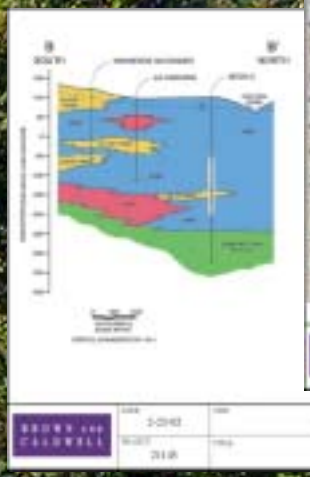
GROUNDWATER RESOURCES MONITORING REPORT AND MANAGEMENT PLAN

Choloma, Republic of Honduras, C. A.



June 2002

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July 25, 2002

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Subject: Groundwater Resources Monitoring Report and Management Plan, Choloma, Honduras, Contract No. 522-C-00-01-00287-00

Dear Ing. Cruz:

In accordance with the above referenced contract, Brown and Caldwell is pleased to forward two copies of the English version of the Groundwater Resources Monitoring Report and Management Plan for Choloma, Honduras. The Spanish language version of this report is being submitted separately. Each report includes the electronic file of the report and the Water Resources Management System on two separate compact disks.

The submittal of this report and the reports for Utila, La Lima, Villanueva, and Limón de la Cerca complete our work under this contract.

We appreciate the opportunity to have been of service to USAID. If you have any questions, please do not hesitate to give me a call at (925) 210-2278.

Sincerely,

BROWN AND CALDWELL

Jeff Nelson, P.E.
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LIST OF ABBREVIATIONS

amsl	above mean sea level
bgs	below ground surface
ft	feet
GIS	geographic information system
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
in	inch
km	kilometer
lpcd	liters per capita per day
lps	liters per second
m	meter
mg/L	milligrams per liter
mgd	million gallons per day
mi	mile
mld	million liters per day
mm	millimeter
TDS	total dissolved solids
USAID	United States Agency for International Development
VOC	volatile organic chemicals
WHO	World Health Organization
WRMS	Water Resources Management System
ZIP	zoned industrial park

GLOSSARY OF TERMS

Alluvial: Pertaining to or composed of alluvium or deposited by a stream or running water.

Alluvium: A general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.

Aquifer: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

Aquifer Test: A test involving the withdrawal of measured quantities of water from or addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition.

Fault: A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are displaced relative to one another and parallel to the plane of fracture.

Fluvial: Of or pertaining to a river; produced by or found in a river.

Fracture Trace: A natural linear features less than 1.6 kilometers (1 mile) long that can be identified by aerial photographs.

Graben: A portion of the Earth's crust, bounded on at least two sides by faults that has dropped downward in relation to adjacent portions.

Groundwater: The body of water that is retained in the saturated zone that tends to move by hydraulic gradient to lower levels.

Irrigation: Application of water to the land to meet the growth needs of plants.

Lithology: The study of rocks; primarily mineral composition.

Metamorphic Rocks: Pertaining to, produced by, or exhibiting, certain changes which minerals or rocks may have undergone since their original deposition; -- especially applied to the recrystallization which sedimentary rocks have undergone through the influence of heat and pressure, after which they are called metamorphic rocks.

Normal Faults: When the fault plane is so inclined that the mass on its upper side has moved up relatively.

Specific Yield: The ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity to the volume of that mass. This ratio is states as a percentage.

Strike-slip Faults: The component of slip on a fault parallel with the linear extension or strike of the fault.

Transmissivity: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

REFERENCES

Departamento de Catastro Municipal. *Choloma Urban Maps.*

Departamento de Servicios Públicos de la Municipalidad de Choloma. *Water Systems Maps.*

Dirección General de Censos y Estadísticas. *Population Statistics.*

Empresa Nacional de Energía Electríca, ENEE. *Energy Users Statistics for Choloma.*

Fundemun. *Choloma Urban Map.*

Hidrosistemas S. de R.L. *Existing Well Construction Reports.*

Ian Walker, Fidel Ordonez, Pedro Serrano, Jonathan Halpern. November. *Pricing, Subsidies, and the Poor; Demand for Improved Water Services in Central America.* (A World Bank Publication No. 2468). November.

Industrial Parks (Empresas Paraíso 1 y 2, Inhdeva, Triple A, Zip San Miguel, Zip Galaxy and Chaín Industrial Park. *Well Operation Reports.*

Ing Juan Miguel Guzman. 1998. *Diseno Final De La Tercera Etapa De Las Mejoras Al Abastecimiento De Agua Potable De Choloma, Departamento De Cortes.*

Instituto Geográfico Nacional. *Mapa Hidrogeológico de la Zona Norte.*

Instituto Geográfico Nacional. *Mapas Topográficos Escala 1:50,000, No. 2662-IV, E752, Edition 3 DMA.*

Lambert, Allan. 2001. *Issues and Needs in Water Loss Reduction – An International Perspective, American Waterworks Conference, D.C.* June.

Library of Congress, Federal Research Division. 1993. *Honduras, a Country Study.*

SERPE S de R.L. *Existing Well Construction Reports.*

USAID. 2000. *Results Review and Resources Request, USAID/Honduras.* March.

World Health Organization. 1996. *Guidelines for Drinking Water Quality, 2nd Edition, Volume 2 Health Criteria and Other Supporting Information, pp. 940-949.*

Zip Choloma Industrial Park/GASA. *Zip Choloma Well Operation Report.*

EXECUTIVE SUMMARY
Groundwater Resources Monitoring Report and Management Plan
Choloma, Honduras
June 2002

The United States Agency for International Development (USAID) contracted Brown and Caldwell to perform groundwater monitoring studies for the Island of Utila and the municipalities of Villanueva, Choloma, La Lima, and the resettlement community of Limón de la Cerca near Choluteca. This Groundwater Resources Monitoring Report and Management Plan (Report) presents the results of the groundwater monitoring study and includes a groundwater resource management plan to help ensure the sustainable management of the groundwater resources for Choloma, Honduras.

Background

The municipality of Choloma is located in the northwestern portion of Honduras, approximately 18 kilometers (11.2 miles) northeast of San Pedro Sula, Cortés, Honduras. The Choloma River, which flows east out of the Merendon Mountains and is a tributary of the Chamelecón River, passes through the northern portion of Choloma. The Chamelecón River flows north to the Caribbean Sea. Choloma lies within the Caribbean lowlands, which have a tropical wet climate with consistently high temperatures and humidity, and receives approximately 2,000 millimeters (mm) (78 inches (in)) of precipitation a year.

Description of Existing Water System and Water Demands

Most of the water system is owned and operated by the municipality of Choloma. There are also independent water systems operated by water boards and private systems owned by factories. Groundwater is the sole source of water supply. Twenty municipal wells provide the groundwater supply for Choloma with a combined capacity of 306 liters per second (lps) (4,866 gallons per minute (gpm)). The municipal water system consists of 15 public storage tanks with a total capacity of 7.1 million liters (1.9 million gallons). The distribution system consists of a network of pipes ranging from 76 mm to 508 mm (3 in to 20 in) in diameter. Five non-municipal wells and fifteen private wells also utilize the groundwater supply.

In the year 2000, the population was estimated at 100,000 residents. Choloma is expected to grow at an annual rate of 4.5 percent through the year 2020. As a result, the population is expected to reach 210,000 residents by the year 2020. Much of the growth is expected to occur in the southern portion of Choloma.

Groundwater use is not precisely known due to a lack of water meters. Current average annual water use is estimated at 23 million liters per day (mld) (6 million gallons per day (mgd)). By the year 2020, average annual water demands are expected to increase to approximately 53 mld (14 mgd). These estimates are based upon a per capita consumption of 151 liters per capita per day (40 gallons

per capita per day), and an assumed water loss of 33 percent of total water production. Maximum day water demand is estimated to be 1.2 times the average annual day. Therefore, maximum day demand is estimated to increase from 26 mld to 64 mld (7 mgd to 17 mgd) by year 2020. If well pumping is limited to a maximum of 20 hours per day, there is a current well supply deficit of 95 lps (1,500 gpm) during the maximum demand day. By 2020, additional well capacity of 9,300 gpm will be required.

Groundwater Resources Evaluation

The groundwater resource evaluation consisted of the development of a conceptual hydrogeologic model, field investigations, the development of a numeric groundwater model, and the identification of potential contamination sources to groundwater.

The conceptual model for Choloma concluded that the upland areas surrounding Choloma serve as the major surface and groundwater recharge areas for the valley. Precipitation recharge to the northern, western, and southern highlands flows through bedrock and sediments, toward the valley, and ultimately discharges to the Choloma River, the major discharge area for the valley hydrologic system. Groundwater production occurs from unconsolidated alluvial deposits associated with the Choloma River Valley. The conceptual groundwater budget indicates that the basin is approximately in balance. Approximately 6,300 gpm is estimated to recharge from the surrounding upland areas and 8,300 gpm from precipitation through areal recharge. Recharge due to leakage from the Choloma River is estimated to be 7,200 gpm. Discharge to the Choloma River is estimated to be 5,000 gpm and outflow to the east is approximately 10,000 gpm. Existing groundwater pumping is 6,700 gpm.

The field investigation consisted of the installation of three wells in the Choloma River Valley to further explore production characteristics in the laterally continuous shallow sand and gravel deposits and the deeper alluvial deposits. Test holes BCCH-1, BCCH-2, and BCCH-3 were drilled to depths of 145 m, 131 m, and 113 m (475, 430, and 370 ft) bgs, respectively to investigate deep water production zones. A laterally continuous sand and gravel aquifer was identified at a depth greater than 30 m (100 ft) bgs that generally increases in thickness to the east and northeast potions of the study area.

The test wells and thirteen selected municipal wells were sampled to provide an understanding of the groundwater quality in Choloma. The survey results showed that the groundwater quality in Choloma meets drinking water standards, except for coliform that was detected in several wells, fecal coliform that was detected in one existing well and one test well, antimony that was detected over the provisional standard in one existing well, and iron and manganese that was detected in one test well over the customer complaint and provisional standard. Not all existing wells were tested and not all drinking water constituents were tested for.

A predictive model simulation was performed to evaluate the potential effects of increasing groundwater production. A portion of the groundwater was assumed to be obtained by additional pumping from the current well field area located to the east of Choloma. A large portion of the

remaining groundwater needs was assumed to be met by developing a well field to the west and up-gradient of Choloma. The simulation results indicate that groundwater levels in year 2020 would drop approximately 5 m (16 ft) in the well field located west of Choloma and approximately 4 m (13 ft) in a well field located to the east of Choloma as groundwater pumping increases. This drop in groundwater levels is considered minimal, but may impact some existing wells.

Potential sources of contamination to the alluvial aquifers near Choloma include sugar cane fields located to the northeast. However, analytical results suggest that the sugar cane fields are currently not a problem for the aquifers investigated. Some areas in the western portion of the study area are used to graze cattle, which introduces the potential for fecal matter to migrate from the surface to the groundwater. However, this activity is not widespread enough at this time to warrant a serious concern. Large zoned industrial parks (ZIPs) are located in the southwest area of Choloma. Although there is some treatment for both industrial and sanitary wastes, most of the wastes are discharged to small surface drainages, and eventually drain into the Choloma River. Some of the existing and new residential areas rely on latrines that discharge directly to the ground. These sanitary wastes may migrate to the shallow aquifer, contaminating groundwater with coliform and nitrate.

The results of the field investigation and the groundwater flow model indicate that the laterally continuous shallow alluvial sand deposits are a source of sustainable water supply for Choloma. The future groundwater needs can be met by both developing a well field to the west and installing additional wells in the current well field to the east of Choloma.

Water Resources Management System

The Water Resources Management System developed for this project is a desktop computer application developed to store, manage, and analyze groundwater technical information gathered for this project plus data that the municipality will collect in the future. The application is a management tool that can be used by the municipality and other decision-makers to sustainably manage Choloma's groundwater resources. The system is composed of both a data management system and a geographic information system linked together as one application.

Recommended Groundwater Resources Management Plan

Figure ES-1 presents a groundwater resources planning map. Figure ES-2 and Figure ES-3 depict geologic cross-sections. The following recommendations are made regarding the management of Choloma's groundwater resources:

1. As water demands increase, install additional wells in the western portion of Choloma, upgradient of the industrial parks and the municipal sewer system, and in the eastern portion of Choloma. As shown on Figure ES-1, install future wells on the east and west sides of Choloma. Approximately 12 new wells will be needed by year 2020, assuming an average well pumping capacity of 47 lps (750 gpm each). These new wells will be required approximately every year and a half. Locate approximately eight of these new wells in the

western well field. Obtain sites (30 m by 30 m (100 ft by 100 ft)) for these future well sites. New wells should be constructed to include disinfection equipment and a 15 m (50 ft) well seal to address bacteriological contamination. The new wells should utilize water lubed vertical turbine pumps and have a water meter. Convert test wells BCCH-2 and BCCH-3 to production wells by installing pumps and connecting pipelines.

2. Conduct a regular groundwater monitoring program consisting of monitoring groundwater levels, groundwater useage, and water quality in selected wells. Fourteen wells are suggested for the initial monitoring program. Conduct monitoring quarterly or every three months. Utilize the database, known as the "Water Resources Management System", to store and analyze the collected data. Conduct a groundwater resources evaluation every 10 to 15 years.

3. Work with other municipalities to help form a regional groundwater management agency. The purpose of this agency would be to help address technical and management issues regarding the groundwater resources.

4. Establish a wellhead protection program to reduce the chance of groundwater contamination impacting water supply wells.

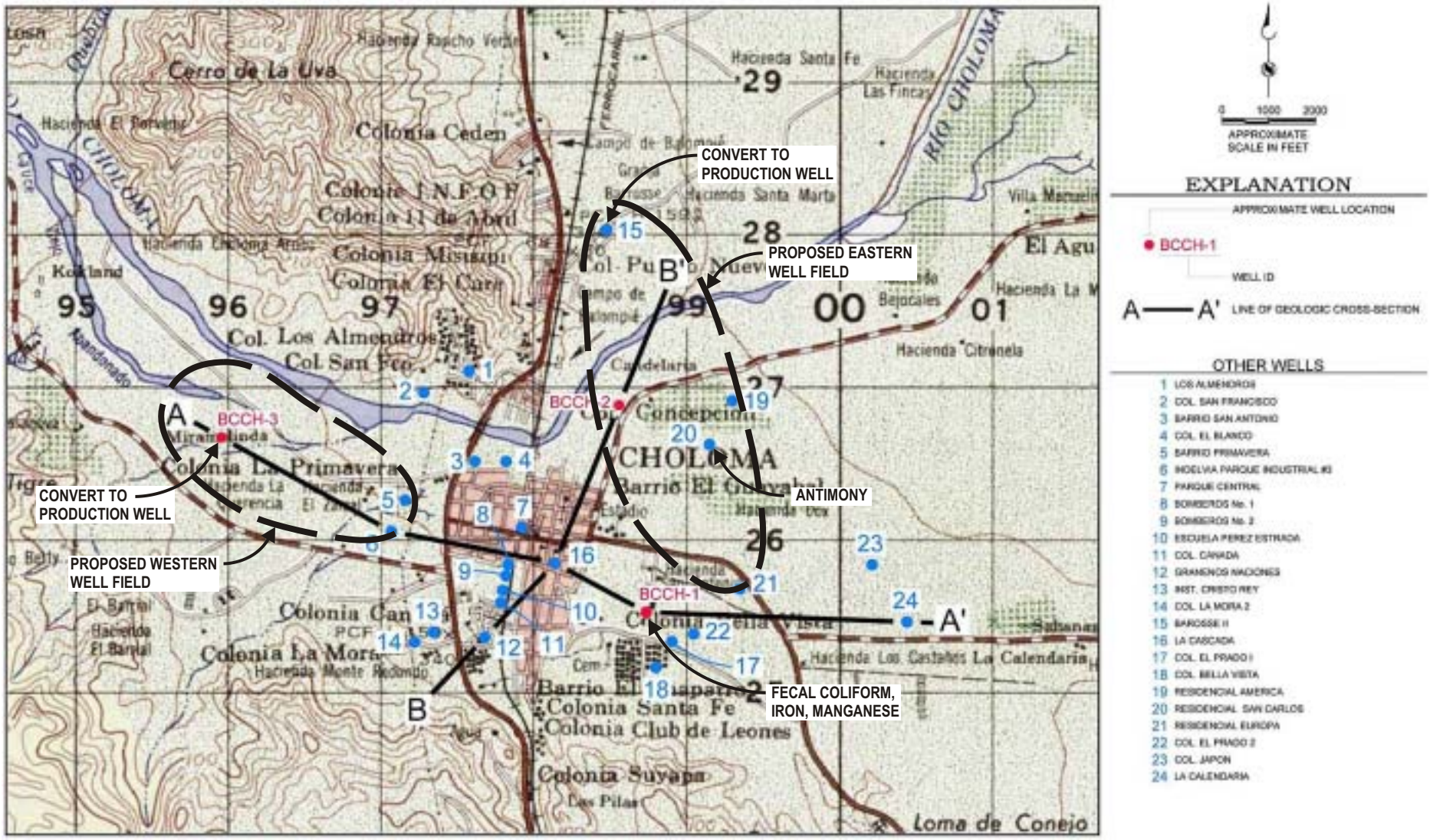
5. Ensure a functioning water utility that is financially self-sufficient by continuing to:
   a. maintain and update the customer inventory;
   b. update the financial plan and charge customers for water useage to ensure that water utility revenues are sufficient to pay for costs;
   c. have trained staff that is familiar with operating a municipal water system; and
   d. investigate potential funding sources for grants and loans.

6. Reduce the number of wells that will be needed in the future by promoting water conservation and reducing leaks from the water distribution system. The first step is to conduct a study to define the amount of water loss and recommend the best areas for leak repair and/or water main replacement.

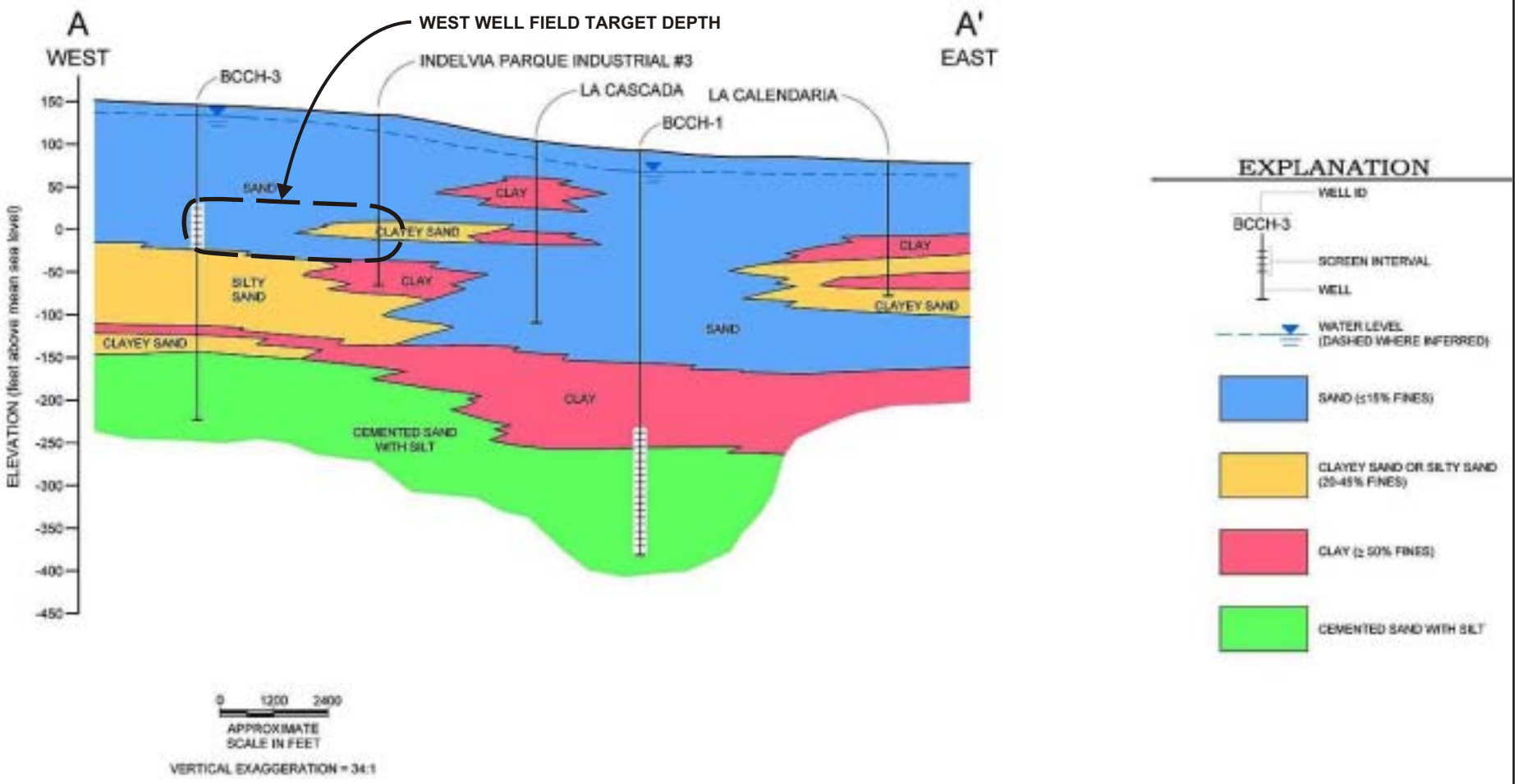
7. Establish control over well construction by others through municipal regulation that provides construction standards and well drilling reporting requirements.

8. Disinfect and retest the wells which have a presence of coliform and fecal coliform.

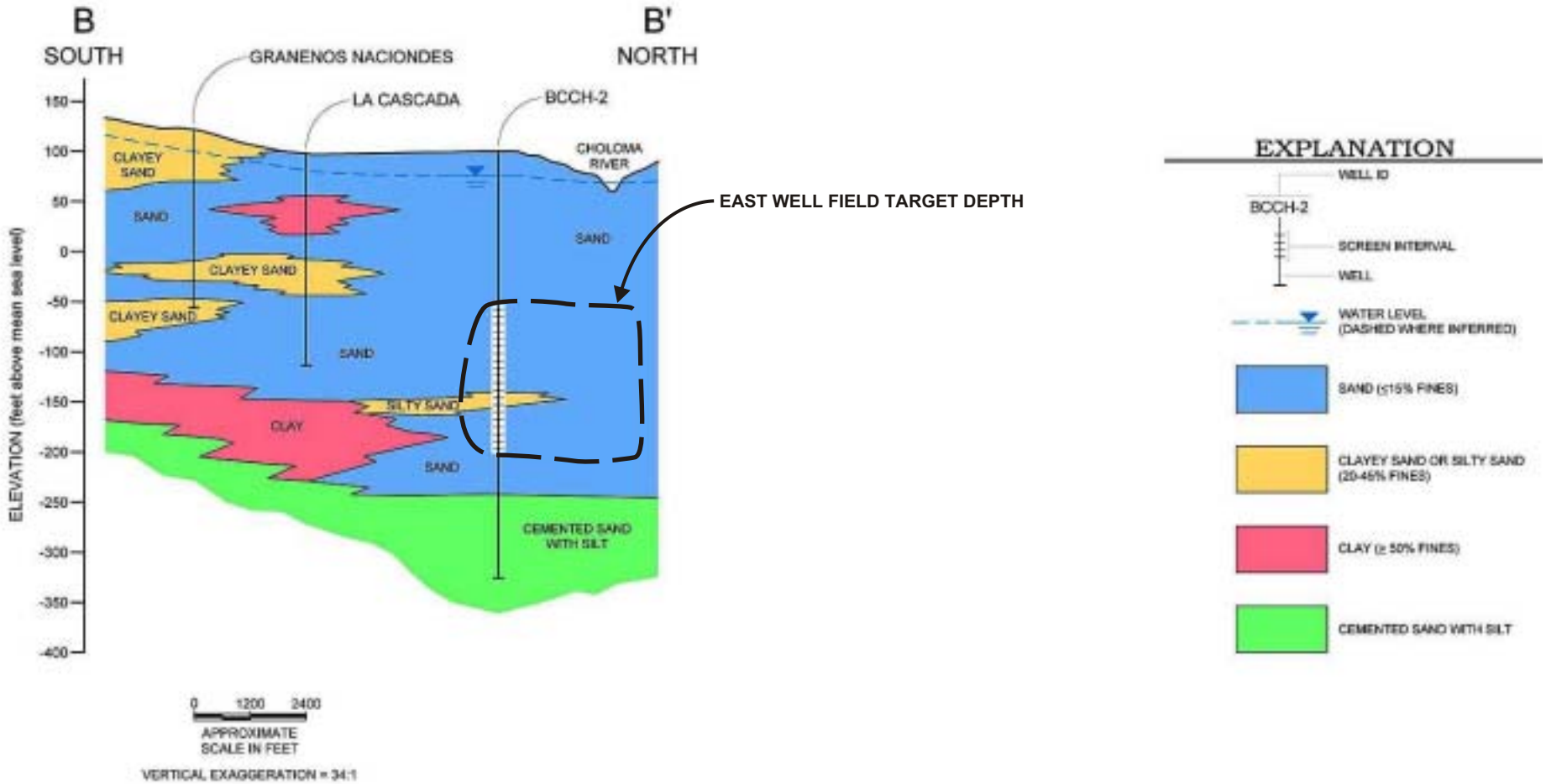
9. Prepare a water system expansion plan that defines needed improvements such as tanks and pipelines. The plan should address how to pump water from the well fields to the upper elevation areas to the south where significant population growth is anticipated.



BROWN AND CALDWELL	DATE 7-3-02	SITE Choloma, Republic of Honduras	FIGURE ES-1
	PROJECT 21143	TITLE Groundwater Resources Planning Map	



BROWN AND CALDWELL	DATE 7-2-02	SITE Choloma, Republic of Honduras	FIGURE ES-2
	PROJECT 21143	TITLE Cross Section A-A'	



BROWN AND CALDWELL	DATE 7-2-02	SITE Choloma, Republic of Honduras	FIGURE ES-3
	PROJECT 21143	TITLE Cross Section B-B'	

1.0 INTRODUCTION

The United States Agency for International Development (USAID) retained Brown and Caldwell to provide architecture and engineering services as part of the Honduras Hurricane Reconstruction Program to assure the sustainability of permanent repairs and expansions of selected water supply systems damaged by Hurricane Mitch. Specifically, this project consists of performing groundwater monitoring studies for the Island of Utila, the Sula Valley (La Lima, Villanueva, and Choloma), and the resettlement community of Nueva Limón de la Cerca near Choluteca.

This Groundwater Resources Monitoring Report and Management Plan (Report) presents the results of the groundwater monitoring study and includes a groundwater resource management plan to help ensure the sustainable management of the groundwater resources of Choloma, Honduras.

This chapter provides a description of the project objectives, scope of work, project background, and the report organization.

1.1 Project History and Objectives

The municipality of Choloma is located in the northwestern portion of Honduras, as depicted in Figure 1-1. Choloma depends exclusively on groundwater as its primary source of municipal water supply. It is anticipated that reliance on groundwater for the municipal water supply will increase as the population growth continues in the future. This project was initiated by USAID due to the increasing population in Choloma, the need to quantify the available groundwater resources for sustainable development in this area, and the need to develop the groundwater resources while avoiding damage due to contamination and floods.

Figure 1-1. Site Location

This project is an important element in meeting overall USAID objectives in Honduras. The two objectives that are addressed best by this project are the sustainable improvements in family health and more responsive and effective municipal governments, as described below (USAID, March 2000).

Sustainable improvements in family health. One of this objective's desired results is the rehabilitation of water system facilities, given that access to potable water reduces child diarrheal deaths, especially in rural areas. The USAID performance indicator for this result is the percentage of rural water systems operating at the "A" level. This is defined as a system where a) water is disinfected, b) there is a water board that meets at least every three months, c) there is a water fee paid by users, d) there is a maintenance employee, and e) water is available from the system on a daily basis.

More responsive and effective municipal government services. This objective includes a desired result of increased coverage of public services, including potable water supply, as measured by the percent of inhabitants receiving public utility services.

To help meet the above objectives, this project evaluated the sustainable yield of the groundwater resources in the Choloma area and developed a groundwater resources management plan to help ensure a sustainable municipal water supply for the urban area of Choloma. Key components of the project include the following:

- identification of groundwater resources available to provide residents with a safe and sustainable water supply;
- development of a groundwater resource management plan and related tools that can be implemented and maintained by the municipality and its staff;
- training of local individuals in groundwater monitoring techniques, data collection, and database management for sustainable management of the groundwater resource; and
- project completion meetings with municipalities to discuss study results, present reports, and describe recommendations to help ensure sustainable water supplies.

1.2 Contract and Scope of Work

This study was conducted by Brown and Caldwell for USAID under contract No. 522-C-00-01-00287-00, dated March 21, 2001. The scope of work for this project defines five phases under which to conduct the study. These five phases are described below.

Phase I – Analysis of Existing Information/Development of Conceptual Hydrogeological Model. This phase consisted of establishing consensus on the projects goals and objectives, data collection, preliminary conceptual hydrogeologic model development, and the identification of additional data needs.

Phase II – Field Investigation. This phase consisted of well drilling, aquifer testing, and water quality monitoring to fill data gaps and help provide data for refining the preliminary conceptual model. In addition, training was provided to local personnel in groundwater monitoring techniques.

Phase III – Hydrogeologic Modeling and Analysis. This phase consisted of refining the conceptual hydrogeologic model through quantitative groundwater modeling and analysis, and development of estimates of the long-term sustainable yield of water resources in the study area.

Phase IV - Database and Training in Monitoring and Database Management. This phase consisted of groundwater database development, database training of local municipal staff, and preparation of training manuals for both the database and monitoring methods. The database is named the Water Resources Management System. The training manuals are included as appendices D and E. This phase was executed concurrently with the other four phases.

Phase V – Final Report. This phase consisted of the development of a final project report that summarizes project data, activities, study results, and recommendations for sustainable management of the water resource in the area. The development of a groundwater resource management plan that includes appropriate measures for the development of the groundwater resources was also completed under this phase. This report represents the Phase V work product for the Choloma urban area.

1.3 Report Organization

This report is organized into six chapters and associated appendices. The contents of each of the remaining chapters is briefly described below:

Chapter 2 – Background: This chapter provides a description of the community, climate, geology and soils, hydrogeology, wastewater management, and the regulatory setting.

Chapter 3 - Existing Water System and Water Demands: This chapter describes the existing water system and summarizes the historical demographics and projects future population and water use.

Chapter 4 - Groundwater Resources Evaluation: This chapter summarizes the methods, procedures, and results of the field investigation program. This chapter also presents a conceptual hydrogeologic model and a numeric groundwater model, recommends and numerically simulates well fields, and identifies potential sources of contamination to the groundwater resource. The training conducted on groundwater monitoring techniques is described in Appendix H.

Chapter 5 - Water Resources Management System: This chapter provides an overview of the water resource database and management tool developed for Choloma and presents instructions for using this tool to assist in the management of Choloma's water resource. The training conducted on the use of the database is described in Appendix H.

Chapter 6 – Conclusions and Recommendations: This chapter presents the conclusions and groundwater resources management recommendations. This chapter also describes the scope for recommended additional studies, if needed. Finally, this chapter presents a recommended groundwater resource management plan and includes policy and institutional recommendations for sustainable management of the resource.

2.0 BACKGROUND

This chapter presents a description of the geographic setting, climate, geology and soils, hydrogeology, land use, wastewater management, and regulatory setting for the Municipality of Choloma.

2.1 Geographical Setting

The Muncipality of Choloma is located in the Sula Valley 18 kilometers (km) 11 miles (mi) northeast of San Pedro Sula, and north of La Lima. The Choloma River passes through the northern portion of Choloma. A view of the community is shown on Figure 2-1. Figure 2-2 depicts a topographic map of the Choloma area.

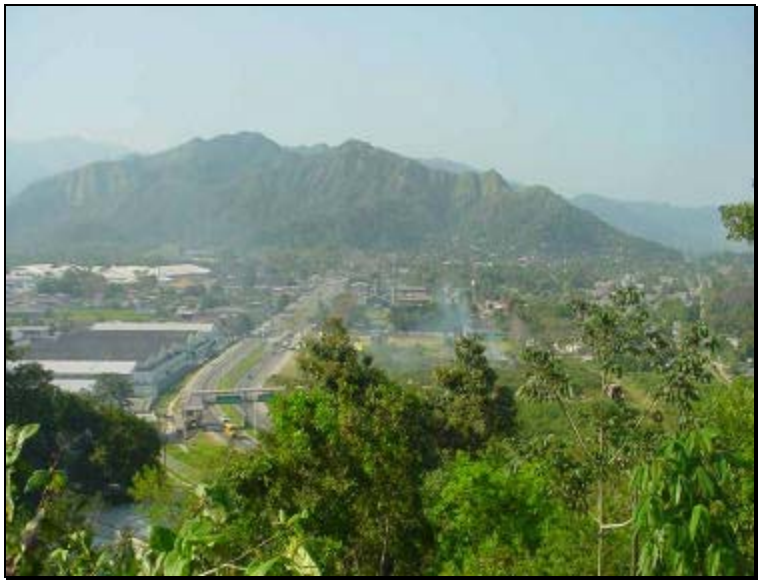


Figure 2-1. View of Community from the South

2.2 Climate

The entire country of Honduras lies within the tropics and consists of three different physiographic regions, referred to as the Caribbean lowlands, Pacific lowlands, and interior highlands. Choloma lies within the Caribbean lowlands, which have a tropical wet climate with consistently high temperatures and humidity, and receives approximately 2,000 millimeters (mm) (79 inches (in)) of precipitation a year. Most rainfall occurs between July and November, (Library of Congress, 1993). Due to the project's short time frame and availability of historical precipitation data, Brown and Caldwell did not collect any supplemental rainfall data. Choloma has a climate similar to San Pedro Sula, which has an average temperature of about 30 to 35 degrees Celsius (86 to 95 degrees Fahrenheit).

2.3 Geology and Soils

The Sula Valley is a prominent north-south trending graben, a valley bound by high-angle normal faults to the east and west that are represented by an abrupt change in topography, located in the north-central portion of the country, as seen in Figure 2-2. The Sula Valley floor is a broad flat plain at an elevation of 31 m (100 ft) above mean sea level (amsl), bound by steep rugged uplands, reaching more than 457 m (1,500 ft) amsl. Choloma is located along the eastern flank of the Merendon Mountains, at the western portion of the Sula Valley. Choloma is situated along the southern banks of the Choloma River, which flows east out of the Merendon Mountains and is a tributary of the Chamelecón River. The Chamelecón River flows to the Carribean Sea. The Ulua River is located approximately 12 km (7.5 mi) east of Choloma.

SOURCE: CHOLOMA, HONDURAS 1:50,000 TOPOGRAPHIC MAP. PREPARED BY INSTITUTO GEOGRAFICO NACIONAL, HONDURAS IN COLLABORATION WITH USA DEFENSE MAPPING AGENCY, 1994.

BROWN AND CALDWELL	DATE 3-21-02	SITE Choloma, Republic of Honduras	FIGURE 2-2
	PROJECT 21143	TITLE Topographic Map Area Choloma and Central Portion of Sula Valley	

The Ulua River basin comprises one of the most extensive watersheds in Honduras. The river enters the Sula Valley from the southwestern highlands and flows to the north. Prior to the formation of the Sula Valley, the area was part of a large uplifted plateau. During this time, the ancestral Choloma River rapidly eroded downward to create incised channels that cut deeply into bedrock, possibly following faults or fracture traces that trend perpendicular to the valley. Subsequent regional plate extension processes lead to normal faulting of surrounding highlands and the formation of the graben areas of the Sula Valley.

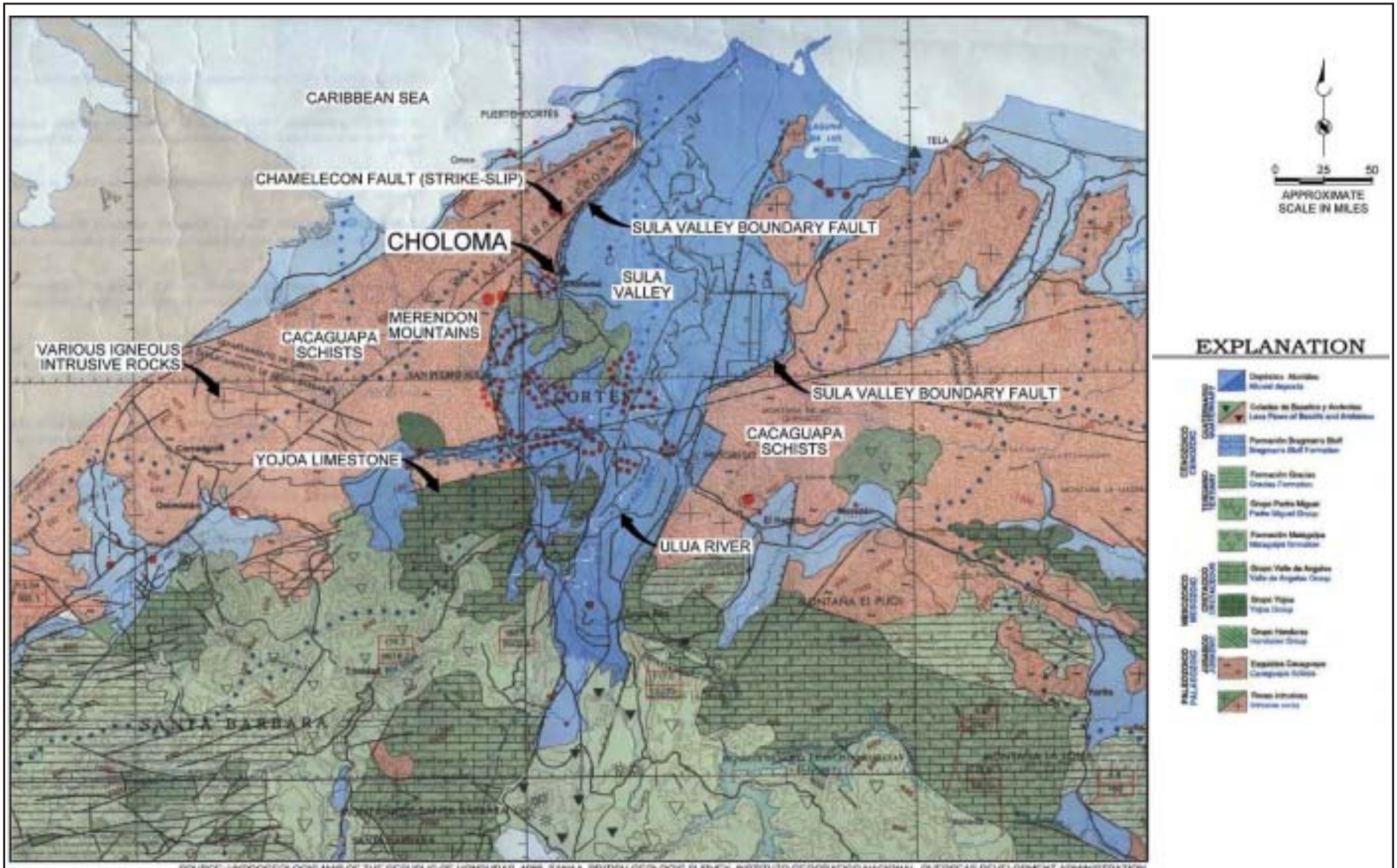
In the vicinity of Choloma, the Sula Valley is more than 20 km (12.4 mi) wide. The flood plain is characterized as a broad flat alluvial plain, with a number of small lagoons, wetlands, and meandering rivers. South of Choloma, the Chamelcon River flows east out of a large valley west of La Lima. Upon entering the Sula Valley, the Chamelcon River flow has been channelized into a flood control canal, located about 1 km (0.6 mi) west of the Ulua River. The Choloma River and Chamelcon River discharge to the Ulua River just north of Choloma.

Honduras and most of Central America is situated in an area characterized by significant volcanic activity and structural deformation as a result of plate tectonics. While there are some active volcanoes in neighboring countries, there are no volcanoes in Honduras. The northern coast of Honduras is part of a strike-slip plate boundary, between the North American Plate and Carribean Plate. This zone is represented by a series of northeast-trending transverse faults that extend throughout the country. North of Choloma, this boundary is represented, in part, by the northeast trending Chamelcon Fault.

The Choloma Valley ranges from 1 to 2.5 km (0.6 to 1.6 mi) in width and is characterized by Quaternary alluvial deposits consisting of discontinuous beds, lenses of alluvial and fluvial channel, and floodplain sands, silts, clays, and gravels that have eroded from surrounding highlands. Total thickness of the alluvial materials is estimated to be greater than 152 m (500 ft) in the vicinity of Choloma. Information from previous drill holes in the area indicate the upper 61 m (200 ft) is characterized as an upward fining sequence of sands and silts. The upper 8 m to 15 m (25 ft to 50 ft) of alluvial materials are characterized as interbedded silts and sands. These materials grade into interbedded fine- to medium-grained sands from 15 m to 31 m (50 ft to 100 ft). Coarse-grained sand and gravel were reported at 31 m (100 ft) below ground surface (bgs). The surrounding Merendon Mountains are comprised of Jurassic-age Cacaguapa Schists and various assemblages of intrusive igneous rocks. The general geology of Choloma is illustrated on Figure 2-3.

2.4 Hydrogeology

The surrounding Merendon Mountains serve as the major surface and groundwater recharge areas for the alluvial materials of the Choloma Valley. Surface water infiltrates into the fracture networks of the metamorphic and igneous rocks, and provides groundwater recharge to the valley bedrock and alluvial materials. Groundwater from these uplands generally flows toward the alluvial valley. Once the groundwater from the upland areas enters the valley alluvium, groundwater flow generally moves down the valley and toward the Choloma River, which serves as the major groundwater



SOURCE: HYDROGEOLOGIC MAP OF THE REPUBLIC OF HONDURAS, 1988. SANAA, BRITISH GEOLOGIC SURVEY, INSTITUTO GEOGRAFICO NACIONAL, OVERSEAS DEVELOPMENT ADMINISTRATION.

BROWN AND CALDWELL	DATE 3-21-02	SITE Choloma, Republic of Honduras	FIGURE 2-3
	PROJECT 21143	TITLE Geologic Map Sula Valley	

discharge points for the valley hydrogeologic system. The Choloma River eventually discharges to the Chamelecón River. The laterally continuous sand and gravel aquifer found below a depth of 31 m (100 ft) reportedly presents the greatest potential for producing sustainable yields. Choloma relies completely on groundwater for its water supply. Approximately 20 municipal groundwater production wells and approximately 15 non-municipal wells exist within the municipal areas. The wells range in depth from 24 m to 61 m (80 ft to 200 ft) bgs. Groundwater production from these wells range from 5 liters per second (lps) to 63 lps (80 gallons per minute (gpm) to 1,000 gpm) with an average yield of 30 lps (475 gpm).

2.5 Land Use

Land use in Choloma consists of residential, commercial, industrial, and agricultural. There are significant industrial operations within the municipality. As previously mentioned, Choloma comprises a very large land area. However, due to agricultural, industrial, and topographical constraints, the total habitable land area is restricted to approximately 1,185 hectares (3,000 acres).

2.6 Wastewater Management

An understanding of wastewater management is important because certain disposal practices can impact groundwater quality. There is a central wastewater collection system in Choloma. Choloma does not have a wastewater treatment system. The sewer system discharges untreated wastewater at several locations into canals, which drain to the Choloma River to the northeast of the city. Some of the industrial parks located to the southwest of the city treat their industrial wastewater and discharge the effluent to the same canals.

