FEDERAL UNIVERSITY OF CEARÁ

COLUMBIA WATER CENTER

FUNDAÇÃO CEARENSE DE PESQUISA E CULTURA

DEPARTMENT OF HYDRAULIC AND ENVIRONMENTAL ENGINEERING

MUNICIPAL WATER PLAN

MILHÃ-Ceará

Seeking universalization and water sustainability.

BEFORE

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FOREWORD

This MUNICIPAL WATER PLAN - PAM - for the municipality of Milhã, in the state of Ceará, has been drafted by the Climate Risk Management and Water Sustainability Group of the **Federal University of Ceará**, under the international cooperation agreement between Fundação Cearense de Pesquisa e Cultura – FCPC/UFC and the **Columbia Water Center** - CWC of Columbia University - New York, sponsored by the **Pepsico Foundation** in the United States of America.

PAM-Milhã is a product of research and proactive actions of structural intervention. It is being developed since 2009 by GGRC/UFC/CWC, investigating water sustainability to provide water for human supply in rural communities in Brazil's semi-arid region, more specifically in the central *sertão* of the state of Ceará, covering the region including the following municipalities: Quixeramobim, Solonópole, Senador Pompeu, Deputado Irapuan Pinheiro and Milhã. Our research focused on the last three municipalities and the focus of structural interventions was the municipality of Milhã.

Institutional support provided by **Milhã's Municipal Government** was crucial for structural actions and development of research in the municipality to be successful. We also emphasize institutional support provided by the **State Secretariat for Agriculture Development** - SDA, through the Program to Fight Rural Poverty in Ceará - **São José Project**. This partnership made our project possible.

The PAM aims to provide the municipality of Milhã with a tool to plan basic sanitation and water resources actions targeting universalization and sustainability of human water supply systems in rural communities within its territory, according to the provisions of Act 11.445 of January 5 2007, known as the Basic Sanitation Act, which provides National Guidelines for basic sanitation and the Federal Policy on Basic Sanitation.

The PAM suggests a shared agenda between levels of government, at the municipal, state and federal levels, with civil society, represented by community associations and non-governmental organizations, in order to achieve the common goal of universalizing human water supply with guarantees in terms of quantity and quality, and its long term sustainability, minimizing the need for emergency action to provide water for people using water trucks in the municipality, in case structural and non-structural interventions proposed here are actually carried out.

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1. INTRODUCTION

The State of Ceará is distributed over a land area of 148,825 km^2 (IBGE, Res. nº 05, 10/10/2002). It has 8,547,809 inhabitants (IBGE, 2009) spread across 184 municipalities, 150 of which are located in Brazil's semi-arid region. This corresponds to 86.83% of the state's total land area. According to data from the Ministry of National Integration (New Borders of Brazil's Semi-Arid Region, MI, Mar 10 2005), Ceará's population totals 2,451,214 inhabitants in urban zones and 1,760,078 in rural zones. The population of Ceará living in the semi-arid rural zone totals 20.5% of the state's total population.

The semi-arid region is officially acknowledged by the Federal Government as an area whose main characteristics are as follows: average rainfall is below 800 mm; an aridity index of up to 0.5 calculated from the water balance between potential precipitation and evapotranspiration from 1961 to 1990; risk of drought greater than 60%, based on the period from 1970 to 1990. In the region of Milhã the rainfall index is 763 mm/year and evaporation exceeds 2069 mm/year.

In addition to the semi-arid climate issue, there is also a geological problem. 80% of the state's land rests on crystalline rock with a layer of superficial soil without underground water resources which could provide water in the amount and quality that are necessary for human supply. Ground water within the crystalline rocks is caught in deep wells with an average flow rate of only 2 m^3/h. It also has high salinity content and is improper for human consumption, requiring its desalination.

The combination of those adverse climate and geological factors in the state of Ceará makes it difficult to supply rural and urban populations and to provide water for economic production activities, above all agriculture and livestock. In drought periods rainfall becomes increasingly irregular across time and space. This compromises human supply and agricultural economic activities, leading to serious economic and, above all, social problems, with families being shattered and the need for government intervention with emergency actions, such as hiring water trucks to provide water for rural communities in the sertão especially, and sometimes expanding the water truck program to municipal centers and large urban districts.

The issue of access to water for scattered rural populations is a challenge still to be overcome. Water supply for population centers with less than 50 families (approximately 250 people) has been proving to be economically unfeasible due to the high cost of necessary water infrastructure, to the fact that communities are scattered across the land and especially due to the **lack of a sustainable and appropriate management model** to promote the implemented systems' operation and maintenance, ensuring a continuous supply of quality water for those populations.

Recognizing the need for the University to be more proactive as a repository of a scientific basis and generation of knowledge, the Climate Risk and Water Sustainability Management Group (GGRC) was set up at the Department of Hydraulic and Environmental Engineering of the Federal University of Ceará, aiming to conduct research and develop strategies for man's adaptation to climate variability and change, incorporating risk management to guarantee water sustainability and safety in human societies in the semi-arid region of Northeast Brazil. Such strategies incorporate the design and implementation of infrastructure as well as its management.

The GGRC/UFC research project was then created based on its partnership with The Earth Institute at Columbia University in New York through its Water Center (CWC) and funded by the Pepsico Foundation to develop an international program that aimed to coordinate a series of scientifically based actions of great impact to reach a solution for the ever growing water crisis in low income areas in Brazil, India, China and Sub-Saharan Africa. In Brazil the project's leading institution is the Federal University of Ceará and Ceará's Foundation for Research and Culture (FCPC) as the operator of funds from Columbia University. The following are among the specific goals of the Brazilian counterpart of the project:

- Defining criteria to design resilient social-natural systems;
- Developing water supply solutions for human populations at a local and specific scale;
- Incorporating climate risk management into the design and management of water systems to improve decision making techniques under uncertainty;
- Developing transparency mechanisms which may improve the water allocation process in Ceará.

The two main goals of the project fit within the scope of looking for alternative solutions to the issue of access to water for small rural communities scattered across the sertão, which are considered the weakest link of the chain of populations that suffer with the hardships of lack of water caused by periodic droughts that occur throughout semi-arid lands in Northeast Brazil. Those communities are often supplied by water trucks during annual droughts, which do not always correspond to actual "dry years"; there is simply no source of water for supply when water stored in small local reservoirs is used up after the rainy season.

The analysis of this matter by the GGRC/CWC reached a conclusion in favor of the following strategy for action:

- Choosing an area to conduct preliminary research within the semi-arid region in the Northeast, particularly in Ceará's central sertão. The following municipalities were selected: Quixeramobim, Senador Pompeu, Deputado Irapuan Pinheiro, Solonópole and Milhã;
- Surveying supply routes of the 2007 Operation Water Truck executed by the Brazilian Army in the researched region in order to identify rural communities included in the program;
- Visiting communities in municipalities supplied by water trucks in order to identify the ones that need water the most;
- Selecting some among those communities to be the object of structural supply actions and to apply a model based on community participatory self-management, utilizing social capital and encouraging their organization capacity;
- Implementing a pilot supply project and following through community management performance.

The results of actions which took place after the implementation of the abovementioned steps by GGRC/CWC have led us to reach the conclusion that it was necessary to draw up a MUNICIPAL WATER PLAN - PAM which addresses the following functions:

- a consolidated diagnosis of **rural communities** in the municipality: identifying communities and their locations through georeferencing and a semi-census;
- diagnosing **available water sources** within the municipality: identifying superficial and underground springs, their location and their quantitative and qualitative water supply capacity to meet water needs;
- diagnosing **water demands** within the municipality: identifying community consumption considering multiple uses of water, but focusing primarily on drinking water;
- diagnosing **water balance**: identifying the difference between available water supply and consumption for multiple uses, prioritizing human supply and drinking water for animals;
- an institutional diagnosis and a diagnosis of the **self-organization capacity** of those communities identifying the available **social capital** in each one;
- drawing up a **plan for new water interventions**: aiming to improve water supply for multiple uses prioritizing human supply and drinking water for animals;
- drawing up a **plan to universalize water supply:** identifying necessary interventions at local, regional and municipal scales to guarantee access to water for the entire population in the municipality;

coming up with a **polymorphic sustainable management model:** identifying the sustainable management models that adapt to different realities observed in the communities in the field, following sustainability principles and aiming to achieve maximum social and economic efficiency managing the systems.

The focus of the MUNICIPAL WATER PLAN - PAM which is now concluded is to work as a planning tool for the municipality in order to suggest strategies to achieve universalization and sustainability of water supply systems for human supply within the municipality, including small rural communities as well as municipal centers and larger district urban centers.

Milhã's PAM therefore corresponds to one of the products of research conducted by the GGRC/CWC, expanding the universe of communities included in the project within the municipality, in addition to communities which received the implementation of a pilot water supply system funded and built by the municipality itself.

Milhã's PAM is presented in nine chapters: The first chapter is the introduction. The second chapter provides an overall description of the municipality of Milhã. The third chapter offers a diagnosis of water resources at the municipal level. The fourth chapter provides a diagnosis of rural communities in the municipality, focusing on the issue of human supply. The fifth chapter presents a suggestion for priority interventions to universalize water supply for rural communities. The sixth chapter offers suggestions of structural interventions to improve municipal water supply in quantitative and qualitative terms for multiple uses, focusing, however, on human supply. Chapter seven shows a consolidation of the estimated cost of interventions. Chapter eight discusses sustainable management models for supply systems in small rural communities and strategies to achieve it. Finally, we provide references that supported the production of this plan.

2. GENERAL FEATURES OF MILHÃ

2.1 Location and Access

The municipality of Milhã is located in the state of Ceará; its geographical coordinates are 5º 40' 30" S, 39º 11' 38" W, in the mesoregion of the Sertão Cearense and the microregion of Sertão of Senador Pompeu within the following borders:

- North: the municipality of Quixeramobim;
- South: the municipalities of Deputado Irapuan Pinheiro and Solonópole;
- East: the municipality of Solonópole;
- West: the municipalities of Quixeramobim and Senador Pompeu.

Figure 2.1 shows the location of the municipality of Milhã.

Figure 2.1: Map showing the location of the municipality of Milhã, State of Ceará, Brazil. **(Source: Wikipedia, 2009)**

The municipality is 301.1 km away from the state capital, Fortaleza. Access to Milhã from Fortaleza is provided through highways CE-060 and BR-226. The route to Milhã is: Fortaleza → Quixeramobim → Senador Pompeu→Milhã. Through state roads, whether paved or carriageable, other interconnected villages, communities and farms around the municipality can be reached. Most of them can be reached any time of the year.

2.2 History of Milhã's Formation

The name Milhã comes from a grasslike plant from that region. Locals are called *milhãense.* Its origins are recent. It used to be a District separated from the neighboring municipality of Solonópole and located on the right bank of the River Capitão-Mor. Milhã started being populated in the early 20th century by small farmers, traders and livestock farmers.

The village of Milhã was promoted to District by Decree number 1.540 of May 3 1935, under the authority of the municipality of Cachoeira. By State Decree number 1.114 of December 30 1943 the municipality of Cachoeira received the name of Solonópole. Milhã was promoted to the category of municipality by State Act number 4.448 of January 3 1959, being separated from Solonópole and including the municipal center in Milhã and the district of Carnaubinha. By State Act number 8.339 of December 14 1965 the municipality of Milhã ceased to exist and its territory was again added to Solonópole.

It was once more promoted to the category of municipality by State Act number 11.011 of February 5 1985, with the municipal center in Milhã and the district of Carnaubinha. In 1988 there was a change to its land division with three districts: the municipal center of Milhã and the districts of Carnaubinha and Monte Grave. According to Municipal Act number 12 of December 16 2002 another three districts were created: Baixa Verde, Barra and Ipueira. Figure 2.2 shows a map of Milhã.

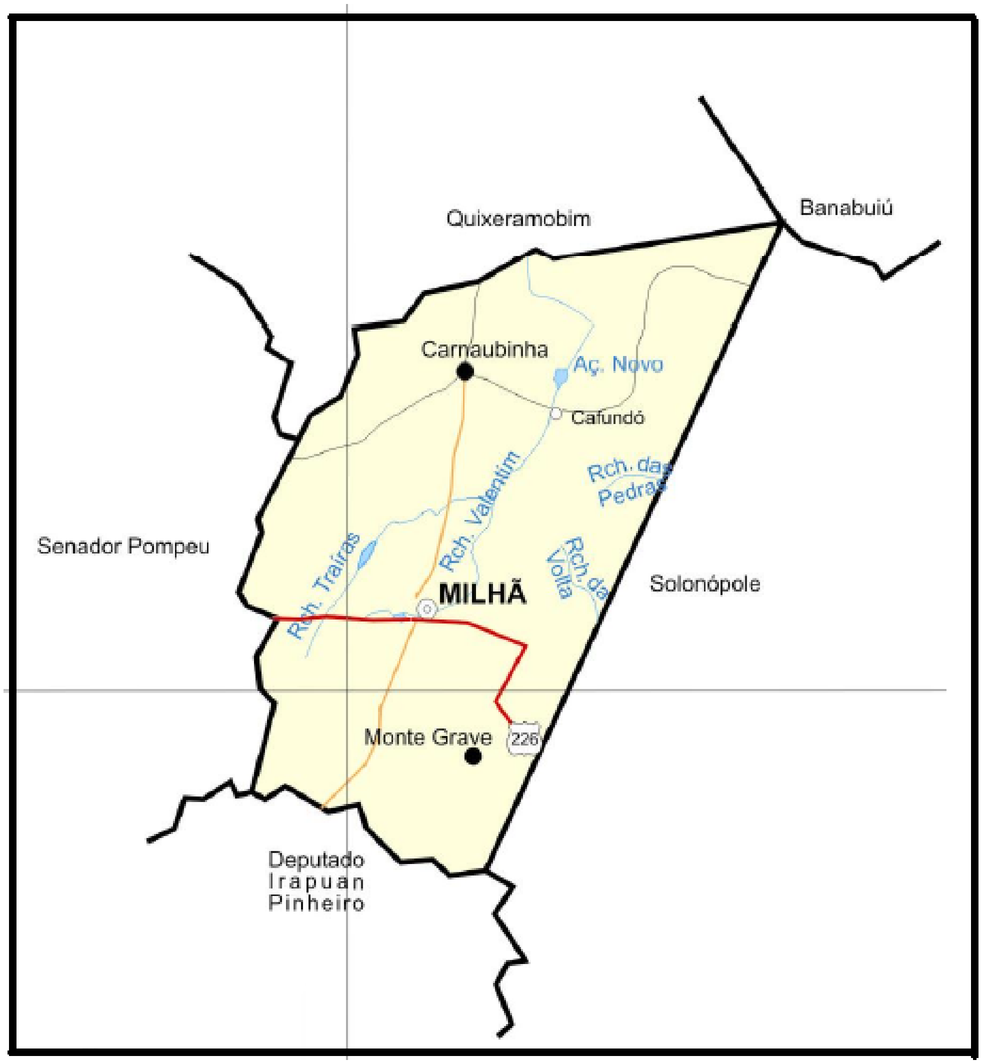


Figure 2.2: Map of Milhã. **(Source: IPECE, 2008)**

2.3 General Information about the Municipality

2.3.1 Area and Population

Area:

The municipality covers an area of 502,036 Km².

Population:

The municipality's population totals **14,826** inhabitants according to IBGE data from 2009. Population data according to the 2000 census was:

• Total Population (2000): 13,028 inhabitants.

• Urban Population (2000): 5,054 inhabitants.

• Rural Population (2000): 7,974 inhabitants.

• Population Density (2000): 25.95 inhabitants/Km².

• Current Population Density: 28.11 inhabitants/Km².

• Rate of Urbanization (2000): 39.79%

The municipality's population evolution is shown in Figure 2.3.

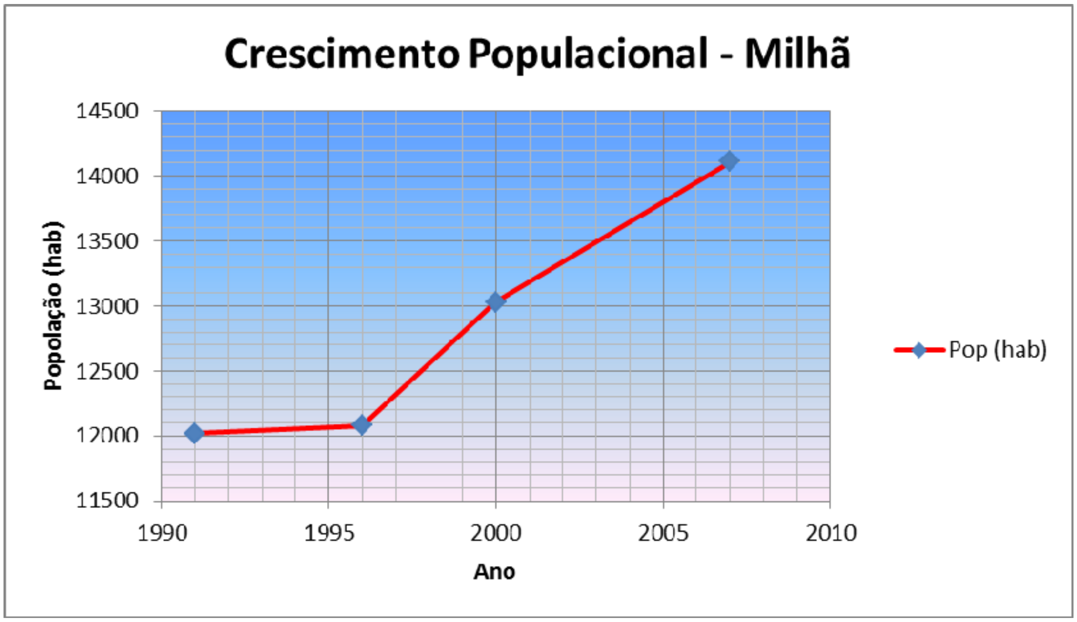


Figure 2.3: Population Growth Curve for Milhã. (Source: IBGE, 2009)

2.3.2 Physiographic Aspects

Temperature:

The average temperature ranges from 26 ºC to 28 ºC with maximum averages of 29 ºC and minimum averages of 23 ºC.

Climate:

Hot tropical semi-arid.

Rainfall:

Averaged annual precipitation is 715 mm/year. Figure 2.4 shows annual rainfall variations in the municipality of Milhã, according to FUNCEME's rainfall station. Figure 2.5 shows average monthly rainfall variations in the municipality.

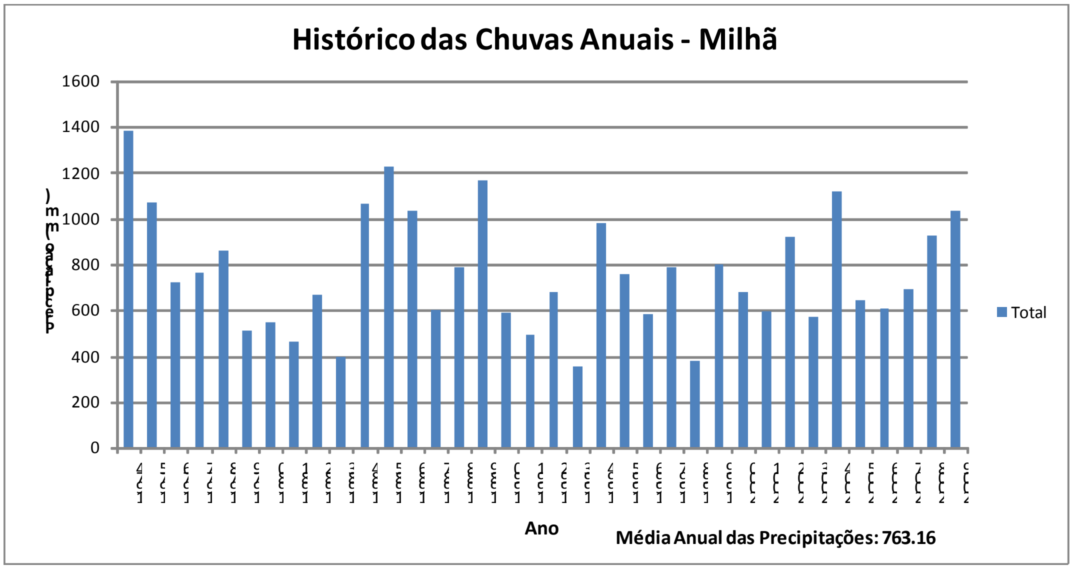


Figure 2.4: History of total annual precipitation in Milhã.

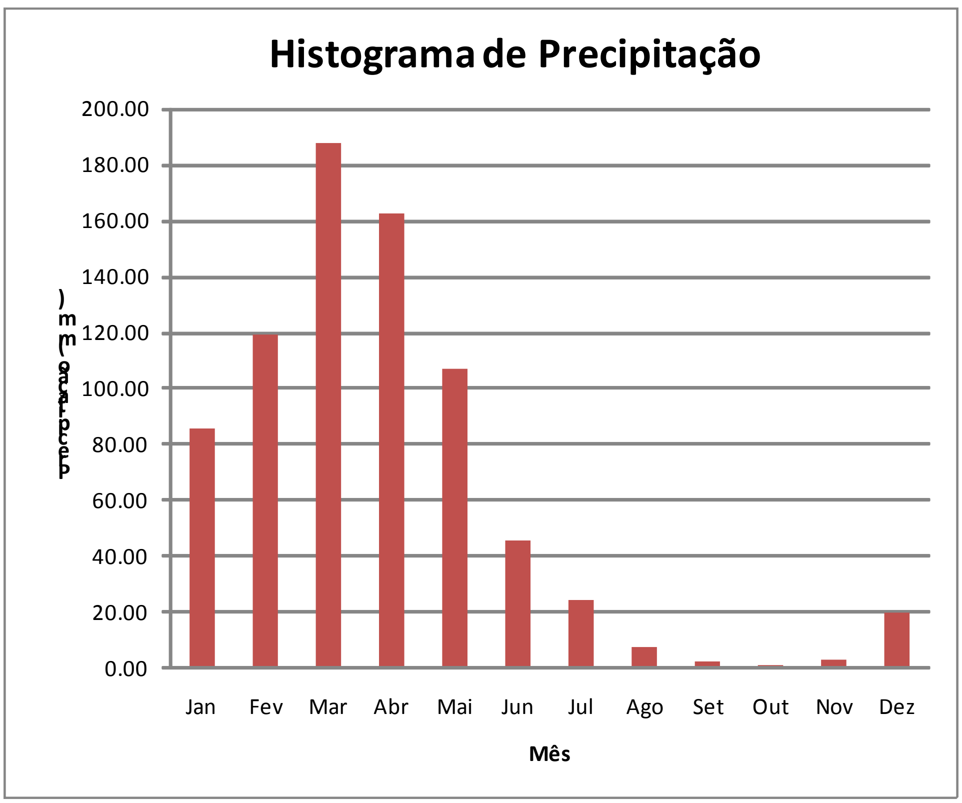


Figure 2.5: Average monthly rainfall variation in Milhã.

Vegetation:

The predominant vegetation type is dense caatinga bushes.

Relief:

Average altitude is 215m. Its relief has soft shapes that are only slightly separated from the Sertaneja Depression, a product of the flattening of surfaces that has occurred since the Cenozoic. Altitudes range from 200 to 500 m.

Soil:

Soils are lithologic and there are Noncalcic Brown, Solodic Planosol, Red-Yellow Podzolic and Regosol soils.

Geology:

According to CPRM data, there are only ancient rocks, granites, gneiss and precambrian migmatites. Small colluvium stains (conglomeratic and sandy sediments) can also be found, as well as alluvium deposits on the beds of main draining rivers. Figure 2.6 shows the inclusion of Milhã within the geological foundation of the State of Ceará.

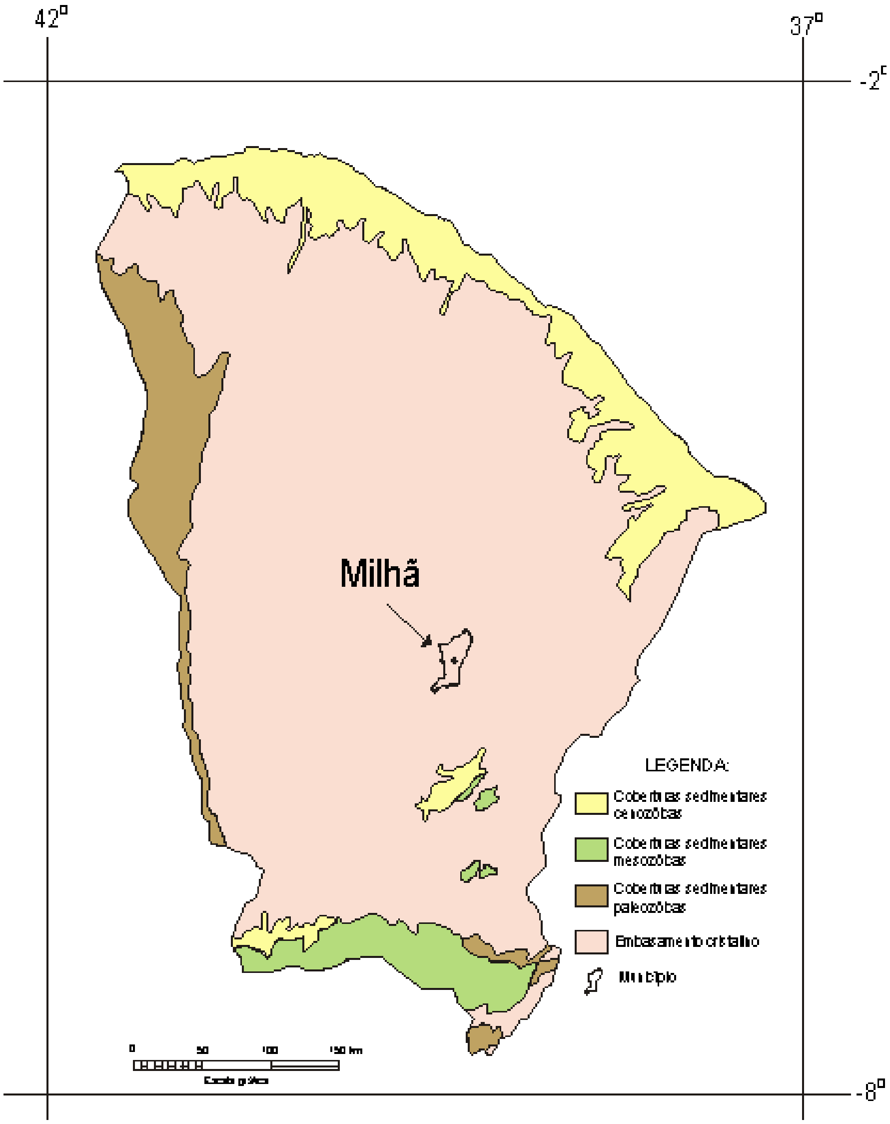


Figure 2.6: Inclusion of Milhã within the geological foundation of the State of Ceará. **(Source: CPRM, 2008)**

2.3.3 Socioeconomic Aspects

The municipality of Milhã has a scenario of relative socioeconomic poverty with respect to key indicators adopted for comparison with other municipalities in the region and Brazil.

Human Development Index

The HDI is one of the main indicators used by international bodies to rank a society's stage of development and economy in a given region or country. The HDI can be used to compare the level of economic development and quality of life offered to people. The HDI ranges hypothetically from 0 (no human development) to 1 (full human development). A country or region becomes more developed as it approaches 1. International ranking considers:

- from 0 to 0.499: countries with low HDI, a sign of underdevelopment;

- from 0.500 to 0,799: countries with an average HDI, a sign of a development process;

- from 0.800 to 1: countries with high HDI, considered to be developed.

Brazil's Global HDI is 0.769 (PNUD 2007/2008). Fortaleza, the capital of Ceará, has an HDI of 0.786, while Milhã's HDI is **0.632**.

Gini Index

The Gini coefficient is a measure of statistical dispersion developed by Italian statistician Corrado Gini. It consists of a number between 0 and 1, 0 being perfect income equality (where everyone has the same income) and 1 being perfect income inequality (where an individual has all the income and the rest have nothing). Figure 2.7 shows the graphic representation of the Gini Coefficient, called the Lorenz curve. The horizontal axis represents income and the vertical axis represents the amount of people. The diagonal line represents perfect income equality and the central yellow area represents the Gini Coefficient or Index.

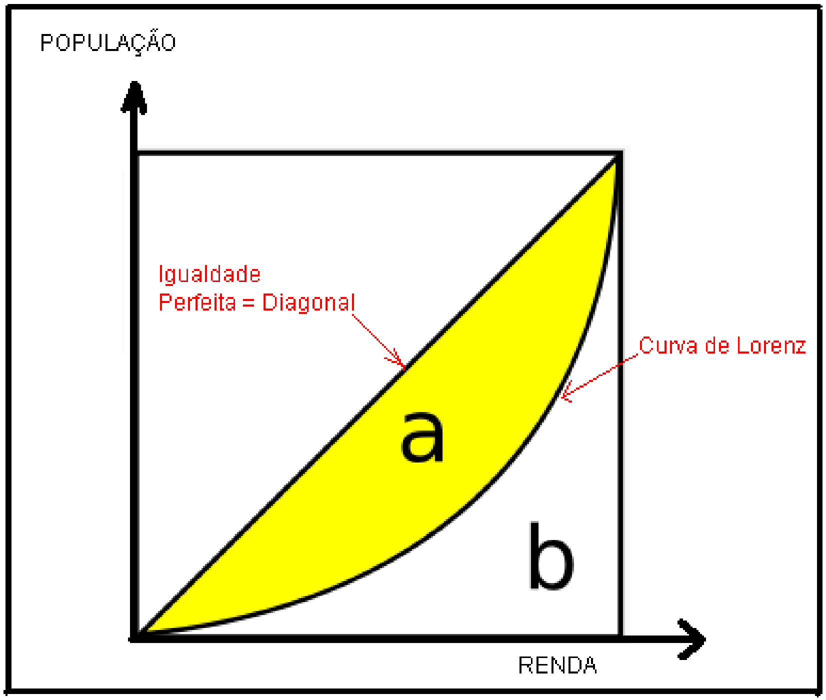


Figure 2.7: Lorenz Curve - Representation of the Gini Index. (Source: Wikipedia, 2009)

If the area between the diagonal line which represents perfect equality and the Lorenz curve is ***a*** and the area below the Lorenz curve is ***b***, then the Gini coefficient equals ***a***/(***a***+***b***).

In the state of Ceará the upper bound of the Gini index is 0.45 (worse distribution of income) and the lower bound is 0.38 (better distribution of income). The Gini Index for Milhã is **0.42**, that is, municipal distribution of income is highly unequal. Figure 2.8 shows the index map for the State of Ceará, highlighting the municipality of Milhã.

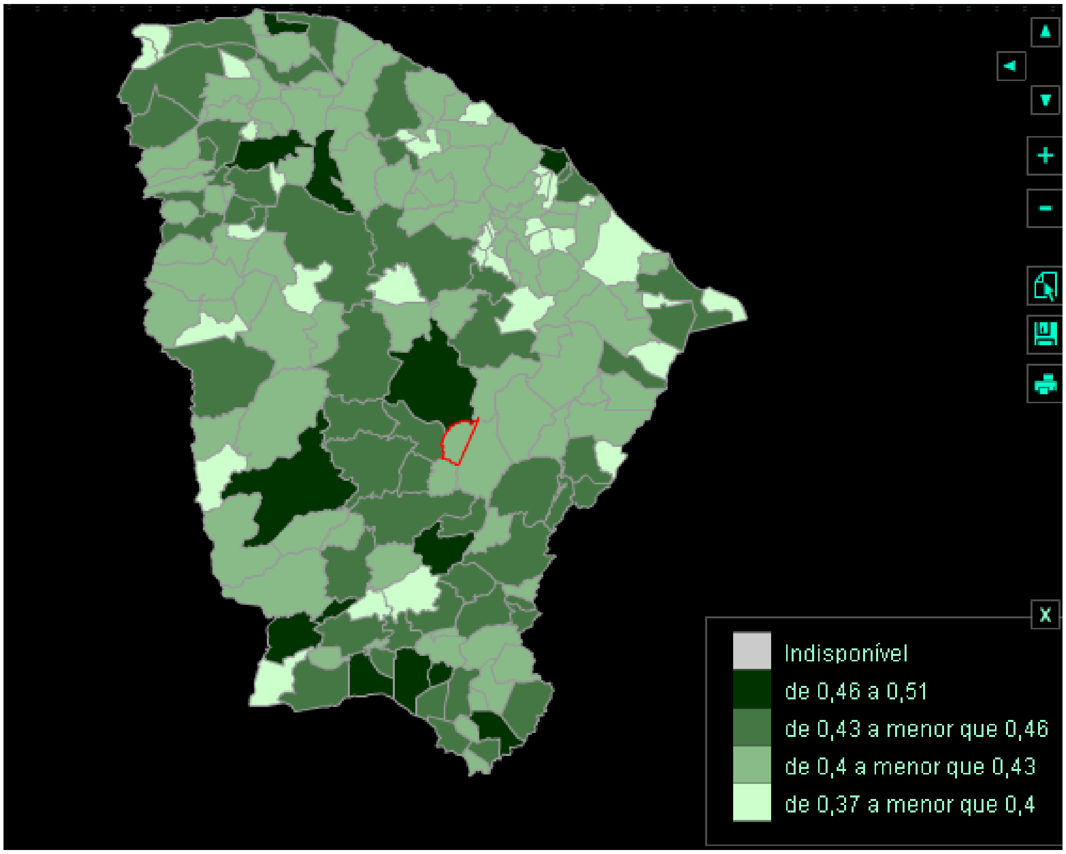


Figure 2.8: Poverty and inequality map in Ceará - Gini Index (Source: IBGE, 2009)

The incidence of poverty is 58.88% while the incidence of subjective poverty is 68.55%.

Social Indicators

Table 2.1 shows a set of social indicators for reference.

Table 2.1: Demographic and Social Reference Indicators (Source: SEPLAN)

[redacted]

Education

Table 2.2 shows a summary of the educational scenario in the municipality of Milhã.

Table 2.2: Summary of the Educational Scenario in Milhã (Source: SEDUC, 2005)

[redacted]

Municipal Economy

Milhã's municipal revenue totals R$13,144.708.00 while expenses total R$11,119,157.00, according to IBGE, whose cited sources are the 2007 Administrative Records of the Ministry of Finance's National Treasury.

The Federal Fund for Municipalities (Fundo de Participação dos Municípios - FPM) provided Milhã with R$6,420,219.51 in 2007.

GDP for 2005 totaled R$35,796,000.00, which corresponds to a GDP per capita of R$2,624.00. The GDP distribution on the local economy is shown in Figure 2.9.

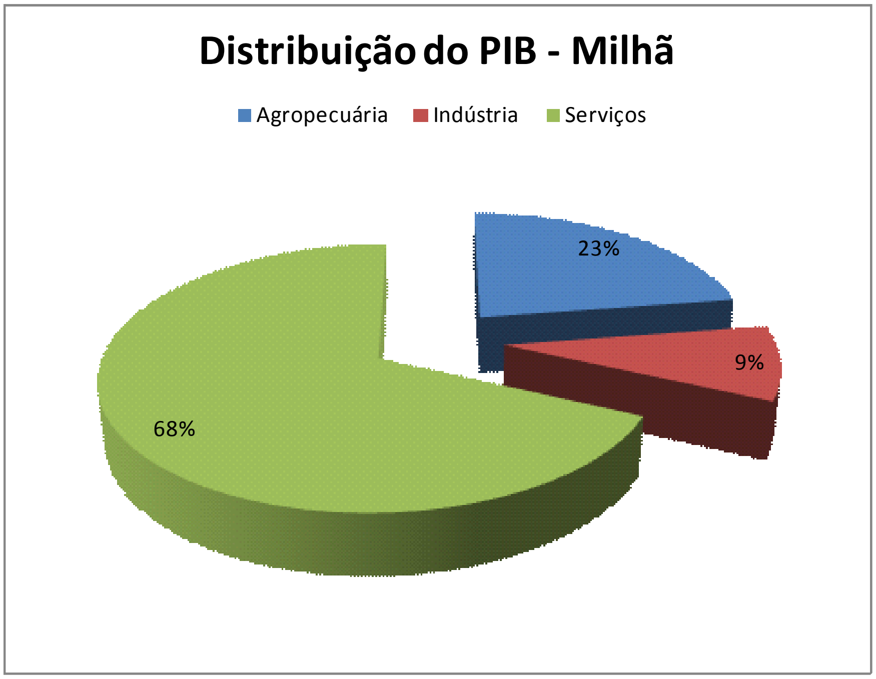


Figure 2.9: GDP Distribution in the Municipality of Milhã. **(Source: IBGE, 2009)**

Municipal Production

Local economy is based on services as shown in Figure 2.9. Agriculture is based on tree and herbaceous cotton, bananas, rice, corn and beans. Livestock is based on cattle, swine and birds. There are few industries, although they account for 9% of municipal GDP.

Table 2.3 shows a summary of municipal agriculture production; Table 2.4 shows a summary of livestock production and Table 2.5 shows a summary of Milhã's industries.

Table 2.3: Summary of Milhã's agriculture production (Source: IBGE, 2008)

[redacted]

Table 2.4: Summary of Milhã's livestock production (**Source:** IBGE, 2008)

[redacted]

Table 2.5: Summary of Milhã's industrial production (**Source:** IBGE, 2008)

[redacted]

3. WATER RESOURCES IN THE MUNICIPALITY

3.1 INTRODUCTION

The municipality of Milhã covers 502.04 km² and has 14,826 inhabitants according to IBGE's 2009 census. Milhã is located in the caatinga biome in Northeast Brazil. In terms of hydrography, the municipality can be divided into 5 hydrographic sub-basins which are part of the Banabuiú and Médio Jaguaribe River basins in the State of Ceará.

Milhã's hydrographic sub-basins originate at topographic boundaries which form the municipality's land geometry. Such boundaries are defined as follows: the municipality of Quixeramobim north; Senador Pompeu east; Deputado Irapuan Pinheiro south. The exits of sub-basins were defined within municipal limits, which characterizes such sub-basins as "*municipal basins*". They are the following:

• The **Riacho do Valentim** (Valentim Creek) sub-basin, which feeds into the Quixeramobim reservoir in the Banabuiú basin;

• The **Riacho Cabeça-de-boi** (Cabeça-de-boi Creek) sub-basin, a tributary of Riacho Valentim, located on the municipality boundaries and also integrated with the Banabuiú basin;

• The **Riacho Capitão Mor** (Capitão Mor Creek) sub-basin, which feeds into the Riacho do Sangue reservoir, part of the Médio Jaguaribe basin;

• The **Riacho da Maré** (Maré Creek) sub-basin, a tributary of Riacho Jenipapeiro (Jenipapeiro Creek) which also feeds into the Riacho do Sangue reservoir, in the Médio Jaguaribe basin;

• The **Riacho Lagoinha** (Lagoinha Creek) sub-basin, a tributary of Riacho Cachoeirinha (Cachoeirinha Creek), then of Capitão Mor and feeding into the Riacho do Sangue reservoir, also part of the Médio Jaguaribe basin.

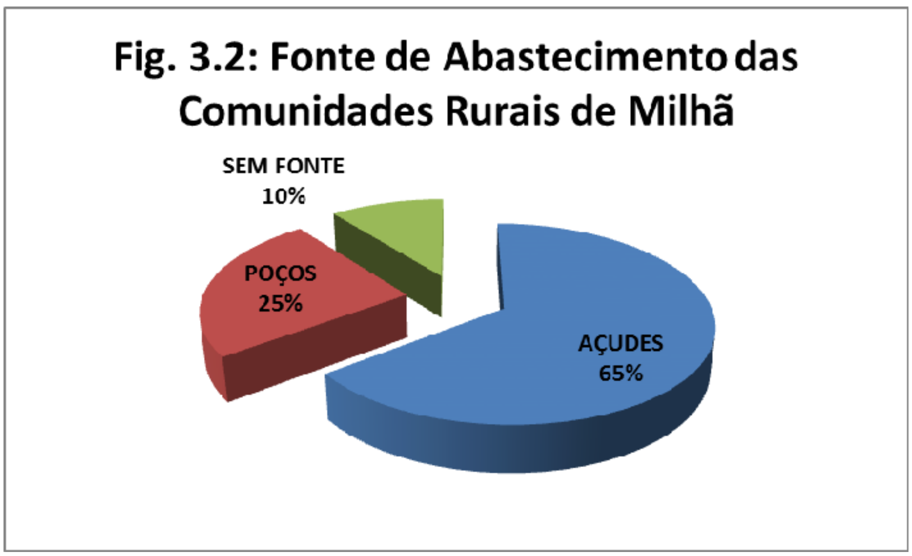
Table 3.1 shows the general features of Milhã's hydrographic sub-basins, while Figure 3.1 shows their location in the municipality map.

The municipality's land area not included in those five sub-basins represents only 60.61 km², that is, 12% of its overall land area, corresponding to creek springs located in the western portion of the municipality, at its straight-line border with the municipality of Solonópole. All such creeks feed into the Riacho do Sangue reservoir and therefore are part of the Médio Jaguaribe basin.

Table 3.1: A Summary of Sub-Basins in the Municipality of Milhã

SUB-BASIN	AREA (Km²)	PERIMETER (Km)	% OF THE MUNICIPALITY'S LAND AREA	STATE BASIN
Valentim	149.55	65.84	29.7	Banabuiú
Cabeça-de-boi	69.11	39.00	13.7	Banabuiú
Capitão Mor	189.97	65.29	37.8	Médio Jaguaribe
Maré	22.65	20.56	4.5	Médio Jaguaribe
Lagoinha	10.15	15.88	2.0	Médio Jaguaribe
TOTAL	**441.43**		**87.92**	

Field research conducted to identify sources of water supply to rural communities of Milhã has verified that 65% of such communities use reservoirs and superficial ponds, while 25% use artesian wells or 'Amazon' dug wells. Figure 3.2 shows the distribution of water sources in the municipality.



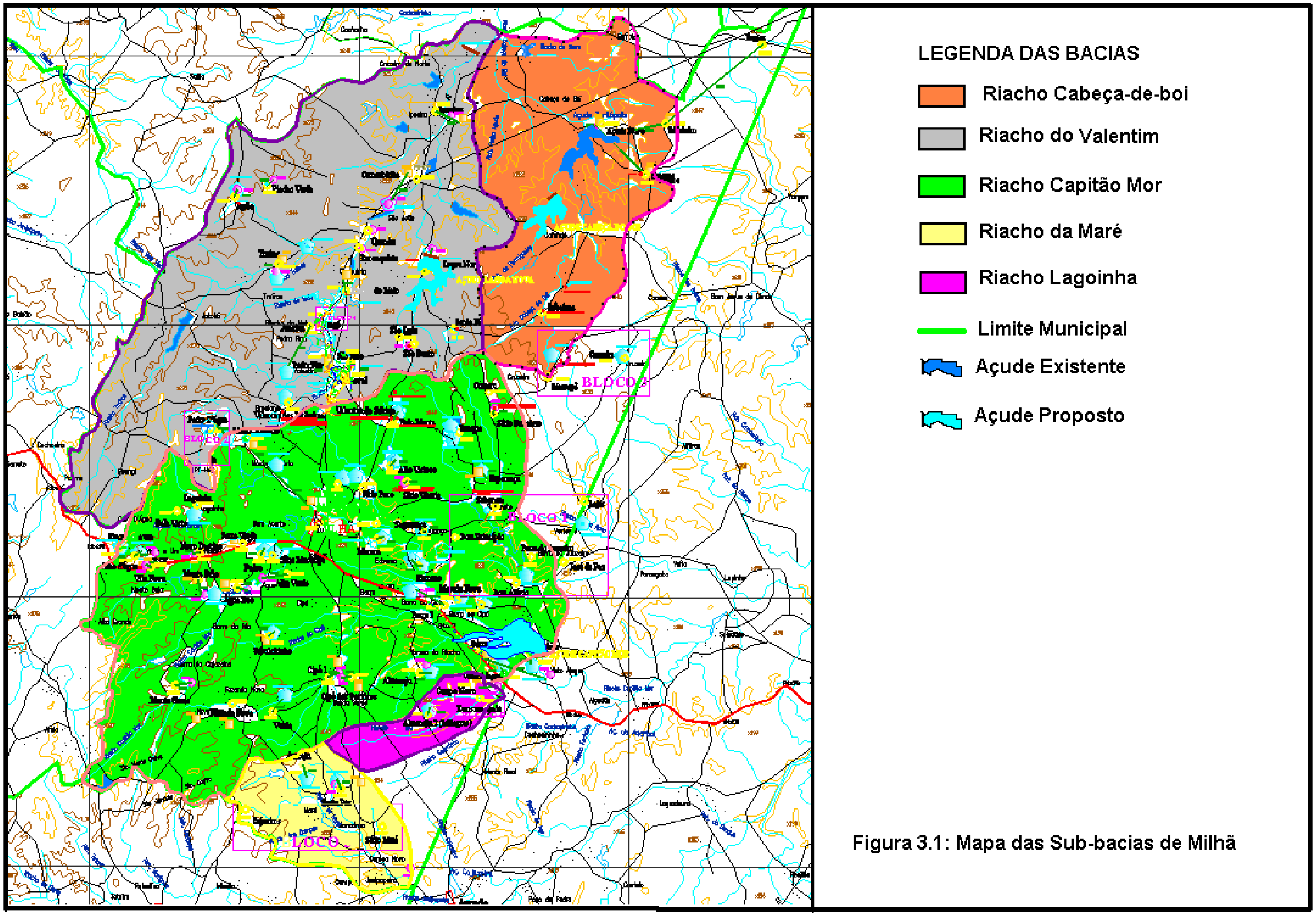


Figura 3.1: Mapa das Sub-bacias de Milhã

3.2 SURFACE WATER RESOURCES

Surface water resources consist of the main source of water for communities, as seen in Figure 3.2. Nevertheless, all reservoirs in the municipality of Milhã have maximum storage capacities below 1.1 hm^3 (one million, one hundred thousand cubic meters), which represents surface water availability that is much below the needs of its population.

There is little information available about Milhã's reservoirs. The most important piece of information is the reservoir surface area obtained through satellite imaging, part of a work conducted by FUNCEME and made available by COGERH. Reservoir distribution across sub-basins is presented in Figure 3.2.

The current main reservoirs of Milhã are described afterward according to their sub-basin.

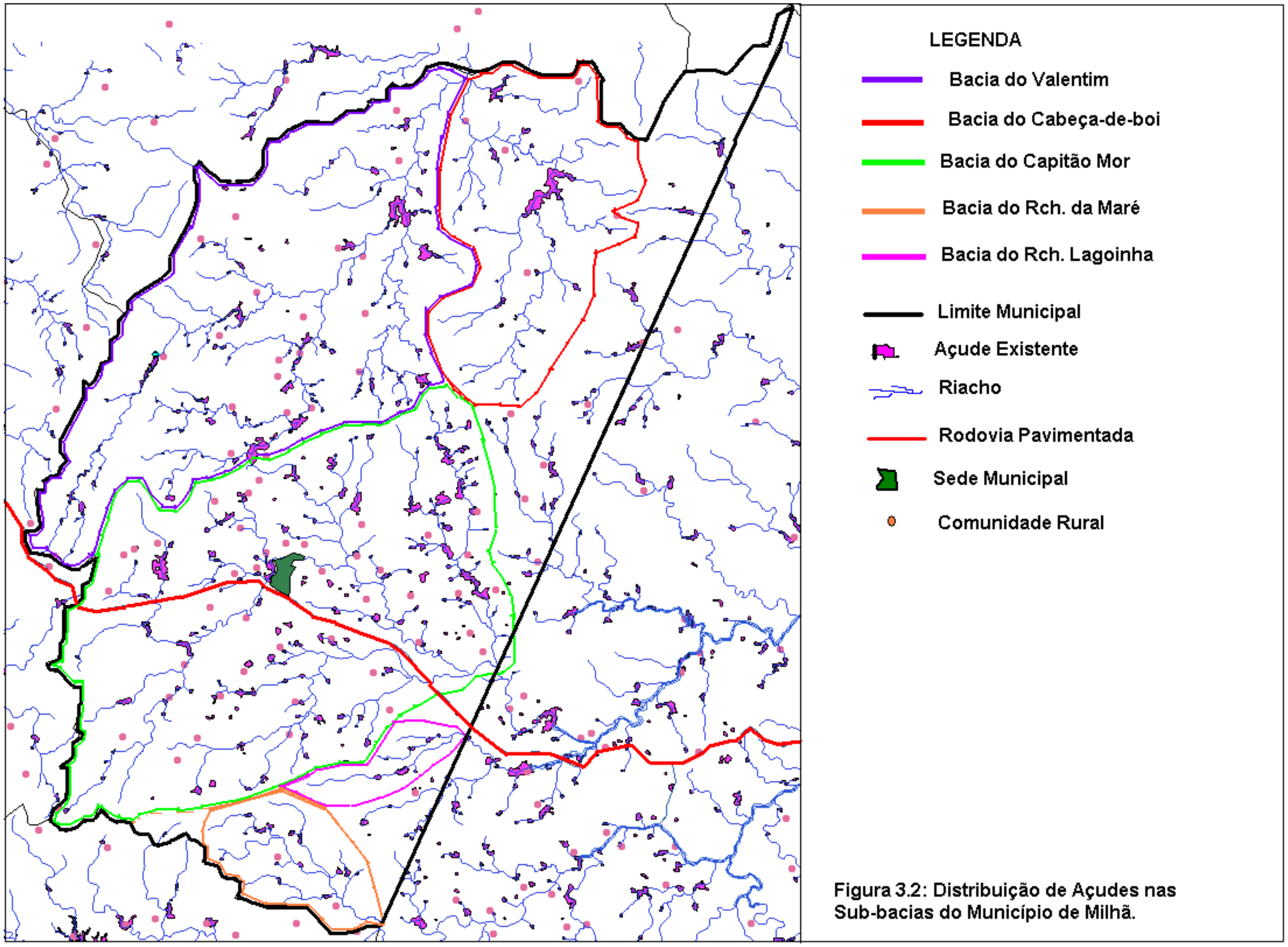


Figura 3.2: Distribuição de Açudes nas Sub-bacias do Município de Milhã.

