, church representatives, government ministries, local government officials and members of the public. There is a high level of dissatisfaction with the present level of services provided by PUB with many considering PUB to be poorly managed. Users leave their taps on continuously to receive whatever water is provided. Domestic customers expressed willingness to pay a higher overall tariff for improved water and sewerage services with the support linked to the nature and quality of the service provided.

While poor service delivery rather than ability to pay considerations is the major cause of current weak collection levels for water services a conservative assessment of ability to pay

trends suggests that 20% to 30% of households on South Tarawa are likely to have limited ability to pay for utility services in the foreseeable future. Although the objective of the roadmap is to eventually extend water supply and sanitation to 100% of the households on South Tarawa it needs to be noted that there will be a proportion of households who through circumstances will not have their own water and sewer connections, for example high density areas where space precludes the ability to provide separate toilet cubicles. These households and low-income groups will depend upon communal toilets and possibly water standpipes or water kiosks. The roadmap raises these options and the possibility of PUB responsibility with management and cleaning contracted to the private sector or community/church groups.

The community can easily distinguish the difference in service levels between those of PUB's water services and other pre-paid utility services currently provided in South Tarawa.

The results of the 2010 poverty study and the recent PUB electricity segmentation study suggest that planning on a cost recovery level of more than 80% for domestic water supply in the medium to long term is unrealistic with an expanded cost base. In the short to medium term water cost recovery targets for use in modelling the supporting financial projections of 80% and 60% for non-domestic and domestic customers respectively are suggested.

Stakeholder consultations suggest there is some support in the community for partial contributions to the cost of domestic sewerage services, subject to the provision of a satisfactory service. At best, partial cost recovery is possible in domestic sewerage services. A target recovery rate of 50% of operating costs appears an upper limit at this point with an expanded cost base.

Many PUB customers are conscious of the difference between functioning pre-paid telecommunication and transport services and PUB's current very poor performing water service, paid in arrears. On balance there is reasonable willingness to make additional payments for water services amongst South Tarawa households providing PUB's water services are maintained at acceptable levels.

WATER AND SANITATION ROADMAP

I. Background

1 Introduction

1. This roadmap for water and sanitation is the result of consultation with stakeholders across government and the private sector. The intention is to create an efficient framework that will enable infrastructure in Tarawa, especially South Tarawa to do what infrastructure is supposed to do: help drive sustainable economic growth for the country and a higher standard of living for the people. Discussions were held with sector stakeholders in preparing this document. Concerns about the short comings of present water and sanitation infrastructure planning and management were raised by officials and the community. The need for a coherent and practical roadmap to bring the desired improvements, while retaining a process that suits the limited resources of Kiribati has wide support.

2. The process of road map development has therefore been guided by consultations at user and management level. These consultations have occurred during the development of the Tarawa Water Master Plan and continued for the development of this roadmap through discussions with the PUB, MPWU, MELAD, MHMS and NWSCC and through a structured program of community consultations organized by TA 7359-KIR. The concerns, perceptions and insights of the communities who depend on water supplies as well as those of the PUB in managing the services and of MPWU and the Government in setting policy have been taken into account in shaping the roadmap. The primary findings of the roadmap were presented to a workshop on sector stakeholders held in the Parliament Buildings, South Tarawa on 28 and 29 November 2011. The findings were received and endorsed by the stakeholders in their discussions.

3. The document starts with a resume of the infrastructure sector, refers to the findings of recent studies and reviews the concerns held regarding the performance of the infrastructure and the key agencies responsible for its delivery. It takes account of the lessons learned in previous projects designed to improve water and sanitation infrastructure and service delivery. The roadmap builds on the policies of the government and thus has a large 'home grown' element.

4. To date all effort to improve the water and sanitation has been largely ineffective with much being written about the needs of South Tarawa and the capabilities of the sector agencies. The preparation of the roadmap involved reading the many previous reports prepared for the development partners and the government since the 1980s. Granted some of these reports fell below expectations and having given inadequate consideration to Kiribati's shallow technical resources and the local customary protocols which inhibit effective water and sanitation provision, contain inappropriate or impractical recommendations. Many however are excellent and represent a considerable national resource. Some of the reports from a decade or more ago contain recommendations that are timely even today, for example the fragility and risks to the freshwater lenses underlying South Tarawa were identified in 1989[1] and this message has been repeated in the reports since. While it is not proposed here that old studies be dug up and the actions resulting from them, reviewed and reported on at depth, the contents of the reports have been assessed to ensure that the roadmap remains targeted on government's genuine needs and actually prioritises the most relevant and acceptable solutions. The feedback from the consultation meetings conducted during the preparation of the roadmap indicates strong frustration at the

[1] The Viability of Groundwater Development on the Islets of the Tarawa Atoll, a Hydrogeological Reconnaissance. Author A M van Putten for Water Resource Assessment and Planning in Pacific Islands, Project RAS/87/009, May 1989

inability to provide water and sanitation services of acceptable standards, and the past work which lead nowhere, nor brought any meaningful change.

5. The problems associated in protecting freshwater resources and in managing population growth has brought the situation to a crisis point where the future of South Tarawa as it exists is at risk and where, without a sustainable water supply and effective sanitation the future is bleak. This situation is not entirely a result of global warming, nor has it creep up in unheralded. While global warming and sea level rise impact on the ability to service future water supply needs and has been taken into account in the roadmap, the main issue is the sheer number of people and future population densities to be serviced. The solutions, that they are, require immediate decision and this roadmap attempts to identify a clear set of actionable recommendations to provide a managed way forward.

2 Overall Approach

6. The requirement of this component of TA 7359-KIR[2] is to deliver a prioritized and costed water supply and sanitation roadmap and investment plan for Tarawa for the period from 2011 to 2030. The roadmap is to be fully consistent with the National Sanitation Policy (NSP), and the National Water Resources Policy (NWRP) and their Implementation Plans. The roadmap is also to identify options and solutions and recommend changes to institutional, regulatory and financial arrangements within the water supply and sanitation sectors to ensure sustainability of water supply and sanitation services in Tarawa.

7. The roadmap does not replace the Tarawa Master Water Plan or the National Water Resources and Sanitation policies and their Implementation Plans. Rather it has taken the investigation and analysis of the policies and their respective 10-year implementation plans, and for water the Tarawa Water Master Plan, to a more detailed level to help clarify the future choices for the sector and the provision of infrastructure with knowledge of priorities, costs and time frames and an understanding of the likely technical requirements and issues relating to operations and maintenance.

8. The sanitation sector has been assessed for sewer and wastewater loads based on population growth projections for high, medium, and low-population growth assuming one hundred percent access to improved sanitation in South Tarawa. Sewerage/sanitation technologies suitable for South Tarawa for both centralized and on-site systems have been assessed as have the sanitation investment options and phasing of sanitation infrastructure for appropriate collection with treatment and disposal of current and projected wastewater loads.

9. The water sector has been assessed for current and projected demand for water and per capita consumption rates for the high, medium, and low-population growth assuming one hundred percent access to clean water. The sustainable abstraction rates for the groundwater reserves in North and South Tarawa have been assessed. The groundwater lenses underlying Bairiki, Betio, and Bikenibeu have been assessed and water quality investigated in order to assess the role of suitable options for treatment for potable use and/or non-potable use and the potential impacts on private shallow wells. A review has been conducted of the options for future freshwater supply proposed in the Tarawa Water Master Plan TWMP) and suitable technologies based on the economic, social and financial feasibility of each option. The condition of South Tarawa's piped water supply infrastructure has been investigated to identify necessary rehabilitation and upgrading works to increase access and reliability of water supply, the water sector investment requirements, and phasing of infrastructure investments for the most appropriate water supply option(s).

10. In Conjunction with the preparation of the roadmap, TA 7359-KIR carried out community consultation and developed a community education and awareness program (CEAP), based on sanitation needs, good hygiene and safe water usage to promote

[2] TA 7359-KIR, Tarawa Sanitation Improvement Project, 2011

behaviour change for improved public health and community demand for improved water supply, and sanitation services. Draft land use / zoning plans for South Tarawa have also been developed in conjunction with the Ministry of Environment, Lands and Agricultural Development (MELAD) and key stakeholders to indicate the phasing of development to 2030 to accommodate population and urban development.

3 Guiding Documents

11. The roadmap draws heavily on the Tarawa Water Master Plan and companion reports; “Te Karau, Rainwater Harvesting, Storage and Use”, “Te Ran, Groundwater; Te Ran-Maitira ae Kainanoaki”, “Future Water Demand; Other Sources” (author Prof Ian White) and the National Water Resource Policy (NWRP) and National Sanitation Policy (NSP). Other documents drawn upon are the Government’s Water, Sanitation and Solid Waste (WSSW) Program and the GWP (2010) Island Water Resource Survey, North Tarawa.

12. The key findings of these documents have been reviewed. The roadmap accepts the findings of the documents and in the interests of brevity does not repeat the comprehensive analyses of each report. Reference is made to the documents from which information or statements have been uplifted with any analysis being confined to updating information where more recent data has come to hand, for example the preliminary results of the 2010 Census and the population and urban growth management predictions developed by TA 7359-KIR. A list of the documents available and referenced in the preparation of this road map is presented as Appendix 1.

4 Layout of the Roadmap – Report and Volumes

13. The Roadmap is presented as three complementary volumes:

a) Volume 1 - the roadmap report (this document) culminating in the future prioritized works and their estimates of cost and the investment plan;

b) Volume 2 - the appendices referred to in this roadmap; and

c) An A3 portfolio of plans, drawings and figures presenting background information and the existing and future water and sanitation infrastructure improvement.

14. Volumes 2 and 3 are fully cross referenced in this roadmap for the convenience of the reader.

5 Acknowledgement

15. The consultant wishes to thank all participants for their contributions and cooperation.

II. The Sector

6 Importance and Relevance to South Tarawa

16. South Tarawa consists of a series of islets joined by causeways and located along the southern rim of Tarawa Atoll with a total land area of just over 12 square kilometres (km^2).[3] High population density, a lack of potable and secondary water supply, poor hygiene practices and inadequate sanitation infrastructure have contributed to a high prevalence of waterborne disease among the local population and the deterioration of the natural environment. The development of the water supply and sanitation roadmap 2011 to 2030 and associated investment plan, with required due diligence[4] has the object of enhancing access by South Tarawa's urban population to improved water and sanitation infrastructure and services.

17. 50,402 people, almost 50% of Kiribati's population of 103,466 live in South Tarawa, the country's political and economic centre. South Tarawa's main urban areas of Bairiki, Betio and Bikenibeu have a combined population of 24,171. Rapid urbanization has resulted in an annual average population growth rate of 4.4% since 2005 with a longer-term underlying growth rate of 3.87%. The average population density in South Tarawa is 4,150 /km^2, and in Betio[5] as high as 10,610/km^2. Population pressures combined with uncontrolled urban settlement have resulted in overcrowding that is putting stress on crucial public infrastructure and the natural environment.

18. Kiribati's per capita Gross Domestic Product is low by Pacific standards but there is little extreme or absolute poverty as households without formal incomes are supported by gardening, fishing, carpentry or handicraft making or receive remittances from family members working abroad. The challenge is to increase the opportunities for economic growth and private sector activity to improve lifestyles and sustainability through assisting the community to meet the costs of infrastructure through equitable tariffs and payments for service.

6.1 Public Health

19. Kiribati has an extremely high incidence of water-borne diseases with an infant mortality rate amongst the highest in the Pacific[6] at 46 per 1,000 live births, which is attributed to infantile diarrhoea.[7] The World Health Organization (WHO) and health officials report[8] an average of three outbreaks of diarrhoea annually directly linked to poor water supplies, inadequate sanitation, unsafe practices and poor public hygiene. In 2010, in South Tarawa almost one person in four was affected by diarrhoea or dysentery to the degree that required a visit to a health clinic. For the crowded area of Betio the percentage increased to 54% visiting a clinic. Infants are particularly vulnerable; a reported four infants/children die of diarrhoea every month in South Tarawa. This high incidence of dysentery and diarrhoea is a gross indicator of potentially more serious water-borne diseases such as typhoid and cholera resulting from the pollution of the water lenses from human and animal wastes. The

[3] Consultant measurement from GIS maps confirmed by SOPAC Land Cover Type Mapping, Tarawa, 29 October 2010
[4] TA 7359-KIR: Preparing the Tarawa Sanitation Improvement Project was approved 1 October 2009.
[5] National Statistics Office, 2010. Census, Household and Population Count. Government of Kiribati. Bairiki.
[6] Mortality rates in 2005 for children under the age of 15 years in the Pacific and selected countries. Country Health Information Profiles, 2005-WHO.
[7] UNICEF. *Country Profile – Kiribati Maternal, Newborn and Child Survival.* November 2008.
[8] Discussions in October 2009.

2005 Census reported the existence of 13,184 pigs on South Tarawa adding to the human waste stream[9] with each pig being equivalent to 2 additional people.

20. The medical services in South Tarawa have been described as being overburdened with dysentery and diarrhoea[10] with high incidences of non-pneumonia (21,686) and pneumonia (1,485) during 2010 (Betio 10,184 and 415 respectively); acute temperature without rash 7,260 (Betio 3,307) and increasing incidents of leprosy, all diseases symptomatic of overcrowded living conditions. In November 2010 the Ministry of Health and Medical Services (MHMS) confirmed an outbreak of fever and vomiting, particularly among children living in Betio and South Tarawa which WHO treated as a typhoid fever outbreak. These poor health statistics lend weight to the urgent need for water supply and sanitation improvements and underscore the future issues for South Tarawa if matters continue unchanged.

6.2 Water Resources

21. The current sustainable yield from the groundwater reserves for South Tarawa of Bonriki and Buota (when reconnected) is estimated at 2,010 m^3 per day.[11] Groundwater is presently being abstracted from the Bonriki water reserve alone at an average rate of around 2,000 m^3 per day exceeding the long-term sustainable abstraction rate by an estimated 20%. This is partly because the Buota reserve was severed from the supply in 2008 when the bridge linking Buota with South Tarawa collapsed. Since then, and with the replacement of the bridge, the well heads and electrical control boxes have been rehabilitated under KAP II along with the replacement of the transmission pipeline. Buota is scheduled to be reconnected in the immediate future.

22. Protection of groundwater in the main reserve at Bonriki is not strictly enforced resulting in human encroachment, illegal sand and gravel mining, construction of latrines, digging of open wells, and active use of cemeteries. The groundwater is already contaminated and a report on the treatment plant and disinfection process later in the roadmap makes an alert to the ability of retaining the Bonriki water reserve as a fresh water resource for South Tarawa into the future. Without urgent action to protect the reserve in a meaningful way, the resource is at extreme risk of being lost as a resource.

23. With an average annual rainfall of 2,040 mm, South Tarawa has significant potential for rainwater harvesting. In 2005 some 43% of households throughout South Tarawa were reported to use rainwater, mostly for drinking and cooking. During the intervening years a number of programs have been implemented to promote the use of rainwater tanks. Seasonal variations in the rainfall pattern and Tarawa's vulnerability to drought make reliance on rainwater as the sole source of drinking water useful as a buffer during “wet” times, but unfeasible as a reliable supply during extended dry periods and droughts. While development partners and the Government have prioritised further development of rainwater harvesting, especially of the large community buildings to balance and supplement the demand for potable water from the groundwater sources this approach needs review to ensure the perceived benefits are materialising and for the actions to support improved public health.

24. The 2010 Census return reveals only 628 or 9% of the households on South Tarawa using rainwater tanks as their main source of drinking water. The 2005 return and community survey results under TA 7359-KIR indicated a preference for rainwater as the “best” and “cleanest” source of drinking water statements which do not to be borne out by the latest census return. Under microcredit arrangements set up under the SAPHE[12] project

[9] 2010 Census figures not yet available for the number of pigs
[10] Health of Health Services – consultation meeting, August 2011
[11] Tarawa Water Master Plan, Te Ran, Groundwater, Dr. Ian White and Tony Falkland. KAP II July 2009
[12] Sanitation, Public Health and Environmental Improvement Project, ADB c 2004

the Kiribati Housing Corporation approved loans for the installation of 1,211 rainwater tanks between 2002 and 2010. This also runs counter to the 2010 census return suggesting that the credits approved may have been applied for purposes other than new rainwater tanks, while other rain water tanks may have fallen into disrepair or disuse. The National Statistics Office NSO has confirmed that in 2005 their census return allowed a multiple response whereas for 2010 the question specifically related to the main source of drinking water. In 2005 the response to all forms of use was around 150% compared to a firm 100% for all main sources of drinking water in 2010.

6.3 Water Supply

25. The piped water supply system on South Tarawa is managed by the Public Utilities Board (PUB) and supplies water to some 4,482 households[13] on an intermittent basis for two hours every second day. Leakage in the system is stated to be around 67%.[14] The quality of the water provided by the public water supply system has decreased over the past years and in 2010 more than 50% of the samples taken by MHMS showed bacteriological loading and did not meet basic WHO standards. Due to the low level of service, the residential bill collection rate has dropped away. The tests of rainwater tanks were little better showing that 50% of the tanks also failed to meet the WHO standard. Recent testing by TA 7359-KIR showed acceptable results in the PUB water at the treatment plant in Bonriki and in the transmission main and the service reservoirs (with one exception at Bairiki where the tank access cover was displaced). Beyond the service reservoirs the water quality dropped off. With few exceptions the testing of rainwater tanks showed poor and unacceptable bacteriological results.

26. Some 1,534 households, 23%[15] of the population makes use of shallow wells (open and protected) as their main source for drinking water, with most groups also relying heavily on this source for daily non–potable water needs. Groundwater in South Tarawa is contaminated and unsafe and has been confirmed as a source of water-borne diseases. MHMS monitors the quality of groundwater in South Tarawa on an eight week cycle and has confirmed that during 2010 around 85% of the samples exceeded WHO standards for faecal coliform. Also of concern is the fact that the 2010 testing showed that 80% of all samples from the wells exceeded the WHO standard for nitrate levels. The recent testing by TA 7359-KIR confirmed the total unacceptability of the lenses for human consumption. Table I shows the 2010 Census return for the source of main drinking water for South Tarawa households.

[13] 2010 Census return

[14] PUB report to NWSCC, 29 August 2010. Twenty-nine percent loss in the main transmission and rising mains plus 50% loss through the reticulation systems. Of the 2000 m^3 extracted from the Bonriki reserve only 705 m^3 estimated is delivered to customers

[15] Census 2005 and Tarawa Water master Plan – Future Demand, Dr. Ian White and Tony Falkland. KAP II August 2009

Table 1: Main Source of Drinking Water (from 2010 Census)

Geographic Location	Total	Rain Water Tank	Piped System (PUB)	Open Well	Protected Well	Bottled Water	Other	Missing
BONRIKI	381	9	103	177	88	0	1	0
TEMAIKU	489	47	22	253	162	1	1	1
BIKENIBEU	1,087	70	839	55	116	2	2	3
ABARAO	414	36	315	44	16	2	0	1
EITA	293	19	133	78	61	0	1	1
TABORIA	186	31	132	16	7	0	0	0
AMBO	332	42	225	11	49	2	0	3
ANTEBUKA	533	40	330	50	111	2	0	0
TAEORAEREKA	484	70	296	73	42	1	1	1
NANIKAI	119	2	115	0	1	0	0	1
BAIRIKI	404	36	353	6	1	4	0	4
BETIO	1,979	226	1,619	42	75	7	2	8
TOTAL	6,701	628	4,482	805	729	21	8	23
PERCENTAGE	100	9	67	12	11	1	0	0

27. Other issues are the lack of a consolidated water and sanitation law, the absence of a sector regulatory framework for acceptable standards and levels of service, and, the financial performance of PUB where most of the twenty-five percent overall recovery from water sales is not from piped water sales but from tanker supplies, for which the charge is related to volume and easily recovered before or at delivery.

28. PUB customers indicate that PUB water is rated as less safe than rain water and marginally better than well water as consumers don't fully trust PUB's disinfection of the piped supply. Because of the high contamination of all supplies MHMS tells people to boil water requiring the use of costly fuel. Paradoxically boiling the water is not a total panacea as the boiling will concentrate the nitrates in the water and will not remove *Giardia* or *Cryptosporidium* if these parasites are present, so boiling water does not necessarily provide safe water. If PUB water is disinfected and can be delivered to customers in acceptable quantities, pressure and quality with residual chlorination, the time and cost to households will be reduced. In the scale of acceptability and reliability the piped water supply should be the potable water of choice. Improved disinfection, improved supply line pressures and network integrity, coupled with regular and transparent testing of water quality will be necessary to build consumer confidence in the supply. The PUB also presently suffers from a serious problem of both customers and non-customers tampering with the water distribution network.[16]

6.4 Sanitation

29. The public sewerage systems in Betio. Bairiki and part Bikenibeu operated by the PUB service around one quarter of South Tarawa's population.[17] To conserve limited freshwater supplies, a saltwater reticulation system supplies seawater for toilet flushing. The traditional practice of defecating in the open is widespread and is reportedly engaged in by some 22% of South Tarawa's population.[18] Leakage of effluent from both pit latrines and poorly constructed and maintained septic tanks contributes to contamination of groundwater.

[16] PUB Business Plan 2010-2011 sec 8 p6

[17] The estimate is based on recent PUB information on existing household connections and the preliminary results of the 2010 Census.

[18] According to the 2010 Census returns, 26% of households in South Tarawa use flush toilets connected to the PUB systems, 39% use flush toilets connected to own septic tanks, 3% use composting toilets, 6% use the sea, 15% use the beach, 8% use pit latrines and 1% use the bush.

Table 2: Main Toilet Facility (from 2010 Census)

Geographic Location	Total	Flush Toilet PUB System	Flush Toilet Own Septic	Pit Latrine	Beach	Compost Toilet	Sea	Bush	Other	Missing
BONRIKI	381	6	143	1	97	1	72	43	16	2
TEMAIKU	489	10	203	11	123	61	38	41	1	1
BIKENIBEU	1,087	367	521	8	75	37	45	1	30	3
ABARAO	415	29	231	37	48	10	47	1	11	1
EITA	293	32	144	30	56	2	29	0	0	0
TABORIA	186	4	130	0	39	1	8	0	3	1
AMBO	332	9	185	0	93	7	34	0	4	0
ANTEBUKA	533	12	279	43	176	1	19	0	3	0
TAEORAEREKA	484	17	255	73	92	3	36	0	7	1
NANIKAI	119	0	64	1	41	2	7	0	3	1
BAIRIKI	404	262	80	0	19	6	32	0	3	2
BETIO	1,978	1,025	362	325	129	42	50	1	40	4
TOTAL	6,701	1,773	2,597	529	988	173	417	87	121	16
PERCENTAGE	100	26	39	8	15	3	6	1	2	0

30. The health impacts of poor sanitation infrastructure in South Tarawa are evident. Inadequate sanitation infrastructure is a key contributor to contamination of freshwater lenses and near-shore areas of the lagoon.[19] Inadequate hand washing and consumption of untreated water and contaminated shellfish have resulted in widespread gastrointestinal disease. Typhoid outbreaks occurred in South Tarawa in 2009 and 2010 (suspected). The infant mortality rate attributable to inadequate sanitation and poor public hygiene is high.

31. Weak capacity to manage existing sanitation assets and operations among PUB and Ministry of Public Works and Utilities (MPWU) staff has contributed to chronic underperformance of both the water supply and sewerage systems. Sewerage services are provided free of charge to customers. While operations and maintenance (O&M) activities for sewerage have been funded through government transfers, periodic capital investments in sanitation system rehabilitation and upgrading have been externally financed by development partners. The current situation has resulted in low sustainability. In the absence of adequate resources, no preventive or routine maintenance is carried out, and instead, maintenance has been deferred until the system has failed. This situation imposes high costs on both the government and the local population in terms of lost productivity, health expenditures, and degradation of freshwater resources and coastal areas.

7 Government Sector Strategy

32. The Kiribati Development Plan 2008-2011 commits to improving health outcomes, strengthening governance in the provision of public services, and investing in infrastructure. In March 2010, the Government of Kiribati requested the Pacific Infrastructure Advisory Centre (PIAC) to assist in formulating a coordinated whole-of-sector program for the water supply, sanitation, and solid waste (WSSW) sector in South Tarawa. This resulted in the development of a government program aimed at achieving improved access and WSSW service delivery. Chaired by the Secretary to the Cabinet, this high-level task force is responsible for monitoring implementation progress of the government's sector program. The task force is also the steering committee for the ADB South Tarawa Sanitation Improvement Sector Project.

33. The National Water and Sanitation Coordinating Committee (NWSCC), chaired by MPWU, is a multi-agency body with representatives from the ministries of health, public works, finance, environment, and internal affairs and nongovernment organizations. It provides a forum for discussing water- and sanitation-related policies, strategies, programs,

[19] D. Ramsay. 2011. Increased Flushing of Tarawa Lagoon: The Potential for Improving Public and Lagoon Ecosystem Health Outcomes. Draft report. National Institute for Water and Atmosphere. Hamilton.

and issues and meets when the need arises. With the funding now being directed to the sector and the funds likely to come, the Committee's role needs strengthening so it can play an effective and increasing role in the decisions required and in the feedback and briefing of constitute ministries and organisations. The appointment of a full-time technical secretary and the adoption of a firm calendar for meetings with action schedules and reporting back would lead to immediate improvement.

34. In 2009 and 2010, the Cabinet endorsed the country's national water resource and sanitation policies, with sector goals and objectives and their complementary 10-year implementation plans.[20] Policy objectives include sustainable water supplies to enhance the welfare and livelihood of I-Kiribati, the protection and conservation of freshwater sources for public water supplies, the efficient and effective delivery of freshwater, the provision of effective, acceptable, and appropriate sanitation, sanitation systems, practices that protect freshwater sources, lagoon waters and the environment, and reduced waterborne illness. These efforts are now supported by this roadmap designed to assist the sector planning efforts and the investments required over the medium to long term.[21]

35. To promote more effective and efficient delivery of water and sanitation services in South Tarawa, the government has recently requested PIAC to carry out a scoping study to assess alternative utility service delivery models with indications the study will start in 2012. Opportunities to increase private sector participation in the water and sanitation sector, such as contracting out of maintenance activities will be investigated.

8 Sector Regulation, Governance and Planning

36. MPWU is responsible for the policies and regulations for the sector. However the Ministry is largely focused on service delivery to the outer islands and little or no staff effort is presently allocated to policy development, review, implementation or monitoring, with the exception of monitoring national water reserves. The institutional assessment under TA 7359-KIR has suggested changes to improve the focus of MPWU activities.[22]

37. The Public Utilities Ordinance of 1977 assigns the responsibility for water supply and waste water management to PUB, with the following rights and obligations; exclusive right to supply water in designated water supply areas (including South Tarawa); transfer of all water supply and sewerage assets to PUB; ability to declare water reserve areas after approval of the MPWU; and, ability to set water tariffs after consultation with MPWU.

38. The TA 7359-KIR institutional assessment notes that "In the current global philosophies of public sector management it would be somewhat natural to assume that PUB is an SOE, to be managed as a "successful business", owned and operated by the State. The present governance structure for PUB, with a high proportion of government officials suggests that the "successful business" model has not been fully applied, and there is some conflict of objectives between business performance and contributing to achieving Government of Kiribati (GoK) objectives. This dichotomy of objectives is reinforced by an examination of the PUB Business Plan. The Plan identifies nine key challenges for PUB, six of which relate to water supplies and sanitation. However, the thrust of the detailed objectives is towards supporting the Kiribati Development Plan goals. Financial issues are addressed in only seven historically focused lines of text, with no reference to such targets as return on assets or investments. Detailed budgets – right down to packets of paperclips and the number and cost of mobile phone recharge cards – are included. Clearly defined

[20] Government of Kiribati. 2010. National Sanitation Policy: Sanitation Options Assessment. Tarawa: Ministry of Public Works and Utilities; Government of Kiribati. 2010. National Sanitation Implementation Plan: Effective Sanitation for Health Communities, Environments and Sustainable Development: A 10-Year Plan. Tarawa: Ministry of Public Works and Utilities.

[21] The roadmap forms a component of TA 7359-KIR: Preparing the Tarawa Sanitation Improvement Project.

[22] TA 7359-KIR Tarawa Sanitation Improvement Project – Institutional Assessment and Report

strategies to address the operational challenges facing PUB are absent unless they are implicit in the wider activities to support Government development plans.[23] "

39. Kiribati has relied upon the development partner community to fund major infrastructure investments. A main difficulty in assessing the sustainability of the infrastructure sector in Kiribati is the fact that capital is, in effect, treated as a free good. As a result, there is a low priority given to infrastructure maintenance activities, and externally financed infrastructure has been allowed to deteriorate often rapidly. Attitudes towards payment for water and sanitation services, as well as the poor quality of service delivery have resulted in low willingness to pay among households. This in turn has contributed to poor financial sustainability of operations, creating a downward spiral in the quality of the services provided.

40. Comprehensive recommendations have been presented by TA 7359-KIR for the institutional strengthening and capacity building of PUB to bring commercial attitudes and performance to its activities. KAP III and the ADB South Tarawa Sanitation Improvement Sector Project (STSISP) propose embedded TA assistance to PUB for financial, operations and asset management and leak detection as key areas of assistance. The roadmap has been developed on the basis that this assistance will be forthcoming and that the necessary changes will take root rapidly in the immediate two to three years.

41. Overall the sector stakeholders and institutions include:

a) The South Tarawa communities;

b) The Ministry for Health and Medical Services – health inspectorate services, water quality monitoring and environmental health;

c) Ministry for the Environment, Lands and Agricultural Development – environment and conservation; policies and regulations for waste and pollution management. Land planning and urban growth management. Responsible for Land of the Water Reserves;

d) Non-government groups: the Kiribati Women's Federation (AMAK), the Kiribati Association of NGOs (KANGO), the Kiribati Chamber of Commerce and Industry (KCC&I) and the Kiribati Council of Churches;

e) The two Urban Councils in South Tarawa, The Betio Town Council (BTC) and Teinainano Urban Council (TUC) with responsibility for urban planning and management and the issue of building, plumbing and drainage permissions;

f) National Water and Sanitation Coordination Committee (NWSCC) chaired by MPWU, an inter-ministerial and civil society forum agreeing and coordinating water and sanitation policies, strategies, planning and programs. The Committee meets as the need arises;

g) The Government's Water Sanitation and Solid Waste Task Force with a mandate for coordinating Government and development partner sector programs and initiatives;

h) Drought Committee. This is being formed, subject to Cabinet approval. Committee members receive monthly summaries of water reserves. The Committee has not met, because of lack of funding;

i) National Disaster Council. This is activated at times of national emergency.

42. The roadmap recognises, preserves and strengthens all the respective stakeholder and beneficiary interests.

[23] TA 7359 (KIR) Tarawa Sanitation Improvement Project – Institutional Assessment and Report

9 Sector Support and Future Needs

43. The development partners have been active in their support for water and sanitation needs with a number of significant completed projects and further identified ongoing and planned projects for South Tarawa. These initiatives are referred to in the roadmap and present projects, or projects which are about to start are identified in the roadmap strategy and investment plan.

44. The support shows a wide response in the coverage of sector needs, but with some remaining gaps relating to the management and protection of the water reserves at Bonriki and Buota, the development of a future water source(s), the rehabilitation of the existing water reticulation network and the eventual extension of sewerage for a 100% coverage in the sewered areas of Betio, Bairiki and Bikenibeu, and for the remainder of South Tarawa. These requirements are incorporated into the costed provisions of this water and sanitation roadmap.

III. Development Partner Sector Activities

10 Involvement

45. All major development partners are involved in Tarawa, in one way or another with sector initiatives. Most of these initiatives are identified in the Government of Kiribati's (GoK's) WSSW programme and cover work proposed under the World Bank supported KAP III, the ADB's STSISP, and the NZAP Urban Development Project (UDP). The Australian Government is involved with UNICEF in the upgrading of school water and sanitation and provides generous support to the other donor projects. The major activities for South Tarawa are summarised in the following statements.

10.1 KAP III

46. KAP III with a project Value of US$10.8 million is being co-financed by the Government of Australia, Japan (PHRD), the Global Facility for Disaster Reduction and Recovery (GFDRR), the Global Environment Fund (GEF) and the Government of Kiribati. The five-year implementation period commenced in September 2011.

47. The project's objective is to improve the resilience of Kiribati to the impacts of climate change on freshwater supply and coastal infrastructure. Component C1 of the project aims to Improve water resource use and management through reduced leakage and wastage in existing systems, increased yield from rainwater harvesting, improved asset management and strategic planning by local agencies in water and coastal engineering, and developing a methodology for community engagement to underwrite future management of the water reserves.

48. Selected South Tarawa communities will benefit through having rainwater harvesting systems installed, to supplement existing sources of water, the supply of which is limited and presently unreliable. The volume of water lost or wasted from the PUB reticulated water supply will be reduced, thereby increasing the volume of safe water available for public consumption. The project also will contribute to the development of staff in MPWU, PUB, OB, MELAD, MHMS, MISA and Island Councils through specific training, coaching and mentorship, and immersion in the project activities. In more specific terms the project will provide for:

a) **Water Reticulation Management** - (Leakage detection and repair of real losses). The project will expand on the small pilot carried out in Betio under KAP II and support the activities with capacity development and community awareness-raising under separate activities. It is understood the amount of US$860,000 has been set aside for this purpose;

b) **Roof Rainwater Harvesting** – To expand the program of installing rainwater harvesting systems on public buildings for community use that was started under KAP II with a budget of US$450,000 for rainwater harvesting associated with community buildings and US$150,000 for households;

c) **Improved Water Management Governance -** Improve the legislative and regulatory framework and governance model for water resources management with a focus on improved management and protection of the water reserves at Bonriki and Buota.

49. Each of the above activities will be supported with capacity enhancement and community consultation and education programs.

50. The leakage/wastage detection and repair program will give emphasis to planning alongside the undertaking field work including:

a) Defining isolation zones;

b) Developing and implementing flow measurement programs;

c) Analyzing flow data;

d) Documenting repair approaches and details;

e) Preparing community communication & education plans;

f) Preparing field work plans;

g) Briefing/coaching field supervisors/leading hands on roles and scheduled activities;

h) Briefing/coaching PUB field team members on roles, responsibilities and approaches to community engagement;

i) Implementing the leak detection and repair programs of work, with follow up monitoring of effectiveness of leakage reduction and take up of community behavior change initiatives.

51. A Senior Water Asset Management/ Operations Engineer is to be seconded into PUB for two years, with the option of extending the engagement to provide hands-on support and mentoring directly to staff for asset management, leak detection and other requirements for new and improved approaches to PUB's water operations. This work is to be compatible with asset management and operations improvement activities under ADB's STSISP and complementary work by the UDP funded by the New Zealand Aid Program.

10.2 New Zealand Aid Programme

52. **Urban Development Programme** - Previously NZAP had the intention to implement an urban development program evolving from a GoK/ Government of New Zealand review of the New Zealand Aid Programme's Kiribati Country Strategy in 2005.[24] In 2011 the Government of New Zealand, in assessing the lessons learned from its former sustainable town's project, concluded that a redesign of the project was in order to improve the focus of the project components and to better define the objectives and outputs to be achieved by the project. This review is proceeding and at the time of drafting this roadmap the final outcome is nearing a decision.

53. NZAP through the NZ High Commission has indicated a continuing desire to support interventions to address the poor living conditions on South Tarawa and to effectively manage urban growth. The questions being reconsidered are the form and direction of this support. The intention is to ensure New Zealand's contribution is properly and adequately targeted to better coordinate investments and achieve maximum impact and consistent with the efforts of the other development partners. NZAP activities will continue, with targeted support for improved sanitation services, possibly commitments to rainwater harvesting, improvement of the Bonriki water reserve to increase abstraction rates, and assistance to PUB for the acquisition of water tankers as an interim measure to improve water supply delivery. For sanitation consideration is likely to be given to the high density, low income areas of Betio with an emphasis on the piloting of a small sanitation improvement project.

54. **Temaiku Urban Subdivision** – engineering design for the Temaiku model urban subdivision and offsite infrastructure is proceeding. The subdivision consists of 150 fully serviced residential lots and associated commercial, light Industrial and community areas including health and education facilities. Civil works are scheduled to commence during 2012. The development is being designed as the centre of a new hub township for Temaiku with land raised to a minimum level of 3.5m UoH[25] Datum to place it above predicted inundation from the combined impacts of sea level rise and storm surge. Areas which are

[24] Joint Review of New Zealand and Australia's Development Cooperation Programmes for Kiribati (2005).
[25] University of Hawaii Datum

unlikely to be affected by irregular inundation, such as playing fields and open space areas, will be raised to a minimum of 3.0m UoH Datum.

55. Water supply for the Temaiku development will come from several sources, namely; reticulated PUB treated water from the Bonriki treatment plant (design of 25 L/pers/day with maximum demand up to 55 L/pers/day) for potable water including rainwater harvesting (up to 35 L/pers/day) for potable water; and (c) local groundwater wells (up to 30 L/pers/day) for non-potable water use.

56. An overall assessment of wastewater reticulation, treatment and disposal alternatives has been completed as part of the preliminary engineering design. A conventional sewerage system has been adopted for the subdivision discharging through a rising main to the existing ocean outfall at Tungaru Hospital. The outfall will be upgraded and deepened. The rising main and outfall will be sized to accommodate the future development of the remaining area of Temaiku and the area of Nawerewere and including the foreshore area in Temaiku past the turnoff to the airport. It would be expected that the upgraded outfall will transfer to PUB on completion of the works.

10.3 South Tarawa Sanitation Improvement Sector Project

57. The Project prepared by TA 7359-KIR during 2011 aims to improve the health of South Tarawa's population. The outcome will be that South Tarawa's urban population has enhanced access to improved sanitation infrastructure and services with outputs including, improved sanitation and hygiene practices among South Tarawa's population, effective management of wastewater in South Tarawa by PUB, MPWU with PUB having the capacity to plan and manage water and sanitation services, adequate funds will be available to PUB to finance sanitation O&M, and project management and implementation services within the Ministry of Finance and Economic Development (MFED) and MPWU will ensure efficient and effective project implementation.

58. The project management and implementation consultant should be appointed in the last quarter of 2011, and project works for a four-year implementation period is scheduled to commence in the third quarter of 2012. The sector project continues until 2019 with extensive community awareness and capacity building programs, and the implementation of new priority candidate sub-projects identified during the course of the project. The selection of the candidate sub-projects will lean heavily on the priorities established by this roadmap.

59. Drawings depicting the nature of the rehabilitation and upgrading works of the core projects on STSISP are included in Volume 3 as Drawings 50663 numbered as sheet 001 to sheet 019.

