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INGEKOMEN - 4 OKT. 1995

A SUCCESSFUL WATER REHABILITATION PROJECT
ARISING FROM DIAGNOSTIC SURVEILLANCE

by

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October 1994

SUBMITTED IN PART-FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

TO: Martha my wife and inspiration;

Helena, my mother.

SUMMARY

1. A pilot rural water rehabilitation project was executed following the Tolima, Nevado del Ruiz volcano disaster;

2. The project was initiated following a surveillance diagnostic of water and sanitation in villages in the disaster area;

3. A new approach to community water supply management was developed in which the criteria of sustainability and cost recovery were implemented;

4. Appropriate technologies involving multistage filtration were adopted to rehabilitate the existing sand filtration plant;

5. Evaluation of key surveillance indicators demonstrated that coverage, continuity and quality were all substantially improved;

6. Quantity however was reduced from previous excessive levels of supply in consideration of improved quality and the majority of the community accepted the requirements to pay for a safer water supply;

7. Follow up evaluation after three (3) years demonstrated that sustainability had been achieved. The successful experience gained have permitted regional replication.

ACKNOWLEDGEMENTS

This work was financial and practical supported by different national and international institutions such as:

* Colombian Ministry of Health
* Tolima Health Service
* Universidad del Valle
* CINARA
* United Kingdom Overseas Development Administration
* The British Council
* The British Red Cross
* CEHE, Centre for Environmental Health & Engineering
* IRC, International Water Supply and Sanitation Centre

I am most grateful to Dr. Barry Lloyd. His patience, experience and knowledge was essential in the development of this thesis. To Dr. Lloyd my respect and gratitude.

Special thanks are to Gerardo Galvis. In the last ten years he has been colleague, critic and especially friend. To Gerardo my permanent gratitude.

The field study would not have been possible without the Tolima Health Service staff and San Felipe Water Board support. The participation of the people like Jaime Duque and Avelino Quintero, the sanitary inspectors, Deogracias Zarate, the water supply system operator, Jaime Buenaventura, the Water Board treasure and Gonzalo Olaya, the Water Board President was one of the key aspect of the project.

During this work many people have contributed with technical advice, support and direct participation. With excuses for any involuntary omission I would like to thanks all of them: Eduardo Lozano, Julio Cesar Quintero, Ramón Duque M., Mariela Garcia, Carlos Dierolf, Javier Fernandez, Viviana Vargas, Jorge Cardona, Noel Muñoz, Johanio Marulanda, Hector Perez, Marlen Florez and other CINARA colleagues, students and support staff.

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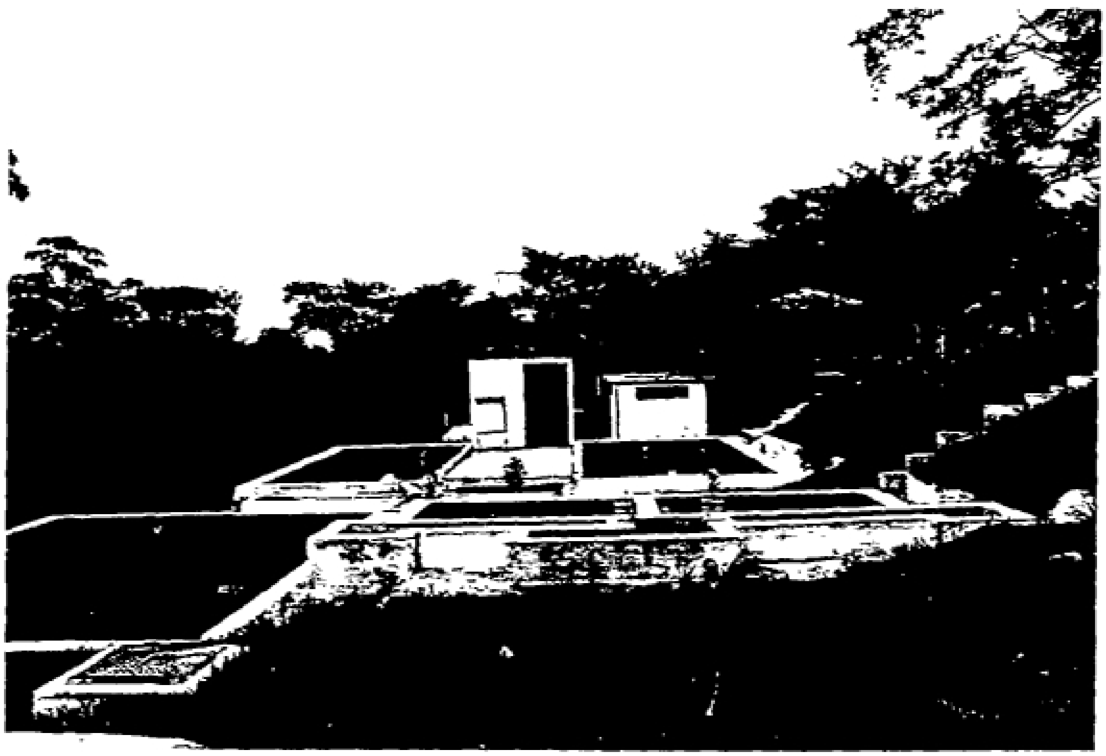
ABBREVIATIONS AND ACRONYMS

ACODAL	Colombian Sanitary Engineering and Environmental Association
CINARA	Interregional Water Supply and Sanitation Centre, Colombia
DANE	National Statistics Administrative Department, Colombia
DNP	National Planning Department, Colombia
HIMAT	Hydrometeorological and Land Adequation Institute, Colombia
IDRC	International Development Research Centre, Canada
IDWSSD	International Drinking Water Supply and Sanitation Decade
IRC	International Water and Sanitation Centre, Holland
MoH	Ministry of Health, Colombia
PAHO	Pan-American Health Organization
TRANSCOL	Technology Transfer Programme in Colombia
UN	United Nations
WASH	Water and Sanitation for Health Project, U.S.A.
WHO	World Health Organization



SAN FELIPE WATER TREATMENT WORKS

INTRODUCTION

In many countries, especially the so-called developing ones, among the principal risks to public health are those associated with the incidence of waterborne diseases, that proliferate due to deficiencies of drinking water supply and sanitation services provision and the absence of hygiene education programmes.

Multiple efforts have been made, especially during the International Drinking Water Supply and Sanitation Decade IDWSSD (1981-90), intended to improve the sanitary infrastructure and service. Increased coverage and the drinking water quality were considered essential parameters to measure improvements.

In Colombia, the advances achieved during the Water Decade were minimal. The existing infrastructure, much of which had recently been built, did not fulfil its objective in the various regions of the country, especially in those which were least developed[1] (DNP, 1991).

Many rural projects were carried out but it provided a deficient and unreliable service. The communities, which were not involved in their conception, execution and development, did not use them or were not worried about their functioning.

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1 The Ministry of Health informed a meeting of the Andean Agreement Hipolito Unanue, held in Manizales city in 1985, that only 13% of a sample of supply systems with treatment plants were producing drinking water according to national standards and that the remaining 87% had operation and maintenance problems.

On the other hand, water surveillance and quality control programme were not implemented in the country. As a consequence the problems and limitations that affected the functioning and utilization of the water supply systems, could not be systematically detected in order to take improvement decisions[2] (MoH-DNP, 1990; Quiroga, 1990).

The evaluations made after the Water Decade (UN, 1990), established the need to seek new approaches that permit and guide the efficient and sustainable sectoral investment and interventions.

At the rural level, the community's needs, expectations and interests must be satisfied; their systems must continue functioning with a minimum of external support. The community must therefore be involved, not just as users or beneficiaries, but as owners and managers of their systems, and working as a team with the professional institutions to make it possible to achieve the success of the projects.

The study presented here evaluated at the local level in a rural area, the parameters that influence the achievement of a reliable and efficient provision of drinking water supply, as well as the factors that make possible the sustainability of the system with a minimum of external support, so that after a period of time the project could

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2 The DNP director, pointed out in the International Seminar on "Efficiency in the Drinking Water and Sanitation Services Provision", held in 1992 in Bogota, that the system monitoring and coverage had not been made periodically; that the sector statistics do not adequately measure the water quality and sewer services; and that the Ministry of Health has not managed to fulfil its responsibilities in water surveillance and quality control programme, in part by not possessing the tools adapted to audit them (DNP, 1992).

be qualified as successful.

The document comprises six chapters. In the first the formulation and justification of the study are presented. The second chapter presents the literature review, which permits the establishment of the context of the research which has been made. This chapter is subdivided in two sections. In the first section the international framework and the water supply and sanitation situation in Colombia is reviewed. The second section explains the factors and parameters that have an impact on project sustainability and providing a reliable and efficient service.

In the third chapter the specific and general objectives are presented. In the fourth chapter, the methodology and materials used for the development of the study are explained, showing the existing infrastructure in the locality which is the object of the research, the criteria for its selection as a pilot demonstration project, the evaluation programme and the procedures and methods of analysis used for the compilation of the information and its subsequent interpretation and management.

The fifth chapter presents the results and experiences obtained, as well as its discussion, in the light of the experiences and additionally investigating reported findings both at national and international level.

Finally, in the sixth chapter the conclusions of the research and the perspectives of water surveillance and quality control programme, as a tool to achieve success in the sector, are presented.

CHAPTER 1

FORMULATION AND JUSTIFICATION OF THE STUDY

1.1 IDENTIFICATION OF THE PROBLEM

During the Water Decade the governments of Colombia have been concerned with offering a reliable and efficient drinking water supply service. Nevertheless, even with the investments made, which amounted to more than 0.4% of the GNP (DNP, 1991), the increases achieved were minimal and the provision of the drinking water supply and sanitation services are very deficient and the differences between rural regions and cities are considerable (Government of Colombia, 1991).

There are several factors that have influenced the provision of a poor water supply in Colombia and other Latin American countries. Among the most important are (Quiroga, 1990b):

* An institutional water sector organization that, because of its complexity, has hindered an effective administrative effort;
* Deterioration in the quantity and quality of the water, as a consequence of the deforestation and the wastewater discharges that seriously affect the watersheds;
* Selection and use of inappropriate technology and insufficient support for its efficient operation and maintenance;
* Inadequate training of the personnel linked to sector;

* Limited community participation, emphasized only in the construction phase of the projects, combined with the absence of hygiene education programmes;
* Absence of a water surveillance and quality control programme.

Another element was the lack of political and financial support for the introduction and organized development of technological solutions for drinking water quality improvement, to make the new investments more efficient, as well as the optimization of the existing infrastructure (DNP,1991).

In order to overcome the problems, the government, in its Economic and Social Development Plan 1990 - 1994, considered that it was necessary **"to endow the sector with the resources, mechanisms and institutions to eliminate the bottle necks and to generalize the access to the drinking water to the population in the context of decentralization"**, and formulated four basic objectives:

* To restructure the institutions of the sector in line with the decentralization policy;
* To increase national drinking water supply coverage;
* To increase drinking water quality, so that all the water delivered to the community would be wholesome;
* To design a strategic plan, directed to treating wastewater of the large cities.

For its achievement, financial resources of several hundred million dollars were assigned to the sector; responsibilities and functions were re-assigned in the public service provision and it was proposed to support institutions such as CINARA, so that there could be appropriate research and development in technological alternatives for improving drinking water quality (DNP,1991).

However, for the achievement of the objectives, and, specifically to increase coverage and drinking water quality improvement it was not enough to have

sufficient economic resources, or legal tools such as procedures, decrees, laws, or the technological alternatives. A different approach is required to ensure that the projects fulfil their objectives, so that the efficient use of the resources and success could be achieved.

Based on the problems outlined, the present study will concentrate on solving the following questions: What factors affect the reliability and efficiency of the drinking water supply service? What is the sustainability of a water supply project and how can sustainability be achieved? and; How is the water surveillance and quality control programme to be used as a tool to achieve these objectives?

1.2. JUSTIFICATION OF THE STUDY

Drinking water quality improvement is one of four objectives of the Development Plan of the Colombian government (DNP,1991). The Plan proposes that all the supply systems should produce safe drinking water.

However, the drinking water production is only one of the aspects that affect the provision of the water supply service, as well as its sustainability. Within the framework of the decentralization policy that is happening in the country, where the Colombian municipality has been placed in charge of the provision of public services (Decree law 77 of 1987), it is necessary to have new approaches to obtain support for projects to fulfil its objectives.

For this reason, and in this context, the present study will try to identify an approach aimed at promoting the optimization of the investments and the interventions in the sector, so that the water supply infrastructure supplies the expected service and the possibilities of its deterioration or loss are reduced.

CHAPTER 2

LITERATURE REVIEW

2.1. WATER SUPPLY AND SANITATION SECTOR SITUATION

During the International Drinking Water Supply and Sanitation Decade IDWSSD (1981-90), the efforts made were concentrated on achieving the improvement, in coverage as well as in quality, of the provision of drinking water supply and sanitation services.

Around the end of 1988, the WHO reported that in the developing countries, excluding China, water supply coverage had increased from 31% to 46% and the differences between rural areas and cities had been reduced (Lloyd et al, 1991c).

In Latin America and the Caribbean, in the period of 1981-1988, the urban coverage of the water supply was increased by 4%, and at rural level 15%, benefitting nearly 70 and 19 million people respectively (PAHO, 1990).

Although the increases in coverage were high, they did not reach the goals established at the beginning of that period (UN, 1990). It is even indicated that the figure of urban zone residents, who did not have sufficient water supply, was almost the same as at the beginning of the Decade (Briscoe, 1992).

But, the most critical aspect of the balance were the deficiencies in providing the drinking water supply service. From the beginning of the Decade, coverage was presented as the primary indicator of success, that led the institutions to make emphasis in the massive construction of new systems, regardless of whether they were functioning or they were being used by their beneficiaries (Chandler, 1989).

The projects, in most cases, were promoted without involving the communities in their conception, development and execution, which divorced the interest and expectations of the beneficiaries from that of the institutions. On the other hand, proper integration with support programmes did not exist to make the efficient provision of the service possible (McPherson et al, 1987; Chandler, 1989; Yacoob, 1990; WASH, 1993).