3.2.1. The Main Reservoirs in the Riacho Valentim Basin

The main reservoirs in the Riacho Valentim basin are presented in order of strategic importance.

Jatobá Reservoir

Jatobá Reservoir is the only one currently being monitored by COGERH in Milhã, precisely because it is one of the springs which supply the municipality center. The Jatobá Reservoir can store 1.070.000 m^3, with a spillway crest height of 213.9 m. Figure 3.3 shows the crest height x surface area x volume curve of the Jatobá reservoir. Figure 3.4 shows a picture of the Jatobá reservoir.

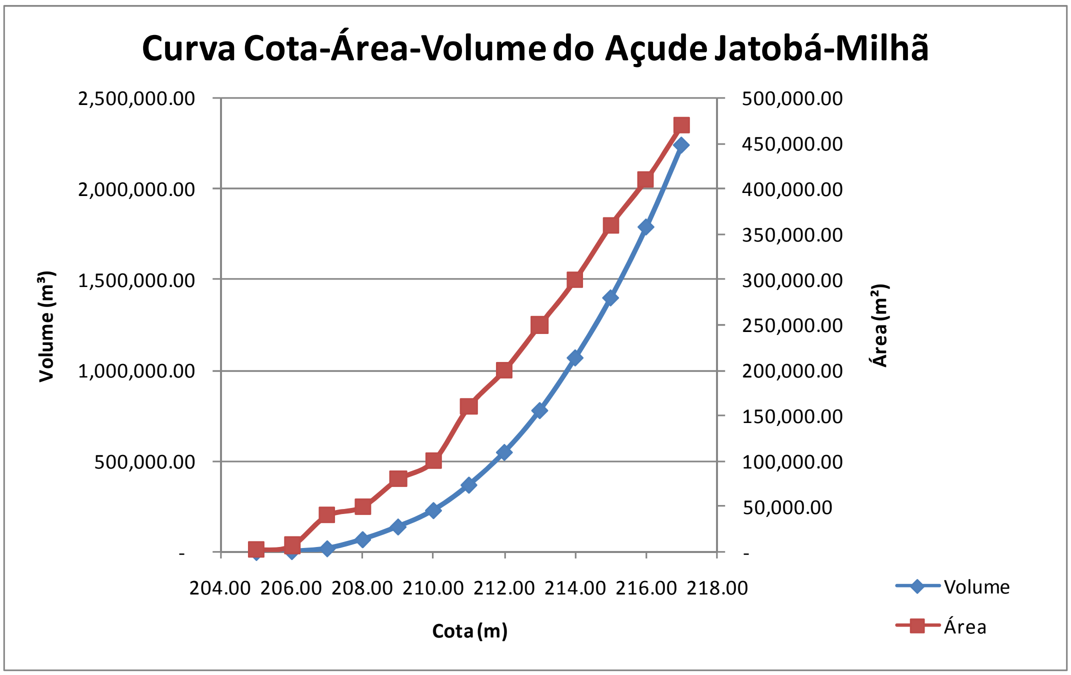


Figure 3.3: CAV curve of the Jatobá Reservoir in Milhã (K=1.070.000 m³). (Source: COGERH, 2005)

The Jatobá Reservoir dams the Traíras Creek, which feeds into the Valentim Creek.

Figure 3.4: Jatobá Reservoir in Milhã.

The Jatobá Reservoir coordinates are: E=473.771 m; N=9.380.448. The Jatobá Reservoir supplies the center of Milhã together with the Monte Sombrio Reservoir and sometimes the water diversion project from the Banabuiú River, fed by the Patu River through a 15 km aqueduct. There is an aqueduct taking water from the Jatobá to the center of Milhã.

Water availability of the Jatobá reservoir has been assessed using Campos' Triangular Regularization Diagram Method[1] (2005), which is considered the best simplified method to assess the regularization capacity of reservoirs under high evaporation rates, such as in the semi-arid region of the Northeast.

Basic data used to apply the method were:

• Storage capacity: K = 1.070 hm^3

• Hydrographic basic area of the Jatobá reservoir: A_{basin} = 19,939,040 m^2 or 19.93 Km^2

• Annual average effective rainfall: 63 mm/year (Source: PERH,1992)

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[1] CAMPOS, J.N.B, *Dimensionamento de Reservatórios: O Método do Diagrama Triangular de Regularização,* Expressão Gráfica, Fortaleza, Ceará, 2005.

• Average annual discharge: μ = 1.256 hm^3/year

• Average evaporation in the dry season (June/January): E_L= 1.027 m

• Shape factor of the reservoir's hydrological basin: α = 1,453.58

• Dimensionless evaporation factor: f_E = 0.323

Regularized streamflows at the Jatobá reservoir according to Campos' DTR Method are presented in Table 3.2.

Table 3.2: Regularized Streamflows at the Jatobá Reservoir

GUARANTEE	ANNUAL REGULARIZED VOLUME (hm^3/year)	REGULARIZED STREAMFLOW (l/s)	REGULARIZED STREAMFLOW (m^3/h)
90%	0,322	10,21	36,75
95%	0,250	7,92	28,53
99%	0,150	4,75	17,12

Considering that the center of Milhã has 1,500 house connections to the public water supply network, 1,280 of them with meters installed, at an average rate of 5 people/household, approximately, average demand for water would be:

$$Q_{med} = \frac{Pop \cdot q}{86400} = \frac{7500 \cdot 150}{86400} = 13{,}02\ l/s$$

Where: Q_{med} = average streamflow required by the population in liters/second;

Pop = number of inhabitants to be supplied;

q = consumption per capita in liters/inhabitant/day;

We can thus verify that the Jatobá reservoir's regularization capacity does not meet the needs of the population in Milhã's center, even for a guarantee percentage of just 90%, that is, 1 supply failure every 10 years. This simplified calculation is supported in practice by the need to supply the municipality center with water trucks in the last dry seasons (1999 and 2002).

Supply to the center of Milhã needs to come from Monte Sombrio and Jatobá reservoirs then, and possibly from a diversion of the Banabuiú River to the Jatobá reservoir from said River's perennialization through relesing water into the Patu reservoir located in Senador Pompeu.

Traíras Novo and São Sebastião Reservoirs

There are two reservoirs in Traíras. The first was built in 1992 and is called São Sebastião; coordinates: E= 476.901 and N= 9.382.000. Its hydrological basin spreads across 18.40 ha. The second was built in 2008, coordinates: E= 478.045 and N= 9.382.890. It is called Traíras Novo and there is no technical information about it.

The São Sebastião (old Traíras) reservoir supplies the communities of Traíras through a supply project implemented by the São José Project through Associação Olímpio Nonato in 1992.

Figure 3.5 shows a photograph of water collection for the community of Traíras in the São Sebastião reservoir.

Figure 3.5: Water collection for Traíras in the São Sebastião reservoir.

Figure 3.6 shows the Traíras Novo reservoir as seen from the top of the dam overlooking the spillway.

Figure 3.6: Traíras Novo Reservoir.

The Traíras Novo Reservoir is regarded as being strategic within the Valentim basin. A water quality sample was collected from the reservoir. The results showed physical-chemical and organoleptic parameters which are compatible with the supply needs of the local population in the case of a Water Truck Operation. The reservoir’s location qualifies it as the only source of water for the communities of Japão, Riacho Verde and Traíras.

<u>Riacho do Meio Reservoir</u>

The Riacho do Meio reservoir is highly strategic within the Valentim basin because it will supply the communities of Riacho do Meio, Quandu, Riacho and Ingá. In the future it may strengthen the supply system for Pedra Fina, São João, Transval and Valentim dos Sabinos through an integration aqueduct.

The Water Supply System for the communities of Riacho do Meio, Reconquista and Quandu has already been implemented in the Riacho do Meio reservoir with operations beginning at the Water Treatment Station ETA - Riacho do Meio. Figure 3.7 shows the reservoir's surface; in the back, to the right, one can see the Riacho do Meio Supply System ETA.

Figure 3.7: Riacho do Meio Reservoir, with the ETA in the back, to the right.

The Riacho do Meio reservoir will be the water source to supply the community of Ingá. The supply project is being implemented by UFC/CWC. The dam is located at coordinates E=479.409 and N=9.381.014. The collection location will be at coordinates E=478.892 and N=9.380.441.

Figure 3.8 shows the approximate level x area x volume curve of the Riacho do Meio reservoir based on bathymetry data collected in the field and interpolated by the regression equation of Engineer Paulo Miranda (COGERH, 2002), which was developed based on bathymetric surveys carried out in 61 reservoirs, of all 125 that are currently managed by COGERH and that would allow for making regression equations of level x area x volume curves based only on measurements of a reservoir's maximum surface area and its maximum depth.

The study took many years to be finished and was validated based on level x area x volume curves (CAV) calculated and measured in field bathymetry. The method's logic is as follows:

As a basic assumption one should obtain a satellite image with few clouds, regardless of its resolution. LANDSAT satellite images are usually used, so far with excellent results.

From the satellite image one can identify the reservoirs to be studied, based on a geoprocessing service.

Once the reservoirs to be studied are chosen, a field visit is made to identify the reservoir "in loco" and to measure the maximum height of their walls and their maximum central depth.

The reservoir surface area is determined based on satellite imaging. Those areas and heights and entered into a spreadsheet with a mathematical model which estimates areas for shorter walls, thus generating an estimated CAV for the reservoirs.

The form of the regression equation is of the following type:

$$A = A_{\max} e^{\left[\left(ax^3 + bx^2 + cx + d\right) - 1\right]}$$

Where:

A = reservoir surface area for a certain height (level);

A_{max} = maximum reservoir surface area measured in the field or estimated through satellite imaging;

e = basis of the Neperian logarithms;

x = relation between different heights and maximum height (height dimensionless);

a, b, c, and ***d*** are regression coefficients defined by the Least Squares Method according to 222 categories of reservoirs estimated in the state of Ceará, which are defined in an Excel spreadsheet.

Once the regression equation has been established, the Level x Area x Volume curve of the desired reservoir is automatically obtained through a distribution of area and heights according to the application of the classic model:

$$\Delta V = \Delta h \left(\frac{A_1 + A_2}{2} \right)$$

The method has been successfully employed in several small reservoirs in Ceará and Piauí and confirmed by comparisons with real bathymetries in the field.

The Riacho do Meio reservoir has a storage capacity of 986,484.65 m³ (0.986 hm³) and it floods a hydrological basin of 56.81 ha.

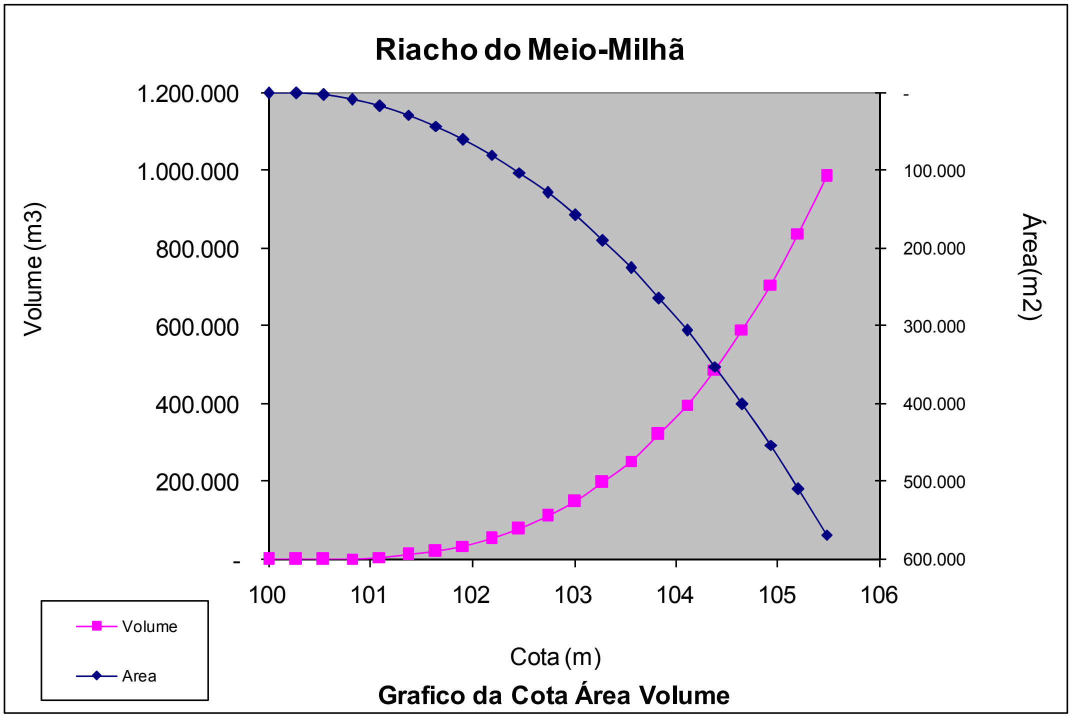


Figure 3.8: Level x Area x Volume Curve of the Riacho do Meio Reservoir.

Water availability of the Riacho do Meio Reservoir has also been assessed by the aforementioned Campos' Triangular Regularization Diagram Method (2005).

Basic data to apply Campos' method to the Riacho do Meio reservoir were:

• Storage capacity: K = 0.986 hm³

• Area of the hydrographic basin of Riacho do Meio reservoir: A_{basin} = 33,656,803.65 m² or 33.65 Km²

• Annual average effective rainfall: 63 mm/year (Source: PERH,1992)

• Average annual discharge: μ = 2.12 hm³/year

• Average evaporation in the dry season (June/January): E_L= 1.027 m

• Shape factor of the reservoir's hydrological basin: α = 6,018.92

• Dimensionless evaporation factor: f_E = 0.436

Regularized streamflows through the Riacho do Meio reservoir according to Campos' DTR Method are shown in Table 3.3.

Table 3.3: Regularized Streamflows through the Riacho do Meio Reservoir

GUARANTEE	ANNUAL REGULARIZED VOLUME (hm³/year)	REGULARIZED STREAMFLOW (l/s)	REGULARIZED STREAMFLOW (m³/h)
90%	0,220	6,97	25,10
95%	0,164	5,20	18,72
99%	0,080	2,53	9,13

Water demands for human supply allocated to the Riacho do Meio Reservoir according to the population of communities to be supplied by the reservoir are shown in Table 3.4.

Table 3.4: Water Demands for Human Supply of Riacho do Meio Reservoir

COMMUNITY	FAMILIES	INHABITANTS	ANNUAL GROWTH RATE	FINAL POP. 2020	CONSUMPTION PER CAPITA (l/inhab/day)	AVERAGE STREAMFLOW (l/s)	AVERAGE STREAMFLOW (m³/h)
Riacho do Meio	32	405	2%	493	100	0,57	2,05
Reconquista	21						
Quandu	15						
Ingá	13						

According to Table 3.4, the Riacho do Meio reservoir would be able to meet the average human supply demands for the next 10 years.

<u>Quandu Reservoir</u>

The Quandu reservoir supplies the district of Carnaubinha, the largest within the municipality of Milhã. The reservoir is located at coordinates E=481.090 and N=9.384.507. A Water Supply System was built for Carnaubinha in 1993. In 2007 the reservoir dried up and it was necessary to have water trucks supply Carnaubinha.

There is not much information available about the Quandu reservoir; there is only one record of the reservoir's surface area of 10.3 ha. Figure 3.9 shows floating water collection for Carnaubinha at the Quandu reservoir.

Figure 3.9: Floating water collection for Carnaubinha at the Quandu reservoir.

3.2.2. The Main Reservoirs in the Riacho Capitão Mor Basin

<u>**Monte Sombrio Reservoir**</u>

It is located at coordinates E=476.459 m and N=9.374.532. It is approximately 2.5 Km away from the center of Milhã. It aims to provide water to the center of Milhã; however, its low storage capacity means it soon dries up. This requires backup water resources to be diverted from the Jatobá reservoir and/or from the River Banabuiú.

The level x area x volume curve shown in Figure 3.10 was also calculated by an approximation process developed by Engineer Paulo Miranda Pereira (COGERH, 2002).

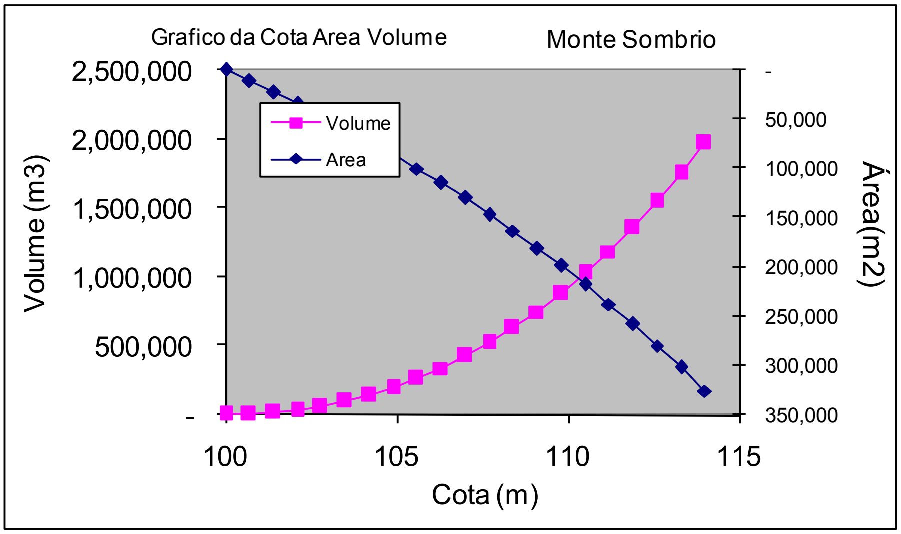


Figure 3.10: Level x Area x Volume curve of the Monte Sombrio Reservoir.

The estimated storage capacity for this reservoir is approximately 1,028,448 m³. Figure 3.11 shows the Monte Sombrio reservoir in Milhã.

Figure 3.11: Monte Sombrio reservoir in Milhã (K = 1,028,448 m³).

Water availability of the Monte Sombrio Reservoir has also been assessed by the abovementioned Campos' Triangular Regularization Diagram Method.

Basic data to apply Campos' method to the Monte Sombrio reservoir were:

• Storage capacity: K = 1.028 hm^3

• Hydrographic basic area of the Monte Sombrio reservoir: A_{basin} = 3,103,097.46 m^2 or 3.103 Km^2

• Annual average effective rainfall: 63 mm/year (Source: PERH,1992)

• Average annual discharge: μ = 0.195 hm^3/year

• Average evaporation in the dry season (June/January): E_L= 1.027 m

• Shape factor of the reservoir's hydrological basin: α = 867.33

• Dimensionless evaporation factor: f_E = 0.507

Regularized streamflows through the Monte Sombrio reservoir according to Campos' DTR Method are shown in Table 3.5.

Table 3.5: Regularized Streamflows through the Monte Sombrio Reservoir

GUARANTEE	ANNUAL REGULARIZED VOLUME (hm^3/year)	REGULARIZED STREAMFLOW (l/s)	REGULARIZED STREAMFLOW (m^3/h)
90%	0,0415	1,315	4,73
95%	0,0260	0,824	2,96
99%	0,0030	0,095	0,34

<u>**Lagoinha Reservoir**</u>

The Lagoinha reservoir is located at coordinates E=473.807 m and N=9.372.155m. It is approximately 4.6 Km away from the center of Milhã. It is a highly strategic reservoir used by the Brazilian Army as a source of water for all 6 water truck routes that supply communities in Milhã during dry seasons. COGERH does not perform quantitative or qualitative reservoir monitoring, in spite of its importance for municipal supply.

Figure 3.12 shows the reservoir's level x area x volume curve. The estimated storage capacity for this reservoir is approximately 1,966,396 m^3.

Figure 3.13 shows the Lagoinha reservoir in Milhã as a source of water for the water truck program.

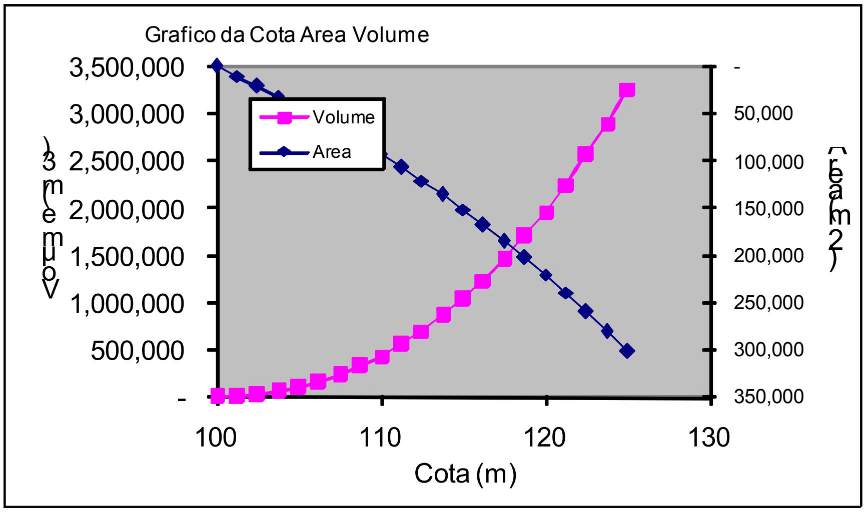


Figure 3.12: Level x Area x Volume curve of the Lagoinha Reservoir.

Figure 3.13: The Lagoinha reservoir in Milhã as a source of water for water trucks (K=1,966,396 m³).

Water availability of the Lagoinha reservoir has thus been determined using the DTR Method:

• Storage capacity: K = 1.966 hm³

• Hydrographic basic area of the Lagoinha reservoir: A_{basin} = 3,725,460.68 m² or 3.725 Km²

• Annual average effective rainfall: 63 mm/year (Source: PERH,1992)

• Average annual discharge: μ = 0.234 hm³/year

• Average evaporation in the dry season (June/January): E_L= 1.027 m

• Shape factor of the reservoir's hydrological basin: α = 238.75

• Dimensionless evaporation factor: f_E = 0.310

Regularized streamflows through the Lagoinha reservoir according to Campos' DTR Method are shown in Table 3.6.

Table 3.6: Regularized Streamflows through the Lagoinha Reservoir

GUARANTEE	ANNUAL REGULARIZED VOLUME (hm³/year)	REGULARIZED STREAMFLOW (l/s)	REGULARIZED STREAMFLOW (m³/h)
90%	0,079	2,505	9,02
95%	0,058	1,839	6,62
99%	0,026	0,824	2,96

3.2.3. The Main Reservoirs in the Riacho Cabeça-de-Boi Basin

Novo Reservoir (Berilópolis)

Novo Reservoir (Berilópolis) is located at coordinates E=488.363 m and N=9.387.232 m. It is approximately 18 Km away from the center of Milhã. This reservoir supplies the communities of Açude Novo, Tabuleiro, Grossos and Cabeça do Boi (Alto Santo). This reservoir is known for not drying up even during prolonged dry periods. Figure 3.14 shows the reservoir's level x area x volume curve, which has been estimated using the same previous procedure. Figure 3.15 shows a photograph of the reservoir.

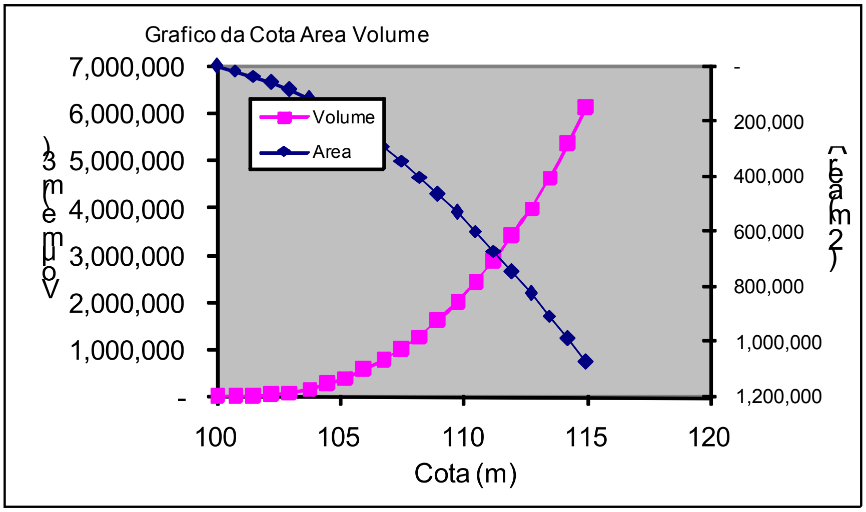


Figure 3.14: Level x Area x Volume curve of Novo Reservoir (Berilópolis).

The estimated storage capacity for this reservoir is approximately 2,411,461 m³.

Figure 3.15: Novo Reservoir (Berilópolis) in Milhã (K = 2,411,461 m³).

Basic data to apply Campos' method to the Berilópolis reservoir were:

• Storage capacity: K = 2.411 hm^3

• Hydrographic basic area of the Berilópolis reservoir: A_{basin} = 38,923,185.22 m^2 or 38.923 Km^2

• Annual average effective rainfall: 63 mm/year (Source: PERH,1992)

• Average annual discharge: μ = 2.452 hm^3/year

• Average evaporation in the dry season (June/January): E_L= 1.027 m

• Shape factor of the reservoir's hydrological basin: α = 2047.21

• Dimensionless evaporation factor: f_E = 0.290

Regularized streamflows through the Berilópolis reservoir according to Campos' DTR Method are shown in Table 3.7.

Table 3.7: Regularized Streamflows through the Berilópolis Reservoir

GUARANTEE	ANNUAL REGULARIZED VOLUME (hm^3/year)	REGULARIZED STREAMFLOW (l/s)	REGULARIZED STREAMFLOW (m^3/h)
90%	0,693	21,97	79,10
95%	0,575	18,23	65,63
99%	0,400	12,68	45,66

3.2.4. Main Reservoirs in the Basins of Rivers Maré and Lagoinha

In the basins of Maré and Lagoinha rivers there are no significant reservoirs. The largest reservoir in the Maré basin is Aracaju, which as a very small hydrological basin of only 5.7 ha, in addition to the Santa Paz reservoir, whose surface area is 4.2 ha.

The only reservoir worth mentioning in the Lagoinha basin is Milagres (Almanaju), whose surface area is 8.5 ha. The abovementioned reservoirs do not even have an annual regularization capacity.

3.3 GROUNDWATER RESOURCES

3.3.1 Geological Domains

According to CPRM[2], three different hydrogeological domains can be identified in Milhã: crystalline rocks, sedimentary cover (colluvium) and alluvium deposits. Crystalline rocks are predominant in the area and represent what is usually called a "fissured aquifer". Since there is basically no primary porosity in this type of rock, the existence of groundwater is conditioned by secondary porosity represented by fractures and crevices, which translates into random, intermittent and small reservoirs. Within this context, streamflows produced by wells are small. Additionally, due to lack of circulation and the effects of the semi-arid climate, water is saline most of the time. Such conditions ascribe low hydrological potential to crystalline rocks without, however, diminishing their relevance as an alternative source of supply for small communities or as strategic reserve in prolonged dry periods.

Sedimentary covers include isolated stains of detrital sediments which, due to being extremely thin, are irrelevant as springs for ground water catchment.

Alluvium deposits consist of recent sandy-clayey deposits which occur along the margins of the main river channels that drain the region. Overall they are a good alternative spring and are relatively important from the hydrogeological perspective, especially in semi-arid regions where crystalline rocks are predominant. Usually the high permeability of sandy soils makes up for lack of thickness, producing significant streamflows.

3.3.2 Exploitation Diagnosis Performed by CPRM (1998)

The survey carried out in Milhã recorded 22 wells, 21 of which are deep tubular wells (17 are publicly and 4 privately owned) and only 1 is of the 'Amazon' type (privately owned), as shown in Figure 3.16 in percentages.

[2] CPRM, Programa de Recenseamento de Fontes de Abastecimento por Água Subterrânea no Estado do Ceará, Diagnóstico do Município de Milhã, Fortaleza, 1998.

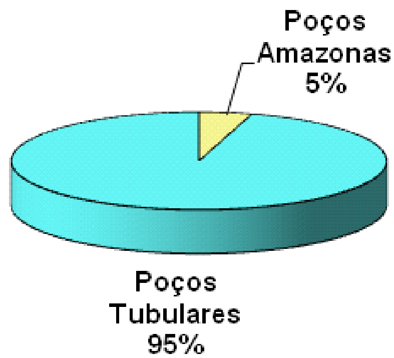


Figure 3.16: Types of Well in Milhã (CPRM, 1998).

With respect to the distribution of tubular wells across hydrogeological domains, it has also been verified that all wells were within the crystalline rocks domain. As for the Amazon-type wells, the only registered well was located in an alluvium domain.

The current situation of those construction works is shown in Table 3.5, also taking into account their public or private nature.

Table 3.5: Current Status of Registered Wells.

PUBLIC				
Type of Well	**Abandoned**	**Inactive**	**Active**	**Not Installed**
Tubular Well	2	7	8	-
PRIVATE				
Type of Well	**Abandoned**	**Inactive**	**Active**	**Not Installed**
Amazon Well	-	-	1	-
Tubular Well	1	2	1	-

Figure 3.17 shows the relation between tubular wells being used at the time and wells that could start being used (not being used - inactive and not installed). It should be noted that the only registered Amazon-type well was private and was being used.

Only one privately-owned tubular well was being used and 2 could start operating. As for publicly-owned wells, 41% (7 wells) were inactive or not installed and consequently could be put to use, while 47% (8 wells) were being used.

Figure 3.17: Relation Between Used and Unused Wells.

3.3.3 Quantitative and Qualitative Aspects

With respect to the quantitative aspect, for calculation purposes only tubular wells have been taken into account, which were systematically exploited through several types of pumping equipment. The basic goal was to obtain a reference measure of ground water production in the municipality and to investigate the increase in water supply coming from existing collection units that remain unused (inactive and not installed).

However, it should be noted that the figures shown in this document represent an estimate based on the average productivity of each considered hydrogeological domain, which have been obtained from previous regional studies. More detailed studies would be necessary to determine the productivity and potential of existing wells more precisely. Such studies would be made from pumping tests performed in all wells, which have not been performed yet.

In Milhã's case, calculations considered the crystalline rock domain only, which covers 95% of existing ground water collection. According to this guideline, for the crystalline rock domain the average streamflow was considered 1.7 m³/h, which resulted from a statistical analysis of over 3,000 wells within the crystalline domain in the state of Ceará (Möbus *et alli,* 1998).

Table 3.6 shows that when 9 tubular wells are considered as being used within the crystalline domain, water production can be inferred as totaling 15.3 m³/h for the entire municipality of Milhã. 13.6 m³/h come from public wells and 1.7 m³/h come from the only private well existing at the time. If a policy to recover and/or install wells that were not being used were to be implemented, it is thought that it would be possible to obtain a 100% increase (15.3 m^3/h) in ground water supply estimated at the time.

Considering publicly-owned wells only, there would be an estimated increase of 11.9 m³/h, that is, 78%.

Table 3.6: Estimated Installed Availability and Potential Availability of Crystalline Rocks in the Municipality of Milhã (Source CPRM, 1998)

Tubular	Estimated Installed Availability	Estimated Potential Installed Availability

Wells	Active	Q_e (units) (m^3/h)	Q_e (total) (m^3/h)	Inactive/ Not Installed	Amount (units) (m^3/h)	Amount (total) (m^3/h)	% increase in current availability
Publiccly-owned	8	1,7	**13,6**	7	1,7	**11,9**	**78**
Privately-owned	1	1,7	**1,7**	2	1,7	**3,4**	**22**
TOTAL	9	-	**15,3**	9	-	**15,3**	**100**
Q_e = Exploitation rate							

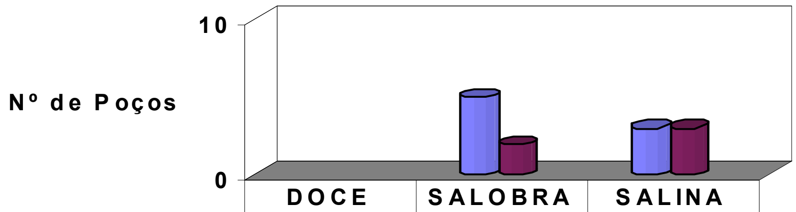
From the qualitative perspective, the following intervals were considered for classification purposes:

0 to 500 mg/L --- Fresh water

500 to 1500 mg/L --- Brackish water

> 1500 mg/L --- Saline Water

Figure 3.18 shows the classification of water in tubular wells in the municipality of Milhã, considering the following scenarios: active, inactive and not installed. It should be noted that only wells from which it was possible to collect water have been analyzed.



	DOCE	SALOBRA	SALINA
Em Uso		5	3
Desativados		2	3
Não Instalados			

Figure 3.18: Groundwater Quality of Tubular Wells in the Municipality of Milhã.

Water from the only registered Amazon-type well has been analyzed and classified as saline. As for tubular wells, results show that there is no fresh water in this area. All water samples have been classified as brackish or saline. Brackish water is predominant among active tubular wells (5 wells). As for wells that are could start operating (inactive + not installed), there is an equal number of wells with brackish or saline water.

3.3.4 Conclusions from the CPRM Report

The analysis of data from the well survey carried out in the municipality of Milhã has allowed us to reach the following conclusions:

- In terms of hydrogeological domains, crystalline rocks are predominant. They have low hydrogeological potential, with low streamflows and poor quality of water. 95% of registered tubular wells in the municipality (21 wells) fit within this context.
- Although there are alluvium deposits, ground water collection within this domain is insignificant (one Amazon-type well).
- The current situation of wells in the municipality is the following:

	Type of Well	Active	Operation Suspended	
			Permanently	**Could Operate Again**
Publiccly-owned	Tubular Wells	47%	12%	41%
Privately-owned	Tubular Wells	25%	25%	50%
	Amazon-type Wells	100%	-	-

- If inactive tubular wells which could operate again are taken into account, water supply for the municipality could increase by approximately 100%, considering publicly and privately-owned wells, or 78%, considering only publicly-owned wells;

- In terms of groundwater quality, analyzed samples have shown that most wells have water with high salt content. Over 45% of sampled tubular wells have saline water, which is only recommended for animal consumption and for secondary human consumption (washing, bathing, etc.).

Based on the above conclusions we have come up with the following recommendations:

- Assessing the potential of alluvium deposits, which apparently are little exploited and could be an alternative to supply several locations;
- Inactive and uninstalled wells should be included in well recovery and installation programs in order to increase water supply in the region;
- Wells whose operation has been suspended due to high salt contents should be analyzed in more detail (streamflow, physical-chemical analysis, number of families served by the well, etc.) so that the feasibility of installing desalination equipment could be studied.
- All wells should undergo periodic maintenance to guarantee their operation, especially in prolonged dry seasons;

- In order to guarantee good quality of water from the bacteriological point of view, health protection measures should be implemented for all of them.

3.3.5 Current Situation

Data presented in the previous items were taken from the 1998 CPRM report and should be taken as a qualitative reference of ground water exploitation conditions in the municipality of Milhã.

4. DIAGNOSIS - CURRENT STATUS OF MUNICIPAL WATER SUPPLY

4.1 Introduction

In this chapter we present a detailed diagnosis of all 85 communities we visited to investigate *in loco* the status of water supply for human needs.

In this diagnosis we have made every effort to obtain the following information using a Technical Form which was filled out by interviewers:

1) Community identification;

2) Communities' GPS coordinates;

3) Number of families living in each community;

4) Identifying and obtaining coordinates of source(s) of public water supply;

5) Survey of physical characteristics of source(s) of water supply:

<u>Reservoirs:</u>

- Reservoir's name;
- Owner;
- GPS location;
- Approximate volume;
- Dam height;
- Photographs of the source of water.

<u>In case of Amazon-type wells:</u>

- Owner;
- GPS location;
- Diameter of the well;
- Depth;
- Type of equipment used to collect water (manual or pump);
- Photographs of the source of water.

Deep wells:

- Owner;

- GPS location;

- Diameter of the well;

- Depth;

- Pumping power;

- Flow rate and pump manometric height (if available);

- Photographs of the source of water.

Other sources:

- Specify the type of source;

- Owner;

- GPS location;

- Equipment used to collect water.

6) Survey of the water delivery system's physical characteristics:

- Description of the water delivery system;

- GPS coordinates for the aqueduct’s starting and finishing points;

- Description of pipes' physical characteristics (diameter, material, etc.);

- Reservoir locations;

7) Survey of community supply projects, plans and proposals drafted by:

- Municipal Governments;

- Residents’ Associations and similar organizations;

-Non-governmental organizations.

Data have received tabular and spatial treatment using a GIS georeferencing system in the ArcView platform. Collected data consist of the most accurate current diagnosis of real conditions experienced by people in each community. Local leaderships have been consulted, as well as water supply system operators, when available.

It is worth noting that water truck routes included in the Brazilian Army report mentioned only 65 communities in the municipality of Milhã, while our diagnosis reports visits to 85 communities, that is, 30.7% more than those mentioned by the Army.

Table 4.1 shows a summary of Technical Forms of diagnosed communities.

INDEX		LOCALIDADE				CAPTAÇÃO						ADUÇÃO							RESERVAÇÃO				
		COORDENADAS		RESID.	POP.	NOME	COORDENADAS		vazão	TRATAMENTO	QUALIDADE DA ÁGUA	TUBUL. (TIPO)	DIAM.	EXTENSÃO	E (INIC)	N (INIC)	E (FINAL)	N (FINAL)	TIPO	VOL. (m^3)	MATERIAL	COORDENADAS	
		E	N				E	N	(m^3/h)				(mm)	(m)								E	N
C1	CARNAUBINHA	482134	9385408	400	2000	AÇ. QUANDU	481087	9384508	52 a 70	CLORO	EXCELENTE	R - PVC	75	300	481167	9384620	481808	9385634	APOIADO	35	CONCRETO	481806	9385634
												A - PVC	85	2500					ELEVADO	55			
C2	ALTO SANTO (CABEÇA DE BOI)	487299	9388140	10	50	–	–	–	–	–	–	PVC	32	2000	–	–	–	–	–	–	–	–	–
C3	AÇUDE NOVO	488986	9387448	68	340	AÇ. BERILÓPOLIS	488677	9387306	15 A 52	–	BOA	R - PVC	60	130	488677	9387306	488762	9387398	ELEVADO	21	CONCRETO	488762	9387398
C4	TABULEIRO	491337	9387464	36	180	–	–	–	–	–	–	PVC	60	1900	490197	9387252	491337	9387464	APOIADO	25	CONCRETO	491337	987464
																			CISTERNA (1)				
																			ELEVADO	21			
C5	FURNAS	494935	9390396	13	65	–	–	–	–	–	–	PVC	35	4000	491337	9387464	494935	9390396	CISTERNA (3)	16	CONCRETO	–	–
C6	GROSSOS	490602	9385578	9	45	–	–	–	–	–	–	PVC	60	4000	488762	9387398	490602	9385578	APOIADO	15	CONCRETO	490602	9385578
C6A	ITABAIANA	486771	9380464	21	105	–	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNA (8)	–	CONCRETO	–	–
C7	IPUEIRAS	482836	9387924	78	390	AÇ. ANTENOR PINHEIRO	–	–	–	–		R - PVC	60	600	483710	9387524	482836	9387924	ELEVADO	21	CONCRETO	483710	9387524
						PÇ. AMAZONAS	483405	9387766			SALGADA	A - PVC	60	960									
C8	QUANDÚ	480324	9383506	9	45	PÇ. AMAZONAS	480479	9383540	–	–	SALGADA	PVC	25	VARIADA	480479	9383540	–	–	–	–	–	–	–
C9	LAGOA NOVA	482433	9382008	50	250	PÇ. AMAZONAS	482687	9382844	21	–	SALGADA	PVC	50	–	482687	9382844	482433	9382008	ELEVADO	21	CONCRETO	482433	9382008
C10	SANTA FÉ	483511	9379856	6	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C11	SÃO BENTO (SÃO LUIZ)	482037	9379316	21	105	PÇ. PROFUNDO	481843	9379240	–	–	BOA	–	–	–	–	–	–	–	CISTERNA (10)	–	CONCRETO	–	–
C12	JAPÃO	475386	9384774	40	200	AÇ. DO ZEZINHO	475478	9385034	–	–	BOA	PVC	50	500	475478	9385034	–	–	CISTERNA(~40)	–	CONCRETO	–	–
C13	RIACHO VERDE	476589	9385168	28	140	AÇ. DA MARTINHA	476814	9385372	–	–	BOA	PVC	25	250	476814	9385372	–	–	CISTERNA(18)	–	CONCRETO	–	–
						PÇ. AMAZONAS	476567	9385250	4,5	–	SALGADA				476567	9385250	–	–					
C14	JOSÉ DE PAZ	487568	9371248	3	15	AÇ. DO ROSIÊ	–	–	–	–	BOA	–	–	–	–	–	–	–	CISTERNA(2)	–	CONCRETO	–	–
C15	CRUZEIRO			5	25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C16	BARRA DO JUAZEIRO	486384	9371448	10	50	–	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNA (4)	–	CONCRETO	–	–
C17	BOM ALÍVIO			10	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C18	LAJES	487184	9372658	6	30	AÇUDE	488269	9372672	–	–	–	–	–	–	–	–	–	–	CISTERNA(1)	–	CONCRETO	–	–
C19	SANTA ROSA	–	–	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNA (1)	–	CONCRETO	–	–
C20	TRAÍRAS	477020	9382300	37	185	AÇ. SÃO SEBASTIÃO	476901	9382000	3,75	–	BOA	PVC	60	240	476901	9382000	477020	9382300	ELEVADO	15	CONCRETO	477020	9382300
						AÇ. TRAÍRAS	478071	9382926	–	–	BOA								CISTERNA (2)	–	CONCRETO	–	–

INDEX		LOCALIDADE				CAPTAÇÃO						ADUÇÃO							RESERVAÇÃO				
		COORDENADAS		RESIDENCIA	POPULAÇÃO	NOME	COORDENADAS		vazão (m³/h)	TRATAMENTO	QUALIDADE DA ÁGUA	TUBUL. (TIPO)	DIAM. (mm)	EXTENSÃO (m)	E (INIC)	N (INIC)	E (FINAL)	N (FINAL)	TIPO	VOL. (m³)	MATERIAL	COORDENADAS	
		E	N				E	N														E	N
C21	RECONQUISTA	479996	9382868	21	105	RIACHO VALETIM	480114	9382834	–	–	POUCO SALGADA	PVC	25	150 A 300	480114	9382834	–	–	–	–	–	–	–
C22	RIACHO DO MEIO	479498	9381280	20	100	RIACHO DO MEIO	479498	9381280	–	–	BOA	PVC	50	–	479405	9381738	–	–	ELEVADO	17	CONCRETO	479405	9381738
C23	TRANSVAL	479678	9378552	6	30	AÇ.TRANSVAL	479832	9378548	–	–	BOA	PVC	25	280	479678	9378548	–	–	CISTERNA (4)	35	CONCRETO	–	–
C24	SÃO JOÃO	479675	9378642	8	40	AÇ. SÃO JOAO	478766	9379422	–	–	–	–	–	–	–	–	–	–	CISTERNA (1)	16	CONCRETO	–	–
C25	VALETIM DO SABINO	478972	9377166	50	250	AÇ. PEDRA FINA	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNA (4)	–	CONCRETO	–	–
C26	PEDRA FINA	478840	9378514	39	195	AÇ. PEDRA FINA	478980	9378232	–	–	POUCO SALOBRA	PVC	75	450	478980	9378232	478729	9378512	ELEVADO	30	CONCRETO	478729	9378512
																			CISTERNA (7)	–	CONCRETO	–	–
C27	INGÁ	478556	9380112	13	65	AÇ. RIACHO DO MEIO	478556	9380112	–	–	–	–	–	–	–	–	–	–	CISTERNA (1)	–	CONCRETO	–	–
C28	MASSAPÊ	486987	9378088	5	25	AÇ. MASSAPÊ	487124	9378912	–	–	BOA	–	–	–	–	–	–	–	CISTERNA (1)	–	CONCRETO	–	–
C29	CRUZEIRO	489839	9378792	6	30	AÇ. CRUZEIRO	489746	9378834	–	–	BOA	PVC	25	100	–	–	–	–	–	–	–	–	–
C30	SÍTIO FORTALEZA	484974	9376720	35	175	PÇ. PROFUNDO	485020	9376950	–		POUCO SALOBRA	PVC	25	240	485020	9376950	484974	9376720	CISTERNA (~35)	–	CONCRETO	–	–
C31	CUMARU	484800	9377536	6	30	–	–	–	–	–	BOA	–	–	–	–	–	–	–	CISTERNA(~6)	–	CONCRETO	–	–
C32	ESPERANÇA	484721	9374320	16	80	AÇ. JOAO VIEIRA	484239	9374360	–	–	BOA	PVC	50	80	484239	9374360	484272	9374430	ELEVADO	16	CONCRETO	484272	9374430
C33	SABONETE	484893	9373160	9	45	–	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNA(9)	–	CONCRETO	–	–
C34	BOM PRINCÍPIO	483403	9372010	9	45	AÇ. SEGURANÇA	483069	9372458	–	–	BOA	–	–	–	–	–	–	–	CISTERNA(1)	–	CONCRETO	–	–
C35	SEGURANÇA	482253	9372214	16	80	AÇ. SEGURANÇA	482039	9372242	2300	–	IMPROPRIA PARA BEBER	PVC	25	200	–	–	–	–	–	–	–	–	–
C36	EXTREMA	482011	9370964	17	85	AÇ. MATIAS	482021	9370868	2300	–	SALOBRA	PVC	25	80	–	–	–	–	–	–	–	–	–
						AÇ. JOSÉ JACKSON	–	–	–	–	–												
C38	MACACO	480514	9371950	12	60	AÇ. ANT° BATISTA	480556	9371888	1000		BOA	PVC	25	100	–	–	–	–	CISTERNA(7)	–	CONCRETO	–	–
C39	MILHÃ VELHA	479803	9373220	60	300	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C40	SITIO BECO	479954	9373846	4	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C41	ALTO VISTOSO	480993	9374664	20	100	AÇ. IPUEIRA	–	–	–	–	BOA	PVC	25	150	481005	9374756	–	–	CISTERNA (8)	–	–	–	–
C42	SÍTIO VITÓRIA	481616	9374084	2	10	PÇ. ARTESIANO (48m)	481507	9374016	1,5	–	POUCO SALOBRA	PVC	25	130	481507	9374016	481616	9374084	CISTERNA (1)	–	–	–	–
C43	BELO MONTE	481120	9376368	40	200	AÇ. VELHO	–	–	–	–	BOA	PVC	25	150	–	–	–	–	–	–	–	–	–
C44	TANQUE	483546	9375890	8	40	AÇ. ANT° ROBERTO	–	–	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
						AÇ. VALDERÍCIO																	
C45	SÍTIO AÇUDE	479640	9374118	18	90	AÇ. SÍTIO AÇUDE	479580	9374194	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
C46	PAU BRANCO	479057	9373990	12	60	AÇ. PAUS BRANCO	479130	9374124	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
C47	VALENTIM DOS PINHEIROS	477238	9377008	18	90	AÇ. SR. MAIRTON	476986	9377142	–	–	POUCO SALOBRA	–	–	–	–	–	–	–	CISTERNAS (9)	–	–	–	–
C48	MILHÃ	478359	9372550	mais de 1000		AÇ. MONTE SOMBRIO	476649	9374588	50	CLORO	BOA	PVC	150	2000	476686	9374702	478090	9373368	ELEVADO	200	CONCRETO	478090	9373368
C49	MONTE SOMBRIO	475707	9375694	29	145	AÇ. MONTE SOMBRIO	476649	9374588	6	–	BOA	PVC	50	1000	476684	9374696	475945	9375452	ELEVADO	15	CONCRETO	475945	9375453
C50	PEDRA D´ÁGUA	474562	9376138	19	95	AÇ. DOS HERDEIROS	–	–	–	–	BOA	PVC	25	100	473960	9376974	–	–	CISTERNA (5)	–	–	–	–
C51	SERROTE	474801	9375608	9	45	AÇ. DOS HERDEIROS	474801	9375608	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