IV. Institutional Roles, Capacity and Performance

11 Ministry of Public Works and Utilities (MPWU)

11.1 Overview

60. The statements in this section have been uplifted from the institutional assessment of TA 7359-KIR and have been incorporated into the roadmap to summarise key findings on the performance of MPWU and PUB and the recommendations for change.

61. There is no regulator for the sector, and differing views have been expressed within the MPWU as to what regulatory oversight they have as a Ministry. MELAD is stated to have been reasonably strong in exercising oversight of environmental requirements relating to water and sanitation. MELAD also undertake some water sampling, as does MHMS.

62. Nearly all staff (96%) within the Water Section of MPWU are focused on monitoring water reserves. About 87% of their effort is allocated to South Tarawa.

63. Although a proposed restructuring plan for MPWU produced in 2010 refers to a strategic move away from being a service provider to one of acting as regulator, it also confirms earlier service delivery statements, and refers to MPWU "responding to competitive pressures from alternative service providers". The structure proposed in the review for the Water Section included positions responsible for design, costing, estimating and drafting, as well as engineers, inspectors, and public relations. A total of 46 positions were proposed – a net increase of 18, or 64%, above the present occupied positions. These proposed positions have not been established.

11.2 Existing Ministry Policy Making and Regulatory Responsibilities

64. MPWU appears to be much more a service deliverer than a policy making and monitoring institution and/or a regulatory institution. No staff are allocated for policy development or regulation, although a substantial proportion of staff are involved in reporting for the purposes of monitoring water reserves, and, if necessary, issuing instructions on water conservation.[26] One consequence of this is the lack of progress on implementation of the water and sanitation policies.

65. Differing views have been expressed as to whether or not MPWU has a regulatory function. No staff members are dedicated to this responsibility, other than monitoring water reserves. Furthermore, the skills required to fulfil the role of a Regulator are at best limited in number within MPWU. Staff members with some skills, such as water resource data analysis, are already full committed. The sector regulatory framework itself also requires development.

66. MELAD and MHMS both exercise some monitoring oversight relating to chemical composition and bacteria and water quality respectively. These are generally not investigated in any depth.

11.3 Future Regulatory Responsibilities

67. Given the ambiguity over existing responsibilities the institutional assessment undertaken by TA 7359-KIR has recommended that a future regulatory regime be defined. This was included as one of the activities identified in the policy implementation plans and the roadmap assumes this will occur. If environmental and water quality requirements are

[26] Staff report some difficulty obtaining compliance from PUB for reduced water draw off at times when water reserves in Tarawa are becoming depleted. There is a risk that the involvement of a private sector operator would exacerbate this situation, since private sector owners will be in a position of wanting to maximize production, and therefore sales.

reasonably well defined, the future regulatory oversight will relate to questions of acceptable service levels, standards of supply and tariff regulation.

11.4 Planning and Performance Management

68. A high proportion of MPWU Water Engineering Unit staff time (over 87%) is allocated to monitoring water reserves, both for Tarawa and the Outer Islands, excluding Kiritimati. This work can be defined more in terms of contingency planning – essential to be undertaken now because a future drought emergency cannot be dismissed. Staff members indicate they receive little or no feedback on the work they produce.

69. The Water Section is expected to produce monthly reports on water reserves throughout the country. This actually covers the work of the highest proportion of staff. There are, however, no other agreed quantified objectives and performance standards, nor is there a formal system of performance monitoring within the Section. It is a challenge to manage untrained staff in the outer islands, especially when workloads are light, and the individuals have limited awareness of the value of their outputs.

11.5 MPWU Existing Staffing

70. In addition to senior management, MPWU has a total authorized staffing level of 199 staff. Currently there are 157 employees, and 42 vacant positions, spread over 8 Sections (Departments). 29 of the employees (18.5%) are employed in administrative or accounting positions.

71. The Water Section has 31 positions, including 3 vacancies with 33% of the staff in the Water Section expected to retire within the next 5 years. Because of the geographically distributed nature of many of these positions (outer islands based), this represents less of an opportunity to reduce costs than would normally apply in a more geographically focused organization. It does present an opportunity to re-evaluate employment contracts or widen community participation in work areas with low workloads. Actual staff numbers in the Water Engineering Unit are equivalent to 17% of all existing MPWU employees.

11.6 Training Needs

72. The Director MPWU at the time of the assessment felt that an independent training needs analysis is required. A number of the training needs, for instance relating to supervision, control systems and performance management, are similar to those of PUB.

11.7 Future role and Responsibilities

73. TA 7359-KIR sees these as a requirement to:

74. **Increase** the **effectiveness of MPWU as an organization focused on policy development, implementation and monitoring**: to remove the conflict of interest inherent in monitoring policy effectiveness when, at the same time, the same organization is judging its own performance as service deliverer. As indicated in the preceding paragraphs, policy development and monitoring, and regulation oversight are currently nonexistent.

75. **Introduce a suitable regulatory regime**: when decisions have been made on the overall scope of regulatory responsibilities, a new regulatory function should be established within the Ministry.

76. **Introduce efficiencies within the water monitoring team**: by changing spans of control and reallocating supervisory responsibilities. This will have the benefit of making better use of the skilled staff within the Section and should provide more fulfilling responsibilities for subordinate staff.

77. **Strengthen and enhance the community awareness program to minimize duplication in** this **area**: Changed community attitudes to sanitation practices are vital. At

present there is no strategic public relations and information dissemination program to increase community awareness of the risks of disease or the benefits of early treatment. There is currently nominal duplication of responsibilities between PUB and MPWU.

78. **Establish future business models in the outer islands, and possibly South Tarawa.** In the longer term, in order to reduce costs of outer island monitoring, a more detailed feasibility study should be undertaken to determine whether community based reporting on water usage could take place, or alternatively to identify additional productive work for Water Technicians in the Outer Islands.

12 Public Utilities Board (PUB)

12.1 Governance and Business Focus

79. PUB operates under a 1977 Ordinance, with subsequent amendments. It therefore came into being well before current philosophies on ownership, privatization and public private partnerships (PPPs). PUB is under the control of "the Minister"[27]. The Minister also has power to give the Board of Directors policy directions[28], in writing addressed to the Board Secretary[29]. The Board can decline to follow policy directives until appropriate funding arrangements have been agreed to cover any losses.

80. There is a Board of Directors, with 7 appointees. Of these, 2 are from GoK Ministries; 2 from GoK enterprises; 2 were formerly employed in GoK enterprises and 1 represents the churches. As indicated, the Public Utilities Ordinance 1977, with amendments, provides for Board appointments to be made by the Beretitenti, acting on the advice of Cabinet. The Ordinance also states that not less than 1 and not more than 3 Board members shall be public officers.

81. The Board of Directors of a successful company will first and foremost be taking a forward looking strategic view of the company and what it wants to achieve. Typically this means approving a rolling 3 year plan, with more detail in the first year. The current plan for PUB is for 1 year only. It contains no vision of what the company wishes to achieve in the medium term. It needs strategies setting out how it will achieve longer term goals. Many of the activities are routine operational functions[30].

82. A review of progress reports by Senior Managers suggests that some of the reporting for the Board tends to focus on isolated performance targets that are not set within an analysis of longer term trends. Financial reports replicate the information one would expect to see at senior management level, with full cost and revenue breakdowns by expenditure category. This will tend to focus the attention of the Board at issues that, under good practice governance principles, should be the focus of senior management, and may deflect Board attention away from a more strategic oversight of the business.

12.2 Organization and Staffing

83. PUB is managed by a Chief Executive Officer (CEO) and four Managers, responsible for Water Engineering, Power Engineering, Finance and Administration Departments. Organization charts exist for all Departments as well as Job Descriptions for

[27] "The Minister" is not defined in the Ordinance. It is accepted that it is the Minister of Public Works and Utilities
[28] Public Utilities Board Ordinance 1977 s 33.1 and amendment 1999.
[29] There is no position of Secretary within PUB.
[30] To "achieve $615,348 earnings from water customers the Department will (i) update the customer data base; (ii) Implement automatic water charge deductions from KHC tenants; (iii) Connect new customers; and (iv) review water tanker delivery charges."

staff. The latter were produced in 2005[31]. While the organisation charts and job descriptions don't necessarily reflect the real position what is more important is knowing what each staff member is contributing towards achieving the wider organizational goals and objectives. Performance management targets along these lines can add much more value by focusing attention on key outputs that are relevant to the time in question. Effort should therefore be directed at developing key performance indicators, initially for senior staff, which should then be updated, and if necessary amended, at regular intervals – certainly no longer than 12 months.

12.3 Staffing and Workload

84. As indicated the organization charts for PUB are not technically accurate. Some reporting lines are incorrect, and some positions are omitted. The actual work groupings used in practice are not reflected in the charts, nor are geographical work allocations. Again Job Descriptions, prepared in 2005, have not been updated[32]. Both situations are quite common in both the public and the private sector. They do not, therefore, present a barrier to performance. In keeping with the performance philosophy in this roadmap, neither issue is really significant, since performance and output is not affected by technical omissions or obsolescence.

85. Of an overall establishment of 162 positions a total of 62 staff, or 37% of the total numbers, are involved in administrative positions. They account for 30% of PUB budgeted expenditure after removing fuel costs, which are essentially non controllable. These positions essentially add cost, not value, to the organization's performance. A key strategic objective for the organization should therefore be to minimize the number of support staff commensurate with strong organizational performance. Of the 21 vacant positions, a small number such as the Water Engineer, exist where the nominated position holder is in full time study. In the meantime the positions are filled on an "acting" basis. This is another example of different philosophies between the public sector and private sector. A private sector approach would be to assess whether higher level education is "nice to have" or "essential for the position". Only a very benign private sector organization would fund long term academic training, usually as part of a structured succession plan. Most private sector organizations would fund shorter term knowledge and skill based training courses intended to improve on the job skills and performance.

12.4 Customer Satisfaction

86. In 2010 there were 1651 complaints regarding water and sanitation services. 73% related to low water pressure. 87% were reported to be resolved. The statistics provided do not indicate response times to complaints, nor do they show what accumulative backlog in complaints exists, or the average time to resolve a complaint. The latter is more a nice to have than a "must have" piece of information. It is noted that a cumulative 27% and 25% of water supply and sewerage complaints in the period December 2010 – April 2011 were not resolved.

87. The sample data available suggests that more needs to be done to resolve customer complaints, or the backlog of complaints resolution work will accumulate. A proposed approach to improve reporting to senior management can be incorporated in a Management Information System upgrade.

88. The first prerequisite to customer satisfaction is to be able to deliver reasonable standards of service – in this case water supplies and sewerage services. Because of

[31] It is interesting that the first question in the Performance Appraisal is whether the Job Description correctly describes the position. This again is an example of being efficient – doing the right thing – but not effective – doing things right – by changing the Job Descriptions when they are inaccurate.
[32] There is provision for staff to indicate during the annual performance review that Job Descriptions are out of date. In common with what is seen in many organizations, this has not been followed up.

difficulties with existing infrastructure this will not be resolved speedily. A better strategy is to manage customer expectations in the short term. Unlike wider sanitation awareness programs this is a public relations task that should be the responsibility of PUB, since it relates to the standard of service they can offer.

89. The suggested action plan for Water Engineering revolves around 5 strategies:

90. **Upgrade** existing **service levels**: The intention here is to look for technical solutions to customer complaints. By actively seeking underlying causes for complaints, rather than simply addressing symptoms, it will be possible to develop a strong case for further investment in the sector.

91. **Improve preventive maintenance**: Inadequate maintenance in the past has led to significant long-term costs from infrastructure that has failed before the end of its optimum life. The approach will be to ensure optimum whole of life availability of plant and infrastructure.

92. **Reducing system losses and illegal connections**: This will increase customer satisfaction levels through improved distribution of existing production. It will not necessarily result in increased revenue until metered tariffs are introduced. Leak detection and loss management will involve continuing programs under PUB's future operational strategies.

93. **Improve Cost Recovery**: This will include financial recovery targets for standalone services such as water tanker supplies and septic tank clearing operations.

94. **Organizational restructuring**: This will remove duplication of staff attending pumping stations, and increasing productivity of staff who are currently underemployed. Also redeployment of underutilized staff to more aggressive leak detection and demand management activities.

12.5 Training Needs

95. The Water Engineering section of PUB has reported that essential training, for instance for electricians in maintenance of new switching gear, has not taken place, resulting in equipment failures that cannot be remedied. Otherwise present PUB Training Needs Analyses have been based on the gap between the 2005 Job Description statements of essential qualifications, and the current qualifications of staff. The Kiribati Institute of Technology and PUB have carried out a review of the training needs for PUB's water supply and plumbing staff for training and certification to Australian standards and the Institute will provide this training for PUB staff.

96. Other training and mentoring requirements have been suggested by PUB, including:

a) Strategic Planning and performance management
b) Governance
c) Development and implementation of preventive maintenance plans, including calculation of minimum cost curves for plant and infrastructure maintenance
d) How best to use control systems
e) Cash flow management and debt recovery
f) Management Information System implementation
g) Competency based staff performance assessment
h) Customer Awareness and Satisfaction
i) Financial information systems for non financial specialists

97. Under the long term assistance (4 years) to be provided to PUB under the STSISP the financial and operational TA should be well placed to provide the training, based on a more intimate understanding of training gaps and needs.

12.6 Tariffs

98. One difference between acting as a Government Department compared to a SOE is how ambitious cost recovery targets are. A second difference is the attitude to updating tariffs. A successful business or SOE will be proactive in determining tariff rates, and getting them approved, or negotiating offsetting subsidies[33].

99. The "Strategic Issues and Challenges" section of the Annual Plan refers to tariffs being unsustainable, and failing to cover full operational costs. The Finance Department Annual Plan refers to a "timely tariff review in line with market situations" – but over a full 12 month period, and with Cabinet approval.

100. The inclusion of this item as a "Strategic Issue and Challenge" is a particular point of concern, which suggests that PUB is not yet fully operating as a successful business. The need for a tariff revision should not be a strategic issue. Under the Public Utilities Ordinance 1977 s.12 it is "the duty of the Board to secure total revenues that are sufficient taking one year with another to meet its total outgoings properly chargeable to revenue including depreciation and interest". Under Section 17 full authority to set tariffs is delegated to the Board. A requirement in the initial Ordinance for involvement of the Minister was removed in 1999. Where it is not possible to recover costs from consumers then a government subsidy is envisaged (s.33).

101. The strategic issue here is fundamental, and one for GoK. If PUB is to act as a successful company then it must be able to set tariffs or require Community Service Obligation subsidies that enable it to recover its full costs. These costs are likely to be considerably higher than those currently in the budget, since these allocations have historically made inadequate provision for electricity costs and essential maintenance and inventory – resulting in much higher long run costs as failed infrastructure is replaced earlier than its expected working life.

12.7 Asset Management

102. PUB maintains a very comprehensive asset register, identifying a total of some 800 rows of assets, many of which are obsolete. It identifies sewerage assets valued at $3.6 million and water assets at $4.6 million. In terms of value, 47% of the current asset value comes from donated assets. Many items on the register are obsolete and written off, but still listed. There is no indication on the asset register of which items still have a book value but are no longer fully functioning. All manner of assets are "grouped" under broad headings such as SAPHE project, etc.

103. Inadequate maintenance funding levels means that infrastructure is not operating at peak levels and essential equipment is out of service. This will impact on service delivery to customers and the productivity of staff expected to work with such equipment. The hidden costs of idle equipment is high, including not only the opportunity cost of service failure but also other hidden costs such as equipment rental e.g. for a portable electric crane hoist.

104. There have been some conflicting statements about reasons for insufficient maintenance funding, and whether higher levels of funding could be received if a compelling case was presented. Whatever the true situation, the fact is that a number of the key assets for water and sewerage are not working, or are only partially working.

[33] A successful business does not necessarily mean that all costs are recovered through tariff charges on customers. It can equally mean that subsidies are received to enable the organization to follow government social goals. In these circumstances success (or competitive tendering) is measured by the minimum level of subsidies necessary to provide sustainable services in the medium to long term.

105. The Manager, Water Engineering (and Power Engineering) must be made accountable for the core assets used in delivering their Departments' services. Their effectiveness at managing these assets will be judged by; asset availability and production; completion of planned maintenance within the scheduled timeframe and budget; and the level of unplanned breakdowns. The Managers should be required to develop adequate maintenance budgets, and to highlight the consequences of inadequate maintenance funding. An initial Asset Management Plan (AMP) has been prepared[34] and the Board of Directors will be required to commit adequate funding to enable the proposed maintenance targets to be achieved and for the additional investigations to refine and improve the AMP. For water, demand management, leak detection and waste management should feature strongly in the programs incorporated in the AMP.

106. Under the South Tarawa Sanitation Improvement Sector Project adequate funds will be available to PUB to finance sanitation O&M. A dedicated sanitation maintenance fund (SMF) will be created under MPWU to ensure that adequate resources are available to finance operations and maintenance activities that are critical for the sustainability of infrastructure investments. Grant funds will provide initial funding for the SMF and an appropriate tariff structure is to be developed in consultation with the government and ADB at the beginning of the project implementation period. Tariffs are then to be phased in over the life of the Project and by the end of 2018 PUB will be expected to recover an increasing amount of O&M costs through user charges. The roadmap assumes the SMF will be established and that PUB through the Asset Management Plan processes will make adequate provision for O&M and estimates of revenue.

[34] TA 7359-KIR Tarawa Sanitation Improvement Project, 2011

IV Population, Urban Growth and Development

13 Process and Outcomes

107. The Strategic Development (SD) and Land Use Planning (LUP) Component of the Roadmap underpins the work on the Sanitation Sector Assessment, Component and the Water Sector Assessment Component, with wastewater load forecasts and per capita demand for water consumption being based on population growth and distribution projections for each South Tarawa area / zone identified in the Land-use Plan (LUP).

108. The preparation of the SD and LUP is integrated with the on-going government plan making activity including the preparation of the Kiribati Development Plan (KDP) 2012-2016 and the updating of existing South Tarawa General Land Use Plans (GLUPs) of the Ministry of Environment, Lands and Agricultural Development (MELAD). Opportunities to contribute to the revision of the MELAD GLUPs have been available as work on these is concurrent with the work of the project. The SD and LUP has been developed with the advice of key stakeholders comprising the Office of the President (OB), the Ministry of Finance and Economic Development (MFED), MELAD, Ministry of Internal and Social Affairs (MISA), the Beito Town Council (BTC) and the Teinainano Urban Council (TUC).

14 Integration with Kiribati Development Plan

109. The high population growth rate in South Tarawa which was confirmed in the 2010 Census Preliminary Results has been acknowledged within the KDP preparation process (along with problems of food security and urban management) and the KDP 2012–2016 may include provision for detailed government consideration and decisions of the issues in the early years of the national plan period. Decisions at such a time on the way forward will enable review of the 2016–2020 water and sanitation investment strategy with further consideration for the remaining 10 years of the investment strategy being endorsed within the following KDP processes. Institutional and organizational re-arrangements for South Tarawa urban management may be linked to this. Acknowledging this, the SD and LUP suggests land use planning options for 2011 – 2030 for government consideration.

15 South Tarawa – Population Size, Distribution and Densities

15.1 Population Size and Distribution

110. The current (2010) population of South Tarawa is 50,402 or 48% of the national population, up from 43.5% in 2005. Forty-nine percent of the South Tarawa population is now concentrated in three Focal Urban Areas: Bikenibeu (5.941 / 12%), Bairiki (3,281 / 7%) and Betio (15,646 / 31%). The overall population is distributed in eastern South Tarawa with 27.77% of the total population); central South Tarawa with 32.63% of the total population); and western South Tarawa comprising Nanikai, Bairiki and Betio with 39.60% of the total population).

111. To calculate the current population densities the land area in each of the 2010 Census Enumeration Areas (EA) has been estimated from GIS maps and verified using satellite imagery. This verification of the useable land area suggests that the (net) developed area is some 11.48 km^2 with a total of some 0.54 km^2 being utilised for roads (0.15 km^2), airport (0.18 km^2) and causeways (0.21 km^2) with a total (gross) land area of 12.02 km^2.[35]

[35] Consultant measurement of land above the beach embankment delineated on GIS plans of South Tarawa. Confirmed by SOPAC Land Cover Type Mapping of Kiribati using pan sharpened Quickbird and Multi-spectral IKONOS images October 2010, Wolf Forstieuter and Taato Murdoch which gave a land area for South Tarawa of 12.04 km^2.

15.2 Population Densities

112. Using these revised land areas, it has been calculated that the three Focal Urban Areas have current population densities of, Bikenibeu 9,700 persons per km^2, Bairiki 16,200 persons per km^2 and Betio 19,100 persons per km^2. Only Nanikai exceeds these density levels, although with a small population. The average population density in the eastern area is the lowest of the three areas in South Tarawa at 1,168 Persons/km^2 and this reflects the extensive undeveloped area in the Temaiku - Bight.

113. The density levels for parts[36] of the three Focal Urban Areas are high in international terms, going as high as 38,200 persons per km^2 in parts of Bairiki (being the equivalent of densities found in Manila, Philippines and Titagarh, India), and Betio also includes areas of very high population density of around 42,000 persons per km^2 (being the equivalent of densities found in Kolkata and Delhi). The highest density found in Bikenibeu is around 19,000 persons/km^2 (the equivalent of densities found in Pasig City, Philippines and Dhaka, Bangladesh. Two areas of Bairiki with exceptional density levels (current population of about 1,000 persons) require immediate assistance.

15.3 Population Growth

114. The population growth rate of South Tarawa is recorded as 4.41% per annum between the censuses of 2005 and 2010. In the same period the national population grew at a recorded rate of 2.26% per annum. As there may have been under-reporting of the South Tarawa population in 2005 and 2010 a longer series of census results (1995 to 2010) has been used to achieve a more reliable estimate of long term growth trends. The long term growth trend for South Tarawa is estimated at 3.87% per annum.

15.4 Distribution of Growth

115. With the growth aggregated to the eastern, central and western areas of South Tarawa, it is shown that the central and western areas have grown at roughly the same high rate with the eastern areas growing quickly but at a slower rate. In the eastern and central areas there are wide variations in growth rates between villages. Bairiki and Betio have similar rates of growth between 2005 and 2010 and are slightly higher than the average for South Tarawa as a whole. Bikenibeu has a slower rate of average annual population growth.

15.5 Population Trends

116. As the age structure and fertility rates of the female population of South Tarawa resemble those of the national population it has been assumed that natural increase of the South Tarawa population is about 2.26% per annum. This implies that in-migration in South Tarawa accounts for approximately 1.19% per annum of the population growth.

117. The age structure of the population is such that there will be no decline in the rate of natural increase within the first half of the road-map period at least. Currently in-migration into South Tarawa accounts for about one third of the overall population growth rate in South Tarawa. Migrants to South Tarawa are attracted by formal employment opportunities in the large public sector and state owned (public) enterprises as well as the informal trading and service industry sector opportunities in South Tarawa. Further “pull” factors to South Tarawa include the health and education facilities available, for example, the junior secondary schools, the Kiribati Institute of Technology and the Marine Training Centre. As South Tarawa is the hub of central government administration and of the commercial sector and will be the focus of major infrastructure projects over the next few years, it is economically rational that new migrants will continue to want to move to the urban areas especially in search of better employment opportunities and higher incomes for themselves and their families. Explicitly attempting to slow or reverse this trend is not likely to be successful and

[36] Enumeration Areas

would not be economically rational, given the important contribution to national economic growth that towns and cities are able to make. The challenge facing Kiribati is how best to improve living and economic conditions in the urban and urbanising areas whilst at the same time not undermining the on-going efforts to develop the Outer Islands.

16 South Tarawa - Population Projections

16.1 Natural Growth and In-migration

118. If it is assumed that in-migration from the outer islands continues at the present rate and assuming that the natural increase trend continues and that no major government growth management initiatives are introduced, a maximum population of about 107,700 can be anticipated in South Tarawa in 2030, with an average annual growth rate 2010 to 2030 of 3.87%. Lower projections have been prepared based on increasing levels of government intervention to manage growth, but this highest growth estimate, assuming very limited government intervention, the worst case scenario, has been assumed to be the projection describing the highest possible level of wastewater loads and per capita demand for water consumption.

16.2 Distribution of Projected Growth

119. The population growth distribution is determined largely by whether the growth is of natural increase of the existing population or in-migration. If it is natural increase the tendency will be for the growth to occur within existing settlement areas. There is some variation in the age structures of the female populations of villages in South Tarawa and this will influence the distribution of growth. In-migrants will be more footloose and will tend to go where land is available, legal or otherwise.

17 Population Forecasts

120. This worst case scenario implies populations of 7,181, 3,967 and 18,916 in Bikenibeu, Bairiki and Betio respectively in 2015 and this is assumed to be fixed. Beyond this period government interventions of various kinds could begin to reduce the growth rate in South Tarawa, but the worst case scenario assumes very limited intervention and projected population growth throughout South Tarawa aligns with the populations shown in Table 3. For comparison the low growth scenario is shown in Table 4 but this would require immediate Government actions to prevent inwards migration and intensive family planning programs, both of which are seen as most unlikely within the planning horizon.

Table 3: High Growth Population Forecast

Area	Population Forecasts				
	2010	**2015**	**2020**	**2025**	**2030**
Bonriki	2,607	3,152	3,811	4,609	5,574
Temaiku	3,123	3,776	4,681	6,560	13,985
Nawerewere	2,324	2,810	3,398	4,109	4,969
Bikenibeu	5,940	7,181	8,684	10,501	12,699
Eastern South Tarawa	**13,994**	**16,919**	**20,574**	**25,779**	**37,227**
Abarao	2,431	2,939	3,554	4,298	5,197
Eita	3,153	3,812	4,610	5,575	6,741
Taboria	1,357	1,641	1,984	2,399	2,901
Ambo	2,297	2,777	3,358	4,061	4,911
Antebuka	3,102	3,750	4,535	5,484	6,629
Teaoraereke	4,106	4,964	6,003	7,259	8,777
Central South Tarawa	**16,446**	**19,883**	**24,044**	**29,076**	**35,156**
Nanikai	1,035	1,251	1,409	1,648	1,648
Bairiki	3,281	3,967	4,796	5,798	6,702
Betio	15,646	18,916	22,897	26,830	26,986
Western South Tarawa	19,962	24,134	29,102	34,276	35,336
Total (rounded)	52,402	60,936	73,720	89,131	107,719

Table 4: Low Growth Population Forecast

Area	Population Forecasts				
	2010	**2015**	**2020**	**2025**	**2030**
Bonriki	2,607	3,152	3,525	3,911	4,249
Temaiku	3,123	3,776	4,638	5,153	5,677
Nawerewere	2,324	2,810	3,142	3,486	3,788
Bikenibeu	5,940	7,181	8,031	8,910	9,682
Eastern South Tarawa	**13,994**	**16,919**	**19,336**	**21,460**	**23,396**
Abarao	2,431	2,939	3,287	3,647	3,963
Eita	3,153	3,812	4,263	4,730	5,139
Taboria	1,357	1,641	1,835	2,036	2,212
Ambo	2,297	2,777	3,106	3,446	3,744
Antebuka	3,102	3,750	4,191	4,653	5,056
Teaoraereke	4,106	4,964	5,551	6,159	6,693
Central South Tarawa	**16,446**	**19,883**	**22,233**	**24,671**	**26,807**
Nanikai	1,035	1,251	1,399	1,553	1,647
Bairiki	3,281	3,967	3,926	4,375	4,783
Betio	15,646	18,916	21,237	23,381	25425
Western South Tarawa	**19,962**	**24,134**	**26,562**	**29,309**	**31,855**
Total (rounded)	**50,402**	**60,936**	**68,131**	**75,440**	**82,058**

18 Land Use Planning

121. With MELAD support, the SD and LUP subsequently undertook a field assessment of the existing GLUPs. As a result of this the land areas available for residential use were further revised taking in to account revised boundaries of non-residential land-uses. Overall these revisions reduced the amount of land available for residential use. Further, not all this land is immediately available for development and there are significant areas of land which are regularly inundated or at risk of inundation which would need to be filled before being available for development (these include the large area of low-lying land at Temaiku). In the longer term land available for development in South Tarawa could also be reduced by increased risk of inundation as a result of sea level rise / climate change. Comparisons were made with the land budgets estimated by the 1996 Kingston Morrison Study.[37]

122. Taking these considerations into account, the worst case growth distribution scenario was constructed by assuming a 3.87% per annum average annual growth rate, distributed evenly initially. With a maximum density set of 150m^2 per household (the maximum density suggested in the draft planning policy guidelines) all villages within Nanikai, Bairiki and Betio are at maximum density by the end of the planning period with no scope for further densification. Elsewhere densities will be between 200m^2 and 300m^2 per household as growth is gradually steered throughout the period to neighbouring areas with lower residential densities (i.e. with potential for further density increases) and this includes Temaiku which is assumed to contribute significantly to continuing accommodation of in-migrants. Although this worst case scenario assumes no migration control, limited land-fill of at "risk areas" including Temaiku, no North Tarawa urbanisation, no rationalisation of land-uses and no accelerated family planning program, it does assume either community or government intervention to allow average residential densities up to 150m^2 per household and to prevent higher densities.

19 Land Tenure

123. A review of land tenure issues has been made but as it is a complex area the work undertaken has been limited to that which is directly relevant to the production of the roadmap and water and sanitation investment strategy.

20 Other Land

124. Field surveys indicate that there are large areas of land which could be bought into more appropriate urban use including: the areas which are at risk of inundation but which could be in-filled/reclaimed (most notably Temaiku and sites in Betio, Etio-Abarao, Ambo and Eita); and, sites in Betio currently occupied by radio and television transmitting installations, a meteorological station and an area previously used as a construction works depot. The amount of land which could be made available in these ways has been measured and calculated.

21 Impact of Population Growth and Land Shortage

21.1 Worsening Environmental Health linked to Water Supply and Sanitation

125. A review of health statistics and issues was carried out (using the 2010 health survey principally) (refer section 6.1). This confirms the high levels of diarrhoea and dysentery from an overcrowded urban environment and inadequate water supply and sanitation services.

[37] TA 2198 KIR South Tarawa Integrated Urban Development Plans and Program Study, Kingston Morrison 1996

21.2 Other significant impacts

126. Other significant impacts were also reviewed including communicable diseases risks associated with high density living[38]; increasing risk to food security; increasing marine environmental degradation (lagoon pollution, contamination of marine fauna, overfishing); increasing demand for adequate garbage and waste disposal; increasing road traffic accidents; and increasing resource abstraction especially sand and gravel.

21.3 Public Services

127. The anticipated population growth rates will also create high demand for public services. This need for education, health, police, maneaba, churches; and initiatives for employment creation in the form of commercial and industrial activities have been raised and discussed with MELAD. These requirements have been accommodated within the draft GLUPs.

21.4 Other Demands

128. The increasing demand on weak planning and urban management institutions has also been assessed and reported on the land use management report prepare by TA 7359-KIR.

22 Summary of Conclusions

129. The analysis confirms that the only ways to reduce the rate of the population growth are: in-migration control, planned out-migration to North Tarawa or elsewhere, and accelerated Family Planning programs. However no policies along these lines will be effective (even if formulated) in the early years of the planning period and there has to be doubt about effectiveness of policy implementation, even if any appropriate policies are formulated. With best efforts and effective implementation of policies to constrain growth, the changes are intergenerational and it is considered unlikely these will have much impact in the planning period to 2030.

130. Planning for the water and sanitation road map has therefore adopted, as a likely reality the highest population growth rate supported by efforts to accommodate the population increase and further urbanisation of South Tarawa through planned and effective use of available land, land zoning and regulation:

a) Areas of higher density - multi-storey (two storey) construction;

b) Bringing Temaiku into use along with other filled low-lying sites;

c) Making better use of under-used sites in Betio and elsewhere;

d) Rationalization of government land and buildings;

e) Rationalization of non-residential land uses to limit further alienation of land for residential occupation (i.e. commercial/industrial expansion, and institutional and community buildings (churches and maneaba);

f) Redistributing the growth to ensure that pockets of very high density are relieved, realizing that the efforts to achieve will require considerable commitment.

131. Initial expectations were for a medium growth between the low-high population range that could be targeted as the option for the likely population scenario and the primary driver for the water and sanitation infrastructure and investment strategy. The reality does not work out that way when possible policies and their impacts are applied. This means that

[38] The Health Section of MHMS referred to an increasing reallocation of resources to these community problems in a losing battle for improved general surgery and health services. Leprosy was described as being on the increase – per con August 2011

the high growth scenario is the most likely probability. Effort will be required to manage and accommodate an expected population of around 107,700 people through a combination of the above measures coupled with effective land management and regulatory control.

132. Population growth and the continuing urbanisation of South Tarawa have immediate implications and warrant recognition in the KDP 2011-2016. It is a matter for public debate and consideration by the new government as soon as it convenes in 2012.

23 GLUPs and Population Densities

133. Drawing sets showing the land uses and constraints and the draft GLUPs for the existing and proposed land uses are incorporated in Volume 3 containing the roadmap drawings as drawings number 50663 sheets 201 to 233. The Land Use Management and Development report of TA 7359-KIR with the spreadsheet showing populations and densities is incorporated into Volume 2 as Appendix 2.

V Water Resource Assessment – Urban Groundwater Lenses

24 Community involvement

134. The Water Resource Assessment (WRA) of the Betio, Bairiki and Bikenibeu groundwater lenses carried out under TA 7359-KIR was explained to church representatives, the Betio Town Council (BTC) and the Teinainano Urban Council (TUC), and to the respective communities' at maneaba meetings in each urban area. Notification was given through radio announcements and broadsheets explaining the purpose of the activities were placed in public buildings, shops and commercial centres. Consultation occurred with the landowners/occupiers where access to land was required for the investigations and testing. On completion the findings were conveyed back to the community at maneaba meetings with the same communities and through radio feedback and newspaper articles.

135. The environmental health section of MHMS supported the community consultation and a MHMS officer participated in the field work and site testing for water quality. MHMS also assisted the test program by providing an incubator for testing.

25 Betio, Bairiki and Bikenibeu Freshwater Lenses - Sustainable Yield

25.1 Approach

136. The groundwater resource (quantity) assessments determined freshwater lens extent and volume estimates for the islets of Betio, Bairiki and Bikenibeu in South Tarawa. From these estimates, sustainable yield estimates were made. The opportunity was taken to assess the groundwater lenses in other locations along South Tarawa.

137. The extent and thickness of the freshwater lenses were mapped using a combination of geophysical survey (EM34) and salinity (EC) measurements at wells and boreholes. Owing to the extensive coverage of electricity and telephone cables and water and sewerage pipes in South Tarawa, which affect the EM34 measurements, reliance was placed on EC measurements to verify EM34 measurements.

138. The salinity data collected from wells was used to determine areas of freshwater with a significant lens thickness. These areas were then assessed for potential use through water quality testing. Areas targeted in Betio, Bairiki and Bikenibeu included open spaces (e.g. the sports complex, TSKL radio mast area and police soccer pitch in Betio, the national stadium in Bairiki, and the Ministry of Agriculture land and KGV school playing field in Bikenibeu).

25.2 Mapping of Lenses

139. Groundwater lens thickness monitoring and EM34 calibration measurements were conducted at eight monitoring boreholes in Bonriki and three monitoring boreholes sited in Bikenibeu, Bairiki and Betio. EC data from 46 wells and EM34 measurements at 49 locations was gathered in Betio. Similarly EC data at 20 wells and EM34 measurements at 20 locations in Bairiki was gathered with EC data for 50 wells and EM34 measurements at 36 locations in Bikenibeu. Additional EM34 measurements and EC data was gathered for Nanikai, Teaoraereke, Abarao, Bikenibeu east and west and at Nawerewere near the Tungaru Central Hospital. The information was used to determine the sustainable yield of the lenses. The current rate of groundwater discharge for the flushing of toilets (from wells) to ocean outfalls via the reticulated sewerage system was estimated and compared with the sustainable yield estimates. Estimates of sea level rise impact on sustainable yield were made. The potential for sustainable groundwater abstraction from infiltration galleries was reviewed. The report of the survey is presented in Appendix 3.

25.3 Assessment of Sustainable Yield

140. Analysis of the data from Betio indicates at significant (average >10m) lens thickness restricted to the very centre of Betio (groundwater bounded by the 5 meter contour), around the sports complex playing field, with contraction of the lens elsewhere due to the increased groundwater abstraction in Betio compared with the less developed and more rural areas, and the increased abstraction rate through the use of fast rate electric pumps (elevated abstraction rates can cause turbulent mixing and long term damage to the lens). Whilst a proportion of the water will return to ground and recharge the groundwater, some is being lost through evaporation, and in greater volumes into the sewerage system where freshwater is bailed from wells to flush toilets that are connected to the PUB sewerage system in the absence of an operating saltwater flushing system.

141. Analysis of the data from Bairiki also indicates a contraction of the lens due to heavy abstraction rates. Observations at wells indicate a reduced salinity at wells dug into the coral rock and gravel as compared with those dug into sand and the extent of the shallow (<3m) rock sub-crop has been mapped through collection of well survey data. Viewed overall the groundwater lens underlying Bairiki is constricted and small and has high salinity rendering it unsuitable for potable use, and marginal for secondary household uses such as personal and clothes washing.

142. The analysis of the Bikenibeu lens also shows contraction and thinning due to abstraction, again with higher than desired levels of salinity for comfortable potable use. The Bikenibeu lens has very limited capacity. Like Bairiki and to a lesser extent Betio, increasing secondary use from an increasing population will compete for any possible use for potable supplies to the point where the longer term sustainability of the lenses must be called into doubt. The lenses for Bairiki and Bikenibeu can therefore be described as fragile and "at risk", especially during a prolonged drought. While the Betio lens would sustain itself through a longer-term drought, it is nevertheless at risk from contamination, and the increased impacts of a burgeoning population. Table 5 summarises the data in the hydrogeological report giving the assessed sustainable yield for the lenses.

Table 5: Groundwater Lenses Sustainable Yield

Area/Lens	Yield m^3/day	Supply[1] L/pers/day	Abstraction[2] m^3/day	2030 Yield m^3/day	Supply L/per/day
Betio	258	16	62 - 312	216	6 - 8
Bairiki	23	7	16 - 21	18	3 - 4
Bikenibeu	12	2	22 - 110	10	1

Notes: 2010 population
Water abstracted and discharged to outfalls as flushing water

143. The estimates of well water abstraction and discharge to outfalls as flushing water for 2011 straddle the sustainable yields for Betio and Bairiki and are in excess of the sustainable yield for Bikenibeu. The sustainable yield for 2030 assumes a 20% reduction in sustainable yield due to climate change associated sea level rise. The Betio lens would only supply 3% of the present population in Betio.