2.7 Regulatory Setting

The water system in Choloma is owned by the municipality. There are several small independent water systems that are operated by community water boards. Many of the industrial facilities have their own water systems.

The water systems in Honduras are regulated by the Honduran Ministry of Health. The drinking water standards in Honduras are equivalent to standards defined by the World Health Organization (WHO). Currently, drinking water standards are not enforced and water compliance monitoring and reporting are not required in Honduras.

The Panamerican Health Organization provides technical support to municipalities through the Ministry of Health for water issues. Some other organizations have been formed in Central America to share experiences in water and sanitation management with municipalities.

3.0 DESCRIPTION OF EXISTING WATER SYSTEM AND WATER DEMANDS

This chapter describes the existing water supply system and municipal water demands in Choloma. The information was obtained from reports prepared by others, discussions with municipal representatives, and our field reconnaissance.

3.1 Water Supply System

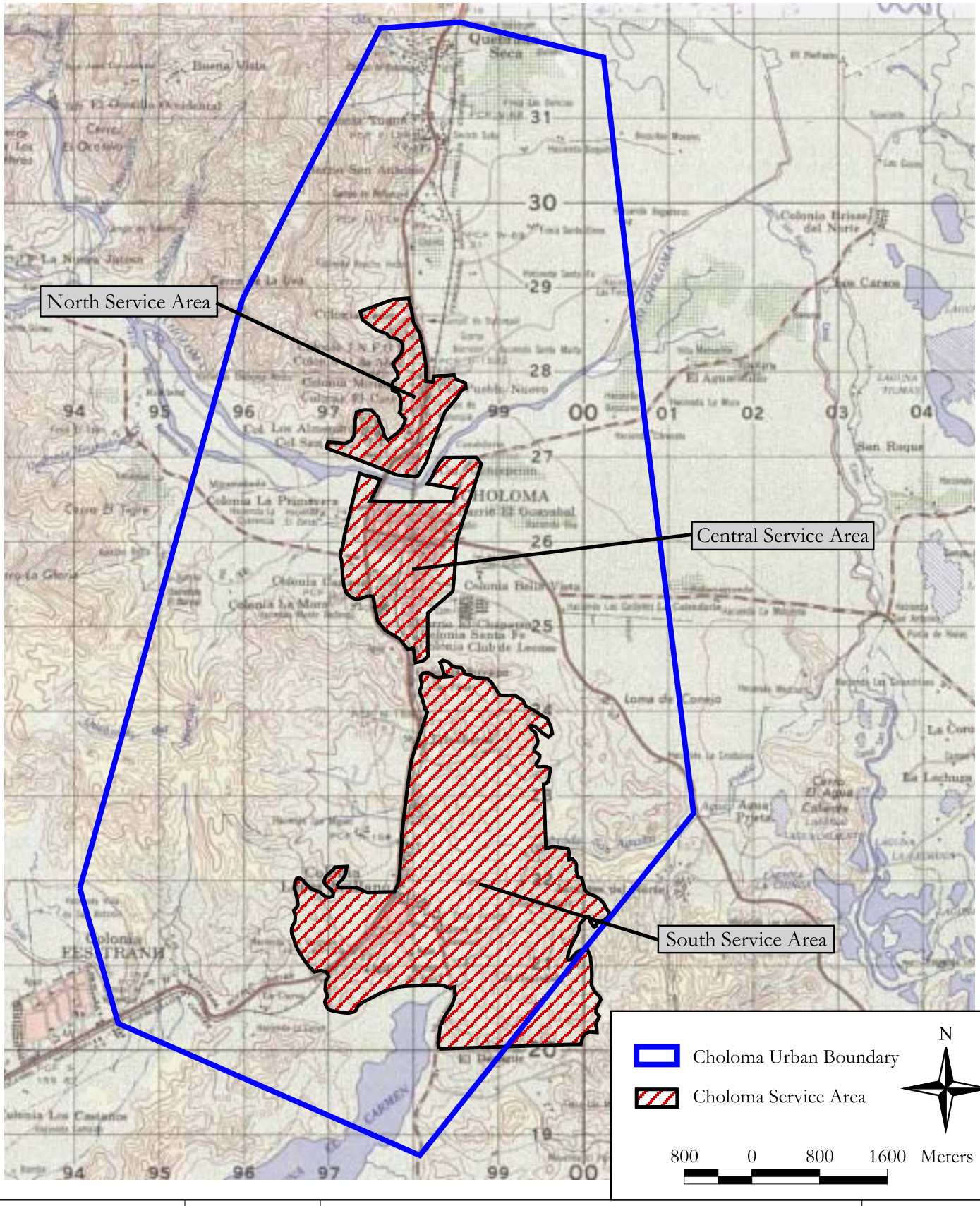
This section describes the service area and the main components of the Choloma municipal water system. The water system is owned and operated by the municipality of Choloma. There are several independent water systems operated by community water boards. Most factories have their own water system. Groundwater is the sole source of water supply. Features and capacities of the municipal wells, the water treatment plant, reservoirs, pumping stations, and the distribution system are described in this section.

3.1.1 Service Area. The municipality of Choloma provides water service to residential, commercial, and a few industrial customers throughout numerous barrios and colonias (neighborhoods and districts). The service area is not all-inclusive, as only about 75 percent of Choloma and the surrounding barrios and colonias are served by the municipality. The remaining areas are served by non municipal or industrial systems. For example, Residencial America, Lomas de Choloma, Quintas San Miguel, Sector de Las Cascadas, and Colonia Los Professionals are operated by water boards. Zoned industrial parks (ZIP) within Choloma also operate private water systems, with the exception of El Tropico, which receives water from the municipal system.

The municipal system can be divided into three service areas; the system north of the Rio Choloma (north service area), the central city area (central service area), and a geographically large service area beginning south of the city (south service area), as seen in Figure 3-1. The central service area also contains a number of small private and municipal systems, collectively referred to as the surrounding central systems.

<u>3.1.1.1 North Service Area:</u> The area north of the Choloma River is served by two wells; Barrosse #1 and Barrosse #2. At the time of this report, Barrosse #2 was out of service. The combined flows from these wells pump directly to two reservoirs; 11 de Abril and Infop. In turn, these reservoirs supply water to the surrounding community through a distribution system comprised of polyvinyl chloride pipe. There is a single emergency interconnection across the Choloma River that connects the north and central systems.

Within the north service area there are two colonies, San Francisco and Care, which have their own water system but are interconnected to the main service area. Colonia San Francisco has a well and the water is pumped directly to the network, while Care has a well and water is pumped to its own storage tank.



BROWN AND CALDWELL	DATE 3/27/2002	SITE Choloma, Honduras, C.A.	FIGURE 3-1
	PROJECT 21143	TITLE Choloma Service Areas	

3.1.1.2 Central Service Area: The central service area is bounded to the north by the Choloma River and to the south by the Barrio Trinchera. The central service area is approximately 680 acres and has a population estimated at more than 24,000 residents. This area is currently served by eight storage tank reservoirs.

Six wells serve as the primary source of supply for the city's central downtown district. Fireman #1, as seen in Figure 3-2, and Esquila Perez #4 pump directly into two concrete tanks that in turn supply the downtown area. These two tanks are collectively referred to as the Trincheras reservoirs, as seen in Figure 3-3.

1. Parque Central well supplies water directly into the Central Area distribution system.

2. Bomberos No. 1 well supplies water into a concrete tank located in Cerro Trincheras, this tank (Bomberos 1) supplies the distribution system, as seen in Figure 3-2.

3. Escuela Prez Estrada well supplies water to another tank located in Cerro Trincheras, this tank (Perez Estrada) supplies water to the Central Area distribution system part time and part time supplies the Colonia Victoria located in the South Area. The tanks located in Cerro Trincheras are collectively referred to as the Trincheras reservoirs, as seen in Figure 3-3.

4. San Antonio well supplies the distribution system of the Central Area.

5. Cañadá well is located west of the city central area and pumps directly into the distribution system. This well is located near a canal discharging untreated factory waste.

Figure 3-2. Fireman Well No. 1

6. La Primavera well supplies water to the distribution system of the Central Area. Located west of the city center, the colonia Primavera of approximately 300 homes is supplied by a single well, known as La Primavera. The system contains no storage facility, and is not interconnected to the adjacent systems.

3.1.1.3 Independent Systems. Located near the city central area are collections of small, independent water systems characterized by a small number of residences. These systems are not interconnected with adjacent systems. The following is a description of these systems.

Figure 3-3. Trincheras Reservoirs

La Mora: This system receives water from their own well known as La Mora well, which supplies water to a concrete storage tank. Additionally the system receives water from an elevated storage tank owned by the Industrial Park ZIP Choloma. As mentioned previously, the majority of the factores within Choloma operate their own water system.

Prado Uno: Coloniua Prado I, located to the East of Central Area, receives water from a storage tank which is supplied by Prado Uno well located next to it. This system supplies to approximately 160 houses. The Prado Uno storage tank is shown on Figure 3-4. Water service is available to this community 24 hours a day.

Figure 3-4. Prado Uno Storage Tank

Prado Dos: Colonia Prado Dos located near Prado Uno is supplied by well Prado II. Water is stored in a 7,000 gallon tank.

Europa: This system is non municipal operated by a water board and is composed of 300 houses. It is comprised of a single well and storage tank. Water service is available 24 hours a day.

San Carlos: A single well and a storage tank that provides potable water to approximately 885 homes. This service is 24 hours per day. San Carlos is a non-municipal system operated by a water board located east of the city center.

Colonia Japon: Colonia Japon is a community of approximately 260 homes served 24 hours per day by a single well and storage tank.

3.1.1.4 South Service Area. Approximately 1,730 acres, beginning south of the Trinchera reservoirs, define the south service area. It also maintains the largest service area population, estimated at more than 53,000 persons in the year 2000. Seven water storage tanks characterize the system. The largest and highest of these, the Santa Fe tank, is filled by the Bella Vista well. The Santa Fe tank, which is depicted on Figure 3-5, then distributes water by gravity to the remaining south tanks. Wells Bella Vista and Perez Estrada are the main source of water supply for the South Service Area. As mentioned previously, well Perez Estrada fills the tank of the same name located in Cerro Trincheras. The city is planning to construct additional wells and a second Santa Fe reservoir in order to supplement the south service area. Until this work is completed, water service to the city's South Service area will remain severely restricted. The other five reservoir tanks are Tanque de la Col. Las Colinas (1), Tanques La Unidad (2), Tanque del Colegio Pagán (1), and Col. Vista Hermosa (1). Information regarding Santa Fe and Trincheras tanks is presented in Appendix B. These small tanks are filled by the large tank Santa Fe. Additionally, these tanks obtain supply from small wells located near by.

Figure 3-5. Santa Fe and South Reservoir System

3.1.2 Municipal Water Supply Wells. Twenty municipal wells provide the groundwater supply for Choloma with a combined capacity of 306 lps (4,866 gpm). Table 3-1 summarizes the information regarding the existing wells. Table 3-1 also presents the estimated hours of pumping per day and resulting daily production of each well based on information collected during the field investigation. Figure 3-6, Figure 3-7, and Figure 3-8 depicts the locations of the key water system facilities. Appendix B presents additional information about the wells.

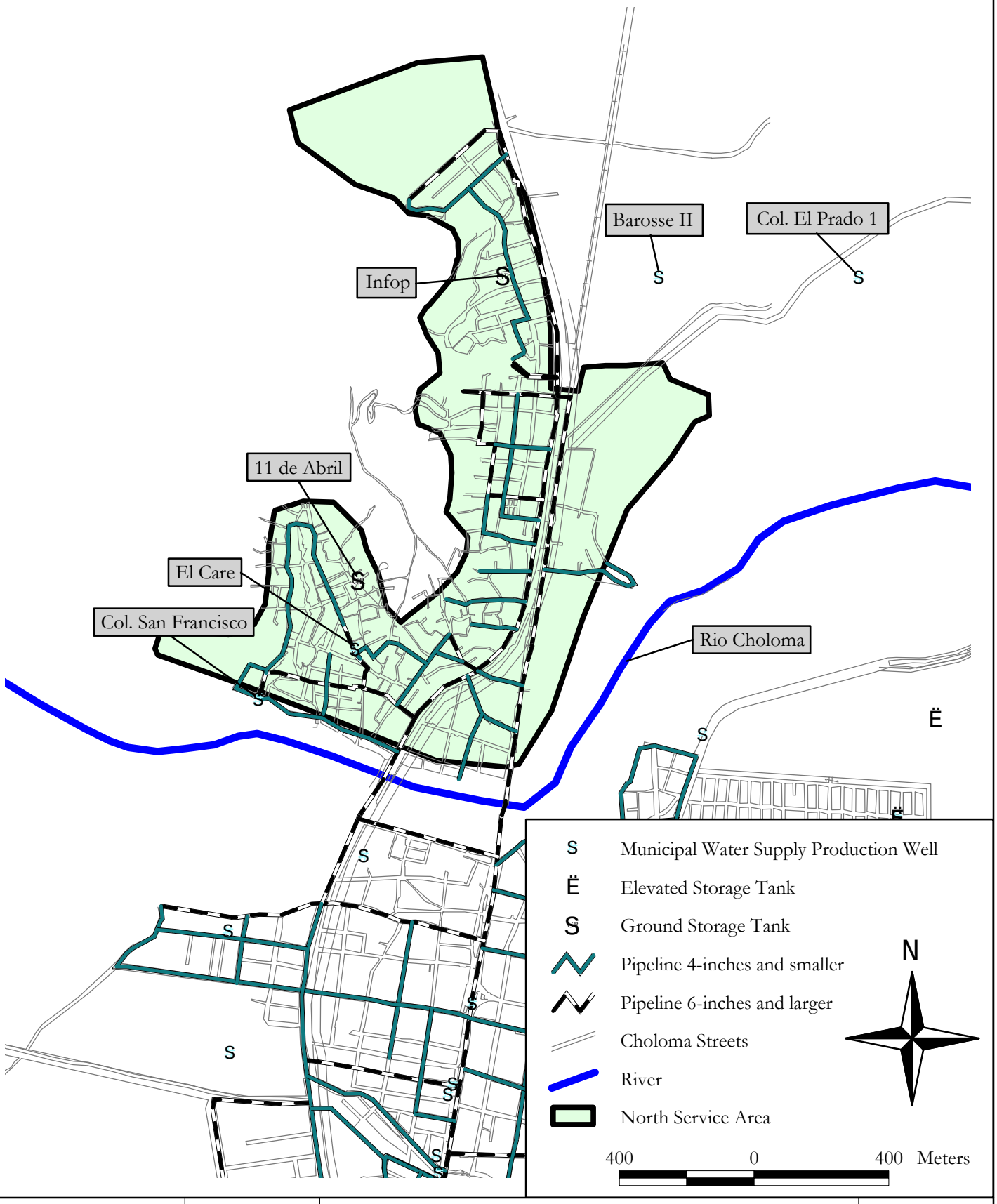
Table 3-1. Municipal Well Information

Name	Capacity		Daily pumping time, hours	Daily production		Well depths, bgs		Area of service
	lps	gpm		lps	gpm	m	ft	
Barrosse II	37[a]	587[a]	24	37	587	61	200	Sector north of the City.
Bella Vista	12[a]	196[a]	22	12	190	63	206	Tank of the Col. Las Colinas (1), Tank La Unidad (2), Tank of the Colegio Pagán (1), Col. Vista Hermosa (1). Total-5 tanks.
Bomberos #1	16[a]	257[a]	24	16	257	61	200	Southeast, southwest, and northeast of the city
Bomberos #2	41	650	10	17	270	61	200	Network of the Col. Las Pilas and Col. Victoria
Canadá	25	400	24	25	400	61	200	Col. Canadá and Barrio Los Cocos del Sur.

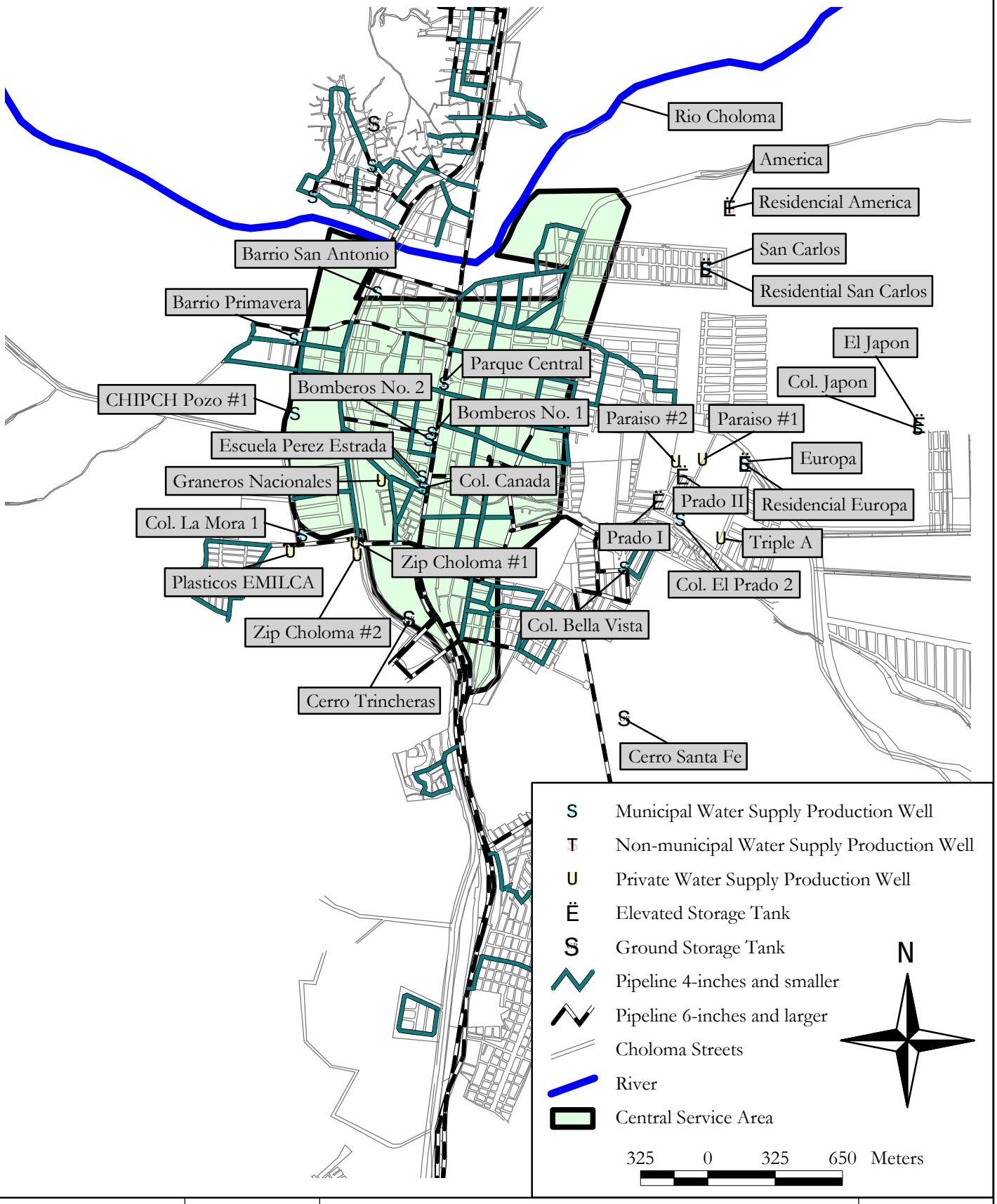
Name	Capacity		Daily pumping time, hours	Daily production		Well depths, bgs		Area of service
	lps	gpm		lps	gpm	m	ft	
El Japón	7	110	10	3	46	30	100	Residencial El Japón
Europa	14	225	21	12	197	36	117	Residencial Europa
Inés Carranza Barnica	11	175	18	8	131	500	500	Col. Inés Carranza Barnica
La Care	2	35	24	2	35	350	350	Col. La Care and Col. 19 de Septiembre.
La Primavera	11	180	24	11	180	61	200	Network of the Col. Primavera
La Mora #1	16	250	24	16	250	61	200	Col. La Mora y fábrica.
Parque Central	22	350	24	22	350	61	200	Center of the city
Pérez Estrada	39[a]	617[a]	24	39	617	61	200	To the network of the Col. Sinor, Santa Fe Central; to the tank of the Col. Victoria and southeast and southwest of the city (Tanque trincheras).
Prado I	4	60	4	1	10	30	100	Col. Prado I
Prado II	4	60	4	1	10	30	100	Col. Prado II and Col. Anexo El Prado
San Antonio	13	200	24	13	200	37	120	Center of the city
San Carlos	19[a]	296[a]	19	15	234	54	176	Residencial San Carlos
San Francisco	6	100	18	5	75	24	80	Barrio Los Almendros and La Care
Victoria #1	4	68	6	1	17	100	329	Network of the Col. Victoria
Victoria #2	3	50	6	1	13	--[b]	--[b]	Network of the Col. Victoria
Total	307	4,866	--	257	4,069	--	--	

[a] Flow rate measured in storage tank
[b] Unknown
bgs = below ground surface
ft = feet
gpm = gallons per minute
lps= liters per second
m = meter

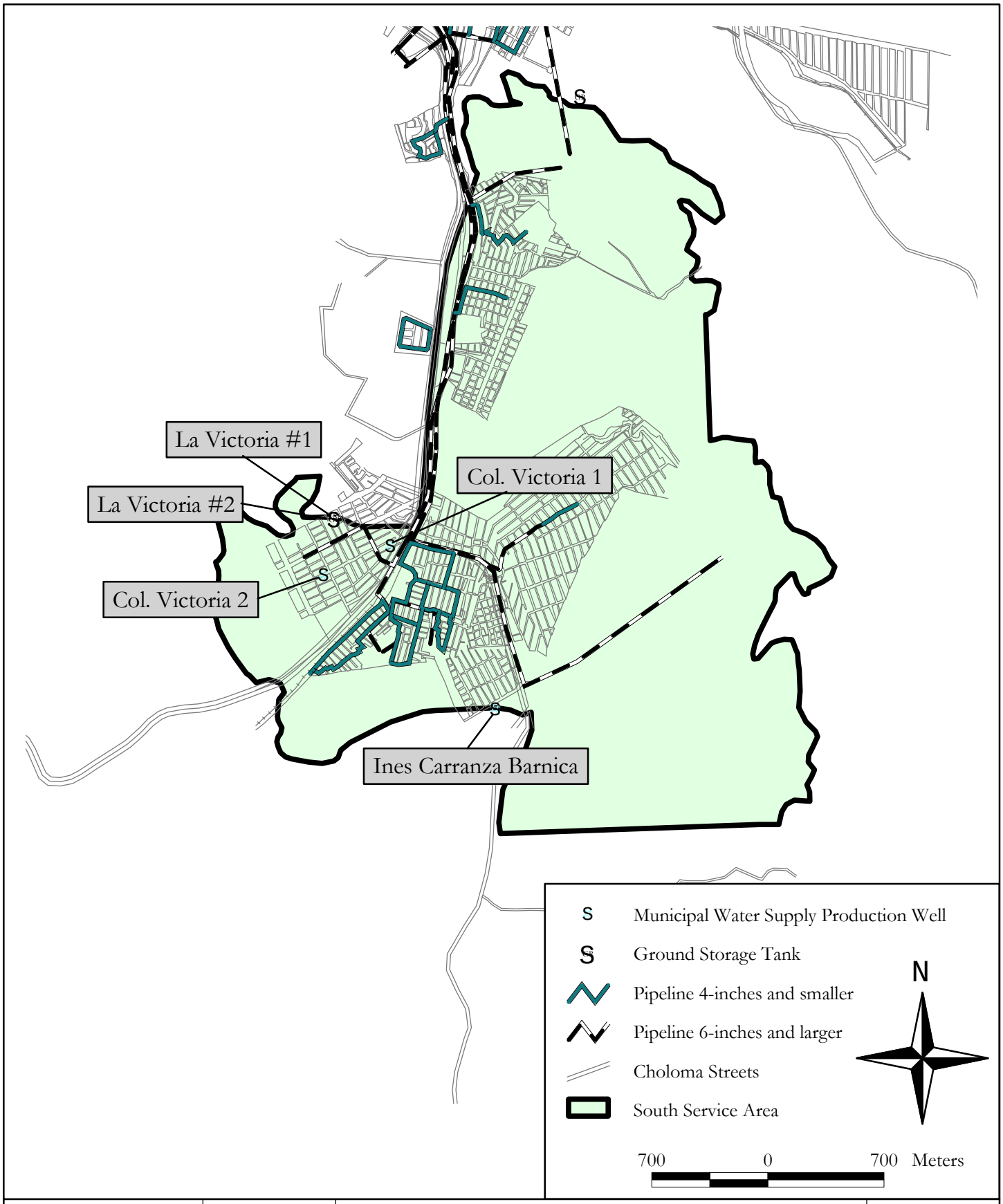
3.1.3 Non-Municipal and Private Water Supply Wells. Five non municipal and fifteen private water supply wells have been identified with a combined capacity of 81 lps (1,276 gpm) and 226 lps (3,579 gpm), respectively. Tables 3-2 and 3-3 summarize the information that was available for non municipal and private wells in Choloma. The estimated daily hours of pumping and resulting daily production are also presented Tables 3-2 and 3-3.



BROWN AND CALDWELL	DATE 6/17/2002	SITE Choloma, Honduras, C.A.	FIGURE 3-6
	PROJECT 21143	TITLE Existing Water Systems - North Service Area	



BROWN AND CALDWELL	DATE 7/1/2002	SITE Choloma, Honduras, C.A.	FIGURE 3-7
	PROJECT 21143	TITLE Existing Water Systems - Central Service Area	



BROWN AND CALDWELL	DATE 6/17/2002	SITE Choloma, Honduras, C.A.	FIGURE 3-8
	PROJECT 21143	TITLE Existing Water Systems - South Service Area	

Table 3-2. Non Municipal Wells Information

Name	Capacity		Daily pumping time, hours	Daily production		Well depth		Area of service
	lbs	gpm		lbs	gpm	m	ft	
Ecoverde No.1[a]	32	500	24	32	500	73	240	
Godoy[a]	2	26	24	2	26	--[b]	--[b]	
Las Cascadas[a]	32	500	24	32	500	61	200	
Residencial América	13	200	20	11	167	--[b]	--[b]	Central
Sinor[a]	3	50	24	3	50	--[b]	--[b]	
Total	82	1,276	--	80	1,243	--	--	--

[a] Not shown on existing water system figure
[b] Unknown

Table 3-3. Private Well Information

Name	Capacity		Daily pumping time, hours	Daily production		Well depth		Area of service
	lbs	gpm		lbs	gpm	m	ft	
Aerosoles de Centroamérica[a]	2	30	12	1	15	85	280	
El Paraiso No.1	2	30	24	2	30	--[b]	--[b]	Central
El Paraiso No.2	2	27	24	2	27	--[b]	--[b]	Central
Elcatex No.1[a]	63	1,000	8	21	333	79	260	
Global Fashion[a]	2	30	24	2	30	76	250	
Graneros Nacionales	2	36	24	2	36	53	175	Central
Laboratorios Quimifar[a]	6	90	12	3	45	49	160	
Mudanzas Gamundi[a]	2	34	24	2	34	41	135	
Parque Industrial Chaín[a]	5	80	24	5	80	73	240	
Parque Industrial Inhdelva No.2[a]	32	500	8	11	167	61	200	
Plásticos Emilca	3	46	24	3	46	55	180	Central
Químicas Dinant[a]	11	176	12	6	88	61	200	
Triple A	25	400	8	8	133	37	120	Central
Zip Choloma No.1	38	600	8	13	200	--[b]	--[b]	Central
Zip Choloma No.2	32	500	8	11	167	--[b]	--[b]	Central
Total	227	3,579	--	92	1,431	--	--	--

[a] Not shown on existing water system figure
[b] Unknown

3.1.4 Water Storage Facilities. The municipal water system currently consists of 15 public storage tanks. The municipal storage tanks have a total capacity of 7.1 million liters (1.9 million gallons). A summary of storage facilities are presented in Table 3-4. Appendix B presents additional information about the tanks.

Table 3-4. Municipal Storage Tanks

Name	Volume, gallons	Type of tank	Service Area
11 de Abril	250,000	ground, concrete	North
19 de Septiembre	18,000	ground, concrete	North
Cerro Santa Fe	500,000	ground, metal	South
El Japón	18,059	elevated, metal	Central
Europa	26,000	elevated, metal	Central
Infop	150,000	ground, concrete	North
La Mora[a]	70,000	ground, concrete	Central
La Victoria #3	59,776	ground, concrete	South
La Victoria #1	217,303	ground, concrete	South
La Victoria #2	70,591	ground, concrete	South
Prado I	7,000	elevated, concrete	Central
Prado II	7,000	elevated, concrete	Central
San Carlos	45,000	elevated, metal	Central
Trincheras	200,000	ground, concrete	Central
Trincheras	250,000	ground, concrete	Central, South
Total	1,888,729		

[a] Not shown on existing water system figure.

3.1.5 Piping System. The Choloma distribution system consists of a network containing pipes ranging from 3-in to 20-in in diameter. This network is depicted on Figure 3-6, Figure 3-7, and Figure 3-8.

3.2 Historical and Projected Water Demands

Water demand projections provide the basis for sizing and staging future water facilities. Water use and production records, combined with projections of residential population and tourism, provide the basis for estimating future water requirements. This section presents a summary of demographic information and water use data, as well as, the resulting projections of future water needs for Choloma.

3.2.1 Demographics. The majority of the city's population lives within the city's three primary service areas referred to as north, central, and south. A central city neighborhood is shown on Figure 3-9. In the year 2000, the combined population for these service areas was estimated at more than 100,000 residents. The population served by the non municipal water systems, excluding the private industrial water supplies, is approximately 25, 000 persons.

Population growth within the three Choloma water service areas is substantial. Population projections were recently developed for Choloma by an independent consultant (ICMA), in cooperation with the United Nations, and published in the city's 1998 potable water study (Ing. Guzman, Juan Miguel, 1998). Based on these projections, Choloma is expected to grow at an annual rate of 4.5 percent through the year 2020. As a result, the combined population for the city's three service areas is expected to approach 210,000 residents by the year 2020. The 1998 population in each sector versus the capacity of each sector is presented in Table 3-5. The anticipated growth within the three primary water services area is summarized in Table 3-6 and illustrated on Figure 3-10. The population served by independent water systems are not included in this population projection.

Figure 3-9. Neighborhood in the Central City Portion of Choloma

Table 3-5. 1998 Population

Sector	Area total (hectares)	% of area occupied (1998)	Population (1998)	Population at capacity
North	210	45	19,845	44,100
Central	275	55	22,688	41,250
South	700	32	47,040	147,000
Totals	1,185	--	89,573	232,350

Table 3-6. Projected Population by Service Area

Service Area	Population				
	2000	2005	2010	2015	2020
North	21,671	27,006	33,654	41,939	44,100
Central	24,776	30,875	38,476	41,250	41,250
South	51,369	64,015	79,774	99,413	123,887
Totals	97,816	121,896	151,904	182,602	209,237

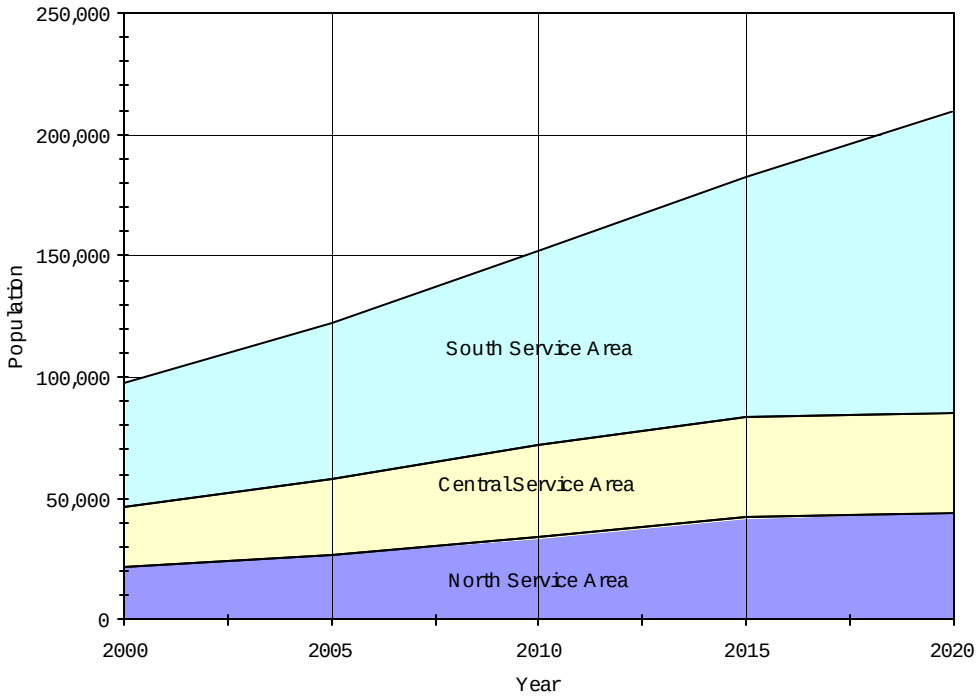


Figure 3-10. Projected Urban Area Population

3.2.2 Historical Water Use. Water production is the volume of water measured at the source, which includes all water delivered to residential, commercial, and public authority connections, as well as unaccounted-for water. This section describes daily water production, maximum day demand, and unaccounted-for water.

Historical water use data is unavailable, due to the absence of production or customer meters. An estimate of year 2000 annual water production by the municipal wells based on the number of hours each well is pumping (Table 3-1) is 22.3 million liters per day (mld) (5.9 million gallons per day (mgd)). This is equivalant to an estimate of water production based on a per capita water usage of 151 liters per capita per day (lpcd) (40 gallons per capita per day (gpcd)), a year 2000 population of 97,816, and a water loss factor due to leakage of 33 percent of total production. These water demand estimates do not include water pumped from the non municipal wells. The groundwater flow model presented in Appendix C use an average annual groundwater extraction rate including the non municipal wells of 263 lps (4,167 gpm) or 23 mld (6 mgd).

Daily demand fluctuates throughout the year based primarily on seasonal climate changes. Water demands are generally higher during warmer months. Therefore, system production facilities should be sized to meet the demand on the maximum day of the year, not just the average demand. Information provided by the 1998 water plan indicates that a 1.2 maximum day to average day demand ratio is appropriate (Ing Guzman, Juan Miguel, 1998). A 1.2 maximum/average day ratio is reasonable and is used in this study to assess future water demands.

3.2.2.1 Lost and Unaccounted-for Water. Lost and unaccounted-for water is defined as the difference between source production and consumption. Unaccounted-for water includes water loss due to leaks, inaccurate meters, and unauthorized usage. Water loss due to deteriorated and poor quality transmission and distribution mains can be significant, and represents a real system demand. Measurements of lost water conducted on some Central American water systems indicate losses as high as 350 gal/day-service (Lambert, Allan 2001). Choloma also reports significant distribution system water losses although the exact quantity cannot be established due to the lack of metering. During a July 2001 tour of Choloma water facilities, Brown and Caldwell staff noted large volumes of potable water discharging into drainage canals, as shown in Figure 3-11. Choloma staff indicated that this discharge is a result of severe distribution system leakage. Given the obvious signs of distribution system water loss, it is prudent to anticipate distribution system leakage when predicting future demands. For the purpose of this report, a 33 percent of total water production water loss factor is applied to develop the water demand projections.

Figure 3-11. Water Lost due to Leaking Watermains likely exceeds 50% of Production

3.2.3 Unit Water Use. To adequately serve new and existing water users, the municipality should estimate future water needs to ensure water is available to meet projected growth. Knowing the quantity, location and time when water will be needed allows systems to properly plan new source development. Future water demand projections are generally developed based upon population projections and historical per capita water usage.

A 1998 potable water study estimated that per capita consumption within the city service areas was approximately 151 lpcd (40 gpcd). This figure agrees with World Bank estimates of per capita usage (World Bank Publication 2468). A 40 gpcd is also reasonable considering the near total absence of industrial customers on the Choloma system and, therefore, will be used in this study. Note that this unit water use of 40 gpcd does not include unaccounted for water such as water loss due to leaks. As mentioned previously, most major industrial users or consumers are supplied by independent water systems. There are a number of factors that impact water demand projections, including maximum day demands, lost and unaccounted-for water, and source reliabilites.

3.2.4 Projected Water Demands. Water demands through the year 2020, given the previously identified population projections, are shown in Table 3-7 and illustrated on Figure 3-12. Table 3-8 presents the projected maximum day demand for each service area. These estimates are based upon a per capita consumption of 151 lpcd (40 gpcd), and an assumed

Table 3-7. Projected Water Demands

Year	Average day water use		Maximum day water use [a]	
	mld	mgd	mld	mgd
2000	22.3	5.9	26.5	7.0
2005	27.6	7.3	33.3	8.8
2010	34.4	9.1	41.3	10.9
2015	42.8	11.3	51.5	13.6
2020	53.4	14.1	64.4	17.0

[a] Maximum day projected water demands based on assumed 1.2 maximum day peaking factor.
mgd = million gallons per day
mld = million liters per day

water loss of 33 percent of total water production. By the year 2020, average annual water demands are expected to increase from 5.9 mgd to 14.1 mgd. By the year 2020, maximum day water demands are expected to increase from 308 lps (4,889 gpm) (7.0 mgd) in 2000 to 743 lps (11,783 gpm) (17.0 mgd) by year 2020. Possible reductions to water due to conservation measures, especially leak detection and repair that may be implemented in the future, are not reflected in the projected water demands. Also, water pumped from non municipal wells is not included in the water demand projections.

Reliability of source production generally takes the form of redundant facilities. Often times, municipal standards require that available source and storage are available in such quantities as to meet maximum day demands with a maximum of 20 hours per day of pumping. For the purposes of this report, however, meeting maximum day demands with 24 hours of pumping will be considered an acceptable standard. Table 3-9 compares year 2002 water demands versus source capacity. An existing deficit is identified for meeting maximum day demands. Apparently, Choloma is currently able to meet this maximum day demand by operating wells up to 24 hours per day and providing only temporary service to some customers.

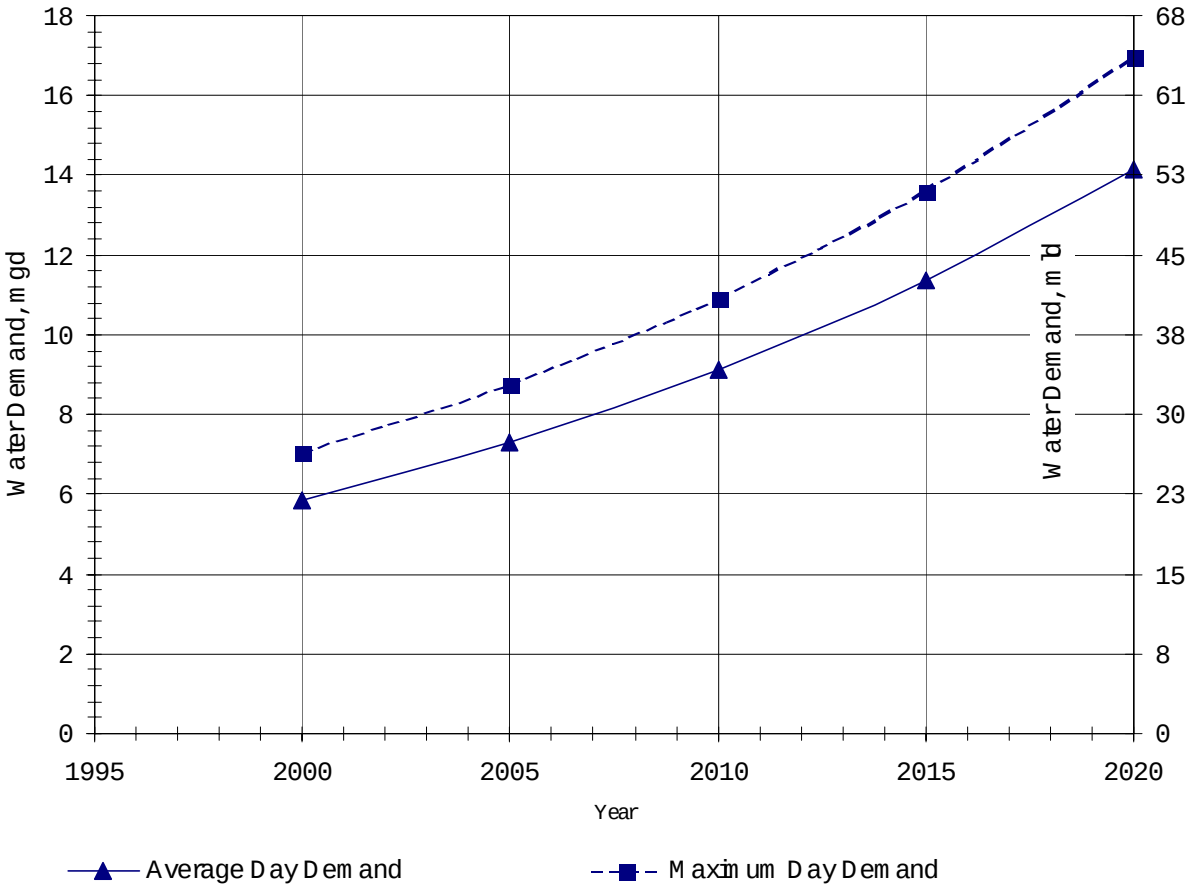


Figure 3-12. Projected Water Demands

Table 3-8. Projected Water System Maximum Day Demand, gpm

Service Area	2000	2005	2010	2015	2020
North	722	900	1,121	1,395	1,738
Central	825	1,028	1,280	1,595	1,990
South	1,712	2,133	2,658	3,312	4,127
Total	3,259	4,061	5,059	6,302	7,855
33% Loss	1,630	2,030	2,530	3,151	3,928
Total	4,889	6,091	7,589	9,453	11,783

gpm = gallons per minute

Table 3-9. Comparison of Water Requirements to Supply

	2002, gpm	2020, gpm
Average day demand	4,436	9,819
Maximum day demand [a]	5,323	11,783
Required supply capacity [b]	6,388	14,140
Available capacity [c]	4,866	4,866
Deficit [d]	1,522	9,274

gpm = gallons per minute
a Maximum day demand based on assumed 1.2 maximum day peaking factor.
b Based on 20 hour/day pumping and meeting maximum day demand.
c Identified existing municipal wells capacity.
d Required well capacity to meet maximum day demand.

4.0 GROUNDWATER RESOURCES EVALUATION

The groundwater resource evaluation for Choloma consisted of the review and analysis of existing geologic, hydrogeologic, and groundwater resource information for the area. Following the initial records review, a site reconnaissance of the area was conducted, followed by the development of a conceptual model, and the performance of a field investigation which included drilling and testing of test wells to explore deep hydrogeologic conditions in the valley. Following data collection and interpretation, a numeric groundwater flow model was developed using data obtained during this evaluation. This chapter presents the results of the groundwater evaluation at Choloma.

4.1 Conceptual Hydrogeologic Model

The conceptual model for Choloma was developed based on the understanding that the upland areas surrounding Choloma serve as the major surface and groundwater recharge areas for the valley. Precipitation recharge to the northern, western and southern highlands flows through bedrock and sediments, toward the valley, and ultimately discharges to the Choloma River, the major discharge area for the valley hydrologic system.