INDEX		LOCALIDADE				CAPTAÇÃO						ADUÇÃO							RESERVAÇÃO				
		COORDENADAS		RESIDENCIA	POPULAÇÃO	NOME	COORDENADAS		vazão	TRATAMENTO	QUALIDADE DA ÁGUA	TUBUL. (TIPO)	DIAM.	EXTENSÃO	E (INIC)	N (INIC)	E (FINAL)	N (FINAL)	TIPO	VOL. (m³)	MATERIAL	COORDENADAS	
		E	N				E	N	(m³/h)				(mm)	(m)								E	N
C52	AMEIXA	476868	9378386	8	40	AÇ. ANTº IRANEUDO	477021	9378042	2	–	BOA	PVC	30	VARIADA	–	–	–	–	CISTERNA	–	–	–	–
C53	BARRA 2	482990	9369494	80	400	PÇ. AMAZONAS (6m)	486926	9366926	–	–	POUCO SALOBRA	PVC	75		486926	9366926	484588	9367662	ELEVADO	45	CONCRETO	484588	9367662
C54	MORADA NOVA	483473	9369678	18	90	AÇ. MORADA NOVA	483490	9369694	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
C55	VISTA ALEGRE	485213	9366962	45	225	AÇ. DO VALDIR	485005	9367200	–	–	BOA	PVC	60	VARIADA	–	–	–	–	CISTERNAS (9)	–	–	–	–
C56	SÍTIO LIBERDADE	486093	9367252	10	50	AÇ. LIBERDADE	486138	9367138	–	–	BOA	PVC	32	130	486926	9366926	484588	9367662	CISTERNAS (3)	–	–	–	–
C57	BARRA 1	482184	9369940	60	300	AÇ. ALMINO ALVES	481612	9369920	–	–	BOA	PVC	25	150	486926	9366926	484588	9367662	CISTERNAS (7)	–	–	–	–
						PÇ. ARTESIANO (53m)	482184	9369940	–	–	SALOBRA												
C58	AMANAJU 1	482092	9366990	22	110	AÇ. DO AMANAJU	482369	9366946	–	–	RUIM	PVC	25	100	–	–	–	–	–	–	–	–	–
						PÇ. ARTESIANO (40m)	482323	9367276	8,3	–									CISTERNAS (8)				
C59	AMANAJU 2 (MILAGRES)	482400	9365430	9	45	AÇ. MILAGRES	482308	9365528	–	–	BOA	PVC	25	50	–	–	–	–	CISTERNAS (3)	–	–	–	–
C60	CAMPO NOVO	484311	9366440	5	25	PÇ. ARTESIANO (60m)	484971	9366486	10	–	BOA (POUCO SALOBRA)	PVC	32		484971	9366486	484311	9366440	APOIADO	5	FIBRA	484311	9366440
C61	DEUS ME AJUDE	484288	9366050	3	15	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
C62	VARZEA ALEGRE	484389	9369522	12	60	AÇ. DO RIVALDO	484355	9369412	–	–	BOA	–	–	–	–	–	–	–	CISTERNAS (6)	–	_	–	–
C63	BOM ALIVIO	485668	9370328	14	70	AÇ. DO SR. ROSIÊ CORINGA	–	–	–	–	–	–	–	–	–	–	–	–	CISTERNAS (4)	–	–	–	–
C64	KM 21	470831	9371382	7	35	AÇ. 21	470876	9371538	–	–	± BOA	PVC	25	150	–	–	–	–	CISTERNAS (1)	–	–	–	–
C65	OLHO D`AGUA	471537	9371328	21	105	AÇ. OLHO D`AGUA	471557	9371348	–	–	BOA	POLIETILENO	25	100	–	–	–	–	CISTERNAS (1)	–	–	–	–
						PÇ. ARTESIANO (62m)																	
C66	VILA NOVA	471931	9371034	52	260	PÇ. ARTESIANO (80m)	471791	9370994	2	CLORO	BOA	PVC	60	–	471791	9370994	471763	9370998	ELEVADO	21	CONCRETO	471763	9370998
C67	NOVO DESTINO	473932	9371450	45	225	PÇ. ARTESIANO (80m)	473752	9371414	2	–	BOA	PVC	100						ELEVADO	20	CONCRETO	474124	9371446
C68	BELA VISTA	473101	9372972	10	50	AÇ. LAGOINHA	–	–	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
C69	LAGOINHA	473852	9373202	5	25	AÇ. LAGOINHA	–	–	–	–	BOA	–	–	–	–	–	–	–	–	–	–	–	–
C70	SERRA VERDE	475532	9371766	30	150	LIGADO SIST. MILHA	–	–	–	–	BOA	PVC	110	–	–	–	–	–	ELEVADO	–	CONCRETO	474667	9371546
C71	SITIO MUCURIPE	476635	9371332	9	45	AÇ. MUCURIPE	476588	9371342	–	–	BOA	–	–	–	–	–	–	–	CISTERNAS(1)	–	–	–	–
C72	SAO PEDRO	476222	9371358	4	20	AÇ. SITIO SAO PEDRO	476196	9371444	–	–	BOA	PVC	25	150	–	–	–	–	–	–	–	–	–
C73	AGUA BOA	475338	9370140	80	400	PÇ. ARTESIANO	475365	9370042	–	–	SALOBRA	PVC	50	–	–	–	–	–	ELEVADO	12	CONCRETO	474802	9370178
C74	CIPO 1	478373	9366840	70	350	PÇ. ARTESIANO (13m)	479027	9366882	–	–	BOA	PVC	50	–	–	–	–	–	ELEVADO	15	CONCRETO	479060	9367242
C75	CIPO DOS PACIFICOS	479560	9366562	52	260	PÇ. ARTESIANO (7m)	478946	9366820	22	–	BOA	PVC	60	700	–	–	–	–	ELEVADO	15	CONCRETO	479611	9366468
C76	BAIXA VERDE	476640	9365564	90	450	AÇ. BAIXA VERDE	476981	9366070	–	–	RUIM	PVC	30	200	–	–	–	–	CISTERNAS (3)	–	–	–	–
C77	CAJUEIROS	475643	9361952	3	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C78	ARACAJU	477649	9363380	13	65	AÇ. ARACAJU	477768	9362984	–	–	BOA	POLIETILENO	30	± 500	–	–	–	–	CISTENAS (2)	–	–	–	–
C79	SANTA PAZ	438812	9362522	16	80	AÇ. SANTA PAZ	478874	9362762	–	–	BOA	PVC	32	–	–	–	–	–	ELEVADO	15	CONCRETO	–	–
						PÇ. PROFUNDO (59m)	478925	9362750															
C80	SITIO MARE	480590	9361132	8	40	PÇ. AMAZONAS	481613	9359600	–	–	–	–	–	–	–	–	–	–	CISTERNAS (8)	–	–	–	–
C81	FAZENDA NOVA	475018	9365652	81	405	–	–	–	–	–	–	–	–	–	–	–	–	–	ELEVADO	20		474823	9365102
C82	MONTE GRAVE	472892	9366336	120	600	PÇ. ARTESIANO (60m)	–	–	17	–	BOA	PVC	60	–	–	–	–	–	ELEVADO	30	CONCRETO	473602	9365300
C83	MONTE BELO	473757	9370240	30	150	PÇ. AMAZONAS (3,5m)	474122	9369896	–	–	RAZOAVEL	PVC	40	–	474122	9369896	473820	9370282	ELEVADO	10,5	CONCRETO	473820	9370282
						AÇ. AGUA BOA																	
C84	ALTO VERDE	476347	9370808	40	200	PÇ. AMAZONAS	476278	9370492	2,1	–	SALOBRA	PVC	60	100	–	–	–	–	CISTERNAS (7)	–	–	–	–
C85	TABULEIRINHO	476520	9368356	7	35	AÇ. TABULEIRINHO	476511	9368368	–	–	BOA	PVC	30	–	–	–	–	–	ELEVADO	7	CONCRETO	476159	9368202
					12340																		

4.2 Detailed Diagnosis for Each Community

4.2.1 C1 - CARNAUBINHA

Population

Carnaubinha is the largest District in the municipality of Milhã. The number of house connections in the district totals 300, with a total population of approximately 1,500 inhabitants. This is consistent with data obtained in the Feasibility Study for the Treatment and Disposal of Solid Waste in the State of Ceará, conducted by PROINTEC consultants for the SECRETARIAT FOR CITIES OF THE STATE OF CEARÁ in 2006/2007, which estimated the population of Canaubinha to total approximately 1,200 inhabitants. However, 2007 data from the Brazilian Army estimates a total of 1.750 people being served by the Water Truck Supply Program.

Population ≈ 1,750 people (Brazilian Army Data).

Location

UTM coordinates: E = 482.134 ; N = 9.385.408

Straight line distance from the municipal center: 13 km.

Figure 4.1 shows an aspect of the District of Carnaubinha.

Figure 4.1: District of Carnaubinha.

Description of the Water Supply System

Urban water supply to the district is provided by an aqueduct coming from the Quandu reservoir (E= 481.087 N = 9.384.508). There is a catchment system in the Quandu reservoir and a treatment system with the following units:

- Floating water catchment;
- Filter;
- Ground level reservoir;
- Color;
- Aqueduct pumping;
- Aqueduct;
- Elevated reservoirs;
- Gravity distribution.

According to local reports, the Quandu reservoir had never reached its full capacity in the past; however, in 2009 it did and locals estimate that the reservoir has a water reserve for the next two years. In 2007 the Quandu reservoir dried up completely and it was necessary to have water trucks supply the local population.

Figure 4.2 shows the Quandu reservoir.

Figure 4.2: Floating water collection device in the Quandu reservoir to provide water to Carnaubinha - 5 HP.

The treatment system was launched in 1993 but the current aqueduct was started operating in 1997.

Figure 4.3 shows the Water Treatment Station - ETA.

Figure 4.3: Carnaubinha's Water Treatment Station.

Figure 4.4 shows the poor state and precarious conditions of the water pumping system of Carnaubinha's ETA.

Figure 4.4: ETA Pumps for the elevated reservoir. Power = 7.5 HP.

The treated and pumped discharge informed by the operation is 52 m^3/h (14.44 L/s). The operator has probably provided incorrect information, since such a discharge would be enough to provide water to a town of up to 10,000 inhabitants with a discharge per capita of 120 L/inhab/day. Considering that the ground level reservoir can store 35 m^3 and the elevated reservoir can store 55 m^3, it is likely that the system's true discharge is below 8 L/s.

Water is filtered and treated with chlorine.

There is a 300-meter long RPVC Φ 75 mm from the collection site to the ETA and a 2,500-meter long PVC Φ 85 mm (3") aqueduct.

Figure 4.5 shows the district's elevated reservoir.

Figure 4.5: Elevated reservoir of the District of Carnaubinha. Vol= 55 m³.

There is a charge of R$ 12.90 on consumption of up to 10 m³. The system is run by SAAE - Milhã's Water and Sewage Autonomous System. There are only about 50 metered units.

Supply Provided by Water Trucks

In 2007 two water truck supply routes were established in Carnaubinha.

Table 4.2: Water Truck Supply

ROUTE	# 5	# 6
# OF PEOPLE SUPPLIED	650	1100
NECESSARY VOLUME OF WATER (m^3)	390	660
DISTANCE ON PAVED ROADS (km)	7	7
DISTANCE ON UNPAVED ROADS (km)	20	20
NUMBER OF WATER LOADS	56	94
MONTHLY DISTANCE ON PAVED ROADS (km)	392	658
MONTHLY DISTANCE ON UNPAVED ROADS (km)	1120	1880
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	10530	17820
MONTHLY COST (R$)	4.368,00	7.392,00
PERSON RESPONSIBLE FOR RECEIVING LOAD	ROBERTO	ROBERTO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

In order to solve their water dependency on the Quandu reservoir, which does not guarantee supply for the district of Carnaubinha during dry times, Milhã's municipal government has drafted a project to connect the current water supply system to an aqueduct that is to be built from the Traíras reservoir, 6 km away from Carnaubinha. There is also the possibility of collecting water from the recently built Antenor Pinheiro reservoir in the municipality of Quixeramobim, which is approximately 10 km away from Carnaubinha.

4.2.2 C2 - ALTO SANTO (CABEÇA DE BOI)

Population

The community of Alto Santo, also known as Cabeça de Boi, is a small community comprising 10 scattered houses near the community of Açude Novo and is under the influence of the latter.

Population ≈ 50 inhabitants.

Figure 4.6 shows the community's overall aspect.

Figure 4.6: Alto Santo Community (Cabeça de Boi).

Location

The community is located 17.3 km Northeast of Milhã at coordinates E=488.603 m and N=9.388.128 m.

Description of the Water Supply System

The community is supplied by a 2 km PVC Φ 32 mm aqueduct that comes from the same system which supplies Açude Novo. There is a gravity distribution system coming out of the Açude Novo elevated reservoir. Of all 10 houses in the community, only two are connected to the system; that is, there are 8 houses that are not supplied by the aqueduct. Figure 4.7 shows a metered house supplied by the abovementioned aqueduct.

Figure 4.7: House in the community of Alto Santo supplied by the Açude Novo aqueduct. The meter can be seen outside the house.

Supply Provided by Water Trucks

The community does not clearly appear as being on the water truck routes in the Brazilian Army's 2007 report.

Community Proposals

No proposals were submitted by the community of Alto Santo during our visit.

4.2.3 C3- AÇUDE NOVO

Population

The community of Açude Novo has about 68 houses. The community has considerable influence over the other 4 communities around it (Alto Santo, Grossos, Tabuleiro and Furnas).

Population ≈ 340 inhabitants.

Figure 4.8 shows an overview of the community.

Figure 4.8: An overview of the community of Açude Novo.

Location

The community of Açude Novo is located at coordinates E = 488.986 m and N = 9.387.448, about 18 km Northeast of Milhã.

Description of the Water Supply System

The water supply system of Açude Novo and of the other four surrounding communities comes from the Berilópolis reservoir, also called Açude Novo. Figure 4.9 shows the Berilópolis reservoir.

Figure 4.9: Berilópolis Reservoir, which supplies the community of Açude Novo.

The system consists of a catchment in the Berilópolis reservoir, at coordinates E = 488.677 and N = 9.387.306, which is pumped through a 130-meter PVC Φ 60 mm (2”) aqueduct to the elevated reservoir where water is distributed to communities.

Water catchment pumping is made by 7.5 HP pumps (Figure 4.10), whose indicated discharge was 15 m³/h. A second pumping with a 3 HP pump is employed to pump water from the reservoir to Grossos and a diversion at Km 2 takes water to Tabuleiro and Furnas.

Figure 4.10: Catchment system used in the Berilópolis reservoir to supply Açude Novo, Alto Santo (Cabeça de Boi), Grossos, Furnas and Tabuleiro.

Pumping to Grossos, Furnas and Tabuleiro is made by the pump shown in Figure 4.11. The equipment in the pump house is evidently in a terrible state.

Figure 4.11: Pump used to deliver water from Açude Novo to the communities of Grosso, Tabuleiro and Furnas.

The Açude Novo elevated reservoir has a storable volume of 21 m³. It was built as precast concrete rings (Figure 4.12). The reservoir was built by FUNASA but the system is run by Milhã's Water and Sewer Autonomous System.

Figure 4.12: The Açude Novo Elevated reservoir which supplies Alto Santo, Grossos, Açude Novo and Tabuleiro.

<u>Supply Provided by Water Trucks</u>

Table 4.3 summarizes water supply provided by water trucks to Açude Novo in 2007.

Table 4.3: Water Truck Supply

ROUTE	# 4
# OF PEOPLE SUPPLIED	75
NECESSARY VOLUME OF WATER (m^3)	45
DISTANCE ON PAVED ROADS (km)	8
DISTANCE ON UNPAVED ROADS (km)	32
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	48
MONTHLY DISTANCE ON UNPAVED ROADS (km)	192
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1800
MONTHLY COST (R$)	748,00
PERSON RESPONSIBLE FOR RECEIVING LOAD	AURILENE
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

According to information provided by people we interviewed, the Berilópolis reservoir has never dried up. The community had to be supplied by water trucks only in 2003 because of poor water quality; according to interviewees, the reservoir was misused. There is no quantitative shortage of water.

4.2.4 C4- TABULEIRO

Population

Tabuleiro is a community with 36 houses located in an area under the influence of the community of Açude Novo .

Population ≈ 180 inhabitants.

Location

The community of Tabuleiro is located at coordinates E = 491.337 m and N = 9.387.464, about 19,6 km Northeast of the center of Milhã.

Description of the Water Supply System

Tabuleiro is supplied by Açude Novo's aqueduct, collecting water from the Berilópolis reservoir. A 1900 meters long, 60mm DN aqueduct diverts water at Km 2 in order to provide water to the 25 m^3 ground level reservoir from where an underwater INAPI pump of 3HP raises water to a 21 m^3 elevated reservoir in Tabuleiro. Figure 4.13 shows Tabuleiro's elevated reservoir.

Only two households are not connected to the water supply system and use rainwater cisterns (Figure 4.14).

Figure 4.13: Tabuleiro's 21 m³ elevated reservoir.

Figure 4.14: Rainwater Cistern in Tabuleiro.

<u>Supply Provided by Water Trucks</u>

The community of Tabuleiro is not on the list of communities supplied by water trucks in the Brazilian Army's 2007 report.

<u>Community Proposals</u>

No proposals have been submitted by the community.

4.2.5 C5-FURNAS

<u>Population</u>

Furnas is a community with 13 homes under the area of influence of Tabuleiro/Açude Novo.

Population ≈ 65 inhabitants.

<u>Location</u>

Furnas is located at coordinates E= 494.935 and N= 9.390.396 in the far north of Milhã.

Description of the Water Supply System

Furnas is supplied by a gravity aqueduct coming from the elevated reservoir in Tabuleiro. It is a 35 mm DN PVC aqueduct, approximately 4,641 meters long.

Only three households are not connected to the water supply network and they use 16 m^3 rainwater cisterns. There are other six households 3 Km away from Tabuleiro that are not connected to the aqueduct system; they also use rainwater cisterns. Figure 4.15 shows one of them.

Figure 4.15: Rainwater Cistern at a home between Tabuleiro and Furnas.

Supply Provided by Water Trucks

The community of Furnas was included in the Water Distribution Program using Water Trucks in 2007, as shown in Table 4.4.

Table 4.4: Water Truck Supply

ROUTE	# 4
# OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (km)	8
DISTANCE ON UNPAVED ROADS (km)	34
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	24
MONTHLY DISTANCE ON UNPAVED ROADS (km)	102
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1008
MONTHLY COST (R$)	419,52
PERSON RESPONSIBLE FOR RECEIVING LOAD	CHICO KAISER
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

Residents consider water from the direct distribution network to be fit for human consumption. There are no other suggestions.

4.2.6 C6-GROSSOS

Population

The community of Grossos has 9 households in the area of influence of the community of Açude Novo, from where it receives water from the Berilópolis reservoir.

Population ≈ 45 inhabitants.

Location

Grossos is located at coordinates E=490.602 and N=9.385.578 northeast of Milhã's city center, approximately 17.6 km away from it.

Description of the Water Supply System

The aqueduct that supplies Grossos comes from Açude Novo (Berilópolis reservoir). It totals 2.6 km and is made of PVC DN 60 mm. Half of the aqueduct is in good conditions and the other half is in poor conditions, with problems in its bells. Water is sent to a 15 m³ ground level/elevated reservoir. There are 10 metered connections to the system, including 9 households and a school. Figure 4.16 shows the Grossos reservoir. Figure 4.17 shows the household where it is located.

Figure 4.16: Grossos ground level/elevated reservoir.

Figure 4.17: House in Grossos where the reservoir is located.

Supply Provided by Water Trucks

The Brazilian Army's 2007 report shows 3 consecutive communities listed as Grossos 01, Grossos 02 and Grossos 03. Data are shown in Table 4.5.

Table 4.5: Water Truck Supply

ROUTE #4	GROSSOS 01	GROSSOS 02	GROSSOS 03
# OF PEOPLE SUPPLIED	85	60	35
NECESSARY VOLUME OF WATER (m^3)	51	36	21
DISTANCE ON PAVED ROADS (km)	8	8	8
DISTANCE ON UNPAVED ROADS (km)	27	30	31
NUMBER OF WATER LOADS	7	5	3
MONTHLY DISTANCE ON PAVED ROADS (km)	56	40	24
MONTHLY DISTANCE ON UNPAVED ROADS (km)	189	150	93
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1785	1368	819
MONTHLY COST (R$)	741,00	568,80	340,62
PERSON RESPONSIBLE FOR	LEOCA	DORINHA	CHICO

RECEIVING LOAD			RAQUEL
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

Local people had been complaining of water shortage for at least a week during our field trip. According to them water came close but did not have enough pressure to reach the Grossos reservoir, probably due to leakages in the aqueduct's bells in its second half.

4.2.7 C7-ITABAIANA

Population

There are 21 households in the community of Itabaiana.

Population ≈ 105 inhabitants.

Location

The community of Itabaiana is located at coordinates E = 486.771 m and N = 9.380.464, about 11 km Northeast of Milhã. Figure 4.18 shows the community of Itabaiana.

Figure 4.18: The community of Itabaiana, late afternoon.

Description of the Water Supply System

There is no water supply system.

Supply Provided by Water Trucks

According to the Brazilian Army 2007 report, there are three consecutive communities listed as Itabaiana 01, Itabaiana 02 and Itabaiana 03. Table 4.6 shows a summary.

Table 4.6: Water Truck Supply

ROUTE #4	ITABAIANA 01	ITABAIANA 02	ITABAIANA 03
# OF PEOPLE SUPPLIED	25	35	60
NECESSARY VOLUME OF WATER (m^3)	15	21	36
DISTANCE ON PAVED ROADS (km)	7	7	7
DISTANCE ON UNPAVED ROADS (km)	17	17	19
NUMBER OF WATER LOADS	2	3	5
MONTHLY DISTANCE ON PAVED ROADS (km)	14	21	35
MONTHLY DISTANCE ON UNPAVED ROADS (km)	34	51	95

TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	360	504	936
MONTHLY COST (R$)	149,10	208,74	388,08
PERSON RESPONSIBLE FOR RECEIVING LOAD	MAURO	BEZERRA	NEZIM
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

There are several proposals to provide water to the community of Itabaiana:

a) Building a dam in the river Cabeça de Boi at coordinates E= 487.748 and N= 9.381.506;
b) Building an aqueduct collecting water from the alluvium well at coordinates E= 487.654 and N= 9.381.434, whose water is considered fit for human consumption;
c) There are two finished wells in the community at coordinates E= 486.810 and N= 9.380.558, with a gasoline-powered engine, awaiting an electricity connection to start operating. However, water is saline.

Alternative (b) seems worthier of attention.

4.2.8 C8-IPUEIRAS

Population

Ipueiras is an Official District of Milhã. According the latest data, there are 78 households in the community. Officially, there are 400 inhabitants.

Population ≈ 390 inhabitants.

Location

Ipueiras is located at coordinates E=482.836 and N=9.387.924. It is approximately 16 Km away from the center of Milhã. Figure 4.19 shows the District of Ipueiras.

Figure 4.19: The District of Ipueiras.

<u>Description of the Water Supply System</u>

The district of Ipueiras used to be supplied by a system that collected water from an Amazon-type well, built in 2001. Water was saline and people used to look for drinking water in the Alberto reservoir. The construction of the Antenor Pinheiro Reservoir has recently promoted the district's isolation during the 2009 flood and has covered the Alberto Reservoir. The current system was underwater at the time and firemen had to save the filter abandoning it on the banks of Antenor Pinheiro Reservoir (Figure 4.20).

Figure 4.20: An abandoned filter on the banks of Antenor Pinheiro Reservoir.

The previous system was made up of an alluvium Amazon-type well where today is the hydrological basin of the Antenor Pinheiro reservoir. The system consisted of a 2.5 HP M4P2-Ebara underwater pump which is currently being kept by the community (Figure 4.21) and it brought the water through a 600 meter-long RPVC DN 60 mm pipe to the elevated reservoir and from there water was taken to the supply network.

The 21 m³ reservoir is located at coordinates E=483.710 and N=9.387.524, and it is isolated by the Antenor Pinheiro reservoir (Figure 4.22).

In 2007 and 2008 the district of Ipueiras had to be supplied by a water truck.

The system is run by Associação Comunitária Hermenegilda de Jesus (Hermenegilda de Jesus Community Association) and it has 40 members. Members pay a R$ 6.00 water fee and non-members pay R$ 7.00.

Figure 4.21: Underwater pump from an abandoned alluvium well.

Figure 4.22: Elevated reservoir of the District of Ipueiras, currently isolated by the Antenor Pinheiro reservoir.

The District of Ipueiras was affected the most by the 2009 floods. It was flooded suddenly by the overflowing of Antenor Pinheiro Reservoir and no arrangements were made to remove families from its hydrological basin. Figure 4.23 shows the homes that were practically under water in the 2009 flood.

Figure 4.23: Homes in Ipueiras that were partially underwater when the Antenor Pinheiro reservoir overflowed in 2009.

Supply Provided by Water Trucks

Table 4.7 shows a summary of water supply to the District of Ipueiras in 2007 provided by water trucks.

Table 4.7: Water Truck Supply

ROUTE	# 5
# OF PEOPLE SUPPLIED	400
NECESSARY VOLUME OF WATER (m^3)	240
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	23
NUMBER OF WATER LOADS	34
MONTHLY DISTANCE ON PAVED ROADS (km)	238
MONTHLY DISTANCE ON UNPAVED ROADS (km)	782
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	7200
MONTHLY COST (R$)	2.990,40
PERSON RESPONSIBLE FOR RECEIVING LOAD	NEURILÂNIA
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposed the construction of a new catchment system to be installed in Antenor Pinheiro reservoir, using the filter that was salvaged by firemen and that is abandoned on its banks, at coordinates E=483.405 and N=9.387.766; the construction of a new elevated reservoir at coordinates E=482.782 and N=9.388.176.

4.2.9 C9-QUANDU

Population

The community of Quandu currently has 9 households.

Population ≈ 45 inhabitants.

Location

Quandu is located at coordinates E=480.324 and N=9.383.506, about 11 Km north of the center of Milhã (Figure 4.24).

Figure 4.24: The community of Quandu.

Description of the Water Supply System

Quandu is supplied by an Amazon-type well located at coordinates E=480.479 and N=9.383.540. There are two pumps in this well (Figures 4.25 and 4.26).

The first pump supplies 6 homes and is managed by Mr. Benedito, who charges a fee of R$ 10.00 per family. The second pump supplies three homes and it is managed by Mr. Francisco Alves de Lima, who charges a fee that ranges from R$ 30.00 to R$ 35.00.

The pipes that supply homes are PVC DN 25 mm.

Figure 4.25: An Amazon-type well that supplies Quandu with two pumps.

Figure 4.26: Pumps in Quandu's Amazon-type well, with different administrators and water charges.

Supply Provided by Water Trucks

The Brazilian Army's 2007 report does not list Quandu in the water truck routes.

Community Proposals

The community of Quandu proposes the construction of a catchment system in the Riacho do Meio reservoir, located upstream . There already is a working system collecting water from the Riacho do Meio reservoir that supplies the community of Riacho do Meio, in addition to a system designed to supply Reconquista and Quandu.

4.2.10 C10-LAGOA NOVA

Population

There are approximately 50 homes in Lagoa Nova with 48 connections to the water system.

Population ≈ 250 inhabitants.

Location

Lagoa Nova is located at coordinates E=482.658 and N=9.384.196, about 10 Km north of the center of Milhã (Figure 4.27).

Figure 4.27: Community of Lagoa Nova.

Description of the Water Supply System

Currently supply is precarious, with water for general use coming from an alluvium Amazon-type well located at coordinates E=482.687 and N=9.382.844 (Figure 4.28), with a 3 HP INAPI pump. Water is brought by a 873 meter-long PVC DN 50 mm aqueduct to a 21 m³ elevated reservoir located at coordinates E=482.433 and N=9.382.008. The system is run by Associação Comunitária São José da Lagoa Nova (São José da Lagoa Nova Community Association) and it has 48 members who pay a minimum fee of R$ 6.00/15 m³.

The well does not provide good quality water for human consumption. According to locals, during the dry season (summer), drinking water comes from the Quandu reservoir, which is approximately 5 km away, and it is brought by a water truck or by donkeys. During the rainy season (winter), water is collected in nearby reservoirs.

Figure 4.28: An Amazon-type well that supplies Lagoa Nova.

Figure 4.29: Lagoa Nova’s Elevated reservoir.

There is also a deep well (Figure 4.27) at Mr. Chico Criança’s house which used to provide water to an old fountain that used to be Lagoa Nova's supply system.

Figure 4.30: Lagoa Nova's old supply fountain.

Supply Provided by Water Trucks

Table 4.8 shows a summary of water supply to Lagoa Nova in 2007 provided by water trucks.

Table 4.8: Water Truck Supply

ROUTE	# 1
# OF PEOPLE SUPPLIED	90
NECESSARY VOLUME OF WATER (m^3)	54
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	14
NUMBER OF WATER LOADS	8
MONTHLY DISTANCE ON PAVED ROADS (km)	56
MONTHLY DISTANCE ON UNPAVED ROADS (km)	112
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1134
MONTHLY COST (R$)	468,72
PERSON RESPONSIBLE FOR RECEIVING LOAD	ZIZI
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

Due to the issue of poor water quality for human supply provided by the current system implemented by the São José Project, the community proposes the construction of rainwater cisterns in most homes through the Programa 1 Milhão de Cisternas (1 Million Cisterns Program).

There is also a deep well that was dug by Milhã's Municipal government two years ago. It is 60 meters deep and has potable water of good quality; however, it is currently inactive. According to sources, its flow rate would be enough to meet local water needs.

Another option would be the construction of the Lagoa Nova reservoir, whose studies were initiated in 1958 by DNOCS. The reservoir would be located at coordinates E=482.417 and N=9.382.784.

In 1992, Professor Osny Silva, who is currently a member of UFC's group on Climate Risk Management and Water Sustainability, was one of the authors of the project for the Lagoa Nova reservoir, prepared by consultancy company VBA for DNOCS. This project included a reservoir capable of storing 3 hm³. Figure 4.31 shows the concrete survey marker positioned by VBA marking the Ground Zero for the left abutment of the Lagoa Nova Dam.

Figure 4.31: Survey marker positioned by VBA on the Lagoa Nova Dam site.

Figure 4.32 shows a general view of the river valley to be dammed.

Figure 4.32: A general view of the abutment, left to right, of the mouth of the Lagoa Nova Dam.

4.2.11 C11-SANTA FÉ

Population

The community of Santa Fé currently has 6 households.

Population ≈ 35 people (Brazilian Army Data).

Location

The community of Santa Fé is located at coordinates E = 483.511 m and N = 9.379.856, about 8,7 km Northeast of Milhã.

Figure 4.32: The community of Santa Fé.

<u>Description of the Water Supply System</u>

The population uses water from a privately owned reservoir in Santa Fé, owned by Mr. Genildo Bezerra. Water for home use is collected directly from the reservoir using buckets. During dry seasons water supply comes from water trucks. There is a private pipe system to two of Mr. Genildo's houses and two other houses in his property will be connected to the system. Only two houses have absolutely no access to water. The Santa Fé reservoir usually dries up after 2 or 3 dry years.

<u>Supply Provided by Water Trucks</u>

Table 4.9 shows a summary of water supply to Santa Fé provided by water trucks.

Figure 4.9: Supply Provided by Water Trucks

ROUTE	# 01
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	13
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS	21

(km)	
MONTHLY DISTANCE ON UNPAVED ROADS (km)	39
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	420
MONTHLY COST (R$)	173.46 inhabitants/Km².
PERSON RESPONSIBLE FOR RECEIVING LOAD	GENILDO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes building rainwater cisterns in both houses that have no connection to the Santa Fé reservoir. There is a deep well at coordinates E=483.616 and N=9.379.862. It has good quality water and the amount is enough that could be used during dry periods (Figure 4.33).

Figure 4.33: A deep well in Santa Fé that could be used for water supply during dry seasons.

4.2.12 C12-SÃO BENTO / SÃO LUIZ

Population

The communities of São Bento and São Luiz total 21 households. There are an estimated 105 inhabitants. According to Brazilian Army data, the population covered by the water truck program totals 90 people.

Population ≈ 90 inhabitants.

Location

The community of São Bento is located at coordinates E = 482.037 m and N = 9.379.316, about 7.5 km Northeast of Milhã. The community of São Luiz is located at coordinates E=481.486 and N=9.379.568. (Figures 4.34 and 4.35)

Figure 4.34: Community of São Bento.

Figure 4.35: Community of São Luiz.

<u>Description of the Water Supply System</u>

There is a single catchment at a private reservoir that provides water to the home of Mrs. Maria da Conceição. This reservoir has never dried up and has good quality water. There is a well built by FUNASA which may be useful as a source of supply.

Figure 4.36: Alluvium well in São Bento for future water supply.

<u>Supply Provided by Water Trucks</u>

Table 4.10 shows a summary of water supply to São Bento and São Luiz provided by water trucks in 2007.

Figure 4.10: Supply Provided by Water Trucks

ROUTE	# 01
# OF PEOPLE SUPPLIED	90
NECESSARY VOLUME OF WATER (m³)	54
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	11
NUMBER OF WATER LOADS	8
MONTHLY DISTANCE ON PAVED ROADS (km)	56
MONTHLY DISTANCE ON UNPAVED	88

ROADS (km)	
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	972
MONTHLY COST (R$)	400.68
PERSON RESPONSIBLE FOR RECEIVING LOAD	JOÃO ANANIAS
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

A few houses are set to receive rainwater cisterns, 5 in São bento and 5 in São Luiz. There is a proposal to use the well implemented by FUNASA, which is supported by the local Community Association.

4.2.13 C13-JAPÃO

Population

The community of Japão has 40 households with a population of 200 inhabitants, exactly the same amount surveyed by the Brazilian Army in 2007.

Population ≈ 200 inhabitants.

Location

The community of Japão is located at coordinates E = 475.386 m and N = 9.384.774, about 12.4 km northeast of the center of Milhã.

Figure 4.37: Community of Japão

<u>Description of the Water Supply System</u>

Almost all homes in Japão have cisterns to store water provided by water trucks. About 8 homes have their own supply system with pipes coming in from the Zezinho reservoir, located at coordinates E=475.478 and N=9.385.034. There are three pumps collecting water from the Zezinho reservoir (Figure 4.38), a 5 HP INAPI pump and two 3 and 7 HP KING pumps, respectively. PVC pipes come out of these pumps to provide water directly to homes, consisting of a DN 40 mm pipe and other two DN 50 mm pipes, approximately 500 meters each.

There is no treatment to the water collected from the Zezinho reservoir.

Figure 4.38: Water catchment from the Zezinho reservoir to homes in the community of Japão.

Supply Provided by Water Trucks

Table 4.11 shows a summary of water supply provided by water trucks in 2007.

Figure 4.11: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	200
NECESSARY VOLUME OF WATER (m^3)	120
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	20
NUMBER OF WATER LOADS	17
MONTHLY DISTANCE ON PAVED ROADS (km)	119
MONTHLY DISTANCE ON UNPAVED ROADS (km)	340
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	3240
MONTHLY COST (R$)	1,344.00
PERSON RESPONSIBLE FOR RECEIVING LOAD	ALMEIDA
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes to build an aqueduct collecting water from the Traíras reservoir, which is 3.2 km away from Japão. There is a project that was drafted with this aim by Milhã's Municipal Government. There is also a well with good quality water built at coordinates E=475.536 and N=9.384.534 that could be used as a spring, with a flow rate of 3 m^3/h or 0.83 L/s.

4.2.14 C14-RIACHO VERDE

Population

Riacho Verde is a 28-household community with an estimated population of 140 inhabitants.

Population ≈ 140 inhabitants.

Location

Riacho Verde (Figure 4.39) is located at coordinates E = 476.589 m and N = 9.385.168, about 12.6 km Northeast of the center of Milhã.

Figure 4.39: Community of Riacho Verde.

Description of the Water Supply System

Water supply is precarious. The existing sources of water are: Martinha reservoir (Figure 4.41) (coordinates E=476.567 and N=9.385.250), with two pumps collecting water, one of which provides water to two families and the other providing water to five families who pay a fee of R$ 10.00. Water from the reservoir is considered as having good quality. Another option is a well (Figure 4.40), which was built to provide water to a school that is currently inactive. Water from this well is considered very saline and families drink water from cisterns. The well has a flow rate of 4.5 m^3/h, with a 3 HP underwater pump, and it provides water to 18 families. A 200-meter long PVC DN 25 mm aqueduct distributes water to homes. Electricity costs to provide water to those 18 homes is paid by Milhã's Municipal Government. There are 18 homes with cisterns that store water from water trucks.

Figure 4.40: Well that provides water to 18 homes in Riacho Verde.

Figure 4.41: Martinha Reservoir in Riacho Verde.

Supply Provided by Water Trucks

According to the Brazilian Army 2007 report, there are two consecutive communities listed as Riacho Verde 01 and Riacho Verde 02, totaling 100 inhabitants. Table 4.12 shows a summary.

Table 4.12: Supply Provided by Water Trucks

ROUTE #02	RIACHO VERDE 01	RIACHO VERDE 02
# OF PEOPLE SUPPLIED	50	50
NECESSARY VOLUME OF WATER (m^3)	30	30
DISTANCE ON PAVED ROADS (km)	7	7
DISTANCE ON UNPAVED ROADS (km)	23	22
NUMBER OF WATER LOADS	4	4
MONTHLY DISTANCE ON PAVED ROADS (km)	28	28
MONTHLY DISTANCE ON UNPAVED ROADS (km)	92	88
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	900	870
MONTHLY COST (R$)	373.80	361.20
PERSON RESPONSIBLE FOR RECEIVING LOAD	ROGERSON	TOTÔ
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

According to sources there was a project to provide water from the Martinha reservoir to all households. The problem is that it will dry up after a year of drought. The cost of the approved project was R$ 97,000.00. There is also the possibility of expanding the Martinha reservoir in order to boost its water supply.

Milhã’s Municipal Government promised another project which consists of making a ramification to the projected aqueduct in order to provide water to the community of Japão by collecting water from the Traíras reservoir.

4.2.15 C15-JOSÉ DE PAZ

Population

There are three houses in the José da Paz ranch, where 11 people live. According to Brazilian Army data, there are 60 people in the area that surrounds the ranch.

Population ≈ 11 inhabitants.

Location

The community of José da Paz is located at coordinates E = 487.568 m and N = 9.371.248 (Figure 4.42), about 9.2 km to the east of Milhã.

Figure 4.42: José de Paz Ranch

Description of the Water Supply System

There is no source of water, except for rainwater cisterns (Figure 4.43).

Figure 4.43: Rainwater cisterns in the José de Paz Ranch.

Supply Provided by Water Trucks

Table 4.13 shows a summary of water supply provided by water trucks in 2007.

Table 4.13: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	60
NECESSARY VOLUME OF WATER (m^3)	36
DISTANCE ON PAVED ROADS (km)	13
DISTANCE ON UNPAVED ROADS (km)	9
NUMBER OF WATER LOADS	5
MONTHLY DISTANCE ON PAVED ROADS (km)	65
MONTHLY DISTANCE ON UNPAVED ROADS (km)	45
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	792
MONTHLY COST (R$)	323.28
PERSON RESPONSIBLE FOR RECEIVING LOAD	EVERARDO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There is a project drafted by the Ranch's Community Association and surrounding areas to build an aqueduct from the Rosiê reservoir. This reservoir is able to resist up to two years of drought. According to the Association President, the definitive solution would be to build the Capitão-Mor dam as well as an approximately 1 km-long aqueduct in its hydrological basin.

4.2.16 C16-CRUZEIRO/JOSÉ DE PAZ

Population

The neighboring community of Cruzeiro has five households where 16 people live. It may be considered an extension of the São José de Paz ranch and all considerations valid for the latter may be applied to the Cruzeiro Ranch.

4.2.17 C17-BARRA DO JUAZEIRO

Population

The community of Barra do Juazeiro has 10 households with 50 inhabitants.

Population ≈ 50 inhabitants.

Location

Barra do Juazeiro (Figure 4.44) is located at coordinates E = 486.384 m and N = 9.371.448, about 8 km to the east of Milhã.

Figure 4.44: Barra do Juazeiro.

<u>Description of the Water Supply System</u>

There is no water source or spring nearby. The population is supplied by water that is transported on donkeys (Figure 4.45), all the way from the Rosiê reservoir. There are rainwater cisterns in four homes built by the 1 Million Cisterns Program.

Figure 4.45: Water transportation on a donkey to Barra do Juazeiro.

<u>Supply Provided by Water Trucks</u>

Table 4.14 shows a summary of water supply provided by water trucks in 2007. According to the Brazilian Army report, there are two locations listed as Barra do Juazeiro 01 and Barra do Juazeiro 02.

Table 4.14: Supply Provided by Water Trucks

ROUTE #02	BARRA DO JUAZEIRO 01	BARRA DO JUAZEIRO 02
# OF PEOPLE SUPPLIED	35	50
NECESSARY VOLUME OF WATER (m^3)	21	30
DISTANCE ON PAVED ROADS (km)	13	13
DISTANCE ON UNPAVED ROADS (km)	7	9
NUMBER OF WATER LOADS	3	4
MONTHLY DISTANCE ON PAVED ROADS (km)	39	52
MONTHLY DISTANCE ON UNPAVED ROADS (km)	21	36
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	420	660
MONTHLY COST (R$)	170.94	269.40

PERSON RESPONSIBLE FOR RECEIVING LOAD	DEIUSON	JOVINA
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

The same as those proposed by the José de Paz Ranch.

4.2.18 C18-BOM ALÍVIO

Population

As described in the 2007 Brazilian Army report, there are two consecutive communities listed as Bom Alívio. There are 14 households and 55 inhabitants in Bom Alívio 01 and 10 households and 5 inhabitants in Bom Alívio 02.

Population ≈ 105 inhabitants.

Location

The joint communities of Bom Alívio (Figure 4.46) are located at coordinates E = 485.668 and N = 9.370.328, about 7.6 km to the east of Milhã.

Figure 4.46: Community of Bom Alívio.

Description of the Water Supply System

There is no source of water nearby. Locals fetch water from the Rosiê Coringa reservoir and bring it using animals from a 2 km distance. There is one family who has built a private cistern (Figure 4.47) and other three families who have been included in the 1 Million Cisterns Program.

Figure 4.47: Private cistern at a home in Bom Alívio.

Water Supply Provided by Water Trucks

Table 4.15 shows a summary of water supply provided by water trucks in 2007.

Table 4.15: Supply Provided by Water Trucks

ROUTE #02	BOM ALÍVIO 01	BOM ALÍVIO 02
# OF PEOPLE SUPPLIED	55	50
NECESSARY VOLUME OF WATER (m^3)	33	30
DISTANCE ON PAVED ROADS (km)	13	13
DISTANCE ON UNPAVED ROADS (km)	5	6

NUMBER OF WATER LOADS	5	4
MONTHLY DISTANCE ON PAVED ROADS (km)	65	52
MONTHLY DISTANCE ON UNPAVED ROADS (km)	25	24
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	594	570
MONTHLY COST (R$)	240.90	231.60
PERSON RESPONSIBLE FOR RECEIVING LOAD	ARLETE	JOÃO BOSCO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Community Proposals

The same as those proposed by the José de Paz Ranch, because the community is in its area of influence.

4.2.19 C19- LAJES

Population

Field research has revealed that Lajes has six homes where 16 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 90 inhabitants, although the location is exactly the same. We have adopted the figures from the field survey.

Population ≈ 16 inhabitants.

Location

The community of Lajes (Figure 4.48) is located at coordinates E = 487.184 and N = 9.372.658, about 9.8 km to the far east of Milhã, next to Solonópole.

Figure 4.48: Community of Lajes

Description of the Water Supply System

Lajes is part of area influenced by the José de Paz Ranch. Two homes get water from the Bolsão reservoir, located at coordinates E=488.269 and N=9.372.672. Other two homes received water from Mr. Iraneudo's private reservoir; donkeys transport water from a 250-meter distance. There is only one home that has been included in the 1 Million Cisterns Program.

Water Supply Provided by Water Trucks

Table 4.16 shows a summary of water supply provided by water trucks in 2007.

Table 4.16: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	90
NECESSARY VOLUME OF WATER (m^3)	54
DISTANCE ON PAVED ROADS (km)	13
DISTANCE ON UNPAVED ROADS (km)	12
NUMBER OF WATER LOADS	8
MONTHLY DISTANCE ON PAVED ROADS (km)	104
MONTHLY DISTANCE ON UNPAVED	96

ROADS (km)	
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1350
MONTHLY COST (R$)	552.96
PERSON RESPONSIBLE FOR RECEIVING LOAD	CHICO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The Lajes community's main proposal is to be a part of the project to be developed in the José de Paz Ranch, which influences the entire surrounding region. There have been attempts to build wells up to 90 meters deep, with unsatisfactory results.

4.2.20 C20- SANTA ROSA

Population

Our field survey has revealed that Santa Rosa has only two homes where 5 people live. There is one house under construction.

Population ≈ 5 inhabitants.

Location

Because it is so small, the coordinates of the community of Santa Rosa were not recorded. It is approximately four kilometers away from José de Paz and three kilometers away from Lajes.

Description of the Water Supply System

There is only one household with a cistern under construction.

Water Supply Provided by Water Trucks

This community is not listed by the Brazilian Army, with respect to the 2007 water truck supply program.

Community Proposals

The Lajes community's main proposal is to become part of the project to be developed in the José de Paz Ranch, which influences the entire surrounding region. However, the system designed for José de Paz does not include water supply to Santa Rosa.

4.2.21 C21-TRAÍRAS

Population

Field research has revealed that Traíras has 37 homes where 185 people live. **Population ≈ 185 inhabitants.**

Location

The community of Traíras is located at coordinates E = 477.020 and N = 9.382.300, about 9.7 km northeast of Milhã.

Description of the Water Supply System

There is a water supply system from the São Sebastião reservoir, which was built in 1992 and renovated in 2008. The São Sebastião reservoir is located at coordinates E= 478.071 and N= 9.382.926. According to sources this reservoir has never dried up and has good quality water. A 1.5 HP Dancor pump with a flow rate of 3.75 m³/h (Figure 4.49) collects water in a floating system. There is no chlorine treatment, but water is filtered. There is a 240 meter-long PVC DN 60 mm aqueduct that takes water to a 15 m³ reservoir (Figure 4.50) located at coordinates E=477.020 and N= 9.382.300.

Figure 4.49: Floating water collection in the São Sebastião reservoir in Traíras.

Figure 4.50: Traíras' Elevated Reservoir.

The system provides water to 41 metered consumption units, 37 of which are homes and four are stables. The system is run by Associação Olímpio Nonato (Olímpio Nonato Association) and it has 65 members. Members pay a R$ 7.00 fee and non-members pay R$ 8.00.

Water Supply Provided by Water Trucks

There is no need for water trucks because the system is self-sustainable. During dry periods the São Sebastião reservoir is used as a water collection source for the Brazilian Army's water truck program, providing water to the nearby communities of Japão, Riacho Verde and Carnaubinha.

Community Proposals

There are no new proposals, since the system works well and provides enough water to the community.

4.2.22 C22-RECONQUISTA

Population

Field research has revealed that Reconquista has 21 homes where 105 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 75 inhabitants. We have adopted the figures from our field survey because there are families who do not benefit from the water truck program due to the fact that they have their own water supply solutions.

Population ≈ 105 inhabitants.

Location

The community of Reconquista is located at coordinates E = 479.996 and N = 9.382.868, about 10.2 km north of Milhã, between the communities of Quandu and Riacho do Meio.

Description of the Water Supply System

There is an Amazon-type well built on Valentim creek's riverbed, at coordinates E=480.114 and N=9.382.834 (Figure 4.51), which provides water to community households. Some families collect water in buckets and others have built private pipe systems with DN 25 mm pipes whose length ranges from 150 to 300 meters. We have identified five 3 HP Inapi pumps feeding shared pipe systems. Six homes pay their pumping bills separately, while for other houses there is a fee of R$ 7.00, and a R$ 10.00 fee for a third home. According to information from locals, the Valentim creek has never dried up and families who have the individual or the Amazon-type well shared water supply system have never needed the assistance of water trucks. Part of the community are members of the Associação da Comunidade Riacho do Meio (Riacho do Meio Community Association).

Figure 4.51: Amazon-type well that provides water to the community of Reconquista.

<u>Water Supply Provided by Water Trucks</u>

Table 4.17 shows a summary of water supply provided by water trucks in 2007.

Table 4.17: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	75
NECESSARY VOLUME OF WATER (m^3)	45
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	13
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	42
MONTHLY DISTANCE ON UNPAVED ROADS (km)	78
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	900
MONTHLY COST (R$)	371.70
PERSON RESPONSIBLE FOR RECEIVING	Antonia Paulina

LOAD	
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community's main proposal is to become a part of the project already drafted for Riacho do Meio.

4.2.23 C23-RIACHO DO MEIO

Population

Our field survey has revealed that Riacho do Meio has 20 homes where 100 people live.

Population ≈ 100 inhabitants.

Location

The community of Riacho do Meio is located at coordinates E = 479.498 and N = 9.381.280, about 8.6 km north of Milhã, between the communities of Ingá and Reconquista.

Figure 4.52: The community of Riacho do Meio, with the reservoir to the left.

<u>Description of the Water Supply System</u>

The community of Riacho do Meio has a water supply system that was built by the state water and sewer system CAGECE, and consists of:

• floating water catchment system in the Riacho do Meio Reservoir (Figure 4.53) a 1 HP Dancor pump;

• a Water Treatment Station - ETA (Figure 4.54) with filtering and chlorine treatment systems;

• an aqueduct to an elevated reservoir (starting at the ETA, coordinates E=479.524 and N=9.381.150) with a 1 ½ HP pump;

• a 17 m³ elevated reservoir at coordinates E=479.405 and N=9.381.738 (Figure 4.55).

