

# **Linden Water Supply Rehabilitation Program (GY-L1036)**

## **Technical Analysis**

### **1. Background**

Guyana Water Incorporated (GWI) is responsible for providing potable water in Linden. The wastewater management falls under the local town councils responsibility.

With coverage of 95%, the Linden water supply system serves 29,500 inhabitants and provides 12-16 hours of service per day. The system comprises five treatment plants, one pressure booster station, four elevated storage tanks (now abandoned), 166 kilometers of transmission and distribution pipelines, and three different sources of water. Issues related to ageing infrastructure, high non-revenue water, and an inconsistent power supply, have all served to compromise GWI's operations and consequently the quality, quantity and reliability of its supply to consumers. In terms of wastewater management, Septic tanks are a common means of domestic sewage disposal, whilst many households also use pit latrines.

The Government of Guyana requested a loan in order to improve the provision of potable water in Linden through improvements in the water production facilities and reductions of NRW levels. Using resources of a technical cooperation (ATN/OC-11805-GY; GY-T1072) an international consulting company (Hydea Consulting) was hired to prepare a master plan and final designs for the rehabilitation of the water supply system in Linden.

The information presented in this document is based on the reports developed by Hydea (2011), and the Water Safety Plan (2009) developed by the Caribbean Environmental Health Institute.

### **2. Current situation and project justification**

*Water Sources.* The system uses three water sources –the Demerara River, the Dakoura Creek, and the Coastal Aquifer (A- Sands). In terms of quantity, these water sources can meet the current demand, however in terms of quality, there is evidence that the ground and surface water is contaminated through usage of pit latrines, and it's been reported that the poor quality of the Demerara River limits the ability of the treatment plants to meet water quality standards. The Dakoura Creek offers good quality water.

*Water Treatment Plants.* Two of the treatment plants (West Watooka and the Wisroc) are located on the Western bank of the Demerara River; the other three treatment plants (Mackenzie, Amelia's Ward and Linden Power Company) are located on the Eastern bank. Each plant, with its associated transmission and distribution network, constitute

separate sub-systems that are connected through valves that are manually adjusted to support the immediate demands of neighboring communities. The average daily water production is estimated at 19,286 m<sup>3</sup>, with each plant operating at different periods of time (see Annex 1), providing an intermittent flow of water from 12 to 16 hours a day. The treatment plants are in various stages of disrepair and operate at various levels of efficiency. Most of the plants are structurally compromised and almost every plant has inoperable components.

*Water Quality.* Even though Guyana has national water quality regulations, they do not address technical standards for potable water quality. The WHO Guidelines for Drinking-Water Quality have been used as a guide by GWI, with a relaxed standard for iron<sup>1</sup>. In all treatment plants, most of the parameters do not comply with acceptable limits, and reporting of water quality is very inconsistent and does not follow a standard procedure. It is also reported that due to problems with transportation and a lack of testing reagents in Georgetown, sampling and testing does not occur according to schedule. Additionally, the limited hours of service and unscheduled service disruptions have caused customers to depend on household storage tanks where water is usually left for a long time, exposed to sunlight and high temperatures, engendering bacteria multiplication.

*Distribution network and other system components.* The 164 Km distribution network is divided into 5 districts (one per treatment plant), with various pipe materials and different installation dates:

<b>Material</b>	<b>Length</b>	<b>%</b>	<b>Installation date</b>
PVC	14,4751.77	88.43	1995-ongoing
Cast iron *	13,669.00	8.35	1970
HDPE	2,403.93	1.47	2004
Everit	1,935.00	1.18	1970
Asbestos cement	682.00	0.42	1970
Galvanized iron	255.00	0.16	1970

\*used only for transporting raw water for industrial use and fire hydrants

In a preliminary pipe inspection performed by Hydea it was observed that the pipes are mainly in fair condition, however water losses in the network are estimated at around 65% on the east bank of the Demerara river and at 60% on the west bank. One of the reasons for these high water losses is that the multiple elevated tanks that the system initially had have been abandoned and the current design allows for head-works supplying peak flow directly into the distribution network, leading to pressure surges.

Estimating water losses for the Linden system is not an easy task, considering that only 9.4% of the customers have meters, and that out of the 16 macro-meters installed, only 10

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<sup>1</sup> This relaxed standard is justified because: i) iron is not detrimental to health, ii) most water sources in Guyana have naturally occurring high levels of iron, iii) and its reduction make treatment very expensive

are working (the other 6 are not activated or by-passed). The inspection performed by Hydea also showed that pipe crossings are in general not adequately protected, with consequential risk of damage of the pipes and contamination of treated water.

