

Executive Project

Drinking Water Supply And Sewage Treatment System For Parque Nacional Isla Contoy Final Report

Preface

This document is aimed to comply with contract signed the 8th of September of 2003 with Lighthouse Foundation. Ecoturismo y Nuevas Tecnologias s.a. de c.v. [ENT] submits this report to LF and PNIC.

This submittal is delivered at PNIC as the beneficiary of this study and we will look forward hearing from inputs and suggestions since this study may be modified or improved after technical issues be discussed between the parts.

ENT has evaluated the possible solutions for Drinking Water supply and sewage treatment system for Parque Nacional Isla Contoy and alternatives have been discussed with the PNIC authorities. This report reflects the results of our investigations.

This executive project is a complement of preliminary project performed by ENT the March of 2003. The preliminary project must be validated with high reliable information taken in the site using comments and observations of PNIC personnel, as well as systems and equipment suppliers. This executive project shows a deep analysis of the issue and is presented along this document.

At the very beginning, E&NT had suggested that both, black and gray water would be treated and recycled in toilets and sinks respectively, however new balances indicate gray water could be recycled and used in toilets while just part of black water would be recycled to be used in toilets too. For showers and sinks, filtered and purified rain water can be used, with no any impact in water reserves along the year. If necessary in the future the water supply system can be easily modified to recycle the black and gray water as originally was suggested with a minimal investment. The figures and calculations are included in this document.

We have included in this report all information needed to back our decision up. We are looking forward to hearing form your comments.

Best Regards,

Ecoturismo y Nuevas Tecnologias s.a. de c.v.

Eng. Arturo Romero Paredes Rubio

Director.

**Drinking Water Supply And Sewage Water Treatment System For
Parque Nacional Isla Contoy
Executive Project
Scope Of Work**

- 1- **Assessment – Present Circumstances**
 - a. Water Availability, storage tanks capacity, actual and projected water demand in the PNIC.
 - b. Micro-biological analysis of the water used for cooking, showers and sinks.
 - c. Cisterns and storage tanks assessment
 - d. Water treatment system assessment
 - e. Actual cost of water supply (potable and no potable)
 - f. Power demand of the currently water supply system and its impact in the hybrid power system.
 - g. Advantages and disadvantages of the present system.
- 2- **Survey Of Existing Equipment And Systems**
 - a. Existing equipment survey and its possible use in the proposed system. (Meetings with suppliers if available)
 - b. Existing parts survey and its possible use in the proposed system (pipelines, storage tanks, etc)
 - c. Proposed final disposal of non useful parts and/or equipments existing (tanks, pipes, filters, etc)
- 3- **Bill Of Materials And Civil Works Required For Proposed System.**
 - a. Description and Technical specification of each equipment.
 - b. Description and Technical specifications of hardware
 - c. Description and Technical specifications for civil works.
 - d. Power demand expected by new system and its impact in the hybrid power system. Recommendations.
- 4- **Topographical Survey And Hydrology.**
 - a. Comparison with existing drawings information
 - b. Contour line assessment.
 - c. Feeding and exhaust water pipeline design
 - d. Plan view drawing for proposed system.
- 5- **Schedule And Budgeting For Proposed System**
 - a. Schedule for project implementation.
 - b. Budget for proposed system including equipment, hardware, labor and transportation.
 - c. O&M estimated cost projected for 20 years.
 - d. Comparative table system proposed vs. other options like RO, and electrical distillation.

Executive Project: Drinking Water Supply And Sewage Treatment System
For Parque Nacional Isla Contoy
Final Report

1. Assessment – Present Circumstances

- e. Water Availability, storage tanks capacity, actual and projected water demand in the PNIC.

a.1- Water availability and its sources:

Rainwater: The collecting area¹ was estimated in 830 m², the annual precipitation is 980 mm, meaning a possible collection of 813 m³ that is equal to 2.2 m³ per day. More than this amount of water demand would be necessary to rice the area of collection. Water channels usually are unclean and it is not possible to clean them up. On the other hand only the 70% of museum roof collect rainwater; since the channel for water is not completed around the museum.

The well: only 0.3 LPS equivalent to 9,460 CMPD is possible to pump from this source. However we think we do not have to use this source since it is not evaluated the environmental impact yet.

a.2 – Storage water capacity:

The PNIC has in the ground, two 71m³ cisterns and a plastic tank of 10 m³, equal to 153 m³ of total storage water capacity and three 1m³ tanks in the roof. The water autonomy is estimated in 78 days for 2 m³ of water demand; just in case they do not use the water from the well any more.

Conclusion: if demand is less than 1.75 m³/day, the Park meets the self sustainable status. See drawings #1 y #2.

a.3 – Water Demand:

Water for Showers and sinks: The 3,100 liters tanks located in the top of the tower meet the needs for showers and sinks. These tanks are filled trice per month in a regular basis and 5 times in particular cases. This water demand represents 50 liters per day-person, which looks reasonable. This demand is equivalent to 19.3% of the total of 300 liters /day as an average.

Water for toilets and urinals: briny water from the well is pumped to 1.1m³ storage tank located in the top of main building second floor. Personnel and tourists use this

¹ The collection area estimated was based on all roof area of the Station.

amount of water during one day. When workshops or meetings are carried out in the station, a double demand of water has been observed. This consumption is equivalent to 15.7 liters per day- person, which looks a very low value; this value also corresponds to 594 m³ per year and this is not an impact for rainwater reserves. On the other hand 594 m³ per year becomes to black water. Table #1 shows black water means the 79.6% of the total.