Figure 4.53: Floating water catchment system in the Riacho do Meio reservoir.

Figure 4.54: CAGECE's ETA in Riacho do Meio - São José Project.

Figure 4.55: Elevated reservoir in Riacho do Meio.

The Riacho do Meio Water Supply System was implemented by CAGECE through the São José Project; however the distribution network is still to be completed. Only three homes currently receive water from this system. 63 families are expected to be connected in the future. There are five families who collect water from the Riacho do

Meio reservoir on their own initiative and other seven that have private pumps and who distribute water among themselves.

The implemented system is not run by CAGECE, but it is under the responsibility of Associação Comunitária Ananias Freire (Ananias Freire Community Association) in Riacho do Meio. There are 32 members who pay a fee of R$ 5.00/month.

Water Supply Provided by Water Trucks

There isn't any.

Community Proposals

The community of Riacho do Meio's main proposal is to implement the water distribution network for homes in the community. A project has been drafted and sent to the State Government (São José Project), applying for funds. The system would be run by SISAR/CAGECE.

4.2.24 C24-TRANSVAL

Population

Our field survey has revealed that the community of Transval has six homes where supposedly 30 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 95 inhabitants, probably because it includes other scattered households nearby in the community of São João. We have adopted the figures provided by the Brazilian Army.

Population ≈ 95 inhabitants.

Location

The community of Transval is located at coordinates E = 479.678 and N = 9.378.552, about 6 km north of Milhã (Figure 4.56).

Figure 4.56: Community of Transval

<u>Description of the Water Supply System</u>

Water supply for this community comes from the Transval reservoir, at coordinates E=479.832 and N=9.378.548. It is privately owned and consists of a 1.5 HP King pump (Figure 4.57) that pumps up to 1 m^3/hour into a 35 m^3 cistern (Figure 4.58). The reservoir has been expanded but it cannot stand two years of drought. Water supply provided by water trucks was necessary up until 2008. From the reservoir to the cistern there is a 25 mm DN PVC aqueduct, whose length is approximately 280 meters. Water from the Transval reservoir is considered as having good quality.

A few families from other communities, twelve from Pedra Fina and two from São João used to get their water from the Transval cistern during the 2007/2008 drought.

Figure 4.57: Water catchment in the Transval reservoir.

Figure 4.58: A 35 m³ cistern in Transval

Water Supply Provided by Water Trucks

Table 4.18 shows a summary of water supply provided by water trucks in 2007.

Table 4.18: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	95
NECESSARY VOLUME OF WATER (m^3)	57
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	7
NUMBER OF WATER LOADS	8
MONTHLY DISTANCE ON PAVED ROADS (km)	56
MONTHLY DISTANCE ON UNPAVED ROADS (km)	56
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	798
MONTHLY COST (R$)	327.18
PERSON RESPONSIBLE FOR RECEIVING LOAD	Zé Ito
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes the expansion of the reservoir in the neighboring community of Pedra Fina. This project would provide enough water for the communities of Pedra Fina, Transval and São João simultaneously.

4.2.25 C25- SÃO JOÃO

Population

Our field survey has revealed that the community of São João has six homes where supposedly 40 people live.

Population ≈ 40 inhabitants.

Location

The community of São João is located at coordinates E = 479.675 and N = 9.378.642, about 6 km north of Milhã (Figure 4.59).

Figure 4.59: Community of São João.

<u>Description of the Water Supply System</u>

The community's water supply is provided by a 16 m³ cistern, built by the 1 Million Cisterns Program (P1MC). Water is collected from the São João (coordinates E= 478.766 e N=9.379.422), Riacho do Meio (3 families) and Mr. Josué's (2 families) reservoirs. The community depends on supply systems of neighboring communities.

Water collected from the São João reservoir (Figure 4.60) is not fit for human consumption, even during the rainy season.

Figure 4.60: São João Reservoir.

Water Supply Provided by Water Trucks

This community is included in the Transval route.

Community Proposals

The community proposes that a reservoir be built in the Valentim creek in the community of São João, close to the homes of Mr. José and Mr. Gilson, at approximate coordinates E=479.052 and N=9.379.302.

4.2.26 C26-VALENTIM DO SABINO

Population

Our field survey has revealed that the community of Valentim do Sabino has 50 homes where 250 people live. However, the field survey has also verified that the local Community Association has 60 members and 30 homes receive water collected from the Pedra Fina reservoir.

Population ≈ 250 inhabitants.

Location

The community of Valentim do Sabino is located at coordinates E = 478.972 and N = 9.377.116 and is 4.5 km north of Milhã (Figure 4.61).

Figure 4.61: Community of Valentim do Sabino.

Description of the Water Supply System

The community's water supply comes from the Integrated Supply System of Pedra Fina Reservoir. Water is fully treated and distribution is metered in 30 households. The local Community Association is private and has 60 members who pay a R$ 1.00 monthly membership fee. The monthly water charge is R$ 10.00. Non-payment for two consecutive months is punished with suspension of the service, but there has not been any disruption so far. There are three families whose payments are usually late. The operator gets a monthly salary of R$ 250.00.

Water Supply Provided by Water Trucks

According to field survey data, the community that receives water from water trucks is Valentim dos Pinheiros and not Valentim do Sabino.

Community Proposals

There are no proposals because the system is self-sustainable.

4.2.27 C27-PEDRA FINA

Population

Our field survey has revealed that the community of Pedra Fina has 39 homes where 195 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 275 inhabitants. The BA Report probably includes other homes from neighboring communities, such as Ingá.

Population ≈ 195 inhabitants.

Location

The community of Pedra Fina is located at coordinates E = 478.840 and N = 9.378.517 and is 5.8 km north of Milhã.

Description of the Water Supply System

There is an Independent Water Supply System in Pedra Fina, at coordinates E=478.980 and N=9.378.232. Water comes from a floating collection system in the Pedra Fina reservoir (Figure 4.62), which pumps water to a Water Treatment Station (ETA, figures 4.63 and 4.64) using a 2 HP King pump. There is a 450-meter long PVC DN 75 mm aqueduct which takes water to a 30 m³ elevated reservoir, located at coordinates E=478.729 and N=9.378.512.

Figure 4.62: Floating water collection in the Pedra Fina reservoir.

Figure 4.63: ETA Filters in Pedra Fina.

Figure 4.64: A general view of water collection in the Pedra Fina reservoir and ETA.

According field survey data, the quality of the water in the Pedra Fina reservoir is not enough for human consumption, especially before the rainy season. Water has a saline taste and people need to get their drinking water supply from water trucks. Seven cisterns have been built in the community under the 1 Million Cisterns Program. There are homes upstream of the Pedra Fina reservoir whose waste water flows into it.

The ETA's electric power system is single-phase (see Figure 4.64), so voltage drops occur when the forage equipment engine starts. Pedra Fina's Independent Water Supply System provides water to Pedra Fina and the communities of Valentim do Sabino and São João. The minimum monthly water charge is R$ 10.00 with a R$ 1.50 fee over each metered 1 m^3 above the consumption limit of 12 m^3.

In the dry periods, while water distribution using water trucks is not initiated, the community receives water from an Amazon-type well that has never dried up; however its water quality is poor, as it is saline. The Pedra Fina reservoir dried up during the dry period between 2007 and 2008, and it was necessary to provide water using water trucks.

Water Supply Provided by Water Trucks

Table 4.19 shows a summary of water supply provided by water trucks in 2007.

Table 4.19: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	275
NECESSARY VOLUME OF WATER (m^3)	165
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	6
NUMBER OF WATER LOADS	24
MONTHLY DISTANCE ON PAVED ROADS (km)	168
MONTHLY DISTANCE ON UNPAVED ROADS (km)	144
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	2145
MONTHLY COST (R$)	877,80
PERSON RESPONSIBLE FOR RECEIVING LOAD	Lucilene
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community suggests drilling wells; however the only time this was done was not a successful experience. They also suggest expanding the Pedra Fina reservoir, although this would entail the inconvenient of expropriating 10 affected homes.

Another suggestion would be building a reservoir on the Valentim Creek, in the community of São João. This would also benefit Pedra Fina.

4.2.28 C28-INGÁ

Population

Our field survey has revealed that the community of Ingá has 13 homes where 65 people live.

Population ≈ 65 inhabitants.

Location

The community of Ingá (Figure 4.65) is located at coordinates E = 478.556 and N = 9.380.112 and is 7.6 km north of Milhã.

Figure 4.65: The community of Ingá.

Description of the Water Supply System

There is no supply system to Ingá. Locals get water from the Riacho do Meio reservoir. Three families have their own water supply using a pump placed in the Riacho do Meio reservoir, and those families pay for electricity costs. The other families use animals (donkeys) to transport water from the reservoir to their homes. The community of Ingá is part of the Pedra Fina and Valentim association and they depend on it to solve their water supply problem.

Water Supply Provided by Water Trucks

A water truck provides water to the community of Ingá during dry periods; however the transportation statistics is included in Table 4.19 about Pedra Fina.

Community Proposals

The community of Ingá wishes to design an independent supply system that collects water from the Riacho do Meio reservoir.

4.2.29 C29-MASSAPÊ

Population

Our field survey has revealed that the community of Massapê has 7 homes where 35 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 25 inhabitants. However, we have identified that out of the seven homes only three are inhabited, totaling 25 people.

Population ≈ 25 inhabitants.

Location

The community of Massapê (Figure 4.66) is located at coordinates E=486.987 and N=9.378.088. It is 10.05 km northeast of Milhã, close to the border with the municipality of Solonópole.

Figure 4.66: Homes in the community of Massapê.

Description of the Water Supply System

The community collects water from the Massapê reservoir, at coordinates E=487.124 and N=9.378.912, which is in Mr. Cícero Neto de Lima's farm. The reservoir has a small storage capacity and usually dries up every year.

The Massapê reservoir is approximately 3 meters high, 80 meters wide and 1 km long.

A 50-meter deep artesian well was drilled (Figure 4.67) in 2008, with an estimated flow rate of 1,000 L/h, located at coordinates E=487.475 and N=9.378.708 in Mr. Cícero's farm. Water quality is poor (saline); however workers who performed the drilling suggested it could be improved with continuous pumping. Nevertheless there is no electricity in the community; therefore the well is not yet used to provide water to locals. According to sources, all reservoirs in the area dried up during the 2007/2008 dry season. There is only one home in the community that was included in the 1 Million Cisterns Program.

Figure 4.67: An artesian well drilled in Massapê; however there is no electricity for it to operate.

One family is a member of the Sítio Fortaleza Community Association (2.4 km southwest of Massapê), while another family is a member of the Itabaiana Community Association (2.4 km north of Massapê).

Annual droughts make it necessary for water trucks to provide water.

<u>Water Supply Provided by Water Trucks</u>

Table 4.20 shows a summary of water supply provided by water trucks in 2007.

Table 4.20: Water Truck Supply

ROUTE	**# 2**
# OF PEOPLE SUPPLIED	25
NECESSARY VOLUME OF WATER (m^3)	15
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	17
NUMBER OF WATER LOADS	2
MONTHLY DISTANCE ON PAVED ROADS (km)	14
MONTHLY DISTANCE ON UNPAVED ROADS (km)	34
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	360
MONTHLY COST (R$)	149,10
PERSON RESPONSIBLE FOR RECEIVING LOAD	Barreira
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community longs for the construction of an electricity network in the municipality and for the artesian well in Mr. Cícero's farm to start operating. Another suggestion is building one rainwater cistern for each family under the 1 Million Cisterns Program. According to locals, there is also a reservoir in Mr. Raimundo François' farm that could provide water to the community, as long as an electricity network was built to allow water to be pumped. Water from this reservoir is saline and would need treatment in order to become potable. According to locals, the reservoir could resist up to two years of drought.

4.2.30 C30-CRUZEIRO

Population

Our field research has revealed that Cruzeiro has 11 homes, of which only six are occupied with a total of 30 people. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 75 inhabitants. In fact there are two nearby, although distinct communities of the same name (Cruzeiro), so the Brazilian Army report groups both communities under a single entry. In our case we only considered the community of Cruzeiro that was nearest the border with Solonópole.

Population ≈ 30 inhabitants.

<u>Location</u>

The community of Cruzeiro (Figure 4.68) is located at coordinates E=489.839 and N=9.378.792. It is 12.8 km northeast of Milhã, close to the border with the municipality of Solonópole.

Figure 4.68: Homes in the community of Cruzeiro.

<u>Description of the Water Supply System</u>

The community collects water from Mr. José Verne’s reservoir, at coordinates E=489.746 and N=9.378.834. The reservoir has a small storage capacity and usually dries up every year.

The José Verne reservoir is approximately 7 meters high, 200 meters wide and 400 meters long (Figure 4.69).

Annual droughts make it necessary for water trucks to provide water.

Figure 4.69: Water collection in the José Verne reservoir in Cruzeiro.

Water Supply Provided by Water Trucks

Table 4.21 shows a summary of water supply provided by water trucks in 2007.

Table 4.21: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	75
NECESSARY VOLUME OF WATER (m^3)	45
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	21
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	42
MONTHLY DISTANCE ON UNPAVED ROADS (km)	126
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	1260
MONTHLY COST (R$)	522,90
PERSON RESPONSIBLE FOR RECEIVING LOAD	Ivan
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes drilling an artesian well, expanding the José Verne reservoir or building another reservoir on Riacho da Pedras (Pedras Creek), near the community of Cruzeiro.

4.2.31 C31-SÍTIO FORTALEZA

Population

Our field research has revealed that Sítio Fortaleza has 35 homes with a total of 175 people. The Brazilian Army's 2007 Water Truck Operation also lists a population of 175 inhabitants divided into Fortaleza 01, 02, 03 and 04.

Population ≈ 175 inhabitants.

Location

The community of Sítio Fortaleza (Figure 4.70) is located at coordinates E = 484.974 and N = 9.376.720 and is 7.6 km northeast of Milhã.

Figure 4.70: Homes and school in the community of Sítio Fortaleza.

Description of the Water Supply System

There is no water supply system in the community of Sítio Fortaleza. The existing source of water is a deep well that was built 20 years ago at coordinates E=485.020 and N=9.376.950 with a flow rate of 4,000 L/h. The well is 58 meters deep. From this well comes a PVC DN 25 mm aqueduct that fills a 5,000-liter tank, with a 2 HP pump. Milhã's Municipal Government covers operation and maintenance costs, including electricity. Water from the well is used for personal hygiene and laundry, in addition to animal watering in dry times. There is piped water supply to Mrs. Maria de Fátima's home and to André Nogueira Pinheiro Primary School (Escola de Ensino Fundamental André Nogueira Pinheiro) only. Almost all families have rainwater cisterns built under the 1 Million Cisterns Program (P1MC) (Figure 4.71).

Figure 4.71: Rainwater Cisterns (P1MC) in Sítio Fortaleza.

Families who do not have cisterns collect water from private reservoirs and use animals for transportation (Figures 4.72 and 4.73).

Figure 4.72: Water transportation using animals - Sítio Fortaleza.

Figure 4.72: Water supply using animals - Sítio Fortaleza.

Water Supply Provided by Water Trucks

Rainwater cisterns store water from water trucks when there is not enough rain.

Tables 4.22 to 4.25 show a summary of water supply provided by water trucks in 2007 to Sítio Fortaleza.

Table 4.22: Water Truck Supply - Fortaleza 01

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	13
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	39
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	420
MONTHLY COST (R$)	173,46
PERSON RESPONSIBLE FOR RECEIVING LOAD	Aldimar
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.23: Water Truck Supply - Fortaleza 02

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	14
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	42
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	441
MONTHLY COST (R$)	182,28
PERSON RESPONSIBLE FOR RECEIVING LOAD	Caboco
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.24: Water Truck Supply - Fortaleza 03

ROUTE	# 2
# OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	15
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	45
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	528
MONTHLY COST (R$)	218,40
PERSON RESPONSIBLE FOR RECEIVING LOAD	Paulo
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.25: Water Truck Supply - Fortaleza 04

ROUTE	# 2
# OF PEOPLE SUPPLIED	65
NECESSARY VOLUME OF WATER (m^3)	39
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	16
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	42
MONTHLY DISTANCE ON UNPAVED ROADS (km)	96
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	897
MONTHLY COST (R$)	371,28
PERSON RESPONSIBLE FOR RECEIVING LOAD	Deusdima
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

Sítio Fortaleza's Community Association has 37 members. The community proposes an integrated water supply project with the distribution of piped water to homes from the existing deep well. Milhã's Municipal Government also has a similar project set to begin in September 2009.

4.2.32 C32-CUMARU

Population

Our field survey has revealed that Cumaru has six homes where 30 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 40 inhabitants.

Population ≈ 40 inhabitants.

Location

The community of Cumaru is located at coordinates E = 484.800 and N = 9.377.536, about 7.9 km northeast of Milhã.

Figure 4.74: Homes in the community of Cumaru.

Description of the Water Supply System

The community has no water supply system. A few homes have rainwater cisterns. People get water in small private reservoirs and use animals for transportation. During dry periods, people depend mostly on water trucks.

Water Supply Provided by Water Trucks

Table 4.26 shows a summary of water supply provided by water trucks in 2007.

Table 4.26: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	17
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	51
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	576
MONTHLY COST (R$)	238.56
PERSON RESPONSIBLE FOR RECEIVING LOAD	Ribamar
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There are seven people in the community who have been members of the Sítio Fortaleza Community Association since 1996. Proposals are the same as those for Sítio Fortaleza, namely the construction of a distribution network from the deep well located at coordinates E=485.020 and N=9.376.950, with a flow rate of 4,000 L/h.

4.2.33 C33-ESPERANÇA

Population

Our field survey has revealed that Esperança has 16 homes where 80 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 115 inhabitants divided into two communities: Esperança 01 and Esperança 02.

Population ≈ 115 inhabitants.

Location

The community of Esperança (Figure 4.75) is located at coordinates E = 484.721 and N = 9.374.320, about 6.4 km east of Milhã.

Figure 4.75: Homes in the community of Esperança.

Description of the Water Supply System

There is a private water supply system coming from Mr. João Filho Vieira's reservoir (Figure 4.76), located at coordinates E=484.239 and N=9.374.360. Water is collected using a 2 HP pump (Figure 4.77). Water comes through a PVC DN 50mm aqueduct into a 16 m³ elevated reservoir (Figure 4.78) at coordinates E=484.272 and N=9.374.430, where it provides water to approximately 10 homes with the help of gravity. Only five families pay for water that comes from Mr. João Vieira's system. An agreement was made with the remaining inhabitants. There is a R$ 10.00 fee and the system is run by Mr. Antonio Robério da Silva, an employee at the farm.

Figure 4.76: Mr. João Filho Vieira's Reservoir.

Figure 4.77: Water collection in Mr. João Filho Vieira's reservoir.

Figure 4.78: Elevated reservoir that provides water to ten homes in Esperança.

Mr. João Filho Vieira's reservoir was built in 2006 and an overflow occurred only during the 2009 flood. The dam is approximately 8 meters high and the reservoir has an average width of 300 meters by 2,000 meters long.

A deep well was built in Mr. Antonio Gonçalves da Silva's property (he is also known as Antonio Paraibano - Figure 4.79). The well is 53 meters deep, with water at 9 meters and a flow rate of 3,000 L/h. Water is very saline and unfit for human consumption.

Figure 4.79: A deep well built in Esperança, flow rate = 3,000 L/h.

Most people in Esperança drink water from cisterns, which were built under the P1MC (Figure 4.80). There are four cisterns currently being built under the same program (Figure 4.81).

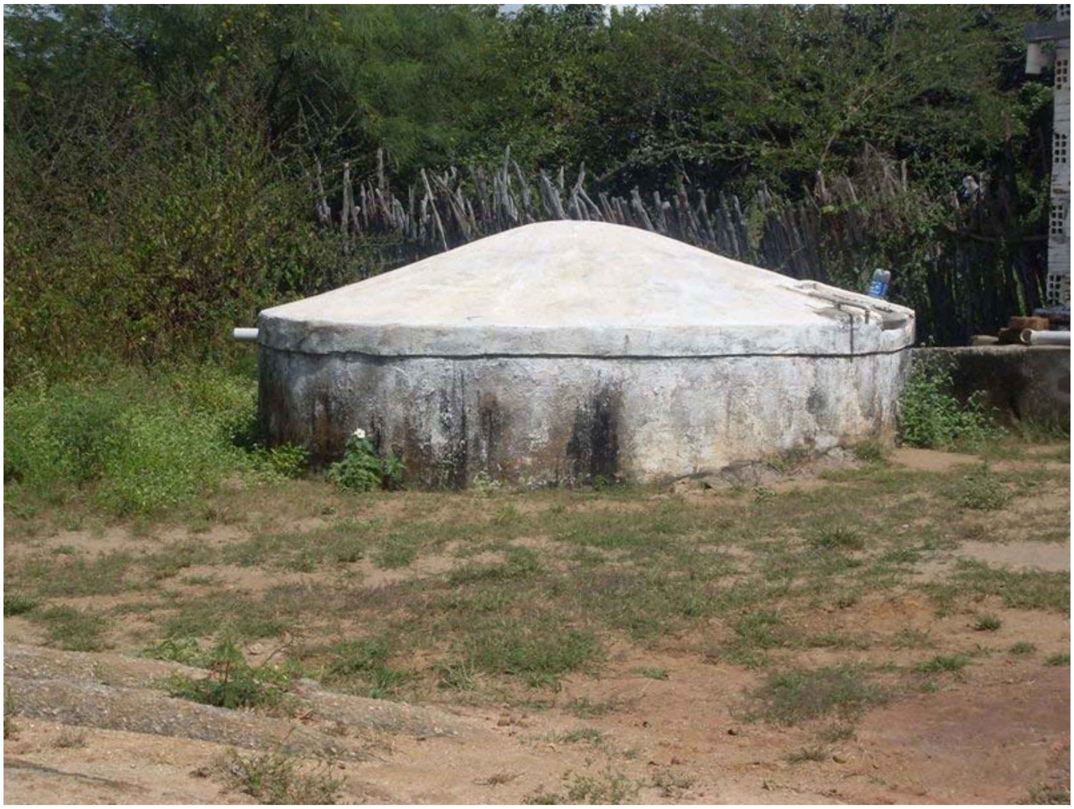


Figure 4.80: Rainwater cistern as an alternative source of potable water in Esperança.

Figure 4.81: Rainwater Cistern under construction in Esperança.

Water Supply Provided by Water Trucks

Tables 4.27 and 4.28 show a summary of water supply provided by water trucks in 2007 to Esperança.

Table 4.27: Supply Provided by Water Trucks - Esperança 01

ROUTE	# 02
# OF PEOPLE SUPPLIED	75
NECESSARY VOLUME OF WATER (m³)	45
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	11
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	42
MONTHLY DISTANCE ON UNPAVED ROADS (km)	66
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	810
MONTHLY COST (R$)	333.90
PERSON RESPONSIBLE FOR RECEIVING	Zé Alfredor

LOAD	
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.28: Supply Provided by Water Trucks - Esperança 02

ROUTE	**# 02**
# OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	12
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	36
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	456
MONTHLY COST (R$)	188.16
PERSON RESPONSIBLE FOR RECEIVING LOAD	Fransquinha
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

Milhã's Municipal Government (PMM) has a project to implement a water supply system which will treat and distribute water to the community of Esperança. The community proposes combining the PMM project with collecting water from the deep well with the reservoir system of Mr. João Vieira.

4.2.34 C34-SABONETE

Population

Our field survey has revealed that Sabonete has nine homes where 45 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 35 inhabitants.

Population ≈ 35 inhabitants.

Location

The community of Sabonete (Figure 4.82) is located at coordinates E = 484.893 and N = 9.373.160, about 6.5 km east of Milhã.

Figure 4.82: Homes in the community of Sabonete.

<u>Description of the Water Supply System</u>

The community's water supply comes from the Sabonete reservoir in Mr. Francisco Eudes de Oliveira's property. Water is collected from the reservoir to the community using a 2 HP Yammar pump (Figure 4.83). The other families use animals to transport water.

The Sabonete reservoir is 3 meters high, 236 meters wide and approximately 500 meters long; it is located at coordinates e=484.692 and N=9.372.918 (Figure 4.84).

Figure 4.83: Yammar pumo collecting water from the Sabonete reservoir.

Figure 4.84: Sabonete Reservoir

The 1 Million Cisterns Program (P1MC) is building rainwater cisterns for the entire community (Figure 4.85).

Figure 4.85: Rainwater Cistern under construction in Sabonete (P1MC).

<u>Water Supply Provided by Water Trucks</u>

Table 4.29 shows a summary of water supply provided by water trucks in 2007.

Table 4.29: Supply Provided by Water Trucks

ROUTE	# 02
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	9
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	27
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	336
MONTHLY COST (R$)	138.18

PERSON RESPONSIBLE FOR RECEIVING LOAD	Ezenário
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community of Sabonete proposes the same interventions as the neighboring community of Esperança. The well built by Milhã's Municipal Government in Mr. Antonio Gonçalves da Silva's property at coordinates E=484.266 and N=9.373.888 could provide water simultaneously to Esperança and Sabonete.

4.2.35 C35-BOM PRINCÍPIO

Population

Our field survey has revealed that Bom Princípio has nine homes where 45 people live.

Population ≈ 45 inhabitants.

Location

The community of Bom Princípio (Figure 4.86) is located at coordinates E = 483.403 and N = 9.372.010, about 5.06 km east of Milhã.

Figure 4.86: Homes in the community of Bom Princípio.

<u>Description of the Water Supply System</u>

The community has no water supply system. Families use animals to transport water collected from the Segurança reservoir in Mr. Antonio Coringa's property, at coordinates E=483.069 and N=9.372.458. The Segurança reservoir (Figure 4.87) is 4 meters high, 100 meters wide and approximately 250 meters long.

Figure 4.87: Segurança Reservoir

There is also an alternative reservoir in Mr. Anildo Junior’s property, at coordinates E=483.113 and N=9.371.686, with a wall height of 3 meters, width 101 meters and length 350 meters (Figure 4.88).

Figure 4.88: Anildo Junior's reservoir.

In the community there is only one family with a private cistern; one other family has been included in the P1MC (Figure 4.89).

Figure 4.89: Rainwater Cistern under construction.

A deep well was built in Mr. Francisco das Chagas Almeida's property, located at coordinates E=483.394 and N=9.371.774. It is 40 meters deep, water was found at 20 meters at a flow rate of 3,300 L/h. However, water is very saline and unfit for human consumption (Figure 4.90).

Figure 4.90: Deep well in the community of Bom Princípio, flow rate of 3,300 L/h.

Water Supply Provided by Water Trucks

The community's rainwater cistern is not enlisted in the Water Truck Program and locals have complained about that.

Community Proposals

The community has one individual who is a member of the Sítio Macaco Community Association. The community longs for the Capitão Mor reservoir to be built, which would be the main water construction work to provide water to Milhã. Alternatively, they propose expanding the Anildo Junior reservoir or building a treatment system (desalinizer) and a distribution network from the deep well drilled in Mr. Francisco das Chagas Almeida's property.

4.2.36 C36-SEGURANÇA

Population

Our field survey has revealed that the community of Segurança has 16 homes where 80 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 105 inhabitants.

Population ≈ 105 inhabitants.

Location

The community of Segurança (Figure 4.91) is located at coordinates E = 482.253 and N = 9.372.214 and is 3.9 km east of Milhã.

Figure 4.91: Homes in the community of Segurança.

Description of the Water Supply System

The source of water in the community is the Segurança reservoir (Figure 4.92), located at coordinates E=482.039 and N=9.372.242 in Mr. Manoel Anildo Junior Pinheiro's property. The reservoir has a wall height of 5 meters; it is 180 meters wide and approximately 600 meters long. According to locals the reservoir is able to resist up to 1.5 years of drought. Seven families have piped water that is pumped from the reservoir by a 0.6 HP Atlantis pump; it has a flow rate of up to 2.3 m^3/hour. Only two families have a water tank. Water is not fit for drinking. The other families use animals to transport water (donkeys).

Figure 4.92: Segurança Reservoir.

Whenever the Segurança reservoir dries up it is necessary to have water delivered by water trucks.

Water Supply Provided by Water Trucks

Table 4.30 shows a summary of water supply provided by water trucks in 2007 in Segurança.

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Table 4.30: Water Truck Supply

ROUTE	# 2

# OF PEOPLE SUPPLIED	105
NECESSARY VOLUME OF WATER (m^3)	63
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	5
NUMBER OF WATER LOADS	9
MONTHLY DISTANCE ON PAVED ROADS (km)	63
MONTHLY DISTANCE ON UNPAVED ROADS (km)	45
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	756
MONTHLY COST (R$)	308,70
PERSON RESPONSIBLE FOR RECEIVING LOAD	Meiriluce
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There is a Community Association representing Extrema and Segurança. It is currently presided over by Francisco Eudes de Oliveira and it currently gathers members from the following communities: Segurança (12); Extrema (21); Milhã Velha (10); Bom Princípio (02); Sabonete (10) and Esperança (05, totaling 60 members.

The Association proposes building approximately 20 small dams along the Capitão Mor creek (Figure 4.93), in case building the Capitão Mor reservoir is not possible.

Figure 4.93: Capitão Mor Creek

4.2.37 C37-EXTREMA

Population

The community of Extrema has 17 homes where 85 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 50 inhabitants.

Population ≈ 50 inhabitants.

Location

The community of Extrema (Figure 4.94) is located at coordinates E = 482.011 and N = 9.370.964 and is 3.9 km east of Milhã.

Figure 4.94: Homes in the community of Extrema.

Description of the Water Supply System

There is no public water supply system. Only two families have a water collection system in reservoirs which pumps water to their homes; the other families use donkeys to transport water (Figure 4.95). The following reservoirs are used:

1) Mr. Matias' (Matias Alves Feitosa) reservoir at coordinates E=482.021 and N=9.370.868, with a wall height of 4 meters, 268 meters wide and approximately 1 km long (Figure 4.96). Water is not fit for drinking;

2) Mr. José Jackson's reservoir, at coordinates E=481.924 and N=9.370.936, with a wall height of 3 meters, 60 meters wide and 150 meters long (Figure 4.97). Water quality is better for drinking.

There is information that the 1 Million Cisterns Program P1MC is arriving this year, between May and June 2009, for discussions in the community.

Figure 4.95: Water transportation on a donkey in the community of Extrema.

Figure 4.96: Mr. Matias' reservoir in Extrema.

Figure 4.97: Mr. Jackson's reservoir in Extrema.

There is also a deep well in Mr. Augusto's property. It is 40 meters deep, at coordinates E=482.497 and N=9.370.848 (Figure 4.98); however water is too saline.

Figure 4.98: A deep well in Mr. Augusto's property. Water is saline.

Water Supply Provided by Water Trucks

Table 4.31 shows a summary of water supply provided by water trucks in 2007 in Extrema.

Table 4.31: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m^3)	30
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	3
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	28
MONTHLY DISTANCE ON UNPAVED ROADS (km)	12
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	300
MONTHLY COST (R$)	121,80
PERSON RESPONSIBLE FOR RECEIVING LOAD	Matias
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community believes that they will only have access to good quality water in Extrema when they get water from Milhã.

4.2.38 C38-MACACO

Population

Our field survey has revealed that the community of Macaco has 12 homes where 60 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 55 inhabitants.

Population ≈ 55 inhabitants.

Location

The community of Macaco (Figure 4.99) is located at coordinates E = 480.514 and N = 9.371.950 and is 2.2 km east of Milhã.

Figure 4.99: Homes in the community of Macaco.

Description of the Water Supply System

The community gets their water from nearby reservoirs:

2) Mr. Antonio Batista's reservoir, at coordinates E=480.556 and N= 9.371.888 (Figure 4.100), with a wall height of 4.5 meters, 100 meters wide and approximately 200 meters long. There are three families that collect water from this reservoir using pumps. It is an underwater 0.6 HP Atlantis pump with a flow rate of 1,000 L/h. This reservoir can resist one year of drought;

2) Mr. Manoel Correia's reservoir, at coordinates E=480.321 and N= 9.372.020 (Figure 4.101), with a wall height of 3.5 meters, 257 meters wide and 300 meters long. Water has good quality.

Figure 4.100: Antonio Batista Reservoir.

Figure 4.101: Manoel Correia Reservoir.

There is 1 HP Inapi pump in the Manoel Correia reservoir that pumps water through a 200 meter-long PVC DN 25 mm pipe.

There are seven families in the community who have been included in the P1MC, through the Community Association of Rural and Agriculture Farmers of Extrema and Macaco Ranches (Associação Comunitária dos Produtores e Agricultores Rurais dos Sítios Extrema e Macaco), founded in October 2008 (Figure 4.102).

Figure 4.102: P1MC Cistern under construction in the community of Macaco.

Water Supply Provided by Water Trucks

Table 4.32 shows a summary of water supply provided by water trucks in 2007 in Macaco.

Table 4.32: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	55
NECESSARY VOLUME OF WATER (m³)	33
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	3
NUMBER OF WATER LOADS	5
MONTHLY DISTANCE ON PAVED ROADS (km)	35
MONTHLY DISTANCE ON UNPAVED ROADS (km)	15
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	330
MONTHLY COST (R$)	133,98
PERSON RESPONSIBLE FOR RECEIVING LOAD	Gledson
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes expanding the reservoir in Mr. Manoel Correia's property. The Association has an ongoing project that awaiting a meeting with a state government representative to discuss it.

4.2.39 C39-MILHÃ VELHA

Population

Our field survey has revealed that the community of Milhã Velha has 60 homes where 300 people live.

Population ≈ 300 inhabitants.

Location

The community of Milhã Velha (Figure 4.103) is located at coordinates E = 479.803 and N = 9.373.220 and is 2.1 km east of Milhã.

Figure 4.103: Homes in the community of Milhã Velha.

Description of the Water Supply System

The community gets piped water from Milhã's municipal center. Milhã Velha is in fact a distant neighborhood that belongs to Milhã's municipal center. Sometimes it takes a while for water to get to a few homes; in the evening, however, when consumption levels in Milhã drop, water finally reaches homes in Milhã Velha.

Water Supply Provided by Water Trucks

There has been no water supply provided by water trucks.

Community Proposals

There aren't any.

4.2.40 C40-SÍTIO BECO

Population

Our field survey has revealed that Sítio Beco has 4 homes where 20 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 35 inhabitants.

Population ≈ 35 inhabitants.

Location

The community of Sítio Beco (Figure 4.104) is located at coordinates E = 479.954 and N = 9.373.846 and is 2.07 km northeast of Milhã.

Figure 4.104: Homes in the community of Sítio Beco.

Description of the Water Supply System

The community gets piped water from Milhã's municipal center. Milhã Velha is in fact a distant neighborhood that belongs to Milhã's municipal center. Sometimes it takes 3 to 4 days for water to reach some homes. During dry periods the situation is worse.

Water Supply Provided by Water Trucks

Table 4.33 shows a summary of water supply provided by water trucks in 2007 in Sítio Beco.

Table 4.33: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	3
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	9

TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	210
MONTHLY COST (R$)	85,26
PERSON RESPONSIBLE FOR RECEIVING LOAD	Alcimar
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There aren't any.

4.2.41 C41-ALTO VISTOSO

Population

Our field survey has revealed that the community of Alto Vistoso has 20 homes where 100 people live. The Brazilian Army's 2007 Water Truck Operation also points to 100 inhabitants subdivided into communities Alto Vistoso 01 and Alto Vistoso 02.

Population ≈ 100 inhabitants.

Location

The community of Alto Vistoso (Figure 4.105) is located at coordinates E = 480.993 and N = 9.374.664 and is 3.3 km northeast of Milhã.

Figure 4.105: Homes in the community of Alto Vistoso.

Description of the Water Supply System

Alto Vistoso's source of water is the Ipueiras reservoir, located at coordinates E=480.933 and N=9.374.746, with a wall height of 6 meters, 231 meters wide and approximately 400 meters long (Figure 4.106). The reservoir can resist up to two years of drought, but during the 2007/2008 drought it was necessary to have water brought by water trucks.

The entire community of Alto Vistoso is supplied jointly by a 1 HP Inapi water pump allocated for every three homes; however only the pump owner pays for electricity costs (Figure 4.107).

Figure 4.106: Alto Vistoso Reservoir.

Figure 4.107: Pump collecting water from the Ipueiras reservoir.

There are two cisterns built by Milhã's Municipal Government, which are approximately 15 years old. There are six rainwater cisterns set to be built for the community under the P1MC program. The community awaits the construction, and excavations have been initiated (Figure 4.108).

Figure 4.108: Excavation for the construction of rainwater cisterns (P1MC).

Water Supply Provided by Water Trucks

Tables 4.34 to 4.35 show a summary of water supply provided by water trucks in 2007 to Alto Vistoso.

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Table 4.31: Water Truck Supply - Alto Vistoso 01

ROUTE	# 2
# OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m³)	24
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	4
NUMBER OF WATER LOADS	3

MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	12
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	264
MONTHLY COST (R$)	107,52
PERSON RESPONSIBLE FOR RECEIVING LOAD	Zé de Luiz
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.35: Water Truck Supply - Alto Vistoso 02

ROUTE	**# 2**
# OF PEOPLE SUPPLIED	60
NECESSARY VOLUME OF WATER (m^3)	36
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	5
NUMBER OF WATER LOADS	5
MONTHLY DISTANCE ON PAVED ROADS (km)	35
MONTHLY DISTANCE ON UNPAVED ROADS (km)	25
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	432
MONTHLY COST (R$)	176,40
PERSON RESPONSIBLE FOR RECEIVING LOAD	Chico Antonio
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There are no recorded proposals.

4.2.42 C42-SÍTIO VITÓRIA

Population

Our field survey has revealed that Sítio Vitória has 2 homes where 10 people live.

Population ≈ 10 inhabitants.

Location

The community of Sítio Vitória (Figure 4.109) is located at coordinates E = 481.616 and N = 9.374.084 and is 3.6 km northeast of Milhã.

Figure 4.109: Homes in the community of Sítio Vitória.

Description of the Water Supply System

Sítio Vitória has an artesian well at coordinates E= 481.507 e N= 9.374.016 in Mr. João Luci de Lima's property. It is 48 meters deep with water at 18 meters and a flow rate of 1,500 L/h (Figure 4.110). There is a 2HP Inapi pump.

Figure 4.110: Well in Sítio Vitória.

People who live in one of the homes also collect water from the reservoir in Mr. Carlos Lopes' property and use animals for transportation (donkeys). According to locals, water is fit for drinking (Figure 4.111).

However, during most of the year drinking water comes from the cistern built under the 1 Million Cisterns Program P1MC in 2006, in Mr. João Luci's home.

Figure 4.111: Mr. Carlos Lopes' reservoir in Sítio Vitória.

Water Supply Provided by Water Trucks

There was no water supply provided by water trucks in 2007.

Community Proposals

There is an ongoing project proposed by Alto Vistoso's Association which aims to expand the Ipueira reservoir. Four homes would possibly benefit from this expansion.

4.2.43 C43-BELO MONTE

Population

Our field survey has revealed that the community of Belo Monte has 40 homes where 200 people live. However, a summary of the Brazilian Army's 2007 Water Truck Operation points to 220 inhabitants scattered across the communities of Belo Monte 01; Belo Monte 02; Belo Monte 03 and Belo Monte 04.

Population ≈ 220 inhabitants.

Location

The community of Belo Monte (Figure 4.112) is located at coordinates E = 481.120 and N = 9.376.368 and is 4.7 km northeast of Milhã.

Figure 4.112: Homes in the community of Belo Monte.

Description of the Water Supply System

The surface water spring in Belo Monte is the Velho reservoir (Figure 4.113), located at coordinates E= 481.054 and N= 9.376.504, with a wall height of 6 meters, 120 meters wide and approximately 400 meters long. There is a 2HP King pump collecting water from this reservoir to Mr. Manoel Barbosa’s home (Figure 4.114).

Figure 4.113: Velho reservoir in the community of Belo Monte.

Figure 4.114: Water collection in the Velho reservoir to Mr. Manoel Barbosa's home.

The other families use donkeys to transport water collected from the reservoir.

There are three wells in Belo Monte:

1) A well at coordinates E= 481.203 and N= 9.376.564, in Mr. Manoel Barbosa’s property; this 60-meter deep well was built in 1980 and it is partially clogged. It is currently 48 meters deep (Figure 4.115);

Figure 4.115: Well #1 in Mr. Manoel Barbosa's property in Belo Monte.

2) A well at coordinates E= 481.413 and N= 9.376.566, also built in Mr. Manoel Barbosa’s property and the land on which it was built has been donated by him. It is 80 meters deep, with water at 12 meters and a flow rate of 2.5 m³/hour (Figure 4.116);

Figure 4.116: Well #2 in Mr. Manoel Barbosa's property in Belo Monte.

3) A well at coordinates E= 481.319 and N= 9.377.524 built by FUNASA in Mr. Ronaldo de Flora's property, but that belongs to the community of Belo Monte (Figure 4.117);

Figure 4.117: Well #3, built by FUNASA in Ronaldo de Flora’s property.

Water from the Velho reservoir is not fit for human consumption due to the fact that wastewater from neighboring homes flows into it.

The community depends on water from rainwater cisterns because water from the Velho reservoir is not fit for human consumption and water from wells is too saline. Six families had rainwater cisterns built under the P1MC program (Figures 4.118 and 4.119).

Figure 4.118: Rainwater cistern recently built in Belo Monte.

Figure 4.119: Rainwater cistern under construction in Belo Monte.

Water Supply Provided by Water Trucks

Tables 4.36 to 4.37 show a summary of water supply provided by water trucks in 2007 to Belo Monte.

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Table 4.36: Water Truck Supply - Belo Monte 01

ROUTE	# 2
# OF PEOPLE SUPPLIED	80
NECESSARY VOLUME OF WATER (m^3)	48
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	6
NUMBER OF WATER LOADS	7
MONTHLY DISTANCE ON PAVED ROADS (km)	49
MONTHLY DISTANCE ON UNPAVED ROADS (km)	42
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	624
MONTHLY COST (R$)	255,36
PERSON RESPONSIBLE FOR RECEIVING LOAD	Carlinhos
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.37: Water Truck Supply - Belo Monte 02

ROUTE	# 2
# OF PEOPLE SUPPLIED	60
NECESSARY VOLUME OF WATER (m^3)	36
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	7
NUMBER OF WATER LOADS	5
MONTHLY DISTANCE ON PAVED ROADS (km)	35
MONTHLY DISTANCE ON UNPAVED ROADS (km)	35
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	504
MONTHLY COST (R$)	206,64
PERSON RESPONSIBLE FOR RECEIVING LOAD	Leonilde
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.38: Water Truck Supply - Belo Monte 03

ROUTE	# 2
# OF PEOPLE SUPPLIED	45
NECESSARY VOLUME OF WATER (m³)	27
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	7
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	28
MONTHLY DISTANCE ON UNPAVED ROADS (km)	28
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	378
MONTHLY COST (R$)	154,98
PERSON RESPONSIBLE FOR RECEIVING LOAD	Ironilde
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.39: Water Truck Supply - Belo Monte 04

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m³)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	8
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	24
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	315
MONTHLY COST (R$)	129,36
PERSON RESPONSIBLE FOR RECEIVING LOAD	Valcisio
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There is a project drafted by the Rural Farmers Association of Belo Monte (Associação dos Produtores Rurais de Belo Monte) which aims to collect water from the deep well built by CONAB in the neighboring community of São Bento. The reservoir would be in Belo Monte at the border with the community of São Bento and would allow water to be distributed using gravity to the communities of Belo Monte, São Bento, São Luiz and Boa Vista. The distance from the well to the reservoir would be 2 kilometers. Another alternative to provide water would be rebuilding the Tanques reservoir in the community of Tanques, which would provide water to all previously mentioned communities.

4.2.44 C44-TANQUES

Population

Our field survey has revealed that the community of Tanques has 8 homes where 40 people live. However, the summary of the Brazilian Army's 2007 Water Truck Operation shows a population of 35 inhabitants.

Population ≈ 35 inhabitants.

Location

The community of Tanques (Figure 4.120) is located at coordinates E = 483.546 and N = 9.375.890 and is 6.1 km northeast of Milhã.

Figure 4.120: The community of Tanques.

<u>Description of the Water Supply System</u>

The Tanques reservoir, which used to be the same source of water, is located at coordinates E= 483.297 and N= 9.375.876 (Figure 4.121). It cracked in March 2009 during the severe flood which occurred that year. The Tanques families use donkeys to get water from two other reservoirs:

1) Mr. Valderício Abílio de Souza's reservoir, at coordinates E=483.574 and N=9.375.844, with a wall height of 4 meters, 80 meters wide and 150 meters long;

2) Mr. Antonio Roberto Pinheiro's reservoir, at coordinates E=482.027 and N=9.376.056, with a wall height of 4.5 meters, 60 meters wide and 150 meters long;

Figure 4.121: The Tanques reservoir, which cracked during the March 2009 flood.

Two families managed to get cisterns built by FECOM through Belo Monte's Association. The other families are listed in the P1MC and await the construction of cisterns.

Water Supply Provided by Water Trucks

Table 4.40 shows a summary of water supply provided by water trucks in 2007 in Tanques.

Table 4.40: Water Truck Supply

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	9
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	27
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	336
MONTHLY COST (R$)	138,18

PERSON RESPONSIBLE FOR RECEIVING LOAD	Olêda
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community's main request is that the Tanques reservoir wall be rebuilt.

4.2.45 C45-SÍTIO AÇUDE

Population

Our field survey has revealed that Sítio Açude has 18 homes where 90 people live.

Population ≈ 90 inhabitants.

Location

The community of Sítio Açude (Figure 4.122) is located at coordinates E = 479.640 and N = 9.374.118 and is 1.5 km northeast of Milhã.

Figure 4.122: Sítio Açude.

Description of the Water Supply System

Homes in Sítio Açude are connected to Milhã's water supply system; however water does not reach a few homes in the community. Sometimes it takes several days for water to reach the community. Therefore, locals are getting water from the Sítio Açude reservoir in Mr. Francisco Anísio de Lima's property, located at coordinates E= 479.580 and N= 9.374.194, with a wall height of 4 meters, 180 meters wide and 250 meters long (Figure 4.123).

Figure 4.123: Sítio Açude reservoir.

The reservoir receives wastewater from approximately four homes.

Water Supply Provided by Water Trucks

Water trucks brought water in 2007 and 2008, but the community is not listed in the 2007 Water Truck Operation, at least not under this name.

Community Proposals

The community's main request is to improve the water supply system that comes from Milhã's municipal center. Milhã's Municipal Government has already built a cistern in Mr. Francisco Anísio's property in order to provide water to the community during dry periods (Figure 4.124).

Figure 4.124: A prismatic cistern built in Sítio Açude by Milhã's Municipal Government.

4.2.46 C46-PAU BRANCO

Population

Our field survey has revealed that Pau Branco has 12 homes where 60 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 50 inhabitants.

Population ≈ 50 inhabitants.

Location

The community of Pau Branco is located at coordinates E = 479.057 and N = 9.373.990, about 1.5 km north of Milhã.

Figure 4.125: Community of Pau Branco.

<u>Description of the Water Supply System</u>

Water supply to the community comes from Milhã's system, due to its proximity. However, water shortages in Pau Branco last up to a month. When there are water shortages people go to the Pau Branco reservoir (Figure 4.126), located at coordinates E = 479.130 and N = 9.374.124, with a wall height of 4 meters, width 50m and length 80 m. The reservoir is in Mr. João Batista Neto's property.

Figure 4.126: Pau Branco Reservoir.

Water Supply Provided by Water Trucks

Table 4.41 shows a summary of water supply provided by water trucks in 2007 to Pau Branco.

Table 4.41: Supply Provided by Water Trucks

ROUTE	**# 04**
# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m³)	30
DISTANCE ON PAVED ROADS (km)	8
DISTANCE ON UNPAVED ROADS (km)	4
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	32
MONTHLY DISTANCE ON UNPAVED ROADS (km)	16
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	360
MONTHLY COST (R$)	146.40
PERSON RESPONSIBLE FOR RECEIVING LOAD	Jarismar
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community's main claim is to solve the issue of distribution of water coming from Milhã's supply system. They suggest building a reservoir in Pau Branco which would solve the problem and provide water to other communities who have the same problem.

4.2.47 C47-VALENTIM DOS PINHEIROS

Population

Our field survey has revealed that Valentim dos Pinheiros has 18 homes where 90 people live.

Population ≈ 90 inhabitants.

Location

The community of Valentim dos Pinheiros is located at coordinates E = 477.238 and N = 9.377.008, about 4.6 km north of Milhã.

Figure 4.127: Home with a cistern in the community of Valentim dos Pinheiros.

Description of the Water Supply System

The community's supply comes from Mr. Francisco Mairton da Silva's reservoir, located at coordinates E = 476.986 and N = 9.377.142, with a wall height of 4.5 meters, width 100 m and length 300 m, approximately (Figure 4.128). Water is considered good for human consumption, but the reservoir can only stand 6 dry months.

Figure 4.128: Mairton's Reservoir.

During summer people collect water from Mr. Francisco Elineu da Silva's reservoir, at coordinates E = 476.830 and N = 9.376.628 (Figure 4.129), with a wall height of 8 meters, width 140 m and length 600 m, approximately.