25.4 Freshwater Lens Volumes and Resilience

144. The volumes of the freshwater lenses have been calculated from the groundwater contour plans referenced as 50663 sheets numbered 301 to 306 in Volume 3. The volumes of available fresh groundwater (to EC = 2,500 μS/cm limit) within the freshwater lenses have been determined and the average groundwater thickness calculated.

145. Figure 6 shows the estimated average residence times of the freshwater within the lenses representing the time for the freshwater as a measure of the time taken for water to

move through the lens, calculated by dividing the average freshwater thickness by the average annual recharge.

Table 6: Freshwater Lens Statistics for Each Islet

Islet	Lens Area (ha)	Freshwater lens volume (million m^3)	Fresh groundwater volume (ML)	Average freshwater lens thickness (m)	Average fresh groundwater thickness (m)	Average residence time (yrs)
Betio	65	1.8	549	2.8	0.8	0.8
Bairiki	11	0.2	52	1.5	0.5	0.4
Bikenibeu	39	0.4	109	0.9	0.3	0.3

Source: Report on lens mapping TA 7359 (KIR)

146. The residence times for all three islets are short and indicate that major variations in recharge may have a significant impact on the freshwater lens volumes. If the thicker parts of the lenses are considered the average residence time is greater. If the groundwater area bounded by the 5 m contour is considered for Betio, the average freshwater lens thickness is approximately 10m and using the estimated annual recharge, the corresponding average residence time is 3.0 years. This is approximately the length of major droughts (e.g. the 1998-2000 drought) and it can be expected that this area of the Betio lens may be sustained even during major droughts.

147. For Bairiki, the area bounded by the 5m contour is negligible. If the 2.5m contour is taken, the average freshwater lens thickness is 3.8m, the average fresh groundwater thickness is 1.1m and the average residence time is 1.1 years – less than the duration of major droughts. Much of the Bairiki lens may therefore be removed during a drought. In Bikenibeu the lens area of thickness is even smaller than for Bairiki, and nearly all of the Bikenibeu lens would also be removed during a drought.

25.5 Assessment of Demand

148. Prior reports on water resources assessments in South Tarawa (including reports held at MFED and MWPU) were reviewed to assist in establishing the context the findings from the survey and field work carried out under TA 7359-KIR.

149. The proportion of the freshwater lens currently being used has been estimated from household questionnaires completed by an I-Kiribati speaking member for the households where wells were sampled. Estimates of household and per capita well water use have been made, based on the data collected. The data has been used for assessing water demand and sewer loadings. The location of all wells and boreholes assessed and sampled have been recorded by GPS and plotted on the base maps for the water resource assessment (WRA) assessment presented on the aforementioned drawings referenced as 50663 sheets 301 to 306 in Volume 3.

150. Dataloggers were installed in pumped and non-pumped (bailed with bucket) wells, to provide validation of this typical household use. Dataloggers were also placed in rain tanks to estimate average household and per capita rainwater use. The data and field observations were used to direct water quality sampling to the most appropriate (potentially contaminated) sites.

151. Table 7 summarises the average household use (all uses) of well water gleaned from a survey of the households where the wells were tested.

Table 7: Average Household Use (all uses) of Well Water

Village	ID	Abstraction Method	Well Water Use	Volume of well water used per person per day in each house (litres) – from household questionnaire	Volume of well water used per person per day in each house (litres) for flushing – from household questionnaire	Is water discharged to outfall (ie toilet connection to PUB?)
Betio	BE4	bucket	Washing, bathing, flushing	28	10 assumed one flush a day	Yes
Bairiki	BA100	bucket	Washing, bathing, flushing	72	40	Yes
Bairiki	BA133	bucket		34	10	Yes
Bikenibeu	B123	Electric pump and hand pump	Bathing, flushing	18	<18 – not broken down	Yes
Bikenibeu	B126	bucket	Drinking, washing, bathing, cooking, flushing	>38	8	Yes
Bikenibeu	B133	bucket	Washing, flushing	40	29	Yes
Average				**38**	**19**	

25.6 Summary of Findings

152. There is the immediate need to protect the groundwater resource, which is heavily relied upon by the South Tarawa population, from depletion through development that could further reduce water quality in terms of contamination and over-abstraction. As a first step a reduction of well water used for flushing sewerage is a priority. The saltwater flushing sewerage system should be rehabilitated as soon as possible and all new systems should rely on saltwater flushing.

153. There is also an immediate need to provide alternative water resources to well water for potable use in South Tarawa, particularly in high density areas without PUB service and where well water is brackish. Reconnection of the Buota water reserve should occur, followed quickly by the development of an addition, reliable supply.

154. Support needs to be provided to households to prevent groundwater contamination, improve well protection and advise households on the suitability of well water for secondary uses, and the high risks of consumption of the contaminated groundwater. Management of the groundwater resource is required including encouraging the use of hand pumps or low rate electric pumps for residential use over fast rate electric pumps to prevent the abstraction of brackish water from the pumped well and surrounding wells, and to prevent turbulent mixing that may cause long term damage to the lens.

155. There would be advantage in conducting a wider study of household water (including well water) consumption to better constrain water demand in the population centres of Betio, Bairiki and Bikenibeu, and to repeat the EM34 surveys during drought periods and carry out regular EC monitoring at select wells to determine the extent of lens shrinkage and to better constrain sustainable yield estimates. The data collected would be used to inform GoK about drought resilience and should be passed on to the GoK Drought Management Committee for review and action where required. These activities should be within the capacity of MPWU and local agencies and are therefore not reflected in the roadmap.

25.7 Groundwater Lens Maps and Data

156. The report and data relating to the mapping of the lenses is incorporated in Appendix 3. As indicated the plans and details of the groundwater lenses are displayed in Volume 3 containing the roadmap drawings.

26 Groundwater and PUB Water Supply Quality

26.1 Characterization of the Groundwater Quality

157. **Planning** - a sampling program was prepared and costed in conjunction with the mapping of the groundwater resources with the involvement of MHMS. The program covered the collection and analysis of groundwater samples with field and certified laboratory testing of the quality of the freshwater lenses in Betio, Bairiki and Bikenibeu, and for completeness other sites along South Tarawa.

158. **Approach** - meetings were held with the Environmental Health Department of MHMS, and the urban councils to discuss water quality and community health problems, and to obtain perspectives on groundwater pollution, known pollution hotspots and anomalies with the number of wells identified in the 2010 census. Water quality data from MHMS monitoring activities and the 2009 US Navy survey results were collected and reviewed. A sampling plan for Betio, Bairiki and Bikenibeu was prepared collaboratively with MHMS and the MPWU. The field work and sampling program in South Tarawa was completed on 22 September 2011 with the results of the laboratory testing following at the end of October.

26.2 Laboratory and Field Analysis

159. The requirements of this phase of TA 7359-KIR are to assess water quality to determine the basic chemistry, biological indicators and possible chemical contamination (hydrocarbons, heavy metals and agricultural chemicals and to identify and assess suitable cost-effective options to treat groundwater for potable and non-potable use

160. Each well was purged equivalent to 1-3 times its static volume and field measurements were taken during this period. The field measurements for each site involved testing for dissolved oxygen, pH, electrical conductivity and temperature and oxidation reduction potential. Forty samples were collected and sent to an internationally certified laboratory in New Zealand for comprehensive analysis including volatile organics, hydrocarbons, PCBs and general analysis depending on the risk profile of each site. Separate samples were taken for microbiological analysis (Presence /Absence and in some cases enumeration and for a limited range of analysis for sulphides, nitrates and ammonia using project resources in Tarawa. In conjunction with the sampling program the previously mentioned water user survey/ interview was carried out to obtain background information on usage patterns, numbers of users for the wells sampled, owner observations and comments.

161. Nine sample sets were despatched to the laboratory on 6 September 2011 and a further 18 sets were dispatched on 16th September with the remaining balance of the samples being dispatched on 22 September. The report on water quality recording the results of the field and controlled tests conducted in South Tarawa is incorporated in Volume 2 as Appendix 4. The results are summarised in the following Tables 8 and 9.

Table 8: Summary of Field and Controlled Tests Conducted in Tarawa

Location and Water Source	N°	Microbiology		No	Salinity as EC		Chemical tests		
		Pos	Neg		Fresh	Brackish	pH	NO_3	Others
Betio:									
PUB	12	7	5	2	2	-	3	3	2
Wells	14	14	-	27	18	9	27	4	18
Rainwater	22	20	2	-	-	-	-	-	-

Bairiki									
PUB	4	3	1	-	-	-	-	-	-
Wells	16	16	-	18	5	13	16	3	20
Rainwater	13	13	-	-	-	-	-	-	-
Bikenibeu									
PUB	3	3	-	-	-	-	1	2	0
Wells	5	5	-	9	8	1	5	1	8
Rainwater	11	8	3	-	-	-	-	-	-
Other communities									
Wells	2	2	-	10	7	3	2	-	-
Rainwater	3	3	-	-	-	-	-	-	-
PUB	1	1	-	-	-	-	-	-	-
Miscellaneous									
Bottled water	9	3	6	2	2	-	-	-	-
MHMS	6	2	4	1	1	-	-	-	-
WTP Ops	3	2	1	-	-	-	2	-	8
Chlorine residual	-	-	-	-	-		-	-	16
TOTAL	124			29			56	13	70

Table 9: Summary of Laboratory Tests

Item	Determinand	Results & Conclusion: Certified Laboratory Testing		
		Betio N=26	**Bairiki N= 17**	**Bikenibeu N=11**
1	General chemistry: alkalinity pH, hardness, boron, calcium magnesium, potassium ,sodium, ammonia	Normal water chemistry. Hard water. *Health risk low.*	Normal water chemistry. Hard water. *Health risk low.*	Normal water chemistry. Hard water. *Health risk low.*
2	Sulphur, sulphates and hydrogen sulphide	7 samples have high concs of these determinands. *Health risk low but odour makes high content water unsuitable for drinking-water as is.*	3 samples have high concs of these determnands. *Health risk low but odour makes high content water unsuitable for drinking-water as is.*	5 samples have high concs of these determinands. *Health risk low but odour makes high content water unsuitable for drinking-water as is.*
3	Nitrate - NO_3	Range from 0.22g./m^3 to 159g/m^3 with 4 samples above the recommended maximum of 50 g/m^3. *Health risk moderate to high.*	Range from 0.44g./m^3 to 810g/m^3 with 4 samples above the recommended maximum of 50 g/m^3. *Health risk moderate to high.*	Range from 0.6g/m^3 to 32.3g/m^3 with nil samples above the recommended maximum of 50 g/m^3. *Health risk low to moderate.*

4	Ammonia	Less than 0.05 g/m^3 but 2 samples about 0.4 g/m^3. *Health risk low.*	Less than 0.2g/$m^{3.}$ *Health risk low.*	Less than 0.2g/$m^{3.}$ *Health risk low.*
6	Heavy metals of health significance: arsenic, cadmium, chromium, copper, nickel, lead and zinc.	Marginally elevated concentrations of arsenic in 3 samples. *Health risk low. - status requires monitoring.*	Marginally elevated concentrations of arsenic and other heavy metals in 4 samples. *Health risk low.*	Heavy metals below not detectable concentrations. *Health risk low.*
7	Oil related contamination : BTEX, PAH (16species) and TPH (3 species)	Slightly elevated levels of PAH found in 4 samples: near oil facilities and the landfill. *Health risk low - but situation needs to be monitored.*	No determinands above detection limits. *Health risk low.*	No determinands above detection limits. *Health risk low.*
8	PCBs - main source is leaking and old stored electrical transformers,	No determinands above detection limits *Health risk low - but situation needs to be monitored.*	No determinands above detection limits. *Health risk low - but situation needs to be monitored.*	No determinands above detection limits. *Health risk low - but situation needs to be monitored.*

NB: Laboratory analyses by a certified NZ Laboratory.

26.3 Assess Impact of Draw-off on Groundwater Water Quality.

162. TA 7359-KIR assessed the potential impacts on private shallow wells in terms of groundwater quality if the abstraction rates from the groundwater reserves were to be increased to the maximum sustainable yield of each reserve.

163. **T**he findings indicate that the lenses are under stress and there is limited scope to extract supplies for both treatment for potable use, and continuing secondary uses for washing of clothes, bathing and general household activities. While an abstraction gallery could be installed in the vicinity of the sports stadium in Betio the natural quality of the water will require reverse osmosis (RO) treatment with considerable cost for the small volume involved (30m^3/day). Of more concern the abstraction of the supplies for potable use will compete with the secondary uses bringing additional stress on the lens, which despite the extended period of wet weather prior to the assessment remains shallow and constricted.

26.4 PUB System Water Quality

164. The water treatment specialist reviewed the operation of the Bonriki water treatment plant and the operation of the transmission main along South Tarawa and service/elevated reservoirs fed by the main. Water samples were collected at the treatment plant and from the service reservoirs, the final reservoir in Betio and from household connections and header tanks. The results in the main system were good, but from there the results deteriorated in the distribution network indicating that much is required to improve the quality of the PUB water at the delivery point to the consumer. The findings are covered in the report received from the water treatment specialist attached as Appendix 5 in Volume 2. Section 41 later in the roadmap discusses the immediate improvements recommended and

their costs which have been carried forward into the roadmap and investment plan. Chlorine demand tests and residual testing have been carried out to determine the optimal chorine dose rate. Recommendations are provided for regular testing and monitoring of the water supply, with particular attention to maintaining residual chlorine at the extremities of the system.

26.5 Household Rainwater Tanks and Other Supplies

165. Samples were collected at random from rain-water tanks. Most of the samples were from household tanks but some were taken from maneaba tanks including well design systems set up under development projects. Household rain water tanks were mostly commercially available tanks constructed of polyethylene, but in some cases comprised a collection of informal drums and containers ranging the full spectrum from large aluminium basins, 2 litre buckets and 20 litre steel and or polyethylene drums.

166. On a few more established houses the collection systems and the tanks were well set up with spouting, down pipes, large tanks and piping to take away overflow water. For many houses the collection system comprised a short length of spouting and a sheet of old corrugated iron to direct the roof catchment water to the tank.

167. It was noted that:

- Lids were often unsecure or missing from tanks,
- It was often difficult filling a container from the tank because the tap was too low to the ground.
- The general tank surrounds were often unsanitary.
- Debris ranging from sandy material to wind-blown vegetation was seen in 8 tanks inspected. In some cases there was old clothing most likely because of the habit of airing bedding and washing on the top of the tanks.

168. The microbiology results for 49 samples taken from rain water tanks are summarised in Table 10. Samples were mainly taken from household tanks but some samples were taken from maneaba rain water tanks and these are identified separately to give an indication of potential impact if the quality of the rain water is unsatisfactory.

169. The results show little relationship with the quality of the tank set-up. Very high readings > 2419.6 E coli per 100ml sample were detected in very poorly set up household systems and at one of the state of the art set up at the maneaba in Taboria Village.

170. Rainwater catchments have always been an ‘at risk’ type supply[39] and it is only excellent management of the rainwater systems and boiling of water that ensures the rain water is safe. Ultra violet disinfection systems are widely used in Australasia to disinfect tap water just prior to use but this is not an appropriate system for Kiribati. MHMS is presently testing a local imported instant microbiological filter – “Life Straw”. If successful this could have application for treating rainwater and to avoid the boiling of the water.

Table 10: Summary of Rain water Tank Microbiology Results

Item No	Location	No of Samples	Microbiology Results (per 100ml)				
			Present	Absent	<10	10-100	>100
1	Betio	20	6	2	4	3	7
2	Ambo	2	-	-	-	-	2
3	Bairiki	12	12	-	1	1	7
4	Bikenibeu	11	6	3			2

39 Pers Comm. Stan Abbott, Director, and a Senior lecturer in Microbiology and Communicable Diseases in the Institute of Food Nutrition and Human Health, Massey University, New Zealand. Specialist field - rainwater harvesting

4	BE11* Betio maneaba	1			1		
5	BE19* Betio maneaba	1				1	
6	Maneaba Taborio Village	1					1
7	Catholic Church/ **maneaba Bairiki	1				1	
Note :	* BE code refers to the well water survey and GPS co-ordinates. For full details refer to the annexes in the Water Quality Report ** Sample taken from old rainwater tanks - tap missing from new installation. Present/Absent refers to the Colilert Presence/Absence test methodology. Nil results for both P/A and the Quanti-Tray method are recorded in the Absent Column The sampling period was 25th August to 21st September						

171. Development partners have recently supported the installation of further household and community tanks fed from maneaba and community buildings. The management of these tanks involves different parties with the likelihood of varying standards of operation. In the absence of formal arrangements for monitoring and the regulation the safety of the water quality will always be of doubt. Considerable improvement is required in training and building community and household capacity to maintain the tanks. While guidelines have been prepared under KAP II and through the work of the other projects considerable improvement is required in the promulgation, acceptance and adherence to these guidelines for rainwater harvesting.

172. Samples of bottled water produced on South Tarawa, and imported bottled water were obtained and tested. These tests also gave disconcerting results and raise the need for the regulation of these supplies and regular monitoring to ensure standards to protect public health. A summary of the test is displayed in Table 11.

Table 11: Microbiology Results for Commercially Produced Bottled Drinking Water

N°	Sample Description	Sampling Date	Microbiology (per 100ml)		
			Coliforms	Faecal Coliforms	E Coli
1	Imported Brand 1	19.09.11	Nil	Nil	Nil
2	Imported Brand 2	19.09.11	Nil	Nil	Nil
3	Imported Brand 3	19.09.11	Nil	Nil	Nil
4	Imported Brand 4	19.09.11	Nil	Nil	Nil
5	Imported Brand 5	19.09.11	Nil	Nil	Nil
6	Imported Brand 5 (Duplicate)	19.09.11	Nil	Nil	Nil
7	Local Supply 20m litre bulk container: Batch 1	19.09.11	P	315.1	315.1
8	Local Supply 20m litre bulk container: Batch 2	20.09.11	P	235.9	235.9
9	Sample taken from Water cooler at MPWU office - filled from well	19.09.11	P	648.8	648.8

.Note: Colilert Presence / Absence used for Coliforms
Colilert Quanti- Tray enumeration systems used for Faecal coliforms and E.Coli.
A distilled water boiled blank gave a nil result.

173. Bottled water was purchased at a South Tarawa supermarket and the local bulk water supply samples (Numbers 7 and 8) were sourced from two different local agencies but were believed to be from the same water source.

174. The imported bottled waters (samples 1-6) have to meet stringent 'bottled at source' and the analyses confirmed they meet all microbiological criteria. Samples of the local bulk supplied bottled water failed to meet microbiological criteria for bottled water and drinking water. MHMS have followed up and subsequent testing has found that the water has met the requirements of zero coliform and e-coli indicating that the previous tests could have come from unsterile bottles or temporary issues with the desalination plant producing the water. It is recommended that MHMS put in place a regular testing program for quality assurance.

175. Well water in Betio is known to be microbiologically polluted and Sample 9 from the water cooler does not meet microbiological criteria for bottled water or drinking water supply. If the cooler has an in-board filter the cooler may be contributing to the problem. Internal filters and the inverted bottle on top of the cooler need to be sanitized on a regular basis and the cooler should be checked to find out when the internal filter was last sanitized.

26.6 Water Quality Maps and Data

176. The water quality data has been recorded on GIS maps of South Tarawa with the position of the well/test fixed by GPS and recording the primary test parameters. For public display and community consultation simplified maps have been developed showing water quality and suitability for use in a colour washed format. The plans displaying the test results and water quality and suitability for use are presented as drawings 50663 sheets numbered 401 to 416 in Volume 3 containing the roadmap drawings. The drawings provide the following information. These drawings are also supported by a further set of drawings references as 50663 sheets 417 to 420 providing tabulation of the test parameters from each sample site.

Location	Figure Numbers			
	Salinity	Microbiology	Nitrate	Contamination
Betio	50663/401	405	409	413
Bairiki	402	406	410	414
Bikenibeu	403, 404	407,408	411, 412	415, 416

27 Implications for Design of Sanitation Systems

177. The options for the design of the future sanitation systems for South Tarawa depend upon water quality and the sustainable yields of the groundwater lenses. For on-site disposal with septic tanks, or for the use of septic tanks as a component of decentralised sewerage schemes there must be sufficient freshwater (albeit contaminated) or brackish water with acceptable saline levels, as the septic tanks and irrigation fields will not function with saltwater or water of high saline content. For freshwater bucket flushing the available lenses must be capable of supporting this draw off and loss by discharge through the ocean outfalls, without compromising the draw off for other secondary uses or the security of the lenses, through periods of drought

178. Table 12 summarises information from the assessment of the groundwater lenses along South Tarawa and the implications of these results on the options for the development of sustainable sanitation systems. The information is carried forward and referred to later in the roadmap in the preliminary design and costing of the sanitation options.

Table 12: Lens Capacity, Water Quality and Implications for Sanitation

Lens	Lens Capacity	Water Quality	Implications
Betio	258 m^3/day	Poor	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Bairiki	23 m^3/day	Poor/saline	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Bikenibeu	12 m^3/day	Poor/saline	Protect water for secondary use. Restore saltwater flushing system and prevent loss of freshwater through toilet flushing
Nanikai	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Teaoraereke	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Eita	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)
Nawerewere	Limited	Saline	Protect water for secondary use. Sanitation systems must be saltwater flushed. On-site systems must return treated effluent to ground, or be dry type (low water use)

VI Water Supply

28 Description of Existing Piped Water Supply System

28.1 Water Resource and Distribution

179. The main road on South Tarawa spans the length of South Tarawa running east to west from Bonriki to the east of the airport to Betio and across causeways that connect the islets and villages along its route. The main transmission main providing the backbone of the water supply system also extends along this east to west corridor for a length of some 30 km. The transmission main supplies drinking water to all the communities of South Tarawa through a series of ground and elevated reservoirs sited along its length.

180. The Government's WSSW Program adopted in February 2011 identified the need to replace an older section of the transmission main between Teaoraereke and Betio and agreement has been reached to replace this pipeline as a component of the World Bank / ADB Tarawa Road Improvement Project to allow coordinated design and construction and to avoid later disturbance to the new road pavement across the narrow causeways. The replacement of this length of transmission main will occur in 2012 and 2013.

181. Water is extracted from the freshwater lens from intake galleries sited at the Bonriki water reserve. The sustainable yield from the Bonriki reserve is established at 1,660 kL a day. The Buota water reserve to the immediate north which was previously connected to the system has a sustainable yield of a further 350 kL a day. The Buota galleries and pipeline across the new bridge connecting the system to the Bonriki treatment plant were re-established under KAP II, but the reserve is waiting to be reconnected. This will occur in the near future.

28.2 Treatment and Supply

182. The water treatment plant located on the Bonriki water reserve treats the water by aeration to remove hydrogen sulphide and injects chlorine gas for disinfection. The limiting unit at the treatment plant is the aerator (25l/sec, 90m^3/hr, 2,160m^3/day). This equates with the sustainable gallery yield from the Bonriki and Buota water reserves and will need upgrading to also accommodate improvements to the Bonriki reserve. The treatment plant is now displaying signs of deterioration through inadequate maintenance and poor housekeeping practices. There is an immediate need to clean the aerator and replace baffles and to improve the disinfection process. From the treatment plant, water is transmitted by pumping and low level reservoirs to 16 water storage reservoirs located at the villages at intervals along the 30 km transmission pipeline, and a large ground level reservoir at the end of the pipeline in the water department compound in the centre of Betio. The Betio area network with the ground level and an elevated reservoir is also fitted with a secondary chlorination unit, although this has fallen into disrepair and is not operating at the time of the inspection.

183. It is reported that at least 7 metered connections exist supplying water to the Tungaru Central Hospital, Otintaai Hotel, foreign embassy compounds, The Fisheries Training Centre and one larger connection to the Marine Training Centre (MTC) in Betio.[40]

184. The first sets of elevated reservoirs along the pipeline are filled by pressure in the line. The elevated reservoirs further up South Tarawa are filled by booster pumps. Under the SAPHE project the transmission main between Bonriki and Teaoraereke was upgraded to 225 mm diameter to allow operation at a lower 30 m pressure head to minimise losses and yet be adequate to maintain supply to the Betio reservoir. The pressure at which the present system operates is not known although it is assumed this will be higher than the 30 m design pressure. The installation of pressure gauges along the transmission main would allow better management of delivery pressures.

[40] PPWA Benchmarking Project

28.3 Monitoring and Unaccounted for Water Losses

185. The SAPHE design for the transmission main did not allow for the supply to any other outlets, other than the reservoirs along its length and there were no illegal connections when the major part of the pipeline length (20 km) was replaced. The transmission main installed under the SAPHE project runs from Bonriki to a point just before the Teaoraereke service reservoirs where it connects with an older μPVC pipeline installed some 20 years previously. This older section of diameter pipeline between Teaoraereke and Betio is cited as the main contributor to losses in the transmission side of the network with illegal connections and many locations where repairs have been attempted with repair clamps. The reported faults are described as large cracks over a considerable length of the pipe where the repair clamps are meant to be only a temporary measure. This section of transmission pipe has therefore been identified as a contributing factor to water loss and a risk for contamination of water in the system.

186. A set of leakage estimates in 2009 put water loss in the whole South Tarawa supply system at 50% of which 20% are assigned to water loss in the 30km main transmission pipeline.[41] A statement by PUB to the NWSCC on 29 August 2011 would now place the unaccounted for losses as around 67%.[42] There is daily monitoring of the drinking water volumes pumped into the main transmission pipeline at Bonriki treatment plant, and daily readings from the meters which are fitted at the discharge side of the services reservoirs with regular reading of the few metered connections. The quantity of water to the transmission main and the delivery from the reservoirs is reviewed daily thus allowing the losses in the transmission main to be established with some certainty. Assessment of water losses beyond the discharge from the reservoirs to the local networks is pure conjecture and at best guesswork. While checks are made to measure the hours of water delivery and quality of supply in terms of the level and rate of flow, the system fails to serve all connections and large sections of the community receive either limited or no supply, or supply tankered in.

187. There are no structured leak detection programs, nor are systematic processes followed to monitor and limit water losses. Despite featuring strongly as a capacity building component in the first part of the SAPHE project the activity receives little attention in the daily activities of PUB. Presently there is one flow meter installed on the 30 km long transmission main, reportedly at the Bagantebure reservoir. Other flow meters are required, with easily accessed and lockable manholes for improved loss management.

188. Leak detection and waste management will be an immediate priority to reduce unaccounted losses and bring the water supply to an efficient balance which will make the best use of available and limited potable water supplies. Leak detection and waste management programs should be developed and operate as a normal component of PUB's annual operations. Leak detection programs require a long-term and continuing effort.

28.4 Condition of Existing Supply System and Deferred Maintenance

189. TA 7539-KIR has inspected the existing water supply system including the galleries and intake pumps at Bonriki, the main transmission lines and service reservoirs and the rechlorination unit at Betio. The report on these main components of the system with recommendations and costs for immediate repairs, maintenance and improvement is covered in section 41 Water Supply System, Upgrading and Maintenance. The identified requirements and estimated costs have been carried forward into the water supply improvements incorporated in the roadmap and investment plan reported later. The

[41] Tarawa Master Plan – Future Demand, Dr.Ian White and Tony Falkland. KAP II, August 2009.
[42] Report to NWSCC stating "The current water transportation loss through the rising main stands now at 29% of total Bonriki production. Hence the quantity available for storage and distribution to the whole of South Tarawa is 1,410 kL per day of which 50% estimated/assumed is lost in the reticulation systems." So of a production of some 2100 kL at Bonriki only around one third or 705 kL is delivered to customers

immediately following sections give attention to the water resources available for future growth.

29 Tarawa Water Master Plan

190. The draft Tarawa Water Master Plan (TWMP) prepared over a period of several years by Prof Ian White of the Australian Open University is a well researched planning document providing options for the sustainable future development, protection and use of freshwater in Tarawa. It is a direct response to the Kiribati National Water Resources Policy (NWRP) and the 10 year National Water Resources Implementation Plan (NWRIP). The TWMP summarises priority issues, estimates existing and expected future freshwater demands of Tarawa's growing population, and assesses current and potential freshwater sources. It takes into account projected impacts of climate change, and provides a range of options, with estimated costs, for meeting those demands, and it recommends management strategies to care for Tarawa's fragile freshwater resources over the next 20 years.[43] The statements in this section of the Water and Sanitation Roadmap borrow heavily from the TWMP to avoid new explanation which although intended to reflect the same views might confuse and therefore detract from the TWMP.

30 Priority Considerations

191. Using 50 years of water studies and projects and drawing on the experiences of people in Tarawa, the TWMP identified a wide range of continuing priority issues which need to be addressed. Primary considerations are; the unacceptably high rates of preventable deaths, illnesses and social and economic impacts due to water-borne diseases, particularly among infants; large, wasteful, and expensive losses of treated freshwater from the reticulation system, especially the domestic supply system; growth in demand for water; and a range of institutional and management issues.

31 Present and Future Water Needs

192. The Urban Growth and Development options developed by TA 7359-KIR outline the circumstances that have propelled residents in South Tarawa from a largely low-density, subsistence lifestyle to a high-density, urban situation. The analyses undertaken indicate that, even if steps were taken to curb inwards migration and natural growth in the period of the new Kiribati Development Plan (2011 to 2016), the effect of any change will take several generations and only start to have effect from 2025-2030 onwards. Continuing high growth will see an urban population in South Tarawa of 107,700 people by 2030 with high population densities.

193. The TWMP notes that determining Tarawa's freshwater needs over the next 20 years is not an easy task made doubly difficult with a lack of data on current freshwater use in Tarawa by the different sectors and from various water sources. Again is was noted that the earlier TWMP assessment was compounded by the difficulties of estimating the change in water demand due to population growth and development, and the result of climate change and water losses.[44]

194. During the recent testing of the wells on South Tarawa for the water resource assessment under TA 7359-KIR, households were surveyed to establish average water use, both from the wells. This exercise confirms an average of 45 L/pers/day for all uses, including bucket flushing of toilets and some potable use, although the respondents were reluctant to admit this. The potable supplies from PUB's piped network are presently delivering an average of around 14 L/pers/day to the consumer, after losses.

[43] Tarawa Water Master Plan, Prof Ian White, Australian Open University, KAP II 2011

[44] Water losses from water supply systems have a wide range of names such as "unaccounted for water" or "non-revenue water". Here, water losses includes leakages from the pipeline, water stolen through illegal connections, water evaporated from head tanks, overflows at head tanks and from the 500 L trickle-feed household tanks.

32 Public Health and Availability of Freshwater

195. The TWMP refers to a World Health Organisation (WHO, 2006) assessment of the public health risks for various levels of service and per capita daily availability of water. Where the availability of a safe freshwater supply is low such as the present value of 14 L/pers/day the WHO assessment confirms an extremely high public health risk associated with this low quantity, and an unequivocal high priority for intervention. The condition of the freshwater lenses and their over exploitation, coupled with the poor piped supplies confirms the urgent priority for the development of a safe water supply for South Tarawa to augment present supplies.

196. The approach taken in the TWMP to estimating Tarawa's freshwater needs are described in the linked report on Te Ran-Maitira ae Kainanoaki, Future Water Demand (White, 2011a). The assumptions that have been made in this earlier estimation are listed in the following statements and updated in the light of new data gathered for the preparation of this roadmap.

33 Adjusted Assumptions Used in Estimating Water Demand

197. The following assumptions have been used to estimate the average water demand per capita.

a) Household wells in South Tarawa have groundwater that is too polluted for use. This is now confirmed by the water quality testing and survey conducted under TA 7359-KIR;

b) Average draw off for Betio is estimated to straddle the sustainable yield and for Bairiki and Bikenibeu to exceed the sustainable (recharge) capacity of the lenses. Resource management will be necessary to preserve the resource for secondary uses such as washing clothes, household cleaning and bathing;

c) TWMP assumes water requirements of institutional, commercial and industrial (ICI) sectors at 10% of the per capita domestic consumption in South Tarawa and 5% in North Tarawa: This assumption is supported and has been adopted for the roadmap assessments of demand;

d) No piped freshwater will be allocated for toilet flushing. No systems will take groundwater for flushing and discharge this to the ocean. All systems, unless saltwater flushed, will return the treated effluent to the lenses;

e) No piped freshwater will be allocated for irrigation in South Tarawa: grey water, washing, bathing and kitchen waste water sources from the piped supply shall be recycled to the lenses;

f) Toilet flushing requirements for centralized systems shall be met from seawater;

g) The reduction from groundwater resources made in the TWMP for climate change has been adopted for the calculations of demand in this roadmap;

h) Similarly the TWMP provision of 2L/pers/day for increased water use due to increasing temperatures has been accepted for incorporation into the demand figures from 2020;

i) All households on South Tarawa will be supplied with piped, treated freshwater;

j) TWMP places limited value on rainwater tanks as the solution to South Tarawa's water supply issues, citing the high cost of providing sufficient storage and the vulnerability to failure in periods of extended drought, which are becoming more frequent and are a higher probability with global climate change. Calculations for the roadmap, confirm that rainwater tanks will only provide 5L/pers/day for an average sized family during a drought of three months, provided the water is rationed from the beginning of the drought period. While recognizing that rainwater has an important

part to play in overall water supply for normal times, the assumption for the roadmap does not accept rainwater tanks as the permanent solution;

k) Pipeline water loss rates will receive attention and will decrease in the future;

l) The current water loss rate in South Tarawa from the main transmission pipeline is around 29%. The distribution system losses are estimated to be at least 50%. These losses totaling 67% are unacceptable and wasteful and cut into the ability to sufficient treated water to satisfy demand. The roadmap makes provision for an aggressive leak detection program with the aim of reducing losses to 25% by 2015. Future provisions aim at bring losses back to 20% by 2030 and 15% by 2030, before stabilizing the losses at this figure; The deficit indicates the quantity of water which will need to be found from a new source.

Table 13: Per Capita Water Demand TWMP Adjusted

198. Based on a similar table in the TWMP Table 13 illustrates adjusted per capita water demand in North and South Tarawa, based on the above assumptions. The data on use gathered during TA 7359-KIR. Population projections provided earlier in Table 3 can now be combined with the estimated required per capita water demand in Table 13 to give estimates of the total daily amount of safe, treated water required to satisfy the future demand in South Tarawa. The deficit indicates the quantity of water which will need to be found from a new source.

Table 13: Per Capita Water Demand TWMP Adjusted

199. To demonstrate the sensitivity of water demand and the present deficit in the supply comparisons are given in Table 14 for a potable water demand of 50L/per/day and Table 15 for a lesser demand of 40L/per/day and illustrated in Figures 1 and 2 respectively. The deficit indicates the quantity of water which will need to be found from a new source.