The lack of community participation and an integral approach between projects and support programmes caused, among other things, the non-opportune detection and identification of systems problems. Monitoring and evaluation actions have been seen as costly, time consuming, and, wherever possible, avoidable. Another aspect was the lack of willingness and capacity of the institutions to change their operation to take account of the problems found by project evaluations (Warner, 1990).

In Colombia, a wide diagnosis of the country (DNP, 1991), indicated that the coverage average achieved was 66% in water supply and 51% in sewerage. This was greater in the large cities and decreasing to the rural level. In the communities of 12,000 inhabitants and less and rural areas where 41% of the total population is concentrated, the coverage only reached 24% in water supply and 8% in sewerage.

With respect to the drinking water quality, 51% of the 1,056 municipalities with water supply system included some treatment process, but 27% were out of operation and for the remaining 73% in operation, it was not clear if they reached their objectives. In the rural water supply systems, only 4% of these had completed treatment process, although, with the absence of an information system, their efficiency and reliability is also not known (CINARA, IRC, 1994).

The deficiencies in the drinking water quality supplied are evident. As is shown in Table 2.1, about 55% of the Colombian population was consuming water that was representing a health risk. The percentage increased with decreasing urbanization level (MoH-DNP, 1990).

TABLE 2.1 Percentage of the Population Consuming Drinking Water With Coliforms Count According to Urbanization Level[3]

LEVEL OF URBANIZATION	COLIFORMS COUNT		
	0	1 - 99	> 100
Dispersed Population	27.5	12.4	60.1
Localities < 2,500 Inhab.	29.8	14.6	55.6
2,500 to 10,000 Inhab.	36 4	18 3	45.3
10,000 to 100,000 Inhab.	25.7	23.1	51.2
100,000 to 500,000 Inhab.	60.0	24.8	15.2
500,000 to 1,500,000 Inhab.	79.1	10.9	10.0
Cities > 1,500,000 Inhab.	80.4	15.8	3.8
TOTAL	45.1	15.8	39.1

Source: MoH-DNP, 1990.

[3] Membrane filter technique was used. From the source of information, it was not clear about if Fecal or Total Coliforms units are reported in the study.

The problems generated by drinking water which does not fulfil the established quality standards, are reflected in the statistics of infant morbi-mortality due to gastrointestinal and parasitic diseases. More than 200,000 children are hospitalized and 50,000 die every year in Colombia (DNP, 1988).

The magnitude of the problem is probably worse than this considering that given some cultural standards and limitations, especially in the low resource sectors, there is great under-reporting. According to Bersh (1986), of each 10 cases of diarrhea, only one requests medical care.

A recent example of drinking water which does not fulfil the required quality, is the Cholera epidemic, where in the year 1991 a total of 12,210 cases and 208 deaths in 248 municipalities were reported, with deficiencies in their sanitary conditions (MoH, 1992).

In summary, in Colombia there is an important lag in the reliable and efficient provision of the drinking water supply and sanitation services, this being more critical in the rural areas and for the small and mid-sized municipalities.

This circumstance has generated angry protests by the communities, expressed in the form of marches and strikes, which in the period 1970-1985, 55% were the result of claims for drinking water. Of this percentage, 53% occurred in localities with less than 20,000 inhabitants (Santana Rodriguez,1989, quoted in CINARA,IDRC, 1991).

2.2. SUCCESSFUL PROJECTS. A NEW APPROACH IN THE SECTOR

After the Water Decade, the evaluations made agreed on the need for modifying the maximum coverage approach with new approaches that permitted better service and success. The success of the projects is achieved when the project produce the social, economic and health benefits expected, is sustained during a meaningful period of time and operated and maintained by the beneficiaries at a reasonable cost (Warner, 1990; Yacoob, 1990; UN, 1990; WASH, 1993).

McPherson et al (1987) and Pardon (1989), indicated that to achieve success, the projects must involve the use of an appropriate technology, one that can be understood and accepted by the users and hopefully largely maintained by them, and that the inclusion of the users in the project implementation is essential.

Several factors are involved in order to achieve better water supply service and success. In the meeting held in New Delhi (UN, 1990), it was considered community management, sustainability and cost recovery, as key aspects.

However, as the required objective is the sustainability of the projects, it depends to a large extent on achieving a reliable and efficient provision of the drinking water supply service. This also involves the selection and introduction of technology for drinking water quality improvement and the continuous monitoring and permanent evaluation of the systems.

2.2.1 Community Management

During the Water Decade, the sustainability of the systems failed very frequently because the community participation was only seen to be required at the construction stage of the works. It remained marginalized from the post-construction phases that make it possible to pass the responsibility, authority and control over the services development.

The experiences gained during the Decade permitted an almost unanimous consensus as to the important role that the community has in all the phases of a project, from its planning, design and construction, to its administration, operation and maintenance (Wijk-Sijbesma, 1985; Burges et al, 1988; McPherson et al, 1987; Pardon, 1989; Yacoob, 1990; CINARA, IDRC, 1990).

The communities should, from the initial phases of a project, be treated as partners and not as beneficiaries of the task to be executed (Wijk-Sijbesma, 1987). Their participation will not be full and conscientious if they are seen only as users and not as owners and managers of their systems (Yacoob, 1990).

As owners and managers, the community can be motivated to be involved in the reliable and efficient provision of drinking water supply service, so that the system, contributing to the welfare and community development, will have greater possibilities of being sustained by its beneficiaries. For this reason it is considered that the participation concept is very limited and that it must be modified toward the community management concept of the services (UN, 1990).

Community management is referred to the capacity and willingness of the users to take charge and to determine the nature of the project that affects them. This management is characterized by three elements (Warner, 1990): a) Authority, the community has the legitimate right to make decisions regarding the system on behalf of the users; b) Responsibility, because the community takes on the ownership of and the obligations to the system; c) Control, the community is able to carry out and determine the outcome of its decisions.

It is important to underline that community management, without the adequate institutional support, can be risky and inefficient. This aspect is basic, especially when the existing water supply system is being optimized using a technological alternative for the drinking water quality improvement, because for a community in a rural area or in a small or mid-sized municipality, it is very different to administer, operate and maintain a water supply system without a treatment plant than one that includes it.

For this reason, the selection and introduction of a technological alternative requires teamwork between the communities and institutions, through a careful analysis, in which are considered not only the technical, socio-economic and cultural conditions existing in the locality, but the effective organization of the community to participate in its sustainability.

2.2.2 Selection and Introduction of a Technological Alternative for Drinking Water Quality Improvement

There are many projects reported which did not perform the service for which they were built. In Kenya, McPherson et al (1984), found that only 40% of the rural

population which was supposed to have drinking water was well served (Quoted in McPherson et al, 1987). Lloyd et al (1991c), indicated that 100% of the small water treatment works in Peru, were not supplying drinking water according to the WHO guidelines.

Some studies have demonstrated that the incorrect selection of technology and the inappropriate use of it, has limited the success of projects (McPherson et al, 1987; Quiroga et al, 1991).

Galvis et al (1993a) indicated that the adopted technological solutions have not been in harmony with the water culture, nor with the management and technical capacity of the commissioned entity in charge of supplying the service.

Special emphasis was put during the Water Decade on the promotion and use of "appropriate technologies", so that they would be simple and low-cost for operation and maintenance. However, the cause of the problem has not only been the existence or availability of a variety of technological alternatives. The existence of "appropriate" technologies by themselves will not solve the water supply problems, because they are also prone to failure if not efficiently maintained.

Visscher (1992), specifies that the appropriate technology term is a myth and not a reality, that the emphasis must be aimed at the selection and appropriate use of the technological alternative, which must guarantee a high service level. The community must be willing to pay and have the institutional capacity for maintenance.

The commonly used technological alternative has been known as "Conventional", that involves such processes as coagulation, flocculation, sedimentation and rapid filtration. However, this technology, which with a correct design, construction, operation and maintenance is efficient, has severe limitations in regions with low or scarce socio-economic or technical capacity. Galvis (1991, 1993a), considered three criteria interrelated that will permit the selection and introduction of technologies:

* The evaluation of the sanitary risk associated with the water source, through methodical observations using sanitary inspection, water quality analysis and, if they exist, reliable epidemiological studies;

* The identification of the treatment technology that makes possible good quality drinking water production. The achievement of this objective is associated with two essential concepts: that of multibarrier treatment and an integrated treatment.

  - The multibarrier concept implies that more than one treatment barrier is required so that, in a consistent and progressive way, quality is improved. The disinfection stage will serve only as a final safety barrier (Lloyd, 1974; Craun, 1988; Lloyd et al, 1991b; Galvis et al, 1991).

  - The integrated treatment concept seeks to complement the multibarrier, because each treatment stage does not achieve equal efficiency in the removal of various types of pollutants. It is required that each barrier fulfil its function so that their deficiencies and limitations will be balanced throughout the process (Lloyd et al, 1991b).

* The establishment of community acceptance and management capacity, aimed at achieving adequate utilization of the adopted technological alternative, in response to the culture, the income level and willingness to pay, as well as the operation and maintenance by the local organization in charge of providing the service.

Although until recently it was unclear what was the best available and most adequate technology to deal with microbial and solids removal from polluted surface waters in developing countries (Lloyd et al, 1991b), projects developed by the University of Surrey (1982) identified the potential of the multistage filtration technology. Subsequently CINARA's research has achieved more than 4 log unit reduction of microbial contamination in pilot and full scale multistage filtration projects (Galvis et al, 1989, 1991, 1992b).

This alternative has low economic and technical requirements, high community acceptance and sustained performance if it is administered, operated and maintained adequately (Pardon, 1989; CINARA, IDRC, 1990).

2.2.3 Cost Recovery

Briscoe (1992), indicated that some donor entities have promoted an approach, that supposes that the poor would have to be supplied with a lower service level because they do not have the capacity to support more "costly" alternatives.

The experiences obtained during the Water Decade, show that this concept is very

far from the reality. The economic sustainability of a system, depends on the reliable and efficient provision of the drinking water supply service, responding to the needs and expectations of the users. It has been verified that, when this service level is reached, the beneficiaries are willing to pay for the water charges (Briscoe, 1992).

The citizen values the availability of the service more, and is prepared to assume its cost, if this is supplied with adequate levels of quality and reliability. Effective demand of the service and willingness, more than the ability to pay, are converted thus into a determinant factor for the sustainability of a water supply system.

Jimenez (1988) makes reference to the initial failure of a project of the Thailand government which dug wells and installed communal hand pumps, when the community preferred their ancient surface water sources with domestic connections. After proving the under utilization of the system and with community involvement, the system was improved and five years later, its functioning costs were completely covered by its users, in spite of the high water charges.

Franceys (1990) summarizes the factors that, according to Whittington (1987), make it possible to achieve the willingness to pay: perceived health benefits; convenience; amenity; time saving and economic benefits; level of service; existence of alternative sources; income; price; different uses; different determinants; value of women's time; and family size.

To achieve a reduction of time and effort of women and children in getting water, is highly valued by the communities because their productive capacity is improved.

Jimenez (1988), indicated that in transporting water and waiting in line to obtain it, the women in Kenya, Korea and Colombia spend 15% of their available time.

Cost recovery in this context, is understood as the full recovery of the operational cost, in addition to a portion of the construction cost. Cost can be recovered through tariffs, which should be established based on four objectives: equity, autonomy, efficiency and expansion of the service (WHO, 1987). To achieve financial viability it is required that the average tariff guarantee that the operating cost will be covered totally, as well as maintaining a reserve fund to support the system (WHO, 1990).

There are various methods proposed for cost recovery. One of them is a standard rate to the user according to consumption, which involves monthly fixed charges by connection and charges based on the consumption record read on a water meter.

In the case of the fixed charges it is considered that its greatest disadvantage is in not encouraging the care in the water use, and that users pay the same without taking into account its consumption and economic possibilities, although for the organization or supplying entity of the service it is easy to administer. The charges depending on consumption are advantageous because the volume of used water can be related to the cost, in addition to motivating the careful use of water.

The measurement option of water consumption has two tariff collection systems that can be used: A fixed charge per unit provided, and supplied unit charges for different consumption levels or types of user. It is considered that the measurement requires an efficient administration of the water supply system, therefore their pros

and cons have been established to guide the decision of its utilization (WHO, 1987, 1990).

Cost recovery requires, in part, not only adequate financial policies, but also the decisive support and community involvement, which implies encouraging attitude and behavior changes of all involved in the drinking water supply service.

On the other hand, the guarantee of autonomy and authority of the local managing entity is required in order to avoid the manipulation by political interests limiting the financial viability of the service, through the freezing of tariff adjustments or the use of income for purposes other than the consolidation of the service (WHO, 1990).

2.2.4 Monitoring and Evaluation of the Drinking Water Supply Systems

To achieve sector success, it is required to develop a well-designed planning procedure which integrates projects and support programmes. This process makes it possible, with a teamwork among the institutions and communities, to seek the better mixes of "hardware" (works) with "software" (support programmes) (Chandler, 1989). With unification of interests, capacities and expectations, the operation, maintenance and management of the systems, even in the most critical situations is achieved.

However, the technological solutions adopted which affect the life of the communities, require the evaluation and assessment of those aspects that affect the fulfillment of its objectives, in order to opportunately detect and identify their

problems and limitations. This is aimed at taking the necessary corrective measures. The continuous monitoring and permanent evaluation of the system is essential to supervise the quality of service provided. CINARA, based on proposals by Lloyd et al (1987), has adapted the parameters which measure the quality of service of drinking water supply:

Quality	Suitable for human consumption and low sanitary risk, that does not deteriorate the distribution system;
Quantity	Sufficient for domestic use. Other consumption under feasibility and profitability studies;
Coverage	Accessible to the greatest number of users. Equality in provision of service;
Continuity	Available 24 hours per day all year;
Cost	Equality for all the users and enough to make the maintenance of the system possible;
Management Capacity	Organization and technical and management capacity of the local level, for operation, maintenance and administration with minimum external support;
Water Culture	Customs, community beliefs and local water uses referring to the water sources utilization, protection and care.