Based on information from local drilling companies, representatives from the municipality as well as residents, groundwater production is known to occur from the alluvial deposits of the shallow aquifer. However, detailed information regarding the nature of this aquifer was limited. Based on the preliminary conceptual model, it was suspected that the alluvial materials associated with the Choloma River presented the greatest potential for producing good well yields; however, more information was needed to assess whether this aquifer would be able to meet sustainable yields for the growing community. The conceptual model developed for Choloma is provided as Appendix A.

4.2 Field Investigation Program

The field investigation conducted at Choloma was tailored to evaluate sustainable groundwater supplies to accommodate the rapid growth of industry and population in the area. Existing wells in the area demonstrate that the unconsolidated alluvial deposits associated with the Choloma River Valley are the source for groundwater supplies. Also, existing well information indicates that good yields (average 28 lps (450 gpm)) can be obtained from sand and gravel deposits below 100 ft bgs. However, the available information on the character and extent of these deposits is limited. Thus, the objective of the field investigation was to further explore the water producing zones in the laterally continuous shallow sand and gravel deposits and to investigate the production characteristics of the deeper alluvial deposits. This included a the performance of a preliminary characterization of the deposits, as well as determining water quality, aquifer transmissivities, specific yields and yield sustainability for this zone.

In support of this objective, the field investigation consisted of the installation of three wells in the Choloma Valley. Geophysical logging and pump tests for aquifer characterizations were conducted and groundwater samples were collected at subsurface intervals identified to yield sufficient

groundwater supplies. This section summarizes the results of the field investigation. Appendix B describes the results of the field investigation in greater detail.

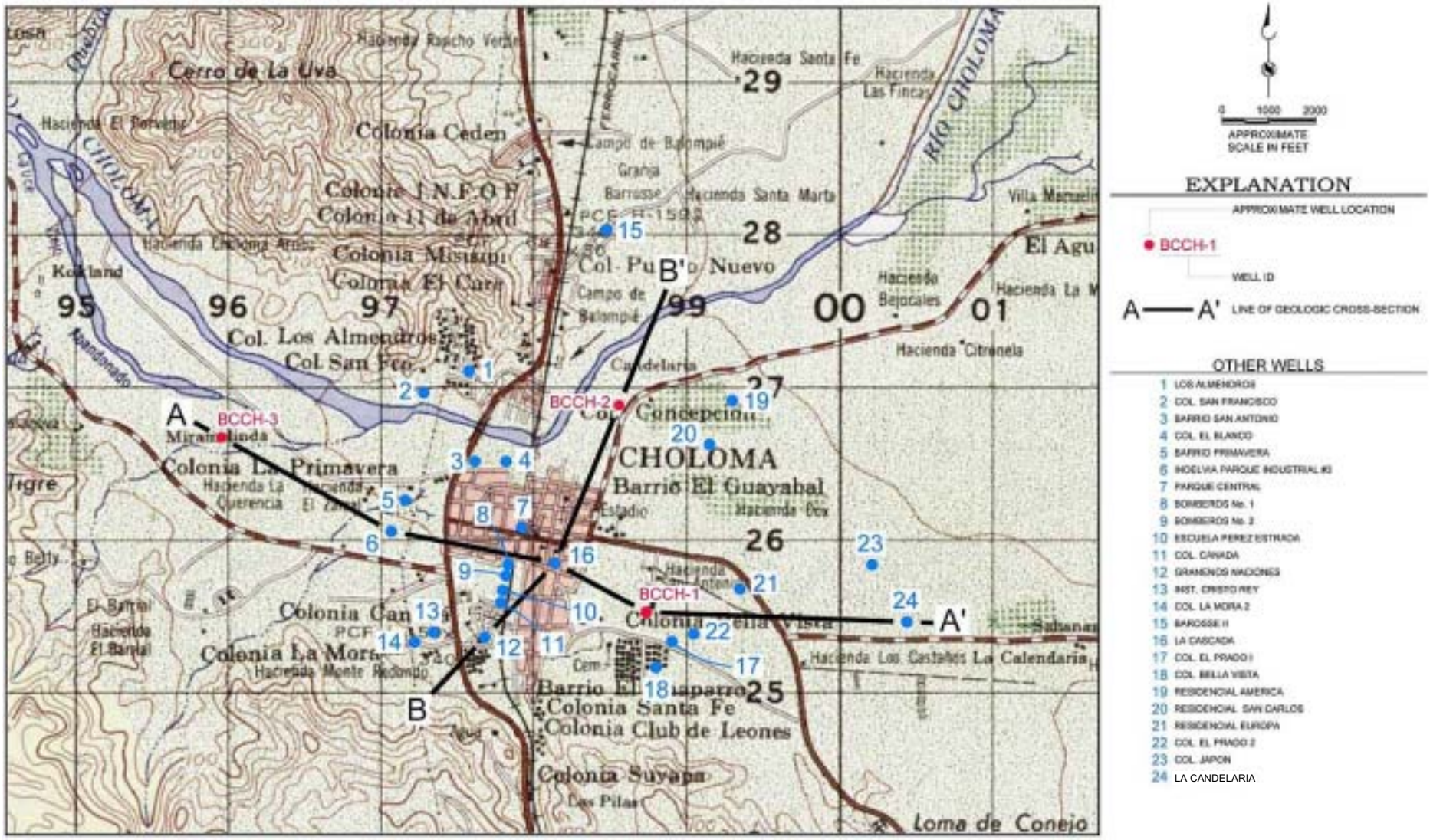
4.2.1 Borehole Analysis and Test Well Installation. Three test wells, BCCH-1, BCCH-2, and BCCH-3, were installed as part of the Brown and Caldwell field investigation. Well BCCH-1 is located approximately 950 meters southeast of Bomberos No. 1, in Colonia La Granja (Figure 4-1). Bomberos No. 1 is a municipal water supply well in central Choloma. Well BCCH-2 is approximately 1.25 kilometers northeast of Bomberos No. 1, along the road to Colonia Brisas del Norte and in Colonia Rubi. Well BCCH-3 is located approximately 2.1 kilometers northwest of Bomberos No. 1, approximately 500 meters north of the road to El Portillo. The locations of the three test wells are presented on Figure 4-2. Detailed borehole analyses, well installation details, pump test analyses, and associated figures are presented in Appendix B.

Figure 4-1. Mud Rotary Drilling, BCCH-1

Test holes BCCH-1, BCCH-2, and BCCH-3 were drilled to depths of 475, 430, and 370 feet bgs respectively (reportedly the deepest borehole penetrations in the area) to investigate deep water production zones. Based on a review of available data for Choloma, a laterally continuous sand and gravel aquifer was identified at a depth greater than 100 feet bgs. The test wells were installed to investigate this sand and gravel aquifer as well as to determine the presence of a deeper bearing zone capable of supporting the current and future demands in Choloma.

Drill cuttings and geophysical logs were evaluated to determine the lithology encountered at each test well site. Lithologic and geophysical logs for BCCH-1, BCCH-2, and BCCH-3 are presented in Appendix B. The results of these inspections indicate that exploratory borehole BCCH-1 penetrated a medium to coarse-grained sand deposit from land surface to approximately 250 feet bgs. This upper sand deposit is moderately- to well-sorted with a predominately felsic mineral composition. Sandy-clay was encountered between 250 and 350 feet bgs. Cemented sand with silt was penetrated from 350 feet to the total depth of the borehole at 475 feet bgs. Based on the results of geophysical logging, the lower cemented sand and silt deposit becomes increasingly cemented from approximately 440 feet bgs to 475 ft. Well BCCH-1 is screened from approximately 322 to 448 feet bgs and was the first well in the area to investigate the lower cemented sand and silt unit.

Well BCCH-2 penetrated deposits of sand and silty-sand from land surface to the total depth of the borehole (approximately 430 feet bgs). Generally, the sand is moderately- to well-sorted, and medium- to coarse-grained. The amount of fine-grained material in the silty-sand intervals is less than or equal to 30 percent. Based on the results of geophysical logging and drilling penetration rate, the lower portion of the borehole is slightly to moderately cemented below approximately



BROWN AND CALDWELL	DATE 2-22-02	SITE Choloma, Republic of Honduras	FIGURE 4-2
	PROJECT 21143	TITLE Well Location Map	

300 feet bgs. The lithology of this lower cemented sand and silt is similar in mineral composition to the cemented sand and silt deposit encountered at BCCH-1. The major water-bearing stratum at the site is the upper sand and silty-sand deposit found from the surface to a depth of 300 feet bgs. Test well BCCH-2 is screened from approximately 160 to 295 feet bgs.

Well BCCH-3 encountered moderately sorted, medium- to coarse-grained sand deposits from land surface to approximately 170 feet bgs. Silty-sand with gravel, with approximately 20 percent silt and clay, was penetrated from approximately 170 to 260 feet bgs. A deposit of clay was encountered between 260 and 270 feet, overlying weakly cemented clayey-sand from 270 to 290 feet bgs. A moderate to strongly cemented sand with silt was penetrated from 290 feet to the total depth of the borehole (370 feet bgs). This cemented deposit is similar in mineralogy to the cemented sand with silt deposits identified in the lower portion of BCCH-1 and BCCH-2. The major water-bearing stratum at the site is the sand deposit to a depth of approximately 170 feet bgs. Test well BCCH-3 is screened from approximately 121 to 169 feet bgs.

After completion of the exploratory boreholes, geophysical logging was conducted and the exploratory boreholes were reamed to a larger diameter to accommodate the test wells. Lithologic logs, geophysical logs, and well designs for wells BCCH-1, BCCH-2, and BCCH-3 are discussed and presented on Figures in Appendix B. A summary of well construction and completion details provided in Table 4-1 below.

Table 4-1. Summary of New Well Completion Details for Choloma

	Total Depth of Borehole		Total Depth of Well		Screened Interval		
Well	m, bgs	ft, bgs	m, bgs	ft, bgs	m, bgs	ft, bgs	Function
BCCH-1	145	475	137	448	98 – 137	322 – 448	Explore potential deep aquifer.
BCCH-2	131	430	91	300	49 – 90	160 – 295	Investigate shallow alluvial deposits.
BCCH-3	113	370	55	179	38 – 52	121 – 169	Investigate shallow alluvial deposits.

bgs=below ground surface
ft=feet
m=meters

4.2.2 Aquifer Testing. Aquifer discharge tests were performed on the BC wells to evaluate the water resource development potential of the laterally continuous shallow sand deposits identified in the area and deeper sand deposits generally encountered between 300 and 350 feet bgs to the total depth of the exploratory borings. During the short-term aquifer test conducted at BCCH-1, excessive groundwater drawdown occurred, and as a result, no further testing was conducted. Both short- and long-term discharge tests were conducted at test well BCCH-2. Due to favorable results from the step-rate discharge test at BCCH-3, only a short-term discharge test was conducted. Detailed aquifer drawdown and recovery plots for the short and long and term tests are presented in Appendix B, and discussed below.

A two-hour step-rate test was conducted at test well BCCH-1 to evaluate the deep sandy deposit encountered between 350 and 440 feet bgs. At the end of each step, the specific capacity was calculated at approximately 0.2 gallons per minute per foot (gpm/ft) of drawdown. At the maximum rate of 2 lps (34 gpm), drawdown was approximately 53 m (174 ft) at the end of the test. The drawdown plot is presented on Figure B-6 in Appendix B. Production from the deep coarse-grained deposit as screened in BCCH-1 is considered poor.

Short-term and long-term aquifer discharge tests were conducted at test well BCCH-2. Specific capacities measured at the end of each step-rate were between approximately 31.5 to 27.6 gpm/ft. The drawdown and recovery plots for the step-rate test is presented on Appendix B0 Figures B-7 and B-10. For the constant-rate test, the well was pumped at an average rate of approximately 26 lps (405 gpm) for 4.5 hours. At the end of the test, the total drawdown in BCCH-2 was approximately 14.5 feet, and the specific capacity of the test well was calculated at approximately 28 gpm/ft. Well water levels recovered 95 percent after 45 minutes. The drawdown and recovery plots are presented as Appendix B Figures B-13 and B-14. Results of the long-term aquifer test data estimates transmissivity at the site to be between approximately 285,000 and 313,800 liters per day per foot (75,300 and 82,900 gallons per day per foot).

Figure 4-3. Step-rate Discharge Test at BCCH-3

A seven-hour step-rate test was conducted at test well BCCH-3 (Figure 4-3). Specific capacities measured during the step-rate test ranged between approximately 20.1 to 13.8 gpm/ft. The drawdown plot is presented on Appendix B Figure B-8.

4.2.3 Water Quality Survey. Groundwater samples were collected from each of the wells installed by Brown and Caldwell during this investigation. In addition, the following selected existing wells in Choloma were included for water quality evaluation: Bomberos No. 1, Colonia Canada, Residencial Europa, Ines Carranza Barnica, Colonia El Prado No.1, Barrio Primavera, Barrio San Antonio, Victoria Gasolinera, San Carlos, Residencial América, Parque Central, Barrose II, and Colonia San Francisco. Municipal wells were selected for sampling to provide a comprehensive understanding of the general water quality in Choloma. The wells selected to sample represent residential, agricultural and industrial areas as well as publicly and privately installed facilities. The selection of wells provides adequate spatial distribution so as to provide a sufficient amount of data to establish a water quality baseline to build on in the future. Not all drinking water constituents were tested for in the sampled wells. The results of the water quality testing are summarized in Table 4-2 and presented in Appendix B. Groundwater monitoring procedures are outlined in Appendix E of this report. Training in groundwater monitoring techniques was conducted for local staff as described in Appendix G.

Table 4-2. Summary of Well Analytical Results

Analytical constituent	Drinking water standard[c]	Test wells			Existing wells[a]						
		BC CH-1	BC CH-2	BC CH-3	Existing wells (range)	Barrio Primavera	Barrio San Antonio	Bomberos No.1	Col San Fransisco	Ines Carranza Barrio	San Carlos
General											
Acidity	mg/l[g]	8	98	25	15-82	15	23	31	82	50	--[d]
Alkalinity	mg/l CaCO3[g]	118.9	30	118	12-374	93	80	112	184	374	--[d]
Chloride	mg/l[g]	22	10	7.5	6-94	8	6	18	17	94	--[d]
Conductivity	us/cm[g]	357	252	264	190-1,027	239	190	269	442	1,027	--[d]
Hardness	mg/l CaCO3[g]	100	126	108	24-184	88	68	100	168	184	--[d]
Iron	0.3[f] mg/l	0.32	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	--[d]
Manganese	0.5 mg/l (P)[e]	1.05	<0.03	<0.03	<0.03-0.05	0.05	<0.03	<0.03	<0.03	<0.03	--[d]
Nitrate	50 mg/l	1.80	2.3	4.30	1.12-9.40	5.35	1.94	4.20	9.40	4.50	--[d]
Metals											
Antimony	0.005 mg/l (P)[e]	<0.005	<0.005	<0.005	<0.005-0.00812	<0.005	<0.005	<0.005	<0.005	<0.005	0.00812
Arsenic	0.01 mg/l (P)[e]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	3 mg/l	0.0721	<0.02	0.059	<0.02-0.0317	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bacteriology											
Total Coliform	UFC/100 ml	47	0	15	0-35	2	11	1	3	35	--[d]
Fecal Coliform	UFC/100 ml	10	0	0	0-9	0	0	0	0	9	--[d]
Radiochemistry											
Gross Alpha activity	5 pCi/L[h]	--[d]	2.4 pCi/L	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]
Gross Beta activity	50 pCi/L[h]	--[d]	2.8 pCi/L	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]
Pesticides	(range)[b] mg/l	None detected	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]
Herbicides	(range)[b] mg/l	None detected	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]
Volatile Organics	(range)[b] ug/l	None detected	--[d]	--[d]	None detected	--[d]	--[d]	--[d]	--[d]	--[d]	None detected

Source: SPL Houston Laboratory and Jordanlab Laboratorio de Analysis Industrial laboratory results. Test dates vary.
Note: Numbers in bold are those over the drinking water standard.
UFC – must not be detectable in any 100 ml sample.
[a] Existing wells that exceed drinking water standards.
[b] Drinking water standard varies by individual constituent.
[c] World Health Organization, 1996. Guidelines for Drinking Water Quality, 2nd ed. Vol 2 Health criteria and other supporting information and Addendum to Vol. 2, 1998.
[d] Lab reports not available/not tested for this constituent.
[e] (P) – provisional guidance value for constituents for which there is some evidence of a potential hazard but where the available information on health effects is limited; or where an uncertainty factor greater than 1,000 has been used in the derivation of the tolerable daily intake.
[f] Levels likely to give rise to customer complaints.
[g] No drinking water standard.
[h.] US standard.

Results for each constituent analyzed for were compared to the Guidelines for Drinking-Water Quality as published in 1996 by the WHO. It should be noted that while the Honduran government has not established country-specific guidelines for drinking-water quality, the Honduran Ministry of Health has accepted the guidelines established by WHO.

The results of the water quality survey shows that the groundwater meets drinking water standards, except as noted below:

1. Coliform was present in two of the three test wells and in five of the nine existing wells that were sampled. Fecal coliform was detected in one of the test wells and in one of the existing wells (Ines Carranza Barrio). This well is located in the southern service area.

2. Antimony was detected slightly over the provisional standard in the San Carlos well.

3. Iron and manganese was detected in one test well (BC CH-1) over the customer complaint and provisional standard, respectively.

4.3 Numerical Simulation of Well Fields

A numerical groundwater flow model was constructed for Choloma to assess the sustainability of future groundwater supply development to meet the needs of the community. The interpretive modeling process produced a calibrated steady state simulation of existing hydrogeologic conditions, which was then used to evaluate the groundwater production of the alluvial aquifer. Also, predictive simulations were performed to evaluate the potential effects of increased groundwater production on the Choloma Valley aquifer system. Based on available data and the data collected during the field investigation, the conceptual model and numerical hydrogeological models can reasonably represent the Choloma Valley aquifer system, and therefore can be used in planning and developing future groundwater resources. A full discussion of the numerical model developed for Choloma is presented in Appendix C.

The conceptual groundwater budget indicates that of the estimated 1,377 lps (21,831 gpm) that enters the Choloma Valley aquifers through mountain front recharge, aerial recharge, and recharge from the Choloma River, approximately 263 lps (4,167 gpm) is currently extracted by production wells, approximately 311 lps (4,953 gpm) flows to the Choloma River and approximately 628 lps (9,961 gpm) flows out of the Choloma Valley aquifer into the Sula Valley aquifer system. This result suggests that the current estimated extraction rate could be increased to 434 lps (6,876 gpm) on a long term, continuous basis before groundwater discharge from the Choloma Valley aquifer system is taken from storage.

The results of transient model simulations indicate that it is possible to increase groundwater production to 757 lps (12,000 gpm) in the Choloma Valley, although a large magnitude of production increase would cause significant changes in the groundwater flow system underlying the valley. The majority of groundwater needs can be obtained from pumping groundwater from the

current well field area located east of Choloma. However, as noted previously, this area has the potential for continued population growth and development, which could have impacts on groundwater quality. A portion of the groundwater projected needs (approximately 60 percent) can be met by developing a well field to the west and upgradient of Choloma. For the predictive simulation, a total of 13 wells with an average production rate of 47 lps (750 gpm) were located in the proposed western and eastern well field areas. The simulation results indicate that aquifer drawdown would be approximately 4 to 5 m (13 to 16 ft) in the vicinities of the two well fields.

4.4 Potential Contamination Sources

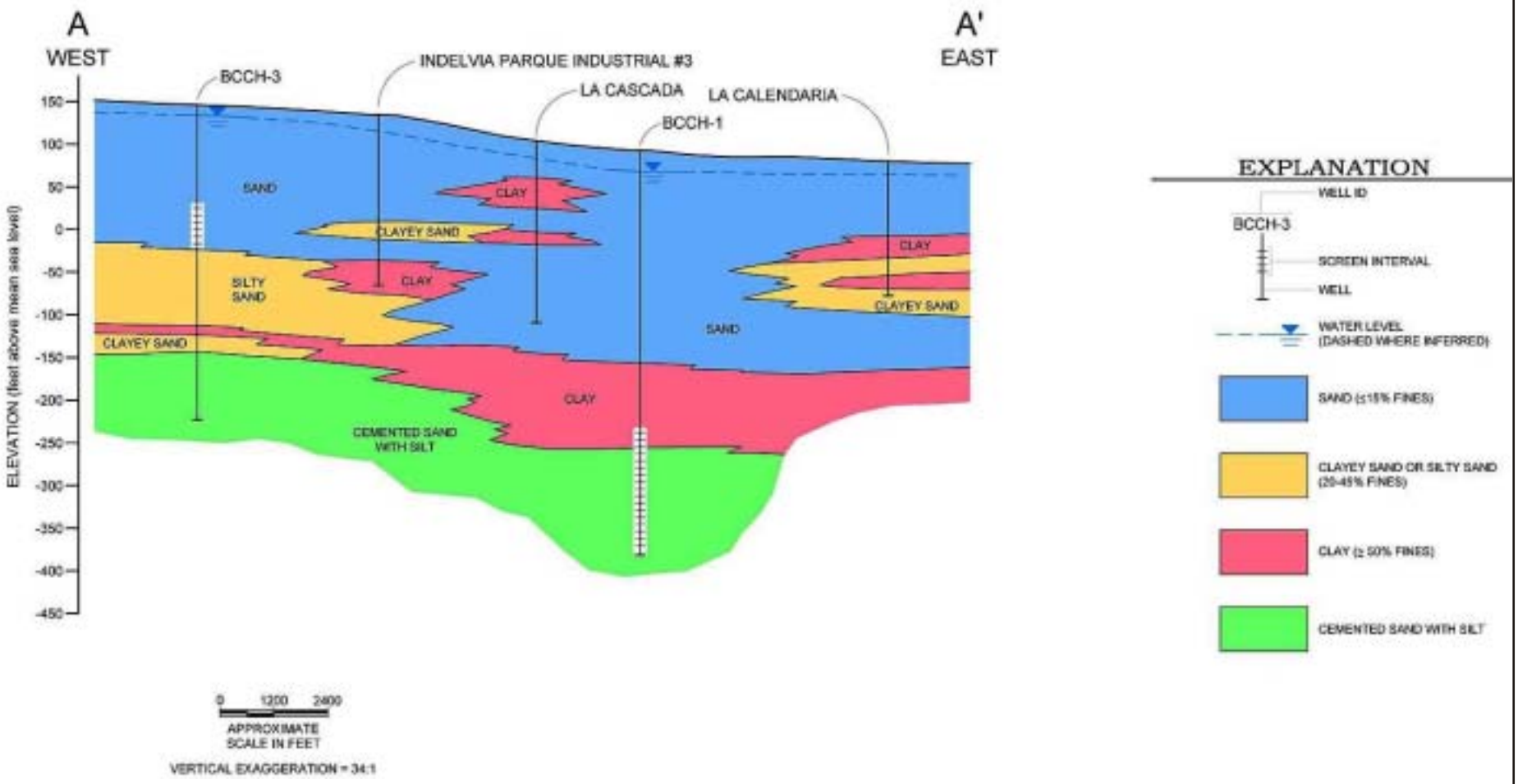
There are several potential sources of contamination to the alluvial aquifers near Choloma. The local economy is driven by both agriculture and manufacturing. Sugar cane is grown in large fields northeast of Choloma and are flood-irrigated from aqueduct channels. It is likely that any fertilizers, pesticides and herbicides that are not carried off with the unused irrigation water, percolate downward to the shallow groundwater, potentially contaminating groundwater supplies of the alluvial aquifer. Analytical results for this project, however, suggest that this is not currently a problem for the aquifers investigated. Some areas in the western portion of the study area are used to graze cattle, which introduces the potential for fecal matter to migrate from the surface to the groundwater. This activity, however, is not widespread enough at this time to warrant a serious concern for the aquifer investigation.

Large ZIPs are located in the southwest area of Choloma. The ZIPs include factories reported to manufacture clothing and plastic parts. In addition, a J.P. Coats facility that may manufacture paint products is located in the ZIP. Although there is some treatment for both industrial and sanitary wastes, most of the wastes are discharged to small surface drainages, and eventually drain into the Choloma River. At least one of the main collectors of municipal waste water discharges into a natural canal, called Quebrada San Agustín, without any treatment.

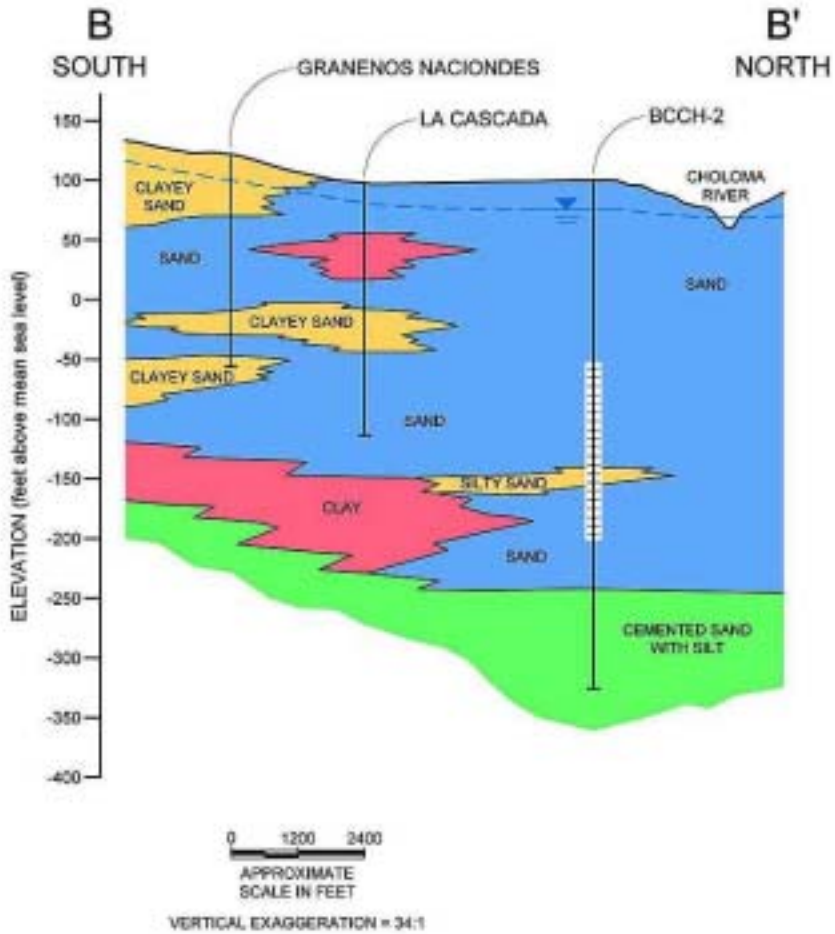
Similarly, many of the existing and new residential areas possess inadequate sanitary facilities and most rely on latrines which discharge directly to the ground. These sanitary wastes likely migrate to the shallow aquifer, contaminating groundwater with coliform and nitrate. Many of the existing residential wells in the area are screened near land surface, which provide direct vertical conduits for contaminants (specifically coliform) to migrate from the shallow subsurface to saturated zones below. The recommendations for a wellhead protection program are provided in Chapter 6 of this report.

4.5 Aquifers and Recommended Well Fields

During the Brown and Caldwell investigation, three wells (BCCH-1, BCCH-2 and BCCH-3) were installed to evaluate the hydrogeologic and water quality conditions along the Choloma River Valley (Figure 4-2). Lithologic information from each of these wells, combined with information from selected existing wells was used to create geologic cross-sections of the Choloma Valley (Figure 4-4 and Figure 4-5). Based on construction details and production volumes from existing municipal and private wells, and the information from the wells installed as part of the field investigation, the



BROWN AND CALDWELL	DATE 2-22-02	SITE Choloma, Republic of Honduras	FIGURE 4-4
	PROJECT 21143	TITLE Cross Section A-A'	



BROWN AND CALDWELL	DATE 2-22-02	SITE Choloma, Republic of Honduras	FIGURE 4-5
	PROJECT 21143	TITLE Cross Section B-B'	

hydrostratigraphic setting beneath the Choloma River Valley is characterized by a sequence of interbedded silts and sands grading into interbedded fine- to medium-grained sands and cemented sands.

The results of the early site reconnaissance, the field investigation, and the preliminary groundwater flow model indicate the laterally continuous shallow alluvial sand deposits are a source of sustainable water supplies for Choloma. The lithologic cross-sections show the laterally continuous nature of the sand deposits, both along the axis of the Choloma river valley as well as across the river basin. The laterally continuous shallow sands generally increases in thickness to the east and northeast portion of the study area. In the western portion of the study area, well BCCH-3 penetrated a medium to coarse-grained sand from land surface to approximately 170 feet bgs. In the central and northern portions of the study area, wells BCCH-1 and BCCH-2 penetrated medium to coarse-grained sand from land surface to approximately 250, and 300 feet bgs, respectively. Finer-grained lenses of clayey sand and clay between 15 and 40 feet thick were observed within the laterally continuous deposit by wells BCCH-2, La Casacoda, Granenos Nacionales, Inhdelva Parque Industrial #3, and La Calendelaria.

Results of aquifer tests conducted on the deeper cemented sands encountered at well BCCH-1 indicated limited production potential. This deeper sand layer is generally separated from the overlying laterally continuous alluvial deposit by a deposit of silty-sand in the western portion of the study area, and by a thick deposit of clay in the central portion of the study area. At well BCCH-2, along the northern portion of the study area, the laterally continuous sands directly overlie the lower cemented sands.

In summary, the laterally continuous shallow sand deposits are considered to be a sustainable source of groundwater for Choloma. If additional supply wells are needed for the municipality, it is recommended that the new wells be installed in the far western portion of the city, upgradient of the industrial parks and the municipal sewer system. Both of these areas are considered potential sources of contamination to shallow groundwater in the area. This is especially important as the city continues to experience growth in industry and population. However, production from wells in this area may be limited due to greater drawdown due to the narrow width of the valley, which limits the aquifer storage area.

5.0 WATER RESOURCES MANAGEMENT SYSTEM

The Water Resources Management System (WRMS) is a desktop computer application developed to store, manage, and analyze technical information gathered and generated for this project. The application is a management tool that can be used by the municipalities and other decision-makers to support sustainable management of their groundwater resources. The system is composed of both a data management system and a geographic information system (GIS) linked together as one application. Through the WRMS, users can:

- manage and generate reports for wells, storage tanks, and springs;
- view well logs and well completion diagrams;
- analyze water quality and water level data;
- track statistics on water use; and
- view wells, water quality information, and aquifer characteristics on maps of the study area.

The WRMS is considered an important component for the water resource management plan. The system is briefly described in this chapter and is described in more detail in the Water Resources Management System Users Guide (Appendix E). The application consists of two primary components; a data management system and a GIS. The application is written so that the two components work together and function as one system. Data are shared back and fourth between the data management system and the GIS.

The data management system used is Microsoft Access, which is a relational database designed to efficiently manage complex data. The data are stored in a series of tables. Each table stores a different type of information, and each table is linked to others by a key field that defines the relationship. For example, one table contains a record of each well, while another table contains all the water level measurements. The table containing the water levels also contains the name of each well so that it can be linked back to the appropriate well in the well table. This way, detailed information on each well and water level measurements can be stored most efficiently, without the need to maintain the same piece of information more than once, which would potentially introduce erroneous data into the system.

The GIS used is ArcView®, by Environmental Science Research Institute. A GIS is an electronic mapping and analysis system. The power of GIS lies in its ability to manipulate, display, and analyze information on a map by linking map elements to attribute data in a database. For example, a well whose location is identified as a dot on the map is connected to the construction data, sampling results, and water level information in the database. The user can post any of this information as text on the map, choose specific symbols or colors to represent these data, and overlay this layer of information on other map features. Because the data management system and GIS work together, it provides the user with a powerful set of management and analysis tools.

Both of these components are linked through a common interface developed in Microsoft Visual Basic. The interface is a series of screens that guide the user through various application functions. Through the interface, the user can enter or update data, view reports, generate graphs, display

scanned images, and create customized maps. The interface can be displayed in English or Spanish, uses water resource terminology, and is designed to be user-friendly. Through this interface, municipalities will be able to continue to update their water resource data and use it for decision-making in the future.

5.1 Benefits of the WRMS

The WRMS consolidates, perhaps for the first time, the most critical water resource information for a municipality. It provides a central place to manage, analyze, and display water resource information in both map and tabular form. The WRMS accommodates all major types of information needed for sound water resource management including data on wells and other water sources, future demand and growth, infrastructure and organizational boundaries, and water quality and aquifer characteristics.

Because the system is designed to accommodate additional data as more information is collected and wells are created or modified in the future, it can be used to facilitate sound water resource decision-making in the future. It is easy to use and requires minimal training, which will facilitate continued system use. It uses a standard methodology for identifying and prioritizing future well sites, which will allow municipalities to continue to apply a consistent planning approach.

5.2 Use and Management

The WRMS is designed to work in conjunction with the findings of this report. Most of the data collected or developed for the report are contained in system, and are available for continued analysis, display, and incorporation with new data as it is collected. The system can be used to view and explore additional details of the existing water system.

The WRMS should be used to provide a common environment for communication among stakeholder agencies for water resource planning. The system provides a consistent view and methodology for analyzing water resource data. Consistently using it as a communication tool among stake-holders will make the sometimes confusing and complex technical information easier to understand. New data, such as new wells, additional sampling results, or new water level measurements should be entered into the system on a regular basis (annually) in order to have the most up-to-date information available for decision-making.

5.3 Choloma Data

Table 5-1 summarizes mapping information collected on Choloma. This data is included for review in the WRMS. There are 68 wells with information collected. Fifteen wells; (Barosse II, Barrio Primavera, Barrio San Antonio, BC-CH-1, BC-CH-2, BC-CH-3, Bomberos No. 1, Col. Canada, Col. El Prado 1, Col. San Francisco, Ines Carranza Barnica, Parque Central, Residencial America, Residencial Europa, and Residential San Carlos) have water quality information in the WRMS.

A compact disk containing the WRMS and all of the Choloma data described above is included with this report.

Table 5-1. Choloma GIS Data Dictionary

File name	File type	Description	Date	Source	Scale of source data
Cholomа_utm.tif	image	Scanned topographic map, aligned in NAD 27	1994	Topographic map prepared by the insitute Geographica Nacional, Honduras in collaboration with Defense Mapping Agency	
Cad-Cholomа-muniboundry.shp	shape	Municipal boundary around Cholomа – line.		CAD	
Cad-Cholomа-muniboundry-poly.shp	shape	Municipal boundary around Cholomа-polygon.		CAD	
Cholomacrecimento.shp	shape	Aligned CAD file containing multiple layers (municipal boundary, streets, etc)			
Cholomа 2000 aerial-adjusted.img	image	Scanned aerial photograph – aligned in NAD 27. One of two.	March 2000	USGS	1:40,000
Cholomа 2000-aerial-adjusted2.img	image	Scanned aerial photograph – aligned in NAD 27. Two of two.	March 2000	USGS	1:40,000
CAD-cholomа-neighborhoods.shp	shape	Outline of Cholomа neighborhoods and colonies.		CAD	
CAD-cholomа-streets.shp	shape	Colomа Streets		CAD	
CAD-cholomа-geology.shp	shape	Geological strata-no data layers		CAD	
CAD-cholomа-urbanboundry.shp	shape	Outline of cholomа urban boundary		CAD	
Aerial-cholomа-developed_area-2000.shp	shape	Polygon of developed areas based on aerial photo	March 2000	USGS Aerial Photo	1:40,000
Topo-cholomа-developed_area.shp	shape	Polygon of developed areas based on topographic map.			
Chlm1-grid	grid	Arcview grid file converted from vector contour file using arcinfo.		Intec Americas vector contour files	30 meter, one arc second
Cholomа-vect1of1.shp	shape	Vector contour file, one of one file.		Intec Americas	30 meter, one arc second

6.0 RECOMMENDED GROUNDWATER RESOURCES MANAGEMENT PLAN

This chapter presents recommendations to ensure water supply sustainability. Recommendations for groundwater management, wells, groundwater monitoring, wellhead and recharge area protection, water utility management, and water supply are presented.

6.1 Groundwater Management

Considering the growing use of groundwater in the Sula Valley, control should be kept to protect the groundwater resource, including control of excessive aquifer water level declines and control of potential contamination sources. Due to financial and technical limitations at each municipality in the Sula Valley and surrounding areas, it is recommended that joint efforts be initiated to create a groundwater management agency. This agency would provide technical advice, keep records of aquifer behavior, and maintain the hydrogeological database. As the private sector of the Sula Valley depends on groundwater for commercial, industrial, and agricultural purposes, it is recommended to develop an agency with a board of directors formed by representatives of the municipalities and private organizations, such as the Chamber of Commerce. This model of institution would give assurance that the agency would maintain independence and stay free of periodic staff changes.

Considering the need to start properly managing the main watershed basins that contribute to the Sula Valley as part of a flood mitigation project, a general plan to protect aquifers would be complementary.

6.2 Drilling Plan

The following recommendations are made regarding drilling of future wells:

1. Drill the future production wells in the western and eastern areas of Choloma. Test wells BCCH-2 and BCCH-3 are suitable to be converted to production wells.
2. Drill a well approximately every year and a half until a total of 12 wells have been completed by the year 2020. This assumes a well capacity of 47 lps (750 gpm) each.
3. Acquire in advance the land needed to construct production wells. A well site with a size of approximately 30 m by 30 m (100 ft by 100 ft) is recommended.
4. The wells should have a depth of approximately 80 m (250 ft).
5. The production wells need to have a sanitary seal with a minimum length of 15 m (50 ft).
6. The diameter of the well casings need to be adequate to install a pump with a capacity sufficient to supply the 47 lps (750 gpm) and lift the water to the water tanks.
7. It is recommended that the wells be equipped with water lubed vertical turbine pumps.
8. Each production well should be equipped with the equipment necessary to disinfect the water, monitor the groundwater level, quality, and production quantity.

6.3 Groundwater Monitoring

An important component of managing the current water supply in Choloma and ensuring compliance with drinking water standards is the development and maintenance of a regular groundwater monitoring program. A regular monitoring program will ensure compliance with drinking water standards and will provide a useful tool for tracking groundwater quality, groundwater levels, and usage, as well as help with growth planning in the future.

There are several components that contribute to a successful monitoring program, each of which are equally important. These components include groundwater level data collection, groundwater production data collection, water sample collection, analysis of water samples and review, and compilation and understanding of water chemistry results. Each of these components is necessary in order to maintain a successful groundwater monitoring program. Information regarding the steps necessary to complete a monitoring program are outlined in the Groundwater Level and Monitoring Program, Field Manual, December 2001, included as Appendix E. This document was distributed to various members of the municipality during the groundwater level and monitoring training provided by Brown and Caldwell in December 2001.

The following recommendations are made regarding groundwater monitoring:

1. The monitoring of the wells should be continued at a three-month frequency.
2. The well monitoring should consist of monitoring and recording the groundwater level and the quantity and quality of the water.
3. It is recommended that the well monitoring network consist of 14 wells, as listed in Appendix E.
4. The collected monitoring information should be recorded in the computer database.

6.4 Wellhead Protection

An important component in protecting the groundwater quality used for public water supply in Choloma is establishing a wellhead protection program. Wellhead protection is the practice of managing the land area around a well to prevent groundwater contamination. Prevention of groundwater contamination is essential to maintain a safe drinking water supply.

Development of a wellhead protection plan for Choloma consists of five key steps that are described in Appendix F. To implement a management plan to protect the well capture areas and the general aquifer recharge areas it is recommended that municipal control be established for the following items:

1. Discharge of municipal wastewater.
2. Discharge of industrial wastewater.
3. Disposition of solid waste.
4. Storage and distribution of hydrocarbon products.
5. Storage and distribution of chemical products (agricultural and industrial).

6.5 Water Resource Management System

Brown and Caldwell developed a Water Resources Management System to store, manage, and analyze water resource related data gathered and generated for this project, and for data to be collected in the future by municipality. The following recommendations are made regarding the Water Resource Management System:

1. The database should be regularly updated by the municipality by adding groundwater level, groundwater production, and water quality data for the wells in the monitoring network.
2. Routinely use the database to input information regarding new wells, well monitoring information, and general water system operation data.

6.6 Water Utility Management

An important aspect of ensuring a sustainable water supply is having a functioning water utility with the proper organizational structure. The water utility is responsible for properly managing, operating, and maintaining the water system, and must be financially self-sufficient. Several water utility management recommendations are listed below.

1. Continue to maintain a complete list of all water system customers that includes descriptive information for each customer. This information should include name, address, service line size, and type of customer (residential, commercial, etc.).
2. Update the financial plan for the water utility that establishes budget needs and defines an equitable rate and new connection fee structure that is adequate to cover the costs of expanding, operating, and maintaining the water system. Continue to ensure that users are routinely charged for and pay for water supply.
3. The water utility should have adequate staff that is trained on a regular basis to address operational and maintenance needs.
4. Investigate possible sources of grant and loan financing to help improve and expand the water system.

6.7 Control Over Well Construction

It is recommended that control over the construction of wells by others be established through municipal regulation. The objectives are to ensure that wells constructed by other parties meet appropriate construction standards and that information obtained during well construction is recorded and placed in the database.

6.8 Control of Water Losses

A program should be developed to detect and eliminate leaks in the water distribution system. The first step is to conduct a study to define the amount of water loss and recommend the best areas for

leak repair and/or main replacement. A water conservation program should be initiated to ensure that customers are using water efficiently.

6.9 Water Quality

The wells should be disinfected with chlorine. For the several wells with a detected presence of total coliform and fecal coliform, it is recommended that they be immediately disinfected followed by a new water quality analysis after the chlorine level is reduced back down to zero. This will determine if the contamination is still entering the well. If the well still has coliform or fecal coliform, consider other measures, including permanent disinfection, identification and elimination of the contamination source, and well closure.

6.10 Water System Expansion Plan

The preparation of a water system expansion plan is recommended. The municipality is responsible for the water supply system. Therefore, the municipality must ensure that the public or private investment for the water system expansion is properly planned. Several objectives are recommended.

1. Reduce the total number of production wells by planning fewer, larger capacity wells in the western and eastern areas.
2. Operate more efficient wells with a greater specific yield.
3. Plan for the construction of new wells, pumping lines, and storage tanks to serve all sectors of the city, including the growing southern portion of Choloma.
4. Investors who wish to start new development projects should receive water from the municipal water system after paying the appropriate connection fees.

APPENDIX A

Conceptual Model and Rationale for Phase II Field Investigation

CONCEPTUAL MODEL AND RATIONALE FOR PHASE II FIELD INVESTIGATION

Muncipality of Choloma, Republic of Honduras, C. A.

July 2001

Sub-

ATICA, S. de R. L.
Asesores Técnicos en Ingeniería y Ciencias Ambientales

Consultant:

BROWN AND CALDWELL
Environmental Engineering and Consulting

INTRODUCTION

This document represents the hydrogeological conceptual model for the Choloma area and the rationale for the conduct of the Phase II field investigation studies. The project background, available water resources and needs, hydrological setting, data gaps, and recommended areas for field investigation and activities are described.

BACKGROUND

The purpose of this project is to develop a water resources management plan for the City of Choloma that addresses a sustainable municipal water supply to ensure sustainable water resources for municipal water supply. This project is funded by the US Agency for International Development (USAID).

The City of Choloma is located in the Province of Cortes approximately 18 kilometers north of San Pedro Sula. The Choloma River runs through the northern portion of the City. The terrain rises to the south. Population, water consumption and water production rate data is not available at this time, however this information is being gathered under Phase I. This information will be presented in the final project report.