Table 13: Per Capita Water Demand TWMP Adjusted

Component	Demand (L/pers/day)		Comments
	South Tarawa	North Tarawa	
Per capita potable demand (excluding toilet flushing)	42	40	Provided from safe sources: treated piped water in South Tarawa, and wells remote from settlements or eventually piped water in North Tarawa
Toilet flushing (non potable)	30	30	Provided from seawater for piped sewage system or well water for onsite systems in North and South Tarawa. All well water for systems recycling water to groundwater lenses
Institutional, Commercial & Industrial use (potable)	6	3	10% of per capita domestic demand in South Tarawa, 5% in North Tarawa provided from safe sources
Irrigation	0	0	Household irrigation and livestock water will be sourced from groundwater wells where suitable and from recycled “grey” water.
Livestock and domestic animal water	0	0	
Climate change (potable)	2	2	Allowance for 1°C rise in atmospheric temperature after 2020
Total per capita demand excluding toilet flushing	**50**	**45**	**Provided from safe sources only**
Toilet flushing	35	30	Saltwater for centralized systems discharging through outfalls to the ocean – otherwise all well water for onsite systems to be recycled to the lenses

Total per capita demand all components	**85**	**75**	Provided from potable, non-potable and saltwater flushing systems
Water losses – rehabilitated system in S. Tarawa (from 2015) and new systems in N. Tarawa	25%	25%	Percentage losses of total water production from piped water system

Source: TWMP with amendments to reflect data and greater certainty from TA 7359-KIR study

Table 14: Estimated Water Balance for South Tarawa – 50L/pers/day

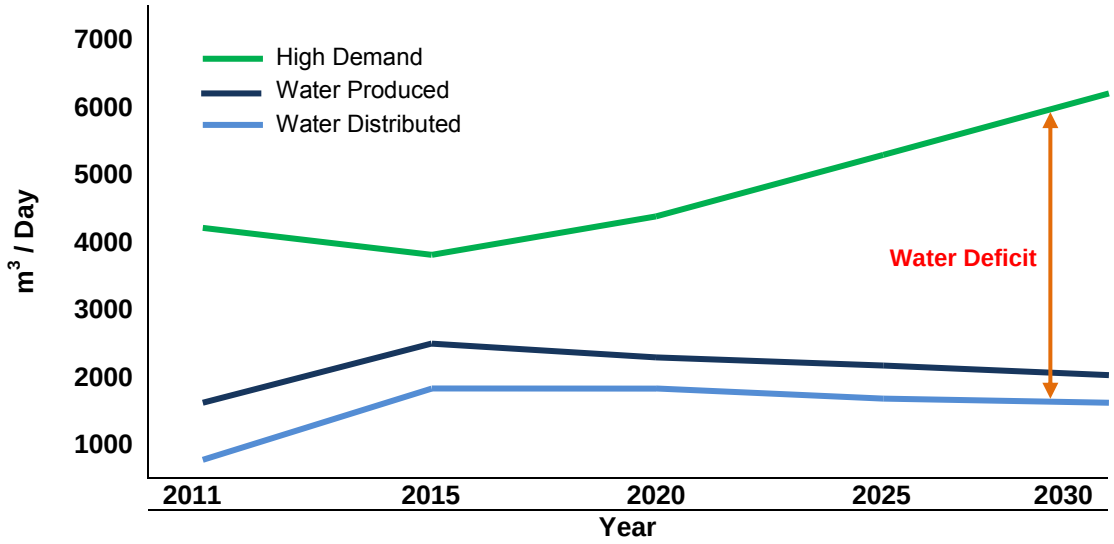
Description	2011	2015	2020	2025	2030
High population growth	50,402	60,936	73,720	89,131	107,719
Water Loss	67%	25%	20%	20%	15%
High growth demand	4,209	3,809	4,423	5,348	6,194
Safe yield[1]	1,660	2,010	2,010	2,010	2,010
Increased production[2]	0	500	500	500	500
Decrease due to climate change[3]			166	333	500
Total water available, Bonriki/Buota	1,660	2,510	2344	2,177	2,010
Water distributed[4]	705	1,878	1,872	1,738	1,705
Deficit (high demand - distribution)	-3,504	-1,931	-2,552	-3,611	-4,489

Notes:
1. Safe yield initially from Bonriki with Buota coming into production in 2012
2. Bonriki clearing palms 2012, infill of borrow pits 2013
3. Loss of 20% of groundwater capacity by 2030
4. Distribution after allowing for losses

Table 15: Estimated Water Balance for South Tarawa – 40L/pers/day

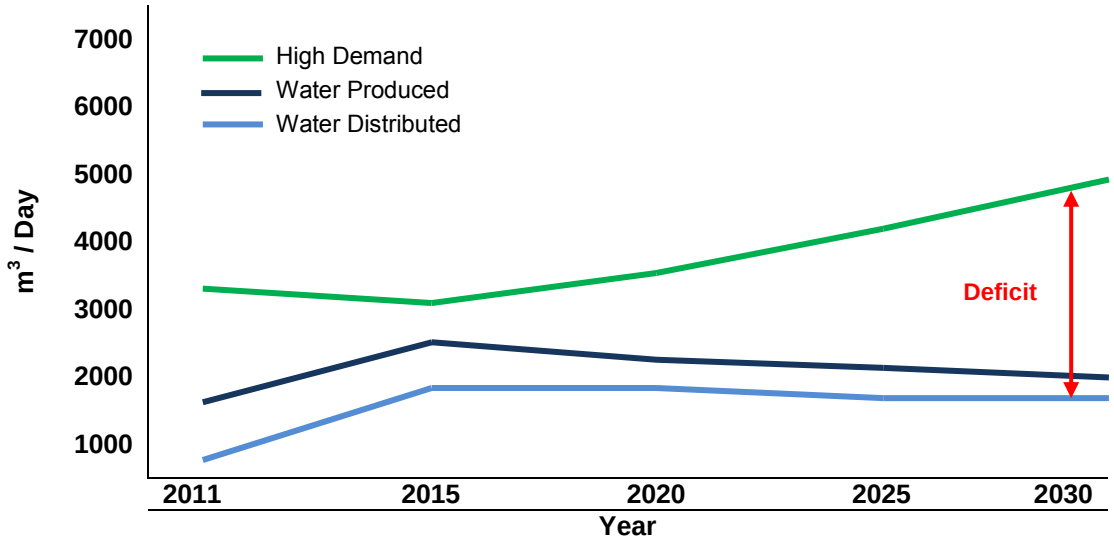
Description	2011	2015	2020	2025	2030
High population growth	50,402	60,936	73,720	89,131	107,719
Water Loss	67%	25%	20%	20%	15%
High growth demand	3,367	3,047	3,539	4,278	4,955
Safe yield[1]	1,660	2,010	2,010	2,010	2,010
Increased production[2]	0	500	500	500	500
Decrease due to climate change[3]			166	333	500
Total water available, Bonriki/Buota	1660	2,510	2,344	2,177	2,010
Water distributed[4]	705	1,878	1,872	1,738	1,705
Deficit (high demand - distribution)	-2,662	-1,169	-1,667	-2,540	-3,250

Notes:
1. Safe yield initially from Bonriki with Buota coming into production in 2012
2. Bonriki clearing palms 2012, infill of borrow pits 2013
3. Loss of 20% of groundwater capacity by 2030
4. Distribution after allowing for losses



Note: "water produced" is the supply from Bonriki and Buota

Figure 1: Illustration of Water Balance at 50L/pers/day Potable Consumption



Note: "water produced" is the supply from Bonriki and Buota

Figure 2: Illustration of Water Balance at 40L/pers/day Potable Consumption

200. In the preceding Figures "water produced" refers to the groundwater abstraction from Bonriki and Buota. The future deficit is sizeable and dramatically displayed in Figures 1 and 2, even with moderate levels of demand and a strong commitment to bring loss and wastage under control.

201. The daily demand is slightly less that the estimates in TWMP due to the anecdotal evidence in other countries with scarce water reserves where the communities, used to marshalling limited supplies are more frugal over use, especially if this is costed and charged for. The approach for the roadmap also sees the introduction of universal metering with tariffs that reflect the true cost of producing and distributing water as means of controlling excessive use and wastage.

202. Alternative sources of safe water are required from 2011 forward with progressive increases to balance supplies and demand. Attention now needs to be given to the manner in which available or future supplies can be developed to meet the deficit between demand and supply.

33.1 Behavioural Change

203. The South Tarawa Sanitation Improvement Sector Project through its long-term community awareness program will provide the scope and opportunity for the embedding of behavioural changes that recognise the importance of water supplies to South Tarawa and the need for concerted resource management, and the control of excessive and wasteful demand. The activities of KAP III and UDP will also address issues of community awareness and processes are in place to harmonise the three programs and their impact in bringing changed attitudes within the community to the value of safe and reliable water and sanitation systems.

204. The harmonisation of the collective community awareness programs of STSISP, KAP III and the NZAP Urban Development Project will strengthen the combined message and add value in a comprehensive and cohesive program for improving community understanding of individual and collective responsibilities in the safeguarding of the water resources and effective delivery of services. The harmonised approach will also avoid over consultation, mixed messages and saturation of the messages to the community to the point where the community "switches off" and losses interest. There is also a need for the harmonised approach to build a relationship with existing organisations like the churches to enlist their assistance in bringing about the required behavioural changes.

33.2 Demand Control Mechanisms

205. There is no legal mechanism in place for controlling excessive water use in Tarawa, since there is no national water legislation specifying who owns groundwater resources, who has rights to withdraw and use the resource and by what manner and in what quantities, and what are the responsibilities of groundwater users. If the scarce primary and secondary groundwater reserves are to be preserved for future generations this control and legislation, and its enforcement is necessary as individuals and families seem unable, or unwilling to think beyond their immediate needs. The roadmap incorporates provision for the development and enactment of appropriate legislation and a regulatory framework for the sector.

206. The traditional way of controlling demand in a reasonably equitable way is to meter water use and to charge for the quantity of water used by the consumer. The only mechanism presently available to the PUB to control demand is to supply piped water intermittently to various regions in South Tarawa for a brief time every second day. This has three disadvantages: households leave taps open to collect water in containers, so losses are high; customers are very reluctant to pay for an intermittent water supply; and intermittent supplies are prone to bacterial build-up in supply lines and in storage units.

207. A problem faced in introducing water tariffs in Tarawa is the number of households with very limited capacity to pay for water. Metering consumption of water and tiered charging provides the only sensible means of controlling excessive demand and wastage provided it is well managed with measures for life-line supplies and tariffs. The installation of water meters is provided for in the future improvements to the water supply system, but after water losses have been tackled and brought under control, and when an alternative source has been established and the system is operating on a twenty-four hour pressurised basis.

208. The arrangement would see a life-line tariff across all connections with a volumetric charge for use above this based on cost recovery for O&M. The meters would be installed gradually with the monthly charges continuing for a period of up to six months while consumers adjust to the actual metered consumption, before the charges by volume become effective.

33.3 Demand Management Difficult but Necessary[45]

209. There are long-standing cultural and social customs in Kiribati that make demand management a difficult issue. These, however, have led to a situation in water supply where

[45] From TWMP, Prof Ian White, KAP II, 2011

the distribution of water in South Tarawa is inequitable, where wastage is not discouraged, where anti-social and even illegal actions are condoned, and where the water supply system is not financially sustainable, and where the very survival of the communities as they presently stand into the future has been placed at risk. If these problems are to be addressed then difficult decisions regarding demand management must be made. They represent the key matters to be addressed in the longer-term campaigns to promote behavioural change and will require underpinning by the necessary legal framework, representing further requirements also reflected in the roadmap.

33.4 Drought Contingency Planning

210. Lengthy, severe droughts are common in Tarawa (White and Falkland, 2010). During these droughts, almost all rainwater tank storages will fail and groundwater lenses will become salty. A Drought Response Plan for South Tarawa for these circumstances was adopted in March 2011. The document outlines the methodology for determining the level or severity of drought condition providing a definition of drought, in the context of the South Tarawa water resources and identifying a procedure for alerting the required government and non-government stakeholders, and community of the drought status. The Plan also outlines the institutional arrangements for the nomination of each of the three drought alert levels and for a Declaration of Drought.

211. Drought in South Tarawa is declared when the main water reserves are under threat from reduced rainfall over a prolonged period and as a result of the subsequent reduced groundwater recharge and there is an observed deterioration of the freshwater lens. This is informed by meteorological analysis of the observed conditions and the forecast climate outlook, in combination with a measured reduction in freshwater lens size and/or increased salinity in the water delivered from the water reserve galleries at Bonriki and Buota by PUB.

212. The provisions of the roadmap are designed to avoid the eventuality of a future water shortage and associated crisis and the need to enact the provisions of the Drought Response Plan.

34 Water Sources and Availability to Meet Needs

34.1 Primary Considerations

213. The TWMP looked at a range of sources to met future safe water requirements. It assumed that water for toilet flushing would continue to be sourced from seawater or household water wells. The mapping of the South Tarawa water lenses and assessment of sustainable use by TA 7359-KIR now establishes that the lenses are too fragile to permit extraction for water for sewer flushing where the water is lost through the network to the ocean. The statement therefore needs to be qualified to the effect that groundwater for toilet flushing can only be accepted where the treated effluent is recycled to the lens. Centralised sewer systems discharging through the ocean outfalls must in future be fully saltwater flushed.

214. For the survival of the communities as they exist now, and their orderly growth the government and the communities will need to work cooperatively to preserve all existing freshwater sources, and to secure new sources to provide potable water to the communities. Water resources for South Tarawa for the foreseeable future will therefore consist of the combination of Bonriki and Buota Water Lenses (lifeline), Rainwater Harvesting (lifeline) and the new water source to be established.

215. Protection and refurbishment of the water lenses in South Tarawa needs to be pursued with urgency, where possible in combination with alternative land uses compatible with water resource conservationThis also means being prepared to contribute equitably to the cost of providing and maintaining the water supply systems. Anything less means the breakdown of society as it presently exist, an increase in water borne diseases, and in all

probability failure of society as people combat failing systems and compete for dwindling resources. Without change the picture is depressing.

216. A major problem in meeting current water needs in South Tarawa is the estimated 67% losses of water from the piped system, particularly from the household domestic systems. Reducing this excessive leakage and addressing the underlying causes should be the first priority. TWMP makes the point that there is little point in introducing new water sources into South Tarawa if leakage rates are not reduced. The roadmap accepts this view and identifies leak detection as a first and most necessary priority.

35 Available Water Sources

217. The TWMP considered a range of water sources and potential sources and assessed their capacity to meet present and future demand, including rainwater harvesting, household water wells, reticulated groundwater from water reserves in Bonriki and Buota, potential new groundwater sources in North Tarawa, and solutions offered through technology as well as non-conventional sources of water. For completeness the TWMP summary is included in this roadmap in the following statements.

35.1 Rainwater

218. Although an important source of freshwater, rainwater harvesting cannot be relied on as a continuous source of water because of the frequent, severe ENSO-related droughts in Tarawa, the limited roof catchment areas and rain tank volumes available and the large average number of people per household. There is the potential to increase rainwater harvesting, especially from large public buildings but this requires a communal system of management and again will not provide the answer to water supply through prolonged droughts. A water balance model for the roadmap analysis confirms this situation where over an three month dry period the tank water for an average household would only deliver 5L/pers/day if marshalled well over the full period

35.2 Household wells

219. Over 35 years ago, it was recommended that the use of local household wells on South Tarawa be abandoned because of the threat of contamination from dense urban settlements. Since then, the population has grown by over 330% and is predicted to more than double over the next twenty years. The recent mapping (2011) of the freshwater lenses underlying South Tarawa and the testing of the well and bore water for salinity, bacterial loadings and chemical parameters now confirms beyond doubt that household wells in South Tarawa are unsuitable for potable use.

35.3 South Tarawa Groundwater

220. The sustainable yield of the current combined groundwater sources of Bonriki and Buota water reserves is 2,010 m^3/day. There is the potential to increase this by 500 m^3/day by removing coconut and pandanus palms from the centre of Bonriki and by infilling brackish saline ponds at the western end of the island. This will involve negotiations with land owners, payment of compensation and possibly increased land rental payments. With this increase, the supply would be inadequate to meet the current needs of South Tarawa and would be totally inadequate to meet the needs of the increasing population and the impacts of climate change, so extra sources of water are required.

35.4 North Tarawa Groundwater

221. The water resources of rural North Tarawa have been recently assessed. It is estimated that the sustainable yield of all major freshwater lenses in North Tarawa is around 3,650m^3/day. When distribution losses are allowed for and when combined with the groundwater sources in South Tarawa this is sufficient to meet the needs of Tarawa until 2020 and will support planned urbanisation on a moderate scale. Exploitation of groundwater sources in North Tarawa for transmission to South Tarawa, however, will require the

installation of a power station, treatment plants and reservoirs and around 30 km of main transmission line including a 16.5km long cross-lagoon section to supply water to South Tarawa and additional reticulation to service the North Tarawa communities. This will change the character of North Tarawa and from the lessons learned during the extensive consultation under KAP II is likely to be unacceptable to communities there, particularly as indications were given when the lenses were being assessed, that the water would not be diverted to South Tarawa. The development of groundwater sources in North Tarawa for freshwater supplies to South Tarawa will therefore require a strong resolve on the part of the Government, extensive negotiations with landowners, compensation payments and expensive, continuing land rental payments. The option also has high capital and annual costs, and high social costs.

222. For completeness the North Tarawa resources are shown in Table 16. The availability of water in South Tarawa and North Tarawa after the diversion of the resources is indicated in Table 17.

Table 16: North Tarawa Water Resources

Islands	Sustainable Yield (m^3/day)	After Distribution Losses (25%)	At 2030 after Climate Loss (20%)
Abatao & Tibituea	220	165	132
Taratai	661	495	396
Buariki	863	647	518
Remainder South Tarawa	1,902	1,426	1,142
TOTAL	**3,651**	**2,733**	**2,188**
Notes:	1. Source of Yields TMWP and GWP mapping of North Tarawa 2. All yields are upper bound levels for extraction		

Table 17: Tarawa Water Balance

Option	Description	Availability South Tarawa L/pers/day			Availability North Tarawa L/pers/day		
		2011	2020	2030	2011	2020	2030
1	Do Nothing	14	8	5	590	466	363
2	Leakage Reduction	14	20	12	590	466	363
3	Improve Bonriki	14	24	12	590	466	363
4	Abatao/Tabiteuea	14	27	17	590	439	342
5	Buariki/Taratai	14	43	28	590	245	192
6	Remainder North Tarawa	14	54	36	590	54	36
Notes:	1. Total diversion from North Tarawa will only meet South Tarawa demand to 2020 2. Any diversion from North Tarawa probably not possible until 2020						

35.5 Other Freshwater Sources

223. The other sources of freshwater considered by the TWMP were: bottled water; recycling of “grey” and “black” water (which the roadmap endorses but with adequate treatment of the “black” water), bulk importation of water by ship; constructed rainwater catchments; a constructed island for groundwater harvesting; solar stills and seawater reverse osmosis (SWRO) desalination. A unit production cost (UPC) analysis using the capital recovery factor (CRF) approach was carried out for groundwater and other options for meeting water needs. SWRO desalination was judged to be the most attractive provided its economic operating lifetime is at least 10 years. While experience in Kiribati is that SWRO

plants have very limited lifetimes and are expensive and complex to operate, SWRO plants elsewhere have operated for more than 10 years. Close geographic examples are SWRO plants in Nauru. The TWMP suggests that maintenance and training of RO plant staff be contracted out to the plant supplier, an approach that has contributed to the success in Nauru, and which the roadmap endorses.

35.6 Seawater RO Desalination

224. The advantages of SWRO desalination are that it can be installed and started quickly, removes pathogens from product water, requires only a small land area with minimal land rental and compensation payments (or none if Government land is used), will involve minimal negotiations with landowners, requires no new legislation, can be supplied in containerised modules, allowing units to be located in areas of highest demand with direct connection into existing water supply pipelines, Energy recovery systems and maintenance and training contracts are available. Their disadvantages are a poor track record of SWRO in Kiribati, the requirement for well trained operators, the need for regular maintenance and monitoring, energy use, and the fact that they are seen as a technological fix.

36 Impacts of Climate Change

36.1 Increased Demand

225. The rise in atmospheric temperatures accompanying climate change (Ali et al. 2001), may be as high as 1°C by 2050 (Metutera, 2002). This has the potential to lead to an increase in the per capita demand for water. Since there is currently little information on the current per capita demand for water in Tarawa, it is difficult to estimate any increase in per capita water demand due to climate change. It has been assumed in the TWMP that the increase in potable water consumption due to climate change will be 2 L/pers/day from 2020. The deficit indicates the quantity of water which will need to be found from a new source.

Table 13: Per Capita Water Demand TWMP Adjusted

36.2 Rainfall and Drought

226. Because of the considerable uncertainties in GCM predictions of tropical rainfall, it has been assumed in the TWMP that the variability of rainfall over the next 20 years in Tarawa will be similar to that experienced in the historic rainfall record over the past 62 years; the frequent severe droughts will occur with similar frequency and longevity.

36.3 Sea Level Rise and Groundwater Source Areas

227. Again quoting from TWMP the impacts on freshwater lenses from projected mean sea level rises and possible changes in recharge have been modelled at the Bonriki water reserve (Alam and Falkland, 1997; World Bank, 2000). It was found that the freshwater zone would initially slightly increase in thickness and volume with sea level rise, as more of the freshwater lens will be within the upper, lower-permeability, Holocene sediments. When, however, land is finally lost due to erosion and inundation at the edges of an island, the island area will be reduced. This decreases the volumes of freshwater lenses and the total sustainable yield.

228. NIWA (2008b) assumed two possible sea level rises relative to 1980-99 mean levels up to 2095 of 0.49 to 0.79 m and produced possible inundation maps for Tarawa. From these, it was estimated that inundation of Bonriki and Buota could lead to a decrease in the sustainable groundwater yields of about 20% by 2030. For the roadmap this reduction has been applied to all groundwater yields in 2030 and incorporated into the estimates of the water balance in the aforementioned Tables 14 and 15.

37 Options for Meeting Increased Demand

37.1 Approach

229. The TWMP summarised the current challenges facing public water supply in Tarawa and identified major future shortfalls. It discounted the use of household wells in South Tarawa a decision which is borne out by the knowledge now that the well water is unacceptable for consumption. The TWMP also concluded that the current treated water supply in South Tarawa is inadequate to provide the quantity of freshwater necessary for the health and well-being of communities in urban South Tarawa, noting that with the expected population growth in South Tarawa, Tarawa's extreme rainfall variability, continued system water losses and the predicted impacts of climate change, the situation will worsen over the next 20 years. It then identified a number of options available for the Government to consider again noting that the choice of options would require a clear vision for the course of the development of Tarawa over the next 20 years. The review required by the roadmap has reassessed the options in the TWMP, using updated data gained from the TA 7359-KIR.

37.2 Impact of Future Development on North and South Tarawa

230. The estimated sustainable yields of safe freshwater sources in South Tarawa are inadequate for its current population and in the face of a continuing large population growth the situation will worsen over the next 20 years. North Tarawa, in sharp contrast, has more than sufficient water for its communities now and will have adequate supplies in the future, provided population growth rates remain at the average rate there over the past 25 years. If the available water resources in North Tarawa were shared with South Tarawa, the reasonable water demands of all of Tarawa could only be met until almost 2020 provided water losses are reduced to 25%.

231. The Government's plans for North Tarawa are unclear. If the aim is to progressively urbanise North Tarawa, and this may be a reality occurring by design or default, then it would reasonable to suggest that North Tarawa should share its groundwater resources. That, however, will be a difficult decision, involving lengthy consultations with communities in North Tarawa. If successful, under present arrangements, it will involve major land rental payments to land owners and will change the character of North Tarawa since it will involve the installation of a power station, pipelines and associated infrastructure. If the aim is to retain North Tarawa as a rural area with its own island-based freshwater resources, which will be adequate for North Tarawa and planned urbanisation there as an outlining growth centre in its own right over the next 20 years, then an alternate water sources needs to be found for South Tarawa.

37.3 Extra Freshwater Sources South Tarawa

232. The recent mapping and quantification of the other freshwater lenses underlying South Tarawa have confirmed their limited capacity and unsuitability as potential source locations. The lenses in Betio, Bairiki and Bikenibeu and along South Tarawa are unsuitable for human consumption and will be hard pressed in supplying secondary water requirements.

37.4 Improved Rainwater harvesting

233. Rainwater harvesting remains an important for the overall provision of water supply and with good management is a relatively safe source for meeting potable water needs in "wet" periods. There is the need to improve the basic design and selection of tanks, promulgate the guidelines for installation, operations and maintenance developed by KAP II and educate and train the households with tanks and the community on the requirements for housekeeping, operating and maintaining the rain water tank installation, including guttering, downpipes and the arrangements for draw off. The urban councils should be included in the awareness and training program so they are in a position to advise the community and to inspect the tank installations for compliance. Rainwater tanks however do not, on their own,

offer the total solution and a reliable, guaranteed potable supply is required to augment the presently available groundwater resources.

38 The Viable Options

234. The TWMP identified a number of options for increasing the water supplies to South Tarawa. The more achievable of these options have been carried forward to the roadmap for further analysis and prioritisation. Again for consistency the statements are from the TWMP, with amendment to update the statements in the light of additional information.

38.1 Option 1 – Tree Removal Bonriki

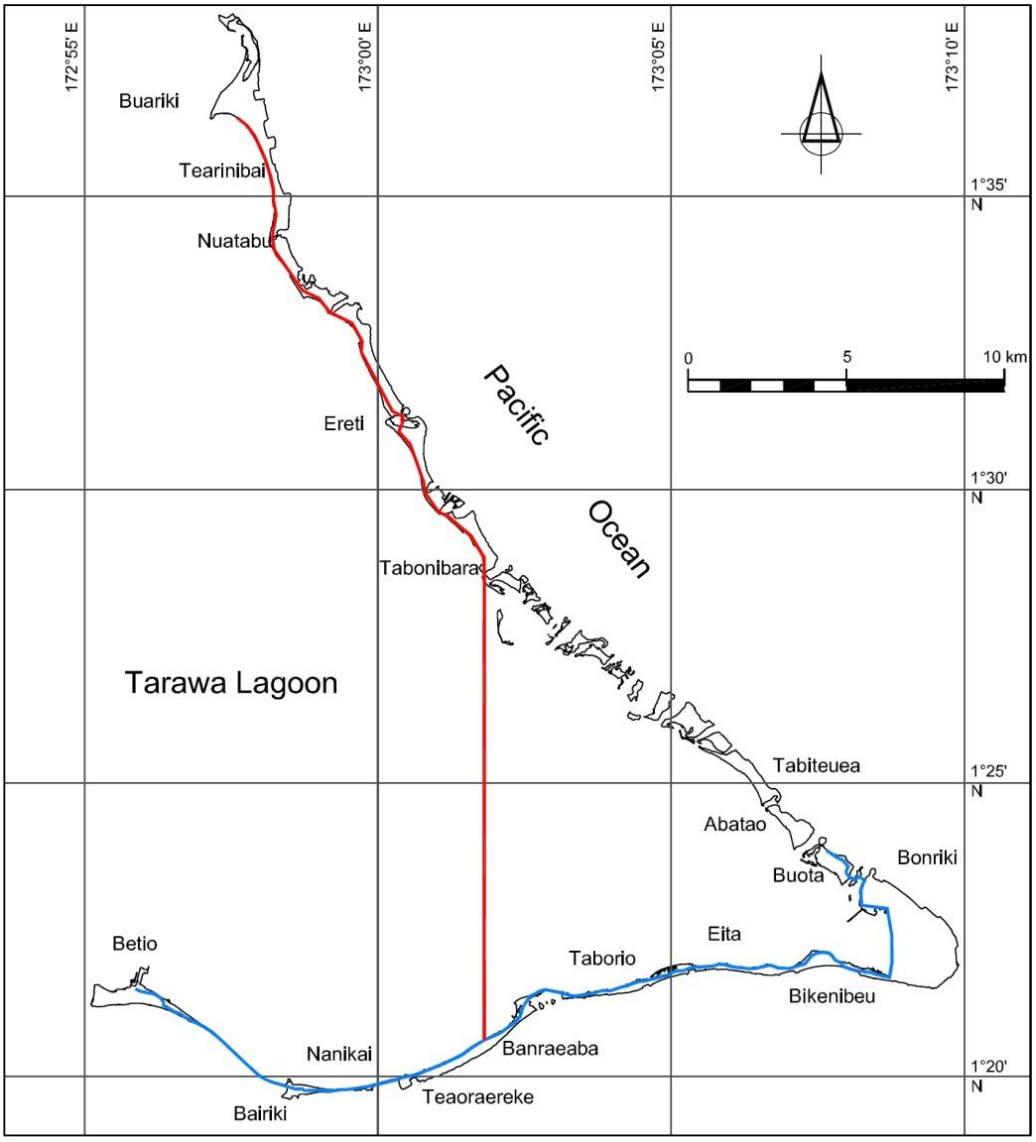
235. Deep rooted trees transpire about 150 L/day of shallow groundwater from the water reserves. Removal of 1,700 deep rooted coconuts from the central portion of Bonriki will increase the sustainable yield of Bonriki by 250m^3/day. Under this option, negotiations with landowners over tree removal and compensation payments will be required. Only minor modification of the existing infrastructure is required. The advantages and disadvantages of this option identified by TWMP and indicative capital costs are summarised in Table 21. The costs have been reviewed for the preparation of the roadmap and confirmed to be appropriate.

38.2 Option 2 – Infilling Ponds, Western end of Bonriki

236. During construction of the airport runway at Bonriki, borrow pits were excavated at the western, lagoon end of Bonriki. These become brackish during drier periods and contribute salinity to the freshwater lens. If the bottom of these ponds were cleaned of organic matter and the ponds infilled with clean, dredged sand, the area and sustainable yield of Bonriki reserve could be increased by a further 250 m^3/day. Again this option will require negotiations with landowners and the Bonriki community who use the ponds for soaking pandanus fronds for thatching, the installation of three new galleries in the reclaimed area and may involve increased land rental payments. The advantages and disadvantages of this option together with indicative capital costs are also summarised in Table 21. The estimates have been reviewed for this roadmap and have been increased to provide improved provision for the construction of the galleries and their connection to the treatment plant.

38.3 Freshwater Sources North Tarawa

237. The main freshwater sources in North Tarawa are the shallow groundwater lenses in major islands. Rainwater harvesting can contribute to potable household use but because North Tarawa is a rural area, the number of buildings with suitable roofs for rainwater collection is limited. Previous suggestions for providing adequate water supply for South Tarawa included the progressive use of groundwater from islands north of Buota with the abstracted groundwater being pumped across the channel between Abatao and Buota. The gradual development of all of the islands in North Tarawa would be a lengthy process and not able to meet the needs in South Tarawa. The TWMP has given consideration to the development of two primary sources: development of groundwater resources in Abatao and Tabiteuea, the islands immediately north of Buota and in the large islands of Buariki and Taratai in the far north of North Tarawa as illustrated in Figure 3.



Source: TWMP, Prof Ian White, KAP II, 2011

Figure 3: Option 4, Development of the Groundwater Lenses at Buariki and Taratai (with a cross-lagoon pipeline from Tabonibara to Ambo (red line) to connect with the Bonriki and Buota to Betio pipeline (blue line))

38.4 Option 3 – Groundwater Production from Abatao and Tibituea

238. In this option, a total of 8 infiltration galleries would be constructed in already surveyed areas in Abatao and Tabiteuea (Falkland et al., 2003) together with a water treatment plant for each island, a cross-channel pipeline to connect with South Tarawa and reticulation systems in each island to supply local household needs. This would increase the sustainable water supply by a modest 220 m^3/day (Table 21). Under this option, lengthy negotiations with landowners together with compensation payments and continuing land-rental payments will be required. New legislation may also be needed for the declaration of water reserves in Abatao and Tabiteuea. The costs have been reviewed and increased in this roadmap to reflect higher costs associated with the construction of the infiltration galleries.

38.5 Option 4 – Groundwater Production from Buariki and Taratai

239. In this option, a total of 18 infiltration galleries would be constructed in the northern islands of Buariki and Taratai together with a power station to supply energy for pumping for the galleries and cross-lagoon transfer, one major water treatment plant, a major water

storage tank, a 16.5 km cross-lagoon maritime pipeline to connect with the South Tarawa reticulation system at Ambo and reticulation systems for the islands in North Tarawa to supply local household needs. This could increase the sustainable water supply by a substantial 1,530 m^3/day (upper yield estimate in Table 21). Under this option, lengthy negotiations with landowners together with compensation payments and continuing, expensive land-rental payments will be required. New legislation will also be needed for the declaration of water reserves in Buariki and Taratai. This option would substantially change the character of North Tarawa and may be resisted by the North Tarawa communities. The estimated costs have been revisited and increased to cover higher anticipated costs of the maritime pipeline, infiltration galleries and the local reticulation and storage

240. The advantages and disadvantages of this option and the large capital costs are summarised in Table 21. Both resources are not immediately available to meet the present deficit or of sufficient quantity to satisfy demand beyond 2020.

38.6 Additional Rain and Groundwater Sources in North and South Tarawa

241. The combined potential freshwater resources in South and North Tarawa in options 1 to 4 above plus increased rainwater harvesting give a potential increase in water supply of 2,310m^3/day. The estimated total capital outlay for this estimated from the TWMP is approximately $A28 million.

38.7 Other Freshwater Sources

242. The supplementary TWMP report on other water sources (White, 2011b) summarises a range of other potential freshwater sources for Tarawa. The principal option with the potential to meet Tarawa's immediate and projected future needs is SWRO desalination.

38.8 Option 5 – Seawater RO Desalination

243. Previous water supply projects for South Tarawa rejected the use of SWRO desalination to supplement water supply because of its cost, energy consumption (Metutera, 2002), and complexity, as well as the short lifetime of previous SWRO units in Tarawa. The raised island of Nauru has successfully run SWRO plants for 10 years, supplying a major proportion of its potable water needs, especially in droughts. Maintenance and technical services for the SWRO plants in Nauru are contracted out to the manufacturer/supplier.

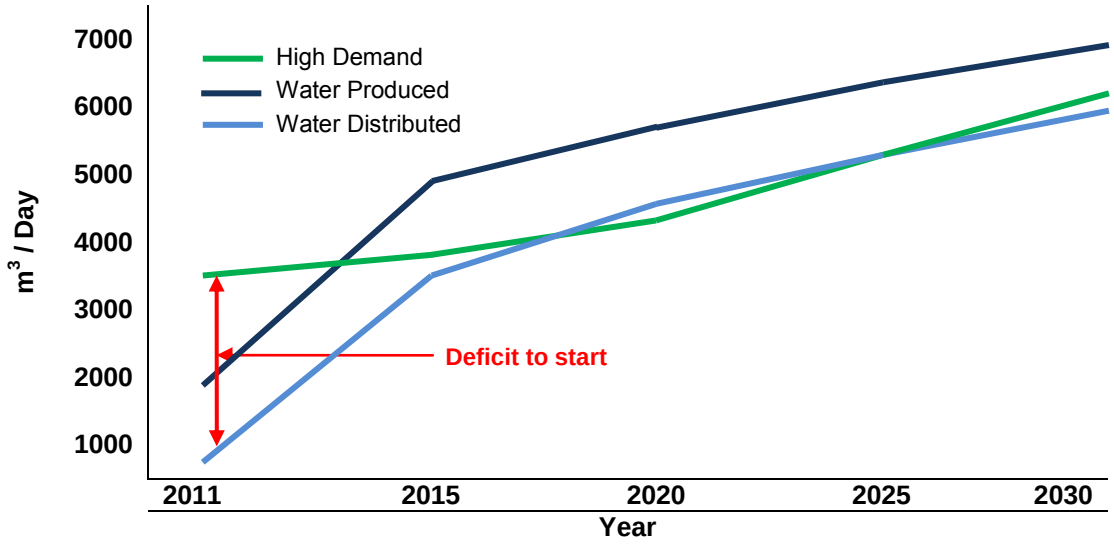
244. The strengths of the SWRO systems are that they can be installed and started quickly, are of small size and can be modularized, do not require lengthy negotiations with communities or excessive land rental payments, and can be installed close to areas of most need. In addition, new modular units can be added as demand increases. The TWMP observes that it does however represent a technological fix, diverting attention from fundamentally important aspects of protection of water sources, water conservation, community engagement and demand management. Table 18 shows the water balance using 50L/pers/day with the provision of desalination in 2014, and the progressive increase of desalination capacity. This is supported by Figure 4 which illustrates the water balance with desalination installed.

Table 18: Estimated Water Balance for South Tarawa – 50L/pers/day with Desalination

Description	2011	2015	2020	2025	2030
High population growth	50,402	60,936	73,720	89,131	107,719
Water Loss	67%	25%	20%	20%	15%
High growth demand	4,209	3,809	4,423	5,348	6,194
Safe yield[1]	1,660	2,010	2,010	2,010	2,010
Increased production[2]	0	500	500	500	500
Decrease due to climate change[3]			166	333	500
With desalination[4]	0	2,211	3,364	4,278	4,955
Total water available	1,934	4,721	5,708	6,455	6,965

Water distributed[5]	705	3,515	4,576	5,168	5,921
Deficit (High demand - distribution)	-3,504	-269	+147	-180	-263

Notes:
1. Safe yield initially from Bonriki with Buota coming into production in 2012
2. Bonriki clearing palms 2012, infill of borrow pits 2013
3. Loss of 20% of groundwater capacity by 2030
4. Introduction of desalination plants by 2014 and progressively thereafter
5. Distribution after allowing for losses



Note: "water produced" is the supply from Bonriki and Buota

Figure 4: Illustration of Water Balance at 50L/pers/day Potable Consumption with Desalination

38.9 Continuing Cost of Land Rental for Water Reserves

245. The current water reserves in South Tarawa were declared over land that was privately owned. This has been highly controversial and has generated long standing disputes between authorities and land holders and their communities. Although the PUB regulations allow the compulsory purchase of land for water reserves, this has never been used by the GoK because of the fundamental importance of land ownership in Kiribati. Instead, the GoK currently pays impacted landowners a land rental of $5,000/ha. For the existing Bonriki and Buota water reserves, the total annual payment for the whole area amounts to around $575,000. If the groundwater options in the North Tarawa islands of Abatao, Tabiteuea, Buariki and Taratai are pursued, the TWMP estimates land rentals there could be higher and an amount of $750,000 has been used in the calculations for the roadmap, apportioned between the two schemes bringing the total land rental up to $1.325 million/year. This is a major recurring cost imposed on the water supply system.

38.10 Review of Costs of Options and Unit Production Costs

246. In addressing the cost effectiveness of the water supply options, the TWMP compared the unit production costs (UPCs) after calculating the annual capital costs and including operations and maintenance costs (O&M) and the land rental/compensation costs. The calculations for TWMP adopted an interest rate of 8%. For consistency and relevant comparison this interest rate has been retained for the latest calculations. The O&M and rental costs have been calculated and included in the assessment.

247. The TWMP compared the UPC for the future water supply options with the current UPC for the existing operations, maintenance and rental costs of water production from the Bonriki and Buota. This cost, however, was artificially low since it did not include the capital costs of the existing system. The Roadmap has therefore obtained the asset value of the

existing system from the PUB accounts and adjusted this with the costs of upgrading the system to full operating potential in order to make the comparison more relevant.

248. UPCs for the groundwater options have been calculated for different water loss rates for water delivered to consumers. The current rate of leakage imposes major cost penalties on supplying water and this situation emphasises the importance of lowering water losses as the highest priority. Lifetime costs, or the time for amortisation of capital costs, of an option makes a major impact on its UPC, particularly for SWRO desalination. Maximising the economic operating lifetime of infrastructure will therefore be a key consideration.

39 The Future Option

249. The TWMP comparison of unit production costs confirms that SWRO desalination is the most cost effective option, provided that it remains operational for 10 years. SWRO plants have been operating in Nauru and elsewhere for over 10 years and recent technological advances and development have improved the operations, costs and longevity of SWRO plants. Contracting out the training of operators, maintenance of units and the provision of technical advice to system manufacturers will significantly increase their lifetime, as has been shown for the installations in Nauru.

250. The condition of the existing urban area groundwater lenses in South Tarawa require an alternative source of water that can be established quickly, at an affordable capital cost, and with the ability to be expanded as the population increases. The supply must also be capable of providing a twenty-four hour pressurised service for the efficient operation of the piped water supply system. These considerations have led to the choice of SWRO desalination over the groundwater options in that: they can be installed and operated rapidly and produce pathogen-free water. It is also unlikely an environmental impact assessment will be required, and there will be no issues of excavation across the lagoon, or negotiation for abstraction rights.

251. The SWRO units can be provided in a variety of sizes in a modular containerised form for placement on a prepared site. Aside from the RO units and a separately packaged pre-filtration unit which is also containerised, other costs will include transportation from the manufacturer to South Tarawa involving freight and port handling charges, civil site works, feed, permeate and distribution tanks, connections and electrical supply. The buildings required will consist of site amenities, a roofed canopy covering the plant and the pre-filtration unit and a chemicals store with a bunded enclosure.

252. The specification for the units must require the latest membrane technology, VDF high pressure pumps, an ERI energy recovery unit resulting in 35% to 55% energy saving, flushing and chemical cleaner, touch screen display and PLC unit and chemical pre-treatment. Other provisions will allow for site safety gear and equipment and onsite installation and commissioning. To filter out marine organisms the saltwater intake should be drawn from bores sunk to the fractured and weathered limestone base material underlying South Tarawa, at the edge of the freshwater lens near the foreshore.

253. The fractured limestone will act as a natural filter for the intake waters. This approach is recommended by the TWMP and will draw on saltwater from well below the freshwater lens. It will have no impact on the freshwater lens. The filtering through the fractured limestone will remove extraneous materials and as the abstraction level is well below sea level all marine organisms will also either not be present, or will be filtered out. Experience with previous desalination plants showed that marine organisms drawn into the plants from shallow seawater intakes were a constant cause of blockage of the membranes.

254. The SWRO desalination units can be manufactured in various combinations and installed into 20 foot and 40 foot containers depending upon the size of the unit. Table 19 illustrates the respective details and indicative costs ex works (Australia) of the different combinations. Presently shipping requirements would limit the units to a size fitting within a 20 foot container.