Chandler (1989), indicated that while evaluation of project outputs (primarily works) has been outlined widely, the evaluation of programme components has received little attention. In this sense, he proposes several indicators to measure the

adequacy of support programmes to ensure long-term functioning and to promote continued utilization of the constructed facilities:

* In the first aspect: a) Successful delegation of responsibility and authority to local institutions by central government; b) The operation and maintenance record at the local level; c) the adequacy of revenue generation to meet recurrent cost; and d) the availability and adequacy of training programmes for the staff of local institutions.

* In the second aspect: a) the convenience of the facilities, from the user's point of view; b) user's satisfaction; c) knowledge and skills of community members in the use and maintenance of the technology; d) community attitudes and beliefs toward health; e) the availability of a support programme to foster hygiene education at the local level.

Warner (1990), suggested that it is necessary to establish new concepts applied to monitoring and evaluation of the projects, and proposed considering the following elements: a) Sustainability, referring to the ability of a project to continue to provide intended benefits for a significant period of time after building; b) Replicability, referring to the project characteristics which allow it to be readily duplicated elsewhere; c) Participatory evaluation, referring to the involvement of project users in the monitoring, analysis, evaluation, and subsequent modifications of their project, making possible the stimulation of their sense of responsibility, authority and control.

The monitoring and evaluation of the water supply systems, known as the water

surveillance and quality control programme, allows for greater links among users, suppliers and regulators, so that a joint action is established and maintained. This makes possible the efficiency of the provision of the drinking water supply service and is supervised for its sustainability.

In Colombia, in the period 1983-1984, the Ministry of Health, provided the elements to promote a water quality control programme oriented towards making possible the fulfillment of decree 2105 of July 26 of 1983. Members of the working group, now assigned to CINARA, participated in the elaboration of an action plan that gave response to that interest, which included surveillance and control activities (Galvis et al, 1984).

In spite of these efforts, the programme was not implemented. Some of the factors that affected this were the lack of: personnel, training, budget, procedures manual, equipment, and of political decision and support (MoH-DNP, 1990).

Although these factors are important, the development of water surveillance and quality control programme in Colombia has been limited additionally by conceptual as well as institutional factors. Some of these are (Quiroga, 1990b):

- The actions of the water surveillance agency have been understood only as inspection tasks in order to identify whether the regulations are not fulfilled according to the law, and to apply the corresponding punishment, without systematically offering follow up solutions or advising and instructing the communities to fortify their management capacity;

- Surveillance and monitoring has been considered only an external activity, without the participation of the community as an internal safeguard of the water supply service. The community does not possess information channels either with the surveillance agency or with the water supplier. Its only reference point to the service is its direct relationship with the operator;
- There has been confusion as to the respective roles and responsibilities of the surveillance agency and the water supplier;
- There is an absence of a strategy and a national plan for the implementation of the programme, which includes the socio-economic, cultural, and historical conditions and the existing policies in the various regions of Colombia.

The drinking water supply surveillance programme, is defined by the WHO (1985) as **"the continuous and vigilant public health assessment and overview of the safety and acceptability of drinking water supplies"**.

The programme is a tool that makes possible the opportune detection, identification and evaluation of deficiencies and limitations that affect or can affect the adequate and normal functioning of a system. It guides the water suppliers, as well as the surveillance and support institutions in prioritizing the improvement actions to be taken. These should be in agreement with the existing sanitary risk level, thus maximizing the efficiency of the use of the available community and institutional resources.

Surveillance and quality control are complementary and compatible activities directed towards guaranteeing not only the quality of the water produced and

supplied, but also the quality of the service in its entirety.

Surveillance is a regular, investigative, preventive and remedial activity (WHO, 1992/93), whose actions imply a periodic audit of all aspects of the system, that systematically and methodically provide a series of referred observations not only on the quality of the water, but at the same time on the functioning, utilization and administration of the system. These are vital aspects in establishing its reliability and efficiency, ensuring that action is taken before public health problems occur.

The information that surveillance generates can be employed to analyze and evaluate the viability and fulfillment of regulations and codes, and to thus adopt corrective measures or to establish support actions or necessary regulations. This analysis of data is very important because in this way the water surveillance programme, which by law is the responsibility of the Ministry of Health in Colombia, is not only an inspection process, but a regulatory activity as well.

In the first instance, the feasibility of developing strategies and actions aimed at progressive improvement must be taken into account, in which the community involvement is an essential element to guarantee its efficiency and maintenance.

Quality control is a dynamic and routine activity for monitoring the supply system, aimed at detecting and eliminating defects that result in water production and distribution which is not suitable for human consumption (Battalha et, 1977). It implies maintaining a continuous evaluation of the production process as well as distribution, from the watershed to final consumption. This is a responsibility of the

water supplier (Lloyd, 1991a).

One of the most important aspects of the surveillance programme, is the creation of favorable conditions for the citizens' participation processes, that stimulate the sense of commitment and ownership regarding the water supply systems.

In this way, communities are the managers of their own tasks (Max-Neff et al, 1986), because they make possible the ability to find solutions in agreement with the local conditions, which make possible their sustainability with minimum external support.

The surveillance and quality control programme is a tool for the real construction of a process of decentralization and municipal and community development, complying with the Colombian governmental policy for the Institutional Development of the Municipalities, whose central objectives are to: **"i) Make more efficient the provision of municipal services and management of resources; and ii) Readapt the operation plans, adopting managerial instruments that involve the community in planning and local management"** (DNP, 1993).

CHAPTER 3

OBJECTIVES

3.1 GENERAL OBJECTIVE

To evaluate the factors that make the reliable and efficient provision of the drinking water supply service possible, as well as its sustainability with a minimum of external support.

3.2 SPECIFIC OBJECTIVES

i) To evaluate the efficiency of the multistage filtration technology for water quality improvement, in a project administered, operated and maintained by a community organization at the local level;

ii) To evaluate the quality, quantity, continuity, coverage and costs, as factors that influence the reliable and efficient drinking water supply service;

iii) To evaluate community management, cost recovery and participatory evaluation, as factors that influence the sustainability of the system;

iv) To make available the experiences gained, and consider the possibility of their replication.

CHAPTER 4

MATERIALS AND METHODS

4.1 INFRASTRUCTURE FOR THE STUDY DEVELOPMENT

This study used the results of the evaluation made of the existing water supply infrastructure in the disaster zone produced by the Nevado del Ruiz volcano eruption (Quiroga et al, 1991). CINARA's experiences in the research, development and technology transfer (TRANSCOL) programme for drinking water quality improvement were applied to the project.

The research was done in a full scale demonstration project, as a strategy that enables us to obtain information on the maintenance and socio-economic acceptance of the technological alternative.

The project was developed in the locality of San Felipe, located in the north of Tolima department, central zone of Colombia (Figure 4.1). The locality is 106 Km from the department's capital. The land is flat and is 450 m above sea level, with an average temperature of 27° C.

The community has 120 houses and approximately 650 inhabitants of which the great majority are peasants. As it is located on the main route that links this zone

with other regions of the country, there is an abundance of tourists. There are two centers of primary basic education, a health post and police station, rural electrification and telecommunications service.

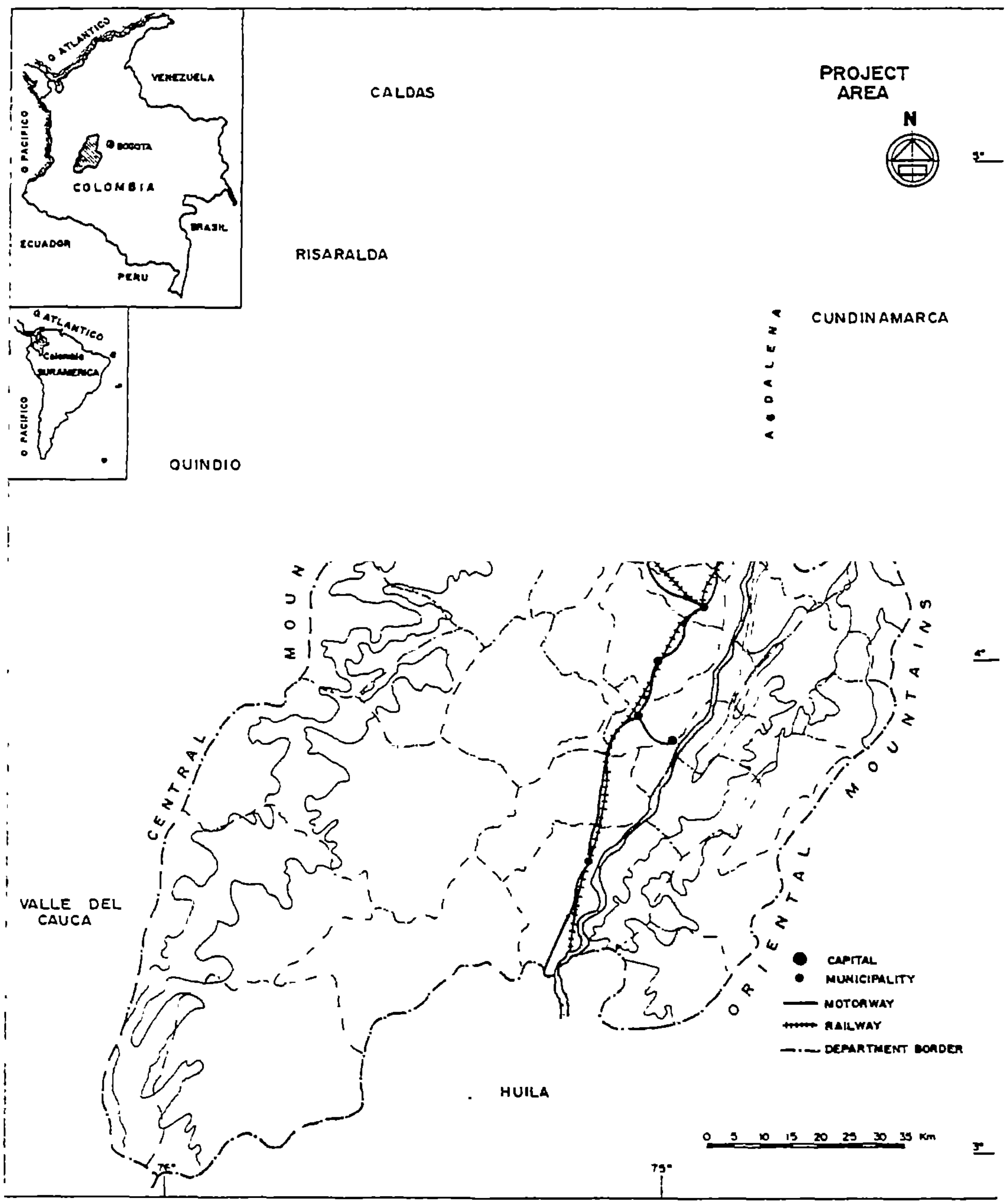

FIGURE 4.1 Project Area. Tolima Department.

4.1.1 Criteria for Selecting the Community

For the demonstration project the San Felipe locality was selected based on a series of criteria which take into account the technical, economic and social viability of the project:

* The community is widely representative of rural communities of the area;
* It has active community leaders in search of solutions to their various problems;
* The community, knowing of the poor water quality, were in agreement with the improvement measures of the system;
* Public sector agencies, interested in the experiences to promote its replicability in other regions, were present in the area;
* The locality and the treatment plant are located in a zone with very easy access and have facilities, especially adapted for monitoring, evaluation, training and dissemination or transfer of the experiences gained.

4.1.2 State and Optimization of the Water Supply System

To facilitate the interpretation and discussion of the results, some considerations on the state of the water supply system before the present study are presented.

The gravity system, was built in 1968, enlarged in 1979, and using the investment funds made available after the Nevado del Ruiz volcano disaster was improved in 1987, including the sand filtration plant. The system consisted of: intake, conduction line, sedimenter, up-flow slow sand filters (with filtration velocity of 0.40 m/h),

storage tank with a capacity of 70 m^3, disinfection and distribution network in a length of more than 8 kms. The network was improved in 1984 and some water meters were installed that were rejected by the community.

The system is supplied by the Murillo river, which upstream of the intake receives the residual water discharges from Falan municipality (2,125 inhabitants) and wastewater originating from washing coffee beans.

An evaluation of the water quality supplied by the system, showed microbial contamination and turbidities in a range of 22-300 FC/100 ml and 5-40 TU (CINARA, Tolima Health Service, Robens Institute, 1989). Terminal disinfection was not applied. The treatment plant was not operating adequately, and in the rainy season was "by passed", because:

* The upflow slow sand filters and sedimenter were the only treatment barriers;
* Given the absence of a roughing pretreatment system and the high filtration velocity[4], in the rainy period, the turbidity peaks were penetrating the slow sand filtration units, forming (Figure 4.2) a mud cap of almost 6 cm thick in the upper part of the sand beds;
* There were no entry structures, nor flow control regulators;
* Due to construction deficiencies, the walls of the slow sand filters remained smooth, causing short-circuits in all the structure; furthermore, for lack of protection of the filtered water, the effluent was poor;
* The sand Washing was deficient due to the upflow wash process that was very difficult for the operator.

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[4] The design flow was of 5.0 liters per second (lps). However, in the system evaluation it was found that the flow affluent was 7.0 lps, which was generating a filtration velocity of 0.56 m/h.