Potable water: 24 bottles, 19 liters each are consumed per month; this value corresponds to 1.6 liters/day-person. Potable water bottles come from Cancun.

a.4 – Actual and Projected Water Demand:

Table #1 shows actual water demand, where we can see rainwater demand does not exceed the 110m³, this explains why the water of one cistern has not been used for a year. On the other hand usage is restricted as maximum avoiding any risk of lack of water supply along the year. Potable water usage is also limited explaining the low values under standards², this analysis also brings the idea once restrictions being eliminated consumptions will rise.

Regarding the rainwater catching capabilities, graphs #1 and #2, show two scenarios 2 m³ and 3m³ water demand per day.

As a conclusion we can estimate 2 m³ per day of water demand as average; 3 m³ of daily water demand means a 50% more than actual and make sense thinking in PNIC growing plans. We also have concluded that the **equilibrium point** is 1.75 m³ of daily water demand to ensure the sustainability in the PNIC.

Graph#1, If water demand does not exceed 2 m³ per day, and with no usage of briny water from well, the Station will be close to the sustainability point, in terms of water, considering a back up of 156 m³ at the beginning.

Graph #2, if water demand is higher than 3 m³ per day, which is probable in 10 years from now, both storage capacity and collection capacity wont be enough to meet the needs. With this analysis we conclude the option to recycle the water is the best, even periodically both gray and black water would be replaced.

² Potable water limitation is due the irregular potable water supply.