*Operation and maintenance (O&M).* GWI Linden has 43 staff dedicated to the operation and maintenance of the system, including 24 treatment plant operators, 6 craftsmen, 3 distribution and production supervisors, 1 electrician, 1 engineer, 1 technician-engineer, 3 fitter machinists, 1 driver, 1 administrative assistant, 1 senior clerk and a manager. Although this crew is enough, the fact that the system has five treatment plants stretches GWI O&M capacity to the limit. Also, the competence of operators could be improved, as the current state of the water supply system infrastructure is partially due to poor O&M practices. GWI Linden doesn't have a preventive maintenance program, and no standard operating procedures. The system has many inoperable components that never got repaired, and there is no consistency in operation practices, and water quality monitoring and reporting.

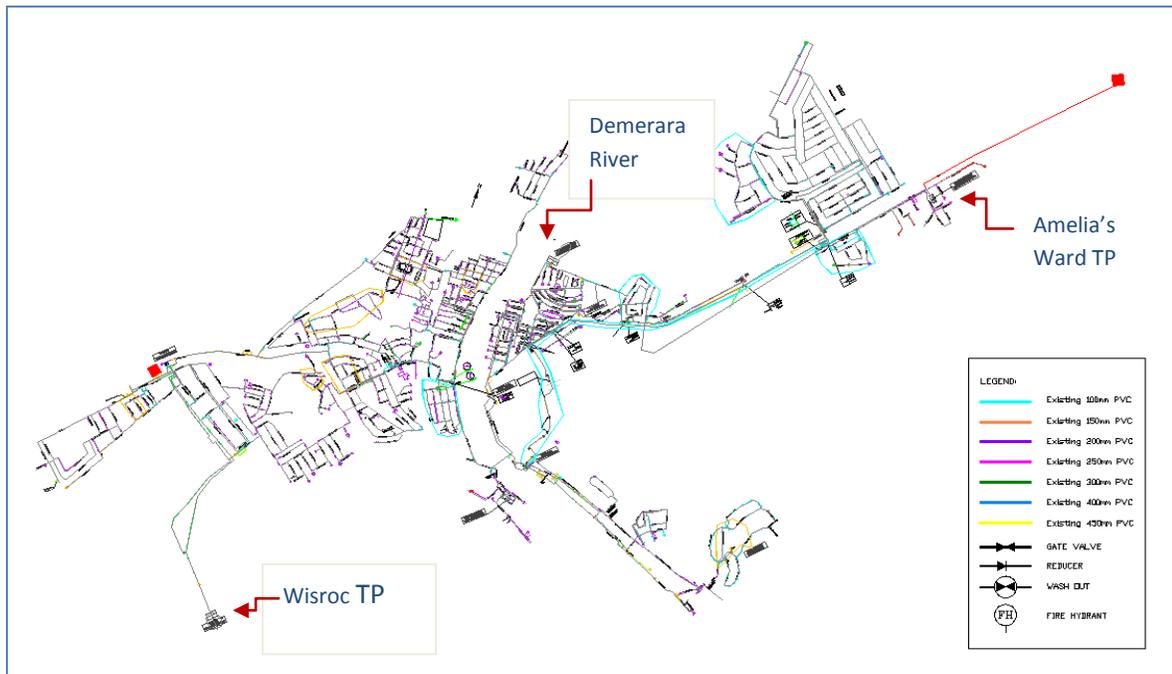
### **3. Project description**

The general objective of the proposed operation is to improve efficiency, quality and sustainability of the potable water services provided in Linden. The specific objectives are to: (i) decrease energy use, improving pressure, quality and continuity of the water supply system; (ii) reduce the level of NRW; and (iii) strengthen GWI performance in terms of operation and maintenance practices. It is proposed that the program be comprised of three components: i) Optimization of the Linden water supply system, ii) NRW Program and iii) Institutional strengthening of GWI.

#### **Component 1: Optimization of the Linden water supply system**

This component will finance the works and activities required to improve the hydraulic performance and the quality of the water supply system in Linden. The project proposes to have two separate systems. One for the western bank of the Demerara River, served by the new treatment plant located at the Wisroc treatment plant site, and the eastern bank system, served by the new treatment plant located at Amelia's Ward site. In terms of water sources, the Demerara River will be abandoned, and only the Dakoura Creek, and the Coastal Aquifer (A- Sands) will continue to be used.