The City relies on groundwater for all of its water supply. It is anticipated that reliance on groundwater for municipal water supply will increase as population growth continues in the future.

EXISTING WATER RESOURCES

The City relies completely on groundwater for its water supply. Approximately 13 groundwater production wells exist within the municipal area. The combined capacity of the City wells is approximately 5,200 gallons per minute (gpm). The wells range in depth from 80 to 200 feet. No disinfection treatment is provided. In addition to these municipal wells, there are industrial and agricultural supply wells, as well as private wells.

The City is divided into the northern, central, and southern zones. There are two municipal wells located in the northern zone and 11 municipal and private wells in the central zone. Groundwater is pumped from the central and northern zones to the southern zone as there is very low groundwater yield in the southern zone wells. The municipality has limited data for the municipal wells and no data on the private wells.

Flouride and arsenic have been detected in some wells in the northeast.

The water distribution system consists of two (2) pressure zones and multiple water storage reservoirs. Two–thirds of the customers are located in the lower pressure zone, which supply the main part of the City. In recent years, the City has been growing into the higher elevation areas to

the south, along the highway to San Pedro Sula. This southern area encompasses the higher-pressure zone.

FUTURE WATER NEEDS

The City has experienced rapid growth in recent years. The addition of several industrial parks on the west side of the City has resulted in new residential customers as wells as increased water use due to larger numbers of employees. Future growth is projected to occur to the south and east. No population figures or projections are available, however this information is being gathered at this time and will be included in the final report.

Since most of the wells lack totalizing meters and individual residences are not metered, the amount of water used by the City cannot be precisely determined. However, water consumption data is being collected by using a portable flow meter that was purchased for this project. The meter will be attached to the discharge side of the well and the flow of the well will be recorded on a weekly basis. The results will be included in the final report. The need for additional wells and the total production required will be determined and recommended in the final report.

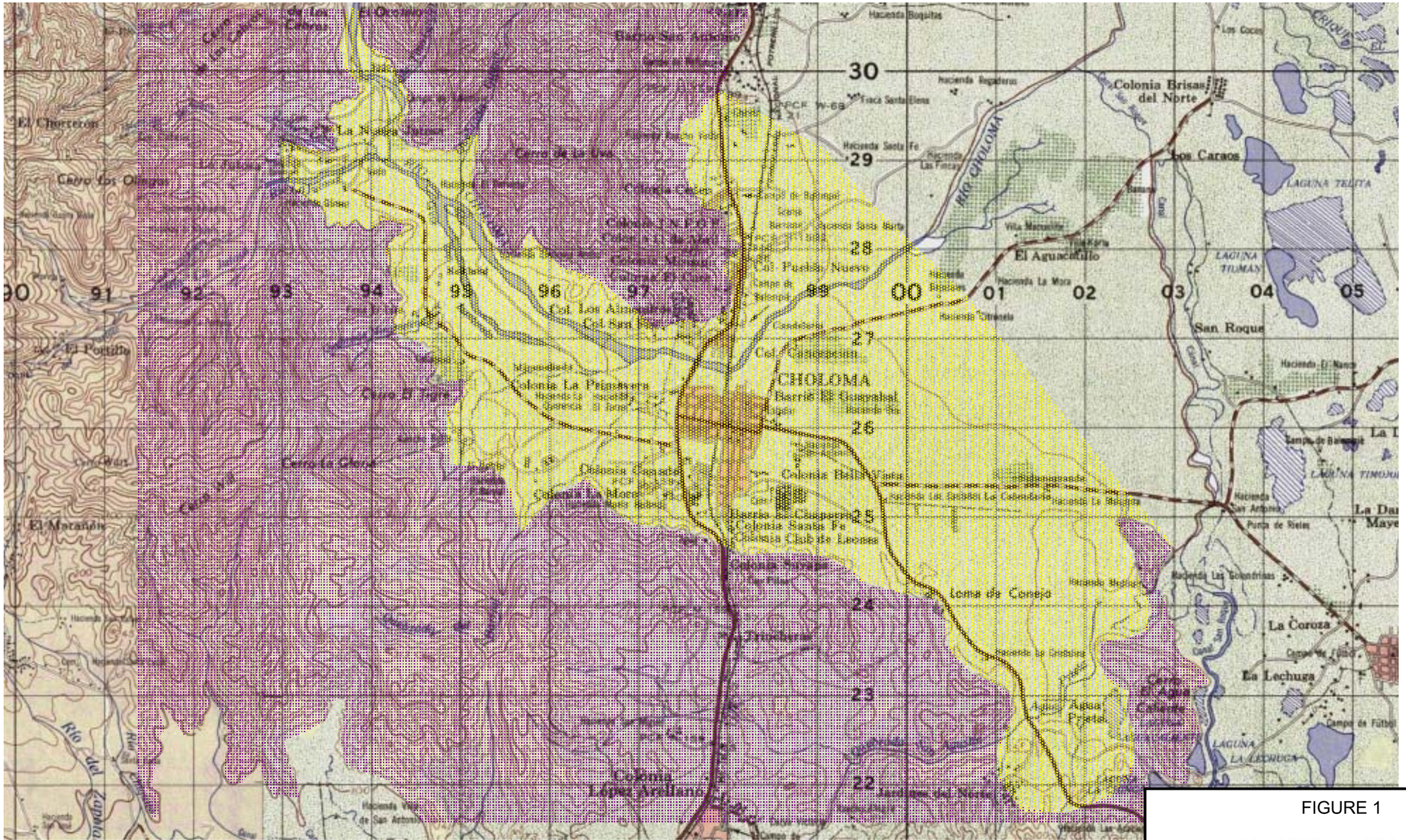
RATIONALE FOR WATER RESOURCE EXPANSION

The objective is to locate sustainable groundwater supplies that can be used in a cost effective manner. The most economical groundwater supplies are close to existing water system infrastructure, have acceptable water quality and a yield that meets anticipated supply needs.

GEOLOGICAL SETTING

Geologically, the low lying areas of the Sula Valley floor are characterized by Quaternary Valle de Sula alluvial deposits, with the valley walls comprised of Jurassic Cacaguapa Schists to the east and west, the Tertiary Matagalpa Formation and Padre Miguel Group and Cretaceous Yojoa Group to the south and southeast. The Sula Valley drains into the Caribbean Sea to the north. Generally, this area receives between 55 and 85 inches of precipitation per year. Additional rain gauging and climatical stations were not necessary to successfully complete this study.

Along the flanks of the Sula Valley, a number of river systems drain the surrounding upland areas. These river systems have associated valleys that adjoin the Sula Valley. Choloma is located within one such valley system that is located on the western flanks of the Sula Valley. The Choloma River traverses the central portion of the valley and serves as the mayor drainage for the area. Upland areas surround the valley to the north and south and are comprised of Jurassic Cacaguapa Schists (see Figure 1).



Choloma Valley Alluvium (Potential High Groundwater Yields)

Upland Areas (Primary Groundwater Recharge Areas)

1000 0 1000 Meters

FIGURE 1

CONCEPTUAL GEOLOGY
OF THE
CHOLOMA VALLEY

The valley is oriented in an east west direction and ranges from 1 to 2.5 kilometers wide. The valley is characterized as a broad flat alluvial plain, which has been deposited by the Choloma Rivers. The total thickness of the alluvial materials is estimated to be greater than 500 feet in the vicinity of Choloma. Boring logs completed within the alluvium indicated that the upper 200 feet of alluvial materials are characterized as a fining upper sequence (see Figure 2). The upper 25 to 50 feet of alluvial materials are characterized as inter-bedded silts and sands. These materials grade into inter-bedded fine to medium sands from approximately 50 to 100 feet. Below 100 medium, coarse sands and gravels have been observed. The full vertical extent of this lower sand unit has yet to be defined. Based on the available information the lower sand and gravel unit is observed throughout the Choloma valley.

Vegetation and Land use maps are not included in this report as they are not considered appropriate at this time.

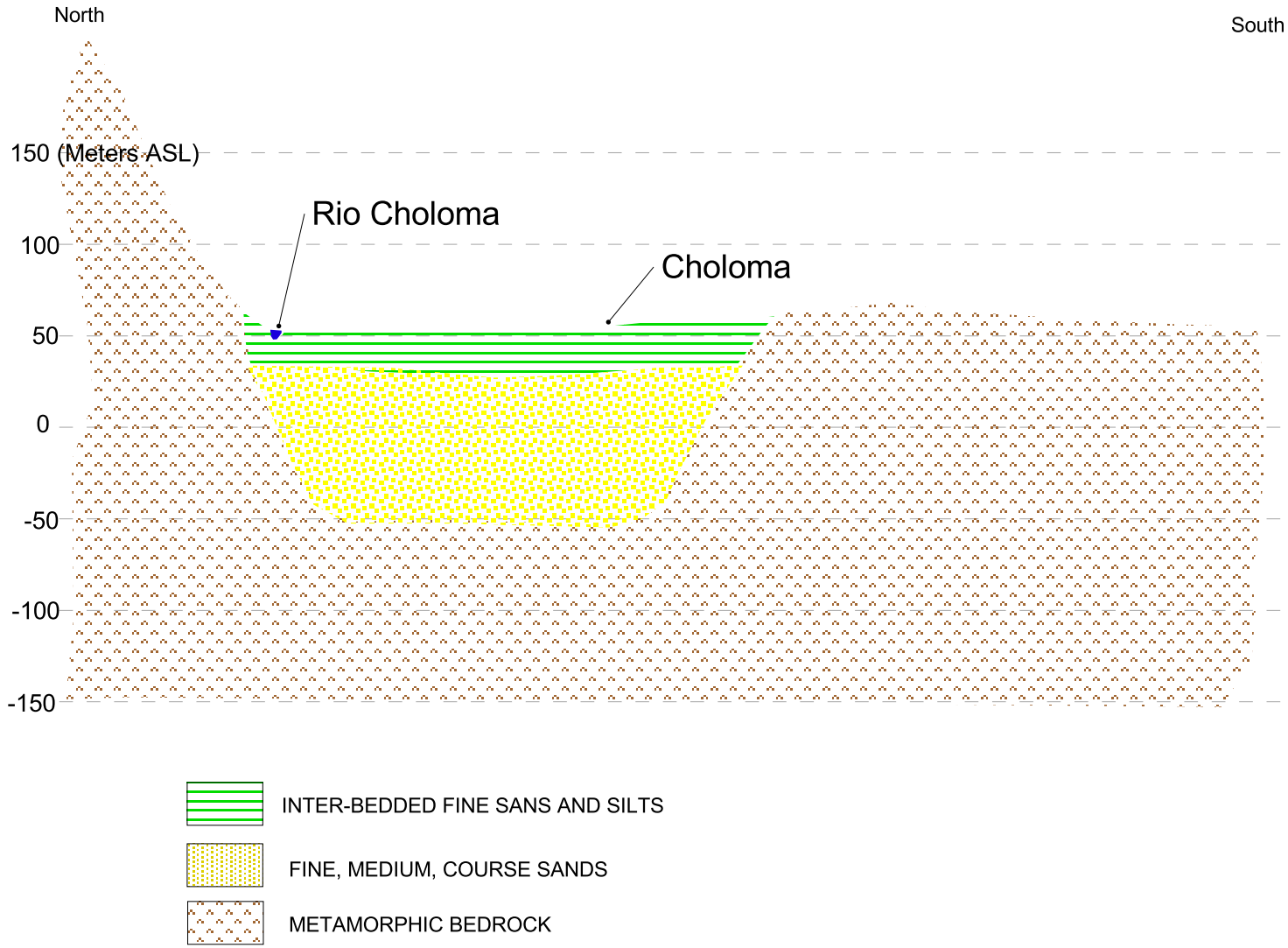
HYDROGEOLOGICAL SETTING

The Choloma Valley is bounded to the north and south by upland areas comprised of Jurassic Cacaguapa Schists. These upland land areas serve as the major surface and groundwater recharge areas for the alluvial materials of the valley. Surface water infiltrates into the fracture networks of the uplands providing groundwater recharge to the valley bedrock and alluvial materials. Groundwater from these uplands generally flows towards the alluvial valley. Once the groundwater from the upland areas enters the Valley alluvium, groundwater flow will generally begin to move down valley and towards the Choloma River, which serve as the major groundwater discharge points for the valley hydrologic system.

The laterally continuous sand and gravel aquifer found below a depth of 100 feet presents the greatest potential for producing sustainable yields. Currently 13 wells (see Figure 3) are screened within the sand and gravel aquifer. Groundwater production from these wells range from 80 to 1,000 gpm with an average yield of 475 gpm.

RECOMMENDED AREAS FOR FIELD INVESTIGATION

Based on a review of the available data for Choloma, the laterally continuous sand and gravel aquifer found from below 100 feet has been identified as having the highest probability of providing sustainable groundwater supplies. As a result, it is recommended that this laterally continuous aquifer and potentially deeper aquifer be further investigated.

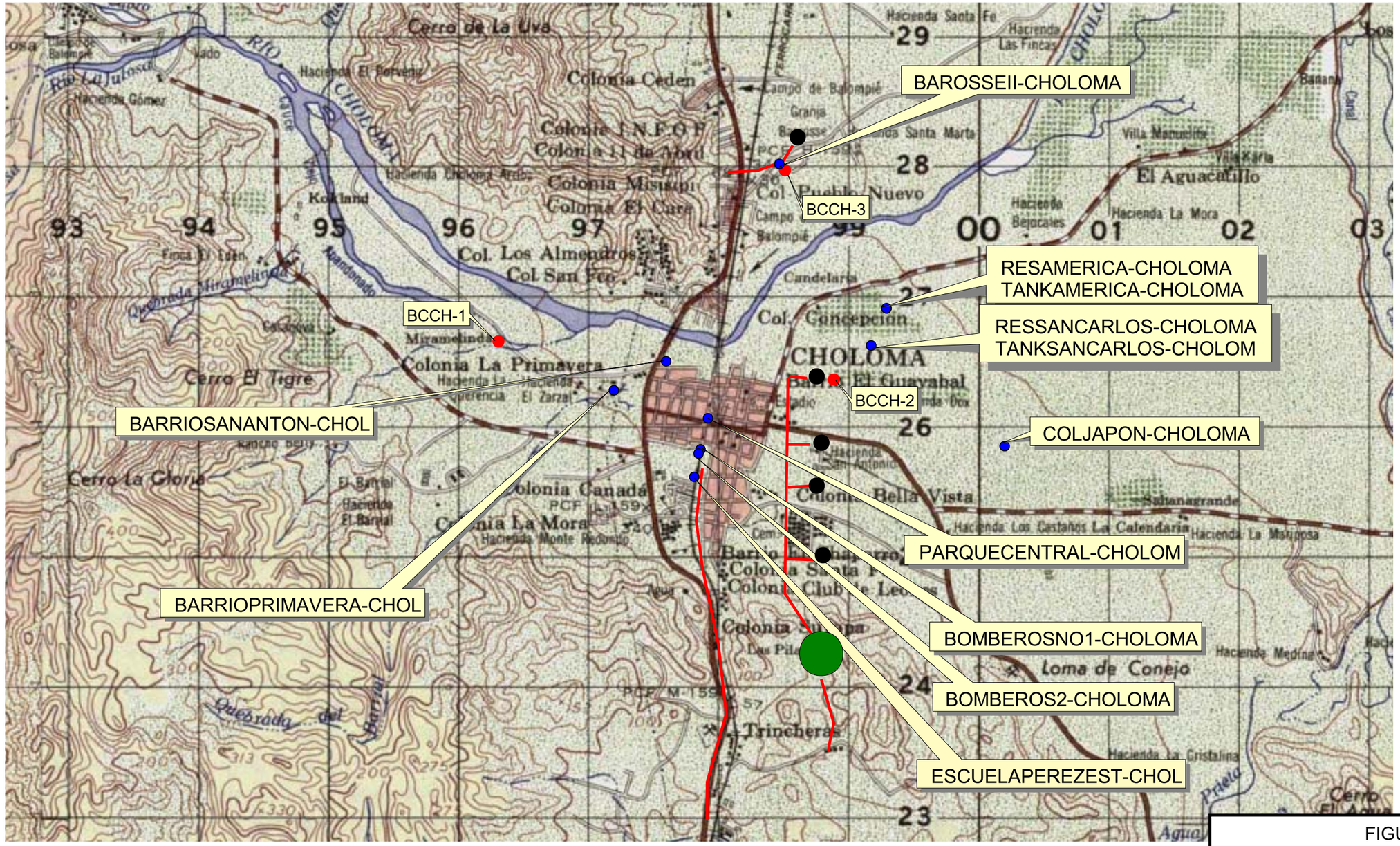


Drawing not to scale.

FIGURE 2

CONCEPTUAL GEOLOGIC CROSS-SECTION

CHOLOMA



EXISTING PRODUCTION WELL

PROPOSED TEST WELL

PROPOSED PRODUCTION, BASED ON PREVIOUS WATER RESOURCE STUDY

EXISTING STORAGE TANK

CURRENT TRUNK DISTRIBUTION SYSTEM

0.4 0 0.4 0.8 1.2 1.6 Kilometers

FIGURE 3

EXISTING AND PROPOSED WELL LOCATIONS

CHOLOMA

DATA GAPS

The Phase I data collection and evaluation has identified the following data gaps:

- Additional information is required to evaluate the alluvial aquifer for sustainable yields of groundwater.
- Additional information is required to support the premise that the aquifer system is laterally continuous.
- Additional information is required to evaluation the potential for deeper aquifers within the alluvial materials.

RECOMMENDED FIELD ACTIVITIES

Geophysical Surveys

Down-hole geophysics will be conducted on each of the boreholes installed during this evaluation. The geophysical suite will include resistivity, spontaneous potential, gamma, caliper, and temperature.

Test and Monitoring Wells

We recommend the installation of three test wells (BCCH-1, BCCH-2, and BCCH-3) to evaluate the Choloma Valley alluvium. These wells are located in area where additional information is required to support the conceptual and numerical model development. The locations of these wells are presented on Figure 3. Each test boring will be drilled to a depth between 400 to 500 feet to evaluate the vertical extent of the aquifer system. Each well will be constructed as a PVC well. The screen intervals will be based on the results of the field observations and the down-hole geophysical survey.

Aquifer Tests

Step testing and recovery testing will be conducted on each newly installed test well to calculate specific capacity, well efficiency, and transmissivity. The step test will be conducted over a 6 to 8 hour period. Following the step tests the wells will be pumped at a constant rate for approximately 12 hours. During this testing, draw-down and recovery data will be collected. The recovery data will be collected until the well is restored to within 90 percent of the original static water level.

Water Quality Sampling

Each interval that is identified as yielding a sufficient amount of groundwater will be tested for the following parameters:

- total dissolved solids
- specific conductance
- pH
- CaCO3
- alkalinity as CaCO3
- nitrate/nitrite
- coliform
- chloride
- TAL metals (arsenic, barium, cadmium, chromium, iron, fluoride, lead, manganese, mercury, nickel, selenium, silver, sodium, and zinc)

ANTICIPATED FIELD RESULTS

The anticipated field results are as follows:

- The installation of the wells will provide information on the geometry of the aquifer system, aquifer transmissivities, aquifer specific yields, and yield sustainability.
- Identification of groundwater production zones of suitable groundwater quality.

APPENDIX B

Phase II Field Investigation Results

PHASE II FIELD INVESTIGATION RESULTS

Choloma, Honduras

June 2002

1.0 INTRODUCTION

As part of Contract Number 522-C-00-01-00287-00, Phase 2 between United States Agency for International Development (USAID) and Brown and Caldwell, three wells were installed and tested in Choloma. Work performed included drilling of exploratory boreholes, down-hole geophysical logs, installation of wells in exploratory boreholes, development of wells, and pump tests. This report provides details on the installation and testing of these wells as well as evaluation of, and conclusions from the data generated from this work.

The wells installed are named BCCH-1, BCCH-2 and BCCH-3. Figure 4-1 in Chapter 4 shows their location in relation to the surrounding municipality. The technical rationale for the location of each well was provided to USAID in the document "Conceptual Model for Choloma" and the technical procedures for conducting the work were outlined in the document "Technical Procedure for Phase II Field Investigation Boreholes and Wells for Choloma". The construction of the wells is summarized in Table B-1. The details of the work performed during the exploration, drilling, well construction and testing of each well are presented in the following sections.

Table B-1. Summary of Installed Wells

Name of Well	Total depth of Borehole (ft bgs)	Total Depth of Well (ft bgs)
BCCH-1	475	448
BCCH-2	430	300
BCCH-3	370	179

ft=feet
bgs=below ground surface

2.0 EXPLORATORY BOREHOLES

At each location an exploratory borehole was drilled first. This hole was later converted to a test or observation well. Well BCCH-1 was installed by HidroSistemas Engineering and Drilling, S. de R. L. (HidroSistemas). BCCH-2 was installed by HidroSistemas, and the final well, BCCH-3 was installed by Servicios de Perforación, S. de R. L. de C. V. (SERPE). Details of borehole completion are provided in Table B-2. Completion of the boreholes was overseen by both Brown and Caldwell and Asesores Técnicos en Ingeniería y Ciencias Ambientales S. de R. L. (ATICA) staff.

Table B-2. Summary of Boreholes

Name of Well	BCCH-1	BCCH-2	BCCH-3
Name of Driller	HidroSistemas	HidroSistemas	SERPE
Date Started	8/7/2001	9/21/2001	9/28/2001
Date Completed	8/24/2001	10/12/2001	10/11/2001
Drilling Equip. and Technique	Ingersol-Rand Rotary Drill T4/RD20, Mud Rotary	Ingersol-Rand Rotary Drill T4/RD20, Mud Rotary	Badger, Mud Rotary
Drilling Fluid	water, bentonite and polymer	water, bentonite and polymer	water, bentonite and polymer
Drill Bit and Size	8-inch Nominal	8 7/8-inch	8-inch Nominal
Total Borehole Depth (ft, bgs)	475	430	370
Penetration Rate (ft/hr)	5.7 to 75	5.7 to 120	2.6 to 14.1
Geophysical Company & Date	Brown and Caldwell 8/24/01	HidroSistemas 10/12/01	SERPE 10/13/01

ft= feet bgs=below ground surface hr=hour

HidroSistemas installed shallow wells adjacent to well sites BCCH-1 and BCCH-2 to acquire the water used for drilling. These shallow wells were abandoned after the test wells were installed. SERPE utilized a water tanker truck to transport water from the Choloma River to the site. Drilling was scheduled to be conducted continuously but occasional mechanical problems with the drill rigs and access problems caused by wet weather resulted in delays of approximately 7 to 10 days at BCCH-2 and BCCH-3. In addition, the drilling of borehole BCCH-3 was delayed due to not having immediate right-of-entry permission.

3.0 LITHOLOGIC LOGGING

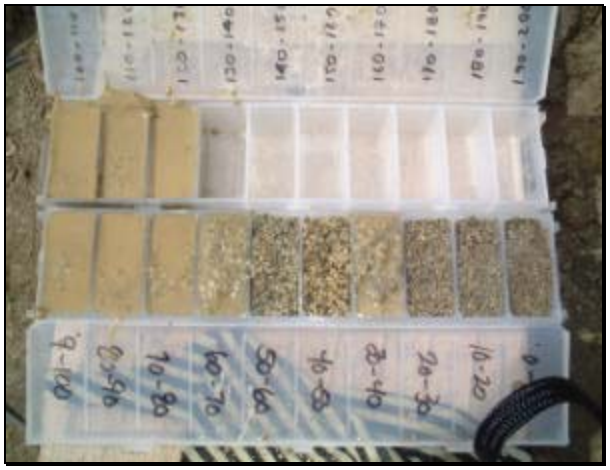


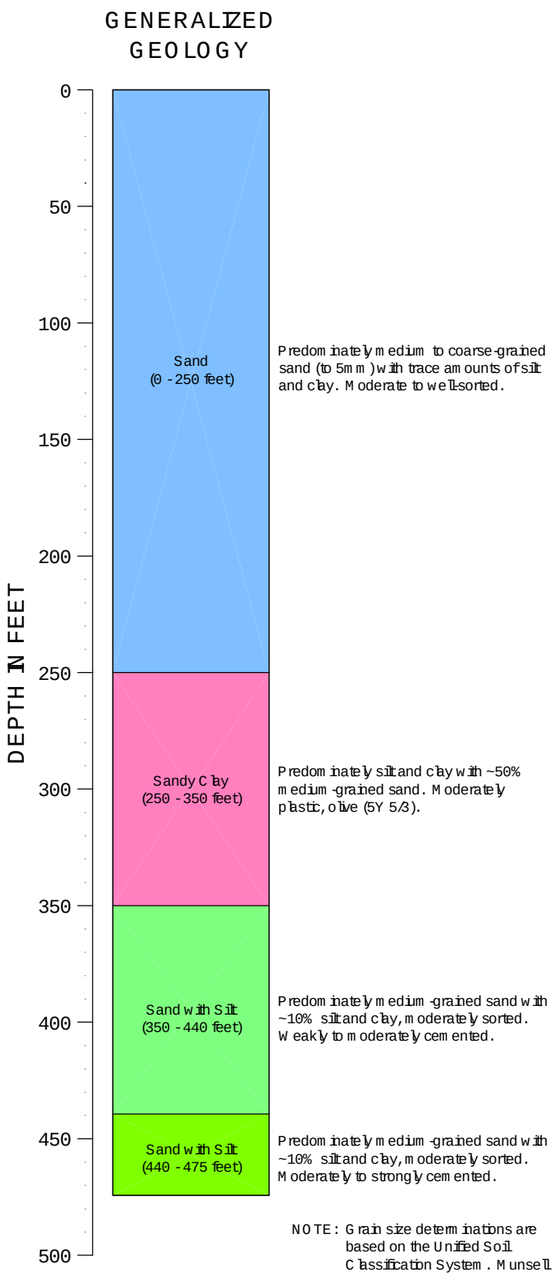
Figure B-1. Chip Trays with Material from BCCH-2

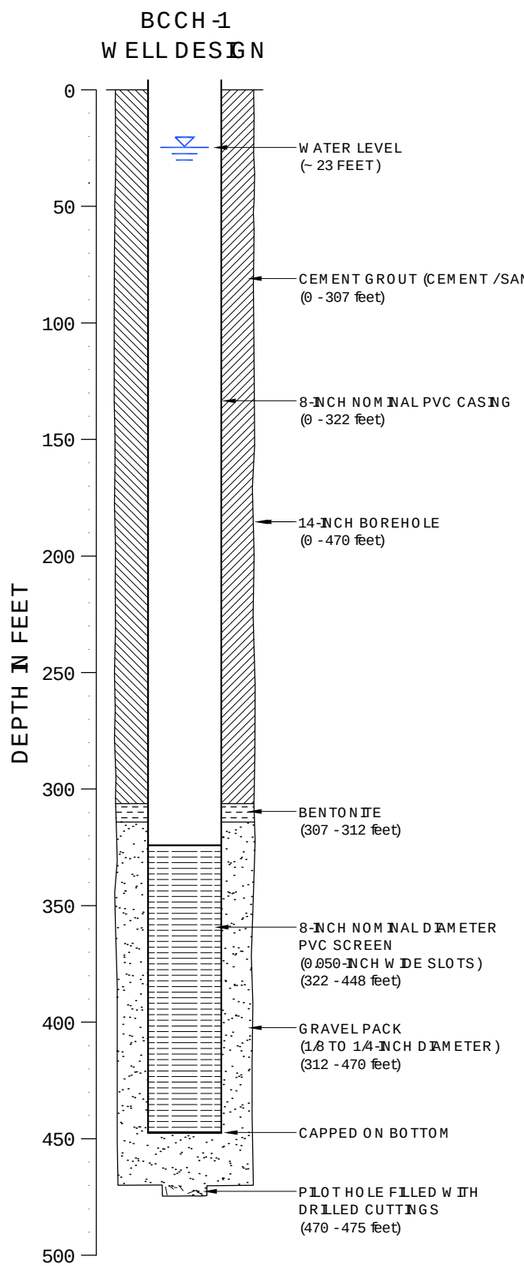
A lithologic log was prepared describing the stratigraphy penetrated throughout each borehole. The information for these logs came from drilled cuttings collected every 10 feet. Cuttings were collected from the drilling fluid with a slotted strainer and were preserved by placing in plastic trays designed for this use (Figure B-1). Generalized lithologic logs, geophysical logs, and well designs for wells BCCH-1, BCCH-2, and BCCH-3 are presented on Figure B-2, Figure B-3, and Figure B-4, respectively.

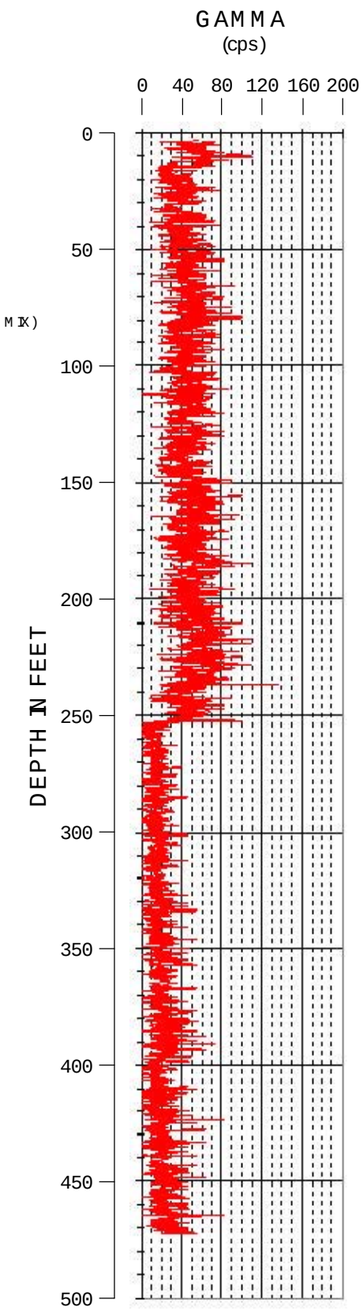
Drilling at each borehole location penetrated two coarse grained deposits. The upper deposit is predominately sand and gravel with some isolated fine-grained deposits and represents the major water bearing deposit for the area. This upper deposit is generally found from land surface to approximately 170 feet in the western portion of the study area and ranges from approximately 250 to 300 feet in the central and eastern portions of the study area. The lower coarse-grained deposit consists of moderately to strongly cemented sand with silt and was encountered at approximately 300 feet in the western portion of the study area and between approximately 300 and 350 feet in the central and eastern portion of the study area. The borings terminated in the cemented sand with silt and bedrock was not encountered.

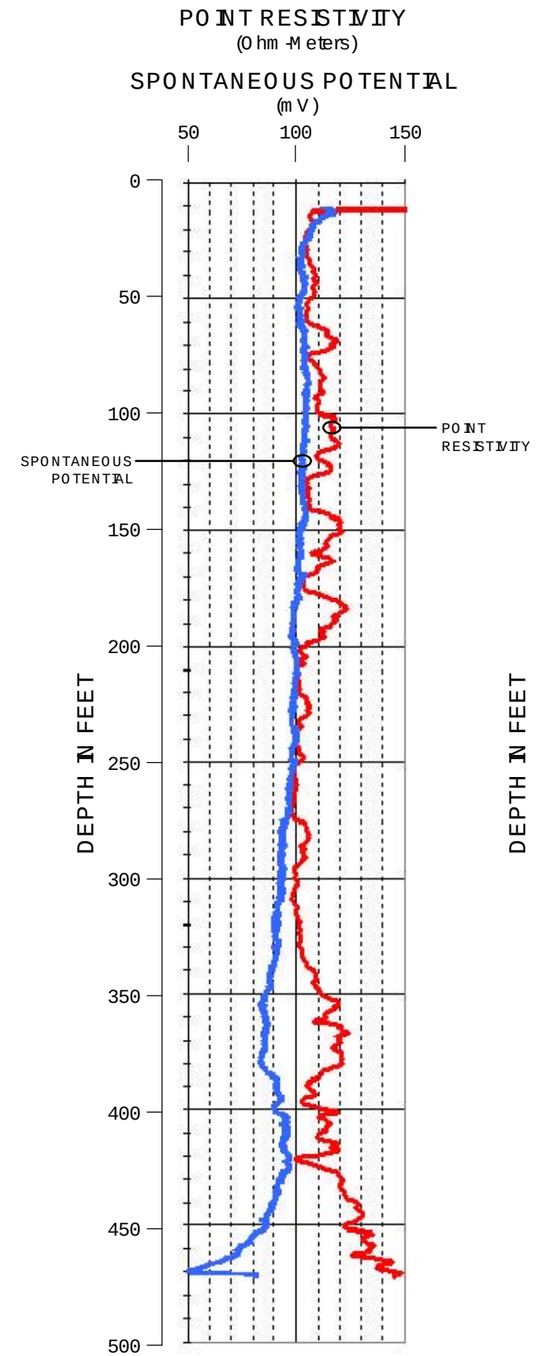
4.0 GEOPHYSICAL LOGGING

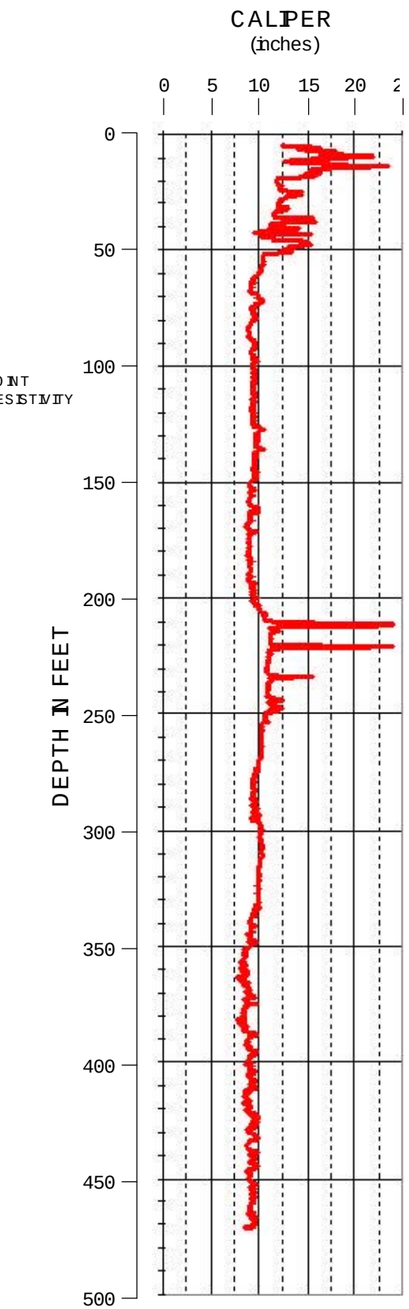
After completion of the exploratory boreholes, geophysical logging was conducted. The geophysical logging suite for BCCH-1 included spontaneous potential, electrical resistivity, caliper, and gamma ray evaluations and was conducted on August 24, 2001. BCCH-2 was logged on October 12, 2001 and BCCH-3 was logged on October 13, 2001. Due to equipment availability, only spontaneous potential and point resistivity were logged for BCCH-2 and BCCH-3. The geophysical logs, lithology, and well designs for BCCH-1, BCCH-2, and BCCH-3 are presented on Figures B-2, B-3 and B-4, respectively.











BROWN AND CALDWELL

Figure B-2

TEST WELL BCCH-1

CHOLOMA, HONDURAS

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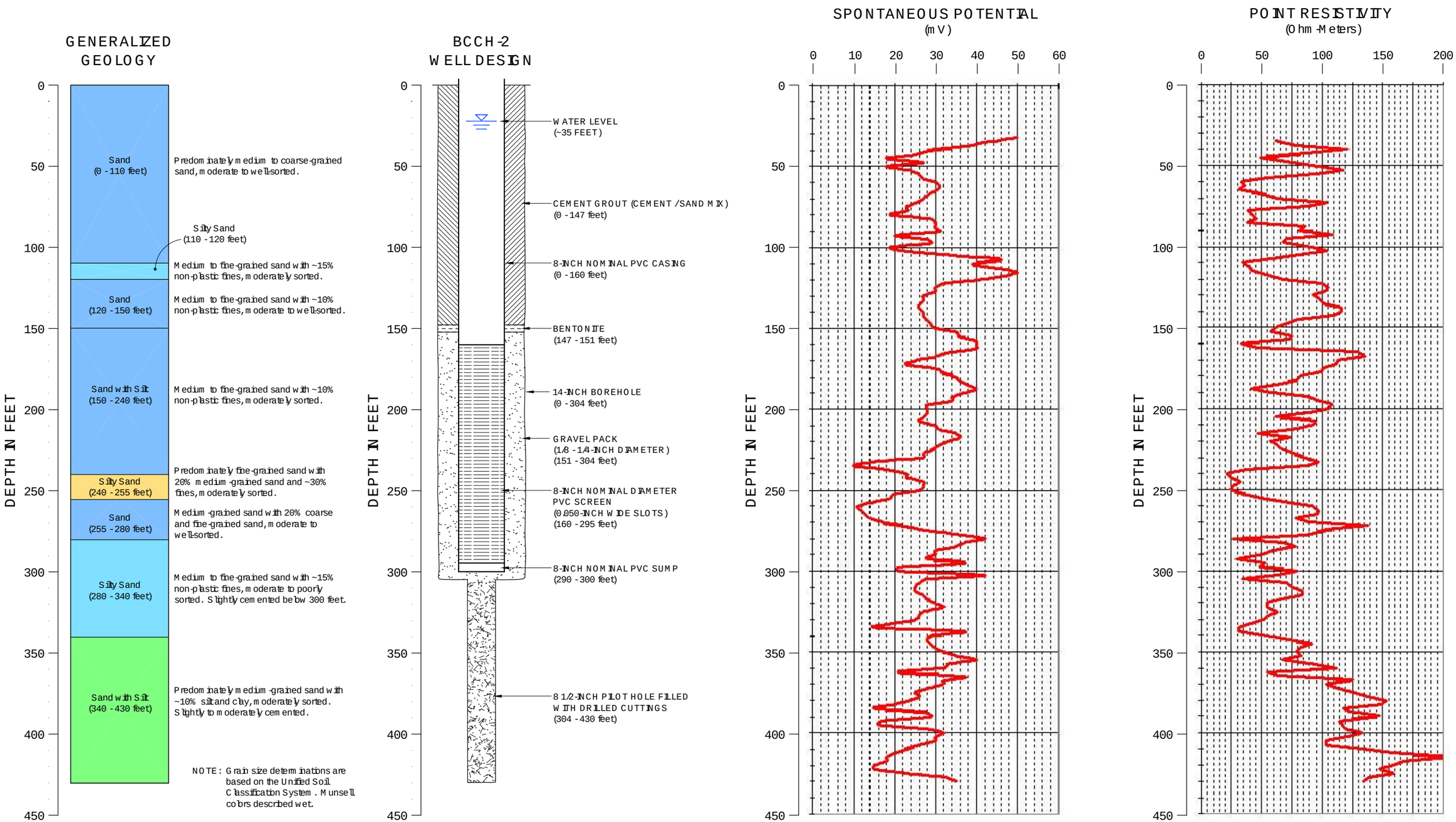

BROWN AND CALDWELL

Figure B-3

TEST WELL BCCH-2

CHOLOMA, HONDURAS

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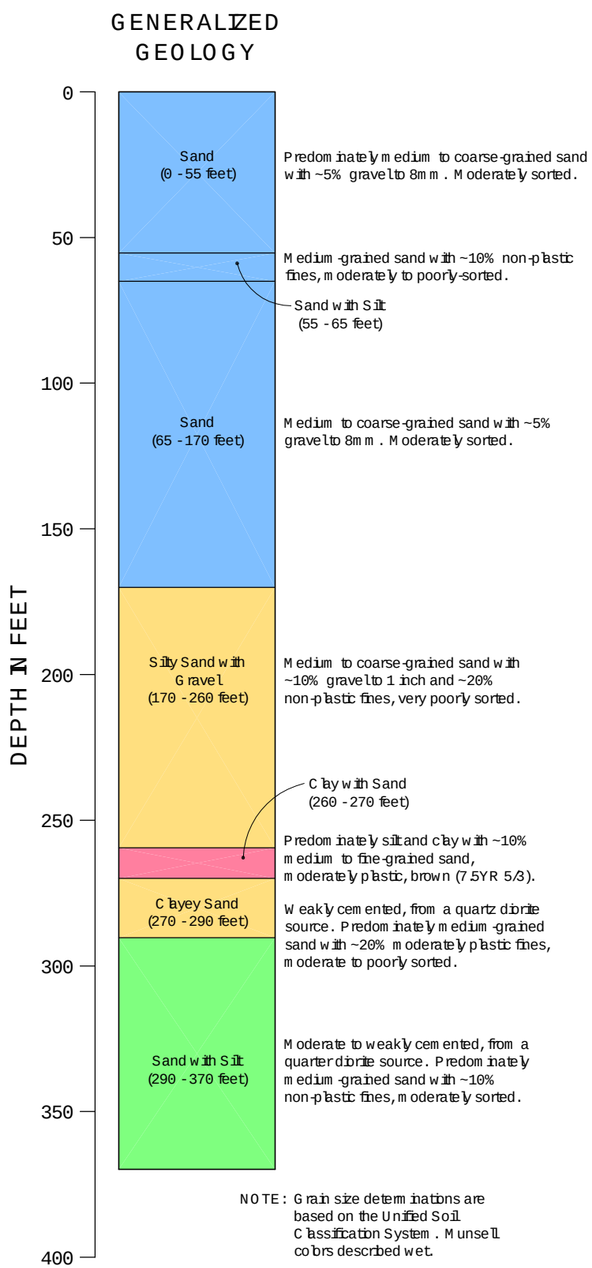

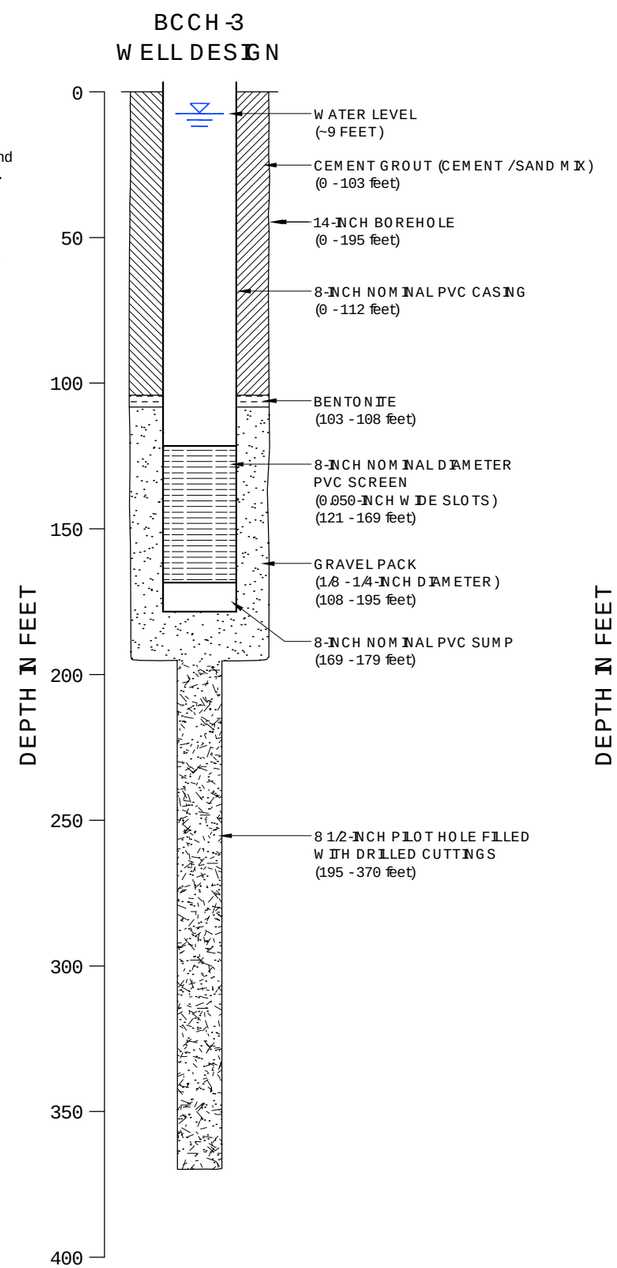

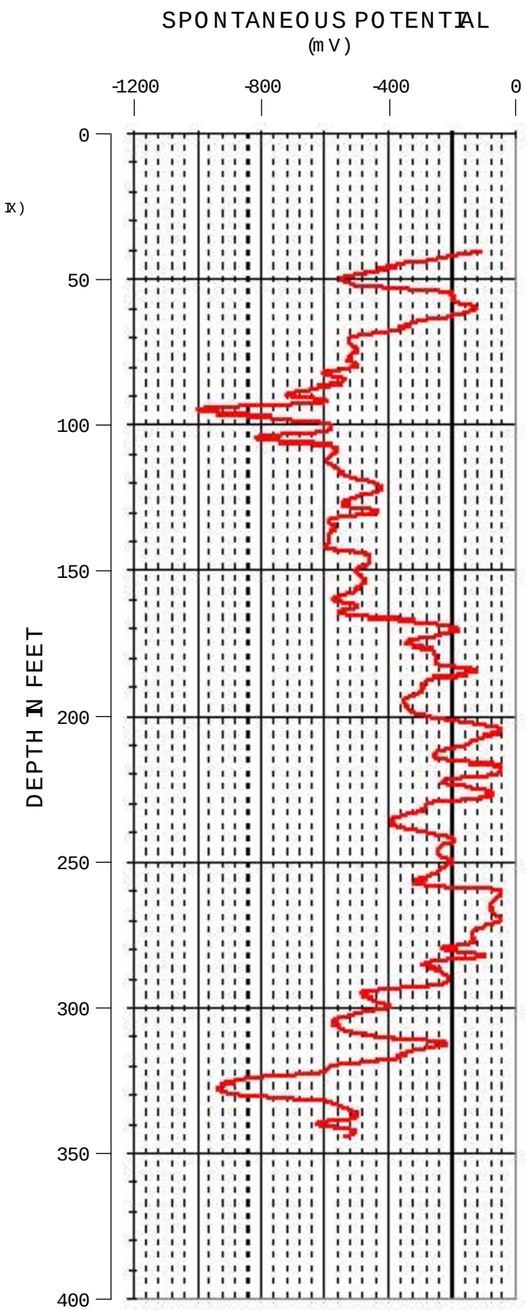

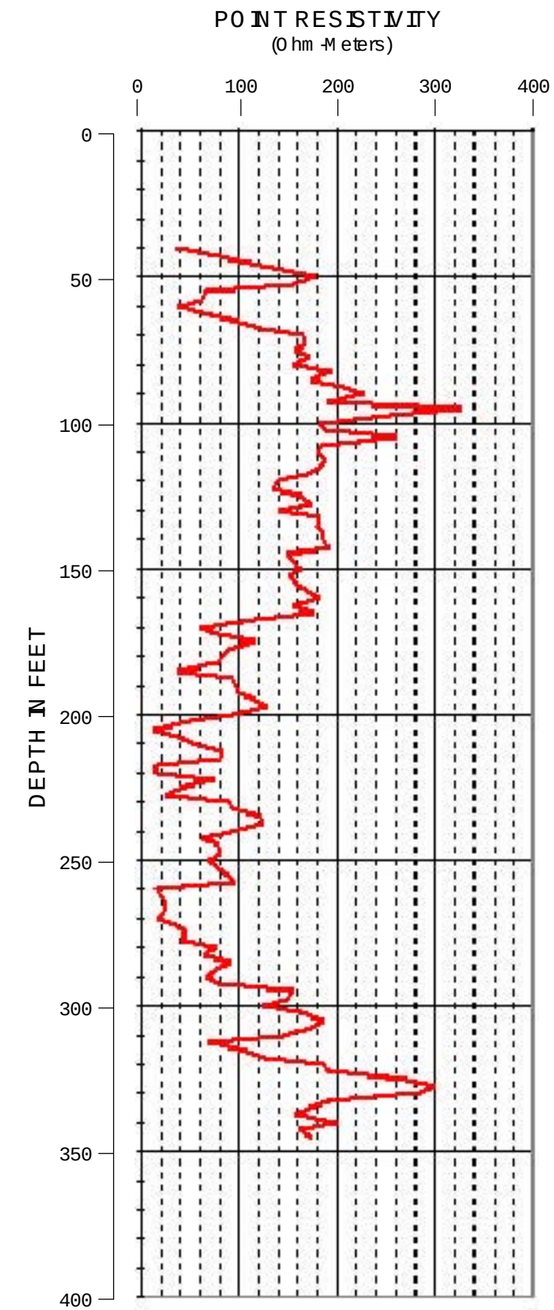

BROWN AND CALDWELL

Figure B-4

TEST WELL BCCH-3

CHOLOMA, HONDURAS

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5.0 WELL DESIGN

Figure B-5. Slotted PVC Screening Installed at BCCH-1

Each of the wells in Choloma were designed to produce water from the saturated sand and gravel rich deposits. Blank PVC casing was installed from land surface to the top of the screened interval. The water bearing units were screened with PVC casing with 0.050-inch wide slots (Figure B-5). A gravel pack was installed adjacent to the screened interval and was isolated from upper portion of the borehole with a thin layer of bentonite chips and a sanitary seal. The sanitary seal consists of a sand and cement grout installed from the top of the bentonite layer to land surface.