Figure 4.129: Mr. Elineu's Reservoir in Valentim dos Pinheiros.

There is also an artesian well that was built by Milhã's Municipal Government in Mr. Manoel Rodrigues de Sila's property, at coordinates E = 477.165 an N = 9.376.804, with a wall height of 48 m, water at 20 m and a flow rate of 2,500 L/h (Figure 4.130).

Figure 4.130: Deep well in Mr. Manoel Rodrigues Sila's property.

In Valentim dos Pinheiros there are nine families who have cisterns from the 1 Million Cisterns Program. Another eight families were included in the program and are waiting for their cisterns to be built (Figure 4.131).

Figure 4.131: Excavations for the construction of cisterns under the 1 Million Cisterns Program.

Water Supply Provided by Water Trucks

There was water supply provided by water trucks in 2007, but the community is not listed in the 2007 Water Truck Report, at least not under this name.

Community Proposals

The community is waiting for a water supply project which will collect water from the deep well built in Mr. Manoel Rodrigues' property, including an elevated reservoir located in this property.

4.2.48 C48-MILHÃ (TOWN CENTER)

Population

Milhã's municipal center has over 1,000 households where approximately 5,000 people live, according to official data.

Population ≈ 5,000 people.

<u>Location</u>

Milhã's municipal center is located at coordinates E= 478.359 and N= 9.372.550 (Milhã's Town Council).

<u>Description of the Water Supply System</u>

Water supply to Milhã is currently based on water collected in the Monte Sombrio reservoir (Figure 4.132), whose dam is at coordinates E= 476.649; N= 9.374.588 and E=476.381; N= 9.374.334, including a dam whose wall height is 369 meters, height 14 m and length 600 m, approximately.

Figure 4.132: Monte Sombrio Reservoir

The Monte Sombrio reservoir can stand up to two years of drought. However, when dries up, people collect water from the Jatobá reservoir, pumping water through a DN 150 mm aqueduct.

The Jatobá reservoir (Figure 4.133) is located at dam coordinates E=473.885; N=9.380.392 and E= 473.755; N=9.380.538, with a wall height of 195 m, height 15 m and length 2 km.

Figure 4.133: The Jatobá Reservoir, which provides water to Milhã during dry periods.

Pumps used in floating water collection allow transporting at a flow rate of 62,000 L/h (62 m^3/h), at 20 HP (Figure 4.134).

Figure 4.134: Floating water catchment to provide water to Milhã.

Water from both reservoirs is taken to a Water Treatment Station (ETA) where it is filtered and treated with chlorine, conventionally (Figure 4.135).

Figure 4.135: Milhã's ETA, operated by the local SAAE.

Figure 4.136: Arrival of the bulk water aqueduct at Milhã's ETA.

Figure 4.137: Filters at Milhã's ETA.

Figure 4.138: Milhã's ETA Chemical Operation Facilities.

Figure 4.139: Treated water pumps at Milhã's ETA.

After being treated water is taken to a 200 m³ elevated reservoir located at coordinates E=478.090 and N= 9.373.368, from where it is distributed using gravity to the population (Figure 4.140).

Figure 4.140: 200 m³ elevated reservoir in Milhã's town center.

In addition to the Monte Sombrio and Jatobá reservoirs, Milhã has an aqueduct coming from the Banabuiú river which is activated in case of prolonged dry periods.

Water Supply Provided by Water Trucks

Milhã's municipal center is not completely free from the need to get their water supply from water trucks in extreme drought situations. Even during normal years it is necessary to use water trucks to provide water to some neighborhoods and nearby communities that use Milhã's supply system, due to low pressure of the distribution system.

Community Proposals

The community's main request is that the Capitão Mor reservoir be built in the river of the same name. This would provide a final solution to the water supply problems faced by the town center and most communities east of the municipal center.

4.2.49 C49-MONTE SOMBRIO

Population

Field research has revealed that Monte Sombrio has 29 homes where 145 people live. However, a summary of the 2007 Water Truck Operation conducted by the Brazilian Army shows a population of 100 inhabitants divided into two communities: Monte Sombrio 01 and Monte Sombrio 02.

Population ≈ 100 inhabitants.

Location

The community of Monte Sombrio (Figure 4.141) is located at coordinates E = 475.707 and N = 9.375.694, about 4.09 km northwest of Milhã.

Figure 4.141: Community of Monte Sombrio

Description of the Water Supply System

The main source of water is the Monte Sombrio reservoir, which also provides water to Milhã. Water treatment is made by Milhã's SAAE. Water is collected at a flow rate of 6 m³/h, at 3HP. There is a charge of R$ 10.00 on consumption of up to 12 m³.

Families also collect water from Mr. Pedro's reservoir for other purposes. The reservoir is located at coordinates E = 475.802 and N = 9.375.808, with a wall height of 3.5 meters, width 40m and length 60 m, approximately (Figure 4.142).

Figure 4.142: Mr. Pedro's Reservoir.

<u>Water Supply Provided by Water Trucks</u>

Although there is a public water supply system, Monte Sombrio still needs water truck supply during dry seasons.

Tables 4.42 and 4.43 show a summary of water supply provided by water trucks in 2007 to Monte Sombrio.

Table 4.42: Supply Provided by Water Trucks - Monte Sombrio 01

ROUTE	# 03

# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m³)	30
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	7
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	28
MONTHLY DISTANCE ON UNPAVED ROADS (km)	28
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	420
MONTHLY COST (R$)	172.20
PERSON RESPONSIBLE FOR RECEIVING LOAD	Neudo
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.43: Supply Provided by Water Trucks - Monte Sombrio 02

ROUTE	**# 03**
# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m³)	30
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	8
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	28
MONTHLY DISTANCE ON UNPAVED ROADS (km)	32
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	450
MONTHLY COST (R$)	184.80
PERSON RESPONSIBLE FOR RECEIVING LOAD	Pedro Bruno
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There were no suggestions.

4.2.50 C50-PEDRA D' ÁGUA

Population

Our field research has revealed that Pedra d'Água has 19 homes where 95 people live.

Population ≈ 95 inhabitants.

Location

The community of Pedra d'Água (Figure 4.143) is located at coordinates E = 474.562 and N = 9.376.138 and is 5.2 km northwest of Milhã.

Figure 4.143: Community of Pedra d'Água.

Description of the Water Supply System

The main source of water for the community is the Herdeiros reservoir in Mr. Raimundo Canuto Clodenildo Moreira's property, located at coordinates E=474.992; N=9.377010 and E=474.047; N=9.376.826, with a wall height of 5 meters and 250 meters long (Figure 4.144).

Figure 4.144: Herdeiros Reservoir in Pedra d'Água.

Approximately six families collect water from the Herdeiros reservoir and have it pumped to their homes (Figure 4.145). Others use donkeys to transport water. There is a second reservoir in the community in Mr. Francisco Macedo's property with a dam at coordinates E=474.382; N=9.376.244 and E=474.452; N=9.376.168, forming a dam that is 103 meters wide, 6 meters tall and 200 meters long.

Figure 4.145: Private water collection in the Herdeiros reservoir.

Approximately five families have been included in the 1 Million Cisterns Program P1MC.

Water Supply Provided by Water Trucks

The community is not listed in the 2007 Water Truck Operation. There is no information with respect to the community's need for water supply.

Community Proposals

The Community Association of Pedra d'Água and surrounding areas has 127 members, of which 20 are from Pedra d'Água, 16 from Milhã, 4 from Serrote, 7 from Tanquinho and 80 from Monte Sombrio. The community's main request is that the Herdeiros reservoir be expanded. A topography survey was conducted and water samples were sent to a laboratory in the city of Iguatu. They propose the construction of a water supply and storage system in Pedra d'Água.

4.2.51 C51-SERROTE

Population

Our field survey has revealed that Serrote has 9 homes where 45 people live. The Brazilian Army's report on the 2007 Water Truck Operation listed 50 inhabitants in the communities of Serrote 01 and Serrote 02.

Population ≈ 50 inhabitants.

Location

The community of Serrote (Figure 4.146) is located at coordinates E = 474.801 and N = 9.375.608 and is 4.8 km northwest of Milhã.

Figure 4.146: Community of Serrote.

Description of the Water Supply System

The main source of water for the community is the Herdeiros reservoir in Mr. Raimundo Canuto Clodenildo Moreira's property, located at coordinates E=474.992; N=9.377010 and E=474.047; N=9.376.826, with a wall height of 5 meters and 250 meters long. All families collect water from this reservoir for their consumption.

Water Supply Provided by Water Trucks

The community received water brought by water trucks in 2007 according to Tables 4.44 and 4.45.

Table 4.44: Water Supply Provided by Water Trucks - Serrote 01

ROUTE	# 3
# OF PEOPLE SUPPLIED	25
NECESSARY VOLUME OF WATER (m^3)	15
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	9
NUMBER OF WATER LOADS	2
MONTHLY DISTANCE ON PAVED ROADS (km)	14
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	240
MONTHLY COST (R$)	98.70
PERSON RESPONSIBLE FOR RECEIVING LOAD	Zé Bruno
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.45: Water Supply Provided by Water Trucks - Serrote 02

ROUTE	# 3
# OF PEOPLE SUPPLIED	25
NECESSARY VOLUME OF WATER (m^3)	15
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	9
NUMBER OF WATER LOADS	2
MONTHLY DISTANCE ON PAVED ROADS (km)	14
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	240
MONTHLY COST (R$)	98.70
PERSON RESPONSIBLE FOR	Almir

RECEIVING LOAD	
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community's main request is that the Herdeiros reservoir be expanded. A topography survey was conducted and water samples were sent to a laboratory in the city of Iguatu. They propose the construction of a water supply and storage system in Serrote.

4.2.52 C52-ALMEIXA

Population

Our field survey has revealed that Serrote has 8 homes where 40 people live. The Brazilian Army's report on the 2007 Water Truck Operation listed 35 inhabitants.

Population ≈ 35 inhabitants.

Location

The community of Almeixa (Figure 4.147) is located at coordinates E = 476.868 and N = 9.378.386 and is 7.2 km north of Milhã.

Figure 4.147: Community of Almeixa.

<u>Description of the Water Supply System</u>

Locals collect water in Mr. Antonio Iraneudo's reservoir, located at coordinates E=477.021 and N=9.378.042, which can resist up to 1.5 years of drought. Some families have rainwater cisterns that have been built under the P1MC (Fig.4. 148)

Fig.4. 148: Rainwater cistern in Almeixa

Water Supply Provided by Water Trucks

The community received water brought by water trucks in 2007 according to Table 4.46.

Table 4.46: Supply Provided by Water Trucks - Almeixa

ROUTE	# 2
# OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (km)	7
DISTANCE ON UNPAVED ROADS (km)	8
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	21
MONTHLY DISTANCE ON UNPAVED ROADS (km)	24
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	315
MONTHLY COST (R$)	129.36

PERSON RESPONSIBLE FOR RECEIVING LOAD	Laudelino
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes expanding Mr. Antonio Iraneudo's reservoir and building a reservoir in the community. Another proposal would be building an aqueduct coming out of the Jatobá reservoir which provides water to Milhã and that is 4.4 km west of Almeixa.

4.2.53 C53-BARRA 2

Population

Our field survey has revealed that the community of Barra 2 has 80 homes where 400 people live. The Brazilian Army's report on the 2007 Water Truck Operation listed a population of 110 inhabitants. The 400 figure is achieved when the four communities under the name of Barra are combined.

Population ≈ 110 inhabitants.

Location

The community of Barra 2 (Figure 4.149) is located at coordinates E= 472.990 and N= 9.369.494 and it is 7.7 km southeast of Milhã.

Figure 4.149: Community of Barra 2.

Description of the Water Supply System

The population receives water through a supply system built from an Amazon-type well, located at coordinates E= 486.926 and N=9.366.926, in Mr. Rosiê Leite da Silva's property, donated to the community. Water is collected using a 7.5 HP centrifugal pump which directs water to an elevated reservoir located at coordinates E= 484.588 and N=9.367.662 that can store 45 m³ (Fig. 4.150). Water is transported to the elevated reservoir using a PVC DN 100 mm pipe, while water is distributed to homes using 75 mm pipes.

The system is run by Barra 1/Barra 2 and Vista Alegre's Community Association. Families pay a charge of R$ 8.00 per month. There are 70 members and 60 metered homes. The Association's average revenue totals R$ 330.00.

Despite the distribution system, six families had rainwater cisterns built under the P1MC program.

Fig.4. 150: Elevated reservoir in Barra 2.

Water Supply Provided by Water Trucks

Despite the existing system, the community received water brought by water trucks in 2007 according to Table 4.47.

Table 4.47: Water Supply Provided by Water Trucks - Barra 02

ROUTE	# 4
# OF PEOPLE SUPPLIED	110
NECESSARY VOLUME OF WATER (m^3)	66
DISTANCE ON PAVED ROADS (km)	11
DISTANCE ON UNPAVED ROADS (km)	2
NUMBER OF WATER LOADS	9
MONTHLY DISTANCE ON PAVED ROADS (km)	99
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	858
MONTHLY COST (R$)	354.84

PERSON RESPONSIBLE FOR RECEIVING LOAD	Zé Pintado
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community's proposal to offer a final solution to provide water to Barra is building the Capitão Mor reservoir, which would be practically built in the ranch where today there is an Amazon-type well providing water to the community.

4.2.54 C54-MORADA NOVA

Population

Our field survey has revealed that the community of Morada Nova has 18 homes where 90 people live. The Brazilian Army's report on the 2007 Water Truck Operation listed 50 inhabitants.

Population ≈ 50 inhabitants.

Location

The community of Morada Nova (Figure 4.151) is located at coordinates E= 483.473 and N= 9.369.678 and it is 5.9 km southeast of Milhã.

Figure 4.151: Community of Morada Nova.

<u>Description of the Water Supply System</u>

The population receives water from the same system as Barra, but there are complaints that water quality is poor. There is a rainwater cistern which is over 20 years old and that was built by Milhã's municipal government (Figure 4.152). Only one family has been included in the P1MC program so far to receive a rainwater cistern. Locals use water that is stored in the Morada Nova reservoir, located at coordinates E=483.490 and N=9.369.694. There is also an Amazon-type masonry well in Mr. Antonio Lima Pessoa's property. It is 2 meters deep and 5 meters wide, and covered with earth.

Fig.4. 152: Masonry cistern built by Milhã's Municipal Government in Morada Nova.

Water Supply Provided by Water Trucks

The community received water brought by water trucks in 2007 according to Table 4.48.

Table 4.48: Water Provided by Water Trucks - Morada Nova

ROUTE	# 2
# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m^3)	30
DISTANCE ON PAVED ROADS (km)	11
DISTANCE ON UNPAVED ROADS (km)	2
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	44
MONTHLY DISTANCE ON UNPAVED	8

ROADS (km)	
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	390
MONTHLY COST (R$)	157.20
PERSON RESPONSIBLE FOR RECEIVING LOAD	Zé dos Santos
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes expanding the Morada Nova reservoir, which can reach up to 2 meters high, and this will benefit the communities of Morada Nova, Várzea Alegre and Barra 1. A supply system would be built including water catchment, treatment, storage and distribution.

4.2.55 C55-VISTA ALEGRE

Population

Our field survey has revealed that Vista Alegre has approximately 45 homes where 225 people live. The Brazilian Army's report on the 2007 Water Truck Operation listed 160 inhabitants in the communities of Vista Alegre 01 and Vista Alegre 02.

Population ≈ 160 inhabitants.

Location

The community of Vista Alegre (Figure 4.153) is located at coordinates E= 485.213 and N= 9.366.962 and it is 8.8 km southeast of Milhã.

Figure 4.153: Community of Vista Alegre.

Description of the Water Supply System

The population receives water from the same system as Barra, but there are also complaints that water quality is poor. Families get water from Valdir's reservoir at coordinates E=485.005 and N=9.367.200, with a wall height of 4.5 meters, dam length 80 meters and fetch distance 150 meters. According to locals, water from Valdir's reservoir (Figure 4.154) is good until the month of October, when the reservoir begins to dry up. Approximately nine families have been awarded rainwater cisterns under the P1MC program.

Fig.4. 154: Valdir's reservoir in Vista Alegre.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007 according to tables 4.49 and 4.50.

Table 4.49: Water Supply Provided by Water Trucks - Vista Alegre 01

ROUTE	# 4
# OF PEOPLE SUPPLIED	50
NECESSARY VOLUME OF WATER (m^3)	30
DISTANCE ON PAVED ROADS (km)	15
DISTANCE ON UNPAVED ROADS (km)	2
NUMBER OF WATER LOADS	4
MONTHLY DISTANCE ON PAVED ROADS (km)	60

MONTHLY DISTANCE ON UNPAVED ROADS (km)	8
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	510
MONTHLY COST (R$)	205.20
PERSON RESPONSIBLE FOR RECEIVING LOAD	Cacai
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Table 4.50: Water Supply Provided by Water Trucks - Vista Alegre 02

ROUTE	**# 4**
# OF PEOPLE SUPPLIED	110
NECESSARY VOLUME OF WATER (m³)	66
DISTANCE ON PAVED ROADS (km)	16
DISTANCE ON UNPAVED ROADS (km)	2
NUMBER OF WATER LOADS	9
MONTHLY DISTANCE ON PAVED ROADS (km)	144
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18
TRANSPORTATION COSTS PER WEIGHT (m³ x km)	1188
MONTHLY COST (R$)	477.84
PERSON RESPONSIBLE FOR RECEIVING LOAD	Cici
SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes building the Capitão Mor reservoir to provide water to surrounding communities.

4.2.56 C56-SÍTIO LIBERDADE

Population

Our field survey has revealed that Sítio Liberdade has approximately 10 homes where 50 people live.

Population ≈ 50 inhabitants.

Location

The community of Sítio Liberdade is located at coordinates E= 486.138 and N= 9.367.138 and it is 9.2 km southeast of Milhã.

Description of the Water Supply System

Locals receive water from the same system that provides water to Barra. The Amazon-type well that provides water to the Barra system is located in Sítio Liberdade (Fig.4. 155).

Fig. 4.155: An Amazon-type well and pump house that belong to the Barra system in Sítio Liberdade.

Two families have been awarded rainwater cisterns under the P1MC program and another family has a cistern built by Milhã's Municipal Government.

There is also the Liberdade reservoir located at coordinates E=486.138 and N=9.367.138, upstream of the Amazon-type well. The Liberdade reservoir is 5 meters tall, dam length 400 meters and fetch length 500 meters.

Fig. 4.156: Liberdade Reservoir.

Water Supply Provided by Water Trucks

The community did not received water from water trucks in 2007.

Community Proposals

The community proposes building the Capitão Mor reservoir to provide water to surrounding communities.

4.2.57 C57-BARRA 01

Population

Our field survey has revealed that Barra 01 has approximately 60 homes where 300 people live. The Brazilian Army's 2007 Water Truck Operation report listed a population of 110 inhabitants in that section of Barra.

Population ≈ 110 inhabitants.

Location

The community of Barra 01 (Figure 4.157) is located at coordinates E= 482.184 and N= 9.369.940 and it is 5.5 km southeast of Milhã.

Fig. 4.157: Community of Barra 01.

<u>Description of the Water Supply System</u>

As in Barra 02, the population of Barra 01 receives water through a supply system built from an Amazon-type well, located at coordinates E= 486.926 and N=9.366.926, in Mr. Rosiê Leite da Silva's property, donated to the community. Water is collected using a 7.5 HP centrifugal pump which directs water to an elevated reservoir located at coordinates E= 484.588 and N=9.367.662 that can store 45 m³. Water is transported to the elevated reservoir using a PVC DN 100 mm pipe, while water is distributed to homes using 75 mm pipes.

The system is run by Barra 1/Barra 2 and Vista Alegre's Community Association. Families pay a monthly charge of R$ 8.00. There are 70 members and 60 metered homes. The Association's average revenue totals R$ 330.00.

Seven families have rainwater cisterns which were built with P1MC funds (Fig.4. 158). In addition, other five families have private masonry cisterns. About six families still have no piped water into their homes and have to use donkeys to collect it from Mr. Almino Alves' reservoir at coordinates E=481.612 and N=9.369.920 (Fig.4.159). The reservoir is 5 meters high, with a 120-meter wide dam and length 200 meters. There is also a 53-meter deep artesian well with a dynamic water level at 20 meters in Mr. Raimundo Alves Maia's property, at coordinates E=482.184 and N=9.369.940 (Fig.4.160).

Fig. 4.158: Rainwater cistern in Barra 01.

Fig.4. 159: Mr. Almino Alves' reservoir in Barra 01.

Fig. 4.160: Deep well in Barra 01.

<u>Water Supply Provided by Water Trucks</u>

The community received water from water trucks in 2007. Table 4.51 shows a summary of the Water Truck Operation in the community of Barra 01.

Table 4.51: Water Supply Provided by Water Trucks - Barra 01

ROUTE	# 4
# OF PEOPLE SUPPLIED	110
NECESSARY VOLUME OF WATER (m^3)	66
DISTANCE ON PAVED ROADS (km)	10
DISTANCE ON UNPAVED ROADS (km)	2
NUMBER OF WATER LOADS	9
MONTHLY DISTANCE ON PAVED ROADS (km)	90
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	792
MONTHLY COST (R$)	319.44
PERSON RESPONSIBLE FOR RECEIVING LOAD	Terezinha

SOURCE OF SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community of Barra 01, similar to most communities southeast of Milhã, proposes building the Capitão Mor reservoir to supply water to surrounding communities.

4.2.58 C58-AMANAJU 01

Population

Our field survey has revealed that Amanaju 01 has approximately 22 homes where 110 people live. The Brazilian Army 2007 Water Truck Operation report has listed 35 inhabitants in that part of the community.

Population ≈ 35 inhabitants.

Location

The community of Amanju 01 (Figure 4.161) is located at coordinates E= 482.092 and N= 9.366.990 and it is 6.7 km southeast of Milhã.

Fig. 4.161: Community of Amanju 01.

<u>Description of the Water Supply System</u>

There is no water supply system in Amanaju. Eight families have been awarded rainwater cisterns under the 1 Million Cisterns Program P1MC (Fig.4. 162).

Fig. 4.162: Rainwater cistern in Amanaju 01.

There is also an artesian well in Mr. José Constantino's property, at coordinates E=482.323 and N=9.367.276, which is 40 meters deep and has a flow rate of 8.3 m³/h. Water is somewhat saline but may improve with use, according to what locals believe (Fig. 4. 163)

Fig. 4.163: Deep well in Amanaju 01.

Other families collect water from the Amanaju reservoir located at coordinates E=482.369 and N=9.366.946 (Fig 4.164), for purposes other than drinking. They only drink water from cisterns or water trucks. They do not use water from the reservoir because of pollution coming from livestock waste that flows into it. The reservoir has a wall height of 8 meters; it is 200 meters long and has a fetch length of 300 meters. According to locals, it can resist up to two years of drought.

Fig. 4.164: Amanaju Reservoir.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007. Table 4.52 shows a summary of the Water Truck Operation in the community of Amanaju 01.

Table 4.52: Water Supply Provided by Water Trucks - Amanaju 01

ROUTE	# 3
NUMBER OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (Km)	9
DISTANCE ON UNPAVED ROADS (Km)	6
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	27
MONTHLY DISTANCE ON UNPAVED ROADS (km)	18

TRANSPORTATION COSTS PER WEIGHT (m^3xKm)	315
MONTHLY COST (R$)	128.52
PERSON RESPONSIBLE FOR RECEIVING LOAD	Dorinha
SOURCE OF WATER SUPPLY	LAGOINHA RESERVOIR

Community Proposals

There is a project drafted by Campo Novo's Community Association to provide water from a well in Mr. Ausivam Pinheiro's property (coordinates E=484.316 and N=9.366.450) to the communities of Campo Novo, Milagres, Deus Me Ajude and Amanaju. The well has a flow rate of 10.3 m^3/h and is 60 meters deep. The dynamic level is at 17 meters. The aqueduct would be 2.9 Km long in a straight line or 5 Km if it followed the roads.

4.2.59 C59-AMANAJU 02

Population

Our field survey has revealed that Amanaju 02 has approximately 9 homes where 45 people live. The Brazilian Army 2007 Water Truck Operation report has listed 35 inhabitants in that part of the community.

Population ≈ 35 inhabitants.

Location

The community of Amanju 02, also known as Milagres (Figure 4.165), is located at coordinates E= 482.400 and N= 9.365.430 and it is 8.2 km southeast of Milhã.

Fig. 4.165: Community of Amanaju 02 (Milagres).

<u>Description of the Water Supply System</u>

There is no water distribution system in Amanaju 02. Drinking water comes from cisterns. There is one family with a cistern that was built under the P1MC program. Other two families have private masonry cisterns. Families use donkeys to get water from the Milagres' reservoir in Mr. Manuel Arivanor Pinheiro's reservoir at coordinates E=482.308 and N=9.365.528 (Fig.4. 166). The reservoir has a wall height of 8 meters; it is 100 meters long and has a water fetch length of 150 meters. It provides water to three families that live in this ranch.

Fig. 4.166: Milagres Reservoir in Amanaju 02.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007. Table 4.53 shows a summary of the Water Truck Operation in the community of Amanaju 02.

Table 4.51: Water Supply Provided by Water Trucks - Amanaju 02

ROUTE	# 3
NUMBER OF PEOPLE SUPPLIED	35
NECESSARY VOLUME OF WATER (m^3)	21
DISTANCE ON PAVED ROADS (Km)	9
DISTANCE ON UNPAVED ROADS (Km)	9
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	27
27 MONTHLY DISTANCE ON UNPAVED ROADS (km)	27

TRANSPORTATION COSTS PER WEIGHT (m^3xKm)	378
MONTHLY COST (R$)	154.98
PERSON RESPONSIBLE FOR RECEIVING LOAD	Rosilene
SOURCE OF WATER SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community of Amanaju 02 has presented the same proposals as Amanaju 01. There is a project drafted by Campo Novo's Community Association to provide water from a well in Mr. Ausivam Pinheiro's property (coordinates E=484316 and N=9366450) to the communities of Campo Novo, Milagres, Deus Me Ajude and Amanaju. The well has a flow rate of 10.3 m^3/h and is 60 meters deep. The dynamic level is at 17 meters.

4.2.60 C60-CAMPO NOVO

Population

Our field survey has revealed that Campo Novo has approximately 5 homes where 25 people live.

Population ≈ 25 inhabitants.

Location

The community of Campo Novo (Figure 4.167) is located at coordinates E= 484.311 and N= 9.366.440 and it is 8.5 km southeast of Milhã.

Fig. 4.167: Community of Campo Novo.

<u>Description of the Water Supply System</u>

The community of Campo Novo receives water from an artesian well built in Mr. Francisco Aurisvam Pinheiro's property (Chico de Joaquim) at coordinates E=484.971 and N=9.366.486; it is 60 meters deep, its dynamic water level is at 2.5 meters and it has a flow rate of 10.2 m^3/h (Fig. 4 168). Water is pumped by a 3 HP pump into a 5,000-liter reservoir built by SOHIDRA from where water is distributed to individual homes.

Fig. 4.168: Deep well in the community of Campo Novo.

Fig. 4.169: Reservoir in Campo Novo.

Water Supply Provided by Water Trucks

The community is not listed in the 2007 water supply operation, at least not under this name. It is known, however, that there was water truck supply in that period.

Community Proposals

The community of Campo Novo has presented the same proposals as Amanaju 01. There is a project drafted by Campo Novo's Community Association to provide water from a well in Mr. Ausivam Pinheiro's property (coordinates E=484316 and N=9366450) to the communities of Campo Novo, Milagres, Deus Me Ajude and Amanaju. The well has a flow rate of 10.3 m^3/h and is 60 meters deep. The dynamic level is at 17 meters.

4.2.61 C61-DEUS ME AJUDE

Population

Our field survey has revealed that Deus Me Ajude has approximately 3 homes where 15 people live. The Brazilian Army 2007 Water Truck Operation report has listed 40 inhabitants in this community.

Population ≈ 40 inhabitants.

Location

The community of Deus Me Ajude (Fig.4.170) is located at coordinates E=484. 288 and N= 9.366.050; it is 8.7 km southeast of Milhã.

Fig. 4.170: Community of Deus Me Ajude.

Description of the Water Supply System

There isn't any type of water supply to the community of Deus Me Ajude. There is only one rainwater cistern built under the P1MC.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007. Table 4.54 shows a summary of the Water Truck Operation in the community of Deus Me Ajude.

Table 4.54: Water Supply Provided by Water Trucks - Deus Me Ajude

ROUTE	# 3
NUMBER OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (Km)	9
DISTANCE ON UNPAVED ROADS (Km)	10
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	27

MONTHLY DISTANCE ON UNPAVED ROADS (km)	30
TRANSPORTATION COSTS PER WEIGHT (m^3xKm)	456
MONTHLY COST (R$)	187.20
PERSON RESPONSIBLE FOR RECEIVING LOAD	Milton
SOURCE OF WATER SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community of Deus Me Ajude has presented the same proposals as Amanaju 01. There is a project drafted by Campo Novo's Community Association to provide water from a well in Mr. Ausivam Pinheiro's property (coordinates E=484316 and N=9366450) to the communities of Campo Novo, Milagres, Deus Me Ajude and Amanaju. The well has a flow rate of 10.3 m^3/h and is 60 meters deep. The dynamic level is at 17 meters.

4.2.62 C62-VÁRZEA ALEGRE

Population

Our field survey has revealed that Várzea Alegre has approximately 12 homes where 60 people live. The Brazilian Army 2007 Water Truck Operation report has listed 75 inhabitants in the community of Várzea Alegre 01.

Population ≈ 75 inhabitants.

Location

The community of Várzea Alegre (Figure 4.171) is located at coordinates E= 484.389 and N= 9.369.522 and it is 6.7 km southeast of Milhã.

Fig. 4.171: Community of Várzea Alegre.

<u>Description of the Water Supply System</u>

The community has piped water coming from the Barra water supply system. A few families use donkeys to get water from Rivaldo's reservoir, located at coordinates E=484.355 and N=9.369.412. Four families have rainwater cisterns built under the P1MC program, while two others have masonry cisterns built by Milhã's Municipal Government.

<u>Water Supply Provided by Water Trucks</u>

The community received water from water trucks in 2007. Table 4.55 shows a summary of the Water Truck Operation in the community of Várzea Alegre.

Table 4.55: Water Supply Provided by Water Trucks - Várzea Alegre

ROUTE	# 2
NUMBER OF PEOPLE SUPPLIED	75
NECESSARY VOLUME OF WATER (m^3)	45
DISTANCE ON PAVED ROADS (Km)	13

DISTANCE ON UNPAVED ROADS (Km)	1
NUMBER OF WATER LOADS	6
MONTHLY DISTANCE ON PAVED ROADS (km)	78
MONTHLY DISTANCE ON UNPAVED ROADS (km)	6
TRANSPORTATION COSTS PER WEIGHT (m^3xKm)	630
MONTHLY COST (R$)	252.90
PERSON RESPONSIBLE FOR RECEIVING LOAD	Germano
SOURCE OF WATER SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community of Várzea Alegre has presented the same proposals as the communities which get water from the Barra system, that is, building the Capitão Mor reservoir.

4.2.63 C63-BOM ALÍVIO

The community C63-Bom Alívio has already been described as community C17, that is, it was inadvertently surveyed twice.

4.2.64 C64-KM 21

Population

Our field survey has revealed that KM 21 has 10 homes where 50 people live. The Brazilian Army 2007 Water Truck Operation report has listed 40 inhabitants in the community of KM 21.

Population ≈ 40 inhabitants.

Location

The community of KM 21 (Figure 4.172) is located at coordinates E= 470.831 and N= 9. 371.382; it is 7.5 km west of Milhã.

Fig. 4.172: Community of KM 21.

<u>Description of the Water Supply System</u>

There is no water supply system. Locals get water from Mr. Medeirinho's reservoir (21), located at coordinates E= 470.876 and N=9.371.538 (Fig. 173). The reservoir has a wall height of 8 meters; it is 180 meters long and has a water fetch length of approximately 300 meters. It can resist approximately two years of drought. In the community there is only one cistern in Mr. Antonio José's property, in Senador Pompeu, since the community is at a municipal border. Two artesian wells have been drilled in the community. The first one is located at coordinates E=470.707 and N=9.371.414 and the second is at coordinates E=470.765 and N=9.371.306; they are both 60 meters deep but their flow rate is not enough to provide water to the community (Figures 4.174 and 4.175).

Fig. 4.173: Mr. Medeirinho's reservoir in KM 21.

Fig. 4.174: Well #1 in KM 21, sealed off for not having enough water.

Fig. 4.175: Well #2 in KM 21, sealed off for not having enough water.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007. Table 4.56 shows a summary of the Water Truck Operation in the community of KM 21.

Table 4.56: Water Supply Provided by Water Trucks - KM 21

ROUTE	# 3
NUMBER OF PEOPLE SUPPLIED	40
NECESSARY VOLUME OF WATER (m^3)	24
DISTANCE ON PAVED ROADS (Km)	5
DISTANCE ON UNPAVED ROADS (Km)	1
NUMBER OF WATER LOADS	3
MONTHLY DISTANCE ON PAVED ROADS (km)	15
MONTHLY DISTANCE ON UNPAVED ROADS (km)	3

TRANSPORTATION COSTS PER WEIGHT (m^3xKm)	144
MONTHLY COST (R$)	58.08
PERSON RESPONSIBLE FOR RECEIVING LOAD	Mivânia
SOURCE OF WATER SUPPLY	LAGOINHA RESERVOIR

Community Proposals

The community proposes building cisterns under the P1MC program. They see no alternative other than building a reservoir in Mr. Gessimar Pinheiro's property (a former mayor), to provide water to the community.

4.2.65 C65-OLHO d'ÁGUA

Population

Our field survey has revealed that Olho d'Água has 21 homes where 105 people live.

Population ≈ 105 inhabitants.

Location

The community of Olho d'Água (Figure 4.176) is located at coordinates E= 471.537 and N= 9.371.328; it is 6.9 km west of Milhã.

Fig. 4.176: Community of Olho d'Água.

<u>Description of the Water Supply System</u>

There is no public water supply system. Locals get water from the Olho d'Água reservoir in Mr. Raimundo Nilson Lopes' property, at coordinates E=471.557 and N=9.371.348 (Figure 177). The reservoir has a wall height of 4 meters; it is 60 meters long and has a water fetch length of 100 meters. There is a masonry cistern that was built by Milhã's municipal government (Fig.4. 178). There is also a deep well in Mr. José Esmeraldo's property, located at coordinates E=470.881 and N=9.371.014. It is 62 meters deep with its dynamic level at 30 meters. The well is used for irrigation (Fig.4. 179).

Fig. 4.177: Olho d'Água reservoir.

Fig. 4.178: Masonry cistern in Olho d'Água.

Fig. 4.179: Well used for irrigation in Olho d'Água.

Water Supply Provided by Water Trucks

The community received water from water trucks in 2007; however it is not listed under this name in the Brazilian Army's 2007 Water Truck Operation.

Community Proposals

The community proposes drilling a public well in the community and distributing water to homes using an elevated reservoir.

4.2.66 C66-VILA NOVA

Population

Our field survey has revealed that Vila Nova has 52 homes where 260 people live.

Population ≈ 260 inhabitants.

Location

The community of Vila Nova (Figure 4.180) is located at coordinates E = 471.931 and N = 9.371.034; it is 6.4 km west of Milhã.

Fig. 4.180: Community of Vila Nova.

<u>Description of the Water Supply System</u>

There is a water supply system coming from catchment in a 80-meter deep well located at coordinates E=471.791 and N=9.370.994 (Fig. 4.181). This was built in 2001 under the São José Project. The well has a flow rate capacity of 2 m^3/h with good quality water. Water is treated with chlorine and pumped (Fig. 4.182) into an elevated reservoir (Fig. 4.183), located at coordinates E=471.763 and N=9.370.998 with total capacity of 21 m^3, from where water is distributed by gravity to homes.

Fig. 4.181: Well in the community of Vila Nova, built under the São José Project.

Fig. 4.182: Pumping and chlorination of water from the well in Vila Nova.

Fig. 4.183: Lagoa Nova's Elevated reservoir.

Water Supply Provided by Water Trucks

Thanks to the system implemented under the São José Project, the community of Vila Nova no longer depends on water provided by water trucks.

Community Proposals

The community proposes expanding the distribution network to homes built after the São José Project's first stage.

4.2.67 C67-NOVO DESTINO

Population

Our field survey has revealed that the community of Novo Destino has 45 homes where 225 people live.

Population ≈ 225 inhabitants.

Location

The community of Novo Destino (Figure 4.184) is located at coordinates E = 473.932 and N = 9.371.450; it is 4.5 km west of Milhã.

Fig. 4.184: Community of Novo Destino.

<u>Description of the Water Supply System</u>

The system that provides water to Novo Destino is similar to that of Vila Nova. There is a deep well built at coordinates E=473.752 and N=9.371.414 (Fig. 4.185) whose water is pumped into an elevated reservoir located at coordinates E=474.124 and N=9.371.446 (Fig. 4.186), from where water is distributed to locals.

Fig. 4.185: Deep well in Novo Destino.

Fig. 4.186: Elevated reservoir in Novo Destino.

Water Supply Provided by Water Trucks

Thanks to the system implemented under the São José Project, the community of Novo Destino no longer depends on water provided by water trucks.

Community Proposals

The community proposes an integrated project with water catchment at the Lagoinha reservoir to provide water to the communities of Bela Vista, Santa Lagoinha and surrounding areas.

5. PRIORITY INTERVENTIONS AT THE LOCAL SCALE

5.1 INTRODUCTION

The interventions considered as a priority at the local scale are those which will enable UNIVERSALIZING HUMAN SUPPLY of potable water in rural communities of the municipality of Milhã. In this context "*universalization*" means providing potable water to households in order to meet the basic needs of human consumption. In the case of rural communities scattered across the municipal area, the issue of water supply universalization affects different stages and does not consist of a single action one could perform through a single intervention.

First of all, **access to water** must be guaranteed to people living in rural communities. The focus should be taking water to households whether through individual cisterns or public distribution networks. Initially the construction of public water supply networks is the priority intervention to be aimed at, as long as there is a viable source of water in terms of supply capabilities and collection and delivery distance. Cisterns would be recommended for small rural communities with scattered homes and places where it would be economically unfeasible to build delivery and home distribution networks.

Secondly **quantitative sustainability in the long term** should also be considered. This relates to the capacity of the water source selected to provide necessary water during periodical droughts that are part of the local climate. This water sustainability is not guaranteed by most sources available within the municipality of Milhã. This fact will require Alternative Water Supply Plans to be implemented during periods of drought. This factor which limits human supply is a reality that will have to be taken into account in any type of strategic planning in order to guarantee water supply to the population during adverse climate events. Among the available alternatives to provide water supply during droughts, **water supply provided by water trucks** must be considered. It is "*demonized*" by successive government agents as a pest to be eliminated. Indeed, water supply provided by water trucks such as it is today, that is, providing water on a yearly basis to scattered rural communities from October to January during the dry season, even in years in which rainfall is normal or above average, is an exception that has become the rule. It is not compatible with rational strategic planning and it is justified by the government's inertia and inability to promote actions that will provide water to communities in normal climate situations even. Water supply provided by water trucks should be an alternative to be considered only in situations of "*real drought*", when annual rainfall may not have been enough to provide minimum recharge of sources of water supply, that is, in real events of periodical climate droughts. A Rational Operation Plan is necessary even when one considers the possibility of water supply provided by water trucks during events of real drought. The current model operated by the Brazilian Army has shortcomings due to the limited amount of information available to planning agents. This PAM, which was drafted for the municipality of Milhã, provides more rational alternatives to plan routes by showing strategic sources of water that are more feasible and reliable in terms of quality and quantity to provide water to the population.

Finally, the third aspect to be considered in water supply universalization is the **quality of water to be provided.** At first one should argue against quality being ranked last during planning, when in fact it should be ranked first, moved by a sanitary interest in the health of the population. However, the aspect "*quality of water*" would limit greatly the availability of sources that provide water to scattered populations. This becomes a limiting factor which would prevent populations from getting average quality water that is appropriate for all other uses except drinking. Our field research experience has demonstrated that populations in scattered rural communities perceive access to water as a priority factor for meeting their water supply needs. This is because once they have this precious liquid at their homes in amounts that will allow them to do their washing, cooking and to meet other basic needs, such as body hygiene, searching for drinking water becomes less strenuous and burdensome.

Considering the factor quality of water as a variable to be taken into account when building public water supply systems in Milhã would demand very a large amount of money. This would include building new reservoirs with greater storage capacity, such as those mentioned in Chapter 6, and municipal aqueduct networks that would take potable and good quality water to several rural communities scattered across the land.

The strategic planning vision adopted in this PAM focuses on what is feasible from the practical perspective with little funds available. These are limited to non-expensive budgets or permanent fiscal budgets and incomes of the municipality. The PAM was not designed with the aim to provide ideal solutions from the technical, sanitary, economic and social point of view, but was rather based on feasibility aspects of execution within the municipality's technical and economic limitations.

5.2 INTERVENTIONS TO UNIVERSALIZE WATER SUPPLY

During the Diagnosis stage we identified 14 rural communities in Milhã which did not have any type of water supply guaranteeing their population access to water. Such communities were divided into six geographical groups for intervention. Table 5.1 shows communities to be targeted by interventions proposed in the PAM. It also shows a summary of intervention costs, which will be detailed later.

Table 5.1: Communities to be targeted by interventions

GROUP/ SUBGROUP	COMMUNITY	NUMBER OF HOUSEHOLDS	POPULATION	COORD. EAST (m)	COORD. NORTH (m)	ESTIMATED COST (R$)	COST PER FAMILY (R$/fam.)
1 / 1.1	Barra do Juazeiro	10	50	486384	9371448	220.875,85	6.902,37
	José de Paz	3	15	487568	9371248		
	Cruzeiro	5	25	487568	9371248		
	Bom Alívio	14	70	485668	9370328		
1 /1.1	Lajes	6	30	487184	9372658	14.129,16	2.354,86
1 /1.2	Esperança	16	80	484721	9374320	94.432,82	3.777,31
	Sabonete	9	45	484893	9373160		
1 /1.3	Bom Princípio	9	45	483403	9372010	77.657,01	8.628,56
2	Pedra d'Água	19	95	474562	9376138	146.927,56	5.247,41
	Serrote	9	45	474801	9375608		
3	Massapê	7(3)	15	486987	9378088	7.064,58	2.354,86
	Cruzeiro	11(6)	30	489839	9378792	14.129,16	2.354,86
4	Ingá	13	65	478556	9380112	65.485,39	5.037,33
5	Sítio Maré	8	40	480590	9361132	69.773,89	8.721,74
	Cajueiros	3	15	475643	9361952	4.709,72	2.354,86
6	Deus Me Ajude	3	15	484288	9366050	7.064,58	2.354,86
	TOTAL	136	680			722,249,72	5.310,65

5.2.1. GROUP 1

Group 1 consists of the following communities: José de Paz (three households), Cruzeiro (five households), Barra do Juazeiro (ten households), Bom Alívio (14 households), Lajes (six households), Bom Princípio (nine households), Esperança (16 households) and Sabonete (nine households), totaling 72 families and an approximate population of 360 inhabitants.

Figure 5.1 shows the location map for those communities while Figure 5.2 shows the same map on a Google Earth image.

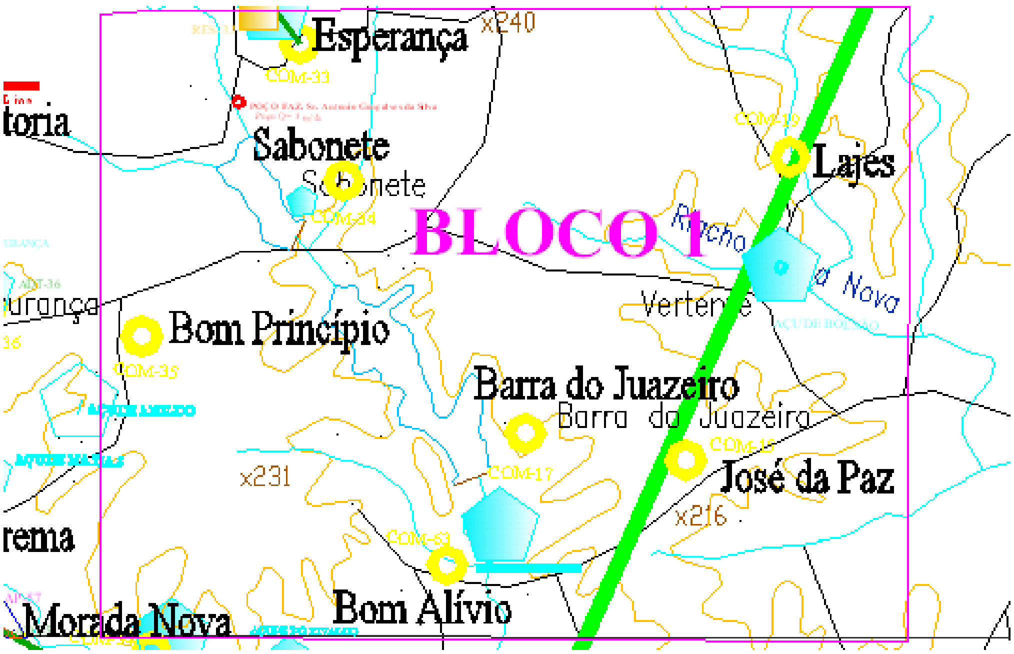


Figure 5.1: Location Map of Group 1 Communities.

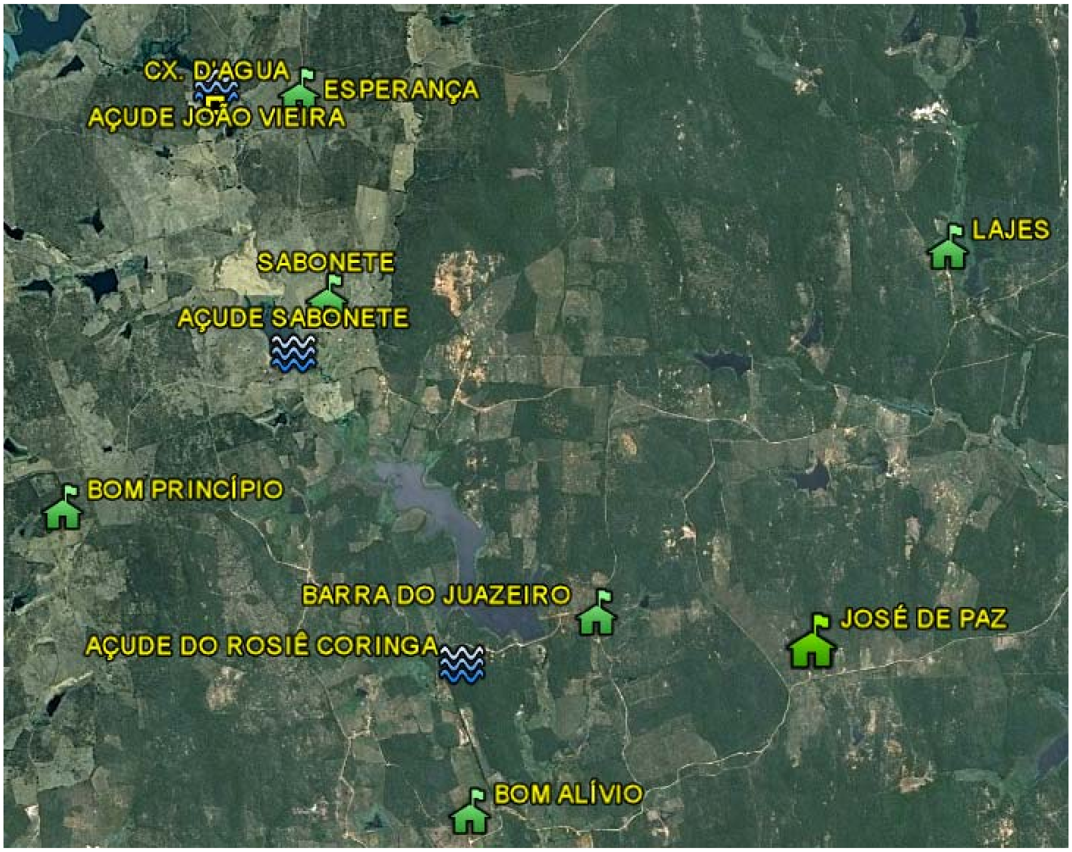


Figure 5.2: Google Earth Image of Group 1 Communities

5.2.1.1. Current Situation

The current situation of water supply to Group 1 communities according to the Diagnosis is the following:

<u>José de Paz:</u>

The community of José de Paz has three households, one of which has a private cistern. Another household has a cistern that was built under the 1 Million Cisterns Program P1MC and the other one has nothing. People get water from the Rosiê Coringa reservoir because it is near their community. There is a project for an integrated water supply system. It was drafted within the context of the São José Program, File number 07177688-5, filed on September 19 2007. It has not yet been implemented and it would include the communities of José de Paz, Cruzeiro, Barra do Juazeiro and Bom Alívio. Water would be collected from the Rosiê Coringa reservoir, which can resist up to two years of drought, according to local residents.

The definite solution pointed out by locals would be building the Capitão Mor reservoir, from where a less than 1-km long water supply aqueduct would come out to provide water to the community.

Cruzeiro

This community has five households and it is in the same situation as José de Paz. It is also part of the integrated water supply system project sent to the São José Project.