The project will include: (i) the construction of two new treatment plants to ensure the correct quality standards to the water provided, (ii) the construction of a large reservoir for the Wisroc system, (iii) the construction of a large reservoir for the Amelia's Ward system, and (iv) in order to guarantee minimum pressure at the highest points of the systems, an elevated tank will be built for the Wisroc system, and the Mckenzie booster station will be rehabilitated for the Amelia's Ward system (this booster station will be used to serve the area of Richmond Hill). The design horizon is year 2030.



*Design flow.* Several economic and population growth scenarios were considered in order to calculate the projected population and design flow. The selected scenario projects a population of 31,700 by year 2030 with 4.23 inhabitants per household. Using a design daily consumption of 180 l/inhab, in addition to non-residential consumption, the design flow is 124 lts/s (70 lts/s from the Dakoura Creek, and 54 lts/s from the Coastal Aquifer). The annual water production at the treatment plants will be 3,253,610 m<sup>3</sup> (with an average daily production of 8,914 m<sup>3</sup>), for which the Dakoura Creek and Coastal Aquifer have enough capacity.

*Intakes.* The intake for Amelia's Ward treatment plant, drawing water from the Coastal Aquifer will be rehabilitated; this entails the rehabilitation of the existing 3 wells and replacement of 3 submersible pumps. The intake for the Wisroc treatment plant will be newly built at the Dakoura Creek; this entails the construction of a chamber on the bank of the Creek and the installation of pipes and electromechanical equipment.

*Treatment Plants.* The Amelia's Ward treatment plant will be composed of i) an aeration tank to oxidize the high contents of iron in the groundwater from the Coastal Aquifer, as well a to partially remove CO<sub>2</sub>, eliminate substances that produce flavor and odor, and remove organic compounds; as the water from the Coastal Aquifer is very acidic (pH= 4.13), lime (calcium hydroxide) is injected during aeration to bring the pH up to a value of 7; ii) a flocculation tank with a retention time of 31 minutes where with the addition of a polymer (high density anionic polyelectrolyte) and slow and prolonged stirring, the light-weight sludge flakes will aggregate; iii) a sedimentation tank with almost 4 hours of retention time where the aggregated sludge flakes will settle to the bottom of the tank,

from where they are easily removed, iv) three 12 m<sup>2</sup> gravity filters with a face areas of 8 m<sup>3</sup>/h m<sup>2</sup> to remove suspended solids; the filter layer will consist of approximately 0.55 m of sand with grain size of 0.9 mm and 0.45 m of gravel with particles size varying from 4mm to 32mm; v) a chlorination tank with 23 minutes of contact time which is sufficient to disinfect 193.7 m<sup>3</sup>/h. The expected chlorine (sodium hypochlorite) dosage is 3.8 l/h; and vi) two drying beds for drying the sludge, with a capacity of 25 m<sup>3</sup> of liquid mud.

The Wisroc treatment plant will be composed of a i) a screening grid to prevent suspended or floating solids of large and medium size to enter the plant; ii) a contact tank where the acidic water (pH = 4.17) of the Dakoura Creek is neutralized with the addition of lime (calcium hydroxide) to bring the pH up to a value of 7; iii) a flocculation tank with a retention time of 48 minutes, iii) a sedimentation tank with almost 3 hours of retention time and filtration, iv) three 18 m<sup>2</sup> gravity filters with a face area of 7 m<sup>3</sup>/h m<sup>2</sup>; the filter layer will consist of approximately 0.55 m of sand with grain size of 0.9 mm and 0.45 m of gravel with particles size varying from 4mm to 32mm; v) a chlorination tank with 24 minutes of contact time which is sufficient to disinfect 252 m<sup>3</sup>/h. The expected chlorine (sodium hypochlorite) dosage is 4.8 l/h; and vi) two drying beds for drying the sludge, with a capacity of 25 m<sup>3</sup> of liquid mud.

*Reservoirs and elevated tanks.* The reservoir at Wisroc will have a capacity of 3400 m<sup>3</sup>, and the elevated tank will have a capacity of 400 m<sup>3</sup>. The reservoir at Amelia's Ward will have a capacity of 2600 m<sup>3</sup>. All reservoirs and tanks will be built with reinforced concrete.