Wells BCCH-2 and BCCH-3 were designed to produce water from the upper coarse-grained deposits. Well BCCH-1 was designed to produce water from the lower coarse-grained deposit that had not been previously investigated. The diameter of each well was selected based on estimated yield following evaluation of the lithologic log, the driller's penetration rate, and the geophysical logs. Eight-inch nominal diameter PVC well casing was installed at each location in Choloma.

6.0 WELL CONSTRUCTION

Wells were constructed after reaming the exploratory borehole to the final diameter with all activity oversight provided by both Brown and Caldwell and ATICA staff. Well construction details for BCCH-1, BCCH-2, and BCCH-3 are presented on Figures B-2, B-3 and B-4, respectively and are summarized in Table B-3.

Table B-3. Summary of Well Construction

Name of Well	BCCH-1	BCCH-2	BCCH-3
Date Started	9/4/2001	10/15/2001	10/22/2001
Date Completed	9/6/2001	10/17/2001	10/22/2001
Diameter of Borehole	14-inch	14-inch	14-inch
Total Depth of Well (ft, bgs)	448	300	179
Casing/Screen Material	8-inch nominal PVC casing	8-inch nominal PVC casing	8-inch nominal PVC casing
Screen Interval	322 – 448	160 – 295	121 – 169
Screen Slot Size	0.05-inch	0.05-inch	0.05-inch
Sanitary Seal Material	sand grout	sand grout	sand grout
Sanitary Seal Interval (ft, bgs)	0 – 307	0 – 147	0 – 103
Bentonite Seal Interval (ft, bgs)	307-312	147-151	103-108
Gravel Pack Material	1/8 to 1/4-inch	1/8 to 1/4-inch	1/8 to 1/4-inch
Gravel Pack Interval (ft, bgs)	312-470	151-304	108-195

ft=feet bgs=below ground surface pvc=polyvinyl chloride

The surface completion of each well consisted of a concrete block housing for the wellhead including a locking steel cover. Additionally, each well includes a stainless steel plaque identifying the well.

7.0 WELL DEVELOPMENT

Following installation of casing, each well was developed by the swab and airlift method. Airlifting was conducted at various rates and was continued until the water was predominantly clear and free of sand and silt. Activities relating to well development are summarized in Table B-4.

Table B-4. Well Development Summary

Name of Well	BCCH-1	BCCH-2	BCCH-3
Date Started	9/7/2001	10/22/2001	10/24/2001
Date Ended	9/11/2001	10/25/2001	10/27/2001
Total Hours	28	24	18
Description of Method	swab and airlift	swab and airlift	swab and airlift

8.0 AQUIFER DISCHARGE TESTS

Aquifer discharge tests were performed on the BC wells to evaluate the water resource development potential of the laterally continuous shallow sand deposits identified in the area and deeper sand deposits generally encountered between 300 and 350 feet bgs to the total depth of the exploratory borings. The purpose of a constant rate discharge test is to determine how the aquifer behaves when subjected to continual pumping at a maximum discharge rate over an extended period of time. A constant rate discharge test was conducted at BCCH-2. Due to excessive drawdown measured during the step rate test, well BCCH-1 did not produce enough water to warrant a constant rate test. A constant rate test for BCCH-3 was not conducted because the step-test data provided enough aquifer data for the numerical model.

During each test, drawdown data was collected with a water level indicator (Figure B-6). After pumping was complete, recovery water levels were recorded, generally until the water level in the pumping well achieved 95 percent recovery.

Figure B-6. Collection of Water Levels at BCCH-3 during Recovery of Step-Rate Discharge Test

Aquifer transmissivity was calculated using the Cooper-Jacob method (Cooper and Jacob, 1946) for analyzing non-equilibrium flow in a confined aquifer system. This method utilizes a semi-log plot of drawdown verses time. Transmissivity can be estimated by measuring the slope of the drawdown plot. An analysis of the water-level recovery test data was used as a verification of aquifer parameters

estimated from the constant-rate pumping test. Recovery tests are a more accurate method of estimating aquifer characteristics due to the absence of pumping effects on the water levels. Recovery test data were analyzed using the Theis recovery method (Theis, 1935), which utilizes a semi-log plot of drawdown verses the time since the pump test started divided by the time since the recovery test started. Transmissivity is estimated from the slope of the recovery plot.

Test well BCCH-1 was installed to investigate the deep sandy deposit encountered between 350 and 440 feet bgs. A two-hour step-rate test was conducted at this well on September 14, 2001. Static water level was measured at approximately 23 feet bgs. BCCH-1 was pumped at two step-rates of approximately 30 and 34 gallons per minute (gpm). At the end of each step, the specific capacity was calculated at approximately 0.2 gallons per minute per foot of drawdown (gpm/ft). At the maximum rate of 34 gpm, drawdown was approximately 174 feet at the end of the test. The results of well step discharge tests are shown on Table B-5. Based on these results, production from the deep coarse-grained deposit as screened in BCCH-1 is considered poor.

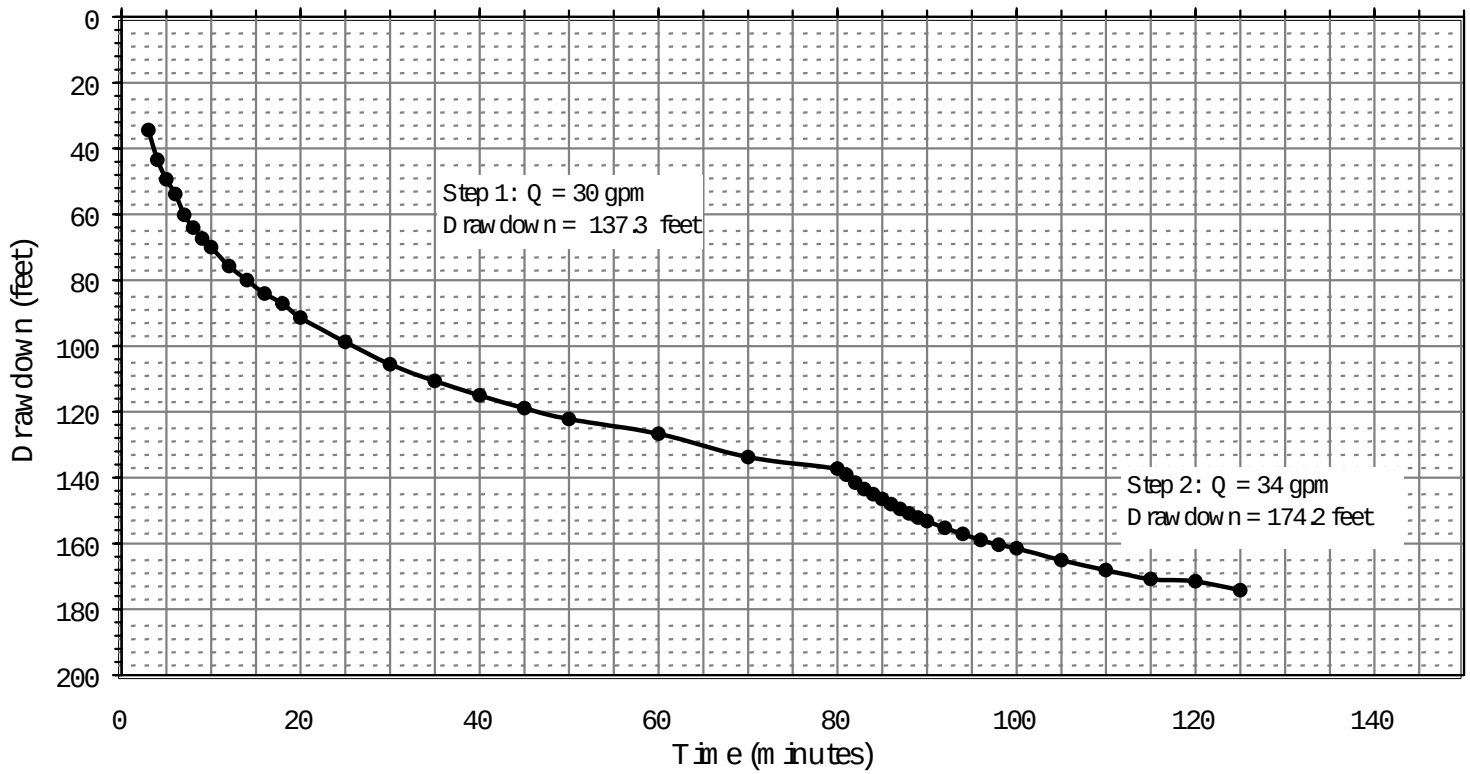
Table B-5. Summary of Step Rate Discharge Tests

Name of Well	BCCH-1	BCCH-2	BCCH-3
Date Started	9/14/2001	11/1/2001	11/6/2001
Duration (hours)	2	7 ½	7
Pump Size/Type	Deming 5.6 hp	Myers 40 hp	Myers 40 hp
Pump Depth (ft, bgs)	220	160	100
Static Water Level (ft, bgs)	22.87	27.27	8.76
Specific Capacity (gpm/ft)	0.22 @ 30 gpm 0.20 @ 34 gpm	31.45 @ 100 gpm 30.33 @ 175 gpm 28.77 @ 250 gpm 27.59 @ 325 gpm 29.59 @ 400 gpm	20.05 @ 150 gpm 17.32 @ 220 gpm 16.16 @ 290 gpm 15.22 @ 360 gpm 13.83 @ 430 gpm

ft=feet
bgs=below ground surface
gpm=gallons per minute
hp=horse power

Short-term and long-term aquifer discharge tests were conducted at test well BCCH-2. A 7.5-hour step-rate discharge test was conducted at BCCH-2 on November 1, 2001. The static water level was approximately 27 feet bgs. The well was pumped at five step-rates of approximately 100, 175, 250, 325, and 400 gpm. At a maximum rate of 400 gpm, the maximum drawdown at the end of the test was approximately 13.5 feet. Specific capacities measured at the end of each step-rate were between approximately 31.5 to 27.6 gpm/ft. The drawdown plot for the step-rate test is presented on Figure B-7 and the recovery plot is presented as Figure B-8.

The constant-rate discharge test at BCCH-2 commenced on December 22, 2001. The test well was pumped at an average rate of approximately 405 gpm for 4.5 hours. The static water level in well BCCH-2 was approximately 26 feet bgs prior to the constant-rate test. At the end of the test, the total drawdown in BCCH-2 was approximately 14.5 feet, and the specific capacity of the test well was calculated at approximately 28 gpm/ft. After the pump test was complete, recovery water levels were recorded. After approximately 45 minutes, water levels recovered 95 percent. Analysis of the long-term aquifer test data estimates transmissivity at the site to be between approximately 75,300



Q - Discharge Rate
gpm - gallons per minute

BROWN AND CALDWELL Phoenix, Arizona	USAID - HONDURAS WELL BCCH-1	Figure B-7 STEP-RATE PUMPING TEST

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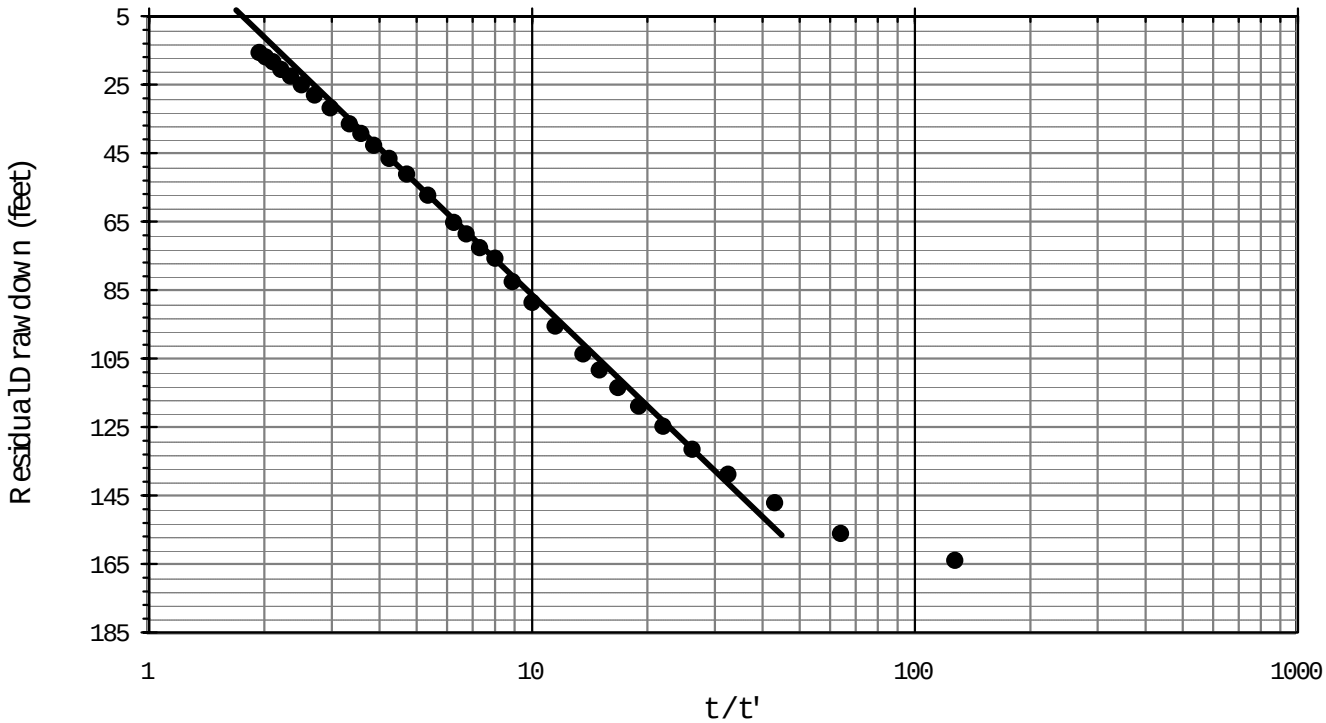


t = time since pumping started (min)
t' = time since pumping ended (min)
Δs = Change in drawdown over one log cycle (feet)
Q = Time weighted average discharge rate (gpm)
T = Transmissivity = 264Q/Δs (gpd/ft)

T = (264)(31.4)/(108)
T ~ 77 gpd/ft

BROWN AND CALDWELL Phoenix, Arizona	USAID-HONDURAS WELL BCCH-1	FIGURE B-8 THEIS RECOVERY PLOT

and 82,900 gallons per day per foot (gpd/ft). The drawdown and recovery plots for BCCH-2 are presented on Figures B-9 and B-10. General water quality test information and preliminary analysis of the constant rate test is included in tables B-6 and B-7.

Table B-6. Summary of Chemical Properties during Pump Tests*

Name of Well	BCCH-1	BCCH-2	BCCH-3
pH	7.54 @ 30 gpm 7.81 @ 34 gpm	7.30 @ 100 gpm 7.15 @ 175 gpm 7.33 @ 250 gpm 7.33 @ 325 gpm 7.30 @ 400 gpm	6.79 @ 150 gpm 6.76 @ 220 gpm 6.78 @ 290 gpm 6.81 @ 360 gpm 6.76 @ 430 gpm
Temperature (degrees F)	75.20 @ 30 gpm 75.89 @ 34 gpm	74.85 @ 100 gpm 75.58 @ 175 gpm 77.19 @ 250 gpm 77.63 @ 325 gpm 78.16 @ 400 gpm	75.83 @ 150 gpm 77.18 @ 220 gpm 78.98 @ 290 gpm 76.91 @ 360 gpm 74.66 @ 430 gpm
Conductivity	383 @ 30 gpm 402 @ 34 gpm	397 @ 100 gpm 399 @ 175 gpm 402 @ 250 gpm 388 @ 325 gpm 426 @ 400 gpm	348 @ 150 gpm 316 @ 220 gpm 306 @ 290 gpm 320 @ 360 gpm 323 @ 430 gpm

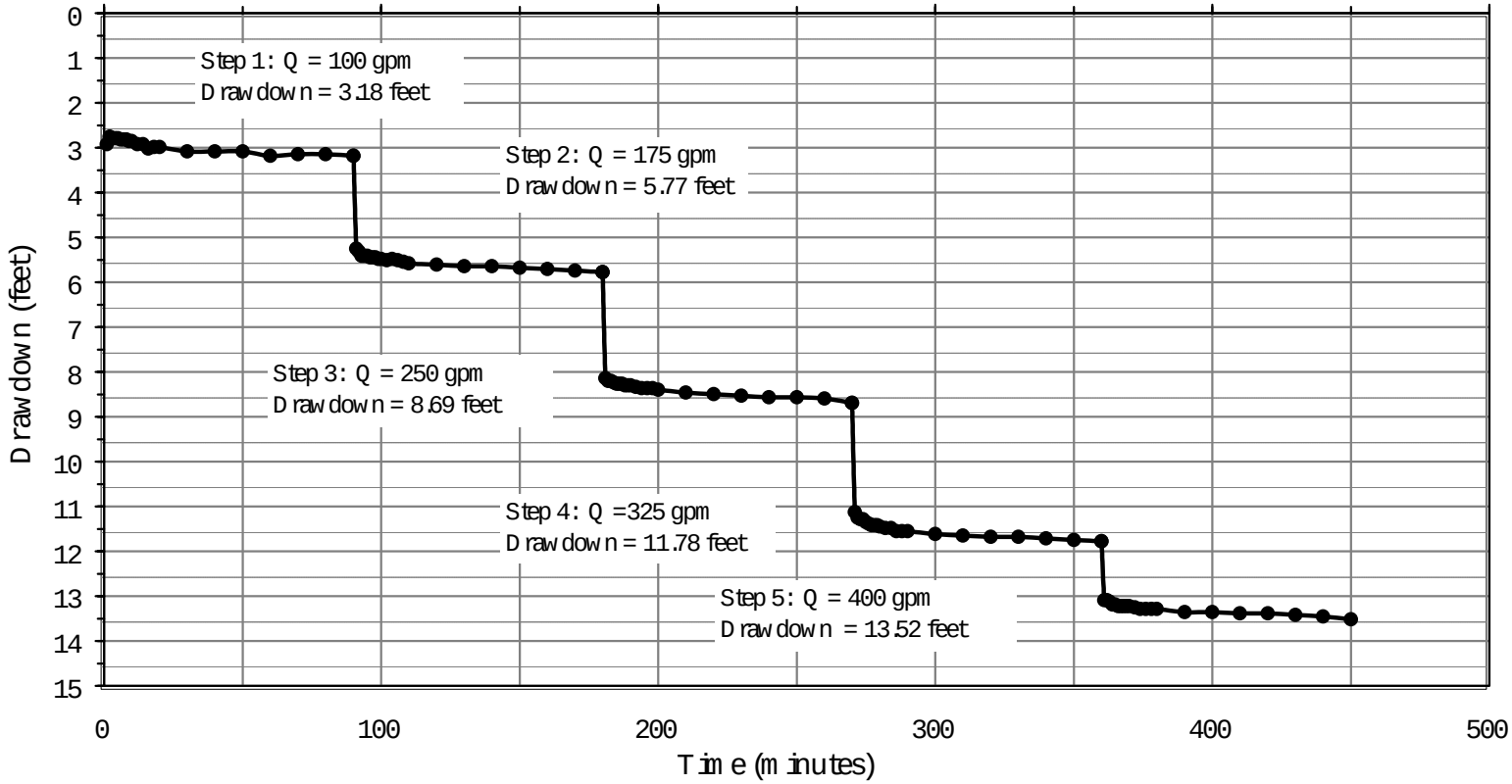
*data presented for each step represent an average of two independent readings spread over the course of the gpm step.
Gpm=gallons per minute
F=Farenheit

Table B-7. Summary of Constant Rate Discharge Test

Name of Well	BCCH-2
Transmissivity Estimated from Drawdown (gpd/ft)	75,300
Transmissivity Estimated from Recovery (gpd/ft)	82,900
Date Started	12/22/2001
Date Ended	12/22/2001
Duration (hours)	4 ½
Depth of Pump (ft, bgs)	120
Pump Rate (gpm)	405
Specific Capacity (gpm/ft)	28.0
Static Water Level (ft bgs)	25.92

gpd=gallons per day
ft=feet
bgs=below ground surface
gpm=gallons per minute

A seven-hour step-rate test was conducted at BCCH-3 on November 6, 2001. The static water level was approximately 9 feet bgs. The well was pumped at five step-rates of approximately 150, 220, 290, 360, and 430 gpm. At a maximum rate of 430 gpm, the maximum drawdown at the end of the test was approximately 31 feet. Specific capacities measured during the step-rate test ranged between approximately 20.1 to 13.8 gpm/ft. The drawdown and recovery plots for BCCH-3 are presented on Figures B-11 and B-12.



Q - Discharge Rate
gpm - gallons per minute

BROWN AND CALDWELL Phoenix, Arizona	USAID - HONDURAS WELL BCCH-2	Figure B-9 STEP-RATE PUMPING TEST

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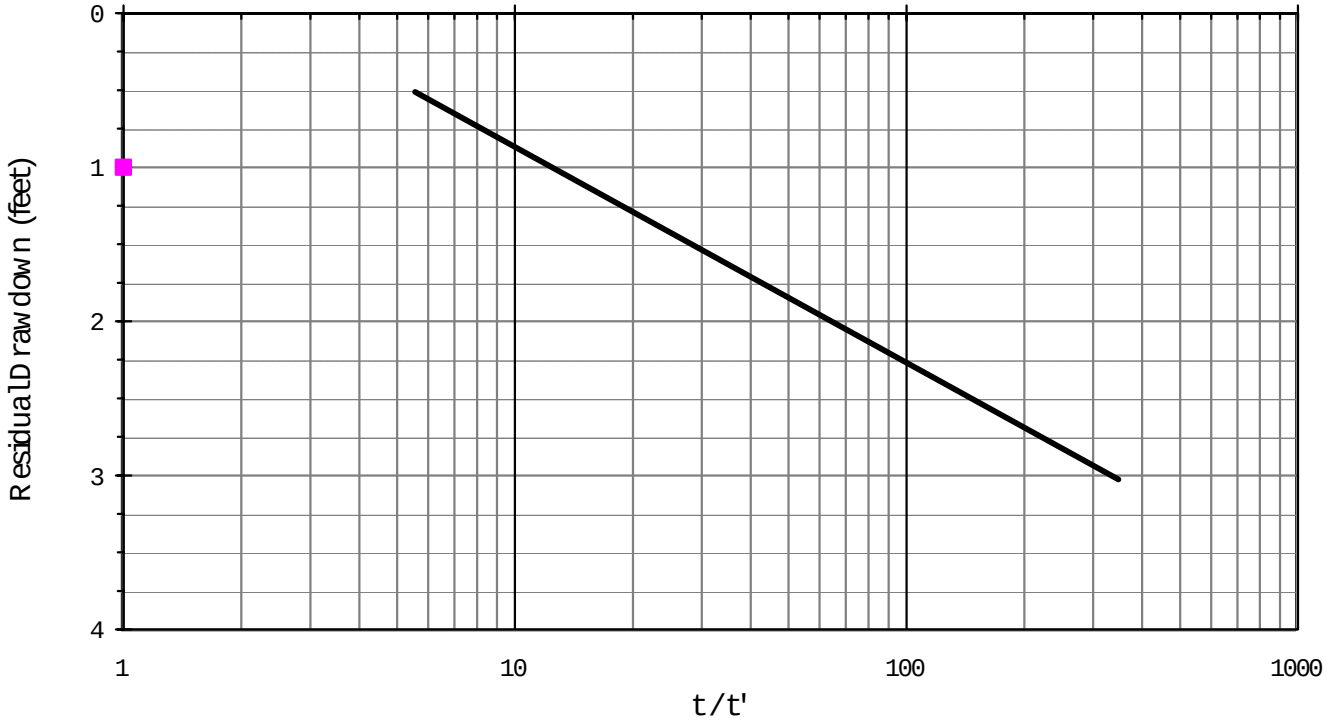

t = time since pumping started (min)
t' = time since pumping ended (min)
Δs = Change in drawdown over one log cycle (feet)
Q = Time weighted average discharge rate (gpm)
T = Transmissivity = 264Q/Δs (gpd/ft)

T = (264)(405)/(1.29)
T ~ 82,900 gpd/ft

BROWN AND CALDWELL Phoenix, Arizona	USAID-HONDURAS WELL BCCH-2	FIGURE B-10 THEIS RECOVERY PLOT

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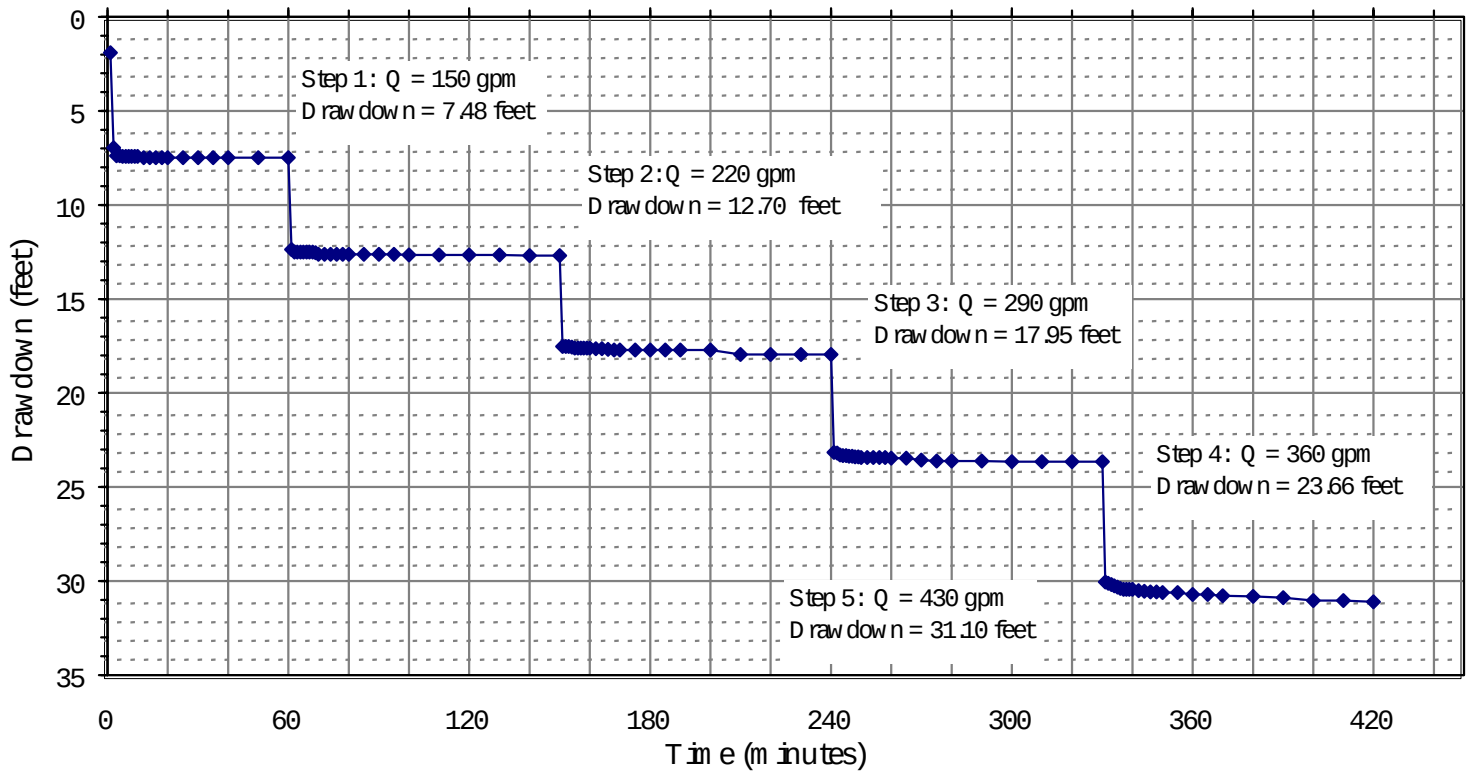

Q - Discharge Rate
gpm - gallons per minute

BROWN AND CALDWELL Phoenix, Arizona	USAID - HONDURAS WELL BCCH-3	Figure B-11 STEP-RATE PUMPING TEST

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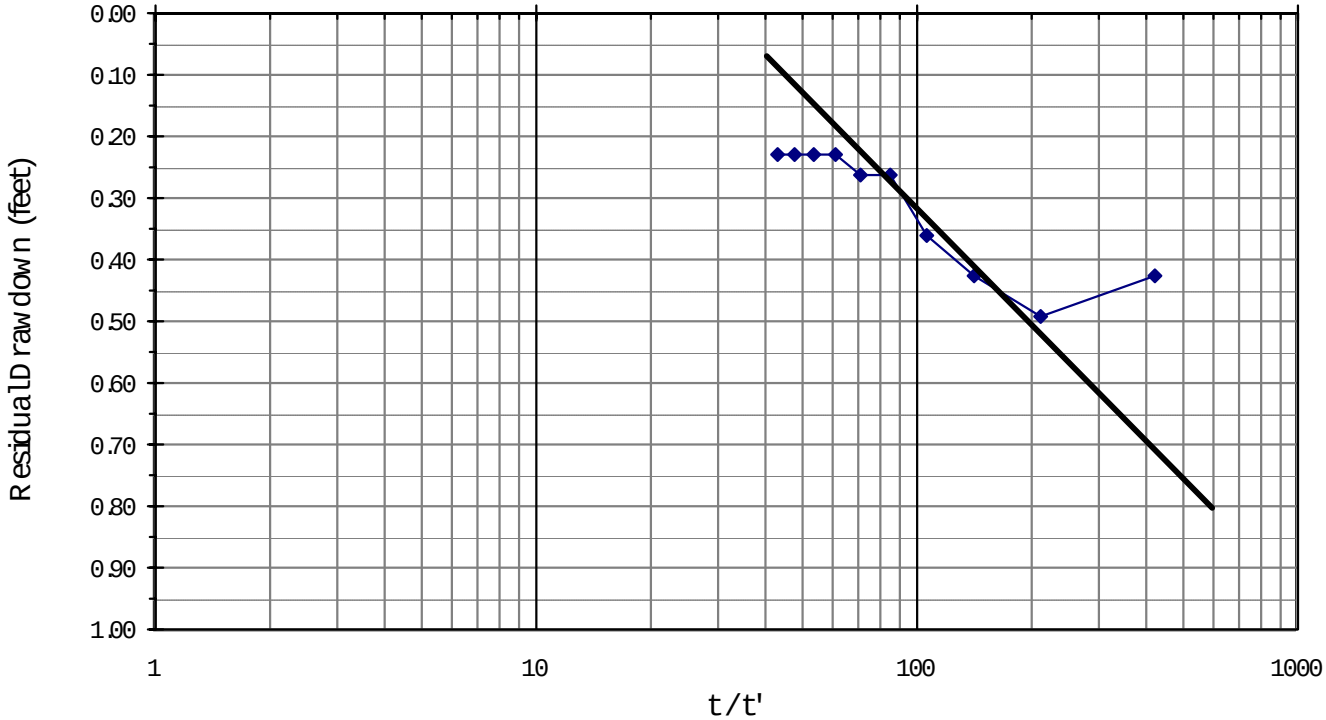

t = time since pumping started (min)
t' = time since pumping ended (min)
Δs = Change in drawdown over one log cycle (feet)
Q = Time weighted average discharge rate (gpm)
T = Transmissivity = 264Q/Δs (gpd/ft)

T = (264)(300)/(0.59)
T ~ 134,000 gpd/ft

BROWN AND CALDWELL Phoenix, Arizona	USAID-HONDURAS WELL BC CH-3	FIGURE B-12 THEIS RECOVERY PLOT

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9.0 WATER QUALITY SAMPLING

A sample of groundwater was collected from each new well either at the end of well development or at the end of the step-rate discharge test. This sampling was conducted in support of the water quality component of the Honduras Groundwater Monitoring Study.

Each well was sampled for general chemistry constituents that include, but are not limited to acidity, alkalinity, hardness, bicarbonate, calcium, magnesium, manganese, sulfates, nitrates and nitrites, sodium and potassium. Each well was also sampled for a limited number of heavy metals including antimony, arsenic, lead, mercury, selenium, cadmium, chromium, nickel, silver and zinc. In addition, most wells were analyzed for total and fecal coliform to assess the amount of fecal matter from untreated wastewater or range/domestic animal wastes infiltrating from the surface to the groundwater supply. Additionally, some of the wells were analyzed for other chemical constituents (chosen on an individual well basis) and included volatile organic compounds (VOCs), pesticides, herbicides and radiological indicators such as gross a and gross ß.

In general, the location of the well provided the main criteria for establishing the list of analytes to be analyzed. For example, a well located in the cañeras would be selected for analysis of pesticides and herbicides to assess whether the chemicals used to deter insects and rodents from the crops were infiltrating to the groundwater supply.

The groundwater sampling procedure for all wells included field water quality measurements (pH, temperature, conductivity) to confirm that pumped groundwater was representative of aquifer pore water. Samples were collected in containers supplied by Jordan Laboratories of San Pedro Sula and Southern Petroleum Laboratories (SPL) of Houston, Texas. Samples were immediately labeled and placed on ice in the laboratory-supplies coolers. Samples for general chemistry and bacteriological analysis were shipped overnight or same-day service to Jordan Laboratories in San Pedro Sula. Samples for metals, pesticides and herbicides, and VOC analysis were shipped to SPL in Houston, Texas. Proper chain-of-custody documentation were filled out and accompanied samples from collection through laboratory analysis.

The water quality sample for BCCH-1 was collected on September 14, 2001 and was collected at the termination of the step-rate discharge test. The water quality sample for BCCH-2 was collected on December 27, 2001 at the end of the step rate discharge test. The water quality sample for BCCH-3 was collected at the end of the step-rate discharge test performed on November 12, 2001 (Figure B-13).

Figure B-13. Collection of Water Quality Sample at BCCH-3

Water quality samples were also collected from specific pre-existing wells that comprise the groundwater-monitoring network established by Brown and Caldwell

for Choloma. Water quality samples were collected from Ines Carranza, Bomberos I, Primavera, San Francisco, Europa, Canada, Prado I, San Antonio and Victoria Gas. Additional samples were collected from Bella Vista, Residential American, Parque Central, Barrosse and San Carlos. Analytical data are discussed in more detail in Chapter 4 of this report. These analytical results are presented in Table B-8 as well as the laboratory reports at the end of this appendix. Table B-9 provides additional well information and Table B-10 provides additional tank information, also at the end of this appendix.

A groundwater sample from well BCCH-1 was submitted for selected general chemistry, VOCs, chlorinated herbicides, organochlorine pesticides, and metals. No VOCs, chlorinated herbicides or organochlorine pesticides were detected. The only metal detected was zinc (0.0721 mg/L). While this exceeds the detection limit capabilities of the laboratory, it falls below the acceptable guidelines established by the WHO. The WHO guideline for zinc is 3 mg/L (WHO, 1996).

The samples collected from the existing wells in the municipality were analyzed for concentrations of selected metals and general chemistry as well as for concentrations of total and fecal coliform. No metals were detected in any of these samples. Conductivity measurements ranged from 190 µS/cm (approximately 114 mg/L TDS) at well Barrio San Antonio to 1,027 µS/cm (approximately 616 mg/L TDS) at well Ines Carranza Barnica. Generally, conductivity measurements for the rest of the wells were 300 to 400 µS/cm (180 to 240 mg/L TDS). TDS is proportional to electrical conductance, with conductance being about 1.6 times greater than TDS concentrations. Normal drinking water has a TDS range of 300 to 800 mg/L. Seawater has a TDS of approximately 32,000 mg/L. The recommended limit for TDS by the WHO is 500 mg/L, with a maximum of 1,500 mg/L.

Concentrations of nitrate were reported in wells BCCH-1 (1.8 mg/L), BCCH-2 (2.3 mg/L), BCCH-3 (4.3 mg/L), Bomberos No. 1 (4.2 mg/L), Colonia Canada (8.4 mg/L), Residencial Europa (3.62 mg/L), Ines Carranza Barnica (4.5 mg/L), Colonia El Prado No. 1 (4.18 mg/L), Barrio Primavera (5.35 mg/L), Barrio San Antonio (1.94 mg/L) and Colonia San Francisco (9.4 mg/L). The WHO acute exposure guideline for nitrate in water is 50 mg/L. Coliform was detected in all wells sampled with the exception of BCCH-2, Residencial Europa, Col. El Prado 1, and Col. Canada. Wells BCCH-1 and Ines Carranza Barnica had the highest concentrations of total coliform at 47 and 35 UFC/100 ml respectively, and had concentrations of fecal coliform at 10 and 9 UFC/100 ml, respectively.

General water chemistry was analyzed for all wells sampled in Choloma. Analysis included the major cations and anions in the groundwater that allows for the determination of water type. In general, the wells screened within the laterally continuous coarse-grained alluvium are a calcium-bicarbonate type groundwater. A sample collected from BCCH-1, which was screened in the cemented sand with silt deposit, is a sodium-bicarbonate type groundwater. A sample collected from the Ines Carranza Barnica well is also a sodium-bicarbonate type groundwater. The Ines Carranza Barnica well is approximately five kilometers south of central Choloma. Elevated conductivity, sodium, bicarbonate, and coliform measured in the sample from the Ines Carranza Barnica well may indicate that the groundwater is impacted and/or the groundwater is significantly different than the groundwater sampled in wells in the Choloma Valley to the north.

10.0 REFERENCES

Cooper, H.H. Jr., and Jacob, C.E., 1946. *A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-field History*, Transactions, American Geophysical Union, 27:526-34.

Theis, C.V., 1935. The Lowering of the Piezometric Surface and the Rate and Discharge of a Well Using Groundwater Storage. Transactions, American Geophysical Union, 16:519-24.

