ECONOMIC ANALYSIS

A. Context of the Analysis[1]

1. The Koror–Airai Sanitation Project is designed to fund and support initial investment in the rehabilitation of the existing sewerage system in Koror with improved system control and maintenance, and to provide a new sewerage system to the community of Kesebelau in Airai. The project will address looming threats to public health and habitability of the urban areas of Palau, and will help to safeguard the land and coastal marine environment on which a continued vibrant tourism sector and a large part of national income depend.

2. Sanitation is very poor in Koror. The system is poorly maintained, and leaks and overflows are a daily occurrence, threatening the livability of urban areas, inland and coastal areas, the coastal marine environment, agriculture (taro patches), and public health. As Palau depends on tourism for 50% of its national income (and most tourists spend the bulk of their time and money in Koror), the dilapidated system also poses a serious threat to future income prospects, as tourism is acutely sensitive to health issues.[2] The implicit threat of an outbreak of a waterborne disease epidemic will increase through time until the system is rehabilitated. If such an event occurs, tourist arrivals would be expected to fall substantially and for an extended time. Under the project, the number of domestic and nondomestic connections will be increased, leaking pipes will be replaced, the sewage treatment plant will be overhauled and capacity expanded, system maintenance will be strengthened, and overflows will be sharply reduced.

3. In Airai, about 325 households and a small number of businesses and public facilities (government offices and a school) make up the community of Kesebelau. The community was established on government land, with housing built and leased to the public. The area has no sewage system; all residents use septic tanks. Because of poor soil conditions for septic leaching, the septic tanks require frequent pumping (twice a week) to avoid overflows, largely creating surface cesspools in residential and agricultural areas. Surveys show that because Kesebelau households do not carry out pumping with the required frequency, surface flows have become continuous, threatening the habitability of the area. A simple sewage collection and package treatment system is proposed, allowing the community to discontinue use of septic tanks, and thus eliminate the present requirement for frequent pumping.

B. Least-Cost Analysis

4. In Koror, three potential solutions to address system deficiencies are (i) the project—a rehabilitated, centralized collection system connected to an overhauled and expanded sewage treatment plant in Malakal; (ii) a new collection system routed around the coastal areas and connected to an overhauled and expanded sewage treatment plant in Malakal; and (iii) a decentralized collection and treatment system, resulting in eight new small collection and treatment plant systems distributed around Koror.

5. As all the alternatives are subject to equivalent energy, operation and maintenance (O&M), and personnel costs, the least-cost decision rests on a comparison of the economic capital costs.[3] For Koror, the project is the least-cost approach ($24.4 million compared with

[1] The economic analysis of the project is provided in a supplementary document that is available upon request.
[2] International Monetary Fund (IMF). 2012. *Republic of Palau: 2012 Article IV Consultation, Staff Report.* IMF Country Report No 12/54.
[3] Calculated in deflated $ converted from financial costs by removing taxes.

$33.0 million for approach 2, and $35.5 million for approach 3) because it minimizes the need for procurement and installation of new facilities.

6. In Airai, the least-cost analysis compares (i) continued use of septic tanks in Kesebelau, combined with pumping and cleaning operations with a frequency sufficient to eliminate the present surface flows of sewage; and (ii) the project—a centralized sewage collection and treatment system serving the same area. Alternative (i) is available at no initial investment cost but high operating cost, while alternative (ii) comes with a significant initial investment cost but comparatively low operating cost.

7. The estimated economic O&M cost of the project includes consumption of 75,000 kilowatt-hours (kWh) of electricity per annum, valued at about $38,000/year (rising at an assumed rate of 1.9%/annum in real terms), and routine system maintenance of approximately $11,000/year, or a total of about $49,000/year at startup. The net present value (NPV) of total costs of the project over its operating life, discounted at 12%, is approximately $4.0 million.

8. The number of households in Kesebelau (currently 325) that would be served by the project is expected to increase at an average of 3.3% per annum, reaching 645 households by 2036. The project would also serve a small number of commercial and government facilities in the area (currently two, increasing to five by 2036).[4] The NPV of total cost of pumping operations over the life of the project (to 2036), discounted at 12%, is approximately $7.7 million. The project is thus the least-cost alternative in Airai in terms of life-cycle costs.

C. Methodology

9. The with– and without project scenarios were compared to identify the benefits of the project and its incremental costs over the project lifetime. Costs and benefits under both scenarios are discounted at the standard economic opportunity cost of capital of 12%.

10. The local currency in Palau is the United States dollar. No levies or duties are applied to imported materials. Local labor is taxed at 6% on all income up to $8,000/year and at 12% on income exceeding $8,000/year. Taxes are excluded from economic costs.

