IMPLICATIONS OF WATER TARIFF STRUCTURE ON WATER DEMAND IN SANTA CRUZ ISLAND (GALÁPAGOS)

By: Maria Reyes, MSc.

m.reyesperez@unesco-ihe.org
Presentation Structure

1) General Information
2) Problem Description
3) Objective
4) Methodology
5) Results
   – Average costs of water supply in Santa Cruz
   – Analysis on willingness to pay and different tariff structures
   – Scenarios
6) Conclusions
7) Further Research
• Located 600 miles off the coast of Ecuador (South America)
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Exponential population growth (INEC, 2010)

Source: DPNG, 2013
Unreliable and intermittent systems

- Brackish-contaminated Water (Liu, 2010)
- Intermittent supply
- Different Tariff Structures
- No metering (Pto Ayora)

6
Water Supply
(different sources)

1. Municipal supply
   - Puerto Ayora
   - Bellavista
2. Private pumping (crevices in P. Ayora) ➔ trucks (Bellavista)

Crevice “Mision Franciscana”

Crevice “Ingala”
3. Bottled water (6 desalination companies)
Water Tariffs

- Fixed monthly tariffs in Puerto Ayora
- Consumption-based tariffs in Bellavista
  - 1.21 USD/m³

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of connections*</th>
<th>Fixed Value (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic (less than 100 m² of area)</td>
<td>1146</td>
<td>5.24</td>
</tr>
<tr>
<td>Commercial</td>
<td>932</td>
<td>11.24</td>
</tr>
<tr>
<td>Industrial (Big hotels and laundries)</td>
<td>21</td>
<td>45</td>
</tr>
<tr>
<td>Residential (small hotels)</td>
<td>20</td>
<td>28.50</td>
</tr>
<tr>
<td>Official</td>
<td>28</td>
<td>6.12</td>
</tr>
</tbody>
</table>
Presentation Structure

1) General Information
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   – Average costs of water supply in Santa Cruz
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-Analyze financial impacts due to faulty meters in Bellavista and fixed tariffs in Puerto Ayora and influence on water demand.

-Assess several scenarios on tariff structures
Presentation Structure

1) General Information
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6) Conclusions
   – Water Supply
   – Water Demand
7) Further Research
Methodology

Water Supply and Demand

- Interviews (6 organizations)
- Site visits: - Puerto Ayora and Bellavista
- 347 Surveys
  - Domestic (299)
    - Puerto Ayora (240)
    - Bellavista (59)
  - Touristic (29)
  - Restaurants (30)
  - Laundries (16)

Water Tariffs

- Analysis of payments and willingness to pay
- Analysis of Cadastre information
- Development of Scenarios
Presentation Structure

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   - Average costs of water supply in Santa Cruz
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7) Further Research
## Average costs of water supply in Puerto Ayora

<table>
<thead>
<tr>
<th>Category</th>
<th>Average number of connections</th>
<th>Fixed Value (USD)</th>
<th>Average revenue (USD/year)</th>
<th>Average demand per premise (m³/month)</th>
<th>Average cost of water (USD/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic (&lt; 100 m²)</td>
<td>1146</td>
<td>5.24</td>
<td>5, 716</td>
<td>16.2</td>
<td>0.31</td>
</tr>
<tr>
<td>Domestic (&gt;100 m²)</td>
<td>886</td>
<td>11.24</td>
<td>10, 275</td>
<td>18</td>
<td>0.61</td>
</tr>
<tr>
<td>Commercial (restaurants)</td>
<td>49</td>
<td>45</td>
<td>162</td>
<td>42.4</td>
<td>0.26</td>
</tr>
<tr>
<td>Small hotels</td>
<td>21</td>
<td>28.50</td>
<td>917</td>
<td>182.9</td>
<td>0.24</td>
</tr>
<tr>
<td>Big hotels</td>
<td>20</td>
<td>6.12</td>
<td>558</td>
<td>235</td>
<td>0.12</td>
</tr>
</tbody>
</table>
## Average costs of water supply in Bellavista