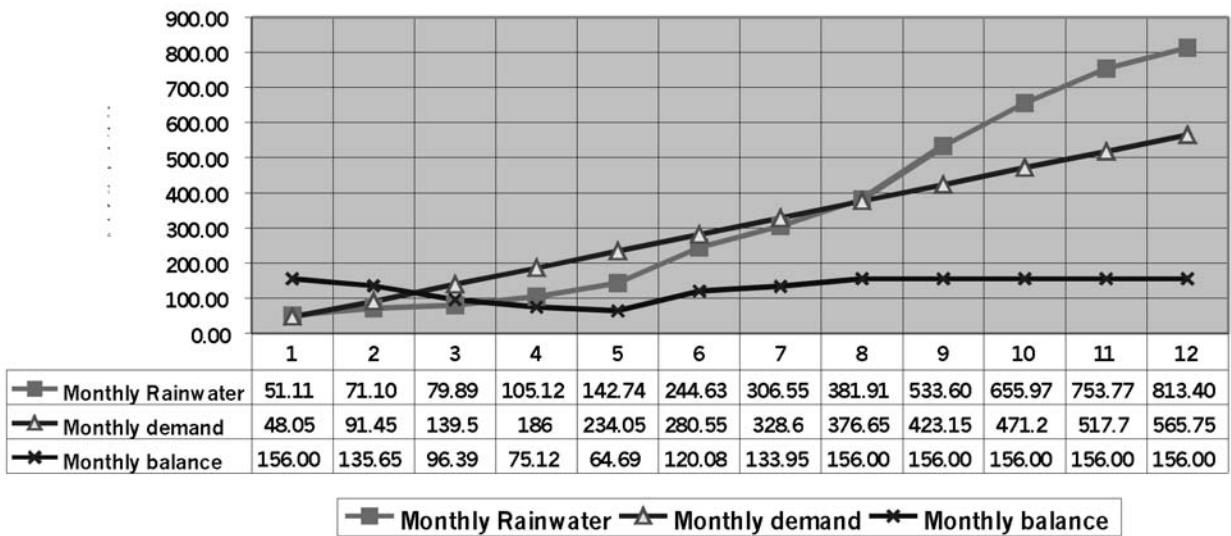
Table #1

Water demand in the PNIC

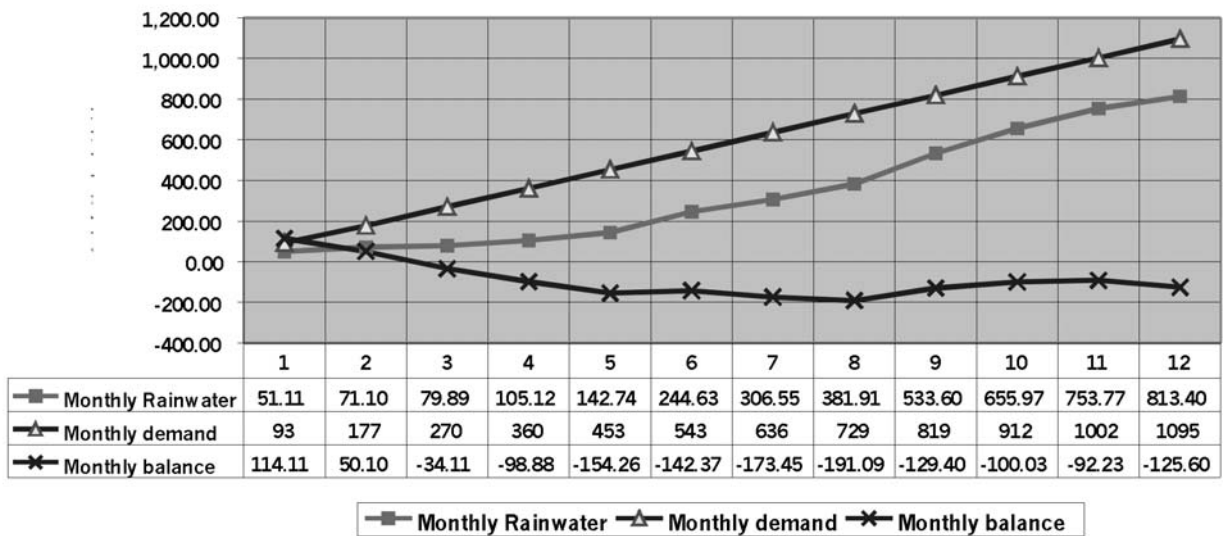
Liters per day - Actual

| | Per day | Max Per day | Avg/ Month | Avg. Per year | % of Total |
|---------------------------------|---------|-------------|------------|---------------|------------|
| Toilets (From the well -actual) | 1,100.0 | 2,200.0 | 49,500.0 | 594,000.0 | 79.59% |
| Rain Water – sink and showers | 300.0 | 500.0 | 12,000.0 | 144,000.0 | 19.29% |
| Potable Water | 16.0 | 32.0 | 720.0 | 8,640.0 | 1.16% |
| Yearly demand | | | | 746,640.0 | 100.00% |
| Dayly demand | | | | 2,045.6 | |

PNIC Rainwater vs Demand 2 m³/day



Rainwater vs Demand 3 m³/day



a. *Quality of the water.*

Rainwater collection path, helps to collect trash, sand and organic materials what is sent to cisterns along with the water.

Water for cooking: PNIC is using potable water, which comes from Cancun by PNIC's boats, while the water to clean kitchen utensils is rainwater.

Sinks and showers: chloride rainwater is used for this purpose.

b. *Diagnosis of cisterns and storage tanks.*

Rainwater laid in two cisterns, as shown in drawing #1, later it is sent to 10 m³ tank where is purified with chloride, Cistern #1 is fed by Cistern #2, which is in a lower level, so eventually it must be pumped. Both cisterns are made by concrete. Cistern #1 contains 70 m³ what wasn't been used during last year.

Concrete-asbestos tanks located in the top of the tower must be replaced.

Briny water tank located in main building roof, is an 1100 liters tank, this water is used for toilets and urinals; this tank requires a control level system to avoid briny water run to rainwater collection system.

c. *Actual condition of water treatment system.*

Sewage pipeline was upgraded during our visit since a problem identified must be corrected immediately. Another problem identified is the high watertable level located at less than 1 m from the ground level.

Old water treatment system is used now, eventhough it is not working at all. Gray water is sent to waterland with no any previous treatment.

New plant must be located few meters below the ground level and a water pumper will be necessary.

d. *Actual cost of water supply. (Potable and non potable water)*

Water supply has three economical impacts:

i. By buying bottles of potable water and their transportation from Cancun to the island, the cost per liter is estimated in \$1.97³ pesos, which means a total cost of \$19,700.00 pesos per year as average.

ii. Second impact regarding the energy to power the pumps, generation, storage and maintenance of power system, just the equivalent fraction. The cost per kWh is estimated in \$13.65 pesos⁴, so the total annual cost is \$ 4,533.80 pesos.

³ Cost of the water, transportation and labor.

⁴ O&M for 20 years has been considered.

iii. Third impact corresponds to labor cost due maintenance and fixing problems in both power system and water treatment system. This impact was estimated in \$11,000.00 pesos per year⁵.

Based on these figures, the total economical impact is \$35,233.84 pesos per year.

e. *Power demand of the currently water supply system and its impact in the hybrid power system.*

PNIC has three water pumps

1. One 1 HP water pumping system to pump briny water to upper tank. This pump is used for 40 minutes per day; it means 660 Wh/day.

2. A second pump what sends water from cistern #2 to 10 m³ tank. It is a 700-Watts pump running one hour per week; it means 100 Wh/day.

3. A third pump that sends water to 3 storages tanks located in the tower, this is a 1.5 HP pump that runs 1 hours every ten days, meaning 150 Wh/day.

The total power demand is 910 Wh/day what corresponds to 13% of total hybrid system generation and 17% of the PV system production.

Pumps are manually operated and frequently are operated simultaneously having an over current demand.

f. *Actual conditions; Advantages and disadvantages*

iv. Advantages:

- 1.1 Rainwater meet almost all needs for sinks and showers.
- 1.2 Briny water meets all needs for toilets and urinals.
- 1.3 Potable water sent from Cancun also meet all needs of drinking water.
- 1.4 Operation cost is quiet cheap.

v. Disadvantages:

- 2.1 Hydraulic system is neither efficient nor effective.
- 2.2 Water from cisterns is polluted in some way; it is not safe to be used.
- 2.3 Asbestos-concrete tanks are not recommendable.
- 2.4 Chlorine in tank is not enough to make water drinkable in the 10-m³ tank.

⁵ At least 15% of personnel time has been considered on.

- 2.5 Pumping water from well is not a good practice while we do not have any environmental impact assessment.
- 2.6 Actual power system is not enough for actual energy demand.
- 2.7 Labor time in maintenance of water system is high.
- 2.8 Water treatment system is not effective.
- 2.9 High probability to get a disease due bad quality of water.
- 2.10 Environmental impact could be high in the future if a correction action is not taken.