11. As Palau citizens have the rights to migrate to, work, and claim social benefits in the United States, Palau has virtually no unemployment and local wage rates are an accurate measure of the opportunity cost of labor. Under these circumstances, the shadow wage rate and exchange rate factors necessary to equilibrate the border and domestic prices of traded and non-traded goods are not materially different from 1.0.

D. Project Economic Costs

12. Project economic costs include initial costs associated with (i) civil and mechanical works and equipment for the development or rehabilitation of sewage collection and treatment facilities; (ii) surveys and other technical investigations contributing to detailed design; and (iii) consulting services for carrying out design work, tendering, implementation supervision, management support activities, and a physical contingency allowance. Economic costs associated with the with-project operations include (i) incremental routine repairs and maintenance, (ii) asset replacements scheduled according to the frequency with which they are

[4] The area has a number of large hotels that have their own sewage treatment and disposal facilities; they are not expected to be connected to the project.

expected to wear out, and (iii) incremental energy costs. Operating costs include personnel costs. The residual value of sewerage assets at the end of their economic life is zero.

E. Project Economic Benefits

13. In both subproject areas (Koror and Airai), the objective of the project is to reduce significant public health and associated environmental risks of poor sanitation by substantially reducing sewage overflows (in Airai, caused by improper maintenance of septic tanks), improving responsiveness of operators to emergencies, and ensuring that effluent ultimately discharged to the environment is properly treated. In the case of Koror (and Palau generally), a key consideration in protecting the environment from pollution from wastewater and foul air is to protect incomes—the economy depends crucially on tourism. Deterioration of Palau's pristine marine and coastal environments—potentially leading to an outbreak of waterborne disease such as cholera or typhoid—would cause grievous damage to the tourism industry in Palau and destruction of livelihoods requiring multiple years to recover, in addition to having a potentially devastating impact on the local population.

14. The approach to economic analysis adopted in Koror measures the direct economic impact of O&M savings, avoided costs due to sewage overflows in terms of health care, environmental cleanup by the government, households, the commercial sector, and detrimental impact on tourism. In Airai, it measures the avoided costs of properly operating and maintaining septic tank systems in the residential area of Kesebelau. In both subprojects, small but significant local employment benefits will be available during project implementation.

15. **Improvements in asset management.** The entity responsible for operating and maintaining the Koror sewage system lacks appropriate control mechanisms for pumps and other equipment, which could wear out and need to be replaced well before their design life expires. Under current conditions assumed to continue without the project, sewage pumps in pump stations typically need to be replaced every 5 years compared with a design life of 15 years. Electrical control boards need to be replaced every 10 years compared with a design life of 20 years. By introducing inexpensive but effective control mechanisms and by applying a coherent asset management plan under the project, these assets will last and remain operable for their full design lives and reduce O&M costs. The difference between the net present asset replacement costs of the with- and without-project scenarios is included as a benefit of the project.

16. **Health benefits (avoided cost of treatment and lost production).** A strong correlation exists between sewage overflows and recorded incidence of gastroenteritis (inflammation of the stomach and intestines due to ingestion of harmful bacteria). A significant overflow is estimated to occur on average twice per week in Koror and reported gastroenteritis incidence (less than actual incidence, since many if not most cases go unreported) averages 40–50 cases per month. On this basis, the average number of cases of gastroenteritis and other serious waterborne diseases in Koror requiring medical care is assumed to 10 per significant sewage overflow. The economic cost of medical care and lost workdays per case is estimated at $170 per case, or $1,700 per overflow. As the system continues to deteriorate without the project, the frequency of overflows is expected to increase. Under these conditions, avoided costs (with the project) for medical treatment and lost production due to infection from overflows is calculated at about $177,000 per annum in the first year of operations, rising gradually to $469,000 per annum by the end of the project period, resulting in an NPV of $1.5 million as a project benefit.

17. **Avoided costs due to cleanup of overflows.** The service provider responsible for O&M of the Koror sewage system is required to make frequent emergency responses for

cleanup of overflows, at considerable cost per incidence. In cases where overflows are not actually cleaned up by the service provider, costs are still borne by those directly affected (e.g., households facing uncovered cesspools in close proximity—their living area will suffer direct cleanup costs or a loss of living standard and use of property and assets; commercial establishments such as tourist resorts or restaurants will undertake strenuous activity to clean up effluent in their vicinity to avoid losing customer patronage). The current economic cost of cleanup of a significant overflow (or the cost of suffering its effects without cleanup) is estimated at approximately $14,900. Without the project, the system is assumed to continue to deteriorate. The frequency of overflows increases through the planning period at a rate of 5% per annum.