<table>
<thead>
<tr>
<th>Month</th>
<th>Registered Consumption (m³)</th>
<th>No. of non-working meters</th>
<th>Average demand/ premise (m³)</th>
<th>Total billed (USD)</th>
<th>Price of water (USD/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>5,376</td>
<td>79</td>
<td>15</td>
<td>6,931</td>
<td>1.05</td>
</tr>
<tr>
<td>February</td>
<td>5,370</td>
<td>83</td>
<td>16</td>
<td>6,926</td>
<td>1.04</td>
</tr>
<tr>
<td>March**</td>
<td>330</td>
<td>404</td>
<td>13</td>
<td>829</td>
<td>0.15</td>
</tr>
<tr>
<td>April**</td>
<td>441</td>
<td>407</td>
<td>37</td>
<td>952</td>
<td>0.06</td>
</tr>
<tr>
<td>May</td>
<td>4,605</td>
<td>71</td>
<td>13</td>
<td>6,002</td>
<td>1.09</td>
</tr>
<tr>
<td>June</td>
<td>6,513</td>
<td>72</td>
<td>18</td>
<td>8,313</td>
<td>1.06</td>
</tr>
<tr>
<td>July</td>
<td>6,262</td>
<td>80</td>
<td>18</td>
<td>8010</td>
<td>1.04</td>
</tr>
<tr>
<td>August</td>
<td>5,559</td>
<td>82</td>
<td>16</td>
<td>7,160</td>
<td>1.04</td>
</tr>
<tr>
<td>September</td>
<td>5,654</td>
<td>89</td>
<td>16</td>
<td>7,277</td>
<td>1.02</td>
</tr>
<tr>
<td>October</td>
<td>5,654</td>
<td>90</td>
<td>16</td>
<td>7,278</td>
<td>1.02</td>
</tr>
<tr>
<td>November</td>
<td>5,098</td>
<td>88</td>
<td>14</td>
<td>6,608</td>
<td>1.04</td>
</tr>
<tr>
<td>December</td>
<td>4,965</td>
<td>87</td>
<td>14</td>
<td>6,450</td>
<td>1.04</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>5,506</td>
<td>82</td>
<td>16</td>
<td>7096</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Payment of Tariffs

Puerto Ayora

Bellavista

- 5.24 USD: 28%
- 11.22 USD: 38%
- 28.5 USD: 33%
- 45 USD: 1%

- 5 to 10 USD: 15%
- 11 to 15 USD: 8%
- 16 to 20 USD: 17%
- 21 to 25 USD: 12%
- Above 25 USD: 10%
- No payment: 10%
Analysis of overdue bills

Percentage

Puerto Ayora

Bellavista

January
February
March
April
May
June
July
August
September
October
November
December
### Financial deficit for Puerto Ayora and Bellavista

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Cost of supplied water* (USD/year)</th>
<th>Total billed (USD/year)</th>
<th>Total collected (USD/year)</th>
<th>Deficit with total billed (USD/year)</th>
<th>Deficit with total collected (USD/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Ayora</td>
<td>993,384</td>
<td>211,538</td>
<td>190,926</td>
<td>781,846</td>
<td>802,458</td>
</tr>
<tr>
<td>Bellavista</td>
<td>114,476</td>
<td>74,744</td>
<td>71,620</td>
<td>39,732</td>
<td>42,856</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,107,860</td>
<td>286,282</td>
<td>257,653</td>
<td>821,578</td>
<td>850,206</td>
</tr>
</tbody>
</table>

*Considering only O&M costs
Analysis on willingness to pay and different tariff structures

Puerto Ayora
Bellavista

NO
YES
NO ANSWER

0%
20%
40%
60%
80%
100%

0 to 10
10 to 20
20 to 30
30 to 40
More than 40
USD

Puerto Ayora
Bellavista

100%
80%
60%
40%
20%
0%
Various scenarios on increase of current water tariffs

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Total Billed for 2013</th>
<th>Scenario 1 (20%)</th>
<th>Scenario 2 (40%)</th>
<th>Scenario 3 (60%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Ayora</td>
<td>211.538</td>
<td>380.768</td>
<td>528.844</td>
<td>634.613</td>
</tr>
<tr>
<td>Bellavista</td>
<td>74.744</td>
<td>126.797</td>
<td>174.082</td>
<td>207.858</td>
</tr>
<tr>
<td>Total</td>
<td>286.282</td>
<td>507.565</td>
<td>702.927</td>
<td>842.470</td>
</tr>
<tr>
<td>Deficit 1*</td>
<td>2.892.547</td>
<td>2.671.264</td>
<td>2.475.902</td>
<td>2.336.358</td>
</tr>
<tr>
<td>Deficit 2**</td>
<td>821.578</td>
<td>600.295</td>
<td>404.933</td>
<td>265.389</td>
</tr>
</tbody>
</table>

*Includes investment costs ** Only operations and management costs
## Implementation of different tariff structures

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Revenue (USD/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Tariff Structure</td>
<td>932,045</td>
</tr>
<tr>
<td>Increased Block Tariff</td>
<td>1,003,428</td>
</tr>
</tbody>
</table>