Table 19: Information on SWRO Desalination Units

Unit Description and Cost	Production (m^3)		Estimated Cost Ex Works $
	Hourly	Daily (22 Hrs)	
Multiple (3) 190 desalination units with a bank of three units each supplied in a 20 foot container with pre filtering installed in an additional 20 foot container (Four banks of multiple units (3) required at total cost of $5,200,000 ex works)	22	528	1,300,000
Single 530 desalination unit supplied in a 40 foot container with pre filtering installed in an additional 20 foot container (Four units required at a total cost of $4,840,000 ex works)	22	484	1,210,000
Single 890 desalination unit supplied in a 40 foot container with pre-filtering installed in an additional 20 foot container (Three units required at a total cost of $4,500,000 ex works)	37	814	1,500,000

Note At present time the shipping arrangements to Kiribati limit containers to 20 foot size

255. While the manufacturing costs are higher for the multiple banks of smaller units this additional cost comes with the advantage of maximum flexibility in operations and the ability to take units out of operation for maintenance and to maintain production in the advent of the outage of one unit. There will also be the advantage of uniform sparing and the training of operators for one unit and specification. The disadvantage will be higher energy consumption and a slightly higher requirement for operators/technicians. The estimates incorporated into the roadmap provide initially for four banks of the multiple groupings (three desalination units) with each multiple installation capable of producing 528 m^3 of freshwater daily and the four multiple groupings giving a total production of 2,112 m^3 daily. The Brine discharge and backwash from the plant can be directed back to the ocean. The Brine is about twice the salinity of sea water (depending on m/c recoveries) and this disperses quickly without issue to the environment. This is the worldwide practice

256. The banks (each comprising three units) would be sited in Betio (2), Bairiki and Nanikai (1), Teaoraereke and Antebuka (1). From their fresh water reservoirs they would be connected to the existing transmission main, thence the service reservoirs and the network. The present system on South Tarawa can be divided into service areas for the operations and management of loss control, with the areas balanced to the capacity of the desalination plants. The remainder of South Tarawa would continue to be supplied from the Bonriki and Buota water reserves. The PUB electricity supply has been checked and presently has the capacity to absorb the power requirements of the initial units.

257. The full capital costs and installation costs are summarised in Table 20.

Table 20: Capital Cost of Desalination Plants – installed and Commissioned

Plant and Civil Works Cost	Cost
Four desalination units (DP190 PX x 3) Cost ex. Australia	5,200,000
Transport, Freight, Insurance to Tarawa Port	100,000
Sub Total Desalination Plants	**5,300,000**
On site electrical/mechanical installations	40,000
Buildings for 4 (3 x DP190 PX) units (10x13x4m)	320,000
Feed or permeate tanks (10,000 litres Capacity)	80,000
System feed pumps for pre-treatment	60,000
Electrical, Communications and data connections external to the Plants	30,000
Chemical Storage	16,000
Site safety gear including safety shower, eye wash	20,000
Site Amenities	40,000
Boreholes, pipes and valves for raw water intakes	300,000
Allow for Connection to rising mains	250,000
Brine discharge pipes and valves	30,000
Commissioning costs	40,000
Subtotal Civil Works, Installation and Commissioning	**1,226,000**
TOTAL BASE COSTS	**6,526,000**
Preliminary & General (10%)	624,600
Contingencies (10%)	624,600
Engineering Design & Supervision (8%)	624,600
Subtotal P&G, etc.	**1,957,800**
GRAND TOTAL	**$8,483,800**

40 Existing Production Costs

258. The current PUB water supply system for South Tarawa delivers an estimated gross amount of some 2,000m^3 per day from the Bonriki reserve to around 4,500 customers, or about 63% of all households in South Tarawa with supply rationed for a few hours every second day. The system is in a state of disrepair with widespread losses and a very low payment of water rates, which are currently set at \$2.20/m^3 for metered supply to commercial and industrial consumers and a flat tariff of \$10 per month for domestic households. PUB does not have an up to date breakdown of its customer database, but it is estimated that around 75% of the volume is supplied to the domestic connections with 25% to commercial and industrial customers. Domestic customers are thought to make up around two-thirds of the connections. Water is also sold by tanker load to some customers.

259. The balance sheet for PUB places the book value of its system at \$4.62 million. The asset management plan prepared under TA 7539-KIR has established the realistic cost of operating and maintaining the water supply system following rehabilitation. The estimates allow for electricity costs for pumping, PUB overheads, spare parts etc. and O&M costs.

260. Adopting these costs the UPC for the water presently distributed is equivalent to \$3.37/m^3 with a 25% loss, and \$7.66/m^3 with the present 67% loss.

Table 21: Comparison of Unit Production Costs (UPC) for Tarawa Water Supply Options

Option	Description	Production (kL/day)	Assumed Lifetime (yr)	Other details	UPC ($/kL)	Comments
	Current GW production from Bonriki and Buota	2,010	Not specified, assume 15	Current system, 25% losses	**3.37**	With capital costs and land lease payments included
				Current system, 67% losses	**7.66**	
1	Increased GW production at Bonriki from tree removal Estimated cost $272,000	250	20	25% losses assumed	**3.97**	Lowest cost option but limited increase in production
				50% losses assumed	**5.95**	
2	Increased GW production at Bonriki from infilling ponds & constructing more galleries Estimated cost $2,500,000	250	20	25% losses assumed	**7.65**	Considerably more costly than clearing trees but still less than North Tarawa groundwater options
				50% losses assumed	**11.48**	
3	Groundwater production from Abatao and Tabiteuea Estimated cost $4,952,560	220	20	25% losses assumed	**10.10**	
				50% losses assumed	**15.15**	
4	Groundwater production from Buariki & Taratai Estimated cost $21,125,000+	1,530	20	25% losses assumed	**9.58**	Generally similar unit costs to those for Abatao & Tabiteuea
				50% losses assumed	**14.38**	
5	Desalination (SWRO) production (based on cost estimates from Veolia Water) Estimated cost $8,483,800	2,200	10	Production costs no losses	**3.88**	Cost very dependent on assumed lifetime, but best option if life time is 10 years
			10	Production costs 25% losses	**5.17**	

Source: TWMP amended to reflect updated costs

261. The UPC for the desalination option allows for all consumables (RO antiscalant, chemicals and replacement micron filter cartridges), chemicals (for membrane cleaning) and membrane replacement at five years (the Nauru membrane has lasted 10 years), electricity, and for a manufacturer's service warranty (three or four year contract with six visits per year). Provision is also made for spare parts amounting to $65,000 annually).

262. The greatest risk of the desalination option is the ability to effectively maintain and operate the plants for at least ten years or more. The risk can be minimised by ensuring the procurement focuses on a selection process which involves world leaders in the field with proven and extensive operational experience and the ability to back up and support their equipment well into the future. The worst possible situation will be to take the lowest price from a supplier without these attributes who is unable to provide technical and parts backup,

and has a high risk of financial and business failure. Ease of support would favour a supplier in the Australasian and Pacific region. The supply arrangement must, at least provide for a maintenance contract with the supplier, with provision for guaranteed payment to ensure the longer term maintenance and operations support.

41 Water Supply System, Upgrading and Maintenance

41.1 Bonriki Galleries and Pumps–

263. Low head Mono-type pumps take water from the twenty-two infiltration galleries that are currently in operation at Bonriki. White and Falkland (KAPII Report on the Protection and Management of Water Reserves, South Tarawa) quote the sustainable yield of the Bonriki galleries as being 1660m^3/day with pumps rated from 55 to 85m^3/day and the mean yield for each gallery being 70.6m^3/day. That same report quotes the average daily production rate at Bonriki for the period 2006-2008 as being 1943 +/- 146m^3/day. They footnote this data with concerns about over production and relate this to incorrect set-up of some gallery pumps that allows sustainable production rates to be exceeded.

264. Gallery pump-rate data was reviewed in the raw form available in the Bonriki treatment plant operator's diary and again in spreadsheet format supplied by PUB. Each gallery pump was refurbished or renewed during SAPHE, fitted with an accumulator type water meter and made secure within a chamber that has a lockable lid. The raw data over the last 11 months was annotated with a number of comments that indicated random temporary failure of some meters and some pumps. These comments were not carried over to the spread sheeted data for Bonriki gallery production rates. The gallery meters are normally read on a monthly basis so if an individual gallery pump or meter malfunctions, there is no early warning that production may not be able to meet demand. The value of reading meters more frequently can be seen in for example March 2011 data that shows Pump 12 produced 39m^3/day on one day but on the next day produced 60m^3/day. A similar anomaly is recorded for Pump 17; 104m^3/ day on one day and 36m^3/day the next day.

265. **Actions**: It is impracticable to read the gallery meters daily so a 150mm electromagnetic type meter with remote readout and dual accumulator and flow functions should be installed on the combined gallery flow inlet to the aerator so that readings outside the norm can be identified and investigated.

266. There are insufficient records to identify whether new pumps or the refurbished pumps installed under SAPHE cause problems but annotations on the operators records indicate that random pumps have failed. These pumps are now about 6 years old and given their condition and the dependence of South Tarawa on this supply, the 22 pumps should be replaced with a sparing of 5 additional mono-pumps.

267. Gallery meter failure (normally temporary) is relatively common. Meters have a finite life span and lose accuracy over time. Twenty-two replacement meters plus 5 units for stock should be supplied and installed on the 50mm pipe work. Fitting the meters is relatively easy because the original installation included Manacon type fittings. In-line Y strainers should be included at each installation.

268. There is no accessible sampling point for the combined raw water flow. A stainless steel ball type valve needs to be installed on a sampling spigot on the raw water flow from the gallery.

269. There is a lot of inefficiency in record keeping. Manual records are kept in a day diary and or on a separate sheet and this information is then eventually transferred to a spreadsheet. The important information that is written in the diary to support unusual events is not transferred to the summary spreadsheet data so this information is not available for the asset management data base. Improvements and efficiencies can be achieved by implementing the relevant recommendations in the Institutional Report and the Asset Management Plan prepared by TA 7359-KIR.

270. Safe yield from Bonriki and management of the reserves has been defined, researched and reported in many reports, the latest being KAP II.[46] The problems and risks associated with this primary potable water source for South Tarawa have also been clearly defined as have recommendations for managing this critically poised water resource. Few if any of the recommendations in these reports have been actioned so this report reinforces the requirement that the relevant institutional changes that are recommended in the above report for the protection and management of the reserve be actioned to ensure meaningful progress in protecting the Bonriki water resource is made.

41.2 Treatment Plant

271. The treatment plant comprises a forced draft aerator, treated water storage (400m^3) chlorine disinfection using chlorine gas and an accumulator type water meter to measure water demand. Anecdotal complaints of sulphide and chlorinous odours associated with the treated water seem to be common. No obnoxious odours were noted during the survey but the records show a prolonged period about a two years ago when the aerator motor was out of service and this led to a slew of complaints.

272. As previously noted, sampling the combined water flow was not possible so water quality tests were carried out to test the efficacy of the treatment system. Raw water is pumped from the combined gallery pipe direct to the forced draft aerator. It is obvious that the panels in the aerator which are coated in thick bio-film have not been cleaned in a long time. Samples were taken post aerator and pre-reservoir and tested for chlorine demand (less than 0.4mg/l), sulphide (less than 0.02mg/l) and ammonia (less than 0.07mg/l). Despite its appearance the aerator is effective as indicated by the toxic/poisonous sulphide odours that are dispersed into the atmosphere and the treated water quality data. The aerator however needs replacement. The steel frame supporting the aerator to reservoir pipeline also needs to be replaced.

273. Gas chlorine is dosed post-reservoir. This is a concern because White and Falkland in their KAP II report confirmed that at least some of the galleries were contaminated by coliforms and the thermo tolerant E. coli. Chlorine requires a contact time of about 30 minutes to be effective against these indicator bacteria. Post-reservoir dosing of chlorine is acceptable in the short term because water is pumped to on-line reservoirs and elevated tanks along the 30km long transmission pipe so contact time is achieved however given the lack of proactive watershed management and lack of a committed will to protect the area it is only a matter of time before microscopic parasites such as *Giardia* and *Cryptosporidium* become endemic in the community. To provide some public health protection chlorine dosing should be changed to pre-reservoir dosing.

274. It is an expensive and difficult exercise to identify whether these microscopic pathogens (*Giardia* and *Cryptosporidium*) are endemic in the community or whether at least some of the time they are the causative agents of the high incidence of diarrhoeal disease in South Tarawa. The conventional protection is to provide public health protection barriers via a multi-barrier treatment approach to prevent these parasites reaching the consumer.

275. The chlorination system was reviewed: chlorine gas is dosed post-reservoir using a new (2010) vacuum chlorinator connected to a 70kg cylinder. The dose rate (450 g/ hr) is set by a PUB staff member at the beginning of each month on the basis of the average demand estimated from the previous months data and is not changed even if demand changes. Daily demand is approximately 1950 m^3/day but the range can vary from about 1910 to 2050m^3/day.

276. The chlorine cylinders on site are not secure. Regardless of whether the cylinders are full or empty they must be chained to a wall or fitting. An escape type chlorine gas safety mask has been supplied by a former project but the canister for the mask is past its due date and there are no spare canisters available.

[46] Report on the Protection and Management of Water Reserves, South Tarawa, Ian White, Tony Falkland, KAPII 2009

277. Chlorine gas is an expensive option (about $15 per kg/chlorine). An alternative option is to install modified calcium hypochlorite tablet feeders. Such systems have a low capital cost, are more economical than chlorine gas and are less of a safety risk. The current chlorine dose rate of 450g/hr matches the theoretical rate calculated from the chlorine demand analysis carried out on the post aerator treated water and the measured free available chlorine rate of 2.5g/m^3 for the estimated 1860m^3/ day demand on the day the tests were carried out. There are several non-working chorine test kits and machines at the treatment plant and the operator used a basic comparator type meter to carry out the chlorine test. The concentration of chlorine in the water was over-estimated using the operator's comparator test kit.

278. Chlorine testing was reported as being carried out once a week and seldom if ever in the distribution system. The day-diary for the year recorded very few readings for chlorine residual in the treated water.

279. The immediate option is to purchase an additional chlorinator head for the second gas cylinder so that the gas chlorinator will automatically change from one cylinder to the other when the working cylinder is empty or do a cost analysis and replace the existing chlorine gas system with a calcium hypochlorite tablet dosing system. In addition the existing 150mm online post-reservoir Kent meter should be replaced with an electromagnetic accumulator and flow transmitter meter as described in the aforementioned Appendix 6 so that whatever chlorine dosing system is selected it can be set up correctly for changing water flow.

280. If correctly managed, Bonriki water reserves could be considered a protected catchment (in terms of barrier treatment - the first line of defence) but evidence confirms it is not a protected catchment and will probably remain unprotected and not appropriately managed.

281. Consideration needs to be given to which of the following options is the preferred risk management option for treatment; post-reservoir dosing of chlorine provides the slimmest of public health protection measures even if management of the water reserves is improved. Evidence from previous reports indicates that the gallery water is now microbiologically polluted, and that even if measures are put in place immediately to reverse negative impacts on the water reserves the gallery water will still be polluted - for this reason the existing post-reservoir chlorine dosing point will have to be shifted to pre-reservoir. . Some of the chlorine will be used up in the Bonriki reservoir so a higher dose rate will have to be applied to enable a high enough residual to be maintained in the transmission main, the elevated reservoirs and the network. The survey suggested that re-chlorination into the transmission main at two other sites may be required to enable an acceptable concentration of about 1-1.2mg/l free chlorine to be maintained in the elevated reservoirs and a lesser but acceptable free chlorine residual at the consumers' taps throughout the system. Setting up this dose regime will require a fine balance between consumers' resistance to the taste of chlorine and public health protection. This option will provide better protection against bacteria and *Giardia* but no protection against *Cryptopsporidium*. If water reserve protection measures are not introduced in the medium term to prevent further degradation of the gallery water it is inevitable there will be *Giardia* and *Cryptosporidium* contamination.

282. Normally when there is a risk of *Giardia / Crypotsporidium* contamination to public water supplies "boil water" advisories are issued. However to be fully effective against *Giardia* long "boil times" are required. Also neither the existing post-treatment or boiling water at the consumer end of the system will destroy *Cryptosporidium*. Conventional treatment such as optimised flocculation and sand filtration will be required to effectively remove *Cryptosporidium* as will membrane treatment (for example reverse osmosis).It should also be noted that boiling the water will also increase the already high nitrate levels, effectively meaning that the urban groundwater in South Tarawa should not be used as a potable source of water.

283. In the course of the compositing toilet trial conducted under the Kiritimati Water and Sanitation Project for the Australian Agency for International Development in 1995 the

Centre for Environmental Studies of the University of Tasmania observed that ... “The sample of fresh faeces from the trial participant households which was examined contained a large number of *Giardia lamblia* cysts, as well as *Trichuris trichiura* eggs. The presence of *Giardia* on Kiritimati was also confirmed by health workers and visiting medical practitioners”. The evidence of *Giardia* amongst I-Kiribati would suggest a presence in South Tarawa as well.

284. *Giardia lamblia* is an intestinal protozoa flagellate that lives on the mucus on the surface of cells in the duodenum and sometimes in the small intestine. The disease produced by infection with *Giardia lamblia* is called “garrdiasis” with symptoms ranging from mild diarrhoea, flatulence, anorexia, cramp-like abdominal pains to full blown malabsorption syndrome. Many waterborne outbreaks of giardiasis have been recorded and it has been demonstrated that *Giardia* is able to withstand filtration and chlorination of the usual sort so it would seem desirable to guard against the contamination of village and town watersheds by human carriers at least. Giardiasis is a disease of “dirty hands” and contaminated food, cleanliness and uncontaminated water constitutes effective measure for containing the disease.

285. The Betio re-chlorination system has failed and despite a new head unit installed last year on the 70kg cylinder the chlorination system is need of replacement. When working, chlorine is injected into the pumped line to the elevated reservoir. A 70kg cylinder at Betio typically lasts 42-46 days compared to Bonriki where a cylinder lasts 7 days. Record keeping is inadequate and there is little or no monitoring of chlorine residuals in the distribution network. The brand of chlorinator at Betio is different to that at Bonriki even though both sets of equipment have been purchased in the recent past. Replacement equipment should be the same brand as that at Bonriki (Acromet brand) because this brand is recognised internationally as being robust and relatively maintenance free.

286. Sampling for chlorine residuals throughout the pipe network during Project field work identified that a free chlorine residual (less than about 0.8mg/l) was maintained as far as the elevated storage tanks used for distribution of treated water to communities. Apart from one occasion at Bairiki, no coliform or thermo-tolerant bacteria were isolated from the reservoirs during the Project sampling program. This fits with the irregular MHMS survey data which records the occasional coliform or thermo-tolerant bacteria in PUB reservoirs and a typically low (less than 0.4-0.5mg/l free chlorine residual) in the reservoirs. This does not mean the treated water is *Giardia* and *Cryptosporidium* free so the treated water supply may still be high risk.

287. In South Tarawa people rely on three sources of water: PUB piped supply, well water and rain water. Project survey data consistently showed that of these three sources, well water and rain water were microbiologically contaminated and PUB supplied water was not. The option above for pre-chlorination and further chlorination along the system is a high capital cost option but that investment may not meet the objective of improved community health and reduced infant morbidity because consumers have very limited awareness of the risks associated with drinking rainwater and well water, a low appreciation of related hygiene issues and for many, poverty is an issue that restricts their choice as to preferred water supply, so any future move to this option must be supported by the planned comprehensive community awareness programs.

288. The recommended strategy is to adopt an integrated approach of improved treatment and management i.e. an improved, reliable and well managed PUB network and a comprehensive and focussed community awareness program. Continuing the present post-treatment chlorination at the Bonriiki galleries is appropriate for the medium term even though it is not a nil risk option but this may need to be superseded in the future by the pre-treatment option if there is an unacceptable salinity increase and increased pollution in the Bonriki gallery water due to the fact that an effective water reserves management plan has not been implemented.

289. One of the galleries, number 18 has the highest electrical conductivity (surrogate for salinity) at about 1200uS/cm yet in terms of abstraction rate it ranks as one of the

highest pumped galleries (106 - 136 m^3/day) In terms of water quality, dilution will currently negate the effects of this salinity concentration] but the long term effect on the water lens from which No 18 gallery pump draws water also needs to be considered hence the urgent need to implement a water reserve management plan.

41.3 Transmission Main

290. The 225 millimetre pipeline from Bonriki to Teaoraereke was constructed under SAPHE (2005) and the remaining old pipeline beyond Teaoraereke will be replaced under the World Bank/ADB Tarawa Road Improvement Project and extended to Betio because of its condition and reported incidence of leaks. The transmission main and Bonriki gallery pumps were designed as a low head system (8-12 metres) with the potential for increased capacity by using pumps to boost capacity. The replacement main has been investigated by the road project, sized and documented with design drawings and a bill of quantities and materials schedule.

291. PUB claims that water losses in the transmission main are of the order 29%. This statement is at variance with the KAPII report on water supply leakage which makes an assumption that transmission leakage is not an issue Taking transmission and network losses and leakages into account PUB estimates that only about 705m^3/day are available to customers. Currently losses due to leakage and insufficient capacity of current sources are managed by supplying water to 51 rationing zones. In practice this means supplying water for 2 hours in 48 hours for each zone. Some households in some zones do not get any water so are supplied by tanker to small PUB supplied household tanks.

292. Little is known about the present hydraulics of the transmission main. The original system operating manual emphasises that direct pumping from the transmission main to the elevated reservoirs in the system has the potential to induce negative pressure so for this reason a strategy needs to be implemented to ensure that the Bonriki pumps and draw-off rates to fill reservoirs are matched.

293. The transmission system and network will need to be modelled. Before that can be done the following issues will need to be addressed; absence of pressure meters and system monitoring, setting of throttle valves at each reservoir, backflow prevention, low flow, lack of information about residual pressure at the final reservoir in Betio under current operating scenarios, PUB's stated claim of 29% leakage in the transmission main, anecdotal evidence of observed leaks in the transmission main, an understanding of the existing hydraulic profile and the importance of maintaining positive pressure in the transmission main and network under existing, modified and future water supply development scenarios.

294. Modelling will also need to take into account limitations on the allowable water take at Bonriki, the impact of climate change and the highly probable scenario of the need to install desalination plant(s) at strategic locations to meet the demand of the burgeoning South Tarawa population.

295. The KAP II report on leakage draws no firm conclusions and recommends that an extensive leakage detection program be implemented to identify unaccounted for water. The preferred option is to address the issues above and to install new 100mm water meters where there are no existing meters on the lines to each reservoirs (supply 10 including 5 spare) and 50mm meters on the outlets to each elevated reservoir (supply 22 meters including 5 spare). There are some existing meters but some are reported to be unreliable. In addition three electromagnetic meters need to be installed on the transmission line. Tentative locations proposed are: after Bangantebue, after Teaoraereke and prior to Betio. Meter information will contribute to baseline data for understanding transmission and network system performance.

41.4 Service Reservoirs

296. The existing system comprises 17 elevated tanks connected directly to the transmission main or through one of 6 low level reservoirs including Betio and the 400m^3

bulk storage tank at Bonriki. There is no management plan or inspection program for these tanks. Some new elevated tanks were installed during SAPHE to meet the demand for water from the rapidly growing urban areas and these are reasonably secure but some of the older tanks and ancillaries need maintenance and replacement.

297. Each service tank needs to be inspected and the following works appropriate to each tank needs to be implemented; PVC pipe exposed to sunlight has embrittled so needs to be replaced and painted for protection, pipe brackets are to be installed where appropriate, leaks particularly where pipe work is fitted to concrete need to be fixed, all pumps need to have new seals and/ or be replaced when it is obvious that pumps are irreparable, heavy concrete tank lids should be replaced by stainless steel lockable plates and gudgeon pins and each water level indicator should be inspected and repaired or replaced as necessary, leaking valves should be repacked if gate type and/ or replaced with alternative new valves. Some of the older tanks need to be drained and sealed with epoxy grouting or similar. In some cases security fences and tower gates need to be replaced and on three sites the tower access ladders and safety cages need to be replaced with triple dipped galvanised steel systems.

298. Microbiological samples were taken from a representative number of low level and elevated tanks and apart from the Bairiki elevated tank yield negative results for coliforms and thermo tolerant coliforms E. Coli). It was noted that the lid was missing from the Bairiki elevated tank.

299. The integrity of the water supply needs to be maintained from water source to consumer. This can be achieved by implementing the actions outlined in (i) the transmission mains section (ii) treatment section and (ii) by developing a reservoir and pipeline management plan. Treated water is at risk at each stage of the water supply system and because it will take time to implement remedial measures for the overall supply system good reservoir management is essential. The plans shall include procedures and frequency for cleaning and disinfecting reservoirs, regular inspection to ensure lids are in place and all treated water storage tanks are vermin and insect proof.

300. The reservoir management plan should include record sheets and a plan for recording chlorine residuals at strategic locations in the systems and taking appropriate action. The modus operandii is for PUB to respond to the infrequent water supply testing program carried out by the under resourced Ministry of Health. This is not good practice so a plan outlining PUB responsibilities with MHMS in surveillance mode is required. Reporting within PUB on the status of the water supply and to external agencies is very limited and what is done is of dubious quality.

301. Entry to reservoirs which are technically confined spaces and potentially dangerous work places is required on a rolling basis and a 24 month cycle. The biggest risks are associated with falling from a height and lack of oxygen or in the case of the Bonriki reservoir, sulphide poisoning. A standard work procedure (SOP), compulsory training and appropriate safety equipment can minimise or eliminate safety related risks. Essential equipment that should be supplied includes; safety tripod and winch, three harness sets, safety rope, hard hats, three personal gas detectors , aluminium ladders for access to each tank, forced draft fan and motive force and a small engine driven water blaster. This equipment is also applicable for sewerage manhole work.

41.5 Additional Storage Betio

302. The transmission pipe is reported by PUB to have sufficient head to fill the low level 2,320m^3 storage tank at Betio on a continuous basis and from there water is pumped to a new elevated tank on an existing tower. Insufficient analysis has been carried out by PUB to determine whether the head available is sufficient on a continuous basis but PUB believes that it is, and that the main reservoir is sufficient to meet demand for the current and future densely population Betio area. The system modelling exercise previous referred to needs to consider whether more storage is required. The South Tarawa population is predicted to increase to 107,700 by 2030 and much of his growth will be in the Betio area.

303. The overall demand situation is complicated by the fact that customers are not getting regular access to the design rate of 40L/pers/day so have reverted to using well water for non drinking household purposes and to using rain water. Additionally the fact that PUB estimates 29% of the water in the transmission main is unaccounted for water and 50% of the 1410m^3/day that does reach the elevated towers is unaccounted for water are important considerations Whether extra storage is required at Betio requires detailed analysis of all the related factors.

41.6 Network Reticulation

304. **T**he network comprises 50mm HDPE pipe work with off-takes to individual connections and 16mm connections to the ineffective constant flow system at the households. In principle the concept is sound but in practice the system had not worked and has lead to significant water wastage. The KAP II water leak study concluded that leakage in the network was not a major concern in at least the pilot areas studied. This reflects the results of observations and discussions with householders during the ground water quality field work program which can be summarised as lack of ownership by householders of the idea that water wastage was a serious concern and because the water supply system was not meeting their needs many householders considered water supply was 'everyone's and no-one's' responsibility.

305. Although the project survey identified free available chlorine residual in the elevated reservoirs the survey did not record free chlorine in the network post elevated reservoir on range of household sites in Bikenibeu, Bairiki and Betio. PUB should retain legal responsibility for water up to the consumer's 'tap' and have an appropriate surveillance system in place. The reality is that PUB has informally stated that it assumes responsibility for water only up to the elevated reservoir because it has no means of managing or controlling the systems beyond this point. Low pressure, lack of back-flow control, misuse of water connections by householders and general unsanitary conditions in much of particularly Betio all need to be improved before the PUB supply can legitimately be recognised as a 'safe' supply. This will, require practical steps and a review of applicable policies and legislation as stated in the TA 7359-KIR Institutional Report and the Asset Management plan.

306. Unaccounted for water whether it be leakage, illegal connections or wastage is costly to the community. While it is recognised that Bonriki does not have the ability to meet demand the best and quickest return on capital investment is leak and wastage detection and reduction with an immediate objective of 25% losses reducing to 20% in the medium term. This should be advanced by the time the options for increasing the supply are put in place.

307. PUB has quantified serious water losses in the water supply system by stating that only about 705 m^3 day of the Bonriki daily production of about 1,950m^3 is available to consumers. Traditional leak detection instrument based programs are not suited to the zone type delivery system trialled in South Tarawa because such systems rely on pressurised pipes , a coherent pipe network, full pipes and in some cases the ability to make contact with metallic pipe components. The KAPII report on leak detection identifies lack of PUB capacity and the lack of will to follow up on the pilot leak detection work. This is not atypical and a change of direction is required to achieve real results. Emphasis on identifying all connections in a zone including informal or illegal connections using a dedicated team will be more cost effective and implementing remedial steps is a more productive use of resources. The TA 7359-KIR Institutional Assessment identifies high staffing in PUB and the opportunity to divert staff effort to leak detection activities.

308. Water loss identification must be integrated with demand management. The new meter at Bonriki, two or three meters in the transmission main, new or replaced meters before and after the elevated reservoir and household and community stand pipe metering and strategically located pressure gauges will provide good tools to evaluate the water supply zone by zone or sub-zone by sub-zone and carry out repairs. The program should be

prioritised for the transmission main and then the network on the basis of night time reservoir drop-studies to identify zones which are of concern. An associated community awareness program should support the technical program and a dedicated team within PUB should be resourced to manage and deliver the program. Such a program must be on-going and requires the full commitment of PUB. Leak and loss detection should initially focus on the areas of highest customer concentration (i.e. Betio for example).

41.7 Demand Management

309. To overcome peak demand issues in high density housing areas constant flow systems with flow restrictors and onsite 250 litre elevated tanks were installed. During the water quality and well survey in Betio and Bairiki where most of the systems are set up it is apparent that the system did not meet customer expectations. Technical reasons include insufficient flow or pressure to fill the tanks which were installed on a plinth, erratic supply of water and general abuse of the systems. Many of the tanks have been taken off the plinths to be filled by rainwater and or existing pipelines from which flow restrictors had been removed. The 16mm lines are often left open at all times and when PUB water is supplied a variety of clean and unsanitary containers were filled then the pipe is commonly directed to a well or rainwater tank or just left to flow into open ground. Very few householders have a cut off nozzle on the end of the 16mm PUB installed pipe.

310. The underlying objective for the water supply is equitable distribution of water with an associated tariff structure that contributes to sustainability of the PUB system. Head loss in the existing zone, discontinuous supply from PUB, illegal connections, wastage and leakage, potential backflow are factors that have to be managed if an equitable supply is to be achieved.

311. Almost all householders extract water from a variety of sources, wells, rainwater tanks and the PUB supply using buckets so in effect few of the household water supplies including the PUB supply is a conventional piped supply. Some householders expressed a lack of confidence in the PUB supply chain and mix rainwater, PUB water and well water in unsanitary containers or use the individual sources for various household use without any consideration of the potential public health risks involved.

312. The PUB approach to supply of water to communities using zones is appropriate given the limited treated water supply and the high unaccounted for water component but once remedial measures are implemented then new demand management measures need to be put in place.

313. The existing constant flow system is not working because of technical problems and abuse by householders. Ultimately and when the system is fully pressurised with adequate water universal metering should occur to allow management of the system and control wastage.

314. A tariff structure incorporating a lifeline block with progressively higher costs based on usage should be introduced and an administrative system set up within PUB to manage the process. Poverty criteria should be used to set the life-line tariffs and installation shall be free, i.e. provided by the Project. Measures such as meter seals and penalties for tampering with the seals as well as for illegal connections, above ground boxes for the meters, backflow preventers installed at each meter and community management of any community standpipes should all be components of a well thought out management strategy.

41.8 Requirements, Abstraction, Treatment, Transmission and Reservoirs

315. The requirements for improvement of the Bonriki Treatment Plant, the disinfection of the PUB piped transmission main and network, and immediate upgrading of the existing system are summarised in Table 22. This summary does not include provision for leak detection which is analysed separately.

Table 22: Summary of Improvements and Costs

No	Description	Cost ($)
1	Gallery management	
a	New 150 mm electromagnetic meter on raw-water line with remote indicator for accumulated and instantaneous flow.	5,000
b	Provide replacements for all 22 mono -pumps and motors plus 5 spares.	60,000
c	Replace 22 water meters plus 5 spares, install Y strainers on meter line, and fit sampling point on raw water line.	20,000
d	Provide and install electricity consumption meters for 22 gallery pumps. 1 Betio WTP and 10 reservoir pump stations and miscellaneous other pumps.	4,000
e	Downrate Bonriki pumps to safe yield - to be done during refit of pumps.	500
f	When Buota galleries are recommissioned both Buota and Bonriki production must not exceed aerator capacity of 25l/sec which is also safe yield from the water reserves. To be planned for during implementation of item 1b.	-
g	Actively promote then establish a water reserve management plan for Bonriki and Buota.	-
2	Raw water data management	
a.	Continue salinity monitoring.	-
b.	Calibrate the salinity meter against standards daily or before it is used if not used on a daily basis.	-
c.	Spreadsheet and trend the salinity data.	-
d	Provide the salinity data in reports to highest authorities.	-
3	Treatment system: Bonriki	
a	Upgrade the aerator to cater for Bonriki and Buota combined, plus increased supply from Bonriki. Install sampling point post-aerator replace support framework for pipe between aerator and reservoir.	100.000
b	Purchase new chlorine cylinder changeover valve and associated equipment for second chlorine cylinder or convert to flow proportional calcium hypochlorite tablet feeders. Change the chlorine dosing point from post-reservoir to pre -reservoir.	5,000
c	If converting to calcium hypochlorite tablets convert the existing chlorine cylinder room to dry secure storage.	10,000
d	Supply two Palin brand 7100 photometers and chemicals for chlorine testing at (i) Bonriki and (ii) Betio.	8,000
e	Replace the existing 150 mm treated water meter with an electromagnetic meter with remote reading of accumulated and instantaneous flow.	5,000
4	Existing re-chlorination facility Betio	
a.	Replace defunct chlorination system in short term with the same brand chlorination equipment as at Bonriki.	4,000

b.	Replace gas chlorinator with a correctly sized flow proportional calcium hypochlorite tablet feeder.	5,000
c.	Modify existing storage facilities to provide safe and dry storage for calcium hypochlorite tablets.	
5	Transmission main	
a.	Install 3 electromagnetic/ district type water meters at pre-determined locations on the transmission main and fit pressure gauges at strategic locations.	18,000
b.	Supply and install and retain spare meters for replacement 10 x 100mm water meters to elevated reservoirs and 22x 50mm water meters from the elevated reservoirs.	35,000
c.	Carryout a labour intensive zone by zone review to identify unaccounted for water supported by a community awareness program based on data derived from newly installed water meters and pressure gauges and a first pass modelling run. Note traditional leak detection equipment analyses are not suitable for this assessment program.	-
d.	Model the water supply system from source to consumer to include the new main proposed for Teaoraereke to Betio, the need for extension of treated water storage at Betio, the impact and preferred location of proposed desalination treatment units to meet demand, to identify low pressure zones and optimisation of the water supply system.	10,000 (software only)
e.	Consultant for modelling, training and mentoring PUB staff in use of model. Two months input and expenses.	50,000
f.	As proposed in the Road Improvement Project replace the transmission main from Teaoraereke to Betio.	Not a component of this project.
6.	Service reservoirs	
a.	Repairs and replacement works as prescribed for each reservoir.	50,000
b.	Confined space safety equipment and formal training plus cleaning equipment for reservoir and manhole work.	25,000
c	Develop a methodology and implement a cleaning program over 24 months for cleaning reservoirs.	-
7.	Chlorine residual monitoring	
a.	Implement a monitoring plan for chlorine residuals in the network and provide feedback information for the hydraulic model. A draft plan is included as Annex 5.	–
b.	Implement contingency plans for non compliance.	-
8.	Network and demand management	
a.	Implement a generic ‘unaccounted for water’ program as defined under 4 c and as described in this report with the immediate objective of reducing losses to less than 25% and a final objective of 20% unaccounted for water.	-
b	Consider installing household c/w meters, automatic stop taps, backflow preventers, tamper-proof seals and	Provided separately in roadmap

	developing community awareness in step with the replacement program.	
9.	Institutional change	
a.	Implement the recommendations in the TA-7359-KIR institutional Report and carry out the required 'change' program.	-
10.	Costs	$414,500
	Contingency 10%	41.500
	Sum total (rounded)	**$456.000**

42 Temaiku Model Subdivision Offsite Water Supply

316. The offsite water infrastructure to service the NZAP supported model urban subdivision is estimated to cost $520,000 and will involve a new dedicated supply line from the Bonriki treatment plant of some 5.9 km length including valves and fittings, a new pump station at Bonriki, a 50m^3 elevated tank within the subdivision and the allocation of approximately $75,000 towards the removal of vegetation to improve the abstraction rate from the Bonriki water reserve. The proposed elevated tank has the capacity to serve some of the surrounding area but there is no provision for any extension with the Temauku contract funds.

43 Tungaru Central Hospital

317. Tungaru is the main hospital in Kiribati and services all of the population for serious medical cases and for when the clinics cannot meet the needs of the sick. The hospital has been located at its present site at Nawerewere since 1991 and was built under a construction grant from the Japanese government. Buildings and facilities were replaced and all centralised medical services were moved to this site. Currently the Ministry of Health and Medical Services Head Offices and Nursing School are located at this site along with the Country Liaison Office of the World Health Organization.

318. The water supply and sanitation systems in the hospital require urgent upgrade, including the reestablishment of saltwater flushing for sanitation and water pumps and storage for rainwater and groundwater plus water treatment and disinfection arrangements and the treatment of sewerage before discharge to the ocean outfall at the hospital. KAP II funded a consultant's report of the requirements and the draft of this is included as Appendix 6 in Volume 2. KAP II also funded the construction of a new water tank stand and provided for the provision and installation of the high level tank. The consultant's estimate for all improvements and upgrading has been placed at $3,378,537. Allowing for price escalation since the preliminary costs were prepared and for a robust contingency the work has now been reassessed at $3,700,000. Provisions for these improvements and associated costs have been included in the roadmap and investment plan.

319. The upgrading of the water and sanitation facilities at the hospital has the highest priority to ensure full and effective operations in the advent of an endemic breakout, a reality for South Tarawa given the poor quality of the water consumed by the population, the crowded living conditions, lack of effective sanitation, and almost total absence good health and hygiene practice.