18. **Local employment benefit.** During the 3-year construction period of the Koror subproject, local labor will be employed, generating local earnings of about $2.3 million.

19. **Prevention of damage to livelihoods derived from tourism.** Koror and the adjacent areas contain beautiful tropical seascapes and scuba diving areas that have made Palau a major international attraction. Tourism contributes about half of the country's gross domestic product (GDP). However, tourism in Palau as elsewhere is highly vulnerable to health threats, similar in this respect to terrorism threats. Frequent overflows caused foul smells in places where tourists congregate and often lead to closure of near-shore water for tourist use. A critical threat in the dense urban environment of Koror is a major outbreak of serious waterborne disease such as cholera or typhoid that could arise from human exposure to raw sewage. Experience with epidemics (e.g., severe acute respiratory syndrome and bird flu) in other parts of the world suggests that tourism in affected areas is severely reduced and takes a number of years to recover. In a small economy such as Palau's, such an impact would be (and as was seen to a degree in the wake of the 9/11 terrorism when tourist traffic worldwide was diminished) devastating to local livelihoods.

20. The sewage system in Koror is already overloaded, leaky, and subject to frequent overflows, presenting a considerable risk to public health. Health and tourism stakeholders are concerned that there is already a significant and rising risk of an outbreak of a seriously contagious waterborne disease, such as cholera or typhoid. Such an outbreak would drive away tourist visitors to Palau and jeopardize the longer-term prospects of the tourism sector. In this sense, the project can be viewed as an insurance policy, addressing the risks faced by an economic sector vital to Palau's national income.

21. The value of the risk to national income from the impact on tourism by the dilapidated sewage system without the project is estimated at $1.4 million (0.5% of gross domestic product [GDP]) in 2013, rising to $2.4 million (0.9% of GDP) in real terms[5] by 2025, and $5.5 million (1.5% of GDP) by 2036. Annual values of the avoided risk due to the project are included in the project's economic benefits.

22. **Avoided costs of septic tank pumping (Airai).** The economic benefit of the project in Airai is the avoided cost from preventing surface flows of sewage without the project. This entails frequent pumping of sludge from all septic tanks by tank truck and cartage, and proper disposal of it at the sewage treatment plant (without the project, the relevant plant is in Malakal).

[5] Expressed in 2011 dollars (costs and benefit projections are expressed in real terms).

F. Economic Internal Rate of Return and Net Present Value

23. Under these parameters and assumptions, the economic internal rate of return (EIRR) of the two subprojects is 18.4%, the NPV (discounted at 12%) is $14.3 million. The EIRR is considered to be acceptable as it exceeds the economic opportunity cost of capital adopted for this analysis of 12%.

G. Sensitivity Analysis

24. Sensitivity analysis was carried out for adverse variations (by 20%) in the following parameters: (i) increase in capital and asset replacement cost; (ii) increase in incremental O&M cost; (iii) increase in rate of real increase in electricity price; (iv) decrease in incremental local employment; (v) decrease in avoided asset replacement, health care, septic tank pumping, and overflow clean-up costs; and (vi) decrease in avoided tourism impact. The analysis shows that the EIRR and NPV are robust to all variations at the 20% level, including when all are applied simultaneously (12.2%). The most sensitive parameter is capital and asset replacement costs, followed by the combined avoided costs included as benefits apart from tourism (avoided health, cleanup, asset replacement, and septic pumping costs). The sensitivity analysis results are summarized in the table.

Sensitivity Analysis

Test Case	Test Variation (+/- %)	ENPV	EIRR	Sensitivity Indicator	Base Case Parameter	Switching Value	Switching Value[a] (+/-%)
Base (reference case)		14,280	18.4%				
Increase in Costs							
Capital and asset replacement costs	20%	9,137	15.6%	1.80	25,717	39,997	55.5%
Incremental O&M costs	20%	13,944	18.3%	0.12	1,680	15,961	849.8%
Electricity price Escalation rate	20%	14,223	18.4%	0.02	1.9%	8.3%	336.3%
Decrease in Benefits							
Avoided costs	(20%)	9,223	16.3%	1.77	25,284	11,004	(56.5%)
Incremental local labor earnings	(20%)	13,784	18.1%	0.17	2,478	(…)	(100.0%)
Adverse tourism impact	(20%)	11,497	17.3%	0.97	13,915	(…)	(100.0%)
All costs increased and all benefits decreased	20%	(…)	12.2%				

( ) = negative value, EIRR = economic internal rate of return, ENPV = economic net present value.
[a] Switching value (+/- %) of (100%) indicates that reducing the parameter to zero does not reduce the EIRR below the 12% threshold.
Source: Asian Development Bank Consultant calculation.