Cost of supply: 1,107,860
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Influence of tariffs in Water Demand

• Puerto Ayora

• Bellavista

\[ R^2 = 0.2737 \]

\[ R^2 = 0.2258 \]

Demand per capita (lpcpd) vs. Number of inhabitants per household

Fixed Tariff → 5.24 USD/month

Consumption-based Tariff → 1.21 USD/m³
Conclusions

• Need for standardized penalties (no payment and spilling tanks)
• High investment is needed if desalination (viable option is installed)
• Installation of water meters to reduce demand (Puerto Ayora)
• Investments could be partly covered by tourists (hotels’ rates)
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# Non-Revenue Water

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Demand (lpcpd)</th>
<th>Total Demand (m³/year)</th>
<th>NRW (m³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Ayora</td>
<td>163</td>
<td>712,188</td>
<td>1,103,760</td>
</tr>
<tr>
<td>Bellavista</td>
<td>96</td>
<td>87,600</td>
<td>94,608</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Demand (lpcpd)</th>
<th>NRW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveys</td>
<td>96</td>
<td>7%</td>
</tr>
<tr>
<td>Municipal Cadastre (1)</td>
<td>56</td>
<td>46%</td>
</tr>
<tr>
<td>Municipal Cadastre (2)</td>
<td>87</td>
<td>16%</td>
</tr>
</tbody>
</table>
Average payment per month for bottled water

Puerto Ayora

- 5 to USD 10: 35%
- 11 to USD 15: 29%
- 16 to USD 20: 22%
- Above 20 USD: 11%

Bellavista

- 5 to 10 USD: 18%
- 11 to 15 USD: 46%
- 16 to 20 USD: 7%
- Above 20 USD: 18%
Fast increment of tourist facilities

• *hotels, restaurants, bars, and others*

→ Higher water demand

→ Pressure on scarce water resources

*Puerto Ayora*
### Quantification of total domestic water demand

#### Municipal Demand

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Bottled Water (m³/year)</th>
<th>Rainwater (m³/year)</th>
<th>Rainwater (m³/year)</th>
<th>Total Demand (m³/year)</th>
<th>Demand per capita (lpcpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Ayora</td>
<td>7,243</td>
<td>57,518</td>
<td>N/A</td>
<td>776,949</td>
<td>177</td>
</tr>
<tr>
<td>Bellavista</td>
<td>2,683</td>
<td>97,444</td>
<td>230,914</td>
<td></td>
<td>253</td>
</tr>
<tr>
<td>TOTAL</td>
<td>9,925</td>
<td>105,825</td>
<td>100,786</td>
<td>97,444</td>
<td>190</td>
</tr>
</tbody>
</table>

#### Municipal Demand

- Puerto Ayora: 7,243 m³/year
- Bellavista: 2,683 m³/year
- Total: 9,925 m³/year

#### Total Demand

- Puerto Ayora: 57,518 m³/year
- Bellavista: 97,444 m³/year
- Total: 105,825 m³/year

#### Municipal Demand per Capita

- Puerto Ayora: 177 lpcpd
- Bellavista: 253 lpcpd
- Average: 190 lpcpd
Total demand quantification
(all categories)

**Demand (m3/day)**

- **Domestic**: 158 m3/day
- **Hotels**: 1,107 m3/day
- **Restaurants**: 70 m3/day
- **Laundries**: 29 m3/day

**Municipal supply**: 1,952 m3/day

**Bottled water**: 1,789 m3/day

**Water Truck**: 1,107 m3/day

**Hotels**: 2,896 m3/day = 55%
Further Research

• Water Balance of Sta. Cruz
• Water Demand Forecasting
• EIA
• Development of Decision Support Tool
Other Problems

- 4) Lack of communication and proper management among institutions
- 5) Wastewater recollection and disposal / contamination
- 6) Lack of information
Overall Objective of PhD Research

To analyse the current water supply situation and demand management practices in Santa Cruz and develop feasible demand management strategies for the future.