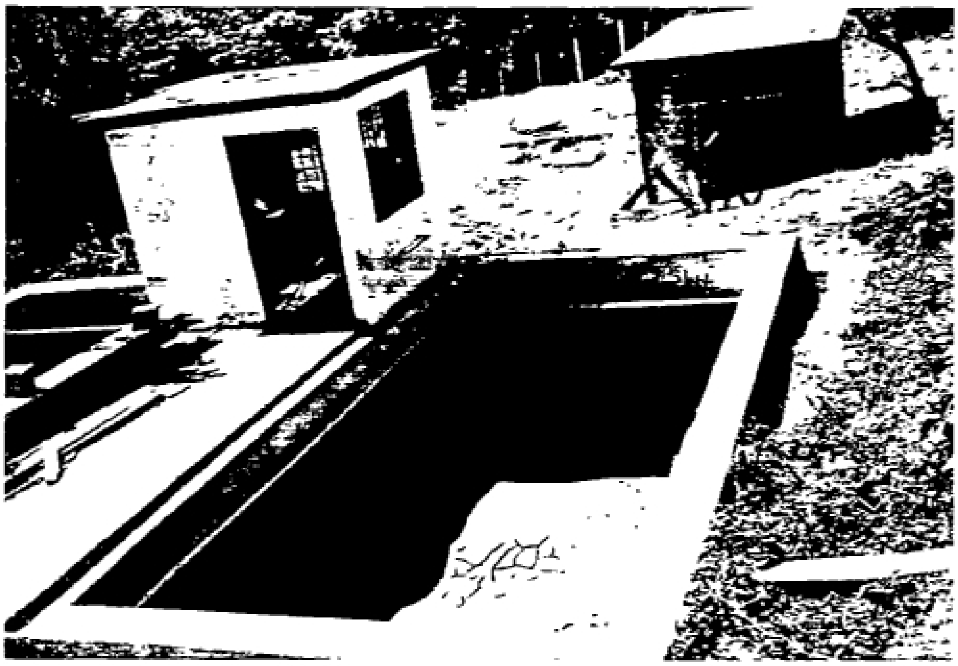
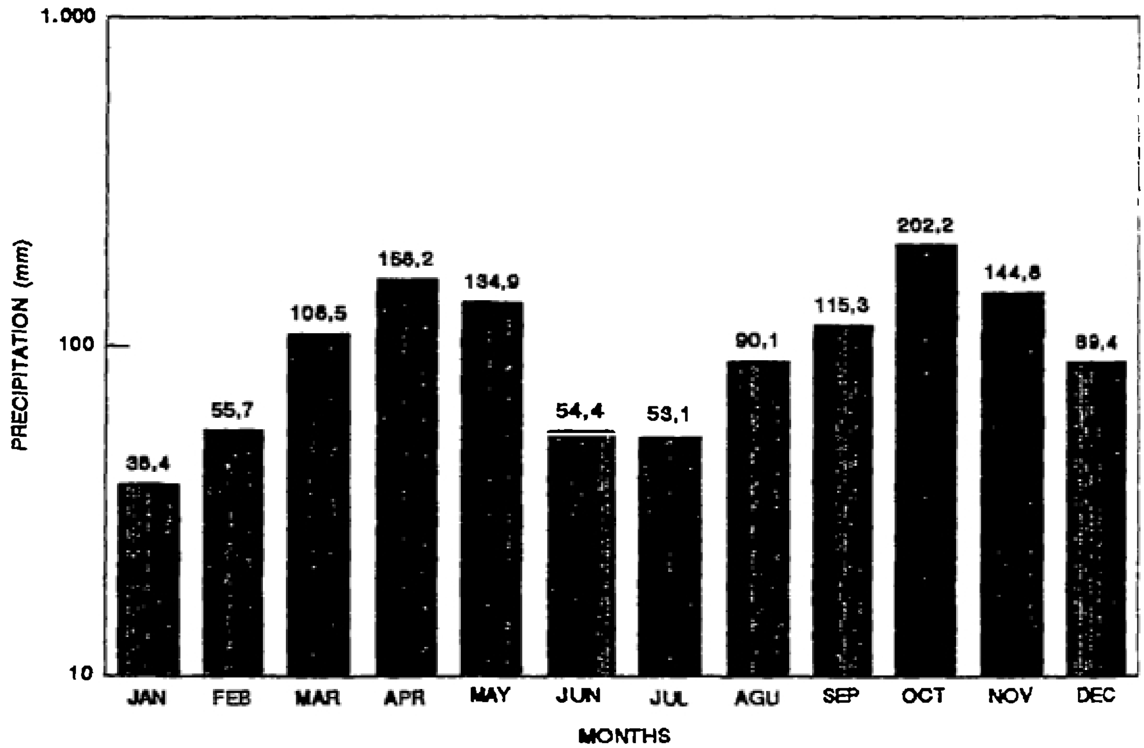


FIGURE 4.2 Mud cap in the upper part of the up-flow slow sand filter bed.

The treatment plant was redesigned in May 1989 for the optimal improvement of the system. The design of the treatment barriers was based on: Pluviometric information (Figure 4.3), where according with data from 18 years, the rainy season is in between March-May and September-November of each year, with a maximum precipitation of 202,2 mm on average; raw water quality study (Table 4.1); the results obtained from a research project in pilot units for processing water from a valley river (Cauca river) (Quiroga, 1988), and also on treatment plants processing water from mountain rivers, all located in the Department of the Valle del Cauca in the southwestern region of Colombia (Galvis et al, 1989).



SOURCE: HIMAT,1989

FIGURE 4.3 Pluviometric Precipitation Histogram Camp. Ambalema Station (1968-1986)

TABLE 4.1 Faecal Coliform Descriptive Statistics. Murillo River (FC/100 ml). 3th March - 27th December 1989

DESCRIPTIVE STATISTICS	RAW WATER LOAD
Mean	153
Standard Dev.	75
Min	50
Max	350
No Samples	18
95% Confidence Limit	(118-187)

The treatment barriers selected, including a new CINARA development in pretreatment stage, have been introduced in the multistage filtration technology, enabling the removal of most bulk material in the first stage while the following ones remove fine particles and microorganisms (Galvis, 1992c).

The system's improvement included the following stages:

Dynamic Roughing Filtration (DyRF), that includes a fine gravel layer on the surface and another of roughing gravel in contact with a lower drainage system. The filtration is downflow. The cleaning is done once or twice a week raking the fine gravel layer (Galvis et al, 1991). The old sedimenter structure was modified for the new DyRF treatment barrier.

Upflow Roughing Filtration in Layers (URFL), consists of a single unit with different size gravel in layers from bulk in the bottom gradually becoming finer towards the surface. This stage has the advantage that the retention of the solids occurs in the lower part of the filtering bed, therefore its removal is very easy through the drainage system of the unit (Galvis,1992c).

Slow Sand Filtration (SSF), designed with the inflow control, starts the filtration run with a minimum water level of almost 20 cm, required to overcome the losses with a clean filter bed and gradually to increase the level as the sand becomes dirty, which permits flexible operation of the system without demanding too much time in its control (Visscher et al, 1992b). A new unit was designed in order to reduce the SSF filtration velocity.

Energy dissipation structures were designed for the water inflow to the slow filters.

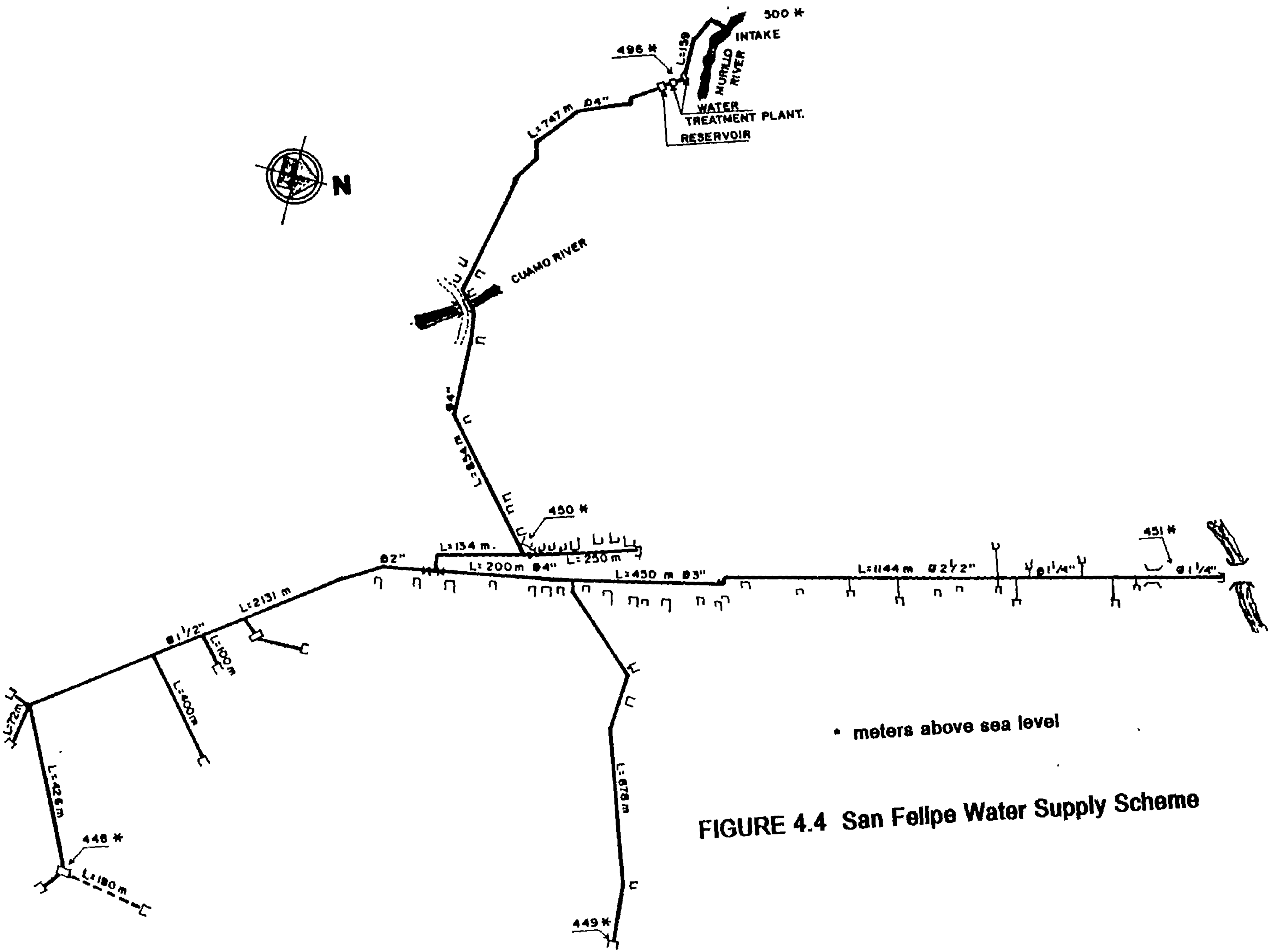
Also structures for the storage of washed sand and for its washing after each scraping were designed. In Figures 4.4 to 4.11 and Table 4.2, the San Felipe water supply scheme and the redesigned water treatment system and basic parameters used are shown.

The construction phase was begun in June of 1990 and was finished in March of 1991. Subsequently it was put into operation.

TABLE 4.2 Basic Design Parameters

FLOW (l/s)	ROUGHING FILTRATION									
	DyRF					URFL				
	GRAVEL BED		# UNITS	AREA PER UNIT (m^2)	FILTRATION VELOCITY (m/h)	GRAVEL BED		# UNITS	AREA PER UNIT (m^2)	FILTRATION VELOCITY (m/h)
	SIZE (mm)	DEPTH (cm)				SIZE (mm)	DEPTH (cm)			
3.5	6.0-9.0	20.0	1	2 76	4.5	3.0-6.0	30	2	8 4	0.75
	12.0-19.0	25.0				6.0-12.0	30			
	19.0-25.0	20.0				12.0-19.0	30			
						19.0-29.0	30			

SLOW SAND FILTRATION					
# UNITS	TOTAL FILTRATION AREA (m^2)	FILTRATION VELOCITY (m^2)	SAND SIZE		SAND DEPTH (cm)
			D_{10} (mm)	C_u	
3	84	0 15	0.19	2.0	100.0



* meters above sea level

FIGURE 4.4 San Felipe Water Supply Scheme

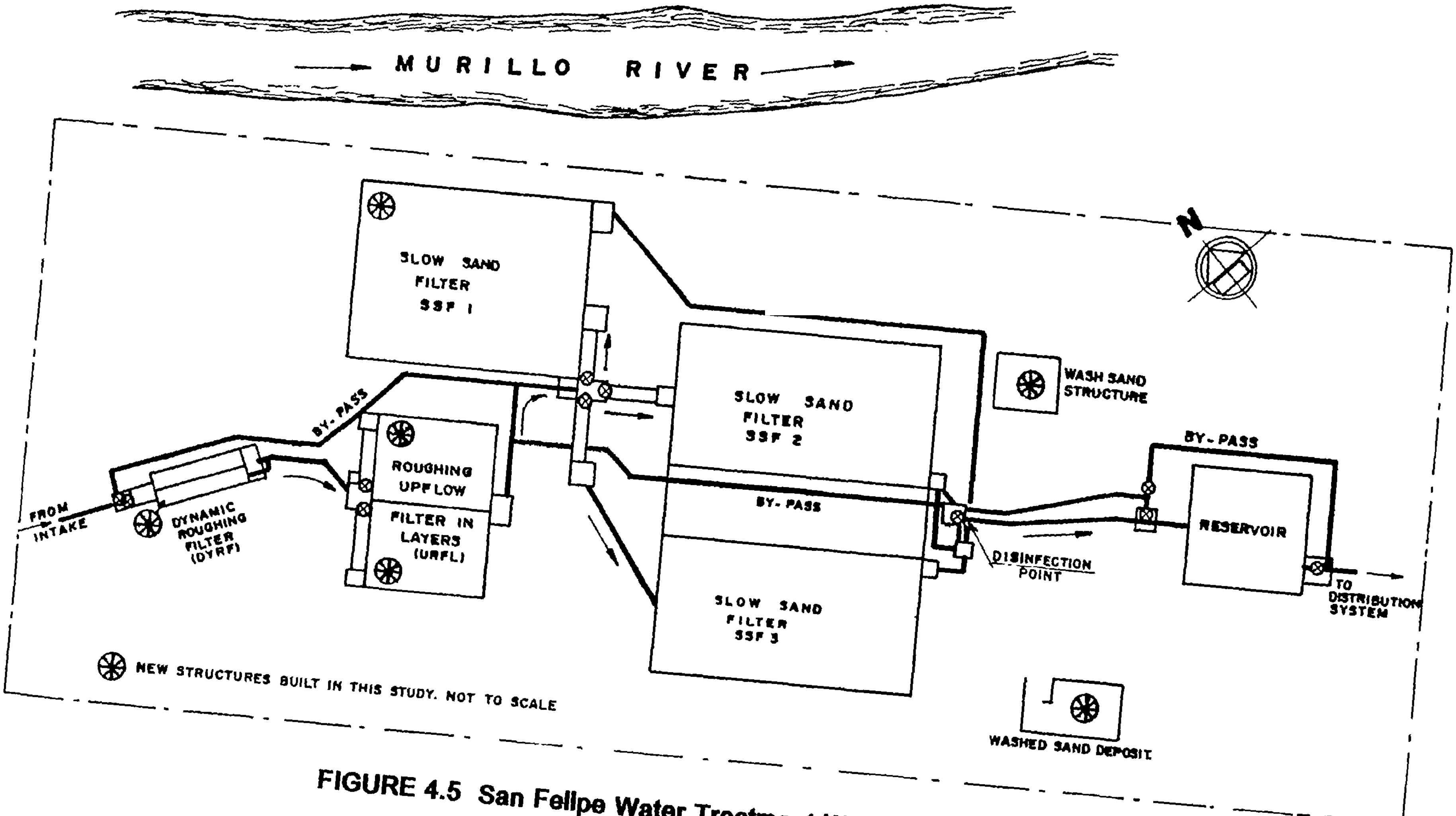


FIGURE 4.5 San Felipe Water Treatment Works Rehabilitation.