2. Surveys of existing equipment and systems.

- a. Existing equipment survey and its possible use in the proposed system. (Meetings with suppliers if available).

Table #2, is shown the general specs of existing equipment. Table #3, shows the bill of parts and its possible use in the PNIC.

| Table #2. Technical specs. | | | | | | |
|-------------------------------|-----------------|------|--------------------|---------------|-------------|------------|
| Filtration equipments | Dimensions (cm) | | Pressure drop | Pressure drop | | |
| Description | Diameter | High | Kg/cm ² | m water | Weight (Kg) | Q Máx. lpm |
| Coal filter (1) | 23 | 107 | 0.8 | 8 | 59 | 15 |
| Particle filter (2) | 23 | 107 | 0.9 | 9 | 59 | 23 |
| Coal Filter (1) | 18 | 33 | 0.14 | 1.4 | 2 | 76 |
| Hydro pneumatic Well Mate (2) | 40 | 60 | NA | NA | | 70 |

| Pumps | HP | Voltage | Power Watts | Application |
|--------------------|-----|---------|-------------|---|
| Submersible LG (1) | 0.8 | 120 | 700 | Cistern to tank 10 m ³ |
| Centrifugal (1) | 1.0 | 120 | 1000 | Briny well |
| Centrifugal (1) | 1.5 | 120 | 1500 | 10- m ³ tank to tower tanks. |

- b. Parts of the actual system that could be used in the new one design).

This information is contained in the section number 3, column of notes.

- c. Proposed final disposal of non useful parts and/or equipments existing (tanks, pipes, filters, etc)

- Old electrical installations out of use must be dismantelled.
- Old water pipelines out of service must be dismantelled.
- Asbestosconcrete tanks must be keep out of use.

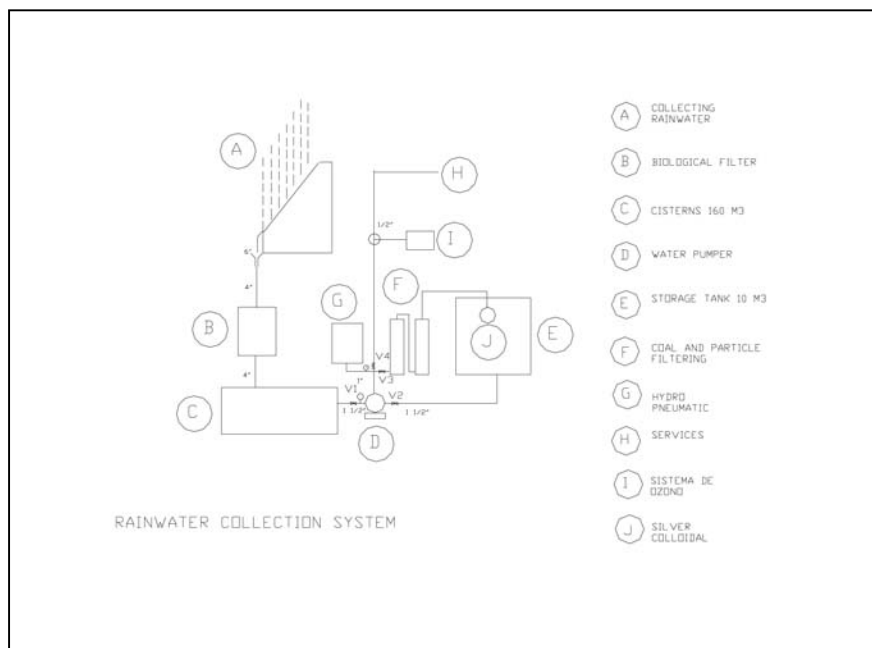
- Parts of RO system with no use must be dismantled and sent to any other station wher can be used.
- Old water tratment system must be dismantled and send it out of the island.

3. Bill Of Materials And Civil Works Required For Proposed System.

a. Description and Technical specification of each equipment.

a.1 Rainwater collection system. Drawing #2, shows the schematic of new system; water collection will be improved by semi-pipe channel system (A), water will run at biological filtering system (B); then water is sent to cistern #1; which will feed the cistern #2 (C). A 1 HP Pump (D) will pump the water to 10 m³ storage tank (E) once it is coal-filtered and particle-filtered (F) the necessary number of times. Solenoids valves V1, V2, V3 y V4 as well as hydro-pneumatic system (G) will help for this purposes. Colloidal-silver-element (J) sited in 10m3 storage tank, will make the water drinkable. Now the water will be ready to be sent to showers and sinks (H) with both pump and hydro-pneumatic system, passing through ozone injection system (I). With this process we are ensuring the quality of water.