Table B-8. Analytical Results

(Page 1 of 8)

Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
Barrio Primavera	Acidez Total	2310-B	15	mg/l	-
Barrio Primavera	Alcalinidad Total	2320-B	93	mg/l CaCO3	-
Barrio Primavera	Bicarbonato (HCO3)	2320-B	114	mg/l	-
Barrio Primavera	Dureza Total	2340-C	88	mg/l CaCO3	-
Barrio Primavera	Conductividad	25100-B	239	us/cm	-
Barrio Primavera	Calcio	3500-Ca D	26	mg/l CaCO3	-
Barrio Primavera	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Barrio Primavera	Magnesio	3500-Mg E	12	mg/l CaCO3	50
Barrio Primavera	Manganeso Total	3500-Mn C	0.05	mg/l	0.5
Barrio Primavera	Cloruros	4500-Cl-B	8	mg/l	250
Barrio Primavera	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Barrio Primavera	Nitratos	4500-NO3-B	5.35	mg/l	50
Barrio Primavera	Sulfatos	4500-SO4	23	mg/l	250
Barrio Primavera	Potasio (K)	AA	3.4	mg/l	10
Barrio Primavera	Sodio (Na)	AA	11.85	mg/l	200
Barrio Primavera	Coliformes Totales	9222-B	2	UFC/100 ml	0
Barrio Primavera	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Barrio Primavera	Antimony	6010B	< 0.005	mg/l	0.005
Barrio Primavera	Arsenic	6010B	< 0.005	mg/l	0.01
Barrio Primavera	Cadmium	6010B	< 0.005	mg/l	0.003
Barrio Primavera	Chromium	6010B	< 0.01	mg/l	0.05
Barrio Primavera	Lead	6010B	< 0.005	mg/l	0.01
Barrio Primavera	Nickel	6010B	< 0.02	mg/l	0.02
Barrio Primavera	Selenium	6010B	< 0.005	mg/l	0.01
Barrio Primavera	Silver	6010B	< 0.01	mg/l	-
Barrio Primavera	Zinc	6010B	< 0.02	mg/l	3
Barrio Primavera	Mercury	7470A	< 0.0002	mg/l	0.001
Water Quality					
Barrio San Antonio	Acidez Total	2310-B	23	mg/l	-
Barrio San Antonio	Alcalinidad Total	2320-B	80	mg/l CaCO3	-
Barrio San Antonio	Bicarbonato (HCO3)	2320-B	80	mg/l	-
Barrio San Antonio	Dureza Total	2340-C	68	mg/l CaCO3	-
Barrio San Antonio	Conductividad	25100-B	190	us/cm	-
Barrio San Antonio	Calcio	3500-Ca D	14	mg/l CaCO3	-
Barrio San Antonio	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Barrio San Antonio	Magnesio	3500-Mg E	8	mg/l CaCO3	50
Barrio San Antonio	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Barrio San Antonio	Cloruros	4500-Cl-B	6	mg/l	250
Barrio San Antonio	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Barrio San Antonio	Nitratos	4500-NO3-B	1.94	mg/l	50
Barrio San Antonio	Sulfatos	4500-SO4	14	mg/l	250
Barrio San Antonio	Potasio (K)	AA	3	mg/l	10
Barrio San Antonio	Sodio (Na)	AA	11.3	mg/l	200
Barrio San Antonio	Coliformes Totales	9222-B	11	UFC/100 ml	0
Barrio San Antonio	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Barrio San Antonio	Antimony	6010B	< 0.005	mg/l	0.005
Barrio San Antonio	Arsenic	6010B	< 0.005	mg/l	0.01
Barrio San Antonio	Cadmium	6010B	< 0.005	mg/l	0.003
Barrio San Antonio	Chromium	6010B	< 0.01	mg/l	0.05
Barrio San Antonio	Lead	6010B	< 0.005	mg/l	0.01
Barrio San Antonio	Nickel	6010B	< 0.02	mg/l	0.02
Barrio San Antonio	Selenium	6010B	< 0.005	mg/l	0.01
Barrio San Antonio	Silver	6010B	< 0.01	mg/l	-
Barrio San Antonio	Zinc	6010B	< 0.02	mg/l	3
Barrio San Antonio	Mercury	7470A	< 0.002	mg/l	0.001

Table B-8. Analytical Results

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Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
BCCH-1	Acidez Total	2310-B	8	mg/l	-
BCCH-1	Alcalinidad Total	2320-B	118.9	mg/l CaCO3	-
BCCH-1	Bicarbonato (HCO3)	2320-B	118.9	mg/l	-
BCCH-1	Dureza Total	2340-C	100	mg/l CaCO3	-
BCCH-1	Conductividad	25100-B	357	us/cm	-
BCCH-1	Calcio	3500-Ca D	15.2	mg/l CaCO3	-
BCCH-1	Hierro Total	3500-Fe-D	0.32	mg/l	0.3
BCCH-1	Magnesio	3500-Mg E	14.88	mg/l CaCO3	50
BCCH-1	Manganeso Total	3500-Mn C	1.05	mg/l	0.5
BCCH-1	Cloruros	4500-Cl-B	22	mg/l	250
BCCH-1	Nitritos	4500-NO2-B	0.06	mg/l	1
BCCH-1	Nitratos	4500-NO3-B	1.8	mg/l	50
BCCH-1	Sulfatos	4500-SO4	22.8	mg/l	250
BCCH-1	Potasio (K)	AA	4.8	mg/L	10
BCCH-1	Sodio (Na)	AA	50	mg/L	200
BCCH-1	Coliformes Totales	9222-B	47	UFC/100 ml	0
BCCH-1	Coliformes Fecales	9222-D	10	UFC/100 ml	0
Metals					
BCCH-1	Antimony	6010B	< 0.005	mg/l	0.005
BCCH-1	Arsenic	6010B	< 0.005	mg/l	0.01
BCCH-1	Cadmium	6010B	< 0.005	mg/l	0.003
BCCH-1	Chromium	6010B	< 0.01	mg/l	0.05
BCCH-1	Lead	6010B	< 0.005	mg/l	0.01
BCCH-1	Nickel	6010B	< 0.02	mg/l	0.02
BCCH-1	Selenium	6010B	< 0.005	mg/l	0.01
BCCH-1	Silver	6010B	< 0.01	mg/l	-
BCCH-1	Zinc	6010B	0.0721	mg/l	3
BCCH-1	Mercury	7470A	< 0.0002	mg/l	0.001
Pesticides					
BCCH-1	4,4'-DDD	8081	< 0.1	ug/L	-
BCCH-1	4,4'-DDE	8081	< 0.1	ug/L	-
BCCH-1	4,4'-DDT	8081	< 0.1	ug/L	2
BCCH-1	Aldrin	8081	< 0.05	ug/L	0.03
BCCH-1	alpha-BHC	8081	< 0.05	ug/L	-
BCCH-1	alpha-Chlordane	8081	< 0.05	ug/L	-
BCCH-1	beta-BHC	8081	< 0.05	ug/L	-
BCCH-1	Chlordane	8081	< 0.5	ug/L	0.2
BCCH-1	delta-BHC	8081	< 0.05	ug/L	-
BCCH-1	Dieldrin	8081	< 0.1	ug/L	-
BCCH-1	Endosulfan I	8081	< 0.05	ug/L	-
BCCH-1	Endosulfan II	8081	< 0.1	ug/L	-
BCCH-1	Endosulfan Sulfate	8081	< 0.1	ug/L	-
BCCH-1	Endrin	8081	< 0.1	ug/L	-
BCCH-1	Endrin aldehyde	8081	< 0.1	ug/L	-
BCCH-1	Endrin ketone	8081	< 0.1	ug/L	-
BCCH-1	gamma-BHC	8081	< 0.05	ug/L	-
BCCH-1	gamma-Chlordane	8081	< 0.05	ug/L	-
BCCH-1	Heptachlor	8081	< 0.05	ug/L	0.03
BCCH-1	Heptachlor epoxide	8081	< 0.05	ug/L	0.03
BCCH-1	Methoxychlor	8081	< 0.5	ug/L	20
BCCH-1	Toxaphene	8081	< 1	ug/L	-

Table B-8. Analytical Results

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Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Herbicides					
BCCH-1	2,4,5-T	8151A	< 1	ug/L	9
BCCH-1	2,4,5-TP (Silvex)	8151A	< 1	ug/L	-
BCCH-1	2,4-D	8151A	< 1	ug/L	30
BCCH-1	2,4-DB	8151A	< 1	ug/L	90
BCCH-1	Dalapon	8151A	< 1	ug/L	-
BCCH-1	Dicamba	8151A	< 1	ug/L	-
BCCH-1	Dichloroprop	8151A	< 1	ug/L	100
BCCH-1	Dinoseb	8151A	< 1	ug/L	-
BCCH-1	MCPA	8151A	< 25	ug/L	2
BCCH-1	MCPP	8151A	< 25	ug/L	-
Volatile Organic Compounds					
BCCH-1	1,1,1,2-Tetrachloroethane	8260B	< 5	ug/L	-
BCCH-1	1,1,1-Trichloroethane	8260B	< 5	ug/L	2000
BCCH-1	1,1,2,2-Tetrachloroethane	8260B	< 5	ug/L	-
BCCH-1	1,1,2-Trichloroethane	8260B	< 5	ug/L	-
BCCH-1	1,1-Dichloroethane	8260B	< 5	ug/L	-
BCCH-1	1,1-Dichloroethene	8260B	< 5	ug/L	30
BCCH-1	1,1-Dichloropropene	8260B	< 5	ug/L	-
BCCH-1	1,2,3-Trichlorobenzene	8260B	< 5	ug/L	-
BCCH-1	1,2,3-Trichloropropane	8260B	< 5	ug/L	-
BCCH-1	1,2,4-Trichlorobenzene	8260B	< 5	ug/L	-
BCCH-1	1,2,4-Trimethylbenzene	8260B	< 5	ug/L	-
BCCH-1	1,2-Dibromo-3-chloropropan	8260B	< 5	ug/L	1
BCCH-1	1,2-Dibromoethane	8260B	< 5	ug/L	0.4-15
BCCH-1	1,2-Dichlorobenzene	8260B	< 5	ug/L	1000
BCCH-1	1,2-Dichloroethane	8260B	< 5	ug/L	30
BCCH-1	1,2-Dichloroethene (total)	8260B	< 5	ug/L	50
BCCH-1	1,2-Dichloropropane	8260B	< 5	ug/L	40
BCCH-1	1,3,5-Trimethylbenzene	8260B	< 5	ug/L	-
BCCH-1	1,3-Dichlorobenzene	8260B	< 5	ug/L	-
BCCH-1	1,3-Dichloropropane	8260B	< 5	ug/L	-
BCCH-1	1,4-Dichlorobenzene	8260B	< 5	ug/L	300
BCCH-1	2,2-Dichloropropane	8260B	< 5	ug/L	-
BCCH-1	2-Butanone	8260B	< 20	ug/L	-
BCCH-1	2-Chloroethylvinylether	8260B	< 10	ug/L	-
BCCH-1	2-Chlorotoluene	8260B	< 5	ug/L	-
BCCH-1	2-Hexanone	8260B	< 10	ug/L	-
BCCH-1	4-Chlorotoluene	8260B	< 5	ug/L	-
BCCH-1	4-Isopropyltoluene	8260B	< 5	ug/L	-
BCCH-1	4-Methyl-2-pentanone	8260B	< 10	ug/L	-
BCCH-1	Acetone	8260B	< 100	ug/L	-
BCCH-1	Acrylonitrile	8260B	< 50	ug/L	-
BCCH-1	Benzene	8260B	< 5	ug/L	10
BCCH-1	Bromobenzene	8260B	< 5	ug/L	-
BCCH-1	Bromochloromethane	8260B	< 5	ug/L	-
BCCH-1	Bromodichloromethane	8260B	< 5	ug/L	60
BCCH-1	Bromoform	8260B	< 5	ug/L	100
BCCH-1	Bromomethane	8260B	< 10	ug/L	-
BCCH-1	Carbon disulfide	8260B	< 5	ug/L	-
BCCH-1	Carbon tetrachloride	8260B	< 5	ug/L	2
BCCH-1	Chlorobenzene	8260B	< 5	ug/L	-
BCCH-1	Chloroethane	8260B	< 10	ug/L	-
BCCH-1	Chloroform	8260B	< 5	ug/L	200
BCCH-1	Chloromethane	8260B	< 10	ug/L	-
BCCH-1	cis-1,2-Dichloroethene	8260B	< 5	ug/L	-
BCCH-1	cis-1,3-Dichloropropene	8260B	< 5	ug/L	-
BCCH-1	Dibromochloromethane	8260B	< 5	ug/L	100

Table B-8. Analytical Results

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Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Volatile Organic Compounds (continued)					
BCCH-1	Dibromomethane	8260B	< 5	ug/L	-
BCCH-1	Dichlorodifluoromethane	8260B	< 10	ug/L	-
BCCH-1	Ethylbenzene	8260B	< 5	ug/L	300
BCCH-1	Hexachlorobutadiene	8260B	< 5	ug/L	0.6
BCCH-1	Isopropylbenzene	8260B	< 5	ug/L	-
BCCH-1	m,p-Xylene	8260B	< 5	ug/L	-
BCCH-1	Methyl tert-butyl ether	8260B	< 5	ug/L	-
BCCH-1	Methylene chloride	8260B	< 5	ug/L	-
BCCH-1	Naphthalene	8260B	< 5	ug/L	-
BCCH-1	n-Butylbenzene	8260B	< 5	ug/L	-
BCCH-1	n-Propylbenzene	8260B	< 5	ug/L	-
BCCH-1	o-Xylene	8260B	< 5	ug/L	-
BCCH-1	sec-Butylbenzene	8260B	< 5	ug/L	-
BCCH-1	Styrene	8260B	< 5	ug/L	20
BCCH-1	tert-Butylbenzene	8260B	< 5	ug/L	-
BCCH-1	Tetrachloroethene	8260B	< 5	ug/L	40
BCCH-1	Toluene	8260B	< 5	ug/L	700
BCCH-1	trans-1,2-Dichloroethene	8260B	< 5	ug/L	-
BCCH-1	trans-1,3-Dichloropropene	8260B	< 5	ug/L	-
BCCH-1	Trichloroethene	8260B	< 5	ug/L	70
BCCH-1	Trichlorofluoromethane	8260B	< 5	ug/L	-
BCCH-1	Vinylacetate	8260B	< 10	ug/L	-
BCCH-1	Vinylchloride	8260B	< 10	ug/L	5
BCCH-1	Xylenes, Total	8260B	< 5	ug/L	500
Water Quality					
BCCH-2	Acidez Total	2310-B	98	mg/l	-
BCCH-2	Alcalinidad Total	2320-B	30	mg/l CaCO3	-
BCCH-2	Bicarbonato (HCO3)	2320-B	30	mg/l	-
BCCH-2	Dureza Total	2340-C	126	mg/l CaCO3	-
BCCH-2	Conductividad	25100-B	252	us/cm	-
BCCH-2	Calcio	3500-Ca D	23	mg/l CaCO3	-
BCCH-2	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
BCCH-2	Magnesio	3500-Mg E	10	mg/l CaCO3	50
BCCH-2	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
BCCH-2	Cloruros	4500-Cl-B	10	mg/l	250
BCCH-2	Nitritos	4500-NO2-B	< 0.01	mg/l	1
BCCH-2	Nitratos	4500-NO3-B	2.3	mg/l	50
BCCH-2	Sulfatos	4500-SO4	20	mg/l	250
BCCH-2	Potasio (K)	AA	3.60	mg/l	10
BCCH-2	Sodio (Na)	AA	20.20	mg/l	200
BCCH-2	Coliformes Totales	9222-B	0	UFC/100ml	0
BCCH-2	Coliformes Fecales	9222-D	0	UFC/100ml	0
Metals					
BCCH-2	Antimony	6010B	< 0.005	mg/l	0.005
BCCH-2	Arsenic	6010B	< 0.005	mg/l	0.01
BCCH-2	Cadmium	6010B	< 0.005	mg/l	0.003
BCCH-2	Chromium	6010B	< 0.01	mg/l	0.05
BCCH-2	Lead	6010B	< 0.005	mg/l	0.01
BCCH-2	Nickel	6010B	< 0.02	mg/l	0.02
BCCH-2	Selenium	6010B	< 0.005	mg/l	0.01
BCCH-2	Silver	6010B	< 0.01	mg/l	-
BCCH-2	Zinc	6010B	< 0.02	mg/l	3
BCCH-2	Mercury	7470A	< 0.0002	mg/l	0.001

Table B-8. Analytical Results

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Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
BCCH-3	Acidez Total	2310-B	25	mg/l	-
BCCH-3	Alcalinidad Total	2320-B	118	mg/l CaCO3	-
BCCH-3	Bicarbonato (HCO3)	2320-B	118	mg/l	-
BCCH-3	Dureza Total	2340-C	108	mg/l CaCO3	-
BCCH-3	Conductividad	25100-B	264	us/cm	-
BCCH-3	Calcio	3500-Ca D	24	mg/l CaCO3	-
BCCH-3	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
BCCH-3	Magnesio	3500-Mg E	12	mg/l CaCO3	50
BCCH-3	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.1
BCCH-3	Cloruros	4500-Cl-B	7.5	mg/l	250
BCCH-3	Nitritos	4500-NO2-B	< 0.01	mg/l	1
BCCH-3	Nitratos	4500-NO3-B	4.3	mg/l	50
BCCH-3	Sulfatos	4500-SO4	3.4	mg/l	250
BCCH-3	Potasio (K)	AA	3.1	mg/l	10
BCCH-3	Sodio (Na)	AA	13.6	mg/l	200
BCCH-3	Coliformes Totales	9222-B	15	UFC/100 ml	0
BCCH-3	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Water Quality					
Bomberos No.1	Acidez Total	2310-B	31	mg/l	-
Bomberos No.1	Alcalinidad Total	2320-B	112	mg/l CaCO3	-
Bomberos No.1	Bicarbonato (HCO3)	2320-B	112	mg/l	-
Bomberos No.1	Dureza Total	2340-C	100	mg/l CaCO3	-
Bomberos No.1	Conductividad	25100-B	269	us/cm	-
Bomberos No.1	Calcio	3500-Ca D	24	mg/l CaCO3	-
Bomberos No.1	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Bomberos No.1	Magnesio	3500-Mg E	10	mg/l CaCO3	50
Bomberos No.1	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Bomberos No.1	Cloruros	4500-Cl-B	8	mg/l	250
Bomberos No.1	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Bomberos No.1	Nitratos	4500-NO3-B	4.2	mg/l	50
Bomberos No.1	Sulfatos	4500-SO4	24	mg/l	250
Bomberos No.1	Potasio (K)	AA	3.45	mg/l	10
Bomberos No.1	Sodio (Na)	AA	14.4	mg/l	200
Bomberos No.1	Coliformes Totales	9222-B	1	UFC/100 ml	0
Bomberos No.1	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Bomberos No.1	Antimony	6010B	< 0.005	mg/L	0.005
Bomberos No.1	Arsenic	6010B	< 0.005	mg/L	0.01
Bomberos No.1	Cadmium	6010B	< 0.005	mg/L	0.003
Bomberos No.1	Chromium	6010B	< 0.01	mg/L	0.05
Bomberos No.1	Lead	6010B	< 0.005	mg/L	0.01
Bomberos No.1	Nickel	6010B	< 0.02	mg/L	0.02
Bomberos No.1	Selenium	6010B	< 0.005	mg/L	0.01
Bomberos No.1	Silver	6010B	< 0.01	mg/L	-
Bomberos No.1	Zinc	6010B	< 0.02	mg/L	3
Bomberos No.1	Mercury	7470A	< 0.0002	mg/L	0.001

Table B-8. Analytical Results

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Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
Col. Canada	Acidez Total	2310-B	27	mg/l	-
Col. Canada	Alcalinidad Total	2320-B	140	mg/l CaCO3	-
Col. Canada	Bicarbonato (HCO3)	2320-B	140	mg/l	-
Col. Canada	Dureza Total	2340-C	128	mg/l CaCO3	-
Col. Canada	Conductividad	25100-B	361	us/cm	-
Col. Canada	Calcio	3500-Ca D	32	mg/l CaCO3	-
Col. Canada	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Col. Canada	Magnesio	3500-Mg E	12	mg/l CaCO3	50
Col. Canada	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Col. Canada	Cloruros	4500-Cl-B	18	mg/l	250
Col. Canada	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Col. Canada	Nitratos	4500-NO3-B	8.4	mg/l	50
Col. Canada	Sulfatos	4500-SO4	25	mg/l	250
Col. Canada	Potasio (K)	AA	2.9	mg/l	10
Col. Canada	Sodio (Na)	AA	19.38	mg/l	200
Col. Canada	Coliformes Totales	9222-B	0	UFC/100 ml	0
Col. Canada	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Col. Canada	Antimony	6010B	< 0.005	mg/l	0.005
Col. Canada	Arsenic	6010B	< 0.005	mg/l	0.01
Col. Canada	Cadmium	6010B	< 0.005	mg/l	0.003
Col. Canada	Chromium	6010B	< 0.01	mg/l	0.05
Col. Canada	Lead	6010B	< 0.005	mg/l	0.01
Col. Canada	Nickel	6010B	< 0.02	mg/l	0.02
Col. Canada	Selenium	6010B	< 0.005	mg/l	0.01
Col. Canada	Silver	6010B	< 0.01	mg/l	-
Col. Canada	Zinc	6010B	< 0.02	mg/l	3
Col. Canada	Mercury	7470A	< 0.0002	mg/l	0.001
Water Quality					
Col. El Prado 1	Acidez Total	2310-B	53	mg/l	-
Col. El Prado 1	Alcalinidad Total	2320-B	167	mg/l CaCO3	-
Col. El Prado 1	Bicarbonato (HCO3)	2320-B	167	mg/l	-
Col. El Prado 1	Dureza Total	2340-C	172	mg/l CaCO3	-
Col. El Prado 1	Conductividad	25100-B	454	us/cm	-
Col. El Prado 1	Calcio	3500-Ca D	39	mg/l CaCO3	-
Col. El Prado 1	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Col. El Prado 1	Magnesio	3500-Mg E	18	mg/l CaCO3	50
Col. El Prado 1	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Col. El Prado 1	Cloruros	4500-Cl-B	18	mg/l	250
Col. El Prado 1	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Col. El Prado 1	Nitratos	4500-NO3-B	4.18	mg/l	50
Col. El Prado 1	Sulfatos	4500-SO4	35	mg/l	250
Col. El Prado 1	Potasio (K)	AA	3.18	mg/l	10
Col. El Prado 1	Sodio (Na)	AA	19.5	mg/l	200
Col. El Prado 1	Coliformes Totales	9222-B	0	UFC/100 ml	0
Col. El Prado 1	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Col. El Prado 1	Antimony	6010B	< 0.005	mg/l	0.005
Col. El Prado 1	Arsenic	6010B	< 0.005	mg/l	0.01
Col. El Prado 1	Cadmium	6010B	< 0.005	mg/l	0.003
Col. El Prado 1	Chromium	6010B	< 0.01	mg/l	0.05
Col. El Prado 1	Lead	6010B	< 0.005	mg/l	0.01
Col. El Prado 1	Nickel	6010B	< 0.02	mg/l	0.02
Col. El Prado 1	Selenium	6010B	< 0.005	mg/l	0.01
Col. El Prado 1	Silver	6010B	< 0.01	mg/l	-
Col. El Prado 1	Zinc	6010B	< 0.02	mg/l	3
Col. El Prado 1	Mercury	7470A	< 0.0002	mg/l	0.001

Table B-8. Analytical Results

(Page 7 of 8)

Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
Col. San Francisco	Acidez Total	2310-B	82	mg/l	-
Col. San Francisco	Alcalinidad Total	2320-B	184	mg/l CaCO3	-
Col. San Francisco	Bicarbonato (HCO3)	2320-B	184	mg/l	-
Col. San Francisco	Dureza Total	2340-C	168	mg/l CaCO3	-
Col. San Francisco	Conductividad	25100-B	442	us/cm	-
Col. San Francisco	Calcio	3500-Ca D	38	mg/l CaCO3	-
Col. San Francisco	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Col. San Francisco	Magnesio	3500-Mg E	17	mg/l CaCO3	50
Col. San Francisco	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Col. San Francisco	Cloruros	4500-Cl-B	17	mg/l	250
Col. San Francisco	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Col. San Francisco	Nitratos	4500-NO3-B	9.4	mg/l	50
Col. San Francisco	Sulfatos	4500-SO4	17	mg/l	250
Col. San Francisco	Sodio (Na)	AA	22.3	mg/L	200
Col. San Francisco	Potasio (K)	AA	5.7	mg/L	10
Col. San Francisco	Coliformes Totales	9222-B	3	UFC/100 ml	0
Col. San Francisco	Coliformes Fecales	9222-D	0	UFC/100 ml	0
Metals					
Col. San Francisco	Antimony	6010B	< 0.005	mg/l	0.005
Col. San Francisco	Arsenic	6010B	< 0.005	mg/l	0.01
Col. San Francisco	Cadmium	6010B	< 0.005	mg/l	0.003
Col. San Francisco	Chromium	6010B	< 0.01	mg/l	0.05
Col. San Francisco	Lead	6010B	< 0.005	mg/l	0.01
Col. San Francisco	Nickel	6010B	< 0.02	mg/l	0.02
Col. San Francisco	Selenium	6010B	< 0.005	mg/l	0.01
Col. San Francisco	Silver	6010B	< 0.01	mg/l	-
Col. San Francisco	Zinc	6010B	< 0.02	mg/l	3
Col. San Francisco	Mercury	7470A	< 0.0002	mg/l	0.001
Water Quality					
Ines Carranza Barrio	Acidez Total	2310-B	50	mg/l	-
Ines Carranza Barrio	Alcalinidad Total	2320-B	374	mg/l CaCO3	-
Ines Carranza Barrio	Bicarbonato (HCO3)	2320-B	374	mg/l	-
Ines Carranza Barrio	Dureza Total	2340-C	184	mg/l CaCO3	-
Ines Carranza Barrio	Conductividad	25100-B	1027	us/cm	-
Ines Carranza Barrio	Calcio	3500-Ca D	30	mg/l CaCO3	-
Ines Carranza Barrio	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Ines Carranza Barrio	Magnesio	3500-Mg E	26	mg/l CaCO3	50
Ines Carranza Barrio	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Ines Carranza Barrio	Cloruros	4500-Cl-B	94	mg/l	250
Ines Carranza Barrio	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Ines Carranza Barrio	Nitratos	4500-NO3-B	4.5	mg/l	50
Ines Carranza Barrio	Sulfatos	4500-SO4	20	mg/l	250
Ines Carranza Barrio	Sodio (Na)	AA	145	mg/L	200
Ines Carranza Barrio	Potasio (K)	AA	7.95	mg/L	10
Ines Carranza Barrio	Coliformes Totales	9222-B	35	UFC/100 ml	0
Ines Carranza Barrio	Coliformes Fecales	9222-D	9	UFC/100 ml	0
Metals					
Ines Carranza Barrio	Antimony	6010B	< 0.005	mg/l	0.005
Ines Carranza Barrio	Arsenic	6010B	< 0.005	mg/l	0.01
Ines Carranza Barrio	Cadmium	6010B	< 0.005	mg/l	0.003
Ines Carranza Barrio	Chromium	6010B	< 0.01	mg/l	0.05
Ines Carranza Barrio	Lead	6010B	< 0.005	mg/l	0.01
Ines Carranza Barrio	Nickel	6010B	< 0.02	mg/l	0.02
Ines Carranza Barrio	Selenium	6010B	< 0.005	mg/l	0.01
Ines Carranza Barrio	Silver	6010B	< 0.01	mg/l	-
Ines Carranza Barrio	Zinc	6010B	< 0.02	mg/l	3
Ines Carranza Barrio	Mercury	7470A	< 0.0002	mg/l	0.001

Table B-8. Analytical Results

(Page 8 of 8)

Well Name	Analytical Constituent	Analytical Method	Result	Unit	WHO Guideline (health based)
Water Quality					
Residencial Europa	Acidez Total	2310-B	23	mg/l	-
Residencial Europa	Alcalinidad Total	2320-B	191	mg/l CaCO3	-
Residencial Europa	Bicarbonato (HCO3)	2320-B	191	mg/l	-
Residencial Europa	Dureza Total	2340-C	180	mg/l CaCO3	-
Residencial Europa	Conductividad	25100-B	465	ms/cm	-
Residencial Europa	Calcio	3500-Ca D	43	mg/l CaCO3	-
Residencial Europa	Hierro Total	3500-Fe-D	< 0.03	mg/l	0.3
Residencial Europa	Magnesio	3500-Mg E	17	mg/l CaCO3	50
Residencial Europa	Manganeso Total	3500-Mn C	< 0.03	mg/l	0.5
Residencial Europa	Cloruros	4500-Cl-B	22	mg/l	250
Residencial Europa	Nitritos	4500-NO2-B	< 0.01	mg/l	1
Residencial Europa	Nitratos	4500-NO3-B	3.62	mg/l	50
Residencial Europa	Sulfatos	4500-SO4	23	mg/l	250
Residencial Europa	Sodio (Na)	AA	21	mg/L	200
Residencial Europa	Potasio (K)	AA	4	mg/L	10
Residencial Europa	Coliformes Totales	9222-B	0	UFC/100ml	0
Residencial Europa	Coliformes Fecales	9222-D	0	UFC/100ml	0
Metals					
Residencial Europa	Antimony	6010B	< 0.005	mg/l	0.005
Residencial Europa	Arsenic	6010B	< 0.005	mg/l	0.01
Residencial Europa	Cadmium	6010B	< 0.005	mg/l	0.003
Residencial Europa	Chromium	6010B	< 0.01	mg/l	0.05
Residencial Europa	Lead	6010B	< 0.005	mg/l	0.01
Residencial Europa	Nickel	6010B	< 0.02	mg/l	0.02
Residencial Europa	Selenium	6010B	< 0.005	mg/l	0.01
Residencial Europa	Silver	6010B	< 0.01	mg/l	-
Residencial Europa	Zinc	6010B	< 0.02	mg/l	3
Residencial Europa	Mercury	7470A	< 0.0002	mg/l	0.001

Table B-9. Well Information

SECTOR ABASTECIDO	INFORMACION DEL POZO				
	Nombre del pozo	Elevación del Pedestal del pozo (metros)	Caudal GPM	Profundidad del Pozo (pies))	Información de la bomba
Col. Canadá y Barrio Los Cocos del Sur.	Canadá (municipal)	32.562	400	200	30 HP sumergible
Centro de la Ciudad	San Antonio (municipal)	34.195	450	120	20 HP Sumergible
Centro de la Ciudad	Parque Central	32.277	350	200	75 HP Turbina Vertical
SE, SW y NE de la ciudad	Bomberos #1 (municipal)	33.132	257.2	200	50 HP Turbina Vertical
Red de la Col. Las Pilas y Col. Victoria	Bomberos #2 (municipal)	32.617	650	200	75 HP Turbina Vertical
A la red de la Col. Sinor, Santa Fe Central; a tanque de la Col. Victoria y SE y SW de la ciudad (Tanque trincheras).	Pérez Estrada (municipal)	32.342	616.81	200	100 HP Turbina
Red de la Col. Victoria	Victoria #1 (municipal)	52.733	68	329	7.5 HP Sumergible
Red de la Col. Victoria	Victoria #2 (municipal)	42.833	50		7.5 HP Sumergible
Red de la Col. Primavera	La Primavera (municipal)	36.644	180	200	10 HP Sumergible
Col. La Mora y fábrica.	La Mora #1 (municipal)	35.957	250	200	25 HP Sumergible
Col. Prado I	Prado I (municipal)	26.433	60	100	5 Hp Sumergible
Col. Prado II y Col. Anexo El Prado	Prado II (municipal)	26.263	60	100	5H P Sumergible
Residencial Europa	Europa (municipal)	24.923	225	117	7.5 HP Sumergible
Residencial San Carlos	San Carlos (municipal)	26.303	296	176	20HP Sumergible
Residencial El Japón	El Japón (municipal)	21.765	110	100	7.5 HP Sumergible
Tanque de la Col. Las Colinas (1), Tanques La Unidad (2), Tanque del Colegio Pagán (1), Col. Vista Hermosa (1). Total 5 tanques.	Bella Vista (municipal)	27.572	196.2	206	125 HP Turbina Vertical
Sector Norte de la ciudad.	Barrosse II (municipal)	26.333	587	200	100 HP Turbina Vertical
Residencial América.	América (non municipal)	26.953	200		10 HP Sumergible
Barrio Los Almendros y La Care	San Francisco (municipal)	37.49	100	80	5HP Sumergible
Col. La Care y Col. 19 de Septiembre.	La Care (municipal)	45.762	35	350	5 HP Sumergible
Col. Inés Carranza Barnica	Inés Carranza Barnica (municipal)	42.833	175	500	7.5 Hp Sumergible

Table B-10. Tank Information

SECTOR ABASTECIDO	INFORMACION DEL ALMACENAMIENTO							Comentarios sobre el Almacenamiento
	Nombre	Volúmen Galones	Material del Tanque	Tipo de Tanque	Altura de Tanque (m)	Disponibilidad del Servicio de agua	Población Estimada para el año 2,000	
Col. Canadá y Barrio Los Cocos del Sur.	Ninguno					24 Hrs	762	
Centro de la Ciudad	Ninguno					24 Hrs	3,051	El sistema está interconectado ; así que los pozos Parque Central, san Antonio ,Bomberos II y Pérez Estrada (cuando bombea al tanque Trincheras) abastecen una población de 3,051
Centro de la Ciudad	Ninguno					3 A m. a 11 P M		
SE, SW y NE de la ciudad	Tanque Trincheras	200,000	Concreto	Apoyado	5.00	5 A M a 10 A M 2 P M a 6 P M		
Red de la Col. Las Pilas y Col. Victoria	Ninguno					5 A M. a 3 P M.	1,290	
A la red de la Col. Sinor, Santa Fe Central; a tanque de la Col. Victoria y SE y SW de la ciudad (Tanque trincheras).	Tanque Trincheras Tanque La Victoria	250,000 500,000	Concreto Concreto	Apoyado Apoyado	5.00 2.5	5 A M a 10 P M. 5 A M a 12 M	765 (Santa Fe y Sinor) El tanque trincheras colabora con la red de 3051 consumidores. 4,314 (tanque al Victoria)	El tanque La Victoria es llenado por la noche, mientras que el pozo abastece en horas de la mañana a las Col. Sinor y Santa Fe Central y llena el tanque de tincheras de 1 PM a 7 PM .
Red de la Col. Victoria	La Victoria #1 La Victoria #2	70,591 59,776	Concreto Concreto	Apoyado Apoyado	3.50 2.85	4 A M a 7 A M.	1,080	Los tanques Victoria #1 y Victoria #2 poseen un bypass .
Red de la Col. Victoria	La Victoria #1 La Victoria #2	70,591 59,776	Concreto Concreto	Apoyado Apoyado	3.5 2.85	y 3 P M a 6 P M		Son llenados a la vez por los dos pozos (victoria #1 y Victoria #2).
Red de la Col. Primavera	Ninguno					24 Hrs	1,872	
Col. La Mora y fábrica.	Tanque La Mora	70,000	Concreto	Apoyado	3.50	24 Hrs	1,848	
Col. Prado I	Tanque Prado I	7,000	Concreto	Elevado	10.00	5 A M a 9 A M 4 P M a 11 P M	966	
Col. Prado II y Col. Anexo El Prado	Tanque Prado II	7,000	Concreto	Elevado	10.00	5 A M a 9 A M 4 P M a 11 P M	2,334	
Residencial Europa	Tanque Europa	26,000	Metálico	Elevado	23.00	24 Hrs		
Residencial San Carlos	Tanque San Carlos	45,000	Metálico	Elevado	18.40	4 A M a 11 P M	5,310	
Residencial El Japón	Tanque El Japón	18,000	Metálico	Elevado	18.00	5 A M a 8 A M 4 P M a 7 P M	1,560	
Tanque de la Col. Las Colinas (1), Tanques La Unidad (2), Tanque del Colegio Pagán (1), Col. Vista Hermosa (1). Total 5 tanques.	Tanque Nuevo Santa Fe	500,000	Metálico	Apoyado	9.00	5 A M a 10 P M	16,506	Rebombea a Tanque de la Col. Las Colinas (1), Tanques La Unidad (2), Tanque del Colegio Pagán (1), Col. Vista Hermosa (1). Total 5 tanques.
Sector Norte de la ciudad.	Tanque Infop	150,000	Concreto	Apoyado	3.50	1 P M a 10 P M	2,544	
	Tanque 11 de Abril	250,000	Concreto	Apoyado	3.50	5 A M a 8 A M 10 A M a 1 P M	4,800	
Residencial América.	Tanque América		Metálico	Elevado	16.40	24 Hrs	4,902	
Barrio Los Almendros y La Care	Ninguno					5 A M. a 11 P M.	2,000	
Col. La Care y Col. 19 de Septiembre.	19 de Septiembre	18,000	Concreto	Apoyado	4.00	24 Hrs día de por medio	1,000	
Col. Inés Carranza Barrica	Ninguno					5 A M a 10 P M	3,762	

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Barrosse 01 2002 **Collected:** 1/3/02 10:45:00 **SPL Sample ID:** 02010098-05

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**	**Units: mg/L**		
Mercury	ND	0.0002	1		01/08/02 11:15	R_T	976528

Prep Method	Prep Date	Prep Initials
SW7470A	01/08/2002 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B	Units: mg/L		
Antimony	ND	0.005		1	01/08/02 19:36	JS	977246
Arsenic	ND	0.005		1	01/08/02 19:36	JS	977246
Lead	ND	0.005		1	01/08/02 19:36	JS	977246
Selenium	ND	0.005		1	01/08/02 19:36	JS	977246
Cadmium	ND	0.005		1	01/08/02 14:09	NS	977311
Chromium	ND	0.01		1	01/08/02 14:09	NS	977311
Nickel	ND	0.02		1	01/08/02 14:09	NS	977311
Silver	ND	0.01		1	01/08/02 14:09	NS	977311
Zinc	ND	0.02		1	01/08/02 14:09	NS	977311

Prep Method	Prep Date	Prep Initials
SW3005A	01/07/2002 12:15	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: BC-CH-1 **Collected:** 9/14/01 12:45:00 **SPL Sample ID:** 01090637-01

Site: Choloma, Honduras

Analyses/Method	Result		Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
CHLORINATED HERBICIDES BY METHOD 8151A			**MCL**	**SW8151A**		**Units: ug/L**		
2,4,5-T	ND		1	1		10/03/01 9:01	SG	849469
2,4,5-TP (Silvex)	ND		1	1		10/03/01 9:01	SG	849469
2,4-D	ND		1	1		10/03/01 9:01	SG	849469
2,4-DB	ND		1	1		10/03/01 9:01	SG	849469
Dalapon	ND		1	1		10/03/01 9:01	SG	849469
Dicamba	ND		1	1		10/03/01 9:01	SG	849469
Dichloroprop	ND		1	1		10/03/01 9:01	SG	849469
Dinoseb	ND		1	1		10/03/01 9:01	SG	849469
MCPA	ND		25	1		10/03/01 9:01	SG	849469
MCPP	ND		25	1		10/03/01 9:01	SG	849469
Surr: DCAA	87.5	%	19-162	1		10/03/01 9:01	SG	849469

Prep Method	Prep Date	Prep Initials
SW3510B	09/20/2001 16:53	J_L

MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND		0.0002	1		09/26/01 11:55	R_T	843229

Prep Method	Prep Date	Prep Initials
SW7470A	09/26/2001 9:35	R_T

METALS BY METHOD 6010B, DISSOLVED			**MCL**	**SW6010B**		**Units: mg/L**		
Antimony	ND		0.005	1		10/01/01 18:42	NS	848136
Arsenic	ND		0.005	1		10/01/01 18:42	NS	848136
Lead	ND		0.005	1		10/01/01 18:42	NS	848136
Selenium	ND		0.005	1		10/01/01 18:42	NS	848136
Cadmium	ND		0.005	1		09/23/01 20:23	EG	839820
Chromium	ND		0.01	1		09/23/01 20:23	EG	839820
Nickel	ND		0.02	1		09/23/01 20:23	EG	839820
Silver	ND		0.01	1		09/23/01 20:23	EG	839820
Zinc	0.0721		0.02	1		09/23/01 20:23	EG	839820

Prep Method	Prep Date	Prep Initials
SW3005	09/21/2001 7:30	MW

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: BC-CH-1 **Collected:** 9/14/01 12:45:00 **SPL Sample ID:** 01090637-01

Site: **Choloma, Honduras**

Analyses/Method	Result		Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
ORGANOCHLORINE PESTICIDES BY METHOD 8081A			**MCL**	**SW8081**		**Units: ug/L**		
4,4´-DDD	ND		0.1	1		09/29/01 4:48	SG	846007
4,4´-DDE	ND		0.1	1		09/29/01 4:48	SG	846007
4,4´-DDT	ND		0.1	1		09/29/01 4:48	SG	846007
Aldrin	ND		0.05	1		09/29/01 4:48	SG	846007
alpha-BHC	ND		0.05	1		09/29/01 4:48	SG	846007
alpha-Chlordane	ND		0.05	1		09/29/01 4:48	SG	846007
beta-BHC	ND		0.05	1		09/29/01 4:48	SG	846007
Chlordane	ND		0.5	1		09/29/01 4:48	SG	846007
delta-BHC	ND		0.05	1		09/29/01 4:48	SG	846007
Dieldrin	ND		0.1	1		09/29/01 4:48	SG	846007
Endosulfan I	ND		0.05	1		09/29/01 4:48	SG	846007
Endosulfan II	ND		0.1	1		09/29/01 4:48	SG	846007
Endosulfan sulfate	ND		0.1	1		09/29/01 4:48	SG	846007
Endrin	ND		0.1	1		09/29/01 4:48	SG	846007
Endrin aldehyde	ND		0.1	1		09/29/01 4:48	SG	846007
Endrin ketone	ND		0.1	1		09/29/01 4:48	SG	846007
gamma-BHC	ND		0.05	1		09/29/01 4:48	SG	846007
gamma-Chlordane	ND		0.05	1		09/29/01 4:48	SG	846007
Heptachlor	ND		0.05	1		09/29/01 4:48	SG	846007
Heptachlor epoxide	ND		0.05	1		09/29/01 4:48	SG	846007
Methoxychlor	ND		0.5	1		09/29/01 4:48	SG	846007
Toxaphene	ND		1	1		09/29/01 4:48	SG	846007
Surr: Decachlorobiphenyl	65.6	%	40-123	1		09/29/01 4:48	SG	846007
Surr: Tetrachloro-m-xylene	79.3	%	39-106	1		09/29/01 4:48	SG	846007

Prep Method	Prep Date	Prep Initials
SW3510B	09/20/2001 16:30	WV

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: BC-CH-1 **Collected:** 9/14/01 12:45:00 **SPL Sample ID:** 01090637-01