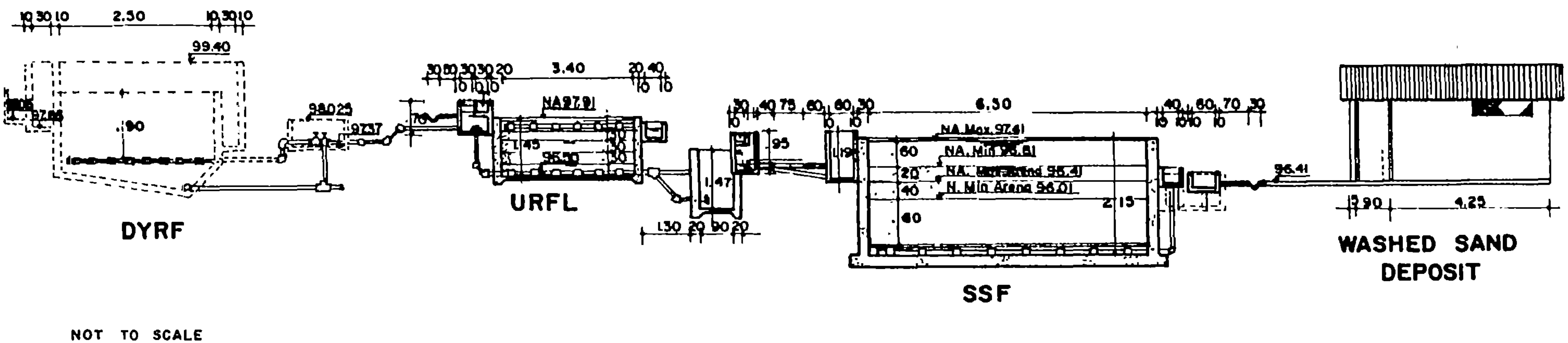


FIGURE 4.6 Profile of the San Felipe Water Treatment Works.

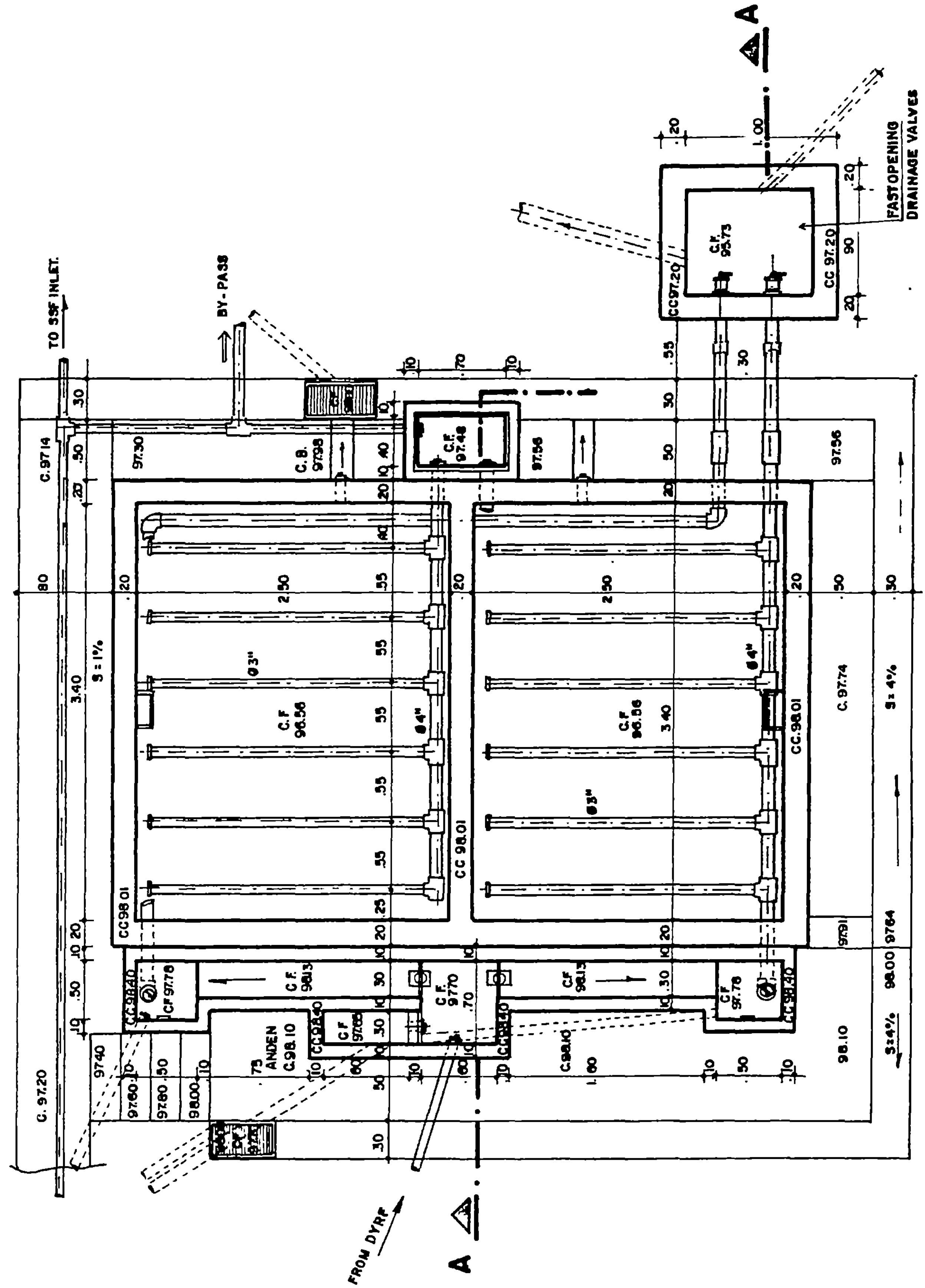


FIGURE 4.7 Plan View of the Roughing Filters in Layers. San Felipe Water Treatment Works.

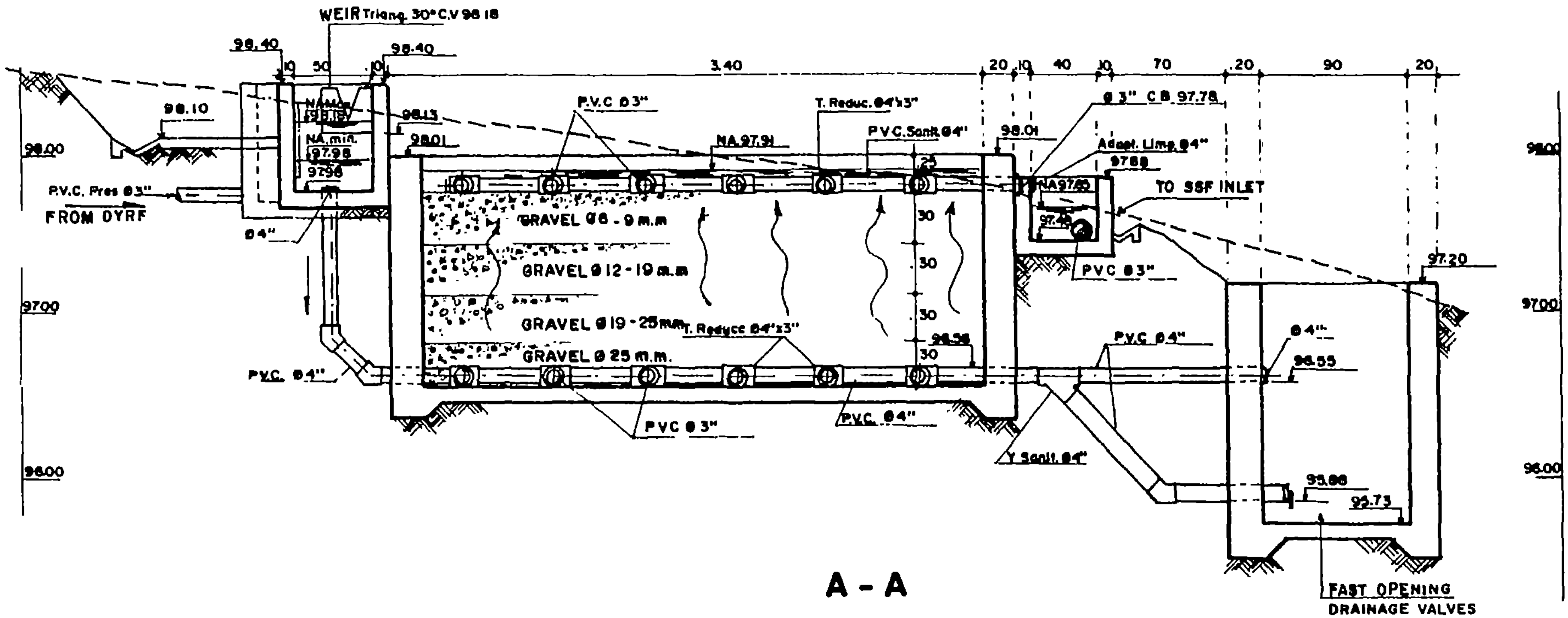


FIGURE 4.8 Side View (A-A) of Upflow Roughing Filters in Layers. San Felipe Water Treatment Works.

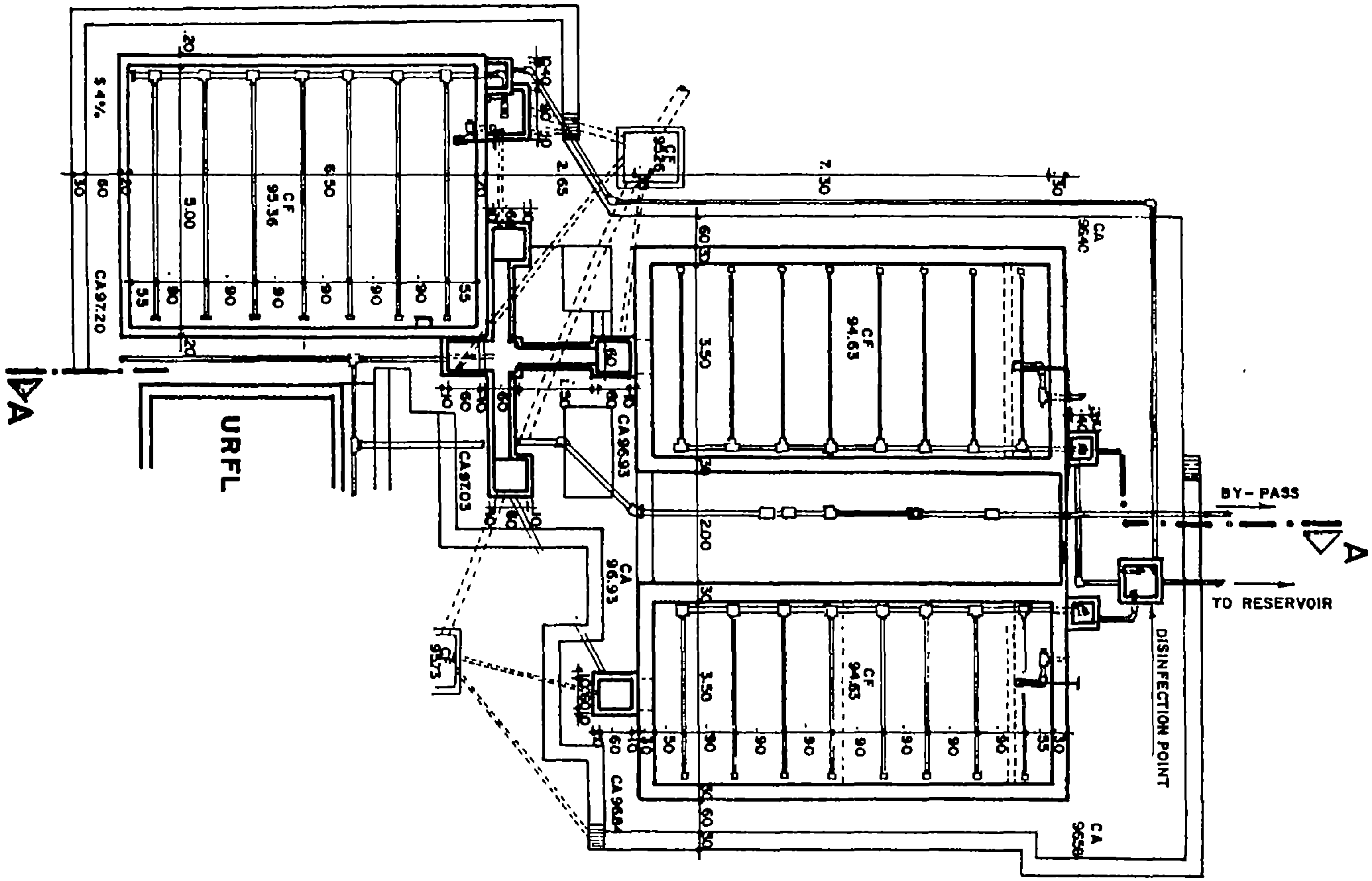


FIGURE 4.9 Plan View of the Slow Sand Filters. San Felipe Water Treatment Works.