44 Summary of Priorities

44.1 Outline of Needs and Improvements

320. The identified requirements for improved water supply and community health will consist of the actions and water supply improvements in Table 23. All interventions comply with the priorities of the TWMP and the NWRP. Present donor response is also indicated.

Table 23: Summary of Priority Actions and Works for Water Supply

Item	Need and/or Improvement	Present Donor Involvement	Comment
1	Regulatory • MPWU role established for sector regulation and policy Sector regulatory framework established. • enactment of water and sanitation Law and regulation to clarify roles, responsibilities and powers of sector agencies	TA 7359-KIR has completed an institutional analysis with recommendations for the focusing of MPWU's future sector role	No provision as yet for the drafting and enactment of a modern water and sanitation law and associated regulations, or for the establishment of the sector regulatory framework.
2	PUB Governance, Institutional and Capacity Building • Capacity building • simpler Business objectives focussing on utility company needs • cost centres for water and sanitation • improved, linked IT and management reporting systems • setting of tariffs for cost recovery and acceptable return on investment • refocusing of staff effort to operations,– reduced overhead costs • focusing operational staff and outputs on key priority areas for a return on assets and effective service delivery • training and capacity building, but confined to activities that immediately benefit PUB's operations	The ADB South Tarawa Sanitation Improvement Sector Project will embed two long-term TAs within PUB, one financial and one engineering/operations position. The TAs will support financial management and cost recovery, the development of management and financial reporting systems, and the engineering position will support asset management, operational procedures, and provide capacity building and on-the-job instruction and training KAP III also plans for the secondment of an engineer to PUB for a two year period, or ;longer if necessary to support leak detection, coordinated asset management and operations (refer item 5 below).	The support for PUB from the South Tarawa Sanitation Improvement Sector Project will commence in the 1st Quarter of 2013 and will continue until the last Quarter of 2017. KAP III commenced activities in September/October 2011 and it is expected the TA will be appointed in the 1st quarter of 2012.

3	Preservation of Assets • adoption of asset management principles and initial AMP • continuing investigations and effort to develop asset management plan • three year budget preparation based on asset management plan, with annual roll-over and approval of the first year as the immediate year's budget • continual improvement of AMP.	Under the ADB South Tarawa Sanitation Improvement Sector Project the TA for engineering/operations will assist investigations, analysis further development and refinement of an Asset Management Plan for water supply and sanitation. KAP III will support these activities in a harmonised manner	As above.
4.	Community Awareness programs • harmonised community awareness programs for maximum impact • engagement of communities in infrastructural improvement initiatives • community mobilisers for grass roots immersion and effective change processes • training government officials and community groups using approaches such as Community-Led Total Sanitation (CLTS), and behaviour change campaigns	The intention will be to harmonize the community awareness of KAP III, the South Tarawa Sanitation Improvement Sector Project and NZAP activities The community awareness programs will be fundamental to the future success of all infrastructure programs and the longer-term programs of STSISP and KAP III are the fundamental building block on which all future activities must be predicated.	
5	Freshwater Resources		
	Supplies to North Tarawa communities	KAP III will benefit two village communities in North Tarawa through the installation of galleries to supply drinking water. The experience gained in community consultation in the water sector under KAP II will be applied.	

	Protection and Improvement • protection of Bonriki and Buota water reserves, legislation, regulation and enforcement, community engagements as part of the solution • protect freshwater resources in North Tarawa in association with the local communities.	KAP III includes provision for the improvement of legislation, regulations and coordinated activities for the protection of the Bonriki and Buota water reserves. KAP III's activities will help raise community awareness of the need to protect the freshwater resources in North Tarawa.	
	• Secondary Groundwater Lenses Betio, Bairiki and Bikenibeu and developed areas along South Tarawa • management of the resource to preserve the lenses for secondary water uses • no removal of groundwater to ocean discharge • recycling of grey water and appropriately treated effluent.		There are no initiatives, as yet related to the preservation of the secondary water lenses under the urban areas of South Tarawa. This is effectively a matter for regulation and control by the Government of Kiribati and its agencies supported by the community awareness programs.
	Improve abstraction from the Bonriki water reserve • enhancement of Bonriki production by selective clearing of 1,700 coconut and pandanus palms • enhancement of Bonriki production by cleaning and filling borrow pits/ponds at northern end of Bonriki	To be confirmed.	NZAP is considering the improvement of Bonriki production associated with the clearance of coconut and pandanus palms, and the improvement to the Bonriki production by cleaning and filling borrow pits/ponds at the northern end of Bonriki. As yet no commitment has been made other than the indication the options are being considered.
6	Water Supply System • Leak Detection and Demand Management • leak detection, watertightness and	KAP III is making provision for leak detection to build on the pilot work undertaken under KAP II in Betio. An allocation of US$860,000 has been	The provision of universal prepay metering is introduced by the roadmap. Metering needs to follow later when the unaccounted losses through leakage are reduced and when a further

	pressurised systems for quality/public health • universal metering.	indicated in the project design. This sub-component of KAP III includes the secondment of a Senior Water Asset Management/ Operations Engineer into PUB for 2 years, with the option of extension if necessary. This will add to PUB's limited capacity and provide hands-on support and mentoring directly to staff as they develop new and improved approaches to PUB's water operations. The work will precede but be compatible with asset management and operations improvement activities under the ADB South Tarawa Sanitation Improvement Sector Project.	supply is established to allow the system to be fully pressurised on a 24 hour basis. As yet there is no commitment to universal metering or declared donor support.
	Immediate upgrading and Improvements • Bonriki, coverage of gallery pumps and electric controls, replace gallery pumps and meters • water treatment plant, replace and upgrade aerator and pipe support, improve chlorination process and unit, replace meter measuring treated outflow with more suitable modern unit • transmission main – replacement of old section of transmission main between Teaoraereke and Betio • install Temaiku offsite water supply infrastructure, including pumps and elevated reservoir • transmission mains, install meters for demand and loss management, also fittings for attachment of pressure gauges • service reservoirs, flush and clean	Teaoraereke to Betio section of transmission main is beng replaced under the World Bank / ADB Tarawa Road Improvement Project The Temaiku offsite infrastructure has been designed and will be funded by NZAP in the course of implementing the Temaiku model urban subdivision.	The other improvements for the water supply system are identified for the first time in the roadmap. There is no donor commitment as yet for the existing water supply system improvements and upgrading identified.

	internally, repair leaks and make good structure damage/defects • Betio disinfection unit, replace non-operative unit with improved disinfection process • update network distribution model		
7	Tungaru Central Hospital	KAP II has assisted with the construction of an elevated tank stand and the high level tank and plumbing.	NZAP is giving consideration to assisting with the replacement of additional pumps and related works, identified as a component of the water system upgrade needs at the hospital. Over and above this support there is further work required for the water improvements at Tungaru Central Hospital.
8	Additional Potable Water Supplied • Rainwater Tanks	KAP III plans to expand the program of installing rainwater harvesting systems on public buildings for community use that was started under KAP II, and has provision for household tanks. $450,000 is provided for community tanks and $150,000 for household tanks.	Rainwater harvesting will require promulgation of the rainwater guidelines developed under KAP II and community education and awareness of the proper management and cleansing of rainwater tanks.
	Additional Potable Water Source • install a total desalination capacity of 2,112m^3/day with 528 m^3 capacity units in Betio (2), Bairiki (1) and Antebuka (1) by 2013 - 2014; • install additional 1,250 m^3/day desalination capacity in 2020; • action further desalination capacity, as required in the future		This significant commitment to develop alternate water supplies and production has no identified funding arrangements or development partner support.

44.2 Schedule Summarizing Work, Cost, Timing and Support

321. A schedule showing all requirements for water with the estimated costs for each item, the appropriate timing and the support is contained in Section VIII of this roadmap following the discussion of the requirements for sanitation, The schedule highlights the justification for all items, their priority and the benefits they will provide

44.3 Provisional implementation and Investment Programs

322. A provisional implementation plan with an associated investment plan for water and sanitation combined is also contained in Section VIII.

VII Sanitation

45 Evaluation of Existing (2011) Sanitation and Systems

45.1 Background

323. Sanitation in South Tarawa in 2011 comprises the three largely non-functioning sewerage systems serving the urban centres of Betio, Bairiki and central Bikenibeu, and elsewhere facilities and practices employing septic tanks, pit latrines, some compost toilets and open air defecation on beaches and bush. The locally constructed septic tanks discharge to soak pits filled with coral gravel to the groundwater lenses. The trends displayed by the census returns from 2005 to 2010 show a marked increase in flush toilets discharging to a septic tank (39% up from 27% in 2005), reflecting a desire on the part of the community for flush toilets. In the same time the practice of defecating on the beach, in bush and open spaces has decreased (22% down from 55.6%). The direct comparison of the 2005 and 2010 returns require careful analysis as although the same questions have been asked a tighter survey discipline in 2010 has give a one hundred percent response rate, compared to a one hundred and fifty percent rate and multiple answer responses in 2005. Allowing for this discrepancy there has still been a marked reduction in open air defecation.

45.2 Existing Urban Sewer Systems

324. The three urban sewer systems originally constructed in the early 1980's by the Australian Government in response to an outbreak of cholera in 1977 were rehabilitated from 2003 to 2004 by the SAPHE project. Due to an absence of maintenance and funding for routine operations and repairs the system by 2010 the systems had degenerated to a state of near collapse.

45.3 Existing Connections

325. The return submitted by PUB to the Pacific Water and Waste Water Association benchmarking of Pacific Authorities in 2011 claims 2,679 sewer connections, against a return in the 2010 Census for Betio, Bairiki and Bikenibeu confirming a total of 1,654 households directly connected to the PUB system. A detailed count conducted by the TA 7359 (KIR) consultants from the permit records aligned to the 2010 Census gives the number of connections and pans shown in Table 24.

Table 24: Existing Sewer Connections and Toilet Pans

Year	Betio	Bairiki	Bikenibeu	Total
Domestic Sewer Connections – 2010 Census and Consultant Count				
	1051	262	367	1,680
Estimate of All Existing Sewer Connections				
Domestic	1,051	262	367	1,680
Commercial	41	9	13	63
Govt, Schools. Industrial	45	26	19	90
Total	**1,137**	**297**	**399**	**1,833**
Estimate of All Existing Toilet Pans				
Domestic	1,051	262	367	1,680
Commercial	69	33	57	159
Govt, Schools. Industrial	155	57	64	276
Total	**1,386**	**352**	**488**	**2,115**

Source: Consultant Count and 2010 Census

45.4 Sewerage Systems, Immediate Improvements – 2011 to 2014

326. At the beginning of 2011 with the system again in a state of collapse, rehabilitation is scheduled through the South Tarawa Sanitation Improvement Sector Project. The 2011 condition of the systems and the interventions proposed under STSISP are presented in summary report contained in Volume 2 as Appendix 7. The design of the Project provides for plant, equipment, and mechanical items to be of a standard suitable for operation in a saltwater environment and Kiribati's harsh ocean climate. Subproject engineering designs have taken into account the possible risks posed by climate change impacts. The Project provides for the rehabilitation of the seawater flushing system in order to conserve scarce freshwater resources and avoid depletion of the freshwater lenses. The rehabilitation will occur between 2012 and 2014.

46 Future Sanitation

46.1 Design Limitations - South Tarawa, outside Betio, Bairiki and Bikenibeu

327. Salinity measurements have been taken at shallow wells along South Tarawa in villages outside the three main urban areas. Electrical conductivity (EC) was the proxy used for salinity. Groundwater with an EC > 2,500 µS/cm was taken to be brackish. Where the EC was found to be < 2,500 µS/cm, the fresh groundwater thickness is taken to be >0.5m, as it is assumed that the wells penetrate at least 0.5m of freshwater.

328. Twenty-one measurements were taken; 5 in Nanikai village, 4 in Teaoraereke village, 9 in Eita village and 3 in Nawerewere. Wells were selected in a line across each village; two lines in Nanikai village, one line in Teaoraereke village, three lines in Eita village and one line in Nawerewere village. The locations of the wells and the EC measurements were used to estimate the fresh groundwater lens width for each village. The results are presented in Table 25 below.

Table 25: Estimated Freshwater Lens Widths at Selected Villages, South Tarawa

Village	Line no.	Wells	Estimated Fresh Groundwater Width (m)
Nanikai	1	1-3	0
Nanikai	2	4-5	<50
Teaoraereke	1	1-4	>230
Eita	1	1-4	50
Eita	2	5-6	70
Eita	3	7-9	<110
Nawerewere	1	1-3	<180

329. The data suggests that, towards the edges of the islets where the fresh groundwater lens is thin, the lens can become brackish, in part due to excessive pumping using an electric pump. This observation, along with the estimated fresh groundwater widths in Table 25 indicate that the freshwater lenses at the selected villages are fragile due to the limited islet widths and existing high abstraction rates.

330. Whilst groundwater is not the main source of potable water, households visited during the water resource survey report that water is used for bathing and washing clothes. As slightly brackish water is used for bathing, care needs to be taken to avoid increasing groundwater salinity by shrinking the lens through abstraction above the sustainable yield, and the transporting of groundwater off site by the flushing of toilets discharging to the ocean outfalls.

331. These considerations therefore limit the design of future centralised sewerage systems to saltwater flushed options.

46.2 Sanitation Guidelines, On-Site Systems

332. **Draft Guidelines** - MPWU has developed draft sanitation guidelines to provide ministries, public utilities and external organisations with a tool for decisions and technical guidance for effective onsite sanitation. The guidelines promote the selection of the effluent disposal systems most suitable for the receiving environment in which the systems are located. The guidelines provide recommendations for the adoption of a range of sanitation systems for the different site conditions likely to be encountered, with the selection in each case being dependent on site conditions and constraints.

333. **Principles** - the following basic principles have been adopted for the development of the guidelines.

a. No untreated wastewater shall be released into the environment (unless via ocean outfall);
b. All sanitation systems should have primary treatment as a minimum, and secondary where practical;
c. All latrines and septic tanks must be watertight in service in the vicinity of potable or brackish groundwater lenses.

334. **Design considerations for Kiribat**i - cultural, environmental and geological attributes common across Tarawa and the outer islands raise unique considerations for the installation of safe sanitation systems.

a. Water availability - there is limited fresh water to be shared between potable and non-potable uses. This limits the availability of water for flushing;

b. Water quality - seawater or water with a high salinity cannot be used in septic tanks, leaving brackish water (2500-3500 µS) found at the interface between the freshwater lens and sea for use in sanitation systems;

c. Shallow groundwater system - fresh water lenses are the primary source of potable water for Kiribati and are typically shallow and highly susceptible to pollution requiring the selection of sanitation systems that avoid discharges to, and pollution of the groundwater;

d. Sea level changes - climate change is of increasing concern with increased salinity of freshwater lens from rising sea levels and storm surges, aspects the siting of sanitation systems need to consider;

e. Traditional practices - where sanitation projects have been implemented I-Kiribati have expressed a preference for water flushing systems using fresh or brackish water. To the extent practicable on-site sanitation system designs need to be culturally acceptable.

335. Options considered in the guidelines - Soils on South Tarawa islets are predominantly clean fine sands. The groundwater lens appears to vary from some 0.5m to 3.0m below ground in the residential areas. Many septic tanks in South Tarawa are improperly constructed and/or poorly maintained, and most discharge to a simple soakage pit, as a result effluent contaminates the groundwater. Pit latrines, which are excavated down to the shallow groundwater, discharge directly into the shallow groundwater, also contaminating it.

336. TA 7359-KIR has confirmed that the groundwater lenses under Tarawa are under threat of overuse and that utilisation of groundwater for toilet flushing with discharge to the sea through the sewer systems and outfalls is not sustainable. Furthermore the water quality is poor. Most wells show contamination by faecal coliforms, many have elevated levels of nitrate, some exceeding the WHO guideline for potable water. As a consequence any long

term sustainable solution which uses the groundwater lens must recycle it back to the lens but in a manner which reduces the concentration of bacteria and nitrogen in the discharge, where that discharge impacts upon a lens used for secondary uses of bathing and washing, and for some disadvantaged groups potable purposes.

337. The objective of the pilot onsite sanitation sub-project is to investigate suitable, low cost on-site wastewater systems which will be sustainable and do not contaminate the groundwater lens; design trial units and determine suitable sites for a range of trial systems which can be installed and monitored. Table 26 below sets out the types of systems recommended to be investigated in the Terms of Reference as compared to the final selection for the pilot sub-project. The final selection was controlled by site constraints.

Table 26: Trial On-Site Systems

Trial Systems	TOR	Final Pilot Sub-Project
Simple Pit Latrine	2 Unsealed, 5 Sealed	3 Unsealed, 5 Sealed
VIP Unsealed Toilet	5	13
Septic Tanks	2 Unsealed, 5 Sealed	0 Unsealed, 15 Sealed: 4 AquaPrivy, 11 Septic Tank's
Dry/Ecosan Toilets	5	6
Nitrogen Removal Trench	5	6

338. The guidelines provide for nitrogen removal trenches to reduce the nitrates entering the freshwater lenses and are structured to assist in the design process for new onsite sanitation systems where centralized sewer services are not available. The onsite systems have been designed for medium-term operation to fill the period until area sewer systems can be constructed

46.3 Piloting of On-Site Systems

339. The fragility of the groundwater lenses underlying South Tarawa and the risks to their sustainability require a change in attitude to the way the resources are protected and used. All practices likely to damage the lenses or risk the loss of the lenses through the transportation of the lens water off-site such as pumping and freshwater flushing of toilets where the water is transported away from the lens need to be curtailed and replaced with an approach which maintains the water balance for secondary water use. On-site disposal must concentrate on systems where the flushing water after treatment is safely returned to the lens, or dry systems with minimal water use. Modern dry toilets may be the only option for significant areas of Tarawa with high water tables. The proposed community awareness programs will assume importance in gaining community acceptance of these options.

340. At MPWU's request TA 7359-KIR provides for the design of the pilot sub-project for the on-site sanitation options, to be implemented early in STSISP as a candidate sub-project. This will "prove" the options for replication in the proposed sanitation guidelines as a practical approach for unsewered areas. The designs for the on-site systems have been developed in collaboration with MPWU staff and with consultation with MHMS, the urban councils and the community and householders involved. The sub-project design includes a monitoring and reporting program for an assessment of performance and effluent quality under operating conditions.

341. MPWU reviewed the 2010 Census figures for sanitation and assessed the need for the systems and after consulting government and institutional sector stakeholders has reached consensus on the locations of the sites for the pilot systems. After consultation with the property owners, twenty-eight pilot sites have been selected for the trialling of the onsite

options. The sites range throughout South Tarawa from Betio in the west to Temaiku and Bonriki in the east. While the on-site pilot project will be funded under STSISP, once the options are proven and incorporated into the national sanitation guidelines future systems and the rehabilitation of existing underperforming systems will occur normally, as now, at the cost of property owners.

342. The investigation and design of the onsite sanitation systems are reported as Appendix 8 in Volume 2 and the design plans are incorporated into Volume 3 as drawings 50663 sheets numbered ENV01 to ENV08. The implementation and monitoring of the pilot onsite sanitation project is covered in the roadmap by a provision of $350,000, of which $60,000 is allowed for the monitoring of performance and laboratory and associated testing for a two year period following construction of the onsite systems.

46.4 The Role for Onsite Sanitation

343. The piloting of the onsite sanitation options will determine the systems that can be supported under the national sanitation guidelines and progressively rolled out for installation in the presently unsewered areas. The onsite options will provide an affordable means of effective sanitation for the medium term and depending upon their performance could provide an effective approach for sanitation into the future allowing time for the gradual installation of area sewer systems along South Tarawa.

344. With the knowledge that the lenses under the developed areas are badly polluted and unfit for human consumption there is no impediment to the recycling of the treated effluent from onsite systems to the lenses. The approach is also supported by the mapping of the lenses and the conclusions that all water removed from the lenses should be returned to the lenses. This occurs with grey water and can also occur with bucket flushed fresh water sanitation where the systems are designed to treat and return the effluent safely back into the lens. Bacteriological loadings should not worsen. While nitrate levels may increase, depending upon the performance and extent of the proposed nitrate removal trenches, this will have limited impact on the use of the lenses for secondary uses. The conditions for onsite disposal will be the availability of a safe and secure primary supply for potable water, and acceptance by the community of modern waterless toilets for locations with a high water table. The performance of the onsite systems to be trialled under the pilot onsite sanitation project with monitoring of their performance for a realistic period following their construction to determine the part the onsite systems can play in the total sanitation response.

345. The PRIF Kiribati Infrastructure Sectors Review of August 2009 raised the high cost of centralised sewer systems and suggested a focus on onsite systems as a more affordable solution. At the same time this roadmap has identified the nature of the groundwater lenses, the high water tables which are predicted to increase with rises in sea level and the high population densities which are poised to more than double in the next twenty years. It is inevitable therefore that with the high population densities centralised sewerage will gradually become necessary, requiring a planned and progressive response. Onsite sanitation therefore has a considerable part to play over the next twenty or more years but will eventually give way to centralise systems. While these centralised systems will be expensive, there will be no escaping their need and the objective will be to approach the provision of the sewerage on a “least cost” approach with the improvements being phased on the basis of established need. The following sections of the roadmap consider how effective area sewerage schemes might be delivered to South Tarawa.

46.5 Improved Coverage

346. The present sewerage systems were originally designed to deliver sewerage services to 80% of the urban population within the service areas. It is desirable that these systems now be extended over time to service 100% of the population in each area, including squatter communities on government land. In these instances land occupation

rights will need to be first rationalised to give security to the “landless” as an incentive for investment in household sanitary facilities and sewer connections.

347. The areas requiring improved coverage have been identified and mapped. Preliminary estimates of cost have been prepared, allowing for sewer extensions, additional pumps, household connections, and a considerable number of communal toilets where the density of the present development prohibits the construction of a separate toilet closet for each household. The community awareness survey and consultation conducted during TA 7359-KIR confirms an acceptance of communal toilets provided arrangements are in place for their cleaning and maintenance. An example of good management was observed for an existing toilet block in Betio where OB has organised cleaning by local women on a roster basis with payment, thereby creating work opportunities, while maintaining the toilets to acceptable standards. The approach has merit and warrants replication for new toilet blocks.

348. Communal toilets will be required in areas where the present density of housing precludes the provision of a separate cubicle for each house. Community feedback suggests acceptance of the communal facilities, with positive feedback from households where the 15 or more inhabitants have difficulty in accessing the single pan available to the household. The comment is such cases suggested the provision of public toilets which would be used rather than the beach, provided the toilets were clean and well maintained. There is the option for PUB to have responsibility for these communal toilets and to contract their management and cleaning to either the private sector or community/church groups. The charge for use would offset these costs.

349. Plans depicting the areas of Betio, Bairiki and Bikenibeu where extensions to the present systems are required are incorporated in Volume 3 as drawings referenced 50663 sheets 101 to 105. While the areas are serviced by the main systems extension is required with secondary lines, pumps and communal toilets to extend the service to all households. The proposed extensions will provide services to 1,917 households through 1,335 direct connections and communal toilet blocks as summarised in Table 27, while Table 28 provides a summary of the preliminary estimate of costs.

Table 27: New Sewer Connections

Unsewered Areas	Area Code[1]	Households	New Toilet Blocks
BETIO			
Angaieta-Kaotitaeka (Temakin)	BET-A	40	3
Onibeeki North (Temakin)	BET-B	35	2
Onibeeki South (Temakin)	BET-B	50	5
St John Bosco (Temakin)	BET-B	30	3
Ocean Side Sport Complex	BET-B	20	0
East of Road St John Bosco to Nippon Maneaba	BET-B	250	9
Nippon Maneaba to Sport Complex	BET-B	200	6
Sport Complex to Tarawa Biscuit Area	BET-B	75	6
Ocean Side-Tatirerei-Nanomatoa	BET-C	50	6
Ueen Te Rooti (St Paul Cathedral)	BET-D	25	4
Ocean Side Labour Line (MTC)	BET-E	65	9
Lagoon Side Police Barrack	BET-F	10	2
Sub Total Betio		**850**	**55**

BAIRIKI			
Tabon-kabauea (Between Causeway and Mormon Compound)	BAI-A	15	3
Arorae Maneaba Area	BAI-B	3	0
Kawan Bairiki	BAI-C	210	10
Sub Total Bairiki		**228**	**13**
BIKENIBEU			
Bikenibeu East (Lagoon side of Outfall PS)	BIK-A	50	2
Central (Vicinity of KGV & EBS Office and Class Rooms)	BIK-B	30	2
Lagoon Side area between PUB Office and Catholic Mission	BIK-C	100	10
Bikenibeu West (Primary School Area to MacKenzie	BIK-D	80	15
Sub Total Bikenibeu		**260**	**29**
Total All Areas		**1,335**	**97**

Note:

1. Relates to areas indicated on plans

Table 28: Sewer Extensions – Preliminary Estimate of Costs

Estimate for Provision of Sewerage[1]	
Betio	1,949,900
Bairiki	485,200
Bikenibeu	867,400
Preliminary and General (20%)	650,500
Engineering Design and Supervision (12%)	396,300
Physical Contingency (10%)	330,250
TOTAL	**$ 4,679,550**

Note:

1. Includes pipes, manholes, pump stations and sewer and saltwater flushing connections

46.6 Decentralized Systems

350. With the assessment of the urban lenses and their fragility the option of using either fresh or brackish water for toilet flushing and primary treatment in the septic tanks where the filtered effluent is conveyed off-site and disposed of through the ocean outfalls is no longer an option. The design options therefore make no provision for decentralised systems.

46.7 Centralized Systems

351. For the same reason all future centralised (area) systems identified below rely totally on saltwater flushing.

47 Sanitation Design

47.1 Introduction

352. The design considerations allow for the decisions already made for the South Tarawa Sanitation Improvement Sector Project providing for the rehabilitation of the existing sewerage system servicing Betio, Bairiki and Central Bikenibeu, and the plans under the NZAP Urban Development Program for the on-site and off-site infrastructure for the model urban subdivision at Temaiku.

353. The future flow and loading of the existing sewer networks in Betio, Bairiki and Bikenibeu have been recalculated on the basis of the estimated discharges and population growth to year 2030. This assessment indicates a capacity within the system for the high growth 2030 population in these urban areas. The rising main for the Temaiku off-site sanitation infrastructure will connect to the ocean outfall at Tungaru Central Hospital which is to be upgraded. The rising main and outfall are to be sized for a future population of 10,000 at Temaiku and for the future population from Bikenibeu east through Nawerewere to the development along the foreshore in Temaiku, east from the airport turnoff.

354. The priority beyond these considerations will be to provide efficient and cost-effective sanitation to the remainder of South Tarawa through appropriate onsite sanitation in the medium term and as urban densification occurs through new area sewer systems. The approach adopted takes into account affordability by phasing the improvements in a progressive and balanced manner taking into account of the absorptive capacity of the Government and its agencies, both in terms of human resources and costs.

47.2 Design Areas

355. The sanitation design areas, including the existing sewered areas of Betio, Bairiki and Bikenibeu and the Temaiku urban subdivision are indicated in Table 29.

Table 29: Summary of Design Areas

Geographic Area	Design Area (Ha)	Remarks
Betio	148	Existing sewer
Bairiki	28	Existing sewer
Bikenibeu Central	44	Existing sewer
Bikenibeu East, Nawerewere	52.68	East and west of Tungaru Hospital
Bikenibeu West	34.61	West from Bikenibeu Central to Abarao
Temaiku	NZAP	Rising main and ocean outfall sized for population of 10,000 plus the discharge from Bikenibeu East - Nawerewere
Nanikai and Taeoraereka West	21.65	
• *Nanikai – 6.62 Ha*		
• *Teaoraereke West – 15,03 Ha*		Area around Catholic HQ
Central South Tarawa	228.87	Teaoraereke West to Abarao
• *Teaoraereke East - 46.10 Ha*		
• *Antebuka 47.76 Ha*		
• *Ambo- 48.06 Ha*		
• *Taboria – 19,25 Ha*		
• *Eita – 53.62 Ha*		
• *Abarao–balance– 13,81 Ha*		

47.3 Design Populations

356. The 2030 high growth population has been adopted for the design of the future sanitation options. The populations to be serviced by new sewerage systems are shown in Table 30. The sanitation systems described later in this roadmap are designed to provide for 100% of the population within these service areas. The 2030 population reflects the findings of the population growth assessment conducted in conjunction with the preparation of this roadmap.

Table 30: Sewerage Systems design Populations

Geographic Area	Population 2010	Design Population 2030
Betio	15,646	33,437
Bairiki	3,251	6,950
Bikenibeu Central, comprising (EAs 17 – 29)	4,855	11,590
Nanikai/Teaoraereke West, comprising • *Catchments A/1, A/2 and A/3 (EAs Part 60, 61 and 62))*	1,717	3,692
Bikenibeu West, comprising • *Catchments B/1, B/2 and B/3 (EAs 30 -34)*	2,805	5,997
Bikenibeu East - Nawerewere, comprising • *Catchments C/1. C/2, C/3 and C/4 (EAs 10 -16)*	3,777	8,072
Central South Tarawa, comprising • *Teaoraereke – balance (EAs 54 – 59)* • *Antebuka (EAs 48 – 53)* • *Ambo (EAs 44 – 47)* • *Taboria (EAs 41 – 43)* • *Eita (EAs 36 – 40)* • *Abarao – balance (EA 35)*	14,034	30,002
TOTAL	**46,085**	**99,740**

Notes: EA = Enumeration Area of 2010 Census; The main off site infrastructure for the Temaiku area in the form of a rising main and ocean outfall is incorporated in the NZAP model urban subdivision project. Further infrastructure is assumed to be part and parcel of the ongoing development of Temaiku and will be subject to GoK decisions to raise the site above future flood levels

47.4 Sanitation Loadings

357. The existing sewer flows, including average daily per capita loading, for the existing and likely future sewerage networks in South Tarawa have been assessed and wastewater load forecasts have been made based on the population growth projections including average daily per capita loads, for the period 2010 to 2030, assuming 100% access to improved sanitation in South Tarawa. The enumeration areas of the 2010 census have been adopted for this calculation. The flow and loading calculations are incorporated as Appendix 9 in volume 2. The high population growth scenario for 2030 and related sanitation flows and loadings have been adopted for the design of the future extensions and area sanitation options.

47.5 Calculations of Design Sewerage Flow

358. **Design Average Daily Water Supply** – a daily water demand/use of 80L/pers/day has been adopted for preliminary design purposes. This reflects a total potable demand of 50L/pers/day and sewer flushing of 30L/pers/day.

359. **Design Average Sewer Flow** - In South Tarawa few kitchens and washing areas are connected to the sewer and grey water has a productive use for watering plants and other secondary uses. The flow to the sewers is limited to direct toilet discharge and flushing. The design calculations using the above consumption is therefore conservative given that the discharge of potable waters to the sewer will be less than 60% of the potable water intake to a household.

360. **Design Peak Hourly Sewer Flow** – for the new area sewerage options the design peak hourly flow has been estimated to determine the cross section of sewers and the capacity of pumps and rising mains. For the purposes of the preliminary assessment the commonly used value of 1.8 times the average daily sewerage has been adopted to give a design peak hourly flow of 120L/pers.

361. **Design Peak Wet Weather Flow** – for the design of the new centralised sewer systems a flow of 5 times the dry weather flow has been used.

362. The sewerage flows for the conventional centralised systems for each geographic area are shown in Table 31.

Table 31: Average Sewerage Flow by District

Geographic Area	Area (Ha)	Design Population	Average Daily Flow (m^3/day)	Peak Hourly Flow (m^3/day)	Sewage Flow per Ha (m^3/sec)
Betio	148	33,437	2,007	3,613	0.00028
Bairiki	28	6,950	421	758	0.00015
Nanikai & Teaoraereke West	21.65	3,690	222	399	0.00021
Central South Tarawa	228.87	30,020	1,723	3,102	0.00016
Bikenibeu West	34.61	5,997	359	647	0.00022
Bikenibeu Central	44	11,550	623	1,122	0.00030
Bikenibeu East	52.68	8,072	484	872	0.00019

48 Provision of Improved Sanitation

363. Suitable sanitation technologies for South Tarawa and materials for sewage collection and treatment and for the area and onsite methods have been evaluated and are reflected in the options considered and costed in this roadmap.

364. While fully welded polyethylene pipes, fittings and maintenance shafts would reduce infiltration and tree root intrusion this comes at the disadvantage of higher costs, especially in the transport of the materials through the longer length and bulkiness of the pipes. The Estimates have therefore been based on the use of PVC pipes which can be transported by container with lower material and freight costs

49 Future Priorities

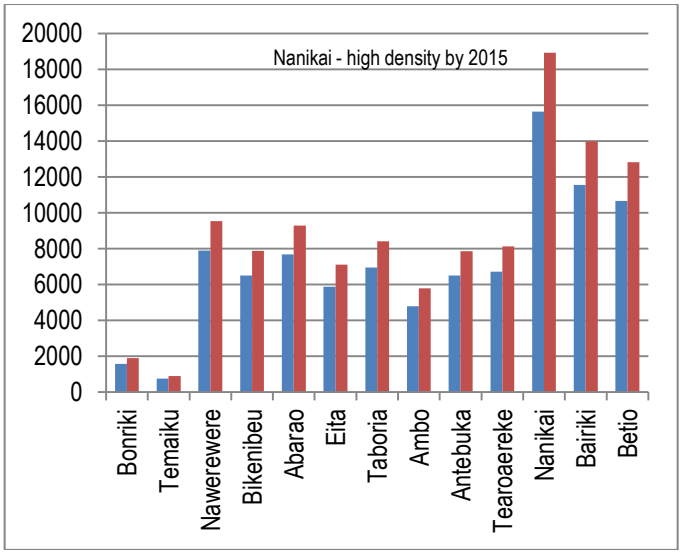
49.1 Consolidation of Existing Urban Sewerage Systems

365. Immediate priority will be given to the rehabilitation of the existing sewer systems in Betio, Bairiki and central Bikenibeu and the restitution of their saltwater flushing systems. In the course of consolidating the core systems effort will be directed towards extending the systems to bring sanitation to 100% of the populations in the main urban centres by the gradual extension of the systems to the areas within the serviced districts that are deficient in sanitation. This work will be carried out as donor and government funds permit over a period of eight years between 2012 and 2020. Drawings showing the extent of the existing

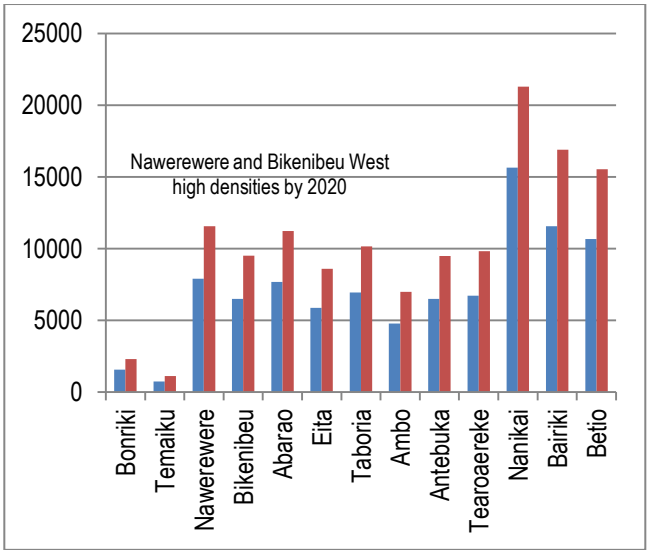
systems are included in Volume 3 referenced as 50663 sheets numbered 106 to 110, saltwater flushing systems and 50663 sheets numbered 111 to 115 for the waste water systems.

49.2 Expansion outwards from Existing Systems

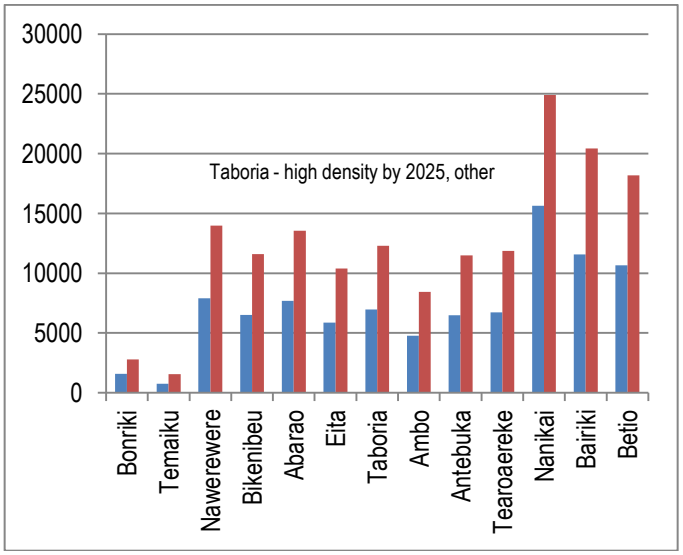
366. The assessment of urban growth has high population densities developing along South Tarawa from 2016 onwards with the general progression indicated in Figure 5 on the following page and Table 32. The drawings referred to are contained in Volume 3 and depict the areas and the conceptual layout of future sewer systems. It is proposed that sewerage coverage for South Tarawa will be installed in stages developing outwards from the existing systems, based initially on the existing outfalls at Bairiki, Tungaru Hospital and Bikenibeu, then for the central villages draining to a new outfall to be located near Taboria.



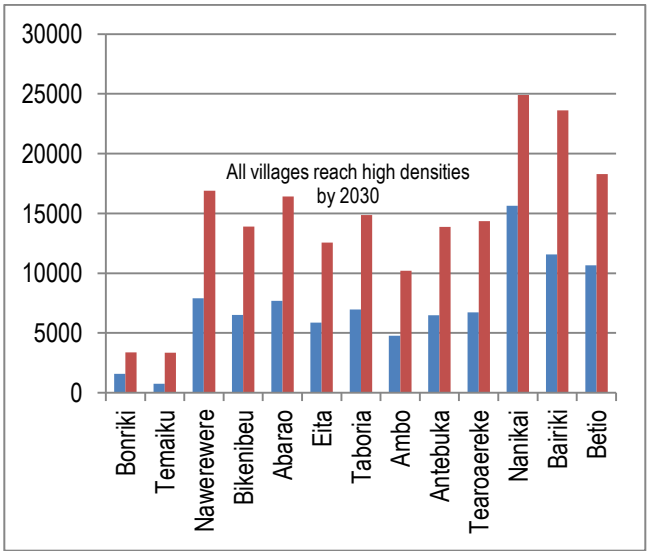
2015: 2010 blue and 2015 red



2020: 2010 blue and 2020 red



2025: 2010 blue and 2025 red



2030: 2010 blue and 2030 red

Figure 5: Population Densities 2010 to 2030

Table 32: Indicative Densification of Urban Centres and Population

Geographic Location/Village	Urban Densification	Drawing Reference
Nanikai to Teaoraereke West	2018	50663 sheets 116, 117 and 118
Bikenibeu East (Nawerewere to Temaiku)	2020	50663 sheets 125 and 126
Bikenibeu West	2023	50663 sheet 124
Teaoraereke to Eita	2023 to 2031	50663 sheets 118, 119, 120 and 121, 122 and 123

367. A description of each sub-system and the proposed scheduling for implementation is provided in Table 33. The proposed scheduling is indicative and reflects the need based upon urban densification balanced with donor and local agency capacity. Implementation could be deferred for a number of years if the piloting of the onsite sanitation proves successful.