Barra do Juazeiro

This consists of a community with 10 families in the same situation as those of José de Paz. They use animals (donkeys) to carry water from the Rosiê Coringa reservoir. They receive water from water trucks. They are also part of the water supply project sent to the São José Project.

Bom Alívio

This consists of a community with 14 households. They use animals (donkeys) to carry water from the Rosiê Coringa reservoir for up to 2 km. One family has a private cistern and three others were included in the P1MC.

Lajes

This community has six households. They are members of the José de Paz Association; however they are not included in the integrated water supply project sent to the São José Project. Two homes have pipes coming from a small reservoir that was expanded eight years ago and that has never dried up. Two other families receive water from water trucks and also take water from Mr. Iraneudo's reservoir, using donkeys to carry it. They do their laundry at another small reservoir called Bolsão. The community aims to become a part of the José de Paz water supply project sent to the São José Project.

Bom Princípio

The community of Bom Princípio has nine households. One family has a private cistern and another was included in the P1MC to receive a rainwater cistern. Other families get water using donkeys from Mr. Antonio Coringa's reservoir, which is called Segurança. According to locals the Segurança reservoir is able to resist only one year of drought. A 40-meter deep well was drilled in July 2009 in Mr. Francisco das Chagas de Almeida's property. It has a flow rate of 3.3 m^3/h. There is still no use for water provided by this well, but it is believed to be saline as in most wells drilled in this region. The community proposes expanding the reservoir in Mr. Anildo Junior and Mr. Francisco das Chagas' properties, but they mention that the definitive solution would be building the Capitão Mor reservoir.

Esperança

There are 16 households in the community of Esperança. There is a private water supply with water coming from Mr. João Vieira's reservoir in his property. The system consists of water collection using a 2 HP pump at the reservoir. Water is taken to an elevated reservoir located at coordinates E= 484236 and N= 9374392 with an estimated capacity of 16 m^3. From this reservoir water is distributed through 32 mm DN PVC pipes to 15 households. Water has good quality according to locals, but it is not treated. Locals have reached an agreement to pay a monthly charge of R$ 10.00 for access to water. Five families pay the charge. The João Vieira reservoir can resist up to three years of drought, according to locals. The community received water from water trucks in 2007 and 2008. Additionally a 52-meter deep well has been drilled in Mr. Antonio Gonçalves da Silva's property, who is also known as Paraibano. Flow rate measured by SOHIDRA was 3 m^3/h; however water is very saline. Most families drink water from cisterns; four have been included in the P1MC. Water from the João Vieira reservoir is not treated and is used only for basic needs except drinking.

Sabonete

The community of Sabonete consists of nine households. Families use donkeys to get water from the reservoir in Francisco Eudes de Oliveira's property. The reservoir is also called Sabonete. Rainwater cisterns are being built for six families under the P1MC program. Families currently only drink mineral water, which is too expensive considering their home budget. One solution provided is the integration with the system implemented in Esperança, treating water from the João Vieira reservoir.

5.2.1.2. Intervention Proposals

Group 1 communities can be divided into ___ subgroups for intervention proposals within the PAM:

• Subgroup 1.1 - Rosiê Coringa Reservoir System

The water supply system coming from the Rosiê Coringa reservoir will correspond to the identical project to be funded by the São José Project to provide water to the communities of Barra do Juazeiro, José de Paz, Cruzeiro and Bom Alívio, totaling 32 families.

The proposed system consists of floating water collection from the Rosiê Coringa reservoir; an approximately 320-meter long bulk water aqueduct until Barra do Juazeiro; a Water Treatment Station in Barra do Juazeiro with the capacity to treat water for the entire population; an elevated reservoir with an upper shaft at 15m in order to provide water using gravity to the community of José de Paz, which is located at the highest level in the system; and an approximately 3,380-meter treated water aqueduct to take water all the way to José de Paz and Bom Alívio.

The community of Lajes should be out of the integrated system coming from the Rosiê Coringa reservoir, since the treated water aqueduct to provide water to the community would be approximately 3,972 meters long. The cost of this aqueduct would be an estimated R$ 128,533.92. This would equal a unit cost of R$ 21,422.32/family, which is absolutely inconsistent from the economic feasibility perspective. We recommend implementing individual cisterns in each household in the community of Lajes.

Figure 5.3 shows a schematic diagram of proposed interventions on a Google Earth image.

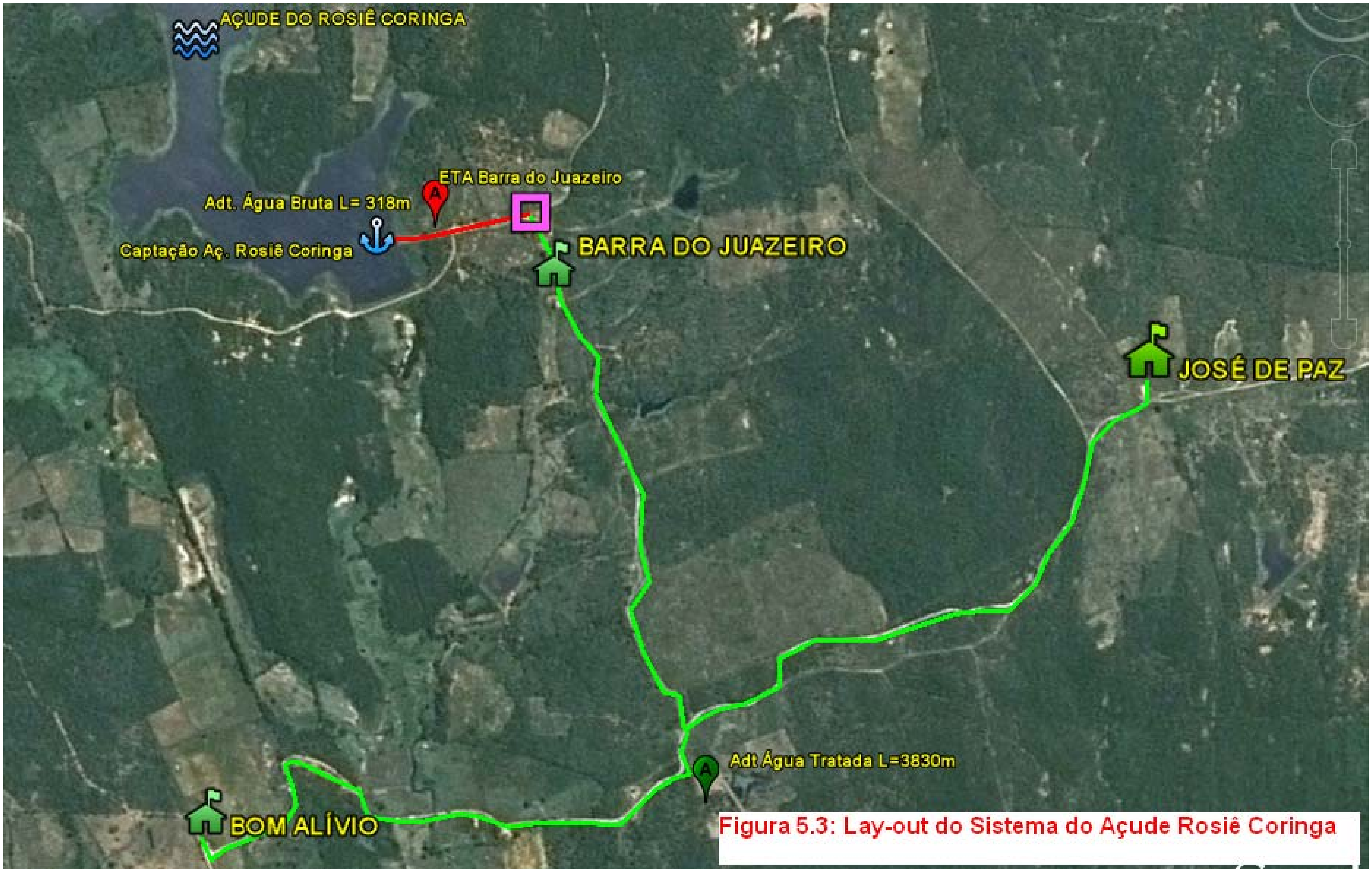


Figura 5.3: Lay-out do Sistema do Açude Rosiê Coringa

Table 5.2 shows a summary of units that make up the system and their estimated cost. The complete spreadsheet with the system's costs and size is presented attached.

Table 5.2: A Summary of the Rosiê Coringa Reservoir System

UNIT	COST (R$)
1. Water collection	**8.322,46**
2. Treatment	**14.600,48**
3. Pumping Water Delivery	**10.355,20**
4. Gravity Water Delivery	**123.938,80**
5. Storage	**22.063,49**
6. Distribution Network	**37.141,34**
7. Building Connections	**4.454,08**
OVERALL TOTAL	**220.875,85**
COST PER FAMILY	**6.902,37**

The unit cost of this proposed system is therefore R$ 6,902.37/family.

The community of Lajes would get six rainwater cisterns that would cost R$ 14,129.16.

• Subgroup 1.2: João Vieira Reservoir System

The water supply system coming from the João Vieira reservoir would provide water to the communities of Esperança and Sabonete. In the community of Esperança there already is a private water collection, storage and distribution system implemented by the farm's owner; there is an agreement with locals according to which they pay a monthly maintenance charge of R$ 10.00. The problem is that water is not treated. The PAM's proposal is to expand water collection, promote water treatment and also distribute treated water through an aqueduct to the community of Sabonete. Figures 5.4 and 5.5 show the João Vieira reservoir and the rudimentary water collection and storage system built privately.

Figure 5.4: João Vieira Reservoir; on the far right, collection of water for Esperança.

Figure 5.5: Water pumping at the João Vieira reservoir; an elevated reservoir in the back, which provides water to the community of Esperança.

Figure 5.6 shows a schematic diagram of the system proposed by the PAM to provide water to Esperança and Sabonete on a Google Earth image. This consists of floating water collection at the João Vieira reservoir using a 1 HP centrifugal pump with a flow rate of 1.25 m³/h and manometric height of 23 mca. There would be a 57-meter, 50 mm DN PVC water delivery pipe reaching the Water Treatment Station ETA which would be built next to the 10 m³ elevated reservoir. A 1,761-meter long 50 mm DN PVC aqueduct would take treated water from the elevated reservoir all the way to Sabonete.

Figure 5.6: A schematic diagram of the water supply system in subgroup 1.2.

Table 5.3 shows a summary of units that make up the system and their estimated cost. The complete spreadsheet with the system's costs and size is presented attached.

Table 5.3: A Summary of the João Vieira Reservoir System

UNIT	COST (R$)
1. **Water collection**	**6.989,09**
2. **Treatment**	**14.600,48**
3. **Pumping Water Delivery**	**1.941,60**
4. **Gravity Water Delivery**	**56.985,96**
5. **Storage**	**0,0**
6. **Distribution Network**	**10.435,94**
7. **Building Connections**	**3.479,75**
OVERALL TOTAL	**94.432,82**
COST PER FAMILY	**3.777,31**

The unit cost of this proposed system is therefore R$ 3,777.31/family.

• Subgroup 1.3: Deep Well in BOM PRINCÍPIO

In the case of Bom Princípio there is no foreseeable possibility of using surface water from local reservoirs to provide water to locals because their capacity is not enough to meet the demand. A solution to provide water to the community permanently should be based on ground water using the deep well that has been drilled in Mr. Francisco das Chagas de Almeida's property, at coordinates E= 483394 and N= 9371774.

According to information from our Diagnosis, the well has a flow rate of 3.3 m³/h, its static water level at 20 meters and dynamic water level at 40 meters. Figure 5.7 shows a photograph of this well.

Figure 5.7: Deep Well in Bom Princípio. Flow rate: 3.3 m³/h.

The system would therefore correspond to: pumping water from the deep well using a 1.5 HP KING 1.5JKB-N46 injection pump to take water from the well through a 345-meter aqueduct to a treatment station with a desalinizer. Due to high costs of desalinized water, there would be no storage or home distribution network. The local population would get water straight from the desalinizing system. They would pay what is usually charged for this kind of service, which ranges from R$ 0.20 to R$ 0.50 per ticket that can be exchanged for 20 liters of water. Figure 5.8 shows a Google Earth image of the proposed system.

Figure 5.8: A deep well and desalinizing system for Bom Princípio.

Table 5.4 shows a summary of units that make up the system and their estimated cost. The complete spreadsheet with the system's costs and size is presented attached.

Table 5.4: A Summary of the Deep Well System in Bom Princípio

UNIT	COST (R$)
1. Water collection	**1.488,81**

2. Treatment	65.004,00
3. Pumping Water Delivery	11.164,20
4. Gravity Water Delivery	0,00
5. Storage	0,00
6. Distribution Network	0,00
7. Building Connections	0,00
OVERALL TOTAL	**77.657,01**
COST PER FAMILY	**8.628,56**

The unit cost of this proposed system is therefore R$ 8,628.56/family.

5.2.2. GROUP 2

Group 2 consists of the communities of Pedra d'Água (19 households) and Serrote (none households), totaling 28 families. Figure 5.9 shows the location of those communities on a map. Figure 5.10 shows a Google Earth image.

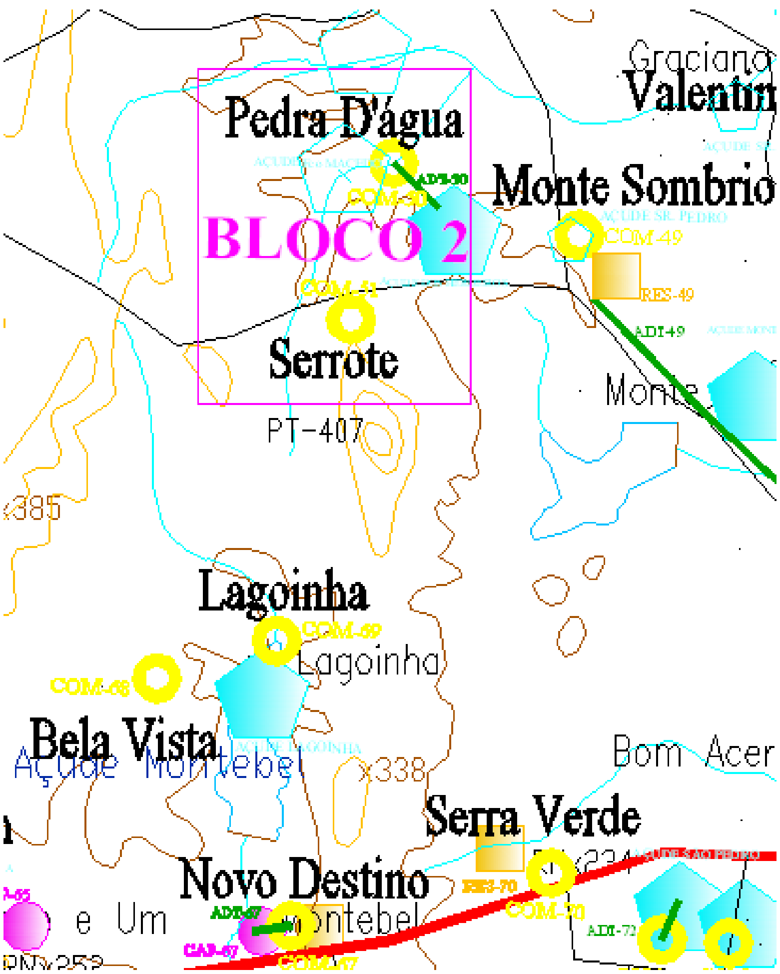


Figure 5.9: Location of Group 2 - Pedra d'Água and Serrote.

Figure 5.10: Google Earth Image of Group 2 Communities

5.2.2.1. Current Situation

The main source of water for both communities is the Herdeiros reservoir, in Mr. Raimundo Canuto Clodenildo Moreira's property, located at coordinates E=474.992; N=9.377010 and E=474.047; N=9.376.826; it is 5 meters high and 250 meters long (Figure 5.11).

Figure 5.11: Herdeiros Reservoir in Pedra d'Água.

Approximately six families collect water from the Herdeiros reservoir and have it pumped to their homes (Figure 5.12). Others use donkeys to carry water. There is a second reservoir in the community owned by Mr. Francisco Macedo, with a dam located at coordinates E= 474.382; N= 9.376.244 and E= 474.452; N=9.376.168. The dam is 103 meters wide, 6 meters tall and 200 meters long.

Approximately five families have been included in the P1MC.

Figure 5.12: Private water collection at the Herdeiros reservoir.

Approximately five families have been included in the P1MC. The Community Association of Pedra d'Água and surrounding areas has 127 members, distributed as follows: 20 from Pedra d'Água; 16 from Milhã; 4 from Serrote; 7 from Tanquinho and 80 Monte Sombrio. The community's main request is expanding the Herdeiros reservoir. A topographic survey was conducted and water samples were sent to a laboratory in Iguatu. They propose building a water supply and storage system in Pedra d'Água.

5.2.2.2. Intervention Proposals

The most feasible alternative to provide water to the group 2 communities of Pedra d'Água and Serrote is indeed expanding the Herdeiros reservoir and building an integrated water supply system consisting of: floating water collection at this reservoir; a bulk water 1,080-meter long 50 mm DN PVC aqueduct going all the way to the ETA in Pedra d'Água; a Water Treatment Station ETA; an elevated reservoir in Pedra d'Água; a treated water pumping aqueduct from Pedra d'Água to Serrote, with a 925-meter long 50 mm DN PVC pipe, which would deliver water directly into the distribution network and avoid having it stored a second time.

Figure 5.13 shows a schematic diagram of the system proposed for Group 2 on a Google Earth image.

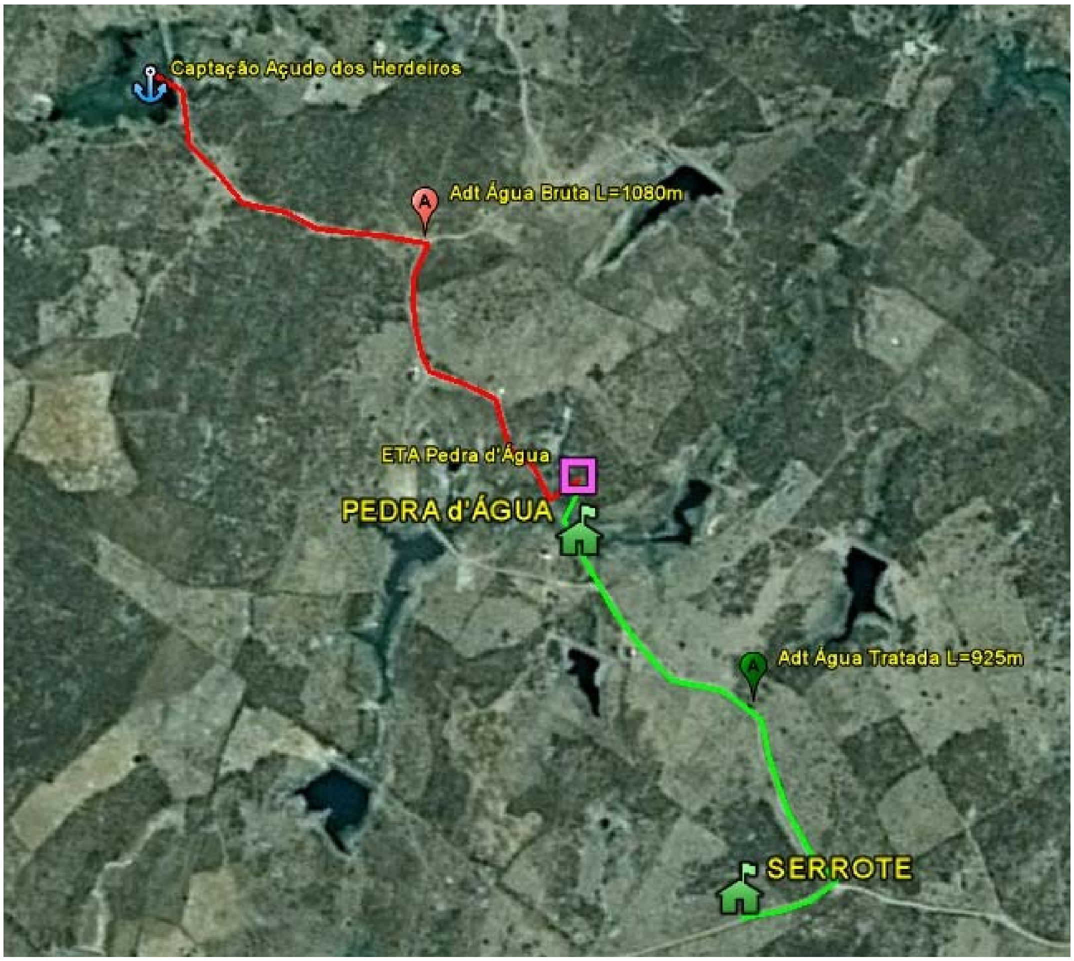


Figure 5.13: Schematic diagram of the system proposed for Group 2.

Table 5.5 shows a summary of units that make up the system and their estimated cost. The complete spreadsheet with the system's costs and size is presented attached.

Table 5.5: A Summary of the Group 2 System - Herdeiros Reservoir

UNIT	COST (R$)
1. Water collection	8.975,85
2. Treatment	14.600,48
3. Pumping Water Delivery	64.881,80
4. Gravity Water Delivery	0,00
5. Storage	22.063,49
6. Distribution Network	32.508,62
7. Building Connections	3897,32
OVERALL TOTAL	146.927,56
COST PER FAMILY	5.247,41

The unit cost of this proposed system is therefore R$ 5,247.41/family.

5.2.3. GROUP 3

Group 3 consists of the communities of Massapê, with seven households, of which only three are inhabited, and Cruzeiro with eleven households, of which only six are inhabited. This totals nine families. Figure 5.14 shows the location of those communities.

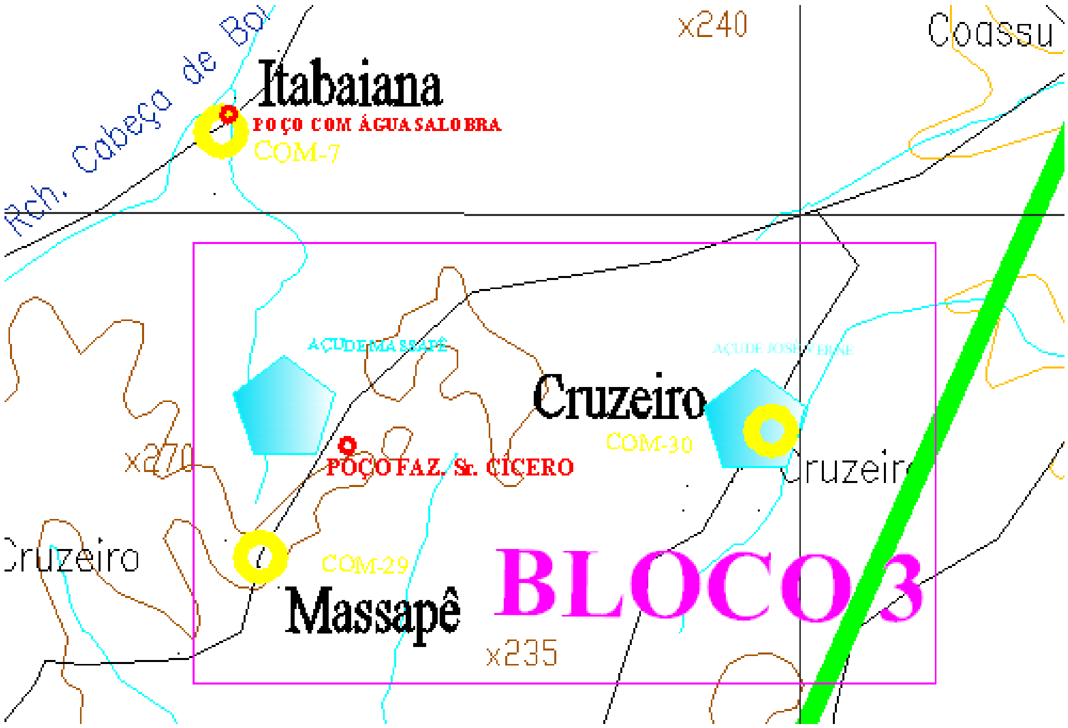


Figure 5.14: Location Map of Group 3 Communities.

5.2.3.1. Current Situation

Massapê

The community of Massapê collects water from the Massapê reservoir, at coordinates E=487.124 and N=9.378.912, which is in Mr. Cícero Neto de Lima's farm. The reservoir has a small storage capacity and usually dries up every year.

The Massapê reservoir is approximately 3 meters high, 80 meters wide and 1 km long.

A 50-meter deep artesian well was drilled (Figure 5.15) in 2008, with an estimated flow rate of 1,000 L/h, located at coordinates E=487.475 and N=9.378.708 in Mr. Cícero's farm. Water quality is poor (saline); however workers who performed the drilling suggested it could be improved with continuous pumping. Nevertheless there is no electricity in the community; therefore the well is not yet used to provide water to locals. According to sources, all reservoirs in the area dried up during the 2007/2008 dry season.

There is only one home in the community that was included in the 1 Million Cisterns Program.

Figure 5.15: An artesian well drilled in Massapê; however there is no electricity for it to operate.

One family is a member of the Sítio Fortaleza Community Association (2.4 km southwest of Massapê), while another family is a member of the Itabaiana Community Association (2.4 km north of Massapê).

Annual droughts make it necessary for water trucks to provide water.

Cruzeiro

The community collects water from Mr. José Verne's reservoir, at coordinates E=489.746 and N=9.378.834. The reservoir has a small storage capacity and usually dries up every year.

The José Verne reservoir is approximately 7 meters high, 200 meters wide and 400 meters long (Figure 5.16).

Annual droughts make it necessary for water trucks to provide water.

Figure 5.16: Water collection in the José Verne reservoir in Cruzeiro.

5.2.3.2. Intervention Proposals

The community longs for the construction of an electricity network in the municipality and for the artesian well in Mr. Cícero's farm to start operating. Another suggestion is building one rainwater cistern for each family under the 1 Million Cisterns Program. According to locals, there is also a reservoir in Mr. Raimundo François' farm that could provide water to the community, as long as an electricity network was built to allow water to be pumped. Water from this reservoir is saline and would need treatment in order to become potable. According to locals, the reservoir could resist up to two years of drought.

The community proposes drilling an artesian well, expanding the José Verne reservoir or building another reservoir on Riacho das Pedras (Pedras Creek), near the community of Cruzeiro.

From the geographical, social and economic perspective, one concludes that the most feasible intervention would be building 16-m³ cisterns to provide water to both communities, which total only three families in Massapê and six families in Cruzeiro.

Providing electricity to the well in Mr. Cícero's farm would not significantly change the desolate water situation in which those communities live because water from this well, in addition to being saline, would require building a 777-meter aqueduct to Massapê and a 2354-meter aqueduct to Cruzeiro. The cost would be absolutely unfeasible and pumping costs would be too high for families to afford.

Figure 5.17 shows a Google Earth Image of those communities.

Figure 5.17: A schematic diagram of the solution proposed for Group 3 communities.

Table 5.6 shows the estimated costs for Group 3 communities.

Table 5.6: Summary of Group 3 Costs - Cisterns

COMMUNITY	COST (R$)
Massapê (3 cisterns)	**7.064,58**
Cruzeiro (6 cisterns)	**14.129,16**
TOTAL	**21.193,74**

The cost of each individual cistern per family will be R$ 2,354.86 for a 16 m³ unit. This cost is greater than that established by ASA-Articulação do Semi-Árido (TN: a network of civil society organizations) through NGOs such as Cáritas and Esplar; however, this is because we are not considering labor as being cost-free, as it is in the Rainwater Cistern Manual of Cáritas.

5.2.4. GROUP 4

Group 4 is formed by the community if Ingá. Figure 5.18 shows the map with the community's location.

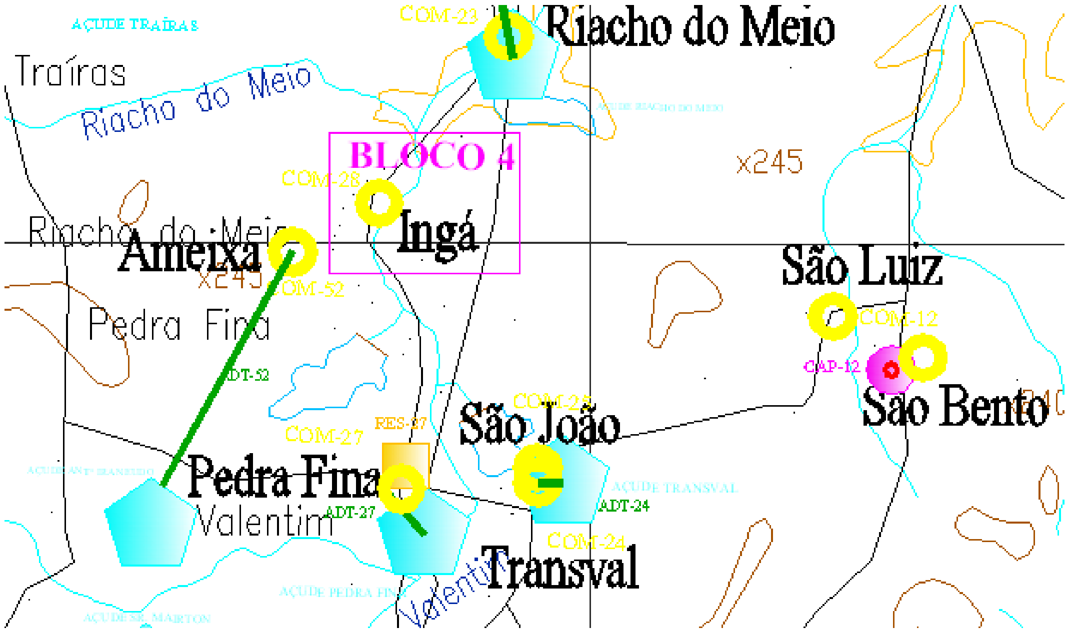


Figure 5.18: Location Map of Group 4 Communities - Ingá.

The community of Ingá consists of 13 households that did not have any type of water supply system. Only one home (Mrs. Dezinha's) had a rainwater cistern built under the 1 Million Cisterns Program P1MC.

The community of Ingá was selected for a Pilot Project to implement a public water supply system with funds from the Cooperation Agreement between the Columbia University/New York's Columbia Water Center and the Federal University of Ceará under the Project Sustainability and Water Safety: Designing Resilient Systems under Climate Stress, conducted by the Climate Risk Management and Water Sustainability Group of the Department of Hydraulic and Environmental Engineering of the Federal University of Ceará.

The project was implemented between January and August 2010 and included not only the community of Ingá but also the neighboring communities of Pedra Fina, São João, Transval and Valentim dos Sabinos. It provided an additional water supply network deriving from the system that was already operating in Pedra Fina, implemented by the São José Project in 2007/2008.

Figure 5.19 shows a schematic diagram of interventions performed in the community of Ingá by the UFC/Columbia Water Center Project.

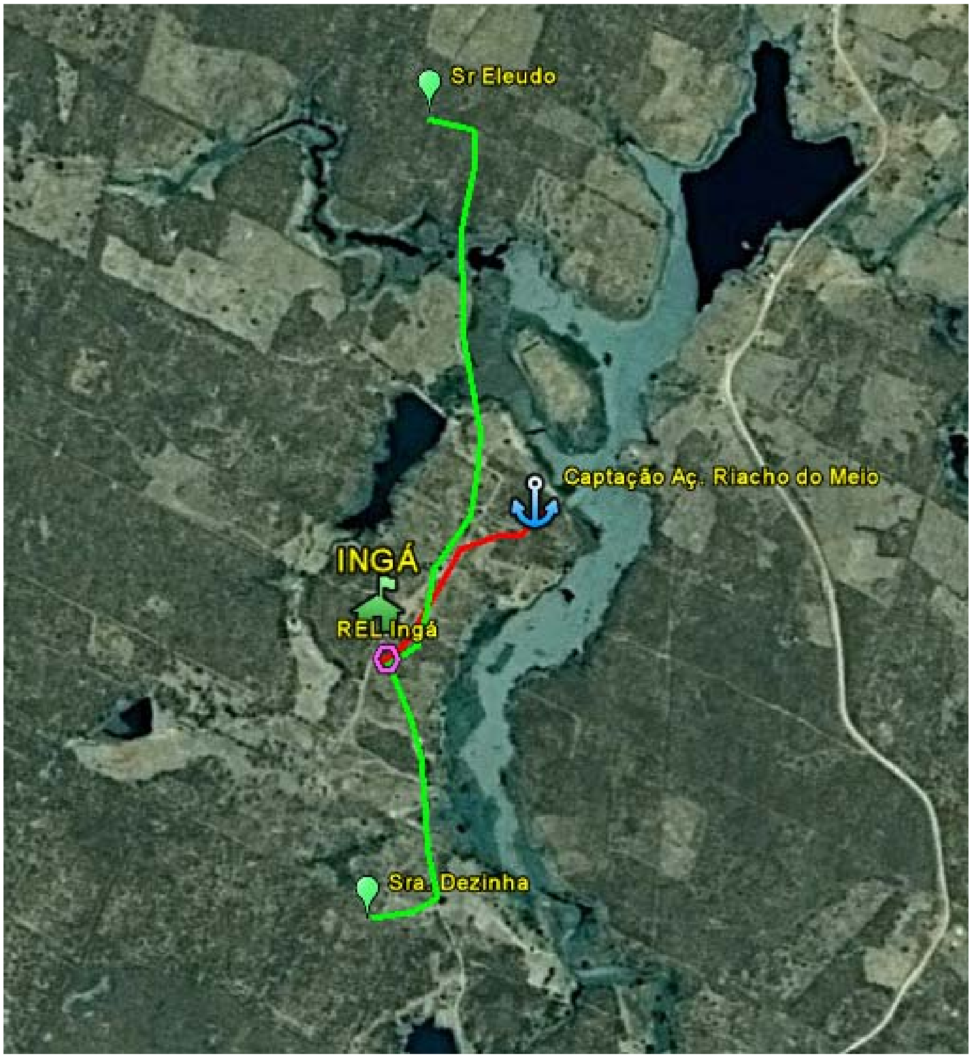


Figure 5.19: Schematic diagram of interventions performed in Ingá by the Columbia Water Center / Federal University of Ceará Project.

Construction works implemented in the communities of Ingá/Pedra Fina/São João/Transval and Valentim dos Sabinos included the following:

1. Construction and installation of **floating water collection in the Riacho do Meio reservoir**, in the community of Ingá. The floating device was located between 198 m level curves, approximately at coordinates E=478.975 and N=9.380.487, about 95 meters away from the transition box on the ground.

The floating device is made of fiberglass; make FC-12 HEMFIBRA, including a floating device and 50 mm DN PEADR pipe floaters extending across 95 meters, approximately.

The floating device was connected to a centrifugal pump set to pump a flow rate of 0.21 L/s or 0.76 m³/h, total manometric height of 30 mca and 0.5 HP.

The approximately 95-meter PEAD DN 50 mm piping was installed over floaters that were no more 5 meters apart.

Water collection works also included building a pump house, electrical panels and facilities for appropriate operation of the water collection system, including 5 KVA mounted distribution transformers according to technical requirements of utility company COELCE;

2. Construction of a **bulk water aqueduct** pump water to Ingá's elevated reservoir. This consists of a Class 12 (NBR 5647) PVC PBA pipe, DN 50 mm, approximately 385 meters long form the transition box at the collection site until Ingá's 12m³ Elevated Reservoir REL. This includes three suction boxes to install triple function DN 50mm PN 25 suction cups;
3. Construction of **Ingá's 12m³ elevated reservoir**, located at coordinates E= 478.579 and N= 9.380.245 at Mr. Chicão's house. The reservoir was built on land bestowed by him. It has a useful volume of 12 m³, an upper shaft of 6 meters and total height 10 meters, consisting of a reservoir built with 2-meter precast concrete rings;
4. Construction of **Ingá's water distribution network.** This consists of a set of DN 50mm PVC PBA CL-12 pipes and accessories, approximately 1,300 meters long, with metered connections to 13 homes in the community of Ingá;
5. Construction of an **additional water distribution network to the communities of Pedra Fina, São João, Valentim dos Sabinos and Transval**, consisting of a set of DN 50mm PVC PBA CL-12 pipes and accessories, approximately 1,630 meters long, with metered connections to 24 homes in the communities of Pedra Fina, São João and Transval.

The following figures show execution details of construction works in the communities of Ingá, Pedra Fina, São João, Transval and Valentim dos Sabinos.

Figure 5.20: A construction work sign with researchers and municipal authorities.

Figure 5.21: Ingá’s Elevated Reservoir at the painting stage.

Figure 5.22: Pump house at the collection site at Riacho do Meio reservoir.

Figure 5.23: Operating machinery at Ingá's water supply construction site.

Figure 5.24: Scraper truck digging a pipe ditch in Ingá.

The direct implementation cost of the water supply system in Ingá and complementing the distribution network in Pedra Fina totaled R$ 88,221.26. Considering only Ingá's system construction costs, this totaled R$ 65,485.39 and equals a cost per family of R$ 5,037.33.

5.2.5. GROUP 5

Group 5 consists of the communities of Cajueiros (three households) and Sítio Maré (nine households), totaling eleven families. Figure 5.25 shows the map with the location communities in this group.

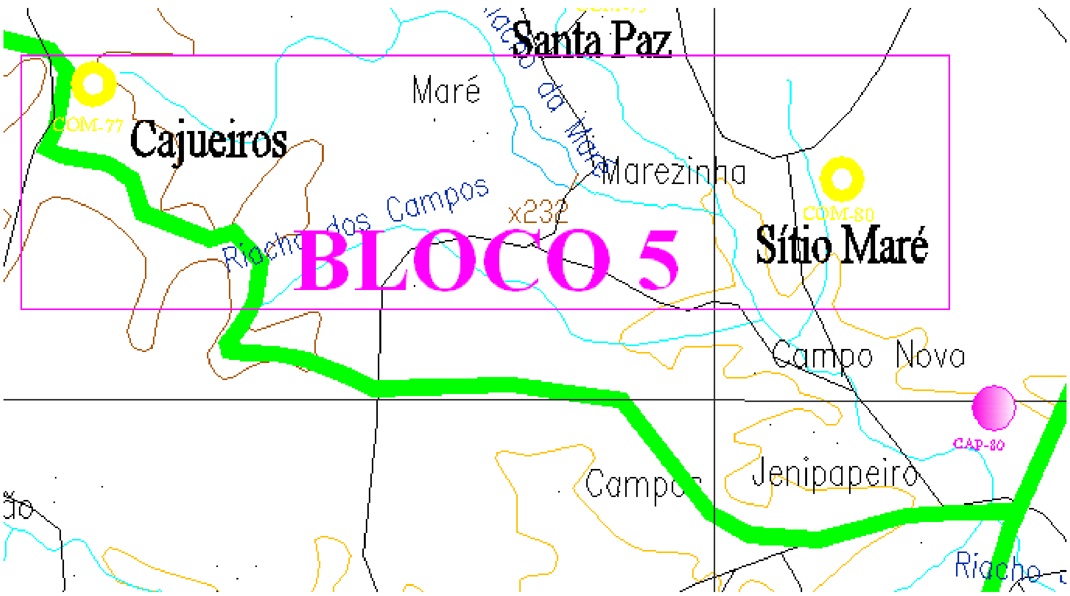


Figure 5.25: Location Map of Group 5 Communities.

5.2.5.1. Current Situation

Cajueiros

The small community of Cajueiros has only one rainwater cistern that may be seen on Figure 5.26. When there is no more rain families have no other alternative but to purchase water from water trucks at R$ 40.00/load of 7m^3. The community is located on a hill at the mouth of River Maré, at 261 meters.

Figure 5.26: Home with a cistern in the community of Cajueiros.

<u>Sítio Maré</u>

The community of Sítio Maré consists of eight families. Although homes have rainwater cisterns built under the P1MC since 2020, there have been two years when they did not fill up completely; the last time was in 2007. Figure 5.27 shows one of such cisterns in Mr. Josemiro Pinheiro's house; a hole appeared in it in 2007.

Figure 5.27: Rainwater cistern in Sítio Maré; it has leaked many times.

When there is no water in the cisterns people have to get water from an Amazon-type well located at coordinates E=481581 and N=9359560 using donkeys to carry it (Figure 5.28).

Figure 5.28: People from Sítio Maré use donkeys to carry water collected from the Amazon-type well.

The Amazon-type well has good quality water and apparently there is a large amount too since it is also used for local irrigation (Figure 5.29).

Figure 5.29: Diesel pump collecting water from the Amazon-type well for irrigation.

Figure 5.30: Water from the Amazon-type well in Sítio Maré.

5.2.5.2. Intervention Proposals

For the community of Cajueiros there is no feasible alternative but to build another two rainwater cisterns in the other homes which do not have one. Due to its higher level and distance to the nearest source of water, which is the Amazon-type well in Sítio Maré, it is impossible to provide water from this source to the community.

For Sítio Maré there is the feasible alternative to collect water from the Amazon-type well and take it through an 867-meter long 50 mm DN PVC pipe to an elevated reservoir which would be placed at coordinates E=480776 and N=9359814, from where water would be distributed by gravity to all households in the community. Figure 5.31 shows a Google Earth image of the proposed solution.

Figure 5.31: Google Earth image of the solution proposed for Group 5.

Table 5.8 shows a summary of units that make up the system and their estimated cost. The complete spreadsheet with the system's costs and size is presented attached.

Table 5.8: Summary of the Group 5 System - Amazon-type Well in Sítio Maré

UNIT	COST (R$)
8. Water collection	1.800,03
9. Treatment	0,0
10. Pumping Water Delivery	28.056,12
11. Gravity Water Delivery	7.313,36
12. Storage	22.063,49
13. Distribution Network	9.288,18
14. Building Connections	1.252,71
OVERALL TOTAL	69.773,89
COST PER FAMILY	8.721,74

The unit cost of this proposed system is therefore R$ 8,721.74/family.

For the community of Cajueiros another two rainwater cisterns would be built at a cost of R$ 4,709.72.

5.2.6. GROUP 6

Group 6 consists of a small community of three households with the suggestive name of Deus me Ajude [TN: God Help Me], which was set by a pioneering local family. When the ranch was later bought by Mr. Joaquim Filomeno Pinheiro it was rechristened to campo Novo and it became part of the community of the same name. The community has a rainwater cistern (Figure 5.32).

Figure 5.32: Rainwater cistern in the community of Deus me Ajude.

Figure 5.33 shows the map with the community's location.

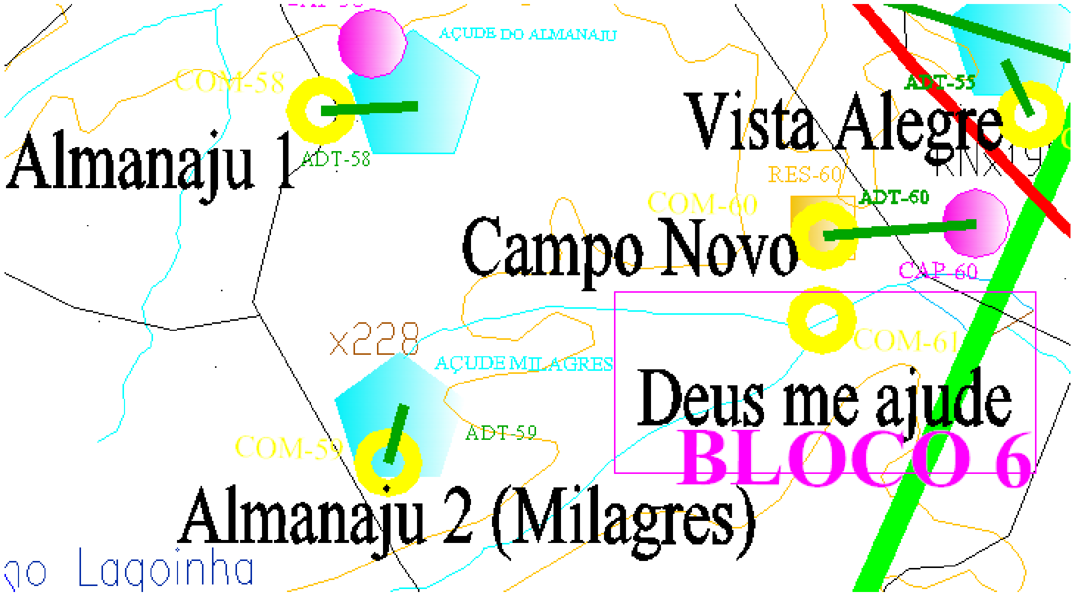


Figure 5.33: Location Map of Group 6 Communities.

For this community the only feasible solution is building two additional rainwater cisterns in homes that do not have one.

Table 5.9 shows the estimated costs for Group 6 communities.

Table 5.9: Summary of Group 6 Costs - Cisterns

COMMUNITY	COST (R$)
Deus me Ajude (two cisterns)	4.709,72
TOTAL	4.709,72

The cost of each individual cistern per family will be R$ 2,354.86 for a 16 m³ unit.

6. WATER BALANCE AND PROPOSAL FOR INTERVENTIONS AT THE MUNICIPAL SCALE

6.1. GLOBAL MUNICIPAL WATER BALANCE

The municipality of Milhã has 14,826 inhabitants according to IBGE's count (2009). Water consumption to supply this population, based on an estimated average flow rate for a 150 L/inhab/day consumption per capita would be:

$$Q_{med} = \frac{Pop \cdot q}{86400} = \frac{14826 \cdot 150}{86400} = 25{,}73\ l/s$$

Where: Q_{med} = average flow rate required by the population in liters/second;

Pop = number of inhabitants to be supplied;

q = consumption per capita in liters/inhabitant/day;

This demand should be supplied with a high level of guarantee; it is standard procedure to consider for human supply a 99% guaranteed reliable water supply to meet the population’s needs.

After conducting a *WATER BALANCE* of water supply provided by the main reservoirs in the municipality, as presented in Chapter 3 and summarized in Table 6.1, we can verify that the municipality of Milhã has a global water deficit, which is worsened by the fact that reservoirs are poorly distributed in relation to the population consumer centers.

Table 6.1: Summary of Water Supply in Milhã's Major Reservoirs

BASIN	RESERVOIR	CAPACITY (m^3)	MAXIMUM CONSTANT DISCHARGE (l/s)		
			99%	95%	90%
Valentim	Jatobá	1.070.000	4,75	7,92	10,21
Valentim	Riacho do Meio	986.484	2,53	5,20	6,97
Capitão Mor	Monte Sombrio	1.028.448	0,09	0,82	1,31
Capitaõ Mor	Lagoinha	1.966.396	0,82	1,83	2,50
Cabeça-de-Boi	Berilópolis	2.411.461	12,68	18,23	21,97
TOTAL		**7.462.789**	**20,87**	**34,00**	**42,96**

Table 6.1 shows that from the global point of view the flow rate required for human consumption in the municipality of Milhã only (25.73 L/s) is greater than the sum of maximum constant discharges by the main reservoirs with a guarantee of 99% (20.87 L/s).

However, the most serious problem is spatial distribution in relation to the population consumption center. The Berilópolis reservoir, which has the highest maximum constant discharge in the municipality, is 22.15 km away from the city center and its flow rate is already used to provide water to the surrounding communities (Açude Novo, Tabuleiro, Grossos), in addition to water use in dairy farming, which is the main source of income for the municipality.

It is urgently necessary to build new reservoirs strategically distributed across municipal land in order to meet water demands both for human supply and dairy farming, which is recognized as the municipality's main economic activity.

6.2. THE ISSUE OF PROVIDING WATER TO MILHÃ'S CITY CENTER

Water supply to Milhã, whose treated demand at Milhã's Water Treatment Station ETA is 40 m³/h (11.11 L/s), is currently provided by a combination of water sources. The first option is delivering water from the Monte Sombrio reservoir, damming a creek that has no official name and that flows into the Capitão Mor creek. The Monte Sombrio reservoir, which has a very low constant discharge capacity as we can see in Table 6.1, practically dries up every year and requires resorting to a second option.

The second option is delivering water from the Jatobá reservoir, damming the Jenipapeiro creek, which flows into the Valentim creek; the latter also has a low constant discharge capacity and there are management problems due to its location in private property.

When those two sources of water are not naturally replenished during the rainy season, then it is necessary to resort to the undesirable 3rd option, which is diverting water from the Banabuiú River into the Jatobá reservoir so it can be collected once again. This causes an unfavorable situation due to its high operational cost, since the aqueduct is 15 km long and requires the activation of two elevation stations whose installed power is 40 HP and 25 HP, with manometric heights of 40 mWC and 15 mWC.

There are other serious problems with the Banabuiú River aqueduct: the first relates to difficult maintenance, since the aqueduct travels across private properties. Whenever this happens, issues of undue diversion of flow and vandalism may arise. The second problem is the fact that it is difficult to manage water released from the Banabuiú at times of crises through the gallery of the Patu reservoir. Negotiation conditions with the respective basin committee to open the Patu's valve in order to keep water running though the Banabuiú are not always favorable. However, the biggest problem relates to the quality of water collected from the River Banabuiú after it has been released from the Patu reservoir. Released water travels on the borders of the town of Senador Pompeu and most of the latter's sewage is discharged into it; this water is later collected to supply Milhã. Although there is a Water Treatment Station (ETA) in Milhã, with two ascending flow Hemfibra filters and a gas chlorination system, there are no guarantees that pollution caught en route between Senador Pompeu and Milhã will be completely removed.