Site: Choloma, Honduras

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
VOLATILE ORGANICS BY METHOD 8260B		**MCL**	**SW8260B**		**Units: ug/L**		
1,1,1,2-Tetrachloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,1,1-Trichloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,1,2,2-Tetrachloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,1,2-Trichloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,1-Dichloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,1-Dichloroethene	ND	5	1		09/25/01 0:41	JC	840677
1,1-Dichloropropene	ND	5	1		09/25/01 0:41	JC	840677
1,2,3-Trichlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
1,2,3-Trichloropropane	ND	5	1		09/25/01 0:41	JC	840677
1,2,4-Trichlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
1,2,4-Trimethylbenzene	ND	5	1		09/25/01 0:41	JC	840677
1,2-Dibromo-3-chloropropane	ND	5	1		09/25/01 0:41	JC	840677
1,2-Dibromoethane	ND	5	1		09/25/01 0:41	JC	840677
1,2-Dichlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
1,2-Dichloroethane	ND	5	1		09/25/01 0:41	JC	840677
1,2-Dichloropropane	ND	5	1		09/25/01 0:41	JC	840677
1,3,5-Trimethylbenzene	ND	5	1		09/25/01 0:41	JC	840677
1,3-Dichlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
1,3-Dichloropropane	ND	5	1		09/25/01 0:41	JC	840677
1,4-Dichlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
2,2-Dichloropropane	ND	5	1		09/25/01 0:41	JC	840677
2-Butanone	ND	20	1		09/25/01 0:41	JC	840677
2-Chloroethyl vinyl ether	ND	10	1		09/25/01 0:41	JC	840677
2-Chlorotoluene	ND	5	1		09/25/01 0:41	JC	840677
2-Hexanone	ND	10	1		09/25/01 0:41	JC	840677
4-Chlorotoluene	ND	5	1		09/25/01 0:41	JC	840677
4-Isopropyltoluene	ND	5	1		09/25/01 0:41	JC	840677
4-Methyl-2-pentanone	ND	10	1		09/25/01 0:41	JC	840677
Acetone	ND	100	1		09/25/01 0:41	JC	840677
Acrylonitrile	ND	50	1		09/25/01 0:41	JC	840677
Benzene	ND	5	1		09/25/01 0:41	JC	840677
Bromobenzene	ND	5	1		09/25/01 0:41	JC	840677
Bromochloromethane	ND	5	1		09/25/01 0:41	JC	840677
Bromodichloromethane	ND	5	1		09/25/01 0:41	JC	840677
Bromoform	ND	5	1		09/25/01 0:41	JC	840677
Bromomethane	ND	10	1		09/25/01 0:41	JC	840677
Carbon disulfide	ND	5	1		09/25/01 0:41	JC	840677
Carbon tetrachloride	ND	5	1		09/25/01 0:41	JC	840677
Chlorobenzene	ND	5	1		09/25/01 0:41	JC	840677
Chloroethane	ND	10	1		09/25/01 0:41	JC	840677

Qualifiers:
ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: BC-CH-1 **Collected:** 9/14/01 12:45:00 **SPL Sample ID:** 01090637-01

Site: **Choloma, Honduras**

Analyses/Method	Result		Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
Chloroform	ND		5	1		09/25/01 0:41	JC	840677
Chloromethane	ND		10	1		09/25/01 0:41	JC	840677
cis-1,3-Dichloropropene	ND		5	1		09/25/01 0:41	JC	840677
Dibromochloromethane	ND		5	1		09/25/01 0:41	JC	840677
Dibromomethane	ND		5	1		09/25/01 0:41	JC	840677
Dichlorodifluoromethane	ND		10	1		09/25/01 0:41	JC	840677
Ethylbenzene	ND		5	1		09/25/01 0:41	JC	840677
Hexachlorobutadiene	ND		5	1		09/25/01 0:41	JC	840677
Isopropylbenzene	ND		5	1		09/25/01 0:41	JC	840677
Methyl tert-butyl ether	ND		5	1		09/25/01 0:41	JC	840677
Methylene chloride	ND		5	1		09/25/01 0:41	JC	840677
n-Butylbenzene	ND		5	1		09/25/01 0:41	JC	840677
n-Propylbenzene	ND		5	1		09/25/01 0:41	JC	840677
Naphthalene	ND		5	1		09/25/01 0:41	JC	840677
sec-Butylbenzene	ND		5	1		09/25/01 0:41	JC	840677
Styrene	ND		5	1		09/25/01 0:41	JC	840677
tert-Butylbenzene	ND		5	1		09/25/01 0:41	JC	840677
Tetrachloroethene	ND		5	1		09/25/01 0:41	JC	840677
Toluene	ND		5	1		09/25/01 0:41	JC	840677
trans-1,3-Dichloropropene	ND		5	1		09/25/01 0:41	JC	840677
Trichloroethene	ND		5	1		09/25/01 0:41	JC	840677
Trichlorofluoromethane	ND		5	1		09/25/01 0:41	JC	840677
Vinyl acetate	ND		10	1		09/25/01 0:41	JC	840677
Vinyl chloride	ND		10	1		09/25/01 0:41	JC	840677
cis-1,2-Dichloroethene	ND		5	1		09/25/01 0:41	JC	840677
m,p-Xylene	ND		5	1		09/25/01 0:41	JC	840677
o-Xylene	ND		5	1		09/25/01 0:41	JC	840677
trans-1,2-Dichloroethene	ND		5	1		09/25/01 0:41	JC	840677
1,2-Dichloroethene (total)	ND		5	1		09/25/01 0:41	JC	840677
Xylenes,Total	ND		5	1		09/25/01 0:41	JC	840677
Surr: 1,2-Dichloroethane-d4	100	%	62-130	1		09/25/01 0:41	JC	840677
Surr: 4-Bromofluorobenzene	104	%	70-130	1		09/25/01 0:41	JC	840677
Surr: Toluene-d8	100	%	74-122	1		09/25/01 0:41	JC	840677

Qualifiers:

ND/U - Not Detected at the Reporting Limit
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J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

JORDANLAB
Laboratorio de Analisis Industrial
Agua Potable,Residual & Industrial Ambientes de Trabajo,Alimentos

6 Ave. 5-6 Calle S.O. San Pedro Sula, Cortés
R. T. N. X4RRMA-U TELFAX: 557-5802, Email: jordanlab@hn2.com

BROWN AND CALDWELL

Solicitado por:Ing. Barbara Goodrich
Muestra # 1035, Agua de Pozo BC-Ch-1, Choloma.
Fecha de Ingreso: 14/09/01

		Norma Nacional			
Parámetros	Unidades	Recomendado	Max. Admisible	Metodo &	Resultados
Acidez Total	mg/l			2310-B	8
Conductividad	us/cm	400		25100-B	357
Alcalinidad Total	mg/l CaCO3			2320-B	118.9
Dureza Total	mg/l CaCO3	400		2340-C	100
Bicarbonato (HCO3)	mg/l				118.9
Calcio	mg/l CaCO3	100		3500-Ca D	15.2
Magnesio	mg/l CaCO3	30	50	3500-Mg E	14.88
Hierro Total	mg/l		0.3	3500-Fe-D	0.32
Manganeso Total	mg/l	0.01	0.5	3500-Mn C	1.05
Cloruros	mg/l	25	250	4500-Cl-B	22
Sulfatos	mg/l	25	250	4500-SO4	22.8
Nitritos	mg/l		1	4500-NO2-B	0.06
Nitratos	mg/l	25	50	4500-NO3-B	1.80
Sodio (Na)*	mg/1	25	200	AA	50.00
Potasio (K)*	mg/l		10	AA	4.80
ANALISIS MICROBIOLOGICOS					
Coliformes Totales			0 UFC/100 ml	9222-B	47
Coliformes Fecales			0 UFC/100 ml	9222-D	10

Norma Nacional: Decreto No.084 del 31de Julio de 1995

& Basados en Standard Methods for the Examination of Water and Wastewater 20 Edition.

*Subcontratado

San Pedro Sula, 25 de Septiembre del 2,001

JORDANLAB LABORATORIO DE ANALISIS INDUSTRIAL

LIC. LILIA J. DE RIVERA
JORDANLAB

JORDANLAB
Laboratorio de Analisis Industrial
Agua Potable,Residual e Industrial Ambientes de Trabajo,Alimentos

6 Ave. 5-6 Calle S.O. San Pedro Sula, Cortés.
R.T.N. X4RRMA-U Tel/Fax: 557-5802, Tel: 557-2753, Email: jordanlab@hn2.com

BROWN AND CALDWELL

Solicitado por: Ing. Barbara Goodrish

A continuación detallo a Ud. el resultado de Análisis Microbiólogicos en Agua de perforación.-

Fecha de Ingreso: 20/09/01

Parametros	Valor Norma	Metodo	Resultados
Coliformes Totales	UFC/100 ml	9222-B	160,000
Coliformes Fecales	UFC/100 ml	9222-D	7,000

Standard Methods Examination of Water and Wastewater 20 Th Edition.

Descripción de Muestras	# de Ingreso
[redacted]	1054

JORDANLAB LABORATORIO ANALISIS INDUSTRIAL

LIC. LILIA J. DE RIVERA
JORDANLAB

San Pedro Sula, 21 de Septiembre del 2,001

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID BC-CH-2 **Collected:** 12/22/01 1:20:00 **SPL Sample ID:** 01121066-01

Site: **Colonia Ruby,Cholama,Honduras**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		01/02/02 12:39	R_T	971167

Run ID/Seq #: HGLB_020102C-971167

Prep Method	Prep Date	Prep Initials
	01/02/2002 9:20	

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		01/03/02 18:30	NS	972748
Arsenic	ND	0.005		1		01/03/02 18:30	NS	972748
Lead	ND	0.005		1		01/03/02 18:30	NS	972748
Selenium	ND	0.005		1		01/03/02 18:30	NS	972748
Cadmium	ND	0.005		1		01/03/02 5:54	EG	972304
Chromium	ND	0.01		1		01/03/02 5:54	EG	972304
Nickel	ND	0.02		1		01/03/02 5:54	EG	972304
Silver	ND	0.01		1		01/03/02 5:54	EG	972304
Zinc	ND	0.02		1		01/03/02 5:54	EG	972304

Run ID/Seq #: TJA_020102F-972304

Prep Method	Prep Date	Prep Initials
SW3005A	12/31/2001 14:00	MME

Run ID/Seq #: TJAT_020103C-972748

Prep Method	Prep Date	Prep Initials
SW3005A	12/31/2001 14:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

ACCULABS INC. GOLDEN, CO
RADIOCHEMISTRY DATA PACKAGE
SAMPLE RESULTS SUMMARY
FORM 1

Client: SPL, Inc.
Proj. Name: 01121066
Proj. Number:

Acculabs Work Order: G02010061
Received Date: 01/03/2002

Field Sample ID	Acculabs ID	Test	Matrix	Analyte	Result +/- 2 s CSU	MDC	Report Units	Report Basis	Qual Flag	Date Analyzed	Batch Id
01121066-1B	G02010061-01A	Gross Alpha/Beta	Aqueous	Alpha	2.4 +/- 1.9	3.4	pCi/L	total	U	01/17/2002	GP00229
01121066-1B	G02010061-01A	Gross Alpha/Beta	Aqueous	Beta	2.8 +/- 1.3	2.2	pCi/L	total		01/17/2002	GP00229

Comments:

Footnotes and Abbreviations:

MDC - Minimum Detectable Concentration (ANSI N42.23)
CSU - Combined Standard Uncertainty (TPU)

Lab Qualifiers:

U = Result < MDC or CSU
J = Estimated result - see narrative for discussion
B = analyte detected in Blank > MDC
JI = Estimated result, bias high due to interference
M = Requested MDC not met - see narrative for discussion

Y = Yield outside default limits
H = High
L = Low
* = DER outside 2 sigma limits

Queried: 01/22/2002 03:55:16 PM
Printed: 01/22/2002 03:55:16 PM

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID: BC-CH-3 **Collected:** 11/6/01 12:30:00 **SPL Sample ID:** 01110479-01

Site: **Choluteca, Honduras**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		11/20/01 14:10	R_T	926169

Prep Method	Prep Date	Prep Initials
SW7470A	11/20/2001 9:30	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		11/27/01 4:56	NS	927013
Arsenic	ND	0.005		1		11/27/01 4:56	NS	927013
Lead	ND	0.005		1		11/27/01 4:56	NS	927013
Selenium	ND	0.005		1		11/27/01 4:56	NS	927013
Cadmium	ND	0.005		1		11/25/01 14:03	EG	925309
Chromium	ND	0.01		1		11/25/01 14:03	EG	925309
Nickel	ND	0.02		1		11/25/01 14:03	EG	925309
Silver	ND	0.01		1		11/25/01 14:03	EG	925309
Zinc	0.059	0.02		1		11/25/01 14:03	EG	925309

Prep Method	Prep Date	Prep Initials
SW3005	11/16/2001 14:30	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

JORDANLAB
Laboratorio de Analisis Industrial
Agua Potable,Residual é Industrial Ambientes de Trabajo,Alimentos
6 Ave. 5-6 Calle S.O. San Pedro Sula, Cortés
R. T. N. X4RRMA-U TELFAX: 557-5802, Email: jordanlab@hn2.com

BROWN AND CALDWELL

Solicitado por:Ing. Barbara Goodrish
Muestra # 1200, BC-CH-3, Choloma, Cortes
Fecha de Ingreso: 6/11/01

	Norma Nacional				
Parametros	Unidades	Recomendado	Máx. Admisi	Método &	Resultados
Acidez Total	mg/l			2310-B	25
Conductividad	us/cm	400		25100-B	264
Alcalinidad Total	mg/l CaCO3			2320-B	118
Dureza Total	mg/l CaCO3	400		2340-C	108
Bicarbonato (HCO3)	mg/l			2320-B	118
Calcio	mg/l CaCO3	100		3500-Ca D	24
Magnesio	mg/l CaCO3	30	50	3500-Mg E	12
Hierro Total	mg/l		0.3	3500-Fe-D	<0.03
Manganeso Total	mg/l	0.01	0.5	3500-Mn C	<0.03
Cloruros	mg/l	25	250	4500-Cl-B	7.5
Sulfatos	mg/l	25	250	4500-SO4	3.4
Nitritos	mg/l		1	4500-NO2-B	<0.01
Nitratos	mg/l	25	50	4500-NO3-B	4.30
Sodio (Na)*	mg/1	25	200	AA	13.6
Potasio (K)*	mg/l		10	AA	3.10
ANALISIS MICROBIOLOGICOS					
Coliformes Totales		UFC/100ml	0	9222-B	15
Coliformes Fecales		UFC/100ml	0	9222-D	0

Norma Nacional: Decreto No.084 del 31de Julio de 1995

& Basados en Standard Methods for the Examination of Water and Wastewater 20 Edition.

*Subcontratado

San Pedro Sula, 12 de Noviembre del 2,001

JORDANLAB LABORATORIO DE ANALISIS INDUSTRIAL

LIC. LILIA J. DE RIVERA
JORDANLAB

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Bomberos I 112001 **Collected:** 11/26/01 11:35:0 **SPL Sample ID:** 01111128-04

Site: Choloma

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**	**Units: mg/L**		
Mercury	ND	0.0002		1	12/05/01 11:10	R_T	937627

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B	Units: mg/L		
Antimony	ND	0.005		1	12/11/01 20:00	NS	945434
Arsenic	ND	0.005		1	12/11/01 20:00	NS	945434
Lead	ND	0.005		1	12/11/01 20:00	NS	945434
Selenium	ND	0.005		1	12/11/01 20:00	NS	945434
Cadmium	ND	0.005		1	12/11/01 15:26	EG	944542
Chromium	ND	0.01		1	12/11/01 15:26	EG	944542
Nickel	ND	0.02		1	12/11/01 15:26	EG	944542
Silver	ND	0.01		1	12/11/01 15:26	EG	944542
Zinc	ND	0.02		1	12/11/01 15:26	EG	944542

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
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JORDANLAB
Laboratorio de Analisis Industrial
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6 Ave. 5-6 Calle S.O.plaaza Victoria, Local # 4, Bo. El Benque, San Pedro Sula, Cortés
R. T. N. X4RRMA-U TELFAX: 557-5802, 227-2753 Email: jordanlab@hn2.com

BROWN AND CALDWELL

Solicitado por: Ing. Barbara Goodrich
Fecha de Ingreso: 26/11/01
Lugar Toma de Muestras:Choloma, Cortés

				Fecha	26/11/2001	26/11/2001	26/11/2001	26/11/2001	26/11/2001	26/11/2001
				Hora	10:35 a.m.	11:35 a.m.	12:18 p.m.	12:54 p.m.	01:55 p.m.	01:15 p.m.
	Norma Nacional			Muestra	Ines Carranza	Bomberos I	Primavera	San Francisco	Europa	[illegible]
Parámetros	Unidades	Recomen.	Max. Adm.	Metodo'&	1262	1263	1264	1265	1266	1267
Acidez Total	mg/l			2310-B	50	31	15	82	23	21
Conductividad	us/cm	400		25100-B	1027	269	239	442	465	465
Alcalinidad Total	mg/l CaCO3			2320-B	374	112	93	184	191	199
Dureza Total	mg/l CaCO3	400		2340-C	184	100	88	168	180	180
Bicarbonato (HCO3)	mg/l			2320-B	374	112	114	184	191	199
Calcio (Ca)	mg/l CaCO3	100		3500-Ca-D	30	24	26	38	43	43
Magnesio (Mg)	mg/l CaCO3	30	50	3500-Mg E	26	10	12	17	17	17
Hierro Total	mg/l		0.3	3500-Fe D	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Hierro Filtrado	mg/l			3500-Fe D	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Manganeso Total	mg/l	0.01	0.5	3500-Mn C	<0.03	<0.03	0.05	<0.03	<0.03	<0.03
Manganeso Filtrado	mg/l			3500-Mn C	<0.03	<0.03	0.05	<0.03	<0.03	<0.03
Cloruros (Cl)	mg/l	25	250	4500-Cl-B	94	8	8	17	22	22
Sulfatos (SO4)	mg/l	25	250	4500-SO4	20	24	23	17	23	25
Nitritos (NO2)	mg/l		1	4500-NO2-B	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitratos (NO3)	mg/l	25	50	4500-NO3-B	4.50	4.20	5.35	9.40	3.62	3.16
Sodio (Na)*	mg/l	25	200	AA	145.00	14.40	11.85	22.30	21.00	21.30
Potasio (K)*	mg/l		10	AA	7.95	3.45	3.40	5.70	4.00	3.95
ANALISIS MICROBIOLOGICOS										
Coliformes Totales		UFC/100ml	0	9222-B	35	1	2	3	0	0
Coliformes Fecales		UFC/100ml	0	9222-D	9	0	0	0	0	0

JORDANLAB LABORATORIO DE ANALISIS INDUSTRIAL

LIC. LIDIA J. DE RIVERA
JORDANLAB

San Pedro Sula, 7 de Diciembre del 2,001

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Canada 112001 **Collected:** 11/27/01 9:40:00 **SPL Sample ID:** 01111128-03

Site: **Choloma**

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**	**Units: mg/L**		
Mercury	ND	0.0002	1		12/05/01 11:10	R_T	937626

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B	Units: mg/L		
Antimony	ND	0.005		1	12/11/01 19:54	NS	945431
Arsenic	ND	0.005		1	12/11/01 19:54	NS	945431
Lead	ND	0.005		1	12/11/01 19:54	NS	945431
Selenium	ND	0.005		1	12/11/01 19:54	NS	945431
Cadmium	ND	0.005		1	12/11/01 15:20	EG	944541
Chromium	ND	0.01		1	12/11/01 15:20	EG	944541
Nickel	ND	0.02		1	12/11/01 15:20	EG	944541
Silver	ND	0.01		1	12/11/01 15:20	EG	944541
Zinc	ND	0.02		1	12/11/01 15:20	EG	944541

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

JORDANLAB
Laboratorio de Analisis Industrial
Agua Potable,Residual e Industrial Ambientes de Trabajo,Alimentos
6 Ave. 5-6 Calle S.O. Plaza Victoria, Local # 4, Bo. El Benque, San Pedro Sula, Cortés
R. T. N. X4RRMA-U TELFAX: 557-5802, 227-2753 Email: jordanlab@hn2.com

BROWN AND CALDWELL

Solicitado por: Ing. Barbara Goodrich
Fecha de Ingreso: 27/11/01, Hora: 1:50 pm
Lugar Toma de Muestras:Choloma, Cortés.

				Fecha	27/11/2001	27/11/2001	27/11/2001	27/11/2001
				Hora	9:40 a.m.	10:55 a.m.	11:30 a.m.	1:10 p.m.
	Norma Nacional			Muestra	Canada	Prado	San Antonio	Victoria Gas
Parametros	Unidades	Recomen.	Max. Adm.	Metodo &	1281	1282	1283	1284
Acidez Total	mg/l			2310-B	27	53	23	37
Conductividad	us/cm	400		25100-B	361	454	190	450
Alcalinidad Total	mg/l CaCO3			2320-B	140	167	80	172
Dureza Total	mg/l CaCO3	400		2340-C	128	172	68	24
Bicarbonato (HCO3)	mg/l			2320-B	140	167	80	172
Calcio (Ca)	mg/l CaCO3	100		3500-Ca-D	32	39	14	4
Magnesio (Mg)	mg/l CaCO3	30	50	3500-Mg E	12	18	8	3
Hierro Total	mg/l		0.3	3500-Fe D	<0.03	<0.03	<0.03	<0.03
Hierro Filtrado	mg/l			3500-Fe D	<0.03	<0.03	<0.03	<0.03
Manganeso Total	mg/l	0.01	0.5	3500-Mn C	<0.03	<0.03	<0.03	<0.03
Manganeso Filtrado	mg/l			3500-Mn C	<0.03	<0.03	<0.03	<0.03
Cloruro (Cl⁻)	mg/l	25	250	4500-Cl-B	18	18	6	39
Sulfatos (SO4)	mg/l	25	250	4500-SO4	25	35	14	12
Nitritos (NO2)	mg/l		1	4500-NO2-B	<0.01	<0.01	<0.01	<0.01
Nitratos (NO3)	mg/l	25	50	4500-NO3-B	8.40	4.18	1.94	1.12
Sodio (Na)*	mg/l	25	200	AA	19.38	19.50	11.30	88.45
Potasio (K)*	mg/l		10	AA	2.9	3.18	3.00	5.28
ANALISIS MICROBIOLOGICOS								
Coliformes Totales		UFC/100ml	0	9222-B	0	0	11	0
Coliformes Fecales		UFC/100ml	0	9222-D	0	0	0	0

San Pedro Sula, 7 de Diciembre del 2,001

JORDANLAB LABORATORIO DE ANALISIS INDUSTRIAL

LIC. LILIA J. DE RIVERA
JORDANLAB

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Europa 112001 **Collected:** 11/26/01 1:55:00 **SPL Sample ID:** 01111128-05

Site: **Choloma**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937628

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		12/11/01 20:06	NS	945437
Arsenic	ND	0.005		1		12/11/01 20:06	NS	945437
Lead	ND	0.005		1		12/11/01 20:06	NS	945437
Selenium	ND	0.005		1		12/11/01 20:06	NS	945437
Cadmium	ND	0.005		1		12/11/01 15:32	EG	944543
Chromium	ND	0.01		1		12/11/01 15:32	EG	944543
Nickel	ND	0.02		1		12/11/01 15:32	EG	944543
Silver	ND	0.01		1		12/11/01 15:32	EG	944543
Zinc	ND	0.02		1		12/11/01 15:32	EG	944543

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Ines Carranza 112001 **Collected:** 11/26/01 10:35:0 **SPL Sample ID:** 01111128-08

Site: Choloma

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937635

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		12/11/01 20:40	NS	945448
Arsenic	ND	0.005		1		12/11/01 20:40	NS	945448
Lead	ND	0.005		1		12/11/01 20:40	NS	945448
Selenium	ND	0.005		1		12/11/01 20:40	NS	945448
Cadmium	ND	0.005		1		12/11/01 16:04	EG	944548
Chromium	ND	0.01		1		12/11/01 16:04	EG	944548
Nickel	ND	0.02		1		12/11/01 16:04	EG	944548
Silver	ND	0.01		1		12/11/01 16:04	EG	944548
Zinc	ND	0.02		1		12/11/01 16:04	EG	944548

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Parque Central 01 2002 **Collected:** 1/3/02 11:45:00 **SPL Sample ID:** 02010098-04

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		01/08/02 11:15	R_T	976527

Prep Method	Prep Date	Prep Initials
SW7470A	01/08/2002 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		01/08/02 19:30	JS	977243
Arsenic	ND	0.005		1		01/08/02 19:30	JS	977243
Lead	ND	0.005		1		01/08/02 19:30	JS	977243
Selenium	ND	0.005		1		01/08/02 19:30	JS	977243
Cadmium	ND	0.005		1		01/08/02 14:04	NS	977310
Chromium	ND	0.01		1		01/08/02 14:04	NS	977310
Nickel	ND	0.02		1		01/08/02 14:04	NS	977310
Silver	ND	0.01		1		01/08/02 14:04	NS	977310
Zinc	ND	0.02		1		01/08/02 14:04	NS	977310

Prep Method	Prep Date	Prep Initials
SW3005A	01/07/2002 12:15	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
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Client Sample ID Primavera 112001 **Collected:** 11/26/01 12:18:0 **SPL Sample ID:** 01111128-07

Site: Choloma

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937634

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		12/11/01 20:34	NS	945446
Arsenic	ND	0.005		1		12/11/01 20:34	NS	945446
Lead	ND	0.005		1		12/11/01 20:34	NS	945446
Selenium	ND	0.005		1		12/11/01 20:34	NS	945446
Cadmium	ND	0.005		1		12/11/01 15:56	EG	944547
Chromium	ND	0.01		1		12/11/01 15:56	EG	944547
Nickel	ND	0.02		1		12/11/01 15:56	EG	944547
Silver	ND	0.01		1		12/11/01 15:56	EG	944547
Zinc	ND	0.02		1		12/11/01 15:56	EG	944547

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:
ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Prodo I 112001 **Collected:** 11/27/01 10:55:0 **SPL Sample ID:** 01111128-10

Site: **Choloma**

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**	**Units: mg/L**		
Mercury	ND	0.0002	1		12/05/01 11:10	R_T	937637

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B	Units: mg/L		
Antimony	ND	0.005		1	12/11/01 20:53	NS	945452
Arsenic	ND	0.005		1	12/11/01 20:53	NS	945452
Lead	ND	0.005		1	12/11/01 20:53	NS	945452
Selenium	ND	0.005		1	12/11/01 20:53	NS	945452
Cadmium	ND	0.005		1	12/11/01 16:17	EG	944550
Chromium	ND	0.01		1	12/11/01 16:17	EG	944550
Nickel	ND	0.02		1	12/11/01 16:17	EG	944550
Silver	ND	0.01		1	12/11/01 16:17	EG	944550
Zinc	ND	0.02		1	12/11/01 16:17	EG	944550

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Residential America 01 2002 **Collected:** 1/3/02 10:15:00 **SPL Sample ID:** 02010098-03

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		01/08/02 11:15	R_T	976526

Prep Method	Prep Date	Prep Initials
SW7470A	01/08/2002 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		01/08/02 19:24	JS	977239
Arsenic	ND	0.005		1		01/08/02 19:24	JS	977239
Lead	ND	0.005		1		01/08/02 19:24	JS	977239
Selenium	0.00505	0.005		1		01/08/02 19:24	JS	977239
Cadmium	ND	0.005		1		01/08/02 14:00	NS	977309
Chromium	ND	0.01		1		01/08/02 14:00	NS	977309
Nickel	ND	0.02		1		01/08/02 14:00	NS	977309
Silver	ND	0.01		1		01/08/02 14:00	NS	977309
Zinc	ND	0.02		1		01/08/02 14:00	NS	977309

Prep Method	Prep Date	Prep Initials
SW3005A	01/07/2002 12:15	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Residential America 01 2002 **Collected:** 1/3/02 10:15:00 **SPL Sample ID:** 02010098-03

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
VOLATILE ORGANICS BY METHOD 8260B		**MCL**	**SW8260B**		**Units: ug/L**		
1,1,1,2-Tetrachloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,1,1-Trichloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,1,2,2-Tetrachloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,1,2-Trichloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,1-Dichloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,1-Dichloroethene	ND	5	1		01/07/02 18:31	JN	976684
1,1-Dichloropropene	ND	5	1		01/07/02 18:31	JN	976684
1,2,3-Trichlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
1,2,3-Trichloropropane	ND	5	1		01/07/02 18:31	JN	976684
1,2,4-Trichlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
1,2,4-Trimethylbenzene	ND	5	1		01/07/02 18:31	JN	976684
1,2-Dibromo-3-chloropropane	ND	5	1		01/07/02 18:31	JN	976684
1,2-Dibromoethane	ND	5	1		01/07/02 18:31	JN	976684
1,2-Dichlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
1,2-Dichloroethane	ND	5	1		01/07/02 18:31	JN	976684
1,2-Dichloropropane	ND	5	1		01/07/02 18:31	JN	976684
1,3,5-Trimethylbenzene	ND	5	1		01/07/02 18:31	JN	976684
1,3-Dichlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
1,3-Dichloropropane	ND	5	1		01/07/02 18:31	JN	976684
1,4-Dichlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
2,2-Dichloropropane	ND	5	1		01/07/02 18:31	JN	976684
2-Butanone	ND	20	1		01/07/02 18:31	JN	976684
2-Chloroethyl vinyl ether	ND	10	1		01/07/02 18:31	JN	976684
2-Chlorotoluene	ND	5	1		01/07/02 18:31	JN	976684
2-Hexanone	ND	10	1		01/07/02 18:31	JN	976684
4-Chlorotoluene	ND	5	1		01/07/02 18:31	JN	976684
4-Isopropyltoluene	ND	5	1		01/07/02 18:31	JN	976684
4-Methyl-2-pentanone	ND	10	1		01/07/02 18:31	JN	976684
Acetone	ND	100	1		01/07/02 18:31	JN	976684
Acrylonitrile	ND	50	1		01/07/02 18:31	JN	976684
Benzene	ND	5	1		01/07/02 18:31	JN	976684
Bromobenzene	ND	5	1		01/07/02 18:31	JN	976684
Bromochloromethane	ND	5	1		01/07/02 18:31	JN	976684
Bromodichloromethane	ND	5	1		01/07/02 18:31	JN	976684
Bromoform	ND	5	1		01/07/02 18:31	JN	976684
Bromomethane	ND	10	1		01/07/02 18:31	JN	976684
Carbon disulfide	ND	5	1		01/07/02 18:31	JN	976684
Carbon tetrachloride	ND	5	1		01/07/02 18:31	JN	976684
Chlorobenzene	ND	5	1		01/07/02 18:31	JN	976684
Chloroethane	ND	10	1		01/07/02 18:31	JN	976684

Qualifiers:
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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Residential America 01 2002 **Collected:** 1/3/02 10:15:00 **SPL Sample ID:** 02010098-03

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result		Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
Chloroform	ND		5	1		01/07/02 18:31	JN	976684
Chloromethane	ND		10	1		01/07/02 18:31	JN	976684
cis-1,3-Dichloropropene	ND		5	1		01/07/02 18:31	JN	976684
Dibromochloromethane	ND		5	1		01/07/02 18:31	JN	976684
Dibromomethane	ND		5	1		01/07/02 18:31	JN	976684
Dichlorodifluoromethane	ND		10	1		01/07/02 18:31	JN	976684
Ethylbenzene	ND		5	1		01/07/02 18:31	JN	976684
Hexachlorobutadiene	ND		5	1		01/07/02 18:31	JN	976684
Isopropylbenzene	ND		5	1		01/07/02 18:31	JN	976684
Methyl tert-butyl ether	ND		5	1		01/07/02 18:31	JN	976684
Methylene chloride	ND		5	1		01/07/02 18:31	JN	976684
n-Butylbenzene	ND		5	1		01/07/02 18:31	JN	976684
n-Propylbenzene	ND		5	1		01/07/02 18:31	JN	976684
Naphthalene	ND		5	1		01/07/02 18:31	JN	976684
sec-Butylbenzene	ND		5	1		01/07/02 18:31	JN	976684
Styrene	ND		5	1		01/07/02 18:31	JN	976684
tert-Butylbenzene	ND		5	1		01/07/02 18:31	JN	976684
Tetrachloroethene	ND		5	1		01/07/02 18:31	JN	976684
Toluene	ND		5	1		01/07/02 18:31	JN	976684
trans-1,3-Dichloropropene	ND		5	1		01/07/02 18:31	JN	976684
Trichloroethene	ND		5	1		01/07/02 18:31	JN	976684
Trichlorofluoromethane	ND		5	1		01/07/02 18:31	JN	976684
Vinyl acetate	ND		10	1		01/07/02 18:31	JN	976684
Vinyl chloride	ND		10	1		01/07/02 18:31	JN	976684
cis-1,2-Dichloroethene	ND		5	1		01/07/02 18:31	JN	976684
m,p-Xylene	ND		5	1		01/07/02 18:31	JN	976684
o-Xylene	ND		5	1		01/07/02 18:31	JN	976684
trans-1,2-Dichloroethene	ND		5	1		01/07/02 18:31	JN	976684
1,2-Dichloroethene (total)	ND		5	1		01/07/02 18:31	JN	976684
Xylenes,Total	ND		5	1		01/07/02 18:31	JN	976684
Surr: 1,2-Dichloroethane-d4	112	%	62-130	1		01/07/02 18:31	JN	976684
Surr: 4-Bromofluorobenzene	80.0	%	70-130	1		01/07/02 18:31	JN	976684
Surr: Toluene-d8	92.0	%	74-122	1		01/07/02 18:31	JN	976684

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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID San Antonio 112001 **Collected:** 11/27/01 11:30:0 **SPL Sample ID:** 01111128-06

Site: Choloma

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**	**Units: mg/L**		
Mercury	ND	0.0002	1		12/05/01 11:10	R_T	937633

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B	Units: mg/L		
Antimony	ND	0.005		1	12/11/01 20:28	NS	945444
Arsenic	ND	0.005		1	12/11/01 20:28	NS	945444
Lead	ND	0.005		1	12/11/01 20:28	NS	945444
Selenium	ND	0.005		1	12/11/01 20:28	NS	945444
Cadmium	ND	0.005		1	12/11/01 15:49	EG	944546
Chromium	ND	0.01		1	12/11/01 15:49	EG	944546
Nickel	ND	0.02		1	12/11/01 15:49	EG	944546
Silver	ND	0.01		1	12/11/01 15:49	EG	944546
Zinc	ND	0.02		1	12/11/01 15:49	EG	944546

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID San Carlos 01 2002 **Collected:** 1/3/02 9:45:00 A **SPL Sample ID:** 02010098-01

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit	.	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		01/08/02 11:15	R_T	976521

Prep Method	Prep Date	Prep Initials
SW7470A	01/08/2002 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	0.00812	0.005		1		01/08/02 18:46	JS	977224
Arsenic	ND	0.005		1		01/08/02 18:46	JS	977224
Lead	ND	0.005		1		01/08/02 18:46	JS	977224
Selenium	ND	0.005		1		01/08/02 18:46	JS	977224
Cadmium	ND	0.005		1		01/08/02 13:39	NS	977305
Chromium	ND	0.01		1		01/08/02 13:39	NS	977305
Nickel	ND	0.02		1		01/08/02 13:39	NS	977305
Silver	ND	0.01		1		01/08/02 13:39	NS	977305
Zinc	0.0317	0.02		1		01/08/02 13:39	NS	977305

Prep Method	Prep Date	Prep Initials
SW3005A	01/07/2002 12:15	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
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J - Estimated Value between MDL and PQL
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MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID San Carlos 01 2002 **Collected:** 1/3/02 9:45:00 A **SPL Sample ID:** 02010098-01

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result	Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
VOLATILE ORGANICS BY METHOD 8260B		**MCL**	**SW8260B**		**Units: ug/L**		
1,1,1,2-Tetrachloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,1,1-Trichloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,1,2,2-Tetrachloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,1,2-Trichloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,1-Dichloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,1-Dichloroethene	ND	5	1		01/07/02 18:03	JN	976683
1,1-Dichloropropene	ND	5	1		01/07/02 18:03	JN	976683
1,2,3-Trichlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
1,2,3-Trichloropropane	ND	5	1		01/07/02 18:03	JN	976683
1,2,4-Trichlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
1,2,4-Trimethylbenzene	ND	5	1		01/07/02 18:03	JN	976683
1,2-Dibromo-3-chloropropane	ND	5	1		01/07/02 18:03	JN	976683
1,2-Dibromoethane	ND	5	1		01/07/02 18:03	JN	976683
1,2-Dichlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
1,2-Dichloroethane	ND	5	1		01/07/02 18:03	JN	976683
1,2-Dichloropropane	ND	5	1		01/07/02 18:03	JN	976683
1,3,5-Trimethylbenzene	ND	5	1		01/07/02 18:03	JN	976683
1,3-Dichlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
1,3-Dichloropropane	ND	5	1		01/07/02 18:03	JN	976683
1,4-Dichlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
2,2-Dichloropropane	ND	5	1		01/07/02 18:03	JN	976683
2-Butanone	ND	20	1		01/07/02 18:03	JN	976683
2-Chloroethyl vinyl ether	ND	10	1		01/07/02 18:03	JN	976683
2-Chlorotoluene	ND	5	1		01/07/02 18:03	JN	976683
2-Hexanone	ND	10	1		01/07/02 18:03	JN	976683
4-Chlorotoluene	ND	5	1		01/07/02 18:03	JN	976683
4-Isopropyltoluene	ND	5	1		01/07/02 18:03	JN	976683
4-Methyl-2-pentanone	ND	10	1		01/07/02 18:03	JN	976683
Acetone	ND	100	1		01/07/02 18:03	JN	976683
Acrylonitrile	ND	50	1		01/07/02 18:03	JN	976683
Benzene	ND	5	1		01/07/02 18:03	JN	976683
Bromobenzene	ND	5	1		01/07/02 18:03	JN	976683
Bromochloromethane	ND	5	1		01/07/02 18:03	JN	976683
Bromodichloromethane	ND	5	1		01/07/02 18:03	JN	976683
Bromoform	ND	5	1		01/07/02 18:03	JN	976683
Bromomethane	ND	10	1		01/07/02 18:03	JN	976683
Carbon disulfide	ND	5	1		01/07/02 18:03	JN	976683
Carbon tetrachloride	ND	5	1		01/07/02 18:03	JN	976683
Chlorobenzene	ND	5	1		01/07/02 18:03	JN	976683
Chloroethane	ND	10	1		01/07/02 18:03	JN	976683

Qualifiers:
ND/U - Not Detected at the Reporting Limit
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D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID San Carlos 01 2002 **Collected:** 1/3/02 9:45:00 A **SPL Sample ID:** 02010098-01

Site: **Choloma, Cortes, Honduras**

Analyses/Method	Result		Rep.Limit	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
Chloroform	ND		5	1		01/07/02 18:03	JN	976683
Chloromethane	ND		10	1		01/07/02 18:03	JN	976683
cis-1,3-Dichloropropene	ND		5	1		01/07/02 18:03	JN	976683
Dibromochloromethane	ND		5	1		01/07/02 18:03	JN	976683
Dibromomethane	ND		5	1		01/07/02 18:03	JN	976683
Dichlorodifluoromethane	ND		10	1		01/07/02 18:03	JN	976683
Ethylbenzene	ND		5	1		01/07/02 18:03	JN	976683
Hexachlorobutadiene	ND		5	1		01/07/02 18:03	JN	976683
Isopropylbenzene	ND		5	1		01/07/02 18:03	JN	976683
Methyl tert-butyl ether	ND		5	1		01/07/02 18:03	JN	976683
Methylene chloride	ND		5	1		01/07/02 18:03	JN	976683
n-Butylbenzene	ND		5	1		01/07/02 18:03	JN	976683
n-Propylbenzene	ND		5	1		01/07/02 18:03	JN	976683
Naphthalene	ND		5	1		01/07/02 18:03	JN	976683
sec-Butylbenzene	ND		5	1		01/07/02 18:03	JN	976683
Styrene	ND		5	1		01/07/02 18:03	JN	976683
tert-Butylbenzene	ND		5	1		01/07/02 18:03	JN	976683
Tetrachloroethene	ND		5	1		01/07/02 18:03	JN	976683
Toluene	ND		5	1		01/07/02 18:03	JN	976683
trans-1,3-Dichloropropene	ND		5	1		01/07/02 18:03	JN	976683
Trichloroethene	ND		5	1		01/07/02 18:03	JN	976683
Trichlorofluoromethane	ND		5	1		01/07/02 18:03	JN	976683
Vinyl acetate	ND		10	1		01/07/02 18:03	JN	976683
Vinyl chloride	ND		10	1		01/07/02 18:03	JN	976683
cis-1,2-Dichloroethene	ND		5	1		01/07/02 18:03	JN	976683
m,p-Xylene	ND		5	1		01/07/02 18:03	JN	976683
o-Xylene	ND		5	1		01/07/02 18:03	JN	976683
trans-1,2-Dichloroethene	ND		5	1		01/07/02 18:03	JN	976683
1,2-Dichloroethene (total)	ND		5	1		01/07/02 18:03	JN	976683
Xylenes,Total	ND		5	1		01/07/02 18:03	JN	976683
Surr: 1,2-Dichloroethane-d4	106	%	62-130	1		01/07/02 18:03	JN	976683
Surr: 4-Bromofluorobenzene	80.0	%	70-130	1		01/07/02 18:03	JN	976683
Surr: Toluene-d8	92.0	%	74-122	1		01/07/02 18:03	JN	976683

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HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
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(713) 660-0901

Client Sample ID San Francisco 112001 **Collected:** 11/26/01 12:54:0 **SPL Sample ID:** 01111128-01

Site: **Choloma**

Analyses/Method	Result	Rep.Limit	.	Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937624

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		12/11/01 19:47	NS	945428
Arsenic	ND	0.005		1		12/11/01 19:47	NS	945428
Lead	ND	0.005		1		12/11/01 19:47	NS	945428
Selenium	ND	0.005		1		12/11/01 19:47	NS	945428
Cadmium	ND	0.005		1		12/11/01 14:48	EG	944536
Chromium	ND	0.01		1		12/11/01 14:48	EG	944536
Nickel	ND	0.02		1		12/11/01 14:48	EG	944536
Silver	ND	0.01		1		12/11/01 14:48	EG	944536
Zinc	ND	0.02		1		12/11/01 14:48	EG	944536

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID SENAC 112001 **Collected:** 11/26/01 1:15:00 **SPL Sample ID:** 01111128-02

Site: **Choloma**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937625

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	0.00512	0.005		1		12/11/01 19:23	NS	945419
Arsenic	ND	0.005		1		12/11/01 19:23	NS	945419
Lead	ND	0.005		1		12/11/01 19:23	NS	945419
Selenium	ND	0.005		1		12/11/01 19:23	NS	945419
Cadmium	ND	0.005		1		12/11/01 15:13	EG	944540
Chromium	ND	0.01		1		12/11/01 15:13	EG	944540
Nickel	ND	0.02		1		12/11/01 15:13	EG	944540
Silver	ND	0.01		1		12/11/01 15:13	EG	944540
Zinc	ND	0.02		1		12/11/01 15:13	EG	944540

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
* - Surrogate Recovery Outside Advisable QC Limits
J - Estimated Value between MDL and PQL
>MCL - Result Over Maximum Contamination Limit(MCL)
D - Surrogate Recovery Unreportable due to Dilution
MI - Matrix Interference

HOUSTON LABORATORY
8880 INTERCHANGE DRIVE
HOUSTON, TX 77054
(713) 660-0901

Client Sample ID Victorio Gas 112001 **Collected:** 11/27/01 1:10:00 **SPL Sample ID:** 01111128-09

Site: **Choloma**

Analyses/Method	Result	Rep.Limit		Dil. Factor	QUAL	Date Analyzed	Analyst	Seq. #
MERCURY, DISSOLVED			**MCL**	**SW7470A**		**Units: mg/L**		
Mercury	ND	0.0002		1		12/05/01 11:10	R_T	937636

Prep Method	Prep Date	Prep Initials
SW7470A	12/05/2001 9:00	R_T

METALS BY METHOD 6010B, DISSOLVED			MCL	SW6010B		Units: mg/L		
Antimony	ND	0.005		1		12/11/01 20:47	NS	945450
Arsenic	ND	0.005		1		12/11/01 20:47	NS	945450
Lead	ND	0.005		1		12/11/01 20:47	NS	945450
Selenium	ND	0.005		1		12/11/01 20:47	NS	945450
Cadmium	ND	0.005		1		12/11/01 16:11	EG	944549
Chromium	ND	0.01		1		12/11/01 16:11	EG	944549
Nickel	ND	0.02		1		12/11/01 16:11	EG	944549
Silver	ND	0.01		1		12/11/01 16:11	EG	944549
Zinc	ND	0.02		1		12/11/01 16:11	EG	944549

Prep Method	Prep Date	Prep Initials
SW3005A	12/03/2001 13:00	MME

Qualifiers:

ND/U - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank
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>MCL - Result Over Maximum Contamination Limit(MCL)
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APPENDIX C

Groundwater Flow Model

GROUNDWATER FLOW MODEL

Choloma, Honduras

June 2002

1.0 INTRODUCTION

A numerical groundwater flow model was constructed for the municipality of Choloma to assess the sustainability of future groundwater supply development to meet the needs of the community. The interpretative modeling process produced a calibrated steady-state simulation of existing hydrogeologic conditions, which was then used to evaluate the groundwater production of the alluvial aquifer.