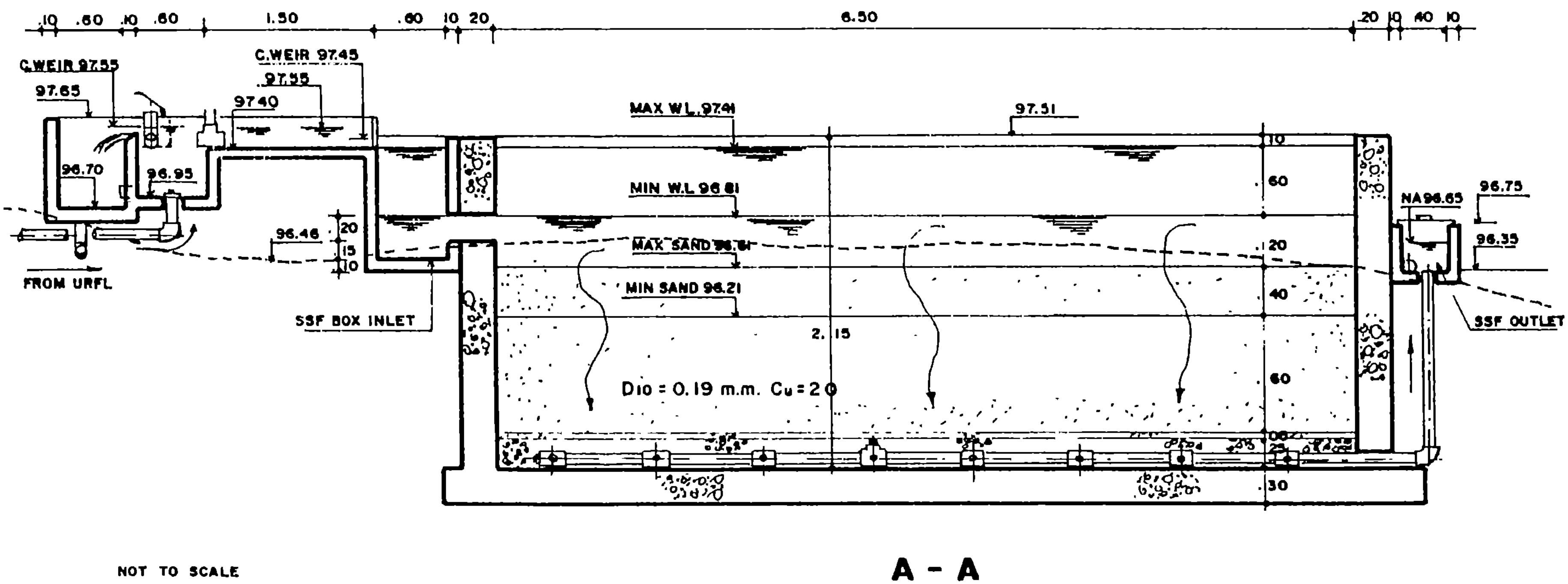


FIGURE 4.10 Side View (A-A) of the Slow Sand Filters. San Felipe Water Treatment Works

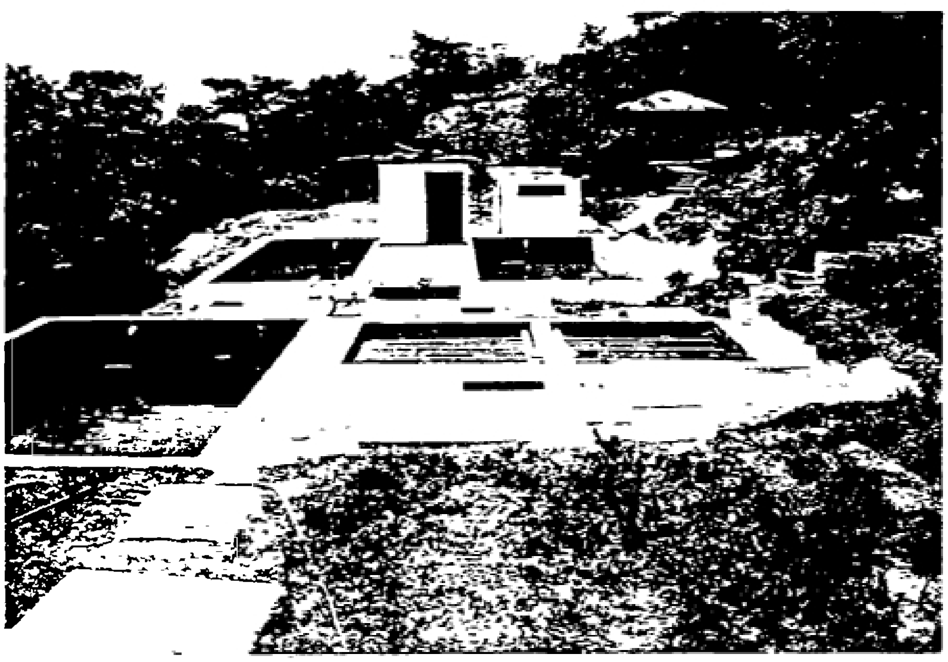


FIGURE 4.11 DyRF, URFL and SSF structures. San Felipe Water Treatment Works.

4.2 EVALUATION PROGRAMME

The evaluation programme was designed so that it encompassed the technical aspects, essential to know the performance of the technology, as well as the social, economic and administrative aspects. The evaluation was conducted between August 1991 to May 1994. A follow up evaluation was carried out on September/94.

The parameters evaluated that measure the reliable and efficient drinking water supply service provision were quality, quantity, coverage, continuity and cost. Simultaneously the flow (lps) and frequency of the slow sand filter scraping were measured and registered. Other parameters associated with the sustainability of the drinking water supply service were evaluated, such as community management, cost recovery and participatory evaluation.

4.3 PROCEDURES AND METHODS OF ANALYSIS

The field information was gathered through sanitary inspections and water quality analyses. After functioning the treatment plant, a census of users and damage to domestic connections and sanitary appliances was conducted. Water Board members and the operator took part in these activities. The forms used were prepared as developed in the Peru surveillance programme (Lloyd, 1991a).

Through the initiative of the community, which assumed the cost, water meters were installed, which registered monthly water consumption. This allowed an analysis of the percentage of rate collection and the financial management of the system.

4.3.1 Points and Sampling Frequencies for Water Quality Analysis

The sampling points included the raw water, the effluent of each treatment stage and the distribution network. The sampling frequency was adjusted according to the decree 2105 of 1983 of the Colombian government related to drinking water.

The water quality analyses were made on site, once a month on average by the sanitary inspector and it was hoped that the operator would make critical water quality analysis daily. Field testkit equipment was supplied and training was given to the sanitary inspector and operator and members of the Board in its use and in the adequate system operation and maintenance.

4.3.2 Methods of Analysis

In water quality monitoring, the "DELAGUA" portable testkit was used. This equipment, designed by Lloyd according to his proposal of examining a water supply system more frequently employing reliable but simple tests, instead of a series of analysis which were more complete but less frequent. It involves the use of more critical parameters for determining the drinking water quality and its sanitary risk by sanitary inspection (Lloyd, 1991a; WHO, 1992/93):

Turbidity (TU). This was measured using the column that comes included in the testkit. In Colombian legislation the acceptable limit is 5 TU for drinking water. This equipment allows for visualizing the acceptability limit on the part of the user.

pH and Residual Chlorine (mg/l). These parameters were measured using a color comparator. pH is determined with the use of Phenol Red pills and the residual chlorine with DPD1 pills.

Fecal Coliforms (FC/100 ml). The determination was effected through the filtration technique using Gelman membrane filters of 0.45 μm porosity, with Lauryl Sulphate broth of Oxoid as a means of cultivation. The processing of the samples was made using the field test equipment, which includes an incubator with the temperature regulated to 44.5° C. The filtration volumes used were those recommended by the Standard Methods (1989), thus:

Raw Water	10 and 1 ml
Conditioned Water	50 and 10 ml
Prefilter Water	100 and 50 ml
Filtered Water	100 ml
Distribution Network	100 ml

Flow (lps). The affluent was measured using triangular weirs with a 30° notch, for which flow rate can be obtained by the relation: $Q = 0.246\ H^{2.5}$ (King, 1962).

4.4 INTERPRETATION AND INFORMATION MANAGEMENT

The interpretation of the information was made through the quality comparison of affluent and effluent water of each treatment stage and the distribution system. The efficiencies and the accrued frequencies for the data obtained in each one of the points selected were determined.

FIGURE 4.12 Sanitarians working with "DELAGUA" portable testkit in San Felipe distribution network.

The monthly consumption was registered by water meters. After their installation, the Water Board decided, without affecting the tariffs, to make the readings over five (5) months. The readings were taken by the operator with the support of the treasurer, so that sufficient information on the consumption trends was available to make decisions.

The information gathered was analyzed using the SAS statistical package, to assess user's average consumption by range, percentages of the total consumption by average range of consumption and monthly consumption for those users that consume volumes in the range of over 100 m^3 and less than 100 m^3.

The report was made monthly by the sanitarians to the Water Board, the

headquarters of the Tolima Health Service in Ibague, as well as to CINARA in Cali. For this a form was used, which was prepared and amended by the regional surveillance agency.

The information gathered in the sanitary inspections, the results of the water quality analyses and of the users and damage census, were communicated to the community in general user assemblies, where the institutional as well as community corrective measures and responsibilities were discussed and agreed upon, to overcome the problems found.

CHAPTER 5

RESULTS AND DISCUSSION

The sustainability of the San Felipe drinking water supply system, according to the criteria proposed by McPherson et al (1987), Warner (1990), Yacoob (1990), UN (1990) and WASH (1993), has been achieved because the provision of drinking water supply service has been efficient and reliable, for which the community management and institutional support have been essential aspects.

The functioning and utilization of the facilities in an efficient and reliable way, which are indicators of a successful project (Chandler, 1989; Hammeijer et al, 1993), has made it possible for the beneficiaries to obtain satisfaction of their needs and to sustain the achieved service level. Three parameters are directly related: the quality, quantity and continuity of the water supplied.

5.1 QUALITY ISSUES

The microbial quality of the water produced by the treatment system, considering the classification proposed by Lloyd et al (1991b)[5], changed from the C/D range to A/B, without including the disinfection stage.

[5] This classification considers the microbiological quality of the water, in terms of colony counts per 100 ml, in ranges thus: A= 0; B= 1-10; C= 11-100; D= 101-1000 and; E> 1000.

Tables 5.1, 5.2 and Figure 5.1, show the descriptive statistics and efficiencies of the treatment system, which was 99.85% with a bacterial reduction of 2.83 log units on average, comparable to the plants operated in the Valle del Cauca department, where this efficiency has been between 2.7 and 4.8 log units (Galvis et al, 1991).

There are no pH data presented, because there was not a meaningful variation and disinfection was applied until July 1993, with many interruptions, due to availability problems with calcium hypochlorite and with its correct dosing.

TABLE 5.1 Faecal Coliform Descriptive Statistics. San Felipe Water Treatment Works. August 1991 - May 1994.

DESCRIPTIVE STATISTICS	RAW WATER LOAD	DyRF	URFL	SSF1	SSF2	SSF3	DISTRIBUTION NETWORK
Mean	3,295	630	280	6	4	5	7
Standard Dev	19,053	1,882	612	8	9	7	8
Min	54	18	10	0	0	0	0
Max	138,000	13,800	4,370	50	60	30	40
No Samples	51	51	51	50	50	50	51
95% Confidence Limit	(0-8,524)	(114-1,147)	(112-447)	(3-8)	(2-7)	(3-7)	(5-9)

TABLE 5.2 Performance of San Felipe Water Treatment Works. August 1991- May 1994.

PROCESS STAGE	FAECAL COLIFORM AVERAGE*/100 ml	LOG. UNITS		% REDUCTION	
		IND.	CUM.	IND.	CUM.
RAW WATER LOAD	3,295	-	-	-	-
DyRF	630	0.72	0.72	81 00	81.00
URFL	280	0.35	1.07	55.56	91.50
SSF 1	6	1.67	2.74	97.86	99.82
SSF 2	4	1.85	2.92	98.57	99.88
SSF 3	5	1.75	2.82	98.21	99.85

*** Means of 51 data in points after each stage of treatment.**
IND. = Individual units.
CUM. = Cumulative.

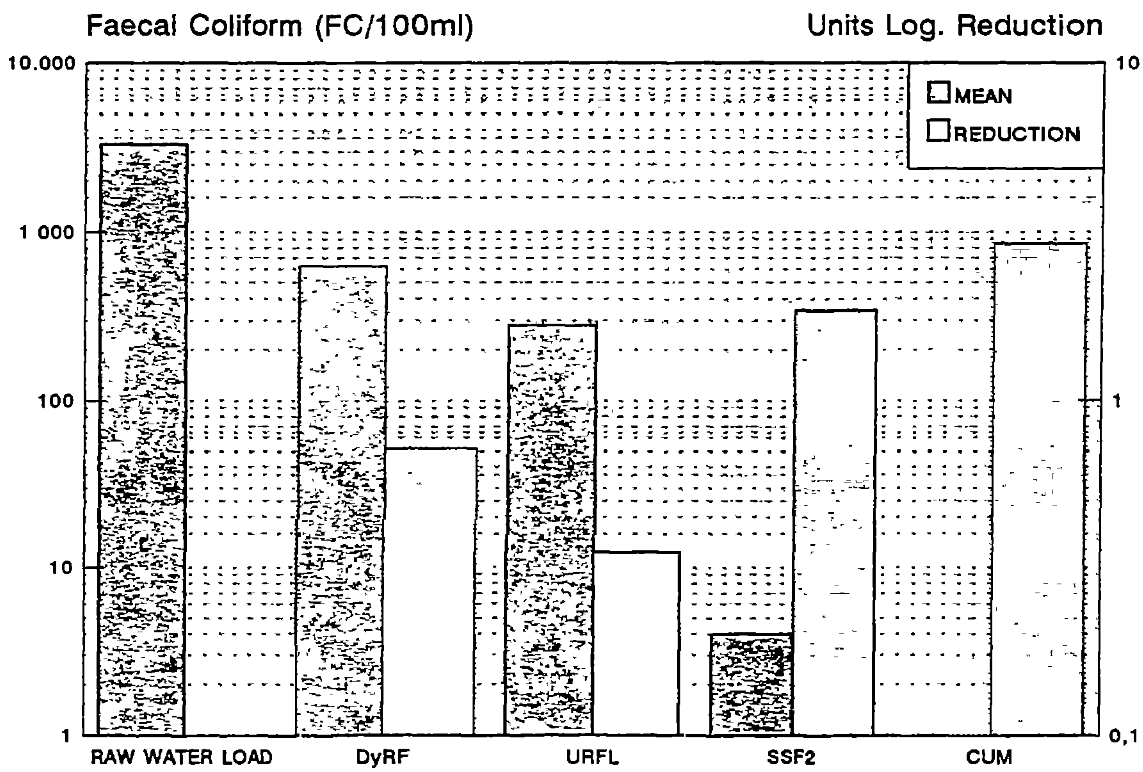


FIGURE 5.1 Average Removal Efficiencies of San Felipe Water Treatment Works.