Without the problematic diversion of the River Banabuiú to the Jatobá reservoir, maximum constant discharge for the Jatobá and Monte Sombrio reservoirs only, to guarantee a **99%** reliability of water supply needs would total only **4.84 L/s**, while average discharge required by Milhã's city center is **11.11 L/s** *(40 m³/h)*; it is currently estimated to be at 13.02 L/s, with a suppressed demand of 1.90 L/s during treatment.

Figures show that maximum constant discharges for the Jatobá and Monte Sombrio reservoirs combined at a level which would guarantee **90%** reliability of water supply needs, totaling **11.52 L/s** (10.21 *L/s + 1.31* L/s), almost do not meet the average ETA demand of the city center. This means that every ten years the system would collapse in at least one of them. In fact, the actual current water supply system goes through periodical supply crises. This requires the Water Truck Operation to come to the city center, as in 1999 and 2002.

According to the *Technical, Environmental, Economic and Financial Feasibility Studies of the Capitão Mor Dam*, conducted by the State Secretariat for Water Resources of Ceará SRH-CE in 2003, the components of the Water Supply System to the center of Milhã are the following:

Water Source: ....01 - River Banabuiú (Made perennial by the Patu reservoir, which started operating in 1987), used as a 3rd option;

02 - Jenipapeiro Creek (Dammed by the private Jatobá reservoir, which dried up in 2001), used as a 2nd option;

03 - S/D/O Creek (Dammed by the Monte Sombrio reservoir, which dries up every year), used as the 1st option.

Catchment: ....01 - (River Banabuiu) - Stationary pumping station, with one backup (1+1);

02 - (Jatobá Reservoir) - Floating pumping station, one backup (1+1);

03 - (Monte Sombrio Reservoir) - Floating pumping station, one backup (1+1).

Bulk Water Aqueduct (water pumping): 01 - (River Banabuiu to Jatobá Reservoir) - 12 km + 3 km pipe (PVC), DN - 150 mm; + 2 km pipe gravity section (PVC), DN - 150 mm;

02 - (Jatobá Reservoir to Milhã's ETA) - 12 km pipe (FoFo), DN - 150 mm. Average state of preservation;

03 - (Monte Sombrio Reservoir to Milhã's ETA) - 0.5 km pipe (asbestos cement), DN - 150mm.

Treated Water Aqueduct (water pumping): (ETA - Milhã's City Center) - 4.00 km pipe (PVC), DN=150 mm.

Water Pumping Station

(catchment and pumping): ...01a - (River Banabuiu to Jatobá Reservoir) Stationary pumping station with an electric pump set (1+1) run by a 40 HP engine; Flow rate of $40m^3/h$; and manometric height of 40 m.c.a.

....01b - (River Banabuiu to Jatobá Reservoir) Stationary pumping station with an electric pump set (1+1) run by a 25 HP engine; Flow rate of $40m^3/h$; and manometric height of 15 m.c.a.

02 - (Jatobá Reservoir to Milhã's ETA) Floating pumping station with an electric pump set (1+1), run by a 15 HP engine; Flow rate of $29m^3/h$; and manometric height of 35 m.c.a.

03 - (Monte Sombrio Reservoir to Milhã's ETA) Floating pumping station with an electric pump set (1+1), run by a 15 HP engine; Flow rate of $45m^3/h$; and manometric height of 30 m.c.a.

(water pumping - treated water): (ETA to Milhã's City Center) Stationary pumping station with an electric pump set, run by a 15 HP engine and flow rate of $40m^3/h$.

Water Treatment

Station (**ETA**): .... Filtration (2 hemfibra filters) with ascending flow. Gas chlorination and addition of aluminum sulfate. Treatment capacity: 40m^3/h.

Storage: .... Elevated distribution reservoir with a volume of 180 m^3 at Milhã's entrance. 45 m^3 ground level reservoir at the ETA (Monte Sombrio).

Distribution: .... Network covers approximately 80% of the city, with 1,500 (94%) active house connections, 100 (6%) inactive house connections, totaling 1,600 (100%). 1,280 (80%) have meters. Water is distributed directly into households in the center of Milhã and the elevated distribution reservoir starts being filled only after homes have been fully supplied.

The solution to provide water to the municipality of Milhã and to its city center involves necessarily increasing water supply, both for human uses and to support the city's main economic activity, which is dairy farming.

Therefore, Milhã's Municipal Water Plan proposes water-related interventions by building new reservoirs, some of which have already been the subject of study in other programs designed to increase water supply, drafted both by the State Secretariat for Water Resources of Ceará (SRH-CE) and the National Department of Construction Works Against Droughts (DNOCS).

6.3. INTERVENTION PROPOSALS

6.3.1. CAPITÃO MOR RESERVOIR TO PROVIDE WATER TO MILHÃ, BARRA, BAIXA VERDE, CIPÓ AND MONTE GRAVE

The State Secretariat for Water Resources (SRH-CE) commissioned in 2002 *Technical, Environmental, Economic and Financial Feasibility Studies of the Capitão Mor Dam* under the Water Resource Management Pilot Program - PROGERIRH Pilot, which was drafted by the Consortium ANB/Hidroestudio and finished in February 2003.

The main goal of the Capitão Mor Dam would be to provide water to the municipality of Milhã, to the districts of Barra, Monte Grave, Baixa Verde and extensions to provide water to the communities of Cipó and Lagoa Nova, joined with Baixa Verde.

The reservoir would be built in Sítio Liberdade, a municipality 10 km east of Milhã's city center, toward Solonópole, with a dam at the following coordinates: Left Abutment, E=486.998 and N=9.367.845; Right Abutment, E=486.521 and N=9.367.767. Figure 6.1 shows the dam's location in the municipality.

The Capitão Mor reservoir would have a storage capacity of 5,335,000 m^3 (5.335 hm^3), flooding a hydrological basin of 219 ha. The spillway crest elevation was set at 183.5 so as not to affect highway BR-226, a concrete bridge with stringer beam levels at 185.00 m.

Maximum constant discharge flowing out of the Capitão Mor dam is shown in Table 6.2 and Figure 6.2.

Table 6.2: Maximum Constant Discharge Flowing out of the Capitão Mor Reservoir

GUARANTEE (%)	MAXIMUM CONSTANT DISCHARGE (m^3/h)	MAXIMUM CONSTANT DISCHARGE (*L/s*)	MAXIMUM CONSTANT DISCHARGE (m^3/h)
100,00	1,45488	46,13	166,08
99,00	1,60044	50,74	182,69
95,00	2,17992	69,12	248,84
90,00	2,92248	92,67	333,61
85,00	3,56304	112,98	406,73

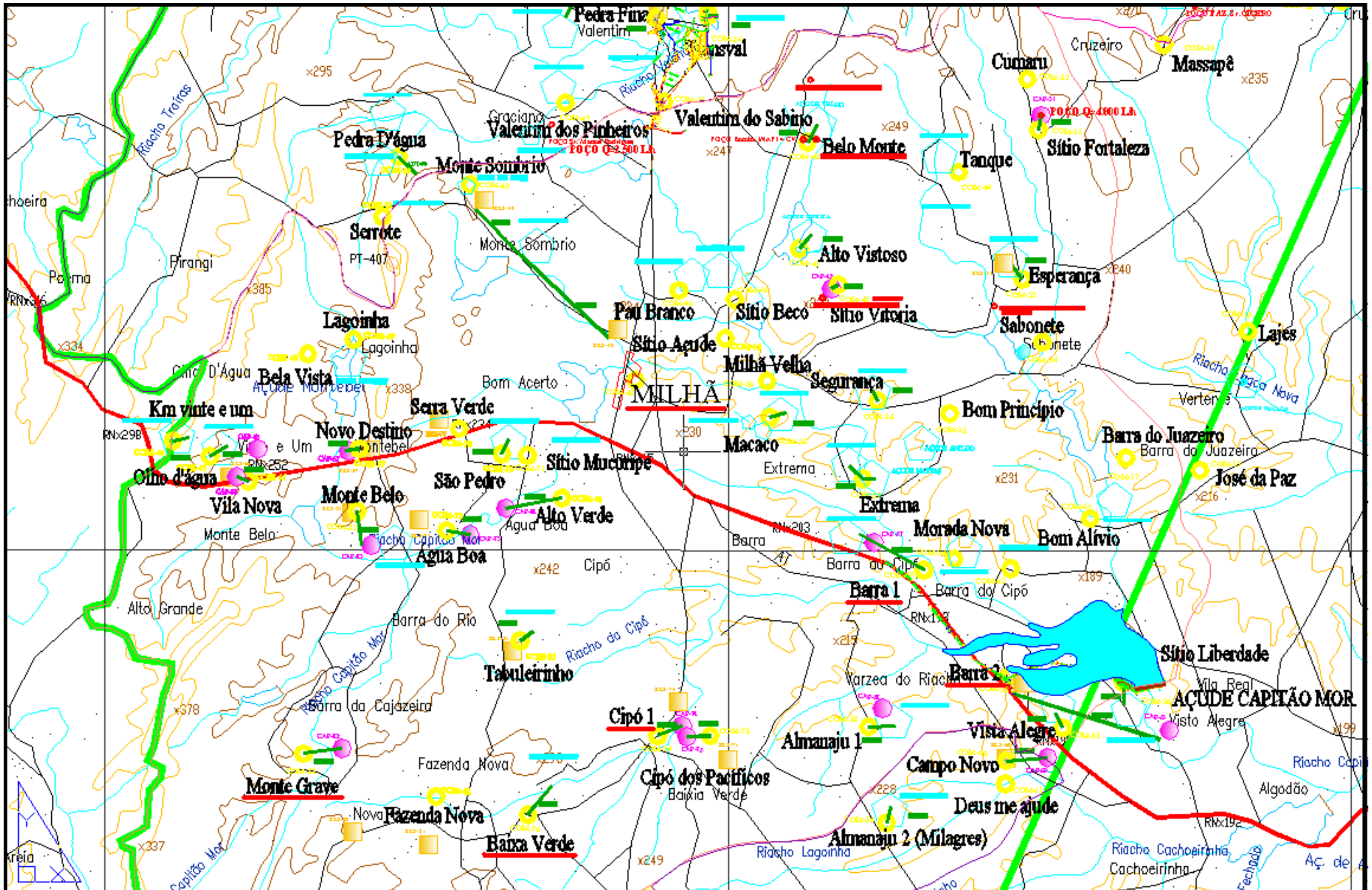


Figura 6.1: Localização do Açude Capitão Mor em relação à Sede de Milhã e Distritos de Monte Grave, Barra, Baixa Verde e comunidade Cipó

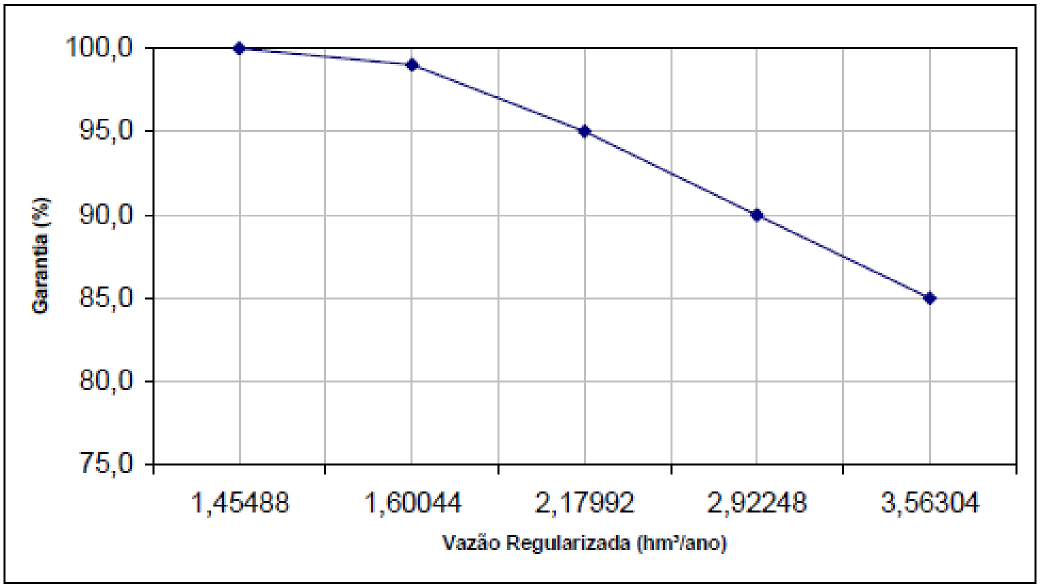


Figure 6.2: Maximum Constant Discharge at the Capitão Mor Reservoir (Source: SRH,2003)

When comparing data from Table 6.2 with 6.1 we notice that the Capitão Mor dam alone would be responsible for increasing water supply by 143% to a level of 99% guaranteed reliable water supply and 115% for a level of 90% guaranteed reliable water supply in relation the sum of water availability provided by the main reservoirs in the municipality.

The strategic location of Capitão Mor reservoir allows it to achieve maximum performance providing water to meet municipal demands, since it will be able to both meet the city center demands and that of the main districts in its hydrographic basin. It would also provide water to at least another 12 rural surrounding communities through integrated delivery and supply projects.

The Technical Specifications for the Capitão Mor reservoir are as follows:

CAPITÃO-MOR DAM

TECHNICAL SPECIFICATIONS

Name .... Capitão-Mor Dam;

Hydrological Basin Area .... 219 ha;

Reservoir Capacity (Level - 183.50 m) .... 5.335 x 106m³;

Dam

Type .... Earth-fill dam;

Maximum height .... 17.0 m;

Crest length .... 430 m;

Crest level .... 186.10 m;

Spillway

Type .... Channel excavated into rock (CCR with "Creager" profile);

Width .... 150 m;

Sill level .... 183 m;

Project Discharge (TR = 1,000 years) 536.49 m3/s

Project Discharge (TR = 10,000 years) 651.07 m3/s

Water Intake

Type .... Gallery with upstream and downstream control;

Dimensions .... 0.30 m x 0.30 m and 300 mm;

Length .... 45 m;

Constant discharge (Q90% guarantee) 0.093 m3/s

Aqueduct

Names .... MILHÃ AND MONTE GRAVE AQUEDUCTS;

Goals .... To provide water to urban populations in the municipalities of Milhã, Monte Grave and scattered communities;

Location .... Municipality of Milhã (CE);

Length .... 10,816 m (Milhã) and 7.740 (Monte Grave);

Pipe diameter .... 200 mm (Milhã) and 100 mm (Monte Grave);

Service pressure .... 200 m.c.a. (Milhã) and 100 m.c.a. (Monte Grave);

Difference in geometric levels................................ 143.50 m (Milhã) and 40.50m (Monte Grave);

Project flow rate .... 23.81 l/s (Milhã) and 2.41 l/s (Monte Grave);

Water source .... Capitão-Mor Reservoir;

Water Catchment Construction Work (Floating)

- Number of elevated sets .... 1 + 1 backup;
- Maximum flow rate per set .... 2.057 m³/day;
- Suction barrel diameter .... 200 mm;
- Diameter of water pumping barrel .... 200 mm;
- Maximum operational level .... Spill level = 183.50 m;
- Minimum operational level .... Alert level = 179 m;

Bulk Water Elevated Station

- Number of sets ……….. 1 + 1 backup;
- Flow rate per set 85.716 m3/h
- Estimated manometric height .... 30 mca;
- Power per set .... 15.87 HP;

Water Treatment Plant

- Flow rate ….. 90 m3/h;
- Loading chamber height .... 7.0 m;
- Loading chamber diameter .... 1.0 m;
- Ascending filter diameter .... 2.0 m;
- Ascending filter total height .... 3.5 m;
- Treated water ground level reservoir capacity 20 m3;

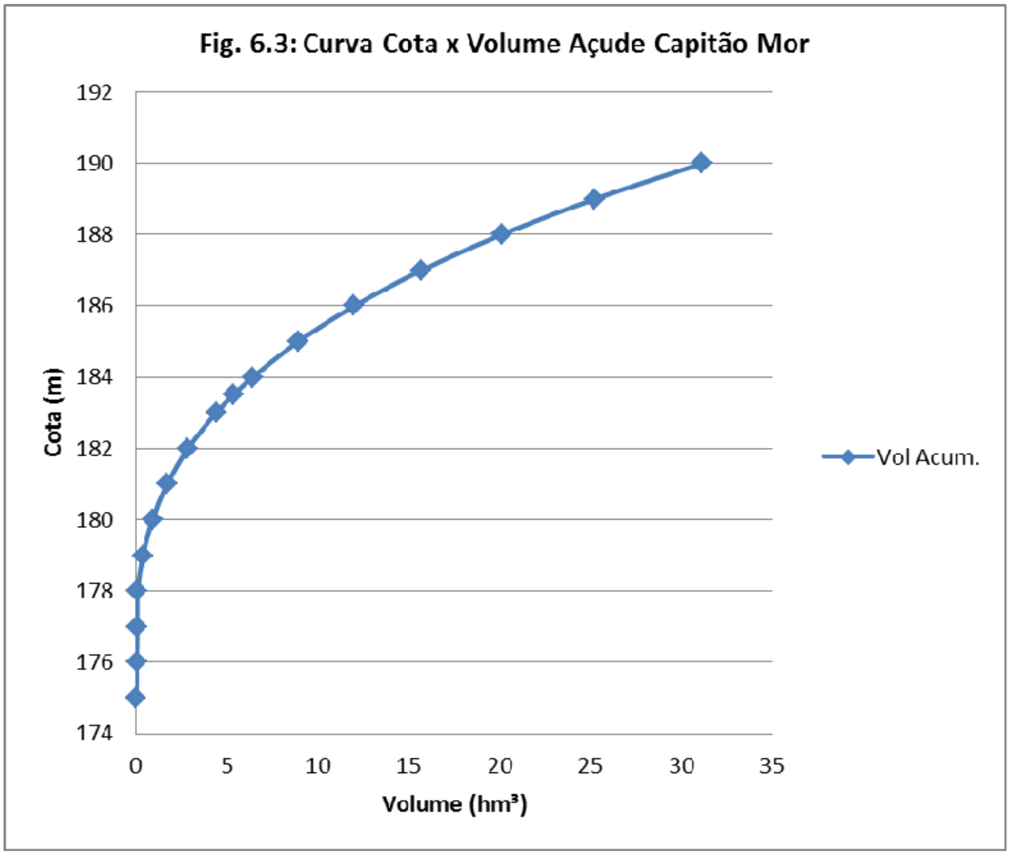
Treated water pumping station

- Electrical pump sets .... 1 + 1 (backup);
- Flow rate per set .... 85.716 m³/h (Milhã) and 8.676 m³/h (Monte Grave);
- Total manometric height .... 75.51 mWC (Milhã) and 50.14 mWC (Monte Grave);
- Power per set .... 34.20 HP (Milhã) and 2.30 HP (Monte Grave);

Storage

- Location .... Municipality of Milhã (CE);
- Capacity.. 686 m³ (Milhã) and 69m³ (Monte Grave).

Figure 6.3 shows the level x volume curve of Capitão Mor Reservoir.



The conclusions and recommendations of the dam's environmental impact studies set out in the Feasibility Studies drafted by SRH-CE are worthy of attention:

"Our work aimed at analyzing the environmental feasibility of the Capitão-Mor Dam project. The results we found are important to the extent that they allow visualizing that the implementation of this construction work is associated with a number of negative changes to the quality of the environment; however, this situation may be mitigated or even solved with the implementation of environmental protection measures by the building agency.

Therefore, the conclusion is that by adopting such measures the project becomes advisable, with a significant beneficial nature for the socioeconomic environmental and a level of adversity that is perfectly tolerable with respect to the natural environment.

An examination of economic effects of the project reveals that the opportunity cost of the area to be flooded is low, since only about 10% of the total property area is used for *agriculture, due to the limitations imposed by scarce water resources and by unfavorable edaphic conditions.*

On the other hand, the use of water resources from the reservoir will support the existing water supply system in Milhã (human and industrial supply) and of communities of Monte Grave, Baixa Verde, Barra, Barra do Cipó, Segurança, Extrema and Cipó, as well as downstream riverbank communities. Keeping the Capitão-Mor Creek perennial will also contribute to the development of diffuse irrigation and to animal watering. There is also the development of fishing in the lake that will be formed.

As for the number of people to be relocated, it is not very significant, totaling five families, most of which may be resettled in remaining areas of those properties. Resettlement alternatives must be analyzed for families whose properties will be totally underwater, including their moving to nearby urban areas or financial compensation, always according to the requests of the target population. The resettlement project should include a program to reactivate local economy, since the population's production activities will be affected. Its scope should also provide for the sanitary aspect in the construction of new homes for resettling families.

Another important aspect is the fact that the reservoir has no irrigated areas located in its rear section; currently there is practically no risk of pollution from agrotoxic products reaching dammed water. As for the risk of pollution from sanitary and industrial effluents reaching dammed water, there is the city of Milhã within the basin that flows into the future reservoir; it is 6.5 km away from its hydrological basin. However, it should be noted that a sanitary drainage system has already been designed for this urban center and funds to implement the construction works are in the final clearing stages. (project already executed, our note)

It should also be noted that the reservoir does not have saline soils in its contributing basin; in addition to a low detention time, this decreases the risk of dammed water becoming saline and therefore this issue need not be considered during the reservoir operation stage.

As for archeological and paleontological heritage, since the Middle Jaguaribe region is regarded by authorities as relatively wealthy with respect to this type of heritage, it is necessary to develop detailed studies in this area before commencement of construction works.

The costs of the Capitão Mor dam have been estimated based on September 2002 prices and the updated amounts are shown in Table 6.3 according to IPCA variations between Sep/2002 to Sep/2009, at 52.98%.

Table 6.3: Implementation Costs - Capitão Mor Reservoir and Aqueducts

CONSTRUCTION WORK	IMPLEMENTATION COST (Sep/2002)	IMPLEMENTATION COST (Sep/2009)
Capitão-Mor Reservoir	5.166.610,00	7.903.879,98
Milhã and Monte Grave	2.580.080,37	3.947.006,95

Aqueducts		
TOTAL	**7.746.690,37**	**11.850.886,93**

The updated cost would be R$ 7,903,879.98 to build the Capitão Mor Reservoir and R$ 3,947,006.95 to build the Milhã and Monte Grave aqueducts, with a total cost of R$ 11,850,886.93 for the entire system.

The economic feasibility study for the Capitão Mor dam reached the following conclusions, taken from the SRH-CE Project:

"Based on this information the SIMOP (Annex II) model was run; we found a positive current net amount of R$ 348,331 at a discount rate of 12% per annum, and an internal rate of return of 12.73%, which is above the minimum rate (12%) required by the IDB.

The IRR of 12.73%, although already demonstrating the project's economic profitability, since it is above the minimum rate required by the IDB, could still achieve even more favorable indicators since other types of benefits that accompany sanitation projects have not been incorporated into the economic flow, such as reductions in morbidity and mortality rates caused by water-related diseases; improvements in habits and behaviors of beneficiaries, with respect to the use of water and its final disposal; and promotion of economic, social and intellectual development of communities through improved sanitary conditions.

Table 1.18 shows a summary of the current values of benefits and costs (investments and O&M) and profitability indicators for the Capitão-Mor Dam and Milhã and Monte Grave Aqueducts Project".

Table 6.4 shows the economic assessment indicators mentioned in the text as Table 1.18 as presented in the dam Feasibility Studies.

Table 6.4: Economic Assessment Indicators of the Capitão Mor Dam

ITEM	RESULTS
BENEFITS (R$)	6.257.104,00
COSTS (R$)	5.908.773,00
Recurring	525.995,00
Non-recurring	5.129.988,00
Variable	252.790,00
CURRENT NET VALUE (R$)	348.331,00
INTERNAL RATE OF RETURN (%)	**12,73**

The conclusion is that the Capitão Mor dam project is technically, socially, environmentally and economically feasible according to the norms required by international supporting and development institutions and it represents the most important water-related intervention for the municipality of Milhã.

6.3.2. LAGOA NOVA RESERVOIR TO PROVIDE WATER TO CARNAUBINHA

The Lagoa Nova reservoir has a storage capacity of 3,000,000 m^3; it is a DNOCS project dating back to October 1992, developed by the company VBA Consultores. The Lagoa Nova reservoir was planned aiming primarily at providing water for human consumption within the district of Carnaubinha, the largest in Milhã, since this district has no sustainable source of water.

Carnaubinha is the largest District in the municipality of Milhã. According to our PAM diagnosis, the number of house connections in the district totals 300, with a total population of approximately 1,500 inhabitants. This is consistent with data obtained in the Feasibility Study for the Treatment and Disposal of Solid Waste in the State of Ceará, conducted by PROINTEC consultants for the SECRETARIAT FOR CITIES OF THE STATE OF CEARÁ in 2006/2007, which estimated the population of Canaubinha to total approximately 1,200 inhabitants. However, 2007 data from the Brazilian Army estimates a total of **1,750** people being served by the Water Truck Supply Program.

Urban water supply to the district is provided by an aqueduct coming from the Quandu reservoir (E= 481.087 N = 9.384.508). There is a catchment system in the Quandu reservoir and a treatment system with the following units: Floating water catchment; ground level reservoir; Chlorination, Pumping to an aqueduct; Aqueduct; Elevated reservoir and Gravity distribution. The flow rate of treated water coming out of Carnaubinha's Water Treatment Station ETA is 52 m^3/h or 14.44 L/s, which seems to overestimate the district's real needs.

According to local reports obtained for the Diagnosis, the Quandu reservoir had never reached its full capacity in the past; however, in 2009 it did and locals estimate that the reservoir has a water reserve for the next two years. In 2007 the Quandu reservoir dried up completely and it was necessary to have water trucks supply the local population.

The treatment system was launched in 1993, but the current aqueduct started operating in 1997. Figure 6.4 shows Carnaubinha's Water Treatment Station - ETA.

Figure 6.4: Carnaubinha's Water Treatment Station.

Water is filtered and treated with chlorine. There is a 300-meter long 75 mm RPVC aqueduct collecting water to the ETA and a 2,500-meter long 85 mm (3") PVC aqueduct. Figure 6.5 shows the district's elevated reservoir.

Figure 6.5: Elevated reservoir of the District of Carnaubinha. Vol= 55 m³.

As mentioned above, the district of Carnaubinha required water trucks to provide water in 2007. Table 6.5 shown in the Diagnosis provides the details of the Water Truck Operation in the district.

Table 6.5: Water Truck Supply in the District of Carnaubinha in 2007.

ROUTE	# 5	# 6
# OF PEOPLE SUPPLIED	650	1100
NECESSARY VOLUME OF WATER (m^3)	390	660
DISTANCE ON PAVED ROADS (km)	7	7
DISTANCE ON UNPAVED ROADS (km)	20	20
NUMBER OF WATER LOADS	56	94
MONTHLY DISTANCE ON PAVED ROADS (km)	392	658
MONTHLY DISTANCE ON UNPAVED ROADS (km)	1120	1880
TRANSPORTATION COSTS PER WEIGHT (m^3 x km)	10530	17820
MONTHLY COST (R$)	4.368,00	7.392,00
PERSON RESPONSIBLE FOR RECEIVING LOAD	ROBERTO	ROBERTO
SOURCE OF SUPPLY	LAGOINHA RESERVOIR	LAGOINHA RESERVOIR

Water supply will only be guaranteed to Carnaubinha when a reservoir is built with enough capacity and that is located as close as possible to the district.

Such conditions are met by the Lagoa Nova dam, located 3 km upstream according to the location map shown in Figure 6.6. The Lagoa Nova dam is located at coordinates: Left Abutment, E=482.400 and N=9.382.600; Right Abutment, E=482.800 and N=9.382.500.

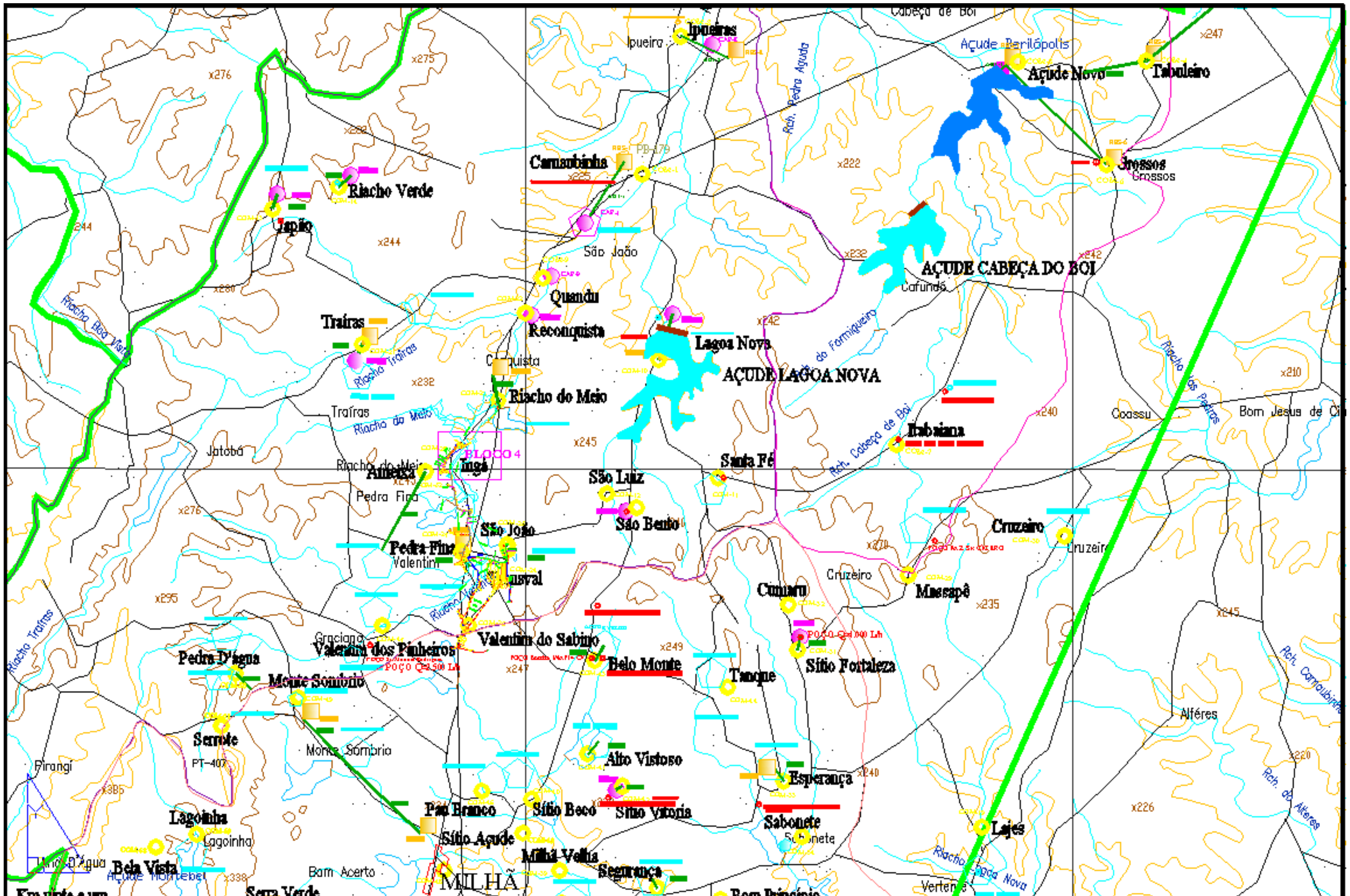


Figura 6.6: Mapa de Localização da Barragem Lagoa Nova e o Distrito de Carnaubinha

The basic units of the Lagoa Nova Dam are the following:

• Homogeneous earth-fill dam, with a maximum height of 14.54 m above the natural ground, and crest 6 meters wide and 310 meters long.

• Spillway on the right abutment, consisting of a channel dug on soil and rock, 40 meters wide;

• Simple water intake, circular, with a 200 mm diameter tube, placed on a simple concrete base and covered with reinforced concrete. Water intake is controlled downstream where there are two valves inside a meter box, which also works as stilling tank. The following are the TECHNICAL SPECIFICATIONS for the Lagoa Nova dam:

- Storage capacity at the spillway crest elevation (CAV level - 98.30, which should be added to the difference in levels Δ=99.445, transported from an IBGE survey marker, to correspond to the real geodesic level of 197.745 m); 3,000,000 m^3 (3 hm^3);
- Hydrographic basin: 16 Km^2;
- Hydrological basin: 64 ha;
- Maximum flood level, at 100.04 m (199.485 m, IBGE): 14.54 m;
- Length by crest: 310 m;
- Spillway width: 40 m
- Average influent surface runoff, calculated using MODHAC: 111.22 mm;
- Average annual influent discharge: 1.779 hm^3/year (MODHAC);
- Type of dam: Homogeneous earth;
- Type of water intake: 200 mm DN, with downstream control.

Other important hydrological information regarding the Lagoa Nova reservoir:

- Basin area: 16 Km^2;
- Perimeter: 15 Km;
- Longest thalweg length: 4.06 Km;
- Compactness index: 1,05;
- Shape factor: 0,97;
- Specific unevenness: 14.12 m;
- Concentration Time: 1.72 hours
- Reservoir shape factor: α = 1.957.44
- Dimensionless evaporation factor: f_E = 0.318
- Average evaporated water depth during dry season (Jun/Jan): E_L = 1027 mm

- Centennial precipitation (TR= 100 years): 103.57 mm
- Effective centennial precipitation (TR= 100 years): 37 mm
- Millennial precipitation (TR= 1000 years): 136.54 mm
- Effective millennial precipitation (TR= 1000 years): 61 mm
- Centennial peak flow rate: 82.27 m³/s
- Millennial peak flow rate: 135.63 m³/s
- Maximum centennial depth: 0.54 m;
- Maximum millennial depth: 0.84 m;
- Clearance above maximum high water: 1.20 m;
- Free board during centennial flood: 1.74 m;
- Spillway crest elevation: 98.30 m (98.30 + 99.445 = 197.745 m)
- Spillway width: 40 m
- Crest level: 100.04 m (100.04 + 99.445 = 199.485 m)
- Clearance above maximum water level during millennial flood: 0.90 m

The maximum constant discharge through the Lagoa Nova Reservoir is shown in Table 6.6:

Table 6.6: Maximum constant discharge through the Lagoa Nova Reservoir

GUARANTEE (%)	MAXIMUM CONSTANT DISCHARGE (hm³/year)	MAXIMUM CONSTANT DISCHARGE (*L/s*)	MAXIMUM CONSTANT DISCHARGE (m³/h)
95,00	0,52	16,489	59,36
90,00	0,63	19,977	71,92

As shown in Table 6.6, the maximum constant discharge through the Lagoa Nova Reservoir with 95% guaranteed reliable water supply is 59.36 m³/h, which is enough to provide water to Carnaubinha's ETA with one estimated failure every 20 years.

No environmental studies or economic analyses have been performed for the Lagoa Nova Dam, since such requirements were considered in studies and projects drafted by DNOCS at that time.

The Lagoa Nova dam implementation costs, updated by the DNOCS Studies and Projects Coordinator's Office for August 2007, according to memorandum MEM # 21/CEST-CE/SC/GAB dated August 5 2008, total **R$ 1,317,650.15**.

No studies have been conducted by DNOCS for the Carnaubinha aqueduct coming out of the Lagoa Nova reservoir.

In this PAM we estimated the size of the aqueduct that would transport water from the Nova reservoir to Carnaubinha’s ETA; it would be approximately 3,821 meters long with a 100 mm DN pipe, taking a flow rate of 6.25 L/s or 22.5 m³/h, calculated for 12 daily pumping hours; this would result in a total manometric height of 75.21 mWC and an adopted 20 HP.

The cost of this aqueduct would total **R$ 403,572.50.** Therefore, the total cost of interventions to build the Lagoa Nova dam and its aqueduct to Carnaubinha would be **R$ 1,721,222.65**.

6.3.3. OTHER SUGGESTED INTERVENTIONS

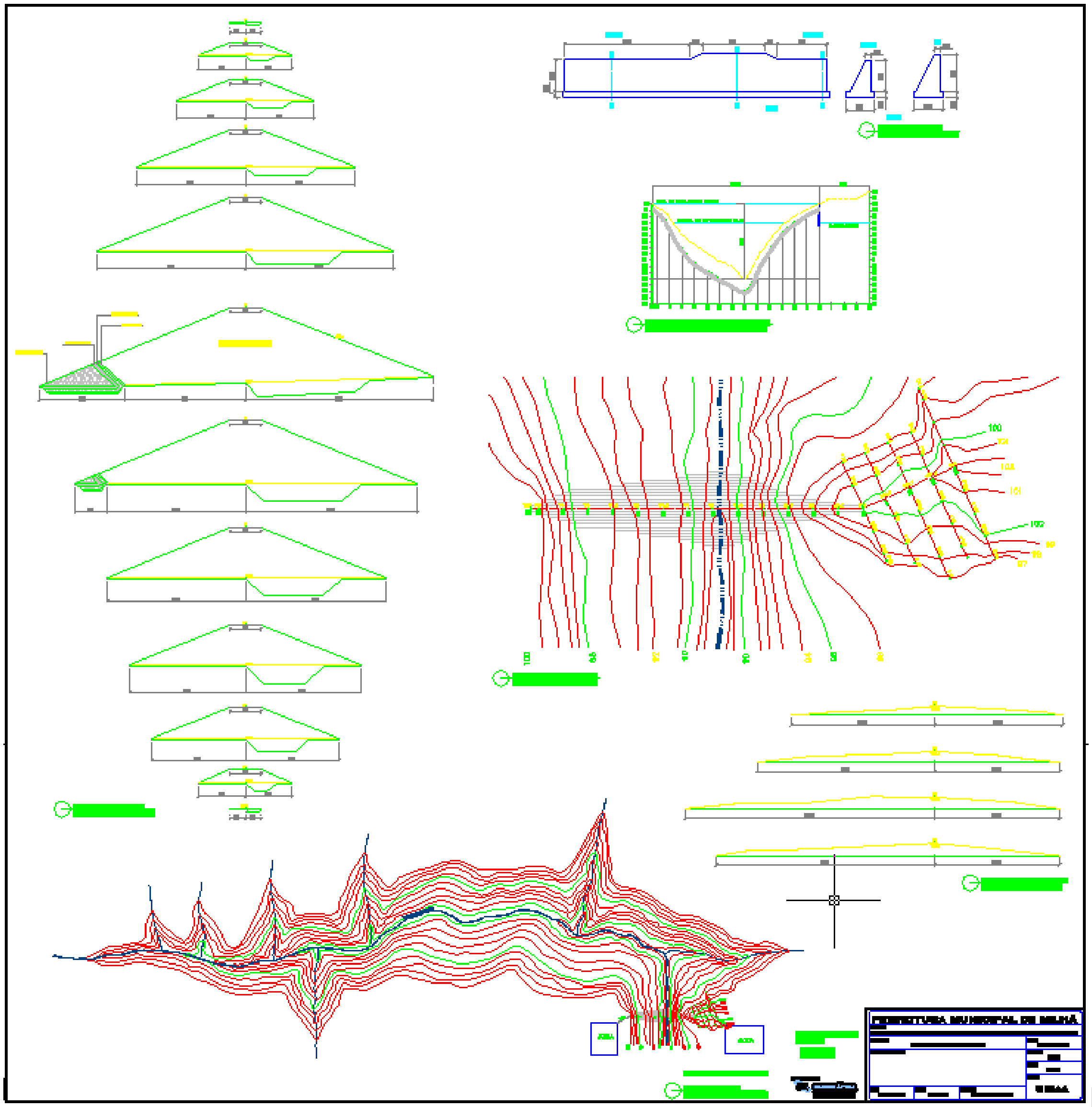
Expanding water supply in the municipality of Milhã also includes, as suggestions, the following construction works:

• Construction of the **Cabeça-de-Boi** reservoir in the basin of the Cabeça-de-Boi creek. It would consist of a 3,200,000 m³ dam whose pre-feasibility has been studied by Milhã’s Municipal Government. The dam would be 12 meters high, with 9 meters of useful height to store water; its crest length would be 266 meters and it would be located between the proposed Lagoa Nova reservoir and the Berilópolis reservoir. The location of the Cabeça-de-Boi reservoir can also be observed in Figure 6.6. Figure 6.7 shows the preliminary project for the Cabeça-de-Boi reservoir.

This reservoir would provide water to the communities of Cabeça-de-Boi (Alto Santo), in Cafundó, and Itabaiana, with a total of 368 people, in addition to providing enough water for irrigation and cattle farming. The estimated cost of the Cabeça-de-Boi dam is **R$ 2,100,000.00**;

• Expansion of the Tabuleiro reservoir to 1.2 hm^3. There has been no access to the project;

• Expansion of the Jatobá reservoir, which may be elevated by 2 meters, expanding its storage capacity from 1,070,000 m^3 to 1,790,000 m^3, according to the level x area x volume curve provided by COGERH, shown in Figure 3.3 in Chapter 3. There is no available information about the cost of this intervention.



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igure 6.7: Preliminary Project for the Cabeça-de-Boi reservoir (SOURCE: Milhã's Municipal Government)

7. CONSOLIDATION OF COSTS AND RANKING OF PROPOSED INTERVENTIONS

7.1 CONSOLIDATED COSTS

The interventions proposed in this Municipal Water Plan - PAM for the municipality of Milhã-CE were presented in chapters 5 and 6. The first lists interventions at a local scale/community level and the second lists larger construction works, especially dams that would form new strategic reservoirs to provide water to the municipal center and its main districts.

Table 7.1 shows information from Table 5.1, summarizing interventions proposed for the local scale. Table 7.2 summarizes interventions proposed at the municipal and regional levels.

Table 7.1: A Summary of Interventions at the Local Level.

GROUP/ SUBGROUP	COMMUNITY	NUMBER OF HOUSEHOLDS	POPULATION	ESTIMATED COST (R$)	COST PER FAMILY (R$/fam.)
1 / 1.1	Barra do Juazeiro	10	50	220,875.85	6,902.37
	José de Paz	3	15		
	Cruzeiro	5	25		
	Bom Alívio	14	70		
1 /1,1	Lajes	6	30	14,129.16	2,354.86
1 /1,2	Esperança	16	80	94,432.82	3,777.31
	Sabonete	9	45		
1 /1,3	Bom Princípio	9	45	77,657.01	8,628.56
2	Pedra d'Água	19	95	146,927.56	5,247.41
	Serrote	9	45		
3	Massapê	7(3)	15	7,064.58	2,354.86
	Cruzeiro	11(6)	30	14,129.16	2,354.86
4	Ingá	13	65	65,485.39*	5,037.33
5	Sítio Maré	8	40	69,773.89	8,721.74
	Cajueiros	3	15	4,709.72	2,354.86
6	Deus Me Ajude	3	15	7,064.58	2,354.86
	TOTAL	136	680	722,249.72	5,310.65

(*): System already deployed by UFC/Columbia Water Center

Table 7.2: A Summary of Interventions at the Municipal Level,

INTERVENTION	GOAL	COST (R$)
Construction of the Capitão Mor Reservoir	Providing water to the center of Milhã, to the districts of Barra, Baixa Verde, Cipó and Monte Grave and other 12 communities	**7,903,879,98**
Capitão Mor Aqueduct	Same as above	**3,947,006,95**
Construction of the Lagoa Nova Reservoir	Providing water to the district of Carnaubinha (the largest in Milhã)	**1,317,650,15**
Lagoa Nova Aqueduct	Same as above	**403,572,50**
Construction of the Cabeça-de-Boi Reservoir	Providing water to the communities of Alto Santo (Cabeça-de-boi), Cafundó and Itabaiana	**2,100,000,00**
TOTAL		**15,672,109,58**

The total cost of interventions presented in table 7,1 should be deducted from the amount corresponding to construction works to provide water to the community of Ingá, in the amount of R$ 65,485,39, since the water supply system for this community has already been built and includes a complement to the distribution network of the Pedra Fina System, all under the cooperation agreement between the Federal University of Ceará / Columbia Water Center, totaling R$ 88,221,26,

Therefore, the cost of universalizing water supply at the local level to provide water to communities that have no access to it would total **R$ 656,764,33,**

On the other hand, the total cost to expand water supply at the municipal level and guarantee water supply both in terms of quantity and quality for the municipal center and districts of Milhã would total **R$ 15,672,109,58**, according to Table 7,2,

The total cost of interventions at both levels would be **R$ 16,328,873,91,**

7.2 RANKING OF PROPOSED INTERVENTIONS

The ranking proposed here within the scope of the PAM to universalize water supply services (access to water) provided to rural communities takes into account: economic factors, such as lower implementation costs and lower costs per family; technical factors, such as availability of water sources that can meet the demands; and social factors, such as how difficult it is for some communities to have access to water when compared to others,

Considering and weighing those factors, we suggest the following steps for implementing water supply systems listed in Chapter 5 and summarized in Table 7.1:

#1 - Implementing a water supply system for the communities of Barra do Juazeiro, José de Paz, Cruzeiro and Bom Alívio from the Rosiê Coringa reservoir, whose project has already been finished and approved under the São José Project under entry number 07177688-5, filed on Sep 19 2007;

#2 - Implementing a water supply system for Esperança and Sabonete from the João Vieira reservoir in the community of Esperança;

#3 - Building cisterns to provide water in the following communities:

- Lajes (6 cisterns)

- Massapê (3 cisterns)

- Cruzeiro (6 cisterns)

- Cajueiros (2 cisterns)

- Deus me Ajude (3 cisterns)

#4 - Implementing the water supply system of Sítio Maré, from the Amazon-type well close to Mr, Josemiro Pinheiro's property, at coordinates

E= 481581 and N= 9359560;

#5 - Implementing the water supply system of Bom Princípio, from the deep well located in Mr, Francisco das Chagas de Almeida's property, at coordinates E=483394 and N=9371774;

#6 - Implementing the integrated water supply system of Pedra Fina and Serrote, from the Herdeiros reservoir,

With respect to interventions at the municipal level with favorable impacts across the entire municipality, above all the center and main districts, we see as a priority building the Capitão Mor reservoir and its water supply aqueduct do the city center and districts of Barra, Monte Grave and communities of Baixa Verde, Cipó and 12 other neighboring communities, including Barra do Juazeiro and others included in the first suggested local intervention system,

After the Capitão Mor reservoir is built, we would suggest building the Lagoa Nova dam to provide water to the district of Carnaubinha, the most densely populated in the municipality,

8. MANAGEMENT OF WATER SUPPLY SYSTEMS IN SCATTERED RURAL POPULATIONS

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Introduction

Under the Millennium Goals (Millennium Development Goals – MDGs) defined in the 2000 United Nations Summit, a commitment was made to “reduce by half the proportion of the population without sustainable access to potable water and basic sanitation” (United Nations, 2010).

With regard to the supply of potable water, the biggest challenge has been to bring water to rural homes reducing the gap between the supply provided to urban and rural populations. The worst disparity in global terms can be verified in Oceania and Sub-Saharan Africa. However, there is still a significant difference in access to potable water between urban and rural areas in Latin America and the Caribbean and Western Asia. In global terms, eight in every ten people who live in rural areas have difficult access to potable water.

This text is based on the experience gathered by the authors with respect to water supply provided to scattered rural populations in the semi-arid region in Northeast Brazil, more specifically in the *sertão central* of the state of Ceará, in the area that includes the municipalities of Milhã, Senador Pompeu, Deputado Irapuan Pinheiro, Quixeramobim and Solonópole. These municipalities were included in the area covered by the research project about water supply and sustainability for rural communities developed by the Federal University of Ceará under a cooperation agreement with Columbia University - New York. The focus of this presentation is the municipality of Milhã, the subject matter of this Municipal Water Plan - PAM.

In the state of Ceará, which is representative of other Northeast states in Brazil according to 2009 data from the State Secretariat for Cities, potable water supply coverage in urban zones totals 92.14%, while in rural zones it totals 18.88%, supporting the previous statement. In the state of Bahia, the largest in terms of size and population in the Northeast, 94.7% of urban areas have water supply while only 16% of rural zones have water.

The combination of several factors may threaten achievement of this millennium goal. Among such factors the current economic crisis stands out, putting at risk the continuity of efforts due to the poor state of global economy and high input costs, such as electricity.

In addition to the economic crisis, environmental factors such as climate change and anthropic factors such as pollution caused by an increase in industrial, agricultural and urban expansion activities, compose a wide range of risk agents that compromise the quality of water available for the population.

Water for human supply competes economically with other consumption uses; this progressively increases costs to catch enough water to meet human demands, in addition to treatment costs which become increasingly higher because of the pollution affecting sources of surface and groundwater, caused by anthropic activity and the expansion of economic activity.

Provision of sanitation services is an activity that depends heavily on the economic **scale** of system operation. According to TUROLLA (2002), the "*sanitation industry has as a prominent feature the presence of fixed costs in highly specific capital*".

In large cities fixed costs with the construction of reservoirs, distribution networks and water and sewage treatment plants are much more significant than short term operational costs such as electricity and chemicals; this makes production costs decrease significantly with the increase in production levels (PACTO DAS ÁGUAS - WATER PACT, 2009).

Thus, in large urban centers there is an economy of scale which is not seen in rural zones. Nevertheless until the 1970's decade in the last century this economy of scale of public water supply in Brazil was little explored and benefitted only 12.6% of the total population, because services used to be municipalized in small separate structures for water supply and sewer drainage (ALBUQUERQUE, 2010).