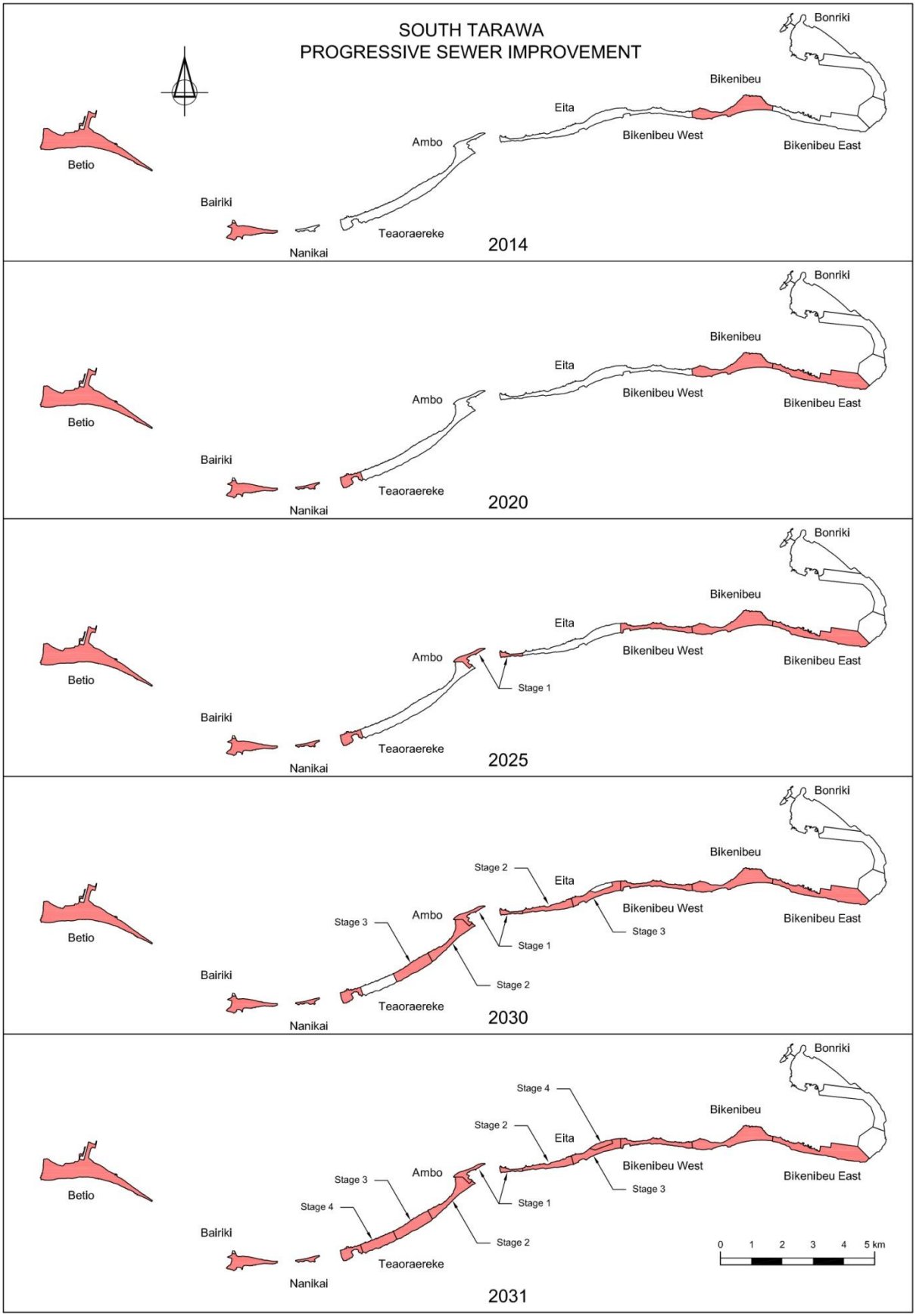
Table 33: Description, Scheduling and Estimated Cost of Centralised Sewerage

Sub System	Description	Schedule	Estimate
Nanikai to Teaoraereke West	Sub system connecting Nanikai and Teaoraereke in vicinity of Catholic Headquarters to Bairiki outfall through a rising main. Provision for the Nanikai landfill leachate discharge	2018	3,021,000
Bikenibeu East (Abarao to Temaiku, including Nawerewere)	Sub system connecting Temaiku ocean side area to the east of the airport turnoff and the area east of hospital through local gravity sewers connecting to a rising main which discharges through the Tungaru hospital outfall Second sub system connecting Abarao east and intervening area through a second rising main to the hospital outfall Hospital outfall upgraded to accommodate flow as a component of NZAP offsite sanitation works for Temaiku model urban subdivision	2020	3,417,000
Bikenibeu West	Sub system connecting the eastern end of Abarao to west Bikenibeu and servicing the intervening lands through local gravity systems connecting to a rising main brought to and discharging through the Bikenibeu ocean outfall	2023	4,010,000

Teaoraereke to Eita (Staged as below) Stage 1: Ambo to Taboria (East)	Provision of a centralised sewer system for the central villages of South Tarawa. This will be approached in stages Providing for the construction of the new centrally located ocean outfall at Taboria and the installation of sewers to service the area from the vicinity of the Catholic church in Ambo in the west to and including Taboria in the east. Local gravity pipelines connecting to a common rising main discharging at the ocean outfall	 2025	 3,907,000
Stage 2: Ambo and Antebuka in the west and Taboria to central Eita in the east	Extended systems moving outwards from the stage 1 improvements with local gravity systems connecting to the common rising main linking to the ocean outfall at Taboria	2027	4,420,000
Stage 3: Teaoraereke East and the bulk of Eita	Further extension from the sewer network established in stages 1 and 2 with local gravity networks connecting to the common rising main linking to the ocean outfall at Taboria.	2029	4,750,000
Stage 4: The remaining section of Teaoraereke in the west and the remaining section of Eita in the east (Tebikenikora)	The completion of the remaining sections of central South Tarawa extending outwards from stages 1, 2 and 3 again with local gravity networks connecting to the common rising main linking to the ocean outfall at Taboria.	2031	2,435,000
TOTAL			**$25,960,000**

368. Figure 6 illustrates the proposed sequencing of the improvements.

Figure 6: Plan showing the Sequencing of South Tarawa Area Sewerage



Note: The Temaiku main sewerage infrastructure will also implemented by 2014 under the NZAP Urban Development Project.

49.3 Operations and Maintenance of New Systems

369. The Operation and Maintenance (O&M) costs for the new sewer extensions have been calculated based on estimates of cost prepared under TA 7359-KIR. These O&M costs average $11.33 per household/mth.

49.4 The Place for On-Site sanitation

370. The provision of effective centralized sanitation is a costly process which needs to be phased over many years. As indicated onsite sanitation will be necessary to bridge the needs and should do this successfully until the area sewerage systems can be implemented. The onsite options being piloted are low-cost designs using local materials and allowing for local preferences and choice for the construction of the toilet cubicles. The roadmap takes the position that onsite sanitation will continue to be provided progressively by the property owner and are therefore not reflected in the future costs of sanitation.

50 A Systematic and Least Cost Approach

371. In summary the proposed staging of the improvements will spread the costs over time and therefore bring a systematic and more affordable approach to the provision of sanitation, with the following sequencing of the work.

50.1 2012 – 2016

372. The rehabilitation of the core urban sewer systems in Betio, Bairiki and Bikenibeu. Commencement of extensions towards 100% coverage.

50.2 2018 – 2023

373. Implementation of sub-systems to Nanikai and Teaoraereke; Bekinibeu east and Bikenibeu west. Continuing extensions in Betio, Bairiki and Bikenibeu core areas towards 100% coverage

50.3 2025

374. Teaoraereke to Eita - stage 1 - Ambo to Taboria (East) and Ocean Outfall

50.4 2027

375. Teaoraereke to Eita stage 2 - Ambo and Antebuka in the west and Taboria to central Eita in the east

50.5 2029

376. Teaoraereke to Eita stage 3 - Teaoraereke East and the bulk of Eita

50.6 2031

377. Teaoraereke to Eita stage 4 - The remaining section of Teaoraereke in the west and the remaining section of Eita in the east (Tebikenikora)

50.7 Outline of Needs and Improvements

378. The identified requirements for sanitation will consist of the actions summarised in Table 34. All priorities conform to those of the National Sanitation Policy and 10-Year Implementation Plan.

Table 34: Summary of Priority Actions and Works for Sanitation

Item	Need and/or Improvement	Present Donor Involvement	Comment
1	Regulatory • MPWU role established for sector regulation and policy Sector regulatory framework established. • enactment of water and sanitation Law and regulation to clarify roles, responsibilities and powers of sector agencies	TA 7359-KIR has completed an institutional analysis with recommendations for the focusing of MPWU's future sector role	No provision as yet for the drafting and enactment of a modern water and sanitation law and associated regulations, or for the establishment of the sector regulatory framework.
2	PUB Governance, Institutional and Capacity Building • Business Plan focussing on utility company needs • cost centres for water and sanitation • improved, linked IT and management reporting systems • setting of tariffs for cost recovery and acceptable return on investment • refocusing effort to operations – reduced overhead costs • focusing operational outputs on key priority areas for a return on assets and effective service delivery • training and capacity building, to benefit PUB's operations	TA 7359-KIR has completed an institutional analysis and report to guide change and capacity building. The ADB South Tarawa Sanitation Improvement Sector Project will embed two long-term TAs within PUB, one financial and one engineering /operations position. The TAs will support financial management and cost recovery, the development of management and financial reporting systems, operational procedures, and provide capacity building and on-the-job instruction and training. KAP III also plans for the secondment of an engineer to PUB for a two year period, or ;longer if necessary to support leak detection and operations (refer item 5 below).	The support for PUB from the South Tarawa Sanitation Improvement Sector Project will commence in the 1st Quarter of 2013 and will continue until the last Quarter of 2017. KAP III commenced in September / October 2011 and will continue for a period of five years. The TA support will be established in the 1st quarter of 2012.
3	Preservation of Sanitation Assets • adoption of asset management principles • continuing investigations and effort to develop	Under the ADB South Tarawa Sanitation Improvement Sector Project the TA for engineering/operations will assist investigations, analysis further development and refinement of	As above.

	asset management plan • three year budget preparation based on asset management plan, with annual roll-over and approval of the first year as the immediate year's budget • continual improvement of AMP.	an Asset Management Plan for water and sanitation. KAP III will support these activities in a harmonised manner.	
4.	Community Awareness programs • harmonised community awareness programs for maximum impact • engagement of communities in infrastructural improvement initiatives • community mobilisers for grass roots immersion and effective change processes • training government officials and community groups using approaches such as Community-Led Total Sanitation (CLTS), and behaviour change campaigns	The intention will be to harmonize the community awareness of KAP III, the South Tarawa Sanitation Improvement Sector Project and NZAP activities. The community awareness programs will be fundamental to the future success of all infrastructure programs and the longer-term programs of STSISP and KAP III are the fundamental building block on which all future activities must be predicated.	
5	Existing Sanitation Systems • Immediate rehabilitation of the sewer and saltwater flushing systems in Betio, Bairiki and Bikenibeu • Provision of sludge digester and procurement of sewer cleaning equipment • Upgrading and reconstruction of ocean outfalls at Betio, Bairiki and Bikenibeu • Planned extension to existing sewer and saltwater flushing systems to service 100% of the population within the service area	The ADB South Tarawa Sanitation Improvement Sector Project will rehabilitate the sewer systems for Betio, Bairiki and Bikenibeu, their saltwater flushing systems and reconstruct the existing ocean outfalls at Betio, Bairiki and Bikenibeu.	
6	On-site Sanitation Systems		

	• Design of a sub- project for the piloting, and evaluation of selected onsite sanitation options • Implementation of pilot onsite sanitation systems, and subsequent monitoring • Roll out of appropriate onsite sanitation options using MPWU sanitation guidelines	TA 7359-KIR has assisted MPWU with the design of the sub- project for the piloting and evaluation of selected onsite sanitation options. The ADB South Tarawa Sanitation Improvement Sector Project will implement the pilot onsite sanitation systems, and the related monitoring program. MPWU will coordinate and manage the roll out of appropriate sanitation options in accordance with the national sanitation guidelines.	Onsite sanitation will have an important part to pay in bridging sanitation needs until the area sanitation systems can be installed.
7	Temaiku Model Urban Subdivision - Offsite Infrastructure • Rising main from the subdivision to a the Tungaru Hospital outfall • Upgrading and improvements to the existing hospital outfall	The Temaiku offsite infrastructure has been designed and will be funded by NZAP in the course of implementing the Temaiku model urban subdivision.	
7	Tungaru Central Hospital • Improvements to sanitation facilities and infrastructure		There is no present commitment or support for the urgent upgrading of the hospital sanitation services and infrastructure
7	Extension of centralised sanitation systems in a sequential manner aligned with available donor support and funding • Nanikai and Teaoraereke extension • East Bikenibeu and Temaiku • West Bikenibeu • Central South Tarawa – Teaoraereke to Eita		No funding has, as yet been allocated for these works. The provision of new area sewer systems will become necessary as the urban areas along South Tarawa densify.

50.8 Schedule Summarizing Work, Cost, Timing and Support

379. Similar to the section for water supply a schedule showing all requirements for sanitation with the estimated costs for each item, the appropriate timing and the present support is contained in Section VIII of the report. The schedule highlights the justification for all items, their priority and the benefits they will provide.

50.9 Provisional implementation and Investment Programs

380. A provisional implementation plan with an associated investment plan for water and sanitation is also contained in Section VIII.

VIII Roadmap Elements, Costs and Scheduling

51 Roadmap Elements

51.1 Factors Influencing Choice

381. This section brings together the combined requirements for water supply and sanitation and displays the priorities for the identified improvements. The priorities have been established from the review of the expected population increases and emerging population densities on South Tarawa. These create a need for the immediate improvement in the provision of safe water supplies to relieve critical shortages, and significantly improved sanitation and hygiene and health practices to head off a surge in waterborne diseases that will otherwise occur from overcrowding and inadequate provision of basic infrastructure.

382. The preceding sections of the roadmap have establish the unrelenting growth in population that will occur between 2011 and 2030, the limited options for deflecting this growth and the high land occupation densities that will occur as a result of the growth. Within the next decade population densities throughout South Tarawa will be as high as any developed urban area in the Asian-Pacific region.

383. The analysis highlights South Tarawa's limited safe water resources, the urgent need to protect the available resources at the Bonriki and Buota reserves from pollution leading to head off the loss of these essential resources. The water resource assessment has confirmed the fragility of the groundwater lenses elsewhere in South Tarawa, their limited ability to survive an extended drought and the high rate of abstraction for secondary use for bathing and washing. The losses through the bucket flushing of toilets and the damage to the lenses through this practice has also been identified.

384. Water quality is poor with high biological contamination, high nitrate levels and in locations the emerging presence of oils and fuels. The only lens with any capacity is at the centre of Betio near the sports stadium at 258m^3/day. Abstraction and treatment for potable use will compete with secondary uses leading to further depletion of the lens. The conclusion is that the urban lens should remain for secondary use. The fresh water bucket flushing of toilets where freshwater is lost by discharge through the ocean outfalls should cease. The circumstances provide three clear messages, the first being the critical shortage of safe water supplies and the vulnerability of the water resources the community presently depends upon for secondary uses, the second being the unacceptable loss of scarce water in the water supply distribution systems, and the third being that future sanitation systems will, of necessity, have to be predicated on the use of saltwater for flushing.

51.2 Summation of Priorities

385. Long-term community awareness programs and capacity building programs are being provided through KAP III, ADB's South Tarawa Sanitation Improvement Sector Project and NZAP's Urban Development program. With these programs in place and harmonized activities the priorities in overall terms are summarised below. The priorities were confirmed by the WSSW workshop convened in South Tarawa on 28 and 29 November 2011.

Water Supplies:

1. Immediate restoration of the Buota water supply connection;
2. Leak detection and demand management of PUB's systems for efficient water supply services;
3. Contingent upon item 2 above the urgent provision of additional water supplies for South Tarawa, through the provision of desalination plants;
4. Immediate protection and quarantining of the Bonriki and Buota water reserves;

5. Improvement of the Bonriki reserve capacity through the selective culling of coconut and pandanus palms, and the clearing and infilling of the borrow pits on the reserve;
6. Continued Rainwater Harvesting;
7. Improvement of the Tungaru Central Hospital water supply system;
8. The sparing of pumps and valves for the Bonriki galleries, improvements to the Bonriki treatment plant, replacement of the Betio rechlorination unit and the cleansing/repair of service reservoirs;
9. Offsite infrastructure (water supply) for the Temaiku model urban subdivision;

Sanitation

1. The rehabilitation of the existing sewer systems with the restoration of the saltwater flushing systems and the upgrading of the ocean outfalls;
2. The pilot onsite sanitation sub-project and monitoring and alignment of the National Sanitation Guidelines;
3. Extension of the existing sewerage systems at Betio, Bairiki and Bikenibeu to provide for the connection of 100% of the population within the service areas;
4. Improvement of the Tungaru Central Hospital sanitation systems;
5. Continuing provision of sanitation to the sections of South Tarawa without sewerage through a combination of extended sewer systems and onsite sanitation;
6. Offsite infrastructure (sanitation) for the Temaiku model urban subdivision.

51.3 Discussion of Priorities

386. All actions indentified by the roadmap are closely intertwined and for sustainability require a whole of sector approach between government and its communities. Institutional alignment will be necessary to strengthen sector policy and regulatory frameworks and the actioning of obligations flowing from these for more effective utility operations. Equitable cost recovery for operations and maintenance will be crucial for sustainability. Least cost options will take precedent over more costly and possibly desirable alternatives, where these least cost options are shown to be effective with acceptable longer-term operating and maintenance costs.

387. Table 35 collates all the recommended initiatives separated for convenience under water supply and sanitation, with an indication of respective priority, timing, estimated costs, development partner support and statements on the ease of implementation or otherwise. The display is confined to the infrastructure components on the premise that the capacity building, institutional and governance issues will be addressed under presently approved projects. The summary also assumes that community awareness and the appreciation of the present circumstances and the challenges and choices for all I-Kiribati living on South Tarawa will be handled within the presently committed community awareness programs and ongoing public debate for the formation of the Kiribati Development Plan 2011-2016.

388. An Initial implementation plan follows in Figure 7 with the summarised Investment Plan presented in Table 36.

389. The investment required over the twenty years to 2030 is substantial amounting to $20,904,039 for water supply improvements and $45,022,389 for sanitation infrastructure. Existing development partner commitments amount to $3,691,000 for water supply and $13,511,000 for sanitation, leaving balances of $17,213,039 and $31,511,389 respectively for which future funding will be required. The investment plan in the roadmap shows the funds required annually on the basis of a proposed implementation plan and the assumptions upon which this is based.

51.4 Overarching Requirements

390. The roadmap recognises the need for fundamental shifts in the past approaches for identifying infrastructure needs and their maintenance and operations into the future. The initial provisions to give impetus to these changes are largely in place within the designs for KAP III and STSISP. These existing commitments and their intended outcomes are covered in the roadmap and the related implementation plan. In summary the proposed activities will provide for:

51.4.1 Sector Regulation and Institutional Strengthening and Capacity Building

1. MPWU role for sector regulation and policy;
2. Enactment of water and sanitation Law, regulation to clarify roles, responsibilities and powers of sector agencies and a regulatory framework for the sector;
3. MPWU capacity strengthened for project design and implementation.

51.4.2 PUB Institutional and Capacity Building

1. Business Plan and strategic plans focused on utility company operations;
2. Cost centres for water and sanitation;
3. Improved, and linked IT, billing and management reporting systems;
4. Setting of tariffs for cost recovery and acceptable return on investment;
5. Refocusing of effort to operations, to give reduced overhead costs;
6. Focusing outputs on key areas for a return on assets and effective service delivery;
7. Training and capacity building that immediately benefits PUB's operations.

51.4.3 Asset Management

1. PUB adoption of asset management principles;
2. Continuing investigations and effort to develop asset management plan;
3. Three year budget preparation based on asset management plan, with annual roll-over and approval of the first year as the immediate year's budget;
4. Continual improvement of AMP.

51.4.4 Community awareness

1. Harmonised development partner community awareness programs for maximum impact;
2. Engagement of communities in infrastructural improvement initiatives;
3. Community mobilisers for grass roots immersion and effective change processes;
4. Training government officials and community groups using approaches such as Community-Led Total Sanitation (CLTS), and behaviour change campaigns;
5. Proactive gender programs for involvement of women in the development activities.

51.4.5 Operations and maintenance

1. For sanitation the immediate application of the Sustainable Maintenance Fund (SMF) provided for in the STSISP design;

2. The refinement of the Asset Management Plan for water supply and sanitation with agreed and adequate provisions for operations and maintenance with a three year rolling budget for the immediate years of the AMP.

51.4.6 Fees and Charges - Sustainability

1. The phasing in of equitable fees and charges for sanitation over five years between 2012 and 2016 to ensure adequate and balanced revenue between user pays and government subsidy, sufficient to guarantee the sustainable operations of the sanitation services provided by PUB.
2. The review of water supply tariffs again on an equitable basis to ensure adequate and balanced revenue between user pays and government subsidy, sufficient to guarantee the sustainable operations of the water supply services provided by PUB.

391. Operations and maintenance costs and fees and charges for sustainability are reported in separate sections immediately following the implementation schedule and investment plan in Figure 7 and Table 36 respectively.

Table 35: Priority, Timing and Estimated Cost of Infrastructure Improvements

Ref	Initiative	Priority	Timing	Estimated Cost $	Support		Comment
					Y/N	Development Partner	
RI	**REGULATORY & INSTITUTIONAL**						
RI1	REGULATORY FRAMEWORK	1	Immediate	220,000	N		Estimated allowance. There is a need for a consolidated water and sanitation Law to specify responsibilities and roles.
RI2	INSTITUTIONAL & CAPACITY BUILDING	1	Immediate	1,417,000 STSISP	Y	ADB – STSISP, KAP III	STSISP and KAP III have integrated provisions for support to PUB to strengthen financial and operational activities.
RI3	ASSET MANAGEMENT	1	Immediate	Included in RC2 above	Y	ADB – STSISP, KAP III	STSISP has provision for embedded engineering support to the development of asset management planning within PUB. KAP III has parallel integrated support.
RI4	COMMUNITY AWARENESS	1	Immediate	2,339,000 STSISP	Y	KAP III, ADB – STSISP, NZAP	STSISP has provision for a long-term eight year community awareness and gender program. KAPIII and NZAP have community awareness provisions. These programs will be harmonized.

	SUB-TOTAL REGULATORY/INSTITUTIONAL			**3,976,000**			
WS	**WATER SUPPLY**						
WS1	FRESHWATER RESOURCES						
	North Tarawa: protect freshwater resources and provide water supplies in North Tarawa.	1	Immediate	420,000	Y	KAP III	For two communities in North Tarawa.
	Buota: Reconnect water reserve to water supply treatment and system.	1	Immediate	37,000	Y	KAP III	Work will proceed in the near future.
	Bonriki and Buota: protect water reserves, legislation, regulation and enforcement with community engagement.	1	Immediate	200,000	Y	KAP III	Estimated cost was difficult to establish from KAP III design document. Estimated cost indicated.
	Bonriki: enhance production by selective clearing of 1,700 aged coconut and pandanus palms.	1	2012	272,000	N	NZAP considering	No definitive development partner commitment. Probable need for additional funding above possible NZAP commitment.
	Bonriki: enhance production by cleaning and filling borrow pits/ponds.	1	2013	2,500,000	N	NZAP considering	No definitive development partner commitment.
	Rainwater Tanks: continue to expand the installation of rainwater harvesting systems on public buildings for community use started by KAP II and NZAP.	1	2012/2015	450,000	Y	KAP III	Provision for materials and work force for implementation of program. NZAP also considering assistance.
	Rainwater Tanks: provision for	1	2013/2015	150,000	Y	KAP III	Possible credit scheme for

	rainwater tanks to households.						roll-out by KAP and others. NZAP also considering assistance.
	Water Supply: provide new secure supply by installing a total desalination capacity of 2,112m^3/day with 528m^3 capacity units in Betio (2), Bairiki (1) and Antebuka (1) by 2013 – 2014.	1	2013/2014	8,483,800	N		Planning should commence immediately and be aligned with progress with leak detection and wastage control. The provision of safe water supplies is an immediate requirement for both economic development and the health and safety of I-Kiribati living in South Tarawa. Timing allows for acceptance of the technology, progress with leak detection and waste control measures and for planning and project preparation.
	Water Supply: increase secure water supply with installation of additional 1,250 m^3/day desalination capacity in 2020.	3	2020	4,010,000	N		Provisional cost is shown in the investment plan. Later expansion of water supply left for reconsideration closer to the need.
WS2	WATER SUPPLY SYSTEM						
	Transmission main: replace old section of transmission main between Teaoraereke and Betio.	1	2012/2013	1,053,000	Y	Incorporated into World Bank / ADB Tarawa Road Improvement Project.	Construction scheduled for 2012 and 2013.
	Leak detection: for watertightness and pressurised systems to guarantee quality and protect public	1	2012 continuing	860,000	Y	KAP III	Funding with embedded support within PUB will make considerable inroads

	health.						into requirements.
	Update network distribution model: – software plus consultant support. Cost allows for contingencies. (refer Appendix 6).	1	2012/2013	66,000	N		Should be done in conjunction with the planning for the desalination plants.
	Temaiku Urban Development: Offsite infrastructure comprising The installation of the supply line (~5.9km) including valves and fittings, a new Pump Station at Bonriki, a 50kL elevated tank within the subdivision.	2	2012	520,000	Y	NZAP	
	Demand management: install 3 electromagnetic/district type meters at predetermined location on transmission main and fit pressure gauges at strategic locations. Supply, install and retain spare meters for replacement of 10 x 100mm water meters to the elevated reservoirs and 22 x 50mm water meters for the connections from the elevated reservoirs for demand and loss management. Cost allows for contingencies. (Appendix 5).	2	2012	58,300	N		Early installation desirable to remove guesswork from demand management and loss assessment.
	Bonriki gallery management: Install new 150 mm electromagnetic meter on raw water line with remote indicator for accumulated and instantaneous flow. Provide replacements for all 22 mono-pumps and motors plus five spares, replace 22 water meters plus 5 spares and install Y strainers on meter lines and fit sampling point on the raw water	1	2012	98,500	N		The galleries are a fundamental part of the system and failure will jeopardise the water supply system. Early procurement of backup equipment and improvement are desirable at an early date.

	line. Downgrade Bonriki pumps to safe yield during refit of pumps. Constrain abstraction from Bonriki and Buota to aerator capacity of 25L/sec. Cost allows for contingencies.						
	Water treatment plant: upgrade aerator, install sampling point post-aerator and replace support framework. Install new chorine change over valve or convert to flow proportional calcium hypochlorite tablet feeders and change the chlorine dosing point to pre-reservoir. Convert chlorine cylinder room to dry storage area and supply two Palin brand 7100 photometers and chemicals for chlorine testing at (i) Bonriki and (ii) Betio. Replace existing 150 mm treated water meter with an electromagnetic meter with remote reading of accumulated and instantaneous flow. Cost allows for contingencies. (Appendix 6).	1	2012	140,800	N		Early improvement desirable to keep treatment plant operating efficiently and to guarantee safety of water supply. Upgrade of aerator needed for Bonriki and Buota supply plus Bonriki improvements.
	Betio re-chlorination unit: replace non-operative unit in short term with same brand equipment as Bonriki. Replace gas chlorinator with flow proportional calcium Hypochlorite tablet feeder. Modify storage facilities to provide safe and dry storage for calcium hypochlorite tablets. Cost allows for contingencies. (Appendix 6).	1	2012	9,900	N		As above
	Service reservoirs: flush and clean	2	2013	82,500	N		As above

	internally, repair leaks and make good structure damage/defects as prescribed for each reservoir. Provision of confined space safety equipment and development of competence based on training, plus cleaning equipment for reservoir and manhole work. Cost allows for contingencies. (Appendix 6).						
	Metering: installation of universal metering	3	2014/2017	1,086,000	N		Will follow and be contingent upon the management of leaks and the installation of the new water supply source (desalination) when the distribution networks are pressurised on a 24/7 basis.
WS3	TUNGARU CENTRAL HOSPITAL						
	Tungaru Central Hospital Improvements to water services, facilities and infrastructure. The improvements involve the reconstruction of tank storage and pump and water pipe replacement.	1	2012/2013	406,239	N	Some probable support from NZAP.	The required work is identified in a 2010 report by GWP Consultants (KAP II). KAP II provided high level water tank and stand during 2010/2011. The estimated costs have been updated. The hospital is important for the public health and welfare. The present situation presents an untenable position. It is important the hospital is fully operational in the advent of an endemic outbreak.

	TOTAL WATER SUPPLY (Including Tungaru Hospital)			**20,904,039**			
SS	**SANITATION**						
SS1	EXISTING SEWER SYSTEMS						
	Betio, Bairiki and Bikenibeu: rehabilitation of the existing sewer and saltwater flushing systems including the supply, installation and commissioning of saltwater pumps and in-line sewerage pumps, with pump controls, electrical switch boards and electricity meters.	1	2012/2015	12,933,000	Y	STSISP will rehabilitate the sewer systems, the saltwater flushing systems and reconstruct the existing ocean outfalls.	Implementation will commence during 3rd quarter of 2012. Includes a sustainable maintenance fund and provision for candidate sub-projects.
	Ocean Outfalls: upgrading of the existing ocean outfalls at Betio, Bairiki and Bikenibeu.	1	2012/2014	Included in above.	Y	As above	As above
	Milli-screens: for primary treatment of discharge at the Betio, Bairiki and Bikenibeu ocean outfalls, including disinfection dosing.	1	2013	Included in above.	Y	As above	As above
	Sewer Cleaning Equipment: one truck-mounted water jetting and vacuum sucking unit, one trailer-mounted water jetting unit, one truck and HIAB unit for screenings removal.	1	2012	Included in above.	Y	As above	As above
	Sludge Digester: provision of sludge digester, with mixing and dewatering unit and gas flare.	1	2013	Included in above.	Y	As above	As above

SS2	EXTENDED SEWER SERVICES						
	Planned extension: to existing sewer and saltwater flushing systems to service 100% of the Betio, Bairiki and Bikenibeu population within the service area.	1	2012/2020	4,679,550	N		No development partner commitment.
	Temaiku Model Subdivision: provision of offsite sewer infrastructure, comprising a rising main and the upgrading of the Tungaru Hospital outfall.	2	2012/2013	210,000	Y	NZAP	
SS3	ONSITE SANITATION OPTIONS						
	Design: of a sub- project for the piloting, and evaluation of suitable on-site sanitation options.	1	2011	18,000	Y	TA 7359-KIR has assisted MPWU with the design of the sub- project.	The on-site systems will play an important part in providing lower-cost sanitation until the density of development demands area systems with coordinated management and operation.
	Implementation: of pilot on-site sanitation systems, and monitoring of performance.	1	2012	350,000	Y	Will be considered as an early candidate sub-project under ADB STSISP.	Includes provision for monitoring and scientific evaluation and reporting of trials.
	Roll-out: of appropriate onsite sanitation options using MPWU sanitation guidelines.	1	2013 onwards	0	N/A		Will take place under national sanitation guidelines (MPWU). Funded by property owners.
SS4	TUNGARU CENTRAL HOSPITAL						

	Urgent upgrade and improvement of sanitation system and facilities, saline system, sanitary upgrade, wastewater treatment.	1	2013/2014	3,306,839	N		The requirements are identified in a report by GWP Consultants with estimated costs. The sanitation components and costs have been extracted and updated. The hospital is important for the public health and welfare. The present situation presents an untenable position. It is important the hospital is fully operational for normal needs and in the advent of an endemic outbreak.
SS5	SEWERAGE FOR REMAINDER OF SOUTH TARAWA						
	Extension of centralised sanitation systems implemented in a sequential manner to provide sanitation throughout South Tarawa.				N		Area sewer systems will become necessary as population densities become too intense and crowded for onsite systems to work effectively and guarantee public health. Priorities established from densification of urban settlements with staging of the improvements from the realisation that the financial commitments required are high and may present funding difficulties..
	Nanikai to Teaoraereke West.	3	2018	3,021,000	N		As above

	Bikenibeu East (Abarao to Temaiku foreshore).	3	2020	3,417,000	N		As above
	Bikenibeu West.	4	2023	4,010,000	N		As above
	Teaoraereke to Eita: Stage 1: Ambo to Taboria.	5	2025	3,907,000	N		Includes new outfall at Taboria. Estimate allows for engineering investigations and design, and an Environmental Impact Assessment.
	Teaoraereke to Eita: Stage 2: Ambo and Antebuka (west) and Taboria to central Eita (east).	5	2027	4,420,000	N		Extensions draining to central area and new outfall.
	Teaoraereke to Eita: Stage 3: Teaoraereke (east) and the bulk of Eita.	6	2029	4,750,000	N		Further extensions outwards from the central sections.
	Teaoraereke to Eita: Stage 4: The remaining section of Teaoraereke (west) and the remaining section of Eita (Tebikenikora).	6	2031	After 2030	N		Further extension outwards from the central section's after 2030 at an estimated cost of $2,435,000.
	TOTAL SANITATION			**45,022,389**			

Figure 7: Water and Sanitation Roadmap Implementation Schedule

Ref	Description	Year / Six Monthly	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
RI	**REGULATORY & INSTITUTIONAL**																					
RI1	REGULATORY FRAMEWORK																					
RI2	CAPACITY BUILDING																					
RI3	ASSET MANAGEMENT																					
RI4	COMMUNITY AWARENESS																					
WS	**WATER SUPPLY**																					
	PRIORITY ONE REQUIREMENTS																					
WS1	WATER RESOURCES																					
	North Tarawa freshwater resources																					
	Bonriki - Buota protect water reserves																					
	Bonriki selective clearing of palms																					
	Bonriki infill of old borrow pits																					
	Water Supply initial desalination																					
	Rainwater tanks to public buildings																					
	Rainwater tanks to households																					
WS2	WATER SUPPLY SYSTEM																					
	Transmission main: replacement																					

Ref	Description	Year	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		Six Monthly																				
	Leak detection program																					
	Network distribution modelling																					
	Bonriki gallery management																					
	Water treatment plant improvements																					
	Betio re-chlorination unit																					
WS3	TUNGARU CENTRAL HOSPITAL																					
	Water storage, pumps and pipes																					
	PRIORITY TWO REQUIREMENTS																					
WS2	WATER SUPPLY SYSTEM																					
	Demand management meters, etc																					
	Service reservoirs, cleaning & repairs																					
	Temaiku model urban subdivision, offsite water supply pipelines, reservoirs and systems																					
	PRIORITY THREE REQUIREMENTS																					
WS1	WATER RESOURCES																					
	Additional desalination units																					
WS2	WATER SUPPLY SYSTEM																					
	Universal metering																					

Ref	Description	Year / Six Monthly	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SS	**SANITATION**																					
	PRIORITY ONE REQUIREMENTS																					
SS1	EXISTING SEWER SYSTEMS																					
	Rehabilitation of existing systems																					
	Upgrading of Ocean outfalls																					
	Milliscreens for primary treatment																					
	cleaning equipment																					
	Sludge digester																					
	Extension within sewered areas for 100% coverage																					
SS3	ONSITE SANITATION OPTIONS																					
	Design of pilot sub-project																					
	Implementation of pilot sub-project																					
	Roll-out of appropriate onsite options																					
SS4	TUNGARU CENTRAL HOSPITAL																					
	Sanitation upgrades & improvement																					
	PRIORITY TWO REQUIREMENTS																					

Ref	Description	Year / Six Monthly	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SS2	EXTENDED SEWER SYSTEMS																					
	Temaiku offsite infrastructure																					
SS5	SOUTH TARAWA SYSTEMS																					
	PRIORITY THREE REQUIREMENTS																					
	Nanikai to Teaoraereke west																					
	Bikenibeu east (Abarao to Temaiku)																					
	PRIORITY FOUR REQUIREMENTS																					
	Bikenibeu west																					
	PRIORITY FIVE REQUIREMENTS																					
	Ambo to Taboria																					
	Ambo and Antebuka, Taboria to Eita																					
	PRIORITY SIX REQUIREMENTS																					
	Teaoraereke east and Eita																					
	Teaoraereke and Eita (remainder)																					

Table 36: Summarized Investment Plan – Infrastructure items ($000 rounded)

Ref	Description	Year									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
WS	**WATER SUPPLY**										
	PRIORITY ONE REQUIREMENTS										
WS1	WATER RESOURCES										
	North Tarawa Freshwater Resources		*210*	*210*							
	Reconnect Buota		*37*								
	Protect Buota and Bonriki		*80*	*60*	*60*						
	Bonriki selective clearing of palms		272								
	Bonriki clearing and filling of borrow pits/ponds			2,500							
	Water supply install initial desalination			1,244	7,240						
	Rainwater tanks to public buildings		*150*	*150*	*150*						
	Rainwater tanks to households			*50*	*50*	*50*					
WS2	WATER SUPPLY SYSTEM										
	Transmission line replacement		*527*	*527*							
	Leak detection program		*260*	*200*	*200*	*200*					
	Network distribution modeling			66							
	Bonriki gallery management		98.5								
	Water treatment plant improvements		141								
	Betio re-chlorination unit replacement		10								
WS3	TUNGARU CENTRAL HOSPITAL		406								
	PRIORITY TWO REQUIREMENTS										
WS2	WATER SUPPLY SYSTEM										
	Demand management, meters/pressure gauges		58								
	Service reservoirs, cleaning and repairs		*0*	82.5							
	Temaiku offsite infrastructure		*520*								
	PRIORITY THREE REQUIREMENTS										
WS1	WATER RESOURCES										
	Additional desalination units 2020									210	3,800
WS2	WATER SUPPLY SYSTEM										
	Universal metering				250	300	300	236			
	SUB_TOTAL		2,769.5	5,089.5	7,950	550	300	236	0	210	3,800
	TOTAL WATER SUPPLY										**20,905**
	FUNDS COMMITTED		***1,784***	***1,197***	***460***	***250***	***0***	***0***	***0***	***0***	***3,691***

Table 36 (Continued)

Ref	Description	Year										
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021-31
SS	**SANITATION**											
	PRIORITY ONE REQUIREMENTS											
SS1	EXISTING SEWER SYSTEMS											
	Rehabilitation of existing systems		*1,453*	*2,180*	*2,180*	*1,375*						
	Upgrading of ocean outfalls		*980*	*1,938*	*968*							
	Milliscreens, equipment, sludge digesters			*1,192*								
	Sewer cleaning equipment		*667*									
SS2	EXTENDED SEWER SYSTEMS											
	Extension within sewered areas for 100% coverage		520	520	520	520	520	520	520	520	520	
SS3	ON-SITE SANITATION PILOT PROJECT											
	Design of pilot sub-project	*18*										
	Implementation and monitoring of pilot sub-project		*200*	*120*	*30*							
	Roll-out of appropriate onsite sanitation				*NC*	*NC*	*NC*	*NC*	*NC*	*NC*	*NC*	*NC*
SS4	TUNGARU CENTRAL HOSPITAL			1,653	1,653							
	PRIORITY TWO REQUIREMENTS											
SS2	EXTENDED SEWER SYSTEMS											
	Temaiku offsite infrastructure		*210*									
SS5	EXTENDED SOUTH TARAWA SYSTEMS											
	PRIORITY THREE REQUIREMENTS											
	Nanikai to Teaoraereke West								3,021			
	Bikenibeu East (Abarao to Temaiku)										3,417	
	PRIORITY FOUR REQUIREMENTS											
	Bikenibeu West - 2023											4,010
	PRIORITY FIVE REQUIREMENTS											
	Ambo to Taboria - 2025											3,907
	Ambo & Antebuka, Taboria to Eita - 2027											4,420
	PRIORITY SIX REQUIREMENTS											
	Teaoraereke East and Eita - 2029											4,750
	Teaoraereke and Eita (remainder) - 2031											
	SUB-TOTAL	**18**	**4,030**	**7,603**	**5,351**	**1,895**	**520**	**520**	**3,541**	**520**	**3,937**	**17,087**
	TOTAL SANITATION											**45,022**
	FUNDS COMMITTED	***18***	***3,510***	***5,430***	***3,178***	***1,375***	***0***	***0***	***0***	***0***	***0***	***13,511***

52 Maintenance and Operations

52.1 Background

388. Inadequate revenues and cash resources have led to poor maintenance of the water supply and sanitation infrastructure for many years with a declining standard of services and failing infrastructure. The cycle of declining services and increasingly poor infrastructure has brought the situation to the point where, in the face of a complete collapse of services, capital to rehabilitate the infrastructure is being committed well in advance normally expected useful life of the infrastructure.