Development of a decision support tool to optimize water resources contributing to better quality of life in the islands.
Approach of PhD Research

WATER SUPPLY ASSESSMENT
- municipal
  (Losses)
- rainwater
- Bottled (DES)
- water trucks

WATER DEMAND QUANTIFICATION
- domestic
- touristic
- commercial

WATER DEMAND FORECASTING
- micro-components
- pop. growth
- climatic variability
  (uncertainties)

WASTE WATER TREATMENT-REUSE
Types of treatment

DECISION SUPPORT TOOL
- Optimal solutions for the next 25 years
  (balance/equilibrium between demand and supply)
- Possible scenarios with alternatives for the next 5, 10, 15, 20 and 25 years

COSTS
- supplied water
- bottled water
- wastewater treatment
- desalination
- drinking treatment
Methodology

STAGE ONE

- Literature Review
- Field Data Collection
- Assessment Report
- Meeting with different stakeholder
- Analysis of municipal supply system
- Study of desalination systems (bottled water)
- Assessment of rainwater harvesting
- Different sources of supply
- Physical conditions of different supply sources
- Water balances
- Wastewater disposal
- Coverage by water trucks/vendors
- Quantities supplied
- Costs
- Area of distribution
- Variation in precipitation
  * Climatic variations
  * Temperatures
Preliminary results of first stage

• Municipal supply system → two independent networks between Puerto Ayora and Bellavista

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Puerto Ayora</th>
<th>Bellavista</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of connections</td>
<td>2591</td>
<td>435</td>
</tr>
<tr>
<td>Type of Tariff</td>
<td>Fixed</td>
<td>Metered</td>
</tr>
<tr>
<td>Extraction site</td>
<td>Crevice &quot;La Camiseta&quot;</td>
<td>Constructed Deep Well</td>
</tr>
<tr>
<td>Type of Water</td>
<td>Brackish</td>
<td>Brackish</td>
</tr>
<tr>
<td>Previous treatment</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Constant Supply</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Management</td>
<td>Department of Potable Water</td>
<td>Department of Potable Water</td>
</tr>
</tbody>
</table>

Comparison between two systems
<table>
<thead>
<tr>
<th>Category</th>
<th>Number of connections</th>
<th>Fixed Value (USD/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered (Bellavista)*</td>
<td>444</td>
<td>1.21/m³</td>
</tr>
<tr>
<td>Domestic</td>
<td>1152</td>
<td>5.24</td>
</tr>
<tr>
<td>Commercial</td>
<td>936</td>
<td>11.24</td>
</tr>
<tr>
<td>Small Hotels</td>
<td>14</td>
<td>28.5</td>
</tr>
<tr>
<td>Industrial/ Laundries</td>
<td>7</td>
<td>45</td>
</tr>
<tr>
<td>Big Hotels</td>
<td>20</td>
<td>45.00</td>
</tr>
<tr>
<td>Official</td>
<td>28</td>
<td>6.12</td>
</tr>
<tr>
<td>Pool</td>
<td>1</td>
<td>28.50</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2602</strong></td>
<td><strong>--</strong></td>
</tr>
</tbody>
</table>
Preliminary results for Stage 2

• Locals have had the need to look for alternative sources of water
Problem Description

4) Lack of communication and proper management among institutions

According to MiNTUR → 159 tourist accommodations (only 53 legally registered)

According to Municipality of SC → 118 accommodations

According to Department of Potable Water and Sanitation (DPWS) → 32 touristic connections
**WATER BALANCE FOR PUERTO AYORA**

**W1** - Municipal Water: 3040 m³/day

**W2** - Bottled Water: 25 m³ each/day = 150 m³/day *(82.7%)= 123 m³/day

**W3** - Direct ‘private’ pumping: 1304 m³/day

\[ C_1 = D_1 + R_1 + H_1 + L_1 \]
\[ C_1 = 1951 m^3 + 69 m^3 + 1107 m^3 + 29 m^3 = 3156 m^3 \]

\[ C_2 = D_2 + R_2 + H_2 \]
\[ C_2 = 19.8 m^3 + 7.6 m^3 + 20.6 m^3 = 48 m^3/day \]

\[ C_3 = D_3 + R_3 + H_3 + L_3 \]
\[ C_3 = 157 m^3 + 51 m^3 + 1789 m^3 + 20 m^3 = 2017 m^3 \]
**WATER BALANCE FOR BELLAVISTA**

**W\(_1\)** - Municipal Water Supply System:
- Deep Well = 259 m\(^3\)/day

**W\(_2\)** - Bottled Water (6 desalination companies):
- 25 m\(^3\) each/day = 150 m\(^3\)/day
  - *(17.2%) = 26 m\(^3\)/day

**W\(_3\)** - Rainwater Harvesting*:
- 247 m\(^3\)/day
  - *based on total roof area and average precipitation for 2011 and 2012.

\[ \text{TOTAL DEMAND} = 500 \text{ m}^3/\text{day} \]

- *excluding water trucks

---

\[ \begin{align*}
C\(_1\) &= 226 \text{ m}^3/\text{day} \\
C\(_2\) &= 7 \text{ m}^3/\text{day} \\
C\(_3\) &= 267 \text{ m}^3/\text{day}
\end{align*} \]
Problem Description

• 5) Wastewater recollection and disposal – contamination
• No wastewater treatment
• Precarious and anti-hygienic septic tanks
• Collapsing
• Contamination of
Problem Description

6) Lack of information

– Lack of information regarding water supply and demand.