The organization of a National Policy for Sanitation in Brazil was launched during the military regime in 1968, when the National Bank for Housing (Banco Nacional de Habitação - BNH) was created and the PLANASA (National Sanitation Plan - Plano Nacional de Saneamento) was established, funded by FGTS (Guarantee Fund for Length of Service).

State sanitation companies were created and they boosted the structuring and commercial exploitation of water and sanitary drainage systems in an integrated and regionalized way.

The model implemented by the military regime acknowledged the need to seek economic self-sustainability through the provision of combined subsidies between municipalities, aiming to enable the implementation of water supply networks in markets that were not very attractive in the countryside, with funds being provided mainly by metropolitan regions that obtained large economies of scale.

The result of policies initiated with PLANASA was favorable: in the early 1980's the percentage of people reached by the water supply service had increased to 42%. In the 2000 Census carried out by the Brazilian Institute for Geography and Statistics, IBGE, this percentage had already increased to 76%, consolidating the model of state-owned companies. Today States have been adopting different strategies to improve their sanitation services: some have been favoring privatization, other municipalization and others strengthening state companies, such as the State of Ceará (ALBUQUERQUE, 2010).

However, small communities and the scattered population of rural environments have not benefitted from the service integration and regionalization process which, at least in terms of water supply, promoted a real increase in service levels. If on the one hand water supply coverage is extensive in urban centers in the countryside, even in small municipalities, the same cannot be said of the rural area where basic sanitation infra-structure, including access to potable water, is precarious or non-existent (PACTO DAS ÁGUAS, 2009).

Scattered rural populations have been almost entirely left out of the improvement in sanitation infra-structure services witnessed in the last few decades; they still face difficulties to economically enable service provision because they lack the economy of scale inherent to metropolitan centers. For this population extreme vulnerability remains; recurrent dependence on water trucks is symbolic of this (PACTO DAS ÁGUAS, 2009).

Brazil interpreted the Millennium Goal as a proposal to ***universalize access to basic sanitation services*** established as the first fundamental principle established by Act 11.445 of January 5 2007, known as the Basic Sanitation Act, which proposed National Guidelines for basic sanitation and for the Federal Policy on Basic Sanitation. Because it is a National Law and not a Basic Sanitation Plan, no deadline was established as a goal to be achieved.

One of the reasons for this is the acknowledgement of enormous difficulties to universalize sustainable urban supply in rural zones and scattered rural communities, due to the sheer extension of Brazil's territory and countless regional oddities, especially in the North and Northeast regions in Brazil, and above all in the *sertão* of the latter region.

Sustainability is the key word of the entire process of access **universalization**.

Those two terms deserve to be better defined both from the technical and political aspects.

Brazilian Act 11.445/07 defines *universalization* as "*progressive expansion of access to basic sanitation to all inhabited households*". The Act, on the other hand, defines *basic sanitation* as "*a set of services, infra-structures and operational facilities relating to: potable water supply; sewer drainage; urban cleaning and solid waste management; and drainage and management of rainwater*". This expanded definition of the term "*basic sanitation"* by Brazilian Law suggests that it would take a long time for this universalization to be achieved.

As for the term *sustainability*, it is perceived explicitly and implicitly in Brazilian Law according to the fundamental principles mentioned in Article 2 of Act 11.445/07:

"*...*

III - water supply, sewer drainage, urban cleaning and management of solid waste performed appropriately in terms of public health and protection of the environment;

...

V - adoption of methods, techniques and procedures that take local and regional features into account;

...

VII - economic efficiency and sustainability;

...

XI - safety, quality and dependability."

The term **sustainability** implicitly indicates that a system has been implemented and it needs to be continuously operated and maintained while achieving the goals for which it was built. In the case of the present analysis, we address a system to provide water meeting human demands of scattered rural populations, regardless of whether this system is collective or individual. Later in this article we will discuss in further detail the different aspects of the term sustainability.

However, even if it is possible to ensure the sustainability of a system inherent to technical design factors, such as choosing correctly a sustainable water source with respect to climate variations; the implemented system's appropriateness to the community's cultural pattern; etc. the system's **management** is the key to its sustainability.

Management is how the implemented system is operated and maintained, ensuring its continuity, effectiveness, efficiency and economic sustainability.

The Management Model to be adopted obviously depends on the scale of the system to be managed, that is, if the system extends over the state, regional, municipal or local/community level.

The management of a water supply system to small rural communities has different sustainability features depending on whether it will involve direct participation of the community served by the system or not.

Several studies conducted by researchers and by the World Bank in the late 1990's decade in rural communities of developing countries, such as those by KATZ & SARA (1998), reached the conclusion that there is greater likelihood of sustainability in communities where systems resulting from the adoption of a *response to demand, encouraged by the community* approach prevailed, rather than a *supplying the community, conducted by the government* approach.

In the first approach there is fair direct participation of community members in the selection of technological options within the project to be implemented; a clear and transparent discussion about inherent costs of system operation and maintenance; and previous discussion about their willingness to pay, contrary to the second approach, where decisions are made vertically and come from governmental agents and/or even counting on the participation of local leaders, who are not always representative of the community as a whole.

Sustainability-related factors come to light in significantly different ways in those two approaches: in the first, the community is part of the project from its very beginning and mobilizes its social capital in order to achieve the common goal, which is the sustainable implementation, operation and maintenance of the project; in the second, without the community's participation in the process of choosing options and decisions to be made there is always a chance that project will be rejected by parts of the community that feel left out or that are clearly excluded from the process. In that case, self-exclusion, lack of interest for the project and non-payment of water charges threaten the sustainability of the project in the long run.

The Management Model to be adopted and the relatively predictable degree of sustainability of a project are then a direct consequence of the system's scale of operation, of the type of approach adopted to build the project, the social capital of the community being served and the technological nature of the implemented system. Such factors will be further discussed throughout the text.

Rural Water Supply Experience in Brazil's Semi-Arid Region

The Brazilian experience targeting structured water supply systems in scattered rural communities is relatively recent. Only after the redemocratization process achieved with the 1988 Constitution, when municipalities were acknowledged as independent federation entities, was that new encouragement was given to the idea of discussing new sanitation policies targeting universal access and full sanitation services, reestablishing for the municipality its role as a participant of the sector planning process and as an owner of rights to provide basic sanitation services.

The aim was thus to reduce the distance between the public government who provides services and state companies who hold most concessions to operate basic sanitation services. Act 11.445/07, however, offers alternatives to regionalize and form public municipal consortiums aiming to maintain scale gains which were one of the main factors in PLANASA's success, saving room for strengthening sanitation companies to focus on service operation (PACTO DAS ÁGUAS, 2009).

In this new perspective there was an urgent need to develop models that would actually lead to universal access to potable water including scattered rural communities, with good quality water in satisfactory amounts. A few experiences were successful, others not so much.

The experience of rural water supply in Brazil is described below according to three aspects. The first shows some management model experiences in the Brazilian semi-arid region. The second and third aspects show the system's funding mechanism, respectively in Ceará and in Brazil.

Management Models

The examples of management models of rural water supply systems developed in Brazil fit into at least three categories. The SISAR/Ceará model, the Centrais/Bahia model and the COPANOR/Minas Gerais model.

SISAR / Ceará

Ceará's Basic Rural Sanitation Program established the Integrated Rural Sanitation System (SISAR) in 1991 based on a financial cooperation agreement between the German government, through the Kreditanstallt für Wiedaraufbau bank (KFW) and the State Government of Ceará.

The model started being implemented in 1995 in the Acaraú and Coreaú basins. SISAR benefits small communities and aims to guarantee the long-term development and maintenance of systems implemented by the company in a self-sustainable way.

SISAR actions include planning, design, construction, operation and maintenance of water supply and sewer systems for rural populations scattered across the land. To that end the system is organized in community associations that are responsible for operating the system locally and collecting water charges.

Associations gather in a non-profit Non-Governmental Organization, which has representatives from each of the communities that belong to the system and also relies of participation and guidance from Ceará's Water and Sewer Company (Companhia de Água e Esgoto do Ceará - CAGECE. Those systems focus on communities that have between 250 and 1,250 inhabitants.

Systems for small communities have high operation and maintenance costs and often need to be subsidized. Charges currently imposed in those systems cover the costs for paying a local operator, electricity costs and equipment and material repair and replacement.

For each SISAR CAGECE maintains an office infrastructure with support from an engineer and support staff. Those systems are currently highly subsidized. One notices that charges are compatible with what water users are able to afford. Amounts paid in 2010 are on average R$ 10.00 per family per month.

One notices that if CAGECE had to operate those systems directly costs would be much higher (e.g. labor) and higher charges would have to be imposed; the State Government would have to provide even more subsidies.

The reduction of costs brought by this solution contributes to having such systems more widely spread across Ceará's territory. There are currently 45 systems implemented in rural communities and spread across 20 municipalities in the Northeast region of Ceará, all of which have water supply and sewer systems. Approximately 38,644 people benefit from this Program.

CAGECE's role in this management model is one of providing support to the system's operation and, by delegation of the State, auditing and controlling SISAR activities, guaranteeing the quality of services and preventing administrative "disobedience". SISAR's organizational structure presented below consists of three levels:

• A Strategic Level, with: a general meeting; a board of directors; a fiscal committee; and an audit committee;

• A Technical Level, with: a technical supervisor; a financial-administrative supervisor; and a social supervisor;

• An Operational Level, with: mechanics, commercial support, administrative assistants, social technicians and janitors.

A SISAR system implementation protocol is described below (ALBUQUERQUE , 2010):

i. When a sanitation system is implemented in a small settlement, the community organizes into an association with support and guidance from CAGECE; the State government lends the set of equipment for this association to use.
ii. Meanwhile the association is granted permission from the Municipal government to operate the system.
iii. When such conditions are met, the association becomes a member of SISAR and of its hydrographic basin, which then begins providing administrative and operational support.

The State funds the water supply infrastructure (catchment, delivery, treatment and distribution), often through the São José Project (further details about this Project will be provided later). There lies another level of subsidy for the system.

As an organizational structure, SISAR is a federation of community associations that is in charge of managing services, guaranteeing people's access to water and the financial sustainability of the system. The following are members of SISAR's board of directors: representatives of member communities; of the State Government, through CAGECE; and representatives of Municipal Governments who benefit from the Program ("co-participants"). The structure of charges imposed on the use of water is defined at SISAR.

SISAR has valuable experience. Its consolidation is still a current challenge. SISAR provides water to 45 settlements today, while the state of Ceará which has a total of 184 municipalities, with 211 urban districts with populations within SISAR's range of action, according to 2000 IBGE data.

The Municipality of Milhã has 15 settlements with population numbers within Sisar's operation range and 70 communities below the minimum of 250 and maximum of 1,250 inhabitants, according to the PAM diagnosis. Would the way SISAR is organized be able to cover all of those communities? Some communities such as Pedra Fina in Milhã do not take part in SISAR claiming they are able to operate the system at lower costs, according to information provided to us by the President of its resident association.

Centrais/Bahia

The Environmental Engineering Company of Bahia (Companhia de Engenharia Ambiental da Bahia - CERB; formerly known as Rural Engineering Company of Bahia - Companhia de Engenharia Rural da Bahia) is a mixed-economy company that is in charge of studies, projects, programs and managing basic sanitation actions and services in scattered rural areas and settlements, including integrated and full rural engineering solutions which aim to universalize services through organization, community participation, social control and socio-economic development of beneficiary rural communities.

CERB operates in all municipalities covered by the São Francisco River. It was set up in 1972 and it has regional centers scattered across the entire state of Bahia. The most important actions currently being performed by CERB are associated with the construction of water supply infrastructure.

According to data provided by the State Secretariat for the Environment in Bahia, 94.7% of urban municipal centers in Bahia had potable water, while only 16% in the rural zone have access to potable water. The Water for All Program (Programa Água para Todos) was set up to expand supply and access to potable water and to perform other basic sanitation actions for people of Bahia. Riverbank populations will benefit from it, as well as centers close to facilities, people who are in the Family Allowance Program (Programa Bolsa Família), those residing in the outskirts of large cities as well in areas of land reform, indigenous communities, *quilombo* remaining members, extractive reservations and also those who face risk of drought.

The Program is coordinated by a collegiate body of secretariats and the state; it has a board of directors that includes, among other institutions, CERB and EMBASA (Water and Sanitation Company of Bahia), etc.

The Water for All Program aimed to guarantee access to quality water, from 2007 to 2010, to 950 thousand people in the rural area. In order to do so, among other things, 100 thousand cisterns would be implemented to collect rainwater falling over roofs, 1,800 tubular wells and 1,500 simplified water supply systems.

In the urban environment, where supply levels were much higher when compared to rural ones, the aim was to benefit 304 thousand Bahia residents by 2010, which would expand service from 94.7% to 98% of the urban population, totaling over 1,254,000 (one million, to hundred and fifty-four) people benefitting from water supply.

Necessary funds would total 2.1 billion reais and would be provided by international, national and state sources. In its mission to bring water to Bahia residents, the program has reached approximately 400 thousand people in the semi-arid region, according to CERB data for July 2009. 33,852 cisterns, 1,326 wells, 868 water supply systems and 13,198 household sanitary improvements were built/made.

COPANOR/ MINAS

The State of Minas Gerais created COPANOR, a public non-profit company, daughter of COPASA, with the aim to provide treated water supply and sewer collection and treatment services. This company was created by Act 16.698 of April 17 2007.

The aim is for COPANOR to have personnel and operational costs that are lower than those of COPASA, enabling cheaper charges that are more compatible with what scattered rural communities are able to afford; this would provide for the social inclusion of thousands of families in basic sanitation services.

COPANOR's focus is: i) the implementation of water supply, sewer collection and treatment systems in all settlements with a population ranging from 200 to 5,000 inhabitants in the North and Northeast of Minas; ii) guaranteeing water quality by meeting the requirements established by the Ministry of Health and the World Health Organization; and iii) establishing charges that are compatible with local reality.

COPASA started in 2009 the process of transferring to Coopanor 71 concessions to provide services to municipalities with less than 5 thousand inhabitants in the State's Northeast region.

SAR Funding and Ceará's Experience

São José Project (Projeto São José)

The São José Project is a program led by Ceará's State Government, funded by the World Bank and created in 1995 with the aim to improve the lives of underprivileged families in Ceará's rural zones with less than 7,500 inhabitants.

According to the State Government Services and Information Portal, São José makes investments in basic infrastructure supporting small producers and creating job opportunities. It also reduces social inequities and improves social and quality of life indicators of Ceará's population.

The main projects developed under São José are: actions to provide electricity to rural areas; community water supply systems; agricultural mechanization; rural housing in settlement areas; and production projects (pilot action under development).

All such actions are coordinated by the Secretariat for Agriculture. In the case of water supply actions, support is provided by the Water Construction Works Superintendent's Office (Superintendência de Obras Hidráulicas - SOHIDRA) and CAGECE.

KFW

The German Bank KFW set up in 1998 a funding called "Ceará's Basic Sanitation Program". This funding has two stages and its goal is to implement or expand water supply and sewer drainage systems in districts and small settlements in the rural zone, with over 300 inhabitants, located in the Banabuiú, Baixo and Médio Jaguaribe, Acaraú and Coreaú Basins.

The institutional development of SISARs (Integrated Rural Sanitation Systems) of the Banabuiú Baixo and Médio Jaguaribe basins took place under this funding.

Federal Programs

One Million Cisterns Program

The Program for Training and Social Mobilization for Living in the Semi-Arid: One Million Rural Cisterns - P1MC started in July 2003. This program aims to provide procedural training and supply to rural populations in the Semi-Arid region. Its goal is to benefit approximately five million people with potable water for drinking and cooking, using rainwater cistern technology.

The type of cistern most commonly built is the rainwater cistern, consisting of covered cylindrical reservoirs that are partially underground. Their size varies according to the size of the family and the roof of the house that will collect rainwater. On average, each cistern is able to store 16 thousand liters of water, but this may range from 10 to 20 thousand liters.

Those cisterns aim to provide water for an eight month horizon. According to ASA (Articulação do Semi-Árido; TN: a network of civil society organizations), until August 31 2010 294,940 cisterns had been built, mobilizing 313,973 families. Approximately 273,124 families received water resources management training; approximately 6,397 Municipal Commissions were trained and 5,541 bricklayers were qualified to build rainwater cisterns.

The cost of a Cistern according to NGO technicians ranges from a minimum of R$ 844.00 to a maximum of R$ 1,400.00 (MEC, 2010). Materials used for construction are cement, sand, iron, wire, pebbles, waterproofing, zing gutters, cloth, PVC pipes and elbows, and whitewash. Under the program, the community gathers together to work on building cisterns. They receive training on how to build them, as well as on maintenance and water treatment.

ANA ATLAS

The National Water Agency (Agência Nacional de Água - ANA) developed the **Northeast Atlas** in 2006 (ANA, 2006). This ATLAS included a diagnosis of water supply to municipal centers with over 5,000 inhabitants located in the Semi-Arid region in the Northeast and surrounding areas. It was later expanded to cover municipal centers with less than 5,000 inhabitants, totaling 1,892 urban centers and approximately 40 million inhabitants.

Studies include all urban centers located in Northeastern States with a semi-arid region (Alagoas, Bahia, Ceará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe), and the semi-arid region in Minas Gerais. It also includes urban centers with over 5,000 inhabitants located in the State of Maranhão and in the São Francisco River basin in Minas Gerais.

The diagnosis made it possible to evaluate water availabilities of the producer system according to foreseen demands. This resulted in identifying investment needs to guarantee water supply. Water supply was then planned based on an analysis of prior studies and projects, as well as an evaluation and selection of technical alternatives with their respective costs, in order to use new sources of water and adapt water production systems.

Management Model Principles

The foundations that will guide a management system are:

- The Principle of Sustainability;
- The Principle of Land Economy;
- The Principle of Response to Demand;
- The Principle of Self-Determination.

The management model of water supply systems is based on the principle of **sustainability** in its **administrative-financial, technical, social and environmental** dimension.

Administrative-financial sustainability translates in to the ability to carry out actions which involve communication with users, accounting actions and raising funds to provide for the system. A relevant challenge for this dimension of sustainability consists of guaranteeing the necessary funds to cover Operation and Maintenance costs (O&M). A system that cannot obtain funding for its operation and maintenance will not provide the benefits it intends to.

O&M funding can be made by users, by the government or both. Field observations show that in several experiences, such as that of wells with desalinizers, the government has trouble guaranteeing continuous operation and maintenance of the system. This is an issue of logistics and financial resources. The longer lasting systems have their O&M significantly funded by the users themselves. One notices that investments are often made by the government.

Technical sustainability (operational) consists of the service's operational guarantee. Technical sustainability consists of human resources and equipment to perform all necessary technical actions to provide water continuously for the population. To that end the following are necessary: a good water supply infrastructure project, qualified personnel to operate the system and, when necessary, specialists.

Social sustainability is the legitimacy and political support that the water supply system gets from the benefitted community. This dimension ensures the adherence of social groups to the water supply system. It is essential in order to provide material conditions for the other sustainable dimensions to occur.

Environmental sustainability consists of guaranteeing ecosystems are protected, mitigating the harmful impact of supply systems. Treatment waste (for instance, desalination waste) needs to be adequately disposed of.

Territorial scales of solutions for supply systems may be very different: State, Region (intermunicipal), Municipal, Local System and Individual System (family). The problem should be solved at smallest possible territorial scale, reducing the system's transaction costs. At the same time the economy of scale in water supply systems should be taken advantage of. The principle of Land Economy consists of combining these two dimensions (subsidiarity and economy of scale), which are often in conflict.

The **principle of procedure based on response to demand** consists of acknowledging the fact that populations that organized to produce a demand for water supply are more ready from the perspective of their social capital and their commitment to the system's sustainable management. Demand should be characterized by a clear commitment from the community to improving water services and expressing clearly how much one is willing to pay for different levels of service.

Community decisions should be respected and no solution should be imposed on them. This is the foundation for the **principle of self-determination**. The community's decision should be an informed decision with a clear understanding of the implications of all alternatives.

Water Supply Model Alternatives

The following are the most relevant dimensions of water supply models: i) Physical Infrastructure Alternatives; ii) Administration Models; iii) Funding Mechanisms; and iv) Technical Support for Operation and Maintenance (O&M). Alternatives for each of those dimensions are described below.

Physical Infrastructure Alternatives

Water resources infrastructure in a rural environment should provide water for drinking and production, for multiple uses. The focus here is the supply system that prioritizes providing water to households.

The water supply system in rural regions consists of a number of alternatives that range from building individual solutions, such as standardized rainwater cisterns under the P1MC Program, to the construction of integrated water supply systems with catchment, delivery, treatment, storage and household distribution networks.

Water supply systems may aim to provide different types of service. Services provided by water supply systems to a household are water for drinking, cooking, bathing, cleaning the household, among others. A few systems have a single service as their goal (e.g. drinking water) while others are multi-service. In a few places one can find one infrastructure to provide drinking water (e.g. cistern) and another for other uses (e.g. a non-treated water network).

It is clear that in rural communities water used for drinking and cooking is different from that used for other purposes, such as bathing, doing dishes, cleaning the household, in terms of the **quality of water** used, or the alleged quality water might have.

For instance, in dozens of rural communities diagnosed by the Municipal Water Plan of Milhã (Plano Municipal de Águas do Município de Milhã - PAM-Milhã), drafted by the Climate Risk Management and Water Sustainability Group of the Federal University of Ceará, together with Columbia University/New York, we observed that many families would rather drink water brought by water trucks than using water provided by the public distribution network, when available.

The reason for this may be understood as misguided faith in the quality of water provided by water trucks, which allegedly comes from a good quality source of water, which was not always true. People were also sure that the water available from sources that supplied the community distribution network, which usually came from a nearby reservoir, was not good enough because of pollution known and perceived by the population.

Water supply infrastructure for populations will ideally include four aspects: (i) choice of water source; (ii) catchment; (iii) treatment and (iv) distribution. Those aspects may appear differently in water supply solutions. In general terms water supply solutions may be classified as Individual Solution or Collective Solution. An individual solution is understood as that which provides water to a single household, whereas a collective one provides water to multiple households.

An individual solution may use different water sources (rainwater, surface and groundwater). In the semi-arid region, under the influence of the *sertão* lowlands and its intermittent rivers, reservoirs are the superficial source of water and crystalline wells are the groundwater sources.

Surface water sources may be activated through a catchment and delivery system to the demanding location, with a network distribution system or by using water trucks. The delivery system has its costs according to flow rates and length of pipes, the type of soil and relief under which aqueducts will be built. The transportation of water from a surface reservoir using water trucks has been causing public health problems, even when there are set rules providing for treatment, for in fact this often does not occur.

Underground springs over the crystalline domain of the *sertão* lowlands provide ground water stored in its fractures. This ground water is very saline and requires desalinizing. Wells with desalinization and fountains are widespread across the entire semi-arid Northeast region. This habit has caused problems associated with financial sustainability (system operation and maintenance costs) and problems associated with the final disposal of treatment waste. Such difficulties have forced operations to be terminated in several locations. The systems that opted for water charges on users survived.

Rainwater is used by cisterns. This water supply solution has no economy of scale and water supply system operation and maintenance costs are an individual responsibility. Water quality is often not monitored in this type of water supply system.

There are different solution scales for water supply, such as an individual system (e.g. cistern), a local collective system (e.g. a small aqueduct to a community), an integrated municipal system (e.g. a large aqueduct to a city which distributes water to people along the way) and an integrated regional system (e.g. water diversion systems or aqueducts to several municipalities). Choosing the most appropriate solution depends on how the population is distributed across the land, on each location's specific characteristics, on the distance from regional projects and on the community's social capital.

Standard projects that will allow for greater flexibility are desirable. The experience acquired with research conducted by the Climate Risk Management and Water Sustainability Group of the Federal University of Ceará in the central *sertão* region of Ceará, more specifically in the municipalities of Milhã, Senador Pompeu and Deputado Irapuan Pinheiro, has reached the conclusion that it is very unusual for rural communities to adopt a single means of water supply.

We have also verified that there is a clear difference in terms of preference for water sources when it comes to drinking water and water for multiple uses, such as family subsistence agriculture, based on small farms, cattle and bird farming. Access to water is a crucial factor when defining the range of options to provide water to a rural community.

The population is unanimous about the fact that it is necessary to have access to water at their homes, preferably based on the implementation of collective water supply systems built by the government. They are willing to pay as long as they are able to afford the charges, often approximately R$ 10.00/month for a consumption level of 10,000 L/family/month. This seems to be a universal standard within the region surveyed.

However, whether people will use this water for drinking depends on their subjective judgment over the quality of water provided by the government, which not always agrees with technical rationality.

For instance, even in some systems that provide undoubtedly treated water that complies with potability sanitary standards according to Regulation 518/2004 of the Ministry of Health, many families still refuse to use it for human consumption, apparently based on the population's knowledge about the original source of water. It is enough for this source to show a visibly identifiable degree of pollution with the presence of macrophytes and marginal eutrophication zones in the reservoir for most people to reject using it for drinking, even after it has been treated.

There is evidence of cultural belief developing progressively among the people of several communities in the municipality of Milhã in the state of Ceará that water from rainwater cisterns is the best for drinking, followed by the local preference for water provided by water trucks, which supposedly comes from a good quality source, such as already mentioned before.

Such cultural aspects should be taken into account when establishing a water supply and access universalization program. Therefore, it is necessary to enforce the principle of procedure based on response to demand led by the community, with direct participation of its members choosing water supply and system alternatives according to their preference. This will ensure their commitment to the sustainable management of the system to be implemented from its early days.

Administration Models

The management model is associated with the type of infrastructure solution chosen for a given location. Despite this fact the model should promote conditions for financial sustainability, operational efficiency, legitimacy and social integration.

The Water Pact (Pacto da Águas - Ceará, 2009, page 232) proposes building a single management model for water supply systems to rural populations based on the experience gathered with Sisar.

The proposal came from acknowledging the need to implement a sustainable management model that would provide water to communities with over 50 families that were not included in Sisar and to communities with less than 50 families. The proposal would be a shared management model for rural sanitation systems involving the State Government, Basins, Municipalities and Communities, covering the entire state of Ceará.

Under this model, the municipality would be in charge of management. The state government would be in charge of encouraging the implementation of a sustainable municipal rural sanitation system in all of them, covering all rural communities within a given municipality. The management of community services would be shared between the community association and the entity in charge of the Municipal Rural Sanitation System (SMSR).

Additionally, each municipality would establish a municipal fund to universalize rural sanitation that would have two purposes: guaranteeing the operation and maintenance of community sanitation systems and subsidizing insufficient community systems.

We evaluate here the difficulty of having a single model for Ceará due to the diversity of social capitals and physical structure, in addition to the crucial need to follow the principle of self-management, which prescribes that each community must be free to choose whether or not to accept any given proposal. In that sense we propose that **multiple social organizations** should manage water supply systems. If the process leads in the end to a single form of organization, this will be wonderful; if not and the system performs well, this will also be wonderful.

Management model alternative types are centralized and decentralized. There are intermediate variations between those extremes. Six management model alternatives have been identified:

- Individual System

- Local System (self-managing networks)
- Integrated Municipal Management: center and rural zone
- Integrated Intermunicipal Consortium: center and rural zone
- State Network - SISAR
- State Rural Sanitation Company (Agency)

For decades political decision-makers have had conflicting experiences with respect to centralized and decentralized management of common-pool resources (ANDERSSON & OSTROM, 2008). There is a general understanding that an entirely centralized governmental system is often inefficient due to its high transaction cost.

On the other hand an entirely decentralized process has been proving to be naive or increasingly difficult (OSTROM, 2005). This fact stands out in water supply solutions due to high costs of infrastructure implementation which often require a funding agent.

Setting up polymorphic system with multiple centers, different jurisdictions and authorities as previously proposed in this chapter complies with the proposition made by Andersson and Ostrom (2008). Where each decision/administration center has the autonomy to establish rules and sanctions for non-compliance, it should be noted that each center has their authority over a given geographic region (CLEAVER, 2000; OSTROM, 2005).

A few principles that must be followed by system management are the following:

- Establishing a level of organization within the community is necessary to succeed;
- Effective family involvement requires an adequate flow of information and social mobilization;
- Basic community management principles include participation, control over decision-making, and cost appropriation and sharing;
- Community management is regarded as the basis for long term maintenance and operation.

According to KATZ & SARA (1998), there are five broad rule categories for projects that are transcribed below:

- *Eligibility criteria:* Rules for participation should be vast enough for eligibility not to be in itself a guarantee that each eligible community will receive service. Service commitments should follow and not precede the community’s initiative to seek improvements;

- *Informed Request from the community:* The project must establish procedures to allow an adequate flow of information for communities. Communities should be able to make informed choices about the possibility to take part in the project. They should know beforehand the terms of their participation and responsibility to support the project;
- *Technical options and levels of service:* Communities should take active part in choosing the levels of service. A range of technical options and levels of service should be offered to communities, with their related operational costs and implications;
- *Cost allocation:* The basic principles of cost sharing should be specified and made clear from the very beginning to all interested parties. Cost sharing should be projected so that the community will choose the levels of service for which it is willing to pay. Ideally, communities that require a higher level (that is, more expensive) of service should pay more than those that prefer a basic level of service;
- *Responsibilities to support investment:* rules about asset ownership, O&M and continuous recovery of system costs should be established and agreed with all parties in interest.

Water supply management solutions should observe the following, according to LOCKWOOD (2002):

- Technical Support: providing support and guidance over a number of support topics regarding the structure of the community management model, as well as providing independent advice in cases where some form of arbitration might be necessary;
- Training: training programs provided to members of relevant commissions in a wide range of operation and physical maintenance subjects in order to promote accounting and hygiene, building skills at the community level;
- Information and Surveillance: regular follow-up on the system's performance and feeding back information about correction measures;
- Coordination and Facilitation: helping establish bonds between community management structures and outside entities, both from the public and private sectors;

Management should be sustainable. According to KATZ & SARA (1998), criteria to evaluate sustainability and performance are:

- The system's physical conditions: Measures the water system's general physical condition. It is based on factors such as quality of construction, the level of pressure in the system and leaks or defects in masonry or pipes;
- Consumer satisfaction: This measures overall consumer satisfaction with the water system. It is based on opinions expressed in factors such as satisfaction with the amount and quality of water they receive, its taste and color, and continuous use of alternative sources;
- O&M Practices: This analyzes factors such as whether the community has a designated operator, access to tools and replacement tools and information about continuing support;
- Financial Management: This evaluation is based on a review of financial records of each community and interviews with the water commission and treasurer;
- Willingness to support the system: community support, measures to support the water system. It evaluates how responsible community members feel for maintaining their system.

Funding Model

The system's funding is a key issue for the feasibility of the water supply solution. The system's funding is often divided into: i) system design and implementation and ii) operation and maintenance. Design and implementation costs are often high and are funded by the government. Operation and maintenance costs are sometimes funded by the government and sometimes funded directly by users. It has been observed that O&M being fully funded by the government is unsustainable, because it is difficult for the state to do this continually; there are also logistic difficulties.

The implementation of infra-structure should be funded by the government with federal, state and municipal resources, with greater federal funding. The possibility of outside funding with permission from the Federal Government and contributions from states and municipalities is always an option to be considered, especially in cases where large integrated water supply systems are being implemented, with high permanent capital costs in terms of catchment, delivery, treatment and distribution.

There are also cases where simplified water supply systems in rural communities are self-funded by the owners of ranches and farms where those communities were set up. They establish a flat water charge for locals without measuring consumption and there is usually some kind of economic or family bond with the property owner. This usually occurs in places where there is a superficial source of water (reservoir) of good or reasonable quality. Several cases were identified during the survey conducted in the municipalities of Milhã, Senador Pompeu and Deputado Irapuan Pinheiro in the state of Ceará.

A small part of this initial investment may be recovered according to the repayment capabilities of the local population. This funding can be provided partly by a specific fund to universalize water supply to rural populations, including resources currently directed to water trucks and/or a specific tax on urban sanitation or electricity services. A similar proposal was submitted in the Water Pact (Pacto das Águas, 2009), suggesting setting up a municipal fund to universalize sanitation.

The system's operation and maintenance cost may be funded by the following mechanisms:

- Self-funding:
- Cross subsidy: municipal center water permissions would fund the rural zone;
- Subsidy provided to families as a direct transfer of funds (Water Allowance - Bolsa Água), the amount would be the same as water truck costs;
- Rural Water Supply Fund (Fundo de Abastecimento Rural) - Subsidy through a specific tax on urban water supply (sanitation or electricity).

Self-funding of O&M of rural communities water supply systems is undoubtedly the most favorable mechanism to ensure long term sustainability of implemented systems. Self-funding stems from mobilizing the community's social capital based on the participation process described here. Beneficiaries agree beforehand on water charges on water consumption taking into account their ability to pay. Charges cover operation and maintenance costs and set up a contingency reserve to replace equipment depreciated by use.

The self-funding mechanism may be used in communities with a large social capital or even in communities that have a small social capital. The difference is that in the first one the system's sustainability is guaranteed by the community regardless of whether there are leaders that will continually encourage maintenance and preservation of the implemented system.

As for communities with a weak social capital, the sustainability process depends on action from strong leaders who put social pressure to guarantee payment of charges, which will in turn guarantee the operation and maintenance of systems.

When those leaders for some reason step away from the community, a power vacuum may be created or unsolvable conflicts may emerge between community members that will threaten payment of charges and the survival of the implemented system.

Such facts have been observed in a few communities of Milhã. The succession of command set forth in all community association statutes is based, on one hand, on democratic principles of alternating power which must guide citizens' social and political participation. On the other hand, it may threaten the sustainability of systems when the community's social capital is weak.

It is possible that opportunist leaders with a false democratic discourse will take over command of community associations with intentions that are not always faithful to the community's interests. The lack of *external control* in self-funded systems is an unfavorable factor to the system's sustainability in such cases of communities with a weak social capital.

The **funding of operation and maintenance** of water supply systems to rural communities, through **cross subsidy**, where **system concessions in municipal urban centers would fund rural zones**, would represent the municipal level offset in the cross subsidy system that already exists at the state level, where the economy of scale obtained in metropolitan areas subsidizes operation and maintenance of smaller scale and deficient systems in the countryside.

The feasibility of using this type of cross subsidy depends on the economy of scale that may be obtained in the municipal center to fully or partially fund operation and maintenance of water supply systems to small communities. One should be careful not to unduly burden urban center consumer charges in order to provide such cross subsidy.

Considering that usually urban center populations are much smaller than populations living in the entire set of rural communities in most municipalities, especially the smaller ones located in the semi-arid region in the Northeast, it would be very difficult to establish marginal revenue from the charges imposed on consumers of urban centers which would be enough to globally cover all operation and maintenance costs of rural systems.

The best way to enable this exchange would be to establish a cross subsidy based on charging a small percentage of urban consumer tariffs to invest in a *municipal reserve fund* that would cover the costs of replacing damaged or worn out equipment of rural community water supply systems.

This fund would be managed by a Managing Committee formed by representatives of municipal governments and community associations. Its statute would bind civil society and user associations into strong participation, guaranteeing the transparency of fund management and inspection.

The fund could be used to replace worn out equipment either at a cost or at no cost. In other words, funds could be provided to communities which undoubtedly cannot afford it, or funds could be lent to communities whose economic scale allowed establishing a compulsory surcharge over a set period of time in order to repay the loan.

If there were large scale revenue from establishing a cross subsidy obtained from urban centers and if such revenue were enough to create a municipal organizational structure to provide technical support to rural communities in the municipality, this would be the best alternative to guarantee long term sustainability of rural systems.

Another mechanism would be establishing a **subsidy provided to families as a direct transfer of funds (Water Allowance - Bolsa Água); the amount would be the same as water truck costs**. This mechanism would be very complex since the costs of water truck supply services change from one community to another according to their consumption levels; to the distance from the water source; to the transportation costs according weight on unpaved and on paved roads. It would be difficult to establish criteria to define such parameters and a high risk of political manipulation of data inherent to those variables, aiming to maximize the revenue of certain communities.

It would be difficult, for instance, when selecting the water source to be allocated when calculating variables for each set of consecutive communities in a water truck route. The subjective nature of the parameter "quality of water" to be provided to the population would be an excuse to maximize distances from the source of water as a way to increase the amount of money provided to each community. Other tricks to achieve this goal can easily be pulled as arguments in political bargains.

Another variant possibility with respect to this source of funding would be transferring the total amount allocated by the Federal Government's water truck water supply program to a municipal fund that would subsidize operation and maintenance of rural community water supply systems. In this case the municipality would receive the total amount intended for the water truck program and would use those funds to implement a program to build, operate and maintain sustainable water supply systems in rural communities.

A **subsidy provided by a Rural Water Supply fund, through a specific tax levied on urban supply (sanitation or electricity)** would be a feasible macroeconomic alternative to solve the problem of universal access to water in rural areas and would probably provide more robust results in terms of guaranteeing the sustainability of implemented systems.

However, it would be very difficult to make it politically feasible, since it clashes against discourses favoring the reduction of national tax burdens and would require high political transaction costs that would be unlikely to be accepted by most of the population. The recent recollection of misguided uses of CPMF charges (Temporary Tax on Financial Transactions), which were initially created to fund improvements to healthcare services and that ended up in the Federal Government's single account to subsidize primary surplus, is still very fresh in Brazilian taxpayers' memories. They would strongly reject creating an additional tax to subsidize water supply to rural communities.

Technical Support

Water supply solutions need technical follow-up, regardless of their scale. This technical support aims to guarantee satisfactory water supply in terms of quality, quantity and financial efficiency. Systematic operation of systems is the goal of this technical support.

Systems of greater complexity require more intense support; the level of expertise of technical support increases with the complexity of the system.

The operation of collective water supply systems in small rural communities usually involves merely turning pumps on and off and a few valve operations in water treatment plants and distribution network. Such simple daily operations may be performed by people from the community itself after training; this training requires a primary level of education.

Maintaining collective systems in small communities usually requires an electrician to provide maintenance to pump control and electrical panels; a plumber to provide maintenance to pipes and accessories; and a pump mechanic to provide pump maintenance. The level of education required for this maintenance is one of secondary level technician and it is difficult to find anyone with that profile in communities. Therefore, it is necessary for an organization to provide qualified personnel for those operations.

The Sisar model adopted in the state of Ceará managed to satisfy this need for maintenance technical support for systems under its jurisdiction. However, small rural communities are not part of Sisar's scale of action. The possibility of setting up a municipal agency or municipal consortium with that specific purpose of providing technical support to rural supply systems is a need that must be duly addressed.

More complex systems that provide water to larger districts and urban communities belong to the Sisar level and technical support should be provided by a state or municipal concession holder, such as it is done today.

Model Selection

Choosing a water supply solution should take into account local physical conditions, possibilities for integration between projects aiming to encourage an economy of scale and the community's social capital.

Local **physical conditions** refer to the following: the type of water source available, whether it is on the surface (reservoir, Amazon-type well or alluvium), or underground (a deep crystalline well); the quality of water found at the source, which will determine the necessary type of treatment; the distance between the water source and the community that will receive water, which will have an impact on implementation and operation costs; elevation disparities between the source of water and the community that will receive water, which will have a direct impact on operation costs due to electricity required for pumping; local geology in the path of the water delivery route and the distribution network which may increase threefold the cost of implementing collective systems when there are rocks in shallow levels; local relief and topography in communities which will determine pressure zones for building elevated reservoirs in distribution networks; the local road network which will determine the path of water delivery and distribution pipes, considering it is inappropriate for them to travel through private property without due expropriation or the owner donating it for public use, etc.

Such physical conditions are crucial when considering alternative solutions to provide water and should be extensively discussed with the community. The economic issue should always be taken into account, aiming to minimize implementation and operation and maintenance costs; the latter should preferably be minimized. The reason for this is that systems are usually implemented with public funding with resources provided by federal, state or municipal governments, which are able to afford greater investment costs in favor of a reduction of operation and maintenance charges imposed on users.

For instance, it would be better for the community to choose a water source that is further away (with higher implementation costs), but whose manometric pumping height is lower than that of a water source closer to the community. This is because electricity costs would be reduced. Since they represent the largest share of operation costs, this would have significant impact on water charges to be paid by families in the community.

The **possibility of integrating water supply projects aiming to expand the economy of scale** should always be a goal when studying alternative solutions to provide water to scattered rural communities.

This integration should always aim at economic efficiency, translated into reducing operation and maintenance costs for communities covered by the system. Economic efficiency in this case is tantamount to energy efficiency.

Electricity costs of water supply systems in rural communities should be minimized as far as possible, even if it is necessary to make a more substantial initial investment when building the system. In other words, a bias should be considered when selecting the economic diameter of pipes, and the choice should always favor the commercial diameter immediately above the one obtained with traditional dimensioning equations such as Bresse's formula; solutions should be sought which will provide integration with joint catchment and a single water treatment plant, and although this implicates in greater global operational costs, it will allow reducing charges according to the group of covered families, making use of an economy of scale; one should consider as priority alternatives integrated solutions that will make it possible to cover the most families with a single pressure zone (elevated reservoir), with distribution of water by gravity into the joint network.

Another crucial factor that should be taken into account when choosing the water supply model to be adopted is the **social capital of each community** or group of communities, when it comes to integrated projects that aim to achieve an economy of scale.

Social capital is closely related to the system's long-term sustainability. KATZ & SARA (1998) proposed six indicators to evaluate communities' social capital with respect to the implementation of water supply systems in rural zones:

• the role of communities in project implementation. This indicator evaluates how the community engaged with the process of implementing the chosen solution for its water supply;

• community involvement with initializing the project. This indicator evaluates whether the procedure was based on demands led by the community or if it resulted from governmental intervention without community participation;

• how informed were the choices made by a community about the type of water supply system built. It evaluates the community's participation in decisions made about the implemented system and the level of information and transparency about costs that will be imposed on the community after the project is implemented;

• the level and quality of households. This indicator evaluates socioeconomic conditions of families in the community;

• the qualifications of the water management committee. This evaluates the level of information and training about system management that has been provided to community managers;

• comparing how the project is perceived by heads of households and by local leaders or members of water management committees. This indicator aims to compare different perceptions among those who lead the process (managers) and users of the implemented system. Its purpose is to identify possible gaps between those who manage the system and its users.

The community's social capital will be the main measure of an implemented project's sustainability. Depending on community engagement, it is possible even for projects with concept and engineering problems to become sustainable due to its community's ability to revert an unfavorable situation and correct its faults.

For instance, it is possible that incorrect pipe or pumping system dimensioning will result in increased electricity costs; therefore also increasing operation costs of an implemented system. Another possibility is an increase in demand generated when other communities and/or isolated families that were not initially included in the original design join in. In this case, the community may find the means to use charges to make up for increased operational costs or to set up a savings account to fix the technical problem.

On the other hand, communities with a low level of engagement tend to make well conceived and optimized engineering projects unfeasible in the long run due to high default, misuse of facilities and by being little or not at all concerned with preventive and predictive maintenance of implemented systems.

Project Upscaling

Shared experiences, common support structures, simplified financing and multi-level institutional connections are among the mechanisms that may be part of the upscaling process (Lockwood, 2004).

Project upscaling can fit into four categories, according to Uvin and Miller (1994):

- **Quantitative Scaling-up (structure).** A program or an organization expands its size through increasing its membership base, its geographic working area or its budget;
- **Functional Scaling-up (programs).** A community-based program or an organization expands the number and the type of its activities. Starting in agricultural production, for example, participatory organizations move into actions in health, nutrition, credit, training, literacy, etc., that is, when they add new activities to their operational range.
- **Political Scaling-up (strategy).** Participatory organizations moving beyond service delivery toward empowerment and change in the structural causes of underdevelopment, that is, its contextual factors and socio-political-economic environment. This will usually involve active political involvement and the development of relations with the state;
- **Organizational Scaling-up (resource base).** Community-based programs or grassroots organizations can increase their organizational strength so as to improve the effectiveness and efficiency of their activities. It can be done financially, by diversifying their sources of subvention and increasing the degree of self-financing.

The experience gained by authors in Ceará's central *sertão*, more specifically in the municipality of Milhã, has led to the conclusion that there is a limit to the extent to which social capital available in communities may be explored with the aim to create sustainable management models of integrated rural water supply systems.

The specific features of certain community leaders and of families themselves with respect to sharing water with other neighboring communities is clear from the practical point of view through the sense of ownership they have over some sources of water.

Joining nearby communities to form economies of scale for water supply is a huge challenge because there are often ancient conflicts that are passed on from one generation to another and have nothing to do with their current water supply needs.

What we have observed in Milhã is that setting up groups of communities sharing the same source of water supply would be highly unlikely, even if it were technically feasible. This depends solely on people who live in those communities, without interference of any outside pressure.

Therefore, in order to achieve an economy of scale in rural water supply systems it is necessary for the government to intervene as inductor of this process, by designing, funding and implementing the project. This option goes against the thesis supported by KATZ & SARA (1998) about the procedure based on response-to-demand presented here. It would be only partly possible to adopt a few principles supported by this approach.

For instance, the water supply system implemented in the community of Ingá by the UFC/Columbia project only became feasible when water sources for Ingá and the system of Pedra Fina were separated, and an independent association was created to manage Ingá's system. The original option was building a shared and interconnected system coming from a single source of water.

Scaling up rural water supply projects from the local community level to the regional, municipal or even to the state level will require the government to take part as an active agent that will induce the process. It will be necessary to adopt a combination of management models ranging from total self-management of systems by communities that have high social capital, to a system management fully subsidized by municipal, state and federal governments.

Community participation in decision-making and management processes which go beyond their local community level would start being more representative than the direct form supported by KATZ & SARA (1998)'s approach.

We should emphasize here the **role of the municipality** as an agent that will encourage water supply universalization for rural communities within their territory, relying on state and federal governments, looking for different funding alternatives; overseeing implementation and providing technical support for the sustainable management of rural systems to be implemented.

In order to achieve such goals a **MUNICIPAL WATER PLAN (PAM)** needs to be drafted offering the following:

• a consolidated diagnosis of **rural communities** in the municipality: identifying communities and their locations through georeferencing and a semi-census;

• diagnosing **available water sources** within the municipality: identifying superficial and underground springs, their location and their quantitative and qualitative water supply capacity to meet water needs;

• diagnosing **water demands** within the municipality: identifying community consumption considering multiple uses of water, but focusing primarily on drinking water;

• a **water** balance diagnosis: what the difference is between available water supply and consumption for multiple uses, prioritizing human supply and drinking water for animals;

• an institutional diagnosis and a diagnosis of the **self-organization capacity** of those communities **identifying the available social capital** in each one;

• drawing up **a plan for new water interventions**: aiming to improve water supply for multiple uses prioritizing human supply and drinking water for animals;

• drawing up a **plan to universalize water supply**: identifying necessary interventions at local, regional and municipal scales to guarantee access to water for the entire population in the municipality;

• coming up with **a polymorphic sustainable management model**: sustainable management models would be applied that adapted to different realities observed in the communities in the field, following sustainability principles and aiming to achieve maximum social and economic efficiency managing the systems.

One of the prerogatives to achieve long term sustainability in rural water supply system management aiming to universalize access to water for the entire population is not being misled by discriminatory, ideological or partisan political prejudices, considering the municipality's population as the target universe. This would be an essential condition to achieve desired success.

9. CONCLUSIONS

Milhã's Municipal Water Plan initially aimed at presenting a consolidated diagnosis of the current water supply situation to rural and urban communities in the municipality including all gatherings with more than three households, to an almost census level. We also performed an overall diagnosis of available water resources and a simplified water balance between availability and actual demand.

Based on this diagnosis we proposed structural interventions with two goals: first of all, we aimed to propose the universalization of human supply to scattered rural communities identified as being the most underprivileged in terms of access to water. Under this perspective we have identified that it would be possible to universalize such access with a total investment of **R$ 656,764.33**.

Secondly, we proposed interventions within the water domain aiming to expand water supply in terms of quantity and quality to provide water to the largest urban centers, including the city center and their main districts.

It is worth noting that structural propositions to improve water supply were based on studies already conducted by government institutions at the federal, state and municipal levels; there is an agreement that feasible alternatives are few and well known to the governments and the municipal population itself.

Among the priority interventions at the municipal and regional levels, we highlight the need to build the Capitão Mor reservoir. This construction work was the subject of a study conducted by the State Secretariat for Water Resources of Ceará in 2003 and it would more than double municipal water availability guaranteeing water in terms of quantity and quality for the city center and the major districts located in the municipality's most densely populated and developed region.

Likewise the Lagoa Nova reservoir, designed by DNOCS in 1992, would be crucial to provide water to the district of Carnaubinha, the most densely populated north of the municipality. Such projects, considering the integrated implementation of the respective water supply aqueducts, would require an investment of **R$ 15,672,109.58.**

Therefore, the PAM points to a global investment of **R$ 16,328,873.91**, considering all priority interventions. Taking into account that this amount represents approximately 40% of the municipality's GDP and 96.4% of the annual gross income in its fiscal budget, clearly it would be necessary to have external funding from a source other than the municipality, as one would expect from most municipalities in the Northeast semi-arid region.

However, this PAM fulfills its role to reveal that it is necessary to study the issue of water supply to urban and rural communities in the semi-arid region. We need to consider the actual size of the problem based on a local diagnosis at the community level so that it may be possible to obtain a relatively precise estimate of needs for real intervention to provide for rational and effective planning.

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