With respect to turbidity, an evaluation of raw water conducted between March 3 and December 27 of 1989 show turbidities in a range of 5-40 TU in 14 samples. Some representative samples taken in 1992, and during the period between March 29 and May 8 of 1994, as is presented in Table 5.3, show turbidities in a range of 75-700 TU. This turbidity increase due to accelerated deforestation in the watershed. This affected the filtration runs of the slow sand filters, that initially were of four months on average, and were reduced to one and half months. In other plants the runs have been maintained at over four months (Galvis et al, 1991).

TABLE 5.3 Removal of Turbidity Peaks in the Different Stages of the San Felipe Treatment Plant in the Rainy Season

DATE	RAW WATER LOAD	DyRF	URFL	SSF
29 - 01 - 92	700	400	100	<5
19 - 02 - 92	500	300	105	<5
25 - 06 - 92	390	170	130	<5
29 - 03 - 94	75	30	5	<5
4 - 04 - 94	180	50	5	<5
9 - 04 - 94	300	75	10	<5
14 - 04 - 94	150	100	50	<5
29 - 04 - 94	75	50	15	<5
6 - 05 - 94	75	75	50	<5
8 - 05 - 94	300	200	75	<5

The efficiency of the DyRF was, on average 45%, which is considered acceptable, while that of URFL was 64%, far from the 80% recommended to avoid the entry into the slow filter of occasional peaks 60 TU, as proposed by Lloyd et al (1991). Now Galvis et al (1993b) propose 25 TU as the maximum load that this stage can receive to adequately fulfil its function.

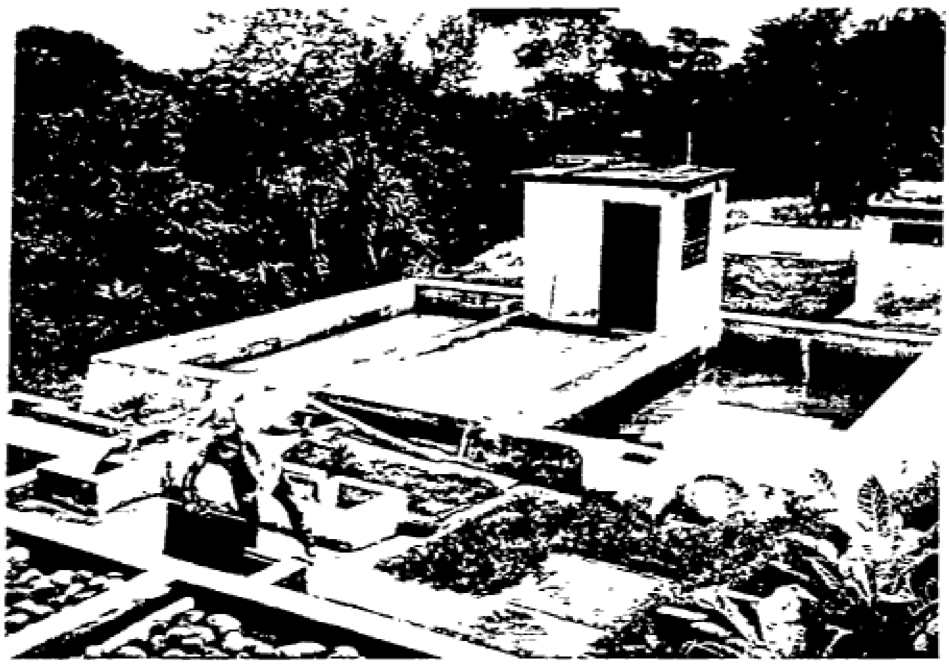


FIGURE 5.2 Turbidity peak into the slow sand filters. 19 February 1992.

Although the system was not designed for this high loading level, which was increased after the treatment plant entered operation, the final effluent was within the acceptable limit of less than 5 TU. The efficiency of the combination of DyRF+URFL+SSF proved the robustness of the multiple barrier and integrated treatment concept. The barriers increased their efficiency with waters that have greater solids loading, demonstrating, as indicated by the experiences of CINARA,IRC (1993), the capacity of multistage filtration technology to be adapted to sharp changes in raw water, a common occurrence in the mountain rivers.

5.2 QUANTITY ISSUES

Once the treatment plant was functioning, the community, accustomed to having

access to large volumes of water, although of poor quality, began to receive a reduced quantity, calculated on the base of 200 lt/inhab/day. This quantity was not supplying the excessive water demand, affecting the continuity, especially in the sectors located in the high points of the distribution network.

This generated complaints and demands for additional water by the users, to which the operator responded by increasing the affluent flow rate up to 100% of the design value. Additionally, the operator even connected the raw water "by-pass" to the storage tank, to compensate the consumption and thus calm the demands of the users. However, this practice deteriorated the quality of water supplied.

A sanitary inspection of the distribution system, showed that more than 90% of the users had domestic connections with taps or damaged sanitary appliances, and hoses without a terminal tap. Furthermore, five users had swimming pools without their own treatment plant.

To solve the problems, the community in a general assembly decided to establish a period of time so that each user should repair the damages detected in their houses and additionally, to buy and to install water meters, with their own resources.

The installation of the water meters done by the Board in December of 1991, permitted the establishment of the consumption behavior. As shown in the Figure 5.3, which gives figures for quarters beginning in January-March of 1992, 1993 and 1994, while 70 users on average (61% of the total) had monthly water consumption in the 0-40 m^3 range, the remaining 39% were in the 41 to more than 100 m^3 range.

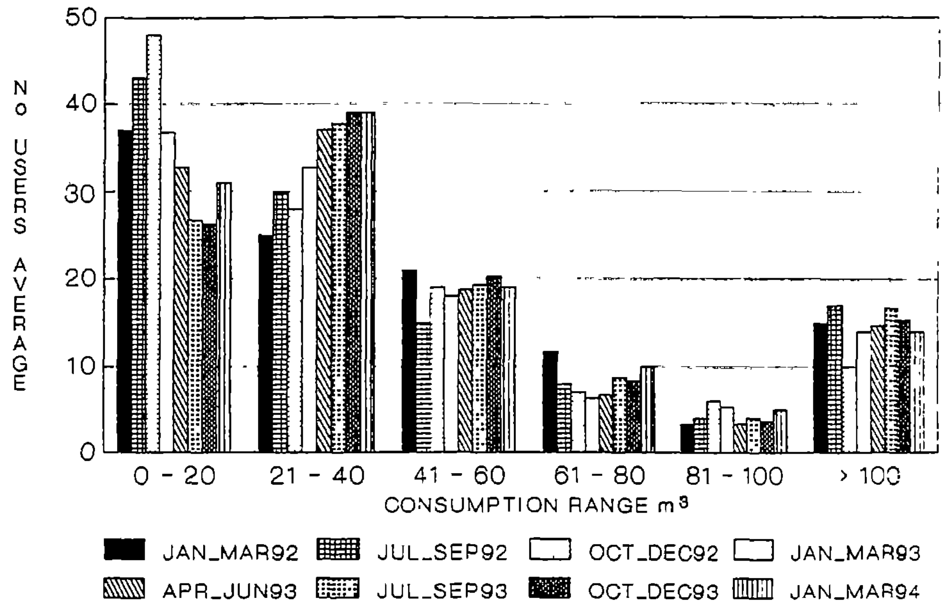


FIGURE 5.3 San Felipe Water Supply System. Average Number of Users per Consumption Range.

Nonetheless, considering the total average consumption, as is presented in Figure 5.4, while the 61% of the total users consume less than 25% of the total volume consumed in the locality, the large users that represent only 10% of the total, consume almost 50% of that volume.

In contrast, Figure 5.5 shows that 90% of the users maintained a monthly consumption average of 30 m^3, while the large users reduced their consumption as a reaction to the installation of water meters and the new tariff scale. This is in agreement with Katko (1988), who asserts that the increase of price generates a reduction of the 20-40% in the water consumption (Quoted in Franceys, 1990).

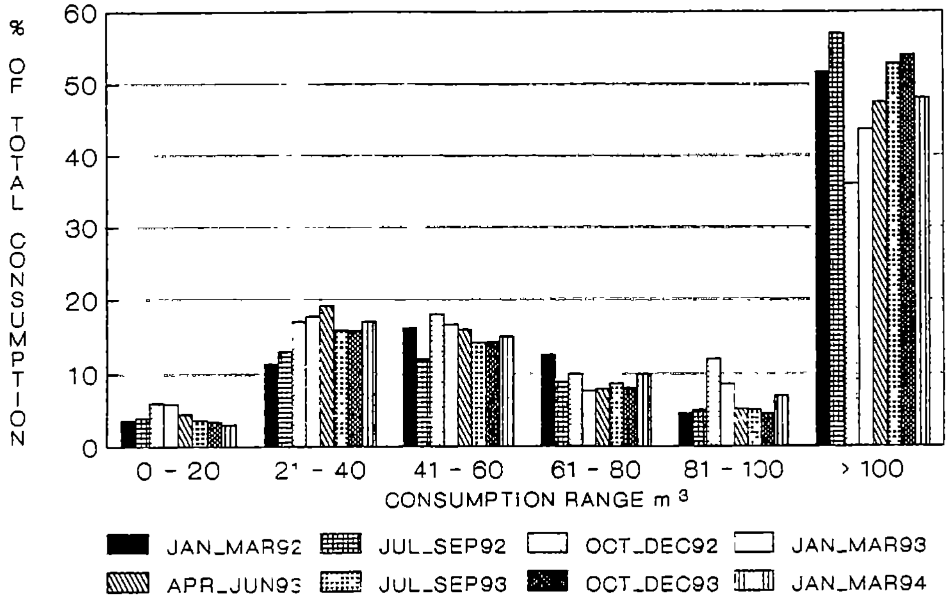


FIGURE 5.4 San Felipe Water Supply System. Total Consumption Percentage per Range.

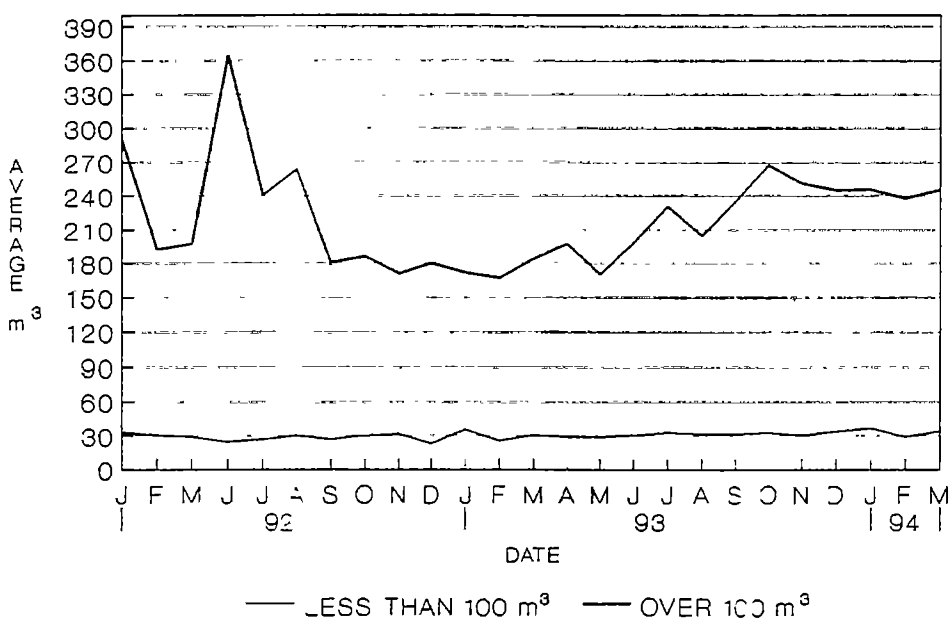


FIGURE 5.5 San Felipe Water Supply System. Average Monthly Consumption.

The meter has additionally had another advantage. The communities in the rural area traditionally measure the quantity of water they have available in terms of "inches of water", in which the diameter of the conduction pipeline is synonymous to the volume supplied in the domestic connection or to the water which arrives at the system from the intake. To express the consumption in terms of cubic meters is not easily understandable, but with the water meter it is possible to make an educational campaign, organized by the Water Board, using the readings that are registered of the monthly consumption.

Wijk-Sijbesma (1987), presented doubts about water meters, arguing that they present problems such as being expensive to install, making the administration more complex and increasing the water cost to the user. However, in this experience, the use of meters has proved to be a valuable tool for water conservation thus reducing the operational problems caused by the improper water use. The complexity elements that are attributed to water meters have been overcome, because the community, upon deciding on their installation and with regular institutional support, has managed to solve the administrative and technical problems associated with their use.

5.3 COVERAGE AND CONTINUITY ISSUES

Once the treatment plant was functioning, the coverage of the system was "theoretically" 98%, a high percentage compared with the national and regional average. However, the "real" coverage was reduced to 60%. This situation was due to problems of quantity and continuity. In these circumstances, although the system

was supplying wholesome water, the efficient and reliable drinking water supply service provision was affected.