Activities under Component 1 will be completed by GWI contracting out the civil works to international firms. The supervision will be contracted with an international company, which at the same time will provide mentoring to GWI personnel on the construction and supervision of this kind of works.

## **Component 2: Non- Revenue Water Program**

This component will finance activities to reduce the level of NRW in Linden. It will include: (i) development of a NRW management program to address, monitor and control physical and commercial losses; (ii) installation of micro-meters; and (iii) rehabilitation of part of the network.

*NRW management.* A detailed water audit is required in order to identify where water losses are concentrating; this audit will include among other activities the performance of hydraulic measurements to ascertain the level of real losses. The unavoidable water losses level will be assessed, as well as the economic optimum water losses level. A real and apparent losses reduction plan will be developed with a schedule and related budget, as well as a plan for ongoing maintenance of the loss control mechanisms. Annex 2 includes some potential actions for a water loss control program.

*Water meter installation program.* A total of 5,200 single jet inferential meters class C will be installed by 2014 (at G\$ 50,000 each including materials and works). This will be completed primarily by GWI contracting out the works to local independent contractors.

*Distribution system rehabilitation.* The results of the water audit will be used to determine sections of the network to be rehabilitated. However a preliminary assessment of existing pipes to be substituted has been done by Hydea, based on the material and age of the pipes. This calculation is the basis for the budgeted amount for this activity. Additionally, the new design proposes the installation of a flow meter that will measure the water supplied to Richmond Hill.

**Component 3: Institutional strengthening of GWI:** This component will address the institutional strengthening needs of GWI in Linden and will improve the understanding of potential problems connected to the uncontrolled disposal of septic tanks sludge. It will include: (i) capacity building activities on O&M; and (ii) preparation of O&M manuals and standard operating procedures for the new system and assets.

#### **4. Alternatives considered**

Three alternatives for the improvement of the Linden Water Supply System, and a no-action alternative have been identified and compared. The three alternatives have as common elements the distribution system rehabilitation, the water meter installation program, and the abandonment of the LPC treatment plan. The differentiating elements are described below:

**Option 1.** Entails the construction of two new treatment plants at the Wisroc and Amelia's Ward sites, the construction of two high-capacity water reservoirs in the areas of Wisroc and Amelia's Ward, the construction of an elevated tank for the Wisroc system, the rehabilitation of the Mckenzie booster station for the Amelia's Ward system, and the laying of transmission mains. The West Watooka and Mckenzie plants would be preserved as emergency sources.

**Option 2.** Entails the construction of a new treatment plant at Wisroc's site and extraordinary maintenance measures for Amelia's Ward treatment plant, the construction of two high-capacity water reservoirs in the areas of Wisroc and Amelia's Ward for the storage of treated water, and two elevated tanks, and the laying of connecting mains. The West Watooka and Mckenzie plants would be preserved as emergency sources.

**Option 3.** Proposes the rehabilitation of West Watooka and Mckenzie treatment plants, rebuilding of Wismar treatment plant, and the construction of three small elevated tanks near the three rehabilitated treatment plants.

Option 1 was selected to be implemented as it meets the project objectives at a rational cost. Annex 3 shows an analysis and comparison of these alternatives, including the no-action scenario.

## 5. Operation and Maintenance

O & M activities will be carried out by GWI, specifically by the Linden's operations unit. The unit will be composed of a manager, a support engineer, 6 craftsmen, 3 distribution and production supervisors, 1 electrician, 1 driver, and 1 administrative assistant. Also, eight operators will be assigned for the treatment plants (3 shifts). Most of the institutional strengthening activities are addressing identified needs related to O&M capacity of GWI Linden.

## 6. Costs and financing

The investments for the rehabilitation of the Linden Water Supply system will be covered by the Ministry of Housing and Water. These investment costs are:

Activity	Estimated budget (US\$ mil)
<b><u>Optimization of the water supply system in Linden</u></b>	<b>7.91</b>
Wisroc intake	0.06
Wisroc Treatment Plant	1.85
Wisroc reservoir	1.59
Wisroc elevated tank	0.20
Amelia's Ward Treatment Plant	1.64
Amelia's Ward reservoir	1.57
Amelia's Ward wells rehabilitation	0.30
Work Supervision / mentoring	0.7
<b><u>NRW Program</u></b>	<b>2.45</b>
Leakage detection program	0.26
Network rehabilitation	2.19
<b><u>Institutional strengthening of GWI</u></b>	<b>0.31</b>
SOP; O&M Training (for the system)	0.19
Costumers Service training	0.025
Public Awareness Campaign	0.05
Training on Environmental and Social issues & Water Quality monitoring	0.045
Project administration	0.23
Audit	0.1
Monitoring	0.02
Mid-term and Final Evaluation	0.06
Contingencies	1.14
Financial charges	0.095
<b>TOTAL</b>	<b>12.3</b>