– Considerable gaps in water demand assessments and technical overlooks of water systems.
Water Demand Quantification

- Survey research method in fieldwork period from September 2013 to January 2014.

<table>
<thead>
<tr>
<th>Type of property</th>
<th>No. of properties</th>
<th>Percentage from the universe</th>
<th>Optimal number of surveys*</th>
<th>Real number of surveys made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>1996</td>
<td>68.9</td>
<td>233.7</td>
<td>240</td>
</tr>
<tr>
<td>Hotels</td>
<td>159</td>
<td>5.5</td>
<td>18.6</td>
<td>29</td>
</tr>
<tr>
<td>Food and Beverages</td>
<td>49</td>
<td>1.7</td>
<td>5.7</td>
<td>30</td>
</tr>
<tr>
<td>Laundries</td>
<td>5</td>
<td>0.2</td>
<td>0.6</td>
<td>16</td>
</tr>
<tr>
<td>Bellavista</td>
<td>435</td>
<td>15.0</td>
<td>50.9</td>
<td>59</td>
</tr>
<tr>
<td>Others (excluded)</td>
<td>251</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total (Universe)</td>
<td>2895</td>
<td>91</td>
<td>310</td>
<td>374</td>
</tr>
</tbody>
</table>
Main parts contained in the survey (Domestic-PA and Bellavista)

• (i) General information ➔ location and description of the household
• (ii) Demand patterns ➔ schedules and habits,
• (iii) Water demand ➔ bottled, municipal, rainwater and from trucks
• (iv) Tariffs and willingness to pay
• (v) Environmental awareness ➔ saving of water and negligences
• (vi) Wastewater treatment
Survey for hotels, restaurants and laundries

• (i) General information
• (ii) Average capacity of customers
• (iii) Water demand quantification regarding different type of sources
• (iv) Willingness to pay
• (v) Environmental awareness
# Results

<table>
<thead>
<tr>
<th>Name</th>
<th>Pumping Flow (l/s)</th>
<th>Pump Power (HP)</th>
<th>Average pumping (h)</th>
<th>Approximate Leakage*</th>
<th>Extraction (m³/d)</th>
<th>Volume (m³/year)</th>
<th>Water treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Camiseta (Puerto Ayora)</td>
<td>35 (2 pumps)</td>
<td>50</td>
<td>12</td>
<td>25%</td>
<td>3024</td>
<td>1103760</td>
<td>NO</td>
</tr>
<tr>
<td>Deep Well (Bella Vista)</td>
<td>6</td>
<td>25</td>
<td>12</td>
<td>15%</td>
<td>259.2</td>
<td>94608</td>
<td>NO</td>
</tr>
</tbody>
</table>
## Private extraction sources

<table>
<thead>
<tr>
<th>Name of crevice</th>
<th>Estimated Extraction (m3/d)</th>
<th>Volume (m3/year)</th>
<th>Water treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingala (1 municipal pump)</td>
<td>648</td>
<td>236520</td>
<td>NO</td>
</tr>
<tr>
<td>Ingala (other private pumps)</td>
<td>296</td>
<td>108040</td>
<td>NO</td>
</tr>
<tr>
<td>Fundacion Charles Darwin</td>
<td>701</td>
<td>255865</td>
<td>NO</td>
</tr>
<tr>
<td>Ninfa</td>
<td>4</td>
<td>1460</td>
<td>NO</td>
</tr>
<tr>
<td>Cascada</td>
<td>192</td>
<td>70080</td>
<td>NO</td>
</tr>
<tr>
<td>Misión Franciscana</td>
<td>25</td>
<td>9125</td>
<td>YES</td>
</tr>
<tr>
<td>Gallardo</td>
<td>25</td>
<td>9125</td>
<td>YES</td>
</tr>
<tr>
<td>Tortuga Bay (3)</td>
<td>60.5</td>
<td>22082.5</td>
<td>SOME</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1951.5</strong></td>
<td><strong>712297.5</strong></td>
<td></td>
</tr>
</tbody>
</table>
Municipal Supply

Connection to Municipal Service

Frequency of service in Puerto Ayora

Frequency of Service in Bellavista
Storage for municipal water

• Due to unreliability of service locals need storage for municipal water