The use of water meters with institutional support was essential to change the consumption behavior. This change has meant the continuity of the supply, which is now 24 hours daily to all sectors of the population. Even in the peak consumption hours, the storage tank has been full, which, according to the operator, had not happened since the installation of the initial system and now coverage is a "real" 98%.

5.4 COST ISSUES

Based on the water meter readings of the January-March quarter of 1992, it was verified that on average, 62 users (54% of the total) had consumption according to the flow design (200 lt/inhab/day), representing 15% of the total consumption. The remaining 46% had consumption of more than 1,000 lt/inhab/day, and specifically 14 users (12.3% of the total) were consuming approximately 51.6% of the total volume consumed in the locality. This critical situation was associated with the low water tariff, where payment was independent of consumption.

The tariffs, that were fixed at an amount of $ 200 monthly (US$ 0.25)[6] for houses and $ 500 (US$ 0.60) for commercial properties, had not been modified since 1989. The Water Board only paid the operator a monthly bonus of $ 25,000 (US$ 31.25), which was paid irregularly because of the high percentage of users who paid late

[6] US $ 1 = $ 800 colombian pesos in March 1994.

(more than 50% of the total), and leaving the Water Board without the financial capacity to make system improvements with their own resources.

Given the problems, that were becoming acute and with some confrontations, the Water Board requested support from the Tolima Health Service to calculate a monthly tariff that would cover the operational costs of the system and leave a margin for future investments.

For this calculation, payment to the operator was increased to the level of a minimum salary defined by the Colombian labor law for 1992, with a reserve for their medical and social provision. This aspect is considered essential by Ittissa (1991), to stimulate and at the same time to control the work of the operator in the operation and maintenance of the system. Together with this cost, and with the purchase of calcium hypochlorite and the creation of a reserve for unforeseen events, the total monthly expenditure was calculated at $ 132,000 (US$ 165).

The proposal, presented by the Water Board for the consideration of the community in a general assembly, held 16th May 1992, in which 71 users (62% of the total) took part, was approved by majority. The new tariff, which meant an increase of 600%, was approved based on two arguments: It was not fair to use water certified as wholesome[7] incorrectly and to waste it, and it was not fair that everybody paid the same when the economic capacity and the consumption of some was above that of the poorest people.

[7] The Water Board, to confirm the bacteriological quality information, paid to a private laboratory to make additional analysis. The results of which were used to convince the users of the validity of the results reported regularly by the Tolima Health Service.

The approved tariff was $ 1,200/user (US$ 1.50) as a fixed charge for a consumption of 0 to 40 m^3. The consumption excesses above this value were to be charged according to the following criteria:

Between:	40 and 60 m^3................................	$ 35/m^3
	61 and 80 m^3................................	$ 40/m^3
	81 and 100 m^3................................	$ 45/m^3
	more than 100 m^3...........................	$ 60/m^3

This proposal, which consists of a fixed tariff and an increasing block depending on the consumption, can be likened to the proposal of Franceys (1990), which considers that the tariffs should be based on increasing block rates, and that they should be widely comprehensible, fair and water conserving.

Two years later (May 1994), the Water Board informed that, although there were initially some reactions, especially from the large consumers objecting to the tariff and its collection method, the percentage of collection was greater than 95%.

The penalization of excessive consumption had generated a monthly average surplus of $ 40,000 (US$ 50) that had made it possible to have a reserve fund of $ 5 million (US$ 6,250) and to carry out some small repairs to the system by themselves.

In contrast, it has been shown that within the zone of influence of the volcano disaster, the communities had difficulty in paying the water supply tariffs, because of the patemalistic attitude of the institutions, which was emphasized even more during rehabilitation actions. For example, in the new districts built after the disaster

in the municipality of Guayabal, about 300 families do not pay the water service charge since they consider that they are not obliged to do so because the system was donated by a state entity (Quiroga et al, 1991).

The experience of San Felipe, in localities such as La Marina and Ceylan in the Valle del Cauca department (Hurtado, 1994), as well as in other regions of Colombia not referred to in the literature, indicate that the willingness to pay for the service is achieved clearly when the user receives a water supply that fulfills his expectations and offers satisfaction, convenience and safety.

The satisfaction of the customer's needs, achieving quality in fact and perception, keeping a systems focus, increasing teamwork and participation, and achieving continuous improvement, as key concepts of the Total Quality Management (Culp and Smith, 1992), have made it possible to achieve the success of the project.

The decisive factors have been the economic and health benefits, among other aspects, that the community has perceived and that Whittington (Quoted in Franceys, 1990) indicated in his work. It is interesting to underline that, in San Felipe the drinking water quality improvement was one of the principal arguments that the Water Board used for the meter installation and the establishment of the tariff scale, and that it was accepted by the community.

The improvement of drinking water quality, which is intangible and in some measure incomprehensible for the community when it receives its supply in the summer period, is clearly understood and valued in the rainy season when the water brings

high solid loading, making its utilization impossible for high-priority drinking uses.

In this sense, the experience of O'Brien in Indonesia, cited in the #207 of the IRC Newsletter (1992), indicated that "communities will tend to pay for an increase in quantity and convenience, **but generally will not pay for an improvement in quality"**, and the arguments of Cairncross (1989) on the importance of guaranteeing quantity more than quality, cannot be generalized. The experiences of communities with restricted access to water supply, a common case in Asia and Africa (Wijk-Sijbesma, 1985) are not applicable to those that, as in the case of Colombia, have counted traditionally on abundant sources originating from Andean rivers.

These rivers are exposed to serious deterioration processes in their watersheds, so that it is practically impossible to use them in the rainy period, until the turbidity peak passes. Therefore the drinking water quality improvement is one of the aspects most appreciated by the communities.

5.5 OPERATION AND MANAGEMENT

The achievement of the reliable and efficient provision of the water supply, has been sustained by the existence of a thoroughly independent community organization, which is autonomous and has authority. It has responsibly assumed the ownership and managing of its system, and through active institutional support, has achieved the control of the operation of the system (McPherson et al, 1987; Wijk-Sijbesma, 1987; Chandler, 1989; Warner, 1990; Yacoob, 1990).

The active community management of the system, understood as the sum of those elements that make planning, development, managing and maintenance of the service possible, has thus been one of the most important elements in sustaining the water supply system.

The Water Board of San Felipe consists of five members, elected by vote in a general users assembly. It operates with legal authority which gives it greater legal autonomy. The administration of the system is governed by some bylaws, prepared by the Regional Health Service and approved by a users general assembly, which establishes their rights and duties.

The president of the Board, who is at the same time councillor of the Guayabal municipality, president of the Communal Board and of the Community Participation Committee, exercises a strong leadership that it is recognized and accepted by his community. This aspect has been underlined as one of the essential factors for the success of a project (McPherson et al, 1987; O'Brien, 1992).

Other leaders also have an important role. For example, the treasurer is the owner of a shop, that is used as the meeting place of the Board and serves to collect the payment of the monthly water rates. The collection system is by means of hand written bills made out by the treasure. He receives no payment for this. For the financial control of the system there are account books, bank books and a kardex. They have a bank account and are audited by the sanitary inspector.

On the other hand, in the planning process of the improvement actions, from their

conception, development, monitoring and evaluation, the participation of many organizations of the regional water sector and the community have been important.

This simplified the understanding of the causes of the problems and, at the same time the community members are principal actors in the search for collective and individual solutions.

These activities and successful results of the project, have made possible the promotion of teamwork at institutional and community level. Additionally, the San Felipe water supply system has fulfilled an important role as a demonstration project since it has generated information on treatment efficiency and the maintenance and sustainability of the water supply system.

The project has served as a site for demonstrating the potential of this approach to rural water supply projects. The community leaders of neighboring and distant populations have exchange opinions with the Board members and users (Figure 5.6), have seen its success and used it in their own systems, with the approach of "see and do" so that "some for all rather than more for some" is achieved, which was the key phrase of the statement issued at the end of the meeting held in New Delhi to review the achievement of IDWSSD (King, 1993).

In spite of the achievements, it is important to underline that the members of the Board have not received any type of training in the administrative aspects on what, unwittingly, is being converted into a public service microenterprise.

FIGURE 5.6 Training activities in San Felipe project.

5.6 FOLLOW UP EVALUATION

After three years of operation, the sustainability of the San Felipe water supply system has been demonstrated. The follow up evaluation carried out by CINARA on September 13-15/94 shows the following results:

The system supplied wholesome water. Table 5.4, shows the faecal coliform density levels for each treatment stage of the San Felipe water works and the distribution network. The overall removal efficiency averaged 99.8%.

This efficiency has been achieved, in spite of the relatively high SSF filtration velocity (0.21 m/h). The filtration velocity is due in the last five months to an average

increase of 1.5 lps in the affluent to the treatment plant (the actual affluent flow is 5.0 lps, although the plant was designed to treat 3.5 lps). The SSF filtration runs however increased to six months on average, due to adequate operation and maintenance activities.

TABLE 5.4 Faecal Coliform (FC/100 ml) Levels in the Different Stages of the San Felipe Treatment Plant and Distribution Network.

DATE	RAW WATER LOAD	DyRF	URFL	SSF1	SSF2	SSF3	DISTRIBUTION NETWORK		
							1	2	3
13-09-94	260	54	18	0	0	0	0	0	0
14-09-94	790	116	14	0	0	0	0	0	0
14-09-94	54	18	14	0	0	0	20	0	0
15-09-94	110	20	10	0	0	1	0	1	16

Terminal disinfection was constantly practiced. Calcium hypochlorite (HTH) in granular form has been used. However, there is no chlorine residual and, as is presented in Table 5.4, the water quality supplied by the system deteriorated in the distribution network. Two principal problems was detected in the evaluation:

* The existence of water storage tanks at the domestic level, which are open and without adequate cleaning;
* The available chlorine in the calcium hypochlorite used, was only 20%, due to improper exposure to air, light and moisture[8]. For that reason the quantity of chlorine dosified was inadequate to maintain a residual in the distribution system.

[8] According with Schulz and Okun (1984), these factors lead to a rapid loss off available chlorine in calcium hypochlorite which ranges between 65-70%.

Improvement actions has been suggested to the Water Board in order to overcome the problems detected. However, the value of the multistage technology alternative, in which disinfection is only a final safety barrier, has been conclusively demonstrated.

In respect to quantity, the water demand is under control. However, according to records affluent flow to the treatment system and a survey of water meters readings, a trend toward an increase in consumption is clearly noted. It seems be associated with the lack of a tariff readjustment and recently with the installation of some small industries, motivated by the good quality in the drinking water supply service. Continuity is maintained 24 hours daily.

The activities related to operation, maintenance and administration of the water supply system continued to be satisfactory. Drinking water service is supplied without any users complaint. The Water Board had assumed its role with responsibility, authority, autonomy and control over the water supply service.

The Water Board is now promoting wastewater disposal solutions. In this aspect, and within Phase II of the TRANSCOL programme, the San Felipe locality has been selected as a demonstration project to develop low technical and economical sanitation alternatives according with local conditions.

The successful San Felipe water supply system has motivated the Ibague municipality, which is capital of Tolima Department, to replicate it in three demonstration water supply projects selected at the rural and fringe areas of the city. Ibagué, according with the last national census (DANE, 1993), has 356,418 inhabitants.

CHAPTER 6

CONCLUSIONS AND PERSPECTIVES

6.1 CONCLUSIONS

The San Felipe community is receiving an efficient and reliable drinking water supply service. The system has been functioning efficiently for almost three years. This has been guaranteed with minimum external support. Some of the factors that impacted and that verify the validity of a new approach to achieve success in rural water supply projects are:

1. The active community involvement that, although it was not given in all the phases of the project, was decisive in the operation, maintenance and administration of the system. The community assumed the main role as owners and managers. It has responsibility, authority, autonomy, self-sufficiency and control in taking and executing important decisions aimed at achieving improvement and sustainability;

2. The successful selection and introduction of the multistage filtration technology permitted the efficient combination of DyRF+URFL+SSF+DISINFECTION, and made it possible for the community to have wholesome water;

3. The community and the surveillance agency, working as a team, in a continuous and coordinated way, developed surveillance and control actions of the system. It was demonstrated that regular visits by a sanitary inspector permitted the opportune detection and identification of their problems and deficiencies and their improvement, without the surveillance agency having to take over the functions and responsibilities of the Water Board;

4. For the recovery of the operational costs, it was essential to have water meters. An adequate, fair, simple, enforceable and water conserving tariff was established. However, in rural communities it is clear that tariffs and water meters cannot be imposed from outside; it must be a community decision, according to the local water culture and obviously with institutional support in administrative and technical aspects;

5. The presence of a leader with charisma and respect was vital, especially in a society such as this, characterized by having a deep-rooted tradition of leadership;

6. The strategy of promoting a full scale demonstration project to evaluate the possibilities and limitations of the surveillance methodology and a technological alternative, proved to be successful. The information and experience gained has permitted a regional replication in Ibague city. The strategies adopted strengthen the capacity and potential, not only of the institutions and their professionals, but of the communities.

6.2 PERSPECTIVES

The preliminary experience of San Felipe contributed positively to understanding the potential of a water surveillance and quality control programme, as a tool to achieve success in the sector. It is clear, however, that the programme can be improved, especially in three basic aspects which are complementary and compatible with the World Health Organization strategy in the post-Decade and with the decentralization policies and of Sectoral Adjustment Plan currently existing in the country:

* Strengthening the capacity of community involvement in the planning and management of drinking water supply systems;
* Strengthening the community and institutional roles in the water surveillance and quality control programme.
* Addressing the close relationship that exists between the environmental deterioration of the watersheds and the quantity and quality of the water available for human consumption.

Within the framework of the strategy of the government of Colombia, for improving the conditions of the sector, CINARA proposed and received the Ministry of Health's acceptance, developing, from January 1992, in two preliminary phases during eighteen months, a project in the Surveillance and Control of Drinking Water Supply Services with Community Participation. The project is aimed at developing, testing and evaluating the methodologies and instruments that make it possible for the surveillance agency, the support organizations and the water suppliers, with community support, to adequately fulfil their responsibilities and functions.

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