## Annex 1

### Linden Treatment Plants Information

Treatment Plant	Location	Source	Year Commissioned	Population served	Treatment Capacity		Components	Hours of Operation	Service Areas
					Design	Operation			
Amelia's Ward	South Amelia's Ward	Ground water - A Sands Aquifer	1985	7,305	3,636 m <sup>3</sup>	3,632 m <sup>3</sup>	Aeration, filtration, chlorination	24 hours	Central, North, South & East Amelia's Ward, Cinderella City, Squatters Area
LPC	Alumina Plant, Spreightland	Demerara River	1961	2,373	5,000 m <sup>3</sup>	2,765 m <sup>3</sup>	Coagulation, flocculation, sedimentation, filtration, chlorination	5:00 am – 10:30 pm	Spreightland, Retrieve, Rainbow City, Industrial Area. Old, New & Lower Kara Kara, North Cocatara
McKenzie	Watooka, at McKenzie/ Wismar Bridge	Demerara River	1956	4,086	5,000 m <sup>3</sup>	3,888 m <sup>3</sup>	Coagulation, flocculation, sedimentation, filtration (pressure), chlorination	5:00 am – 10:30 pm	Old, New & Lower Kara Kara, Rainbow City, Retrieve, Industrial Area, North McKenzie, Noitgedacht, Cocatara, Redwood Crescent, Constabulary Compound, Watooka, Fairs Rust, Surapana, Richmond Hill
West Watooka	West Watooka	Demerara River	1968	12,233	7,272 m <sup>3</sup>	4,105 m <sup>3</sup>	Coagulation, flocculation, sedimentation, filtration, chlorination	5:00 am – 10:30 pm	West Watooka, Wismar Silver town, Silver City, Christianburg, Half Mile
Wisroc	Wisroc on Dakoura Creek	Dakoura Creek	1976	3,502	5,909 m <sup>3</sup>	4,897 m <sup>3</sup>	Pre-Filtration, chlorination	24 hours	Wisroc, Block 22, Blueberry Hill, Canvas City, Section of One Mile

## **Annex 2**

### **Potential Actions for a Water Loss Control Program**

1. Overhead reduction tasks (real losses)
  - a. Leakage reduction
  - b. Hydraulic controls (pressure management)
  - c. Pipe repair and replacement
  - d. Customer service pipe replacement
  - e. Condition assessment and rehabilitation
  - f. Energy management
  - g. Resources management
2. Revenue stream enhancement (apparent losses)
  - a. Baseline analysis
  - b. Meter population management
  - c. Meter testing and change out
  - d. Meter correct sizing and change out
  - e. Periodic testing
  - f. Automatic meter reading (MR)
3. Billing structure analysis and improvements
  - a. Non-payment actions
    - i. Turn off supply
    - ii. Reduce supply to minimum
    - iii. Legal action
    - iv. Prepayment schemes
    - v. Reduction of fraud and illegal connections
    - vi. Continuous field inspections and testing
  - b. Tariff management
  - c. Customer base management