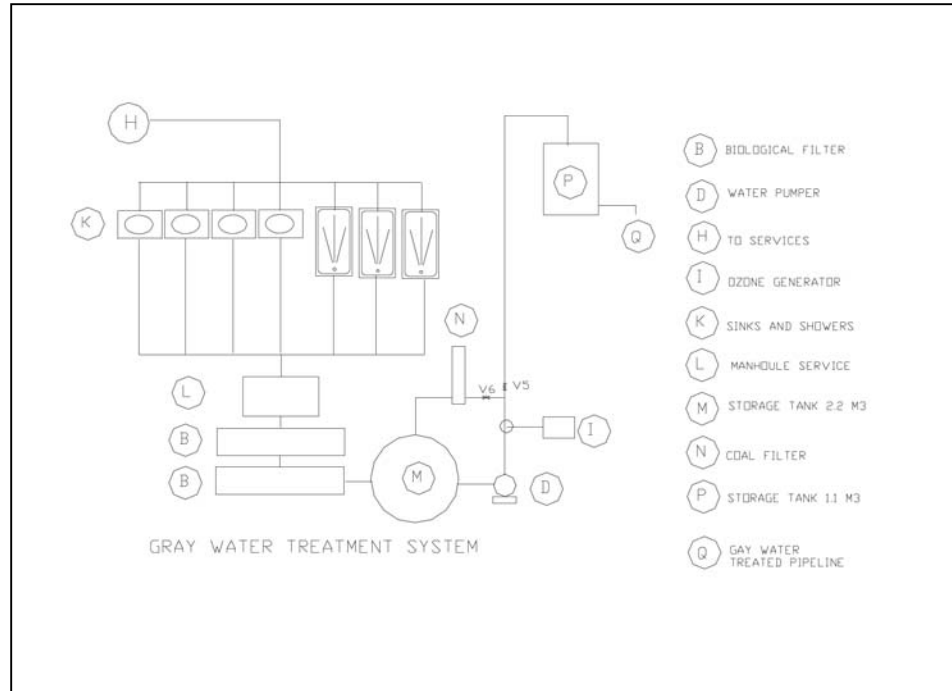
Drawing #2:



a.2 Water for sinks, showers and gray water treatment. Drawing #3, shows rainwater (H) feeds all sinks and showers (K); needed pressure will be provided by hydro-pneumatic system (G). Gray water as result of this stage will be sent to solids tramp

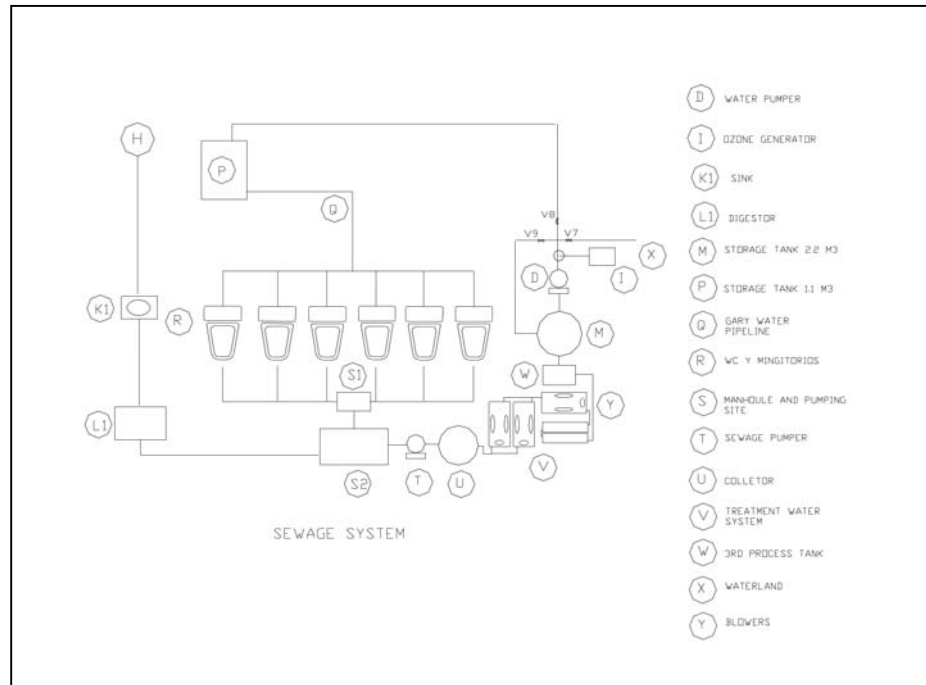
(L) and later will be sent to biological filter (B); this gray filtered water will be kept in a 2 m³ tank (M). A 1 HP pump (D) will pump the water to pass through coal filter (N); ozone system (I) also will help to eliminate any odor from water. Solenoid valves will help to choose: recycling water or send it to gray water treated tank (P) to serve the lavatories (Q).

Drawing #3:



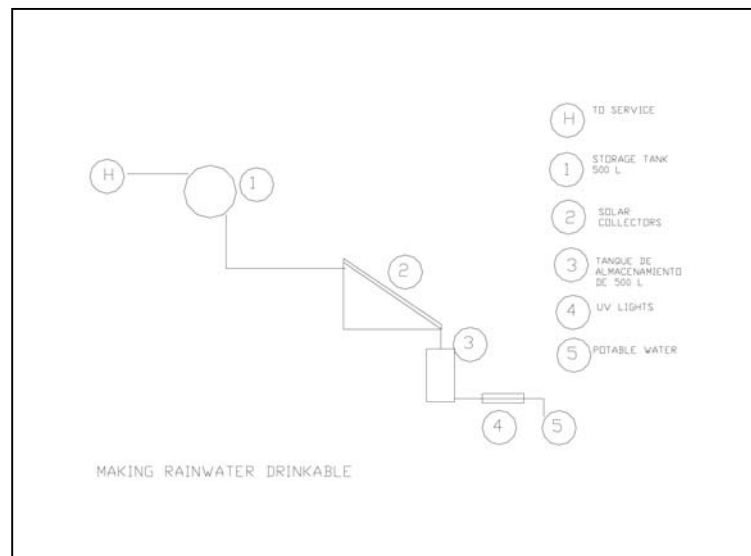
a.3 Gray water usage and sewage water treatment: Drawing #4, shows treated gray water (Q) feeds toilets and urinals (R). Black water will be collected in a manhole (S1) and then will run at suction pit (S2). Pump process (T) is necessary due the low water-table level. Sewage water is pumped to 400 liters tank (U) to feed the water treatment system (V). A third stage treatment has been included (W) to ensure a maximum capacity to serve to 60 persons per day. Sewage water treated will be pumped to 2.2 m³ tank (M) and then will be pumped (D) to wetland (X) or be recycled in the tank and pumped to treated gray water tank (P). An ozone system (I) will help to eliminate any odor from water. On the other hand, water from kitchen (K1) will pass though digester (L1) before is sent to sewage treatment plan.