389. Many PUB customers have signalled their discontent with the current quality of PUB's water service by electing not to pay their monthly bills. They are conscious of the difference between functioning pre-paid telecommunication and transport services and PUB's current very poor performing water service, paid on an arrears basis. On balance there is reasonable willingness to make additional payments for water services amongst South Tarawa households providing PUB's water services are maintained at acceptable levels.

52.2 Apportionment of Costs to Water Supply and Sanitation

390. PUB's past accounts do not provide an accurate breakdown of the total costs for providing water supply and sanitation and there has in the past been a considerable element of cross-subsidy from the electricity activities to water supply and sanitation. Power consumption for operating the water supply and sewerage pumps has not been recorded or costed in the accounts. Similarly shared operations and maintenance, staffing and administration functions have not been apportioned between the cost centres. While steps are being taken to define separate cost centres for water and sanitation it will take time for the costs to be correctly aligned. Early assessment of electricity usage based on pump capacities makes assumptions of actual working loads and hours of operation. The improvements identified in this roadmap therefore allows for the installation of electricity meters on all pumps and electrical equipment.

52.3 Operations and Maintenance and Capital Expenditure

391. PUB has been, and continues to be constrained by its weak financial position for the purchase of essential spare parts and materials for the maintenance of plant, equipment and infrastructure which to date has not been carried out to a level sufficient to maintain the assets for the full duration of their useful economic life. All capital expenditure for the replacement of equipment and upgrading has been reliant on donor funding. As indicated throughout this roadmap this has lead to deteriorating assets, unreliable services, default on the part of customers and a spiralling downwards cycle of infrastructure and service failure. In its current position PUB needs continuing government and development partner support to maintain its operations.

52.4 Opportunities for Out-Sourcing

392. PUB carries a large staff complement for the size of its operations. It has tended to be viewed by government and past administrations as an employer of people rather than a lean and focused utility operator. An example of this is the very high number of administration staff (62 out of a total staff of 162 representing 37% of total staff numbers) and their costs (30% of PUB's total budget) as fixed overheads eat away at the profitability of PUB's activities. Improved computer systems and programs with linked billing, transaction accounting and consolidated financial and management reporting will allow PUB to function both smarter and more efficiently with a much reduced administrative and non-productive operating costs. These changes should be a goal over the immediate two years as PUB

reshapes itself for the future with the challenges of a much increased ad technically advanced infrastructure.

393. With utility operations any activity which can be specified and to which a performance requirement and terms of payment can be placed can potentially be contracted out to the private sector. This has distinct advantages for the utility operator in that the services are only employed for the task required on the basis of a defined need, and for the time of this need. While the contracted costs have a higher rate that direct employment of staff, the utility operator can avoid the non-productive costs that came from holding staff in readiness for work that, while vital to the operations, may not be continuous. The overheads, social and employment costs incurred by the employment of the staff are also negated. Most efficient utility operators constrain core staff numbers and develop flexible contract arrangements for many of their activities. The opportunities are many and for PUB the following amongst other activities could be considered as potential opportunities for out-sourcing:

a) Financial and Administration

- billing
- IT support
- debtors recovery
- auditing

b) Operations

- meter reading (electrical and later water supply)
- leak detection programs and monitoring
- routing network inspections and work programming
- valve inspection and maintenance
- hydrant inspection, checking and maintenance
- manhole sections, checking and maintenance
- pump and pump controls inspection and routine testing
- pump cleaning insitu (water blasting), checking, testing and replacement of anodes
- pump servicing, maintenance and repairs
- water quality monitoring and testing
- servicing, maintenance and repairs of plant, equipment and vehicles

394. There will be other activities that can be added to this list. For government and largely uncontested SOE activities which retain a government service ethos and related employment attitudes around 80% of costs can be salary, wages and employment cost related including offices, works buildings, transport and aspects of the operations driven by employment conditions and staff numbers. These costs are unproductive in terms of the core business of the organisation and the challenge is to reduce the costs to the lowest sustainable level. The process for review should look at each budget item for operations and maintenance de novo and:

- Determine the core business of PUB and the areas where it can compete effectively.
- Establish whether PUB should, or needs to undertake a particular activity for its core business. If not then discard the activity and its costs.
- Decide whether PUB MUST handle the task/activity directly, or whether the task could be handled external to PUB.
- Review the costs for the activity assessing the full costs of holding staff and equipment within PUB for the purpose against the comparative costs of out-sourcing the task and engaging a private sector provider for the time and effort of the task only.

395. The private sector capacity in South Tarawa is presently limited and will require effort on PUB's part to foster and develop a range of small private sector contractors for

competitive response to its contractual requirements. The effort will however be worthwhile as it will provide PUB with choice and a flexible operating environment which will allow it to focus of the operations and maintenance of its systems and service to its customer as opposed to the “employment of personnel”. It will also foster employment opportunities and help build a more resilient local economy and private sector capacity. There will also be the opportunity to assist the employed staff to set up as independent contractors, contracting their services on an as required basis to PUB and others.

52.5 Operations of Desalination (SWRO) Plants

396. In section 40, paragraph 262, reference is made to the importance surrounding procurement processes that will ensure the supply of “best” desalination plants and the arrangements for their operation to guarantee at least 10 years or longer operating life. There are options for this in the form of:

- Contracted maintenance to the manufacturer/supplier similar to the arrangements that have applied in the case of the Bikenibeu generating plant – but with a sovereign guarantee of payment.
- Build, Own, Operate, Lease, Transfer arrangements.
- Build, Own, Operate and Maintain arrangements.

397. The first option contemplates PUB operating the plants with Government/PUB entering into a renewable long-term contract with the manufacturer/supplier of the plants for regular inspection and all routine and planned maintenance, including allowances for chemicals, spare parts and renewal of components and membranes on a scheduled basis. To ensure a lasting arrangement and continuation of the maintenance activities a guaranteed form of payment to the operator will be required.

398. The second option contemplates an arrangement where Government would invite a proposal from a suitable company to build, own and operate the plants under a lease arrangement from government. The lease would be for the period of the payback to the company of the original investment and would allow a margin, or return to the company from the water produced. At the end of this period the operating and maintained plants would be transferred to the Government/PUB. The option of engaging the company for a further period under a management contract could also be considered.

399. The third option provides for circumstances where Government/PUB invites a company to supply, operate, manage and maintain the plants with PUB purchasing the desalinated water on a “take or pay” basis, which would remove the operation and maintenance risks. This arrangement could also provide for increased production capacity under predetermined and agreed circumstances with the company investing in the capital costs of the extended production. The option has merit in that it removes the risks from Government/PUB, and provides for future increase in capacity but obviously will have implications of a higher cost of water.

400. The detailed feasibility study of the desalination option will need to measure and cost all options for the operation and maintenance of the desalination plants, and outline the contractual conditions and obligations of each for Government, PUB and the operator.

52.6 Assessment of Operations and Maintenance Requirements

401. The estimation of Operations and Maintenance needs and costs has presented some difficulty as information on the assets has been confounded by the state of PUB’s asset register which retains old and failed assets and aggregated assets as rather meaningless line items. The asset register needs to be purged to identify those assets which are currently employed and of value to PUB’s operations to allow O&M estimates to be prepared.

402. The financial analysis for STSISP considered the annual O&M costs for the existing sewerage services to the urban areas of Betio, Bairiki and Bikenibeu, assessing the present annual costs at $730,240, without depreciation or debt servicing. Based upon the present sewer connections, rounded out to 2000 this represents an average annual cost of the order of $365 per connection per year or $30 per month.

403. The proposed area sewer systems proposed under the roadmap for the presently unsewered areas of South Tarawa will be constructed or come into operation after 2020. The O&M cost of each area scheme has been estimated and is indicated in Table 37. The costs are lower than for the existing sewer systems in Betio, Bairiki and Bikenibu due to the lineal nature and simpler layout of the systems, and the adoption of a common rising main to reduce the size of the gravity reticulation and the pumping requirements and associated costs.

Table 37: Extended Sanitation Area Systems, O&M Costs

Area System	O&M	Ha	HH	Pop	$/HH	$/mth
Nanikai - Teaoraereke	126,775	24.78	466	3,692	272.05	22.67
Bikenibeu West	111,012	34.61	1,100	7,517	100.92	8.41
Bikenibeu East	139,522	52.73	1,350	9,603	103.35	8.61
Ambo – Taborio East	99,935	22.52	505	3,132	197.89	16.49
Banraeaba – Taborio East	151,117	71.34	1,500	9,568	100.74	8.40
Antebuka – Eita West	151,585	73.33	1,648	11,143	91.98	7.67
Teaoraereke West – Eita East	102,516	37.53	1,205	8,592	85.08	7.09
Average						**11.33**

404. In the course of developing this roadmap further information on PUB's operations and related costs have been established. Choices have also been identified for future water sources and the eventual provision of sewerage for South Tarawa. This has enabled more appropriate O&M costs to be captured. Spread sheets presenting these costs are incorporated as Figure 8 Water Supply O&M Costs and Figure 9 Sanitation O&M Costs. The information is aligned with the initial financial assessment for STSISP and the initial draft Asset Management Plan (AMP) for PUB prepared by TA 7359-KIR. The spread sheets cover the period between 2010 and 2020 to match the period of the AMP. The water supply costs incorporate the maintenance and operations of the proposed banks (4) of desalination (SWRO) units.

52.7 Updated O&M Costs

405. The update O&M costs have been developed on the following basis:

Water Supply

1. Domestic revenue from 2015 onwards following the installation of the desalination units is based on increasing the real cost of water from $2/m^3$ to $3/m^3$ from 2015 to 2020, and increasing recovery from 50% to 60% of the costs in the same period.
2. Similarly the cost of water to industry, commerce and institutional organisations is increased from $2/m^3$ to $3/m^3$ in the same period with recovery increasing from 80% to 90% by 2020.
3. A government subsidy or a combination of government support and a sustainable maintenance fund supported by development partners) of between 50% and 60% will be required from the present time to 2015. From this point on the sustainable maintenance fund will gradually reduce as the system operates efficiently and

customer support is re-established. The take-up of PUB water will also grow as other options are limited and the fact that PUB supplies should be of higher quality and reliability. These levels of initial subsidy are indicated by the assessment of the constraints and political realities of fees and charges undertaken by TA 7359-KIR and reported in summary in the following section 53: Fees and Charges – Sustainability.

4. The provision for water sold for industrial, commercial and institutional use is based on the 6L/person/day allowance for these activities.
5. Other provisions allow electricity costs using PUB estimates of usage, and for the operations and maintenance of the proposed four banks of desalination units. The costs for each bank were developed by TA 7359-KIR and cross-check independently with a leading manufacturer of such units. The independent costing from the company concerned is incorporated in Volume 2 as Appendix 10.
6. Population and household formation and growth has adopted the high growth (most probable) scenario of the urban growth and development analysis conducted by TA 7359-KIR.

Sanitation

1. The connection fee has taken the existing provision in PUB's accounts and increased this in line with expected inflation. With the extension of the systems to service 100% of the population this allocation could increase significantly.
2. Domestic revenue provides for the introduction of a pan charge from 2013 onwards with an initial increase from $20 to $60 per annum and thereafter smaller annual increases.
3. Non-domestic pan charges again with an introduction in 2013 and adjustment by 2015 to the full cost identified by the financial analysis conducted for TA7359-KIR. Thereafter small annual adjustment in line for expected escalation of costs.
4. Pumping and electrical costs as estimated by the pump manufacturers and suppliers.
5. O&M subsidy from a combination of government funds and the SMF decreasing over the period from 100% to around 50% of the costs. This is in line with the findings of the study under TA 7359-KIR of the constricts and political realities for cost recovery through fees and charges.
6. The costs relate to the existing sewer systems and have assumed the base populations of Betio, Bairiki and Bikenibeu and the anticipated growth and household formation from the TA 7359-KIR analysis of urban growth and development. The population served is increased from present levels to 100% of the population and households by 2020 as provided for in the roadmap.
7. Pan charges have been established using the recommendations of the financial analysis of the sanitation sector conducted by TA 7359-KIR. The full costs are applied to the non-domestic connections (pans) while a much reduced figure is used for the residential charge.

Figure 8: Water Supply Operation and Maintenance Costs

Item	Description			Year 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	**REVENUE**												
1.1	Water sales - domestic[1]			337,668	347,798	358,232	368,979	992,203	1,085,742	1,335,432	1,592,959	1,730,985	1,870,821
1.2	Water Sales - Industrial/commercial[2]			175,223	180,480	185,894	191,471	213,532	243,975	276,455	330,526	369,726	435,669
1.3	Sundry sales - water delivery			17,000	17,510	18,035	18,576	19,134	19,708	20,299	20,908	21,535	22,181
1.4	Other revenue			12,646	13,026	13,416	13,819	14,234	14,660	15,100	15,553	16,020	16,501
	Total Income			**542,537**	**558,814**	**575,577**	**592,845**	**1,239,102**	**1,364,085**	**1,647,286**	**1,959,945**	**2,138,266**	**2,345,172**
2	**EXPENDITURE - O&M**												
2.1	Management and administration			120,240	123,847	127,563	131,389	135,331	139,391	143,573	147,880	152,316	156,886
2.1	Pumping and electrical			530,283	546,191	562,577	579,454	596,838	614,743	633,185	652,181	671,746	691,899
2.3	Staff and labour			301,858	310,914	320,241	329,848	339,744	349,936	360,434	371,247	382,385	393,856
2.4	Staff social and related costs			84,766	87,309	89,928	102,626	105,705	108,876	112,142	116,507	118,972	122,541
2.5	Repairs			131,491	135,436	139,499	173,684	178,894	219,261	225,839	232,614	239,593	246,780
2.6	Plant and equipment			33,146	34,140	35,165	36,220	37,306	38,425	39,578	40,765	41,988	43,248
2.7	Desalination (SWRO) O&M			0	0	0	0	1,853,648	1,872,934	1,892,429	1,912,133	1,932,051	1,952,183
	Total Expenditure - O&M			**1,201,784**	**1,237,837**	**1,274,973**	**1,353,221**	**3,247,466**	**3,343,566**	**3,407,180**	**3,473,327**	**3,539,051**	**3,607,393**
	Deficit - Expenditure less revenue			659,247	679,023	699,396	760,376	2,008,364	1,979,482	1,759,894	1,513,382	1,400,785	1,262,221
	Goverment subsidy/SMF %[3]			55	55	55	56	62	59	52	44	40	35
3	**DESALINATION (SWRO) O&M COSTS**												
3.1	Electricity costs							1,006,000	1,016,060	1,026,221	1,036,483	1,046,848	1,057,316
3.2	VWS service labour costs							443,064	447,495	451,970	456,489	461,054	465,665
3.3	Chemicals							24,584	24,830	25,078	25,329	25,582	25,838
3.4	Annual allowance for membrane replacement							45,000	45,450	45,905	46,364	46,827	47,295
3.5	Miscellaneous spare parts							260,000	262,600	265,226	267,878	270,557	273,263
3.6	PUB technicians and labour							75,000	76,500	78,030	79,591	81,182	82,806
	Total Desalination O&M							**1,853,648**	**1,872,934**	**1,892,429**	**1,912,133**	**1,932,051**	**1,952,183**
4	**POPULATION AND HOUSEHOLDS SERVED**												
4.1	Population Increase	3.87%	50,402	52,353	54,379	56,483	58,669	60,939	63,298	65,747	68,292	70,935	73,680
4.2	Household Increase		6,720	6,980	7,250	7,531	7,823	8,125	8,440	8,766	9,106	9,458	9,824
4.3	Average Occupancy		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
4.4	Percent Population served	%	58%	55%	55%	63%	63%	100%	100%	100%	100%	100%	100%
4.5	Population Served			28,794	29,908	35,584	36,961	60,939	63,298	65,747	68,292	70,935	73,680
4.6	Households Served		3,900	3,839	3,988	4,745	4,928	8,125	8,440	8,766	9,106	9,458	9,824
5	**WATER PRODUCED**												
5.1	Production Supply Capacity	m^3/d		2,010	2,010	2,010	2,010	4,112	4,112	4,112	4,112	4,112	4,112
5.2	Total Available Production	m^3/y		733,650	733,650	733,650	733,650	1,500,880	1,500,880	1,500,880	1,500,880	1,500,880	1,500,880
5.3	Percent Loss			67%	50%	40%	25%	25%	25%	23%	22%	21%	20%
5.4	Unaccounted for Water	m^3/y		491,546	366,825	293,460	183,413	375,220	375,220	345,202	330,194	315,185	300,176
5.5	Water availble for consumption	m^3/y		242,105	366,825	440,190	550,238	1,125,660	1,125,660	1,155,678	1,170,686	1,185,695	1,200,704
5.6	Water Sold	m^3/y		242,105	366,825	440,190	550,238	1,125,660	1,125,660	1,155,678	1,170,686	1,185,695	1,200,704
5.7	Daily Domestic Consumption	l/c.d		15	25	34	41	51	49	48	47	46	45
5.8	Total All Average Day	l/c.d		23	35	40	42	83	51	50	49	48	46
	TOTAL WATER USE	**m^3/y**		**733,650**	**733,650**	**733,650**	**733,650**	**1,500,880**	**1,500,880**	**1,500,880**	**1,500,880**	**1,500,880**	**1,500,880**
6	**WATER SOLD**	**m^3/y**											
6.1	Domestic	l/popn/d		179,046	301,326	362,260	469,292	992,203	987,038	1,011,691	1,021,127	1,030,348	1,039,345
6.2	Institutional[4]	3.00		31,529	32,750	38,965	40,473	66,729	69,311	71,993	74,780	77,674	80,680
6.3	Industrial/Commercial[4]	3.00		31,529	32,750	38,965	40,473	66,729	69,311	71,993	74,780	77,674	80,680
	TOTAL WATER SOLD			**242,105**	**366,825**	**440,190**	**550,238**	**1,125,660**	**1,125,660**	**1,155,678**	**1,170,686**	**1,185,695**	**1,200,704**

Figure 9: Sanitation Operation and Maintenance Costs

Item	Description			Year									
				2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	**REVENUE**												
1.1	Connection fee - sewerage[1]			4,500	4,725	4,961	5,209	5,470	8,205	8,615	9,046	9,498	9,973
1.2	Other revenue			9,000	9,450	9,923	10,419	10,940	16,409	17,230	18,091	9,498	9,973
1.3	Domestic pan charge[2]			0	0	54,248	121,958	204,448	231,598	253,283	279,814	305,665	337,133
1.4	Non-domestic pan charge[3]			0	0	55,379	114,081	176,255	186,989	198,376	210,457	223,274	236,872
	Total Income			**13,500**	**14,175**	**124,511**	**251,667**	**397,113**	**443,200**	**477,505**	**517,408**	**547,935**	**593,950**
2	**EXPENDITURE - O&M**												
2.1	Management and administration			120,240	123,847	127,563	131,389	135,331	139,391	143,573	147,880	152,316	156,886
2.1	Pumping and electrical[4]			91,827	94,582	97,419	127,169	130,984	134,914	138,961	143,130	147,424	151,846
2.3	Staff and labour			245,226	247,583	250,010	257,511	265,236	273,193	281,389	289,830	298,525	307,481
2.4	Staff social and related costs			71,149	73,283	75,482	77,746	80,079	82,481	84,956	87,504	90,129	92,833
2.5	Repairs			125,414	129,176	133,052	137,043	141,155	190,389	196,101	201,984	208,043	214,285
2.6	Plant and equipment			21,415	30,057	30,959	31,888	32,845	33,830	34,845	35,890	36,969	38,076
2.7	Miscellaneous and other			55,069	56,721	58,423	60,175	61,981	63,840	65,755	67,728	69,760	71,853
2.8	Desalination (SWRO) O&M												
	Total Expenditure - O&M			**730,340**	**755,249**	**772,908**	**822,921**	**847,611**	**918,038**	**945,580**	**973,946**	**1,003,166**	**1,033,260**
	Deficit - Expenditure less revenue			716,840	741,074	648,397	571,255	450,498	474,838	468,076	456,537	455,231	439,309
	Goverment subsidy/SMF %[5]			98	98	84	69	53	52	50	47	45	43
4	**POPULATION AND GROWTH**												
4.1	Population Betio, Bairiki and Bikenibeu	3.87%	24,867	25,829	26,829	27,867	28,946	30,066	31,229	32,438	33,693	34,997	36,352
4.2	Households Betio, Bairiki and Bikenibeu		3,316	3,444	3,577	3,716	3,859	4,009	4,164	4,325	4,492	4,666	4,847
4.3	Average Occupancy		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
4.4	Percent Population served[6]	%	55%	60%	67%	73%	79%	85%	90%	92%	95%	97%	100%
4.5	Population Served		13,677	15,498	17,975	20,343	22,867	25,556	28,106	29,843	32,009	33,947	36,352
4.6	Households Served (potential 2010)		1,824	2,066	2,397	2,712	3,049	3,407	3,748	3,979	4,268	4,526	4,847
5	**NUMBER OF TOILET PANS**												
5.1	Domestic	No.		2,066	2,397	2,712	3,049	3,407	3,748	3,979	4,268	4,526	4,847
5.2	Non-Domestic	No.		435	448	461	475	490	504	519	535	551	568
5.3	**Total**			2,501	2,845	3,174	3,524	3,897	4,252	4,498	4,803	5,077	5,414
6	**PAN CHARGE**												
6.1	**Domestic**[7]	$/yr		0	0	20	40	60	62	64	66	68	70
6.2	Non-Domestic[7]	$/yr		0	0	120	240	360	371	382	393	405	417

53 Fees and Charges - Sustainability

53.1 Introduction

406. The statements in this section summarize the findings of the additional study conducted under TA 7359-KIR relating to the Political Economy of Water and Sewerage Tariff Reform in South Tarawa. The study was conducted between October and November 2011.

407. The provision of water and sewerage services in South Tarawa has been heavily dependent on government subsidies for a prolonged period. Water service operating losses were approximately $513,000 in 2010. Annual government subsidies for sewerage services currently amount to $480,000 in 2010, funding a significant part of the annual budgeted sewerage operating costs. Weaknesses in cost allocation have resulted in budgeted water and sewerage operating costs being understated with costs for electricity being bundled into the electricity operations and not separated for water supply and sanitation which are both heavily dependent upon pumping and electrical equipment.

408. A small section of non-domestic customer supplies are metered. Domestic water supply is not metered. The tariff structure for non-metered domestic and non-domestic customers comprises a $10 monthly fixed user charge. The PUB achieved revenue collection rates in 2010 of 84.5%% and 70% for domestic and non-domestic customers respectively (inclusive of arrears). No sewerage tariffs have been promulgated to date.

53.2 Poor Revenue Management

409. PUB has consistently incurred operating deficits, after allowing for government subsidies, since at least 2004. As a result PUB has experienced a continual run down in its cash resources and a steady increase in its overdraft. The inevitable resulting cash crisis finally arose earlier in 2011.

410. PUB's water tariffs have not been revised for some time. The SAPHE project's recommended sewerage tariff was never implemented. Poor billing and collection activities in recent years has meant that many of PUB's customers have responded by failing to make the necessary payments for water and electricity services provided. Water (and electricity) service delivery have been compromised by the PUB Board's weak supervision of revenue management.

411. PUB's domestic customers, who generally have a good understanding about paying for utility services through regular usage of pre-paid telecommunication and transport services, have responded to the decline in service delivery standards by withholding their payments, without incurring any service delivery penalties. Customer payment levels have also been influenced to some degree by a historical belief on the part of some customers that PUB water services should be free in view of the Kiribati government's earlier practices of not imposing charges for a range of public services.

53.3 Cultural and Social Impacts

412. A sizeable proportion of older Kiribati adults view PUB as an extension of government and consider government is directly responsible for the delivery of water services. As the Kiribati government in previous years provided a range of services free of charge, some PUB customers continue to believe that water and sanitation should also be provided free and these customers have not paid their water charges. Non-paying water customers have not been penalised through service reductions due to PUB's weak revenue management.

413. The present perception in some sections of the community that water should not be priced is not surprising in view of PUB's lack of transparency. The increasing youthfulness of the Kiribati population, who use pre-paid utility services, may well lead to a

gradual change in perceptions about the pricing of government services and could be built upon for the future.

414. Kiribati is a highly egalitarian society. There is a belief that all individuals should be treated equally. This view poses major challenges for future tariff reform. One stakeholder noted that the incidence of illegal domestic water connections could be viewed in an egalitarian context where those domestic customers without access to a regular water supply should, nevertheless, be able to secure access via an illegal water connection. The non-payment of domestic water charges could also be viewed in a similar manner where some customers know of others who do not pay their water charges and then elect not to make payments to PUB.

415. Reciprocity is an important aspect of Pacific Island culture. This practice, known as "bubuti" in Kiribati, is known to take place in the context of water service delivery through PUB staff facilitating illegal water connections for people with whom they have some connection. It could also result in user charges being waived.

416. Kiribati people are described as very conservative. Considerable public consultation will be required if changes are proposed to current monthly domestic water tariffs and service delivery arrangements. Proposed changes would have to be supported by demonstrable community benefits to gain public support.

53.4 Community Attitudes to Present Water Services

417. Consultations were held under TA 739-KIR with a range of stakeholders to gain an understanding of community attitudes towards current water and sewerage service delivery outcomes. The stakeholders included accommodation providers, business services, church representatives, government ministries, local government officials and members of the public.

418. The overwhelming theme arising from the consultations was a high level of dissatisfaction with the quality of the present level of services provided by PUB. Many people consider PUB is poorly managed. Dissatisfaction with water services results in some users leaving their taps on continuously to receive whatever water is provided. It was reported that there is considerable discussion in community forums about PUB's present poor performance.

419. Some stakeholders suggested there is modest community understanding as to the rationale for making payments to PUB for water. Perceptions about water resources were reported to vary in the community with some people believing there is plenty of water.

420. Community dissatisfaction with current water services in South Tarawa results in many domestic customers electing not to regularly pay their monthly water charges. No penalty is incurred in the event of non-payment of water charges.

421. Domestic customers expressed some willingness to pay a higher overall tariff for improved water and sewerage services but this support is heavily linked to satisfaction with the nature and quality of the service provided.

53.5 Household Ability to Pay for Utility Services

422. No formal quantitative data is available to provide a basis for an informed assessment of the distribution of ability to pay for utility services in South Tarawa.

423. The sole robust data on the distribution of ability to pay in Kiribati is the 2006 Household Income and Expenditure Survey (HIES). This survey covered 330 households in South Tarawa. Electricity and telephone expenditure is included in the "Expenditure on household operations" category. The HIES report provides no disaggregated data across the major urban areas of South Tarawa due to the small sample size used.

424. The HIES results were later used by UNDP in 2010 to prepare estimates of the national food and basic needs poverty lines for three regions of Kiribati, including South Tarawa. The latter poverty assessment calculated basic needs poverty on South Tarawa at 18.3% of households, and 24.2% of the population (the highest in Kiribati). The poverty assessment suggests that it is likely that the lowest 30% of households in terms of income and expenditure will have difficulty in promptly paying utility charges provided on credit and billed on an arrears basis in view of their very limited ability to pay.

425. The intention of the roadmap has been to cover the question of the "offsite" infrastructure. Although mention is made of the intention to extend water supplies and sanitation to 100% of households it should be noted that this may occur in a variety of ways; through communal and/or public toilets, water tanker supply and communal standpipes and water kiosks, which will only require the householders on limited incomes to either pay a small amount upfront, or payment of minimal charges related to direct use. Paragraph 348 has already alluded to the arrangements for management and maintenance with the possibility of PUB having responsibility for the communal toilets and standpipes/water kiosks with the management and cleaning being contracted to the private sector or community/church groups, and charges fir use being minimal and related to the cost of management and cleaning only.

53.6 Ability to Pay – Prepaid Services

426. South Tarawa residents do make payments for utility services that are provided as private goods in economic terms and payments are made on a pre-paid basis with the result that customers are prevented from using services if they do not pay the respective user charges. The supply of pre-paid utility services, where no collection difficulties are incurred, has increased in recent years with the establishment of internet café services and prepaid telephone services. Users of the Nippon Causeway generally pay for the use of this service although it is possible that a negligible amount of waiving of charges to related users may arise. As the toll booth is located at the Betio end of the causeway, one could argue that users travelling from Bairiki to Betio pay on an arrears basis. Users of mini-bus services have traditionally paid for these services.

427. The above-mentioned pre-paid services all differ from the provision of current water services in one major respect in that they are provided effectively as outlined by the respective service providers.

428. No distributional data in respect of pre-paid utility services was sighted. Households with very limited ability to pay would find some money to pay for urgently required pre-paid services when the need arose.

429. There is growing consumerism in Kiribati. It was reported that some young people on South Tarawa no longer wish to drink well water and would rather use better quality water available at retail outlets. People will therefore make spending decisions linked to the relative level of service.

53.7 Assessment of Situation

430. Improved revenue management by PUB for water (and electricity) services could provide some marginal improvement in overall collection revenue rates for both services in the short term in spite of prevailing ability to pay trends.

431. A conservative assessment of ability to pay trends suggests, however, that 20% to 30% of households on South Tarawa are likely to have limited ability to pay for utility services in the foreseeable future.

432. Poor service delivery rather than ability to pay considerations is the major cause of current weak collection levels for water services. The community can easily distinguish the

difference in service levels between those of PUB's water services and other pre-paid utility services currently provided in South Tarawa.

433. The achievement of a material increase in water revenues from current levels and gaining of community support for the introduction of a new sewerage user charge is strongly linked to the provision of sustainable improvements in water and sewerage services. In view of PUB's poor water services over recent years, the South Tarawa community will be cautious in committing to making additional payments for water-related services until they are convinced that the service levels are satisfactory and are being sustained. There is little prospect of a material increases in domestic water revenue collection rates until PUB's revenue management practices improve and a material improvement has been achieved in the quality of water services provided on South Tarawa.

434. The increasing youthfulness of the population, sensitized to user charges for telecommunication services, may help to progressively offset the long-held view of many older members of the population that government services should be free.

53.8 Lessons Learned

435. The major technical assistance provided to PUB since 2000 was undertaken during the ADB's Sanitation Public Health and Environment Improvement (SAPHE) Project between 2000 and 2002.

436. The SAPHE project did not facilitate the achievement of all the intended gains in PUB's financial governance. The prevailing corporate governance environment in Kiribati did not provide material support for sustaining the restructuring activities undertaken at PUB. Scheduled improvements in asset management, financial management and planning were not totally achieved as a robust foundation on which to build these improvements did not exist during the project and the supporting TA was not provided over a sufficiently long enough term. This also resulted in planned gains in service and efficiency levels not being achieved. Local monitoring of the project was poor.

437. It is evident that local social, cultural and political influences were not given sufficient weighting in the design of the SAPHE project. Local impediments to the implementation of the project could not be fully addressed. A more integrated approach was required in the design of the project.

438. Obtaining material improvements in the financial governance and service delivery capability of a utility is going to take a considerable period of time when the overall capacity level is relatively low at the commencement and during the duration of a program of this nature. The proposed term of the project must be realistic and an integrated approach must be adopted. This has been recognised and provided for in the design of STSISP.

53.9 Considerations of Public Good

439. The present poor public health statistics resulting partially from the current unsatisfactory nature of water and sewerage services demonstrates that there will be a significant public good component in sewerage services when these become effective again and to a lesser degree in improved water services because of the community benefits or externalities arising from the provision of these upgraded services. This feature lends support for at least a partial government subsidy to be used to assist the long-term funding of water services.

53.10 Cross Subsidies

440. Given the need to boost private sector development in Kiribati and the already high cost of utility services in Kiribati, business owners should not be asked to make any cross-subsidy to water and sewerage services provided to domestic customers, particularly low-

income households, but they should nevertheless pay the full cost of their respective services.

53.11 Introduction of Sewerage Tariff

441. Stakeholder consultations suggest there is some support in the community for partial contributions to the cost of domestic sewerage services, subject to the provision of a satisfactory service.

442. The introduction of a partial sewerage tariff should occur in parallel with the proposed sewerage upgrading program.

53.12 Ability to Pay Considerations

443. Ability to pay constraints will continue to impact on water services revenues for some years, certainly at least for the medium term.

444. The results of the 2010 poverty study and the recent PUB electricity segmentation study suggest that planning on a cost recovery level of more than 80% for domestic water supply in the medium to long term is unrealistic with an expanded cost base. In the short to medium term water cost recovery targets for use in modelling the supporting financial projections of 80% and 60% for non-domestic and domestic customers respectively are suggested.

445. Stakeholder consultations suggest there is some support in the community for partial contributions to the cost of domestic sewerage services, subject to the provision of a satisfactory service. At best, partial cost recovery is possible in domestic sewerage services. A target recovery rate of 50% of operating costs appears an upper limit at this point with an expanded cost base.

446. The introduction of a partial sewerage tariff should be introduced alongside the proposed sewerage upgrading program.

53.13 Building Community Support

447. A prolonged public consultation program will be required to build awareness about all the relevant issues associated with the proposed upgrading of water and sewerage services in South Tarawa. Constructive changes in community attitudes relating to the provision of and payment for water services cannot be achieved without such a program.

448. The suggested consultation program must be accompanied by significantly increased annual disclosures by PUB about its operations. Innovative measures such as prompt payment discounts and competitions may well generate additional marginal improvements in cost recovery levels but are unlikely to have a material impact in generating additional revenue flows.

449. The major catalysts for achieved improved cost recovery in water services are the provision of sustainable services accompanied by a material increase in the transparency of all major aspects of PUB's operations and supported by a prolonged public consultation program during the term of the water and sanitation infrastructure upgrading programs.

53.14 Conclusions

450. Corporate governance, political, cultural and social factors in Kiribati have had varying levels of influence on PUB's water and sewerage operations and its resulting revenue streams in recent years. These influences are likely to continue in the medium to long term although their relative magnitude may well vary over time.

451. Dissatisfaction with the present quality of water services and ability to pay constraints are the principal factors contributing to shortfalls in water revenue budgets. Ability to pay constraints will continue to have a negative impact on revenue flows in the

foreseeable future as approximately 20% to 30% of households have very limited ability to pay for utility services. The public good component of projected enhanced water and sewerage services results justifies the provision of a partial subsidy for these services on economic efficiency grounds. A higher subsidy is appropriate for sewerage services in view of the greater externalities associated with these services on South Tarawa compared with those applicable to water services.

452. Domestic water revenue cost recovery levels are unlikely to exceed 80% of allocated costs in the long term. A medium to long term target of 50% for domestic sewerage cost recovery levels looks appropriate at this point having regard to the respective externalities. PUB should seek to recover the full cost of water services provided to non-domestic users in the long term.

453. Immediate improvements are recommended in PUB's accounting and recording practices. These will facilitate some improvement in water revenues in the near term and provide a more informed basis for developing water and sewerage tariffs for implementation after the completion of the planned upgrading of water and sewerage infrastructure.

454. Many PUB customers have signalled their discontent with the current quality of PUB's water service by electing not to pay their monthly bills. They are conscious of the difference between functioning pre-paid telecommunication and transport services and PUB's current very poor performing water service, paid on an arrears basis. On balance there is reasonable willingness to make additional payments for water services amongst South Tarawa households providing PUB's water services are maintained at acceptable levels.

455. For the sections of the community of limited means and therefore the ability to pay supply arrangements such as maintained and managed communal/public toilets, water supply standpipes and water kiosks should be considered, where payment will be minimal and directly related to use.