### Annex 3

#### Analysis of Alternatives for Rehabilitation of the Linden Water System

OBJECTIVES	OPTIONS			
	Option #1	Option #2	Option # 3	Option#4 - No- Action
Ensure the continuity of water supply to the customers.	<ul style="list-style-type: none"> <li>- The reservoirs ensure the continuity of water distribution and the reduction of energy consumption</li> <li>- The elevated tank for the Wisroc system and the booster station for the Amelia's Ward system ensure water distribution even to the higher elevations. Additionally the elevated tank at Wisroc will allow compensation capacity for possible future development needs</li> </ul>	<ul style="list-style-type: none"> <li>- The reservoirs ensure the continuity of water distribution and the reduction of energy consumption</li> <li>- The elevated tanks ensure water distribution even to the higher elevations in the town and allow compensation capacity for possible future development needs</li> </ul>	<ul style="list-style-type: none"> <li>- The elevated tanks (near TPs at low elevations) ensure water compensation capacity for customers (limited capacity)</li> <li>- No large storage reservoirs - Water supply continuity is not guaranteed globally across the system</li> </ul>	<ul style="list-style-type: none"> <li>- Continue the use of existing plants without storage reservoirs and with only minor repairs                             <ul style="list-style-type: none"> <li>➤ No improvement in continuity of supply</li> <li>➤ Continued Dissatisfaction by residents</li> </ul> </li> </ul>
<b>Option Meets Objective?</b>	<b>Objective Met</b>	<b>Objective Met</b>	<b>Objective Partially Met</b>	<b>Objective Not Met</b>
Ensure the correct water quality standards	<ul style="list-style-type: none"> <li>- The new treatment plants ensure the improvement of the water quality</li> </ul>	<ul style="list-style-type: none"> <li>- The new treatment plant in Wisroc ensures the improvement of the water quality of water supplied.</li> <li>- The extra-ordinary measures for Amelia's Ward improves the water quality but not at the level of Option #1.</li> </ul>	<ul style="list-style-type: none"> <li>- The rehabilitation of the existing West Watooka and McKenzie TPs and the reconstruction of Wismar TP improves the water quality in sectors of the system served by the treatment plants</li> <li>- Limited water quality improvement in the areas serviced by the Amelia's Ward TP</li> </ul>	<ul style="list-style-type: none"> <li>- Continue use of existing treatment plants with minor and routine repairs                             <ul style="list-style-type: none"> <li>➤ Limited improvement in water quality of supply</li> <li>➤ Continued dissatisfaction by residents</li> <li>➤ Continued disposal of sludge and back wash water into the Demerara River ( West Watooka Plant)</li> </ul> </li> </ul>
<b>Option Meets Objective?</b>	<b>Objective Met</b>	<b>Objective Partially Met</b>	<b>Objective Partially Met</b>	<b>Objective Not Met</b>

OBJECTIVES	OPTIONS			
	Option #1	Option #2	Option # 3	Option#4 - No- Action
Optimize the distribution system to minimize water losses	<ul style="list-style-type: none"> <li>- Leakage detection campaign – facilitates identification of the sections of the network to be substituted</li> <li>- The rehabilitation of the defective sections of the network ensures the reduction of water losses and eliminate the risk of contamination of drinkable water</li> <li>- Reduction of the annual energy and maintenance costs</li> </ul>	<ul style="list-style-type: none"> <li>- Leakage detection campaign - facilitates identification of the sections of the network to be substituted</li> <li>- The rehabilitation of the defective sections of the network ensures the reduction of water losses and eliminate the risk of contamination of drinkable water</li> <li>- Reduction of the annual energy and maintenance costs</li> </ul>	<ul style="list-style-type: none"> <li>- Leakage detection campaign - allows for an exact identification of the sections of the network to be substituted</li> <li>- The rehabilitation of the defective sections of the network ensures the reduction of water losses and eliminate the risk of contamination of drinkable water</li> </ul>	<ul style="list-style-type: none"> <li>- No leakage detection study</li> <li>- No replacement of damaged sections <ul style="list-style-type: none"> <li>➤ Continued high losses</li> <li>➤ High levels of NRW</li> <li>➤ Potential contamination due to leakage</li> </ul> </li> </ul>
<b>Option Meets Objective?</b>	<b>Objective Met</b>	<b>Objective Met</b>	<b>Objective Partially Met</b>	<b>Objective Not Met</b>
<b>Disadvantages</b>	The most expensive option	<ul style="list-style-type: none"> <li>- Keeping the existing treatment plant in Amelia's Ward means lower water quality for the Eastern supply network with respect to the Western network (social discrimination)</li> <li>- Lower quality compared with Option # 1</li> </ul>	<ul style="list-style-type: none"> <li>- Water supply continuity is not guaranteed globally due to the absence of large ground storage reservoirs</li> <li>- The location of the elevated tanks in low areas does not guarantee the correct supply to the high areas of Linden (to be served with direct pumping)</li> <li>- Excessive energy consumption and low pressure (as in the present s and continuous direct pumping in the network</li> </ul>	Existing conditions remain unchanged : <ul style="list-style-type: none"> <li>- Discontinuity of supply</li> <li>- Continued delivery of low quality water through the distribution system</li> <li>- Continued losses and high energy costs</li> <li>- Continued risk to public health</li> <li>- Continued dependence on household storage with attendant risks</li> </ul>