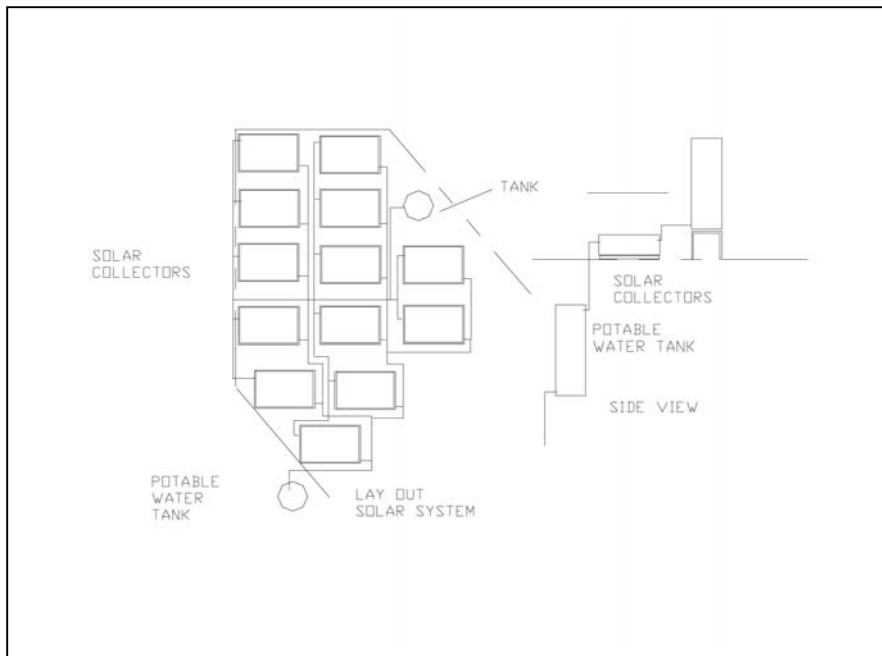
Drawing #4:



a.4 Potable water system: Drawing #5, shows rainwater (H) feeds solar distillation system that comes with 500 liters storage tank (1), solar system (2) and a second storage tank (3). In the kitchen will be located a UV light system (4). Redundancy will ensure 100% drinkable water for the PNIC. The maximum capacity will be of 40 liters per day; based on first figures this amount of water will mean 10 days of autonomy. Drawing #6, shows the solar system layout.

Drawing #5:





Drawing #6.

Note: The following sections from de original one document in Spanish, describe the Bill of materials and activities to be carried out for project implementation. We think do not worth to be translated into English, if LF requires this part in English please let us know.

- b. Description and Technical specifications of hardware
- c. Description and Technical specifications for civil works.

d. Power demand expected by new system and its impact in the hybrid power system. Recommendations.

Table #5, Power demand Estimated for the PNIC.

| Table #5 Power Demand | | | | | | | |
|--|---------------------|-----|-------------|------------|-----------|---------|------------|
| | Description | Qty | Power Watts | Hours/ day | Days/week | WH /day | % Of total |
| I. Water pumping system | | | | | | | |
| I.1 | Rainwater | 1 | 1,000 | 1.3 | 7.0 | 1,300.0 | 12.9% |
| I.2 | Gray Water | 1 | 1,000 | 1.3 | 7.0 | 1,300.0 | 12.9% |
| I.3 | Sewage | 1 | 250 | 0.33 | 7.0 | 82.5 | 0.8% |
| I.4 | Treated water | 1 | 1,000 | 1.0 | 7.0 | 1,000.0 | 9.9% |
| | Subtotal | | | | | 3,682.5 | 36.5% |
| II.- Treatment water system | | | | | | | |
| II.1 | UV Light | 1 | 35 | 4.0 | 7.0 | 140.0 | 1.4% |
| II.2 | Ozone system | 1 | 55 | 5.0 | 7.0 | 275.0 | 2.7% |
| II.3 | Air supply | 1 | 15 | 12.0 | 7.0 | 180.0 | 1.8% |
| II.4 | Solenoids | 8 | 2 | 5.0 | 7.0 | 80.0 | 0.8% |
| | Subtotal | | | | | 675.0 | 6.7% |
| III.- Lights and fans | | | | | | | |
| III.1 | 13 Watts lights | 60 | 13 | 0.8 | 7.0 | 585.0 | 5.8% |
| III.2 | Fans | 25 | 300 | 0.8 | 5.0 | 4,285.7 | 42.4% |
| III.3 | Museum equipment | 1 | 350 | 1.0 | 6.0 | 300.0 | 3.0% |
| | Subtotal | | | | | 5,170.7 | 51.2% |
| IV.- Audiovisual equipment and PC | | | | | | | |
| IV.1 | Projector | 1 | 250 | 5.0 | 1.5 | 267.9 | 2.7% |
| IV.2 | Computers (laptops) | 4 | 65 | 4.0 | 2.0 | 297.1 | 2.9% |
| IV.3 | Printers | 1 | 55 | 0.3 | 2.0 | 4.7 | 0.0% |
| | Subtotal | | | | | 569.7 | 5.6% |

| Summary | % (If applicable) | Unit |
|-----------------------------------|-------------------|-------------|
| Daily power demand | | 10,097.9 Wh |
| + 15% - future - | | 11,612.6 Wh |
| Voltage | | 48.0 CDV |
| DC Amp demand | | 241.9 Amp |
| 90% Eff. inverter | | 12,902.9 Wh |
| Efficiency (Battery, cables, etc) | | 2,470.1 Wh |
| Total power to generate | 100.0% | 15,373.0 Wh |
| PV system production | 24.5% | 3,768.0 Wh |
| Wind production | 53.2% | 8,180.0 Wh |
| Diesel production | 22.3% | 3,425.0 Wh |
| Battery bank capacity | | 68,324.3 Wh |
| Autonomy days | | 4 Days |

Comments: 43% of energy will be used for water system; which will mean an important power demand. The second one higher demand is fans.

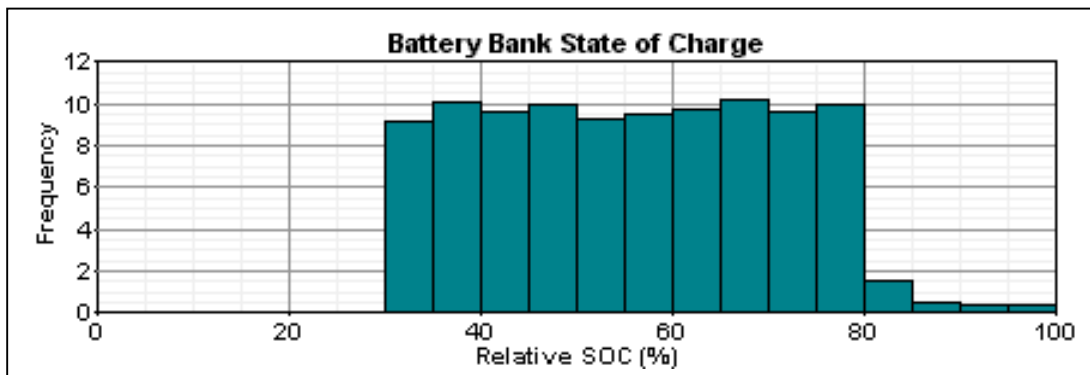
e. Engineering of power system. Consideration for Wind system:

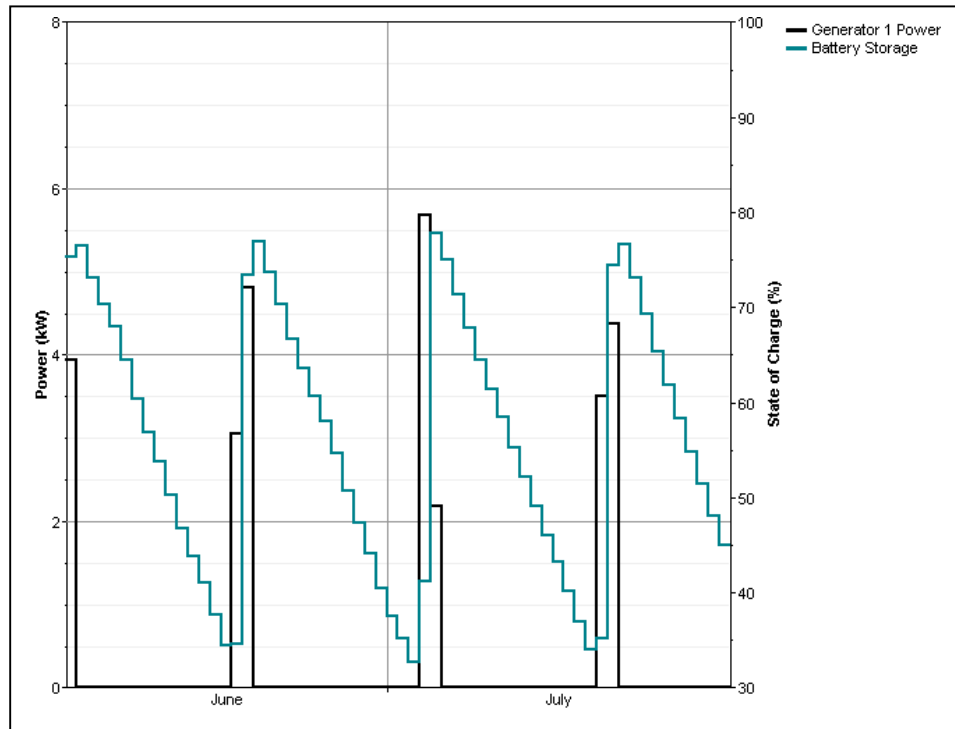
Ropatec, taking into account the E&NT wind and load inputs, provided part of this information.

The 6 kW Wind machine will generate 53% of the total demand considering 5 m/s as wind speed annual average @ 10 m over ground level. Drawing 120310-231 shows the one line diagram taking into account the existing system and new wind generator.

Conclusion: PV system along with Ropatec wind machine will not be enough power suppliers to meet the power needs of PNIC. The 35 kW diesel machine (already exists) will cover the lack of generation by renewable. Diesel will run just to charge the battery bank. A program for both Saving energy and water, must be implemented in the Isla Contoy in order to save high cost for battery bank replacements and maintenance.

Battery bank cycle charging by diesel generator is the most convenient way to use the big diesel machine. By this way the diesel will run 400 hours per year, will perform 22 starts. The typical power of this machine will be 10 kW, and will burn 2, 148 liters per year. The expected life of this generator is 20 year under this work conditions. Drawings 8a and 8b shows the battery performance and the cycle charging battery simulation, respectively.





4. Topographical Survey And Hydrology.

a. Comparison with existing drawings information

Existing drawings are not updated even they are the last one version. Once project been in process will be updated and issued a new one version. Drawings received were helpful.

b. Contour line assessment.

Contour line reported in drawings were reviewed and rechecked. During dry season the water table is as much as 66 cm under ground level and this point corresponds where the water treatment system will be located.

c. Feeding and exhaust water pipeline design

Drawing 200310-230 shows the complete water system for the PNIC including: feeding, systems to make drinkable the water and exhaust pipelines and the water treatment systems. This drawing also includes the electrical diagram to power pumps and the rest of the equipment.

d. Plan view drawing for proposed system.

Drawing 200310-230 shows also the plan view of all parts and their location in the park.

6- **Schedule And Budgeting For Proposed System**

a. Schedule for project implementation.

A complete schedule was figured out to find out the shortest period of time to perform all activities and upgrade the water conditions in the PNIC. The schedule reflects the minimum period of time to carry out all activities would be 14 weeks after the PO is located. The main activities included are: Procurement, transportation and construction. Also On Site Acceptance Test has been included as an important task.

b. Budget for proposed system including equipment, hardware, labor and transportation.

Based on both Bill Of Materials and labor costs the total amount of investment is: \$1,022,340.00 pesos (Equivalent of \$90, 472.00 USD at exchange rate of \$11.30 pesos/dollar). The following table breakdowns the costs (all in Mexican pesos)

| Description | Cost | Shipment cost | Travel expenses | Total |
|---|-----------|---------------|-----------------|--------------|
| 1. Equipment for all processes | \$191,893 | | | \$209,893 |
| 2. Hardware, pipes and others | \$67,812 | | | \$67,812 |
| 3. Generation system equipment and hardware | \$384,777 | \$18,000 | | \$384,777 |
| 4. Labor Costs | \$126,711 | | \$15,800.00 | \$142,511.00 |
| Sum | | | | \$804,499 |
| 10% | | | | \$80,499 |
| 17% Overhead | | | | \$136,849 |
| Sum | | | | \$1,022,340 |
| 15% Taxes | | | | \$153,351 |
| Total | | | | \$1,175,691 |

In the Spanish version we have included 5 tables that itemizes all needed parts. If LF needs these tables in English version please let us know.

c. O&M estimated cost projected for 20 years.

The analysis was made taking the following data:

Period: 20 years
 Interest rate: 16%
 Inflation: 5%
 Discount rate: 11%
 Subtotals per group are:
 Sewage system: \$27,303.00
 Gray Water system: \$ 25,928.00
 Rainwater system: \$ 69,247.00
 Making water drinkable: \$ 47,075.00

Total: \$169,555.00

Capital cost: \$ 533,672.00

Total Investment @20 years: \$703,227.00

Cubic meters in 20 years: 21,900

The net present value per liter: \$0.032 pesos

Power system analysis:

O&M in 20 years: \$268,530.00

Capital cost: \$495,207.00

Total investment: \$763,737.00

KWh in 20 years: 112,201

Net present value per kWh: \$6.81

Impact of energy cost in Water production: \$329,934.00

Cost per liter due energy: \$0.02

d. Comparative analysis: proposed system vs. other options like RO, and electrical distillation.

The final analysis was done to compare the cost per liter using other methods to make drinkable water.

1. Distillation using resistors:

Capital cost: \$68,592.00

O&M (20 years): \$96,028.00

Energy cost: \$1,385,832.00

Cubic meters in 20 years: 1,460

Cost per liter: \$1.06

2. Reverse osmosis

Capital cost: \$95,000.00

O&M (20 years): \$418,000.00

Energy cost: \$692,916.00

Cubic meters in 20 years: 43,800

Cost per liter: \$0.03

3. Solar system

Capital cost: \$70,000.00

O&M (20 years): \$42,000.00

Energy cost: \$577.00

Cubic meters in 20 years: 365

Cost per liter: \$0.31

Conclusions.

The feasibility and income return of project has been validated. The system will demand minimal labor for O&M. and the most important thing is ensuring the water availability and minimal environmental impact.

Acknowledgments

Ecoturismo y nuevas tecnologías s.a. de c.v. thanks to both Lighthouse Foundation and Parque Nacional Isla Contoy for the opportunity and trust in us to carry out this executive project.

We have tried hard to comply with this commitment and we look forward for hearing any comment or input to improve this report if were necessary.