The municipality of Choloma is located in the Province of Cortes approximately 18 kilometers north of San Pedro Sula, and the extent of the project area is approximately 143 square kilometers. The population of the municipality is approximately 100,000 people.

The historical and current analytical data indicate that this well is being contaminated from outside sources. Choloma suffers a shortcoming of available water due mainly to the old water supply system of the town. Operating wells are more than 27 years old, and the wells, pipes, and pumps are in poor condition. Groundwater exploitation in the area, as is similar to most other regions of the country, has been done "without consideration of the regional hydrogeological system as a whole", due mainly to lack of knowledge and funds.

The municipality of Choloma relies exclusively on groundwater for its water supply. It is anticipated that reliance on groundwater for municipal water supplies will increase as population growth continues in the future.

1.1 Objectives

The following sections describe the purpose, goals, and applicability of the groundwater flow model.

1.1.1 Purpose and Goals. The primary purpose and goal of the numerical groundwater flow model for the municipality of Choloma was to assess the sustainability of future groundwater supply development to meet the needs of the community.

1.1.2 Applicability. The groundwater flow model was developed to numerically represent our hydrogeologic conceptual model of the Choloma valley aquifer system. The groundwater flow model is intended for use in the evaluation of potential groundwater resources available to support the projected future water supply needs of the Choloma community.

Based on the available data and the data collected by Brown and Caldwell (BC), BC feels that the conceptual and numerical hydrogeologic models are reasonable representations of the valley aquifer system; therefore, they can be used in planning and developing future groundwater resources. However, as additional geologic and hydrogeologic information is collected, the site conceptual and numerical models should be refined, thereby increasing the effectiveness of the numerical model as a tool to manage the community's groundwater resources.

1.2 General Topography of Model Area

Along the flanks of the Sula Valley, a number of river systems drain the surrounding upland areas. These river systems have associated valleys that adjoin the Sula Valley. Choloma is located within one such valley system on the western flanks of the Sula Valley. The Choloma River traverses the central portion of the valley and serves as the major drainage for the area. The valley is oriented in an east-west direction and ranges from 1 to 2.5 kilometers wide. The valley to the east and north is characterized by a broad flat alluvial plain, which has been deposited by the Choloma River, located north of the city. The municipality of Choloma lies within this valley floodplain. Several small lakes and smaller tributaries of the Sula Valley are also found within the valley east of Choloma. The Sula Valley eventually drains into the Caribbean Sea to the north. Steep topographic features are located to the northwest, west, and southwest of Choloma with less pronounced topographic features to the south. Figure C-1 presents a topographic map of the Choloma River valley.

2.0 CONCEPTUAL MODEL

The conceptual hydrogeologic model for the Choloma area was developed from previous studies, interviews with local representatives, field reconnaissance, and data collected from three new wells (BCCH-1, BCCH-2, and BCCH-3) installed during the BC investigation. The hydrostratigraphy of the Choloma River valley is characterized by a sequence of interbedded silts and sands grading into interbedded fine to medium sands and gravels. Numerous wells have been installed at different depths for domestic and industrial water production.

2.1 Hydrogeologic Boundaries

In the conceptual model, precipitation falling on the surrounding upland areas infiltrates the fractured metamorphic rocks and migrates toward the Choloma River valley. The infiltrated precipitation from the upland areas recharges the alluvial aquifers of the valley along the surrounding mountain front. Additional recharge to the aquifers occurs through precipitation falling directly on the surface of the valley floor. Recharge from precipitation is believed to be the major source of groundwater recharge to the alluvium.

The Choloma River, which traverses the model from east to west, acts as both a source and a sink for groundwater depending on the river stage. Water flows from the aquifer to the river during periods of low flow, and from the river to the aquifer during periods of high flow

Groundwater entering the aquifer system of the Choloma River valley that is not removed by pumping or discharge to the Choloma River flows generally to the east, and leaves the modeled area at the eastern model area boundary.

SOURCE: CHOLOMA, HONDURAS 1:50,000 TOPOGRAPHIC MAP, PREPARED BY INSTITUTO GEOGRAFICO NACIONAL, HONDURAS IN COLLABORATION WITH USA DEFENSE MAPPING AGENCY, 1994.

BROWN AND CALDWELL	DATE 3-21-02	SITE Choloma, Republic of Honduras	FIGURE C-1
	PROJECT 21143	TITLE Topographic Map Area Choloma and Central Portion of Sula Valley	

2.2 Hydraulic Properties

Step-drawdown and constant-rate aquifer tests were performed on selected wells to evaluate the water resource development potential and provide aquifer hydraulic data. Step-drawdown tests were performed on test wells BCCH-1, BCCH-2 and BCCH-3. The groundwater yield from BCCH-1 was less than 10 gpm, and step-drawdown test results indicated that yields from BCCH-3 would likely be around 100 - 200 gpm. The step-drawdown test at BCCH-2 indicated that yields from this well could be in excess of 1,000 gpm. A 4.5-hour constant-rate aquifer test was then performed on well BCCH-2. BCCH-2 was selected for the constant-rate aquifer test because it was the highest yielding well of the three newly installed wells. During the test, the well maintained a flow rate of 405 gpm with a maximum drawdown of 12.96 feet. Table G-1 summarizes the transmissivities determined during step-tests and aquifer tests of wells BCCH-1, BCCH-2, and BCCH-3.

Table C-1. Aquifer Transmissivity and Hydraulic Conductivity

Well ID	Transmissivity (m^2/day)	Hydraulic conductivity (m/day)
BCCH-1	1.55	0.041
BCCH-2	700 – 1030	21 – 31
BCCH-3	1660 - 3580	109 - 235

2.3 Aquifer System

The site is conceptually divided into four units in order to represent the heterogeneity of the aquifer system. The divisions are based on site stratigraphy, geophysical logs, and the observed aquifer response to constant-rate and step-drawdown tests performed at the site.

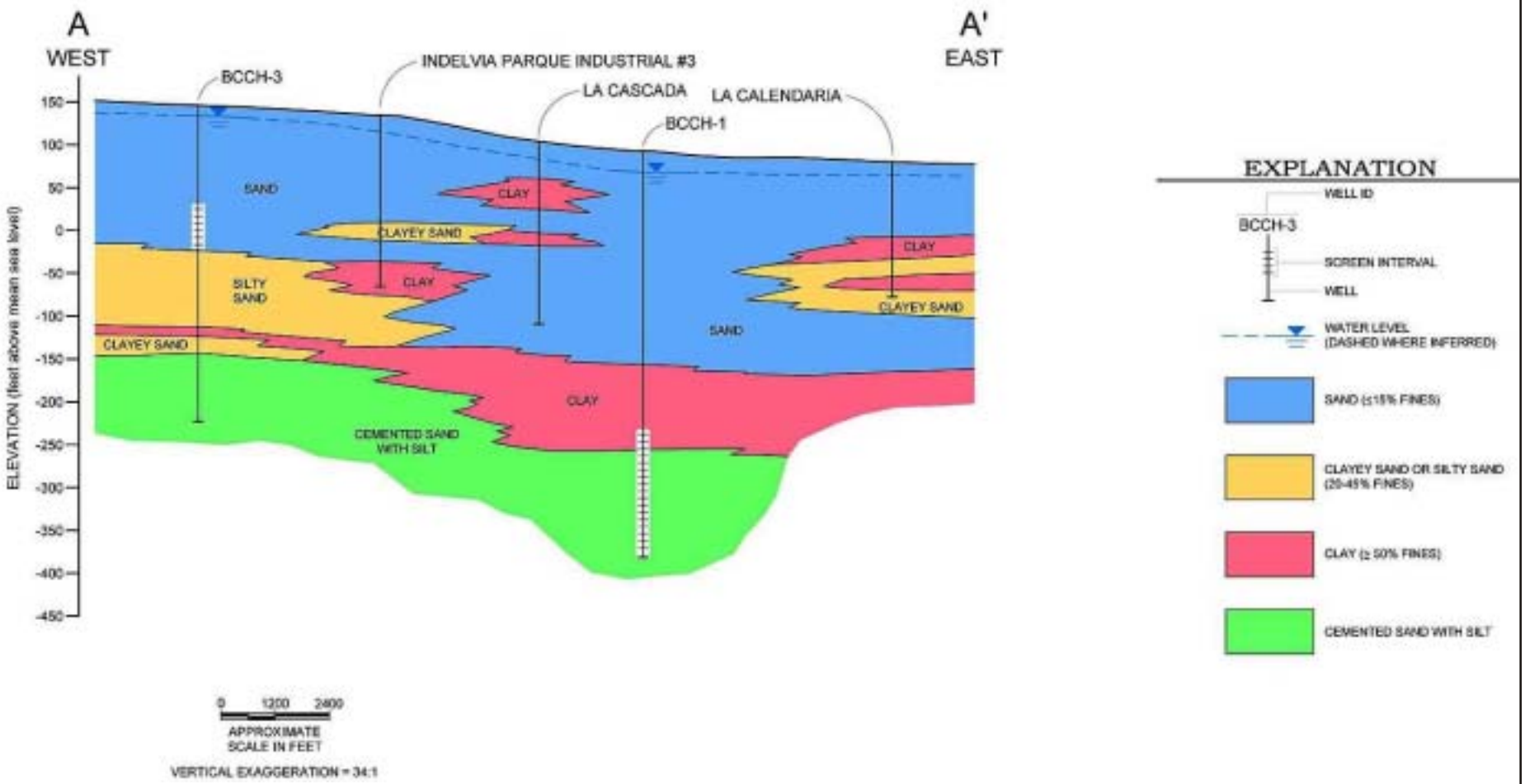
The hydrostratigraphic units are depicted in the generalized cross-section presented in Figures C-2 and C-3. The hydrostratigraphic units are described briefly, as follows:

1st Unit – represents a medium to coarse sand with a high hydraulic conductivity.

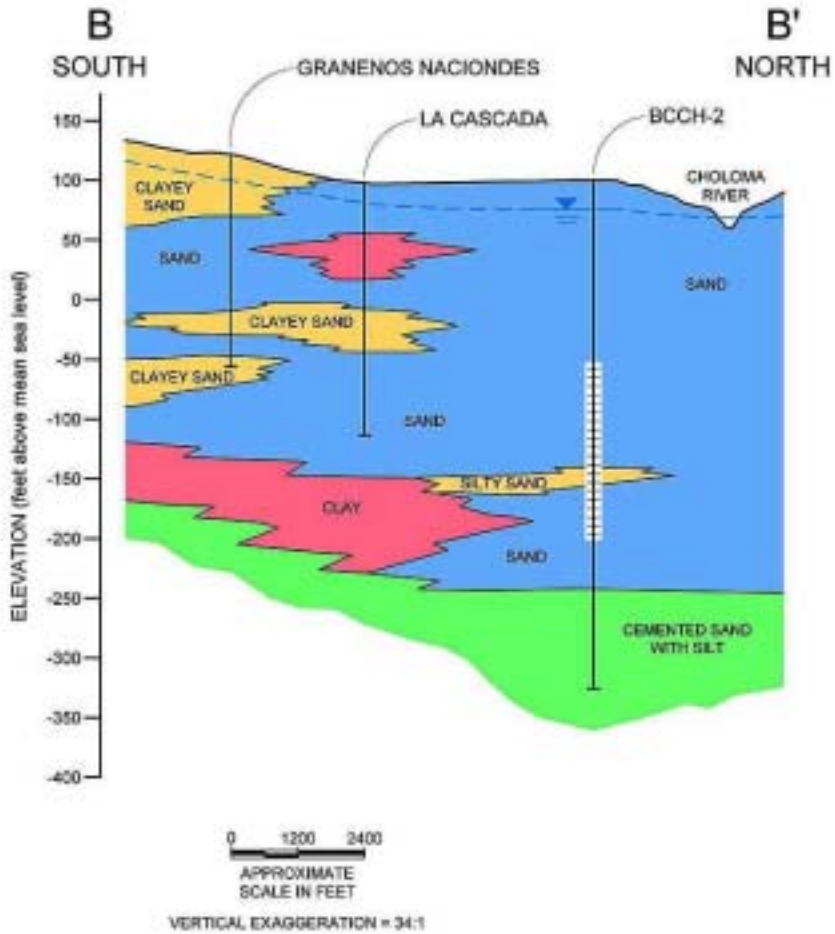
2nd Unit – represents a thinner layer of interfingering clay, clayey sand, and sand with variable high and low hydraulic conductivity throughout the modeled area.

3rd Unit – represents another thin layer of interfingering silty sand, clay, clayey sand, and sand with variable high and low hydraulic conductivity throughout the modeled area.

4th Unit – represents a layer of clay, cemented sand and silt, and sand with variable high and low hydraulic conductivity throughout the extent of the site.



BROWN AND CALDWELL	DATE 2-22-02	SITE Choloma, Republic of Honduras	FIGURE C-2
	PROJECT 21143	TITLE Cross Section A-A'	



BROWN AND CALDWELL	DATE 2-22-02	SITE Choloma, Republic of Honduras	FIGURE C-3
	PROJECT 21143	TITLE Cross Section B-B'	

2.4 Conceptual Water Budget

A conceptual groundwater budget for the aquifer system in Choloma was calculated to provide constraints for numerical modeling. The conceptual budget is based on previous investigations, field data collection, assumptions about precipitation infiltration, and anecdotal information from long-term residents.

For the modeled area, inflow to the aquifer system consists mainly of recharge from precipitation. Groundwater is removed from the system via (1) industrial and municipal well pumping, and (2) discharge to the Choloma River.

2.4.1 Inflow. The Choloma valley receives between 1.4 and 2.2 meters of precipitation annually, although, most of the precipitation occurs during the monsoon season. This averages about 4.9×10^{3} m/day, of which approximately 12 percent infiltrates into the aquifer. One of the primary sources of recharge is from the surrounding upland areas. Approximately 58,300,000 m^2 was estimated to represent the upland recharge area associated with the model domain.

Assuming a 12 percent infiltration rate, an estimated 34,500 m^3/day is recharging to the aquifer system from the upland areas. The rest of the valley is approximately 76,800,000 m^2 in size. Using 12 percent of the average precipitation value, an estimated 45,500 m^3/day is in the form of areal recharge. Estimated recharge rates of approximately 12% seem viable given the coarse-grained nature of the surface soils in the Choloma valley.

The upper reach of the Choloma River is believed to be recharging to groundwater (losing stream). Recharge of groundwater from the Choloma River was calculated using the MODFLOW river package flux formulation. Based on a 6500-meter river segment length, 10-meter average channel width, an estimated vertical hydraulic conductivity of 10 meters per day, an estimated river bed thickness of five meters, and a head difference between the aquifer and the river surface of 0.3 meters, the recharge from the Choloma River is estimated to be approximately 39,000 m^3/day.

2.4.2 Outflow. There are numerous domestic, municipal, commercial/agricultural, and industrial wells pumping in the Choloma area. Because an official estimate of total pumping from these wells is not available, it was assumed that the accumulative total pumping is approximately 22,710 m^3/day. This number is derived from pumping rates from wells in which sufficient information was available. The rates are based on the assumption that the wells are only pumping intermittently (approximately 14 hours total) throughout the day. Table C-2 summarizes the pumping rates of the wells.

Table C-2. Pumping Wells

Pumping well name	Estimated pumping rates (m^3/day)
Barrio Primavera	582
Barrio San Antonio	1,454
Bomberos No. 1	830
Bomberos No. 2	2,100
Col. El Prado 2	194
Col. Japon	355
Col. San Francisco	323
Residential San Carlos	1,131
Barosse II	2,277
Col. Bella Vista	760
Col. Canada	1,552
Col. La Mora 2	970
Escuela Perez Estrada	2,394
Los Almendros	136
Paraiso #1	116
Paraiso #2	105
Parque Central	1,358
Plasticos EMILCA	155
Residencial Europa	873
Triple A	1,552
Zip Choloma #1	1,940
Zip Choloma #2	1,553
Total Pumping	22,710

Groundwater discharges to the lower reach of the Choloma River was calculated using the MODFLOW river package flux formulation. Based on a 4500-meter river segment length, 10-meter average channel width, an estimated vertical hydraulic conductivity of 10 meters per day, an estimated river bed thickness of five meters, and a head difference between the aquifer and the river surface of 0.3 meters, the discharge to the Chamelecón River is estimated to be approximately 27,000 m^3/day.

Outflux from the valley to the east of the modeled area leaves the system through aquifer. The outflux to the aquifer was based on the assumption that the aquifer is approximately 6,500 meters wide and 89 meters thick, and the average gradient is approximately 0.001. The average conductivity was estimated to be 94 meters per day. Approximately 54,380 m^3/day is estimated to be flowing out of the aquifer to the east.

Table C-3 presents the annualized, conceptual groundwater budget for the Choloma model region.

Table C-3. Conceptual Groundwater Budget for Choloma Model Area

IN	M^3 per day	M^3 per year	Gallons per minute
Recharge Up-lands	34,500	12,592,500	6,329
Recharge Valley Alluvium	45,500	16,607,500	8,347
Choloma River Leakage to Aquifer	39,000	14,235,000	7,155
Total	119,000	43,435,000	21,831
OUT			
Choloma Pumping Wells	22,712	8,289,880	4,167
Discharge to Choloma River	22,000	9,855,000	4,953
Flux through Eastern Model Area	54,380	19,848,700	9,961
Total	104,092	37,993,580	19,081
IN – OUT (change in storage)	14,908	2,781,300	2,750

Based on these estimates, there is a daily surplus of 14,908 m^3 /day indicating that groundwater supplies are being added to storage.

3.0 COMPUTER CODE

The modular, three-dimensional, finite difference groundwater model code (MODFLOW) was used for this project. The U.S. Geological Survey (McDonald and Harbaugh, 1988) developed the original code. However, a slightly modified version of the code marketed by Environmental Simulations Inc. was used for this site. The version is designed to interact with Groundwater Vistas, a pre- and post-processor used for data input and output.

3.1 Model Assumptions

Several assumptions were necessary in the development of the Choloma groundwater flow model because of limited data available on the hydrogeologic system of the valley. The data that are available are primarily from recently completed borehole logs and aquifer testing, and are limited to a small portion of the modeled area where recent groundwater development has occurred.

The following is a summary of the assumptions used in the development of the Choloma groundwater model:

Groundwater flow directions throughout the modeled area are generally to the east.

Areal recharge occurs over the entire surface of the modeled area at a uniform rate; seasonal precipitation can be normalized to daily averages.

Upland recharge to the modeled area is proportional to the areas of watersheds in the surrounding highlands.

4.0 MODEL CONSTRUCTION

The following sections describe the model domain used in this analysis, layer hydraulic parameters, groundwater sources, and selection of calibration targets and goals.

4.1 Model Domain

The model domain and grid used in this analysis are presented on Figure C-4. The model grid is centered on the municipality of Choloma and consists of 95 rows and 95 columns. The dimensions of the individual cells range from 100 by 100 meters in the area of Choloma to 100 by 500 meters at the eastern margin of the grid. The finer grid spacing was selected to provide a more refined depiction of conditions within the Choloma River valley. Larger cells were used beyond the project area where hydrologic information was not known. The grid is oriented so that the X-axis of the grid parallels the primary groundwater flow direction within the upper aquifer.

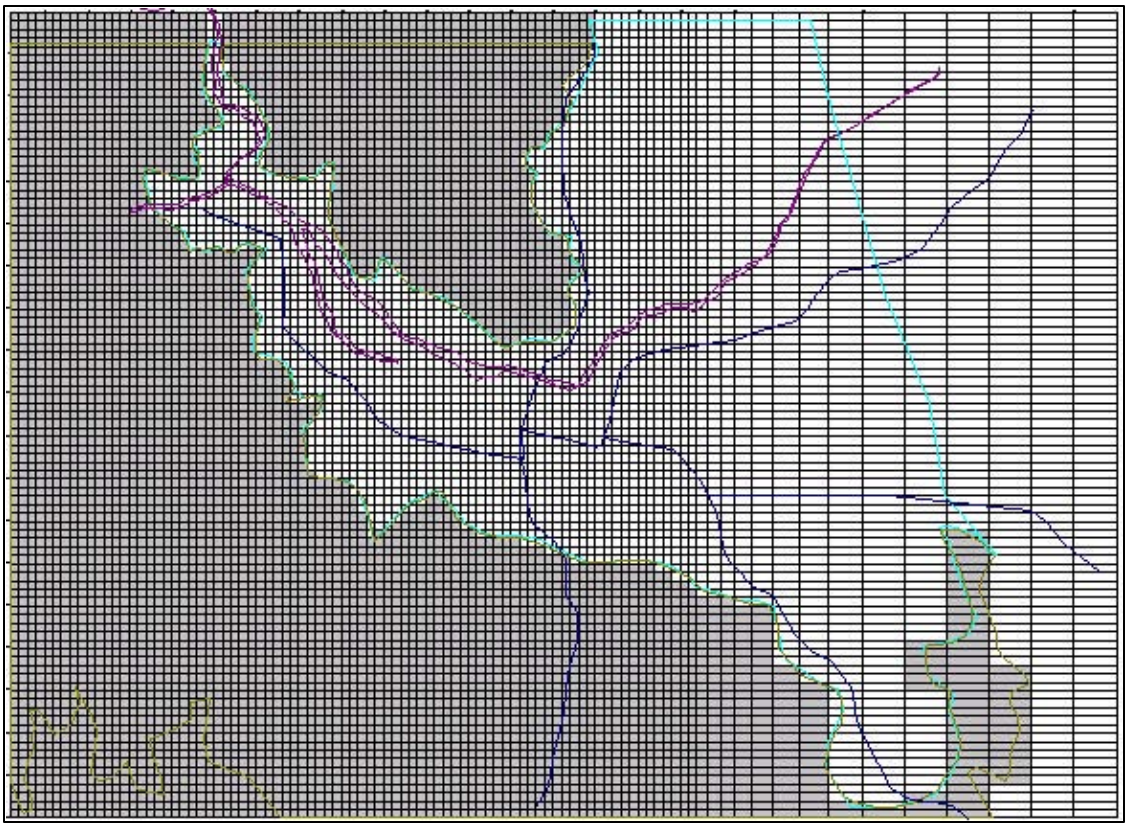
As presented earlier, the hydrostratigraphy setting beneath the study area is characterized by an alluvial aquifer system comprised of gravels, sands, silts, and clays. Vertically, the grid consists of 4 layers to represent the heterogeneity of the aquifer system. The top elevation of layer 1 is based on digital ground surface elevation data. Layer bottom elevations were estimated using the geologic cross-sections. The thickness of layer 1 varies across the site with the topographic surface. The bottom elevation of layer 1 is sea level. Layers 2, 3, and 4 are 27.43 m, 18.29 m, and 30.48 m thick, respectively.

4.2 Hydraulic Parameters

Layer 1 simulates groundwater flow within a predominately sand unit across the site. Hydraulic conductivity was chosen to be 90 m/day along the upper reaches of the Choloma River and 275 m/day east of the municipality of Choloma (Figure C-5).

Layer 2 simulates groundwater flow within a predominately sand unit and a silty/clayey sand and clay unit. Hydraulic conductivity values ranges from 0.1 m/day in the southern portion of the model area (representing the silty/clayey sand and clay unit), and 5 m/day in the northern portion of the model area (representing the sand unit). Figure C-6 represents the hydraulic conductivity in layer 2.

Layer 3 also simulates groundwater flow within a predominately sand unit and a silty/clayey sand and clay unit. Hydraulic conductivities range from 1 m/day in the southern and eastern portions of the model area (representing the silty sand unit) to 50 m/day in the northern portion of the model (representing the sand unit). Figure C-7 represents the hydraulic conductivity in layer 3.



North

Inactive Model Cells

FIGURE C-4

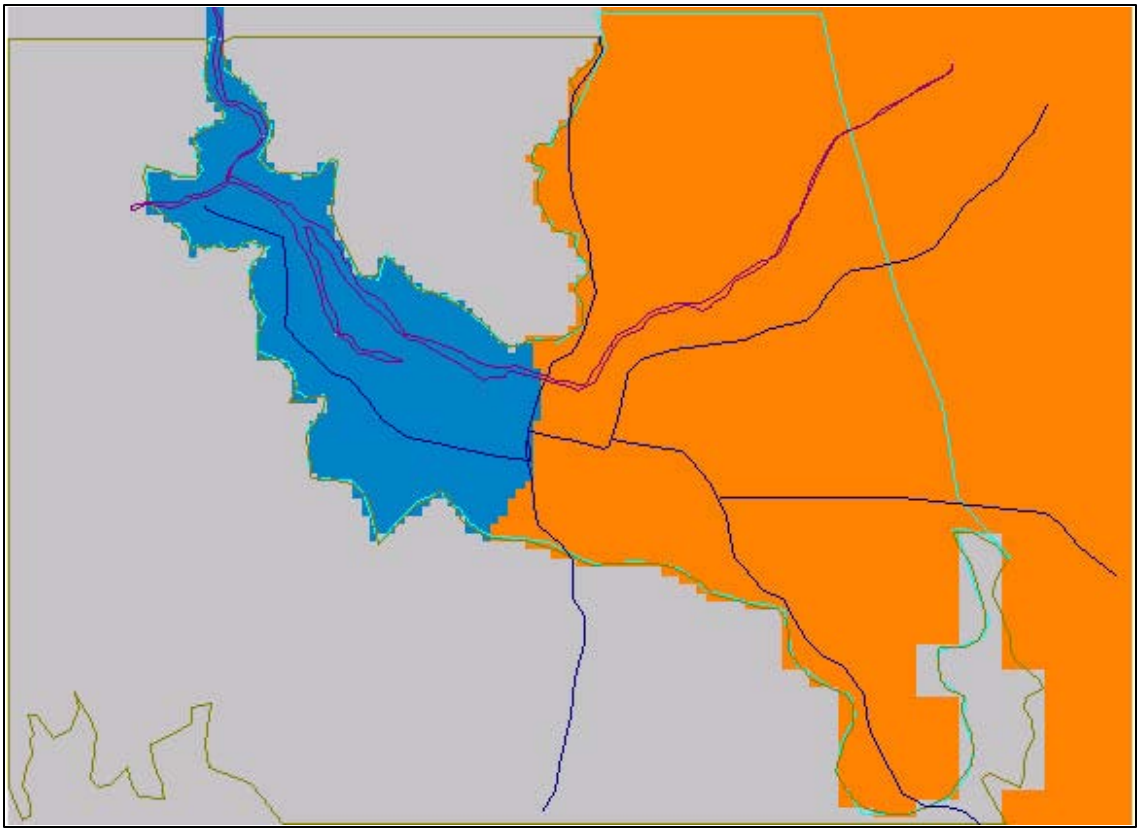
MODEL GRID

Choloma, Honduras

USAID

BROWN AND CALDWELL

*Not to Scale



Inactive Model Cells

K=100 m/day
Vertical K = 10 m/day

K= 275 m/day
Vertical K = 27.5 m/day

North

*Not to Scale

FIGURE C-5

LAYER 1 HYDRAULIC CONDUCTIVITY (K) AND VERTICAL HYDRAULIC CONDUCTIVITY

Choloma, Honduras

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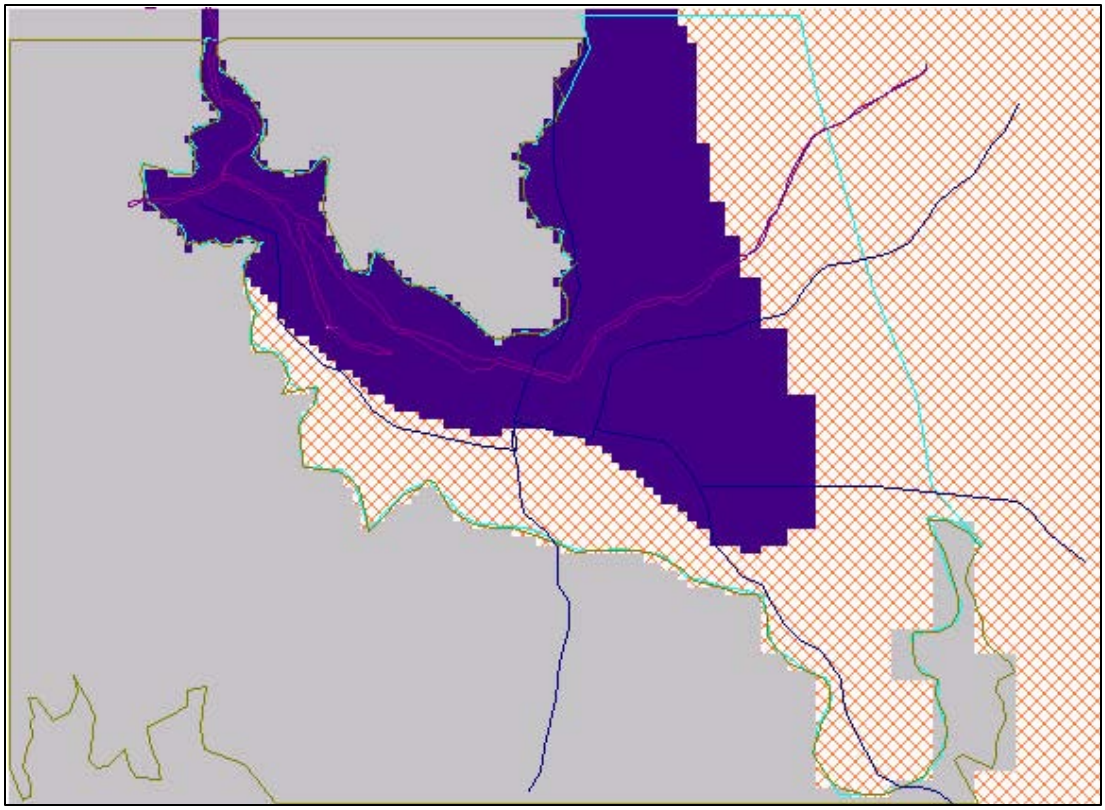
BROWN AND CALDWELL



North

Inactive Model Cells

K = 20 m/day
Vertical K = 2 m/day

K = 0.075 m/day
Vertical K = 0.0075 m/day

*Not to Scale

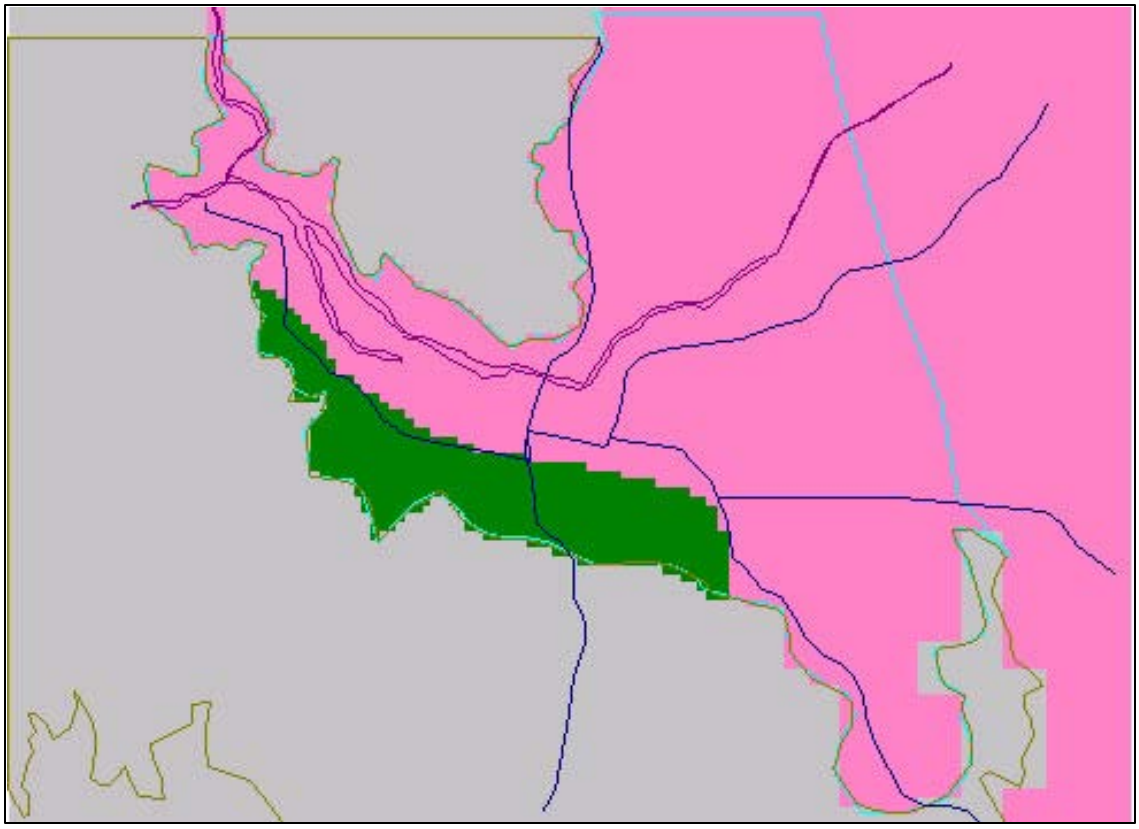
FIGURE C-6

LAYER 2 HYDRAULIC CONDUCTIVITY (K) AND VERTICAL HYDRAULIC CONDUCTIVITY

Choloma, Honduras

USAID

BROWN AND CALDWELL



North

Inactive Model Cells

K=1 m/day
Vertical K = 0.1 m/day

K=50 m/day
Vertical K = 5 m/day

*Not to Scale

FIGURE C-7

LAYER 3 HYDRAULIC CONDUCTIVITY (K) AND VERTICAL HYDRAULIC CONDUCTIVITY

Choloma, Honduras

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Layer 4 simulates groundwater flow within a sand unit and a clay unit. Hydraulic conductivities range from 0.075 m/day (representing the clay and cemented sand unit) in the western portion of the model to 120 m/day (representing the sand unit). Figure C-8 represents the hydraulic conductivity in layer 4.

4.3 Sources

The following sections describe groundwater sources including rivers, recharge, and wells.

4.3.1 Rivers. The Choloma River is considered to be the primary groundwater discharge area for model layer 1. This discharge was simulated using river nodes cells. An average elevation of the river surface (specified head) in these cells was obtained from the topographic map of the area. The river nodes are presented on Figure C-9.

4.3.2 Recharge. Infiltration from upland areas is represented in the model as flux boundaries along the margins of the upland areas. The flux boundary for all layers is shown in Figure C-9. The flux was distributed among the flux boundaries located in layers 1, 2, 3, and 4. Input from flux cells ranges from 45 m^3/day in the upper reaches of the valley to 1 m^3/day around the lower reaches.

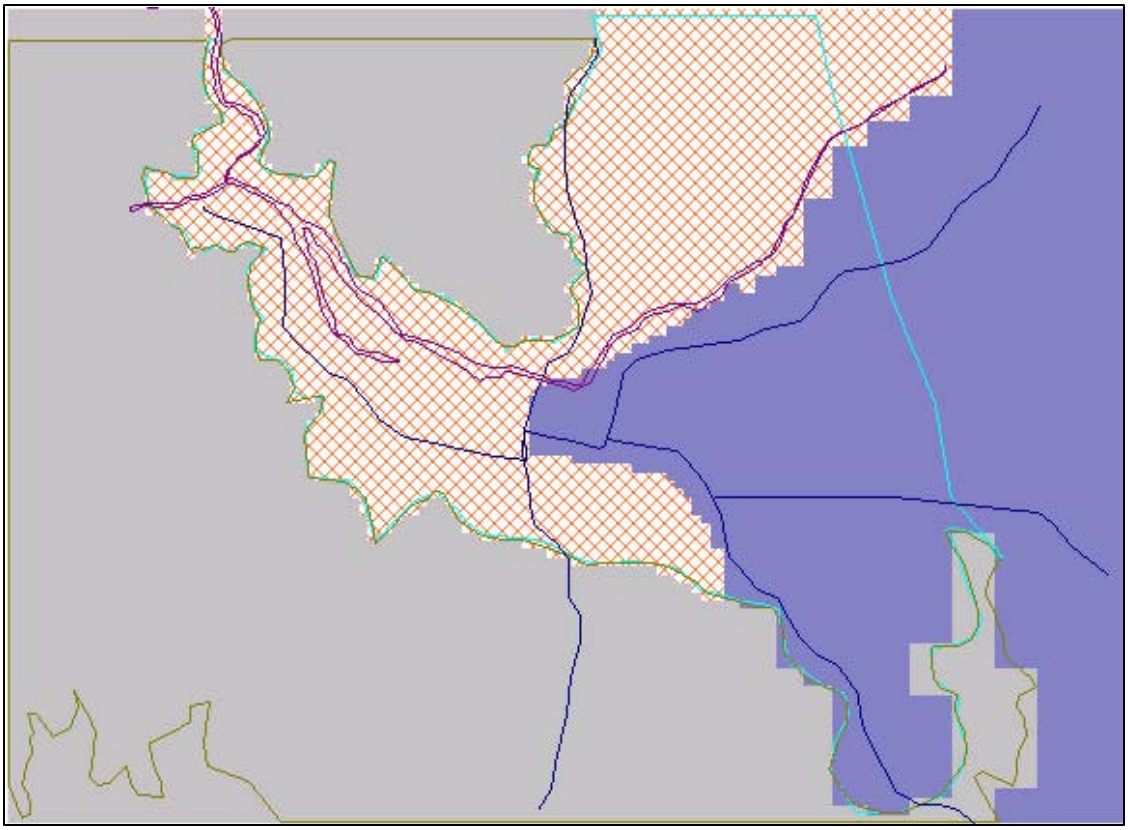
An areal recharge rate of 3.0×10^{-3} m/day was assigned to the uppermost active layer in the model along the upper reaches of the Choloma River valley and 2.5×10^{-4} m/day in the lower reaches. Figure C-10 shows the distribution of recharge values in layer 1.

4.3.3 Wells. Numerous wells were identified at Choloma as possible influences on groundwater conditions at the site within the alluvial aquifer. These wells are used for domestic, municipal, commercial/agricultural, and industrial water purposes. A total of 22,710 m^3/day is assumed to be pumping from 22 wells in the Choloma valley. There are several other wells pumping in the area, but data from these wells was inaccessible. Figure C-11 shows the locations of the pumping wells in Layer 1. Figure C-12 shows the locations of the pumping wells in Layer 2.

4.4 Boundary Conditions

Boundary conditions including no-flow, general head, constant flux, and river boundaries are described in the following sections.

4.4.1 No-Flow Boundaries. No-flow boundaries are used to represent a small area of bedrock in the southeastern portion of the Choloma model area (Figure C-9).



North

Inactive Model Cells

K = 120 m/day
Vertical K = 12 m/day

K = 0.075 m/day
Vertical K = 0.0075 m/day

*Not to Scale

FIGURE C-8

LAYER 4 HYDRAULIC CONDUCTIVITY (K) AND VERTICAL HYDRAULIC CONDUCTIVITY

Choloma, Honduras

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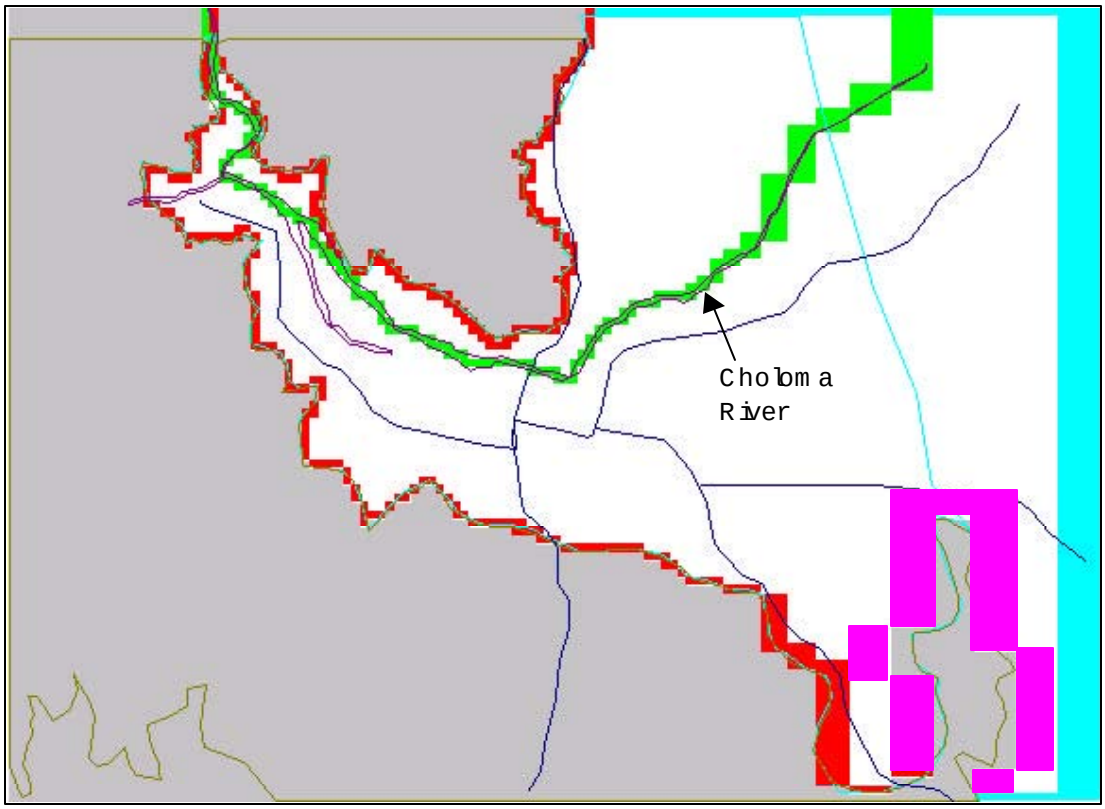

Inactive Model Cells

River Nodes

General Head Boundary

Flux Boundary

No-Flow Boundary

North

*Not to Scale

FIGURE C-9

LAYER 1 BOUNDARY CONDITIONS

Choloma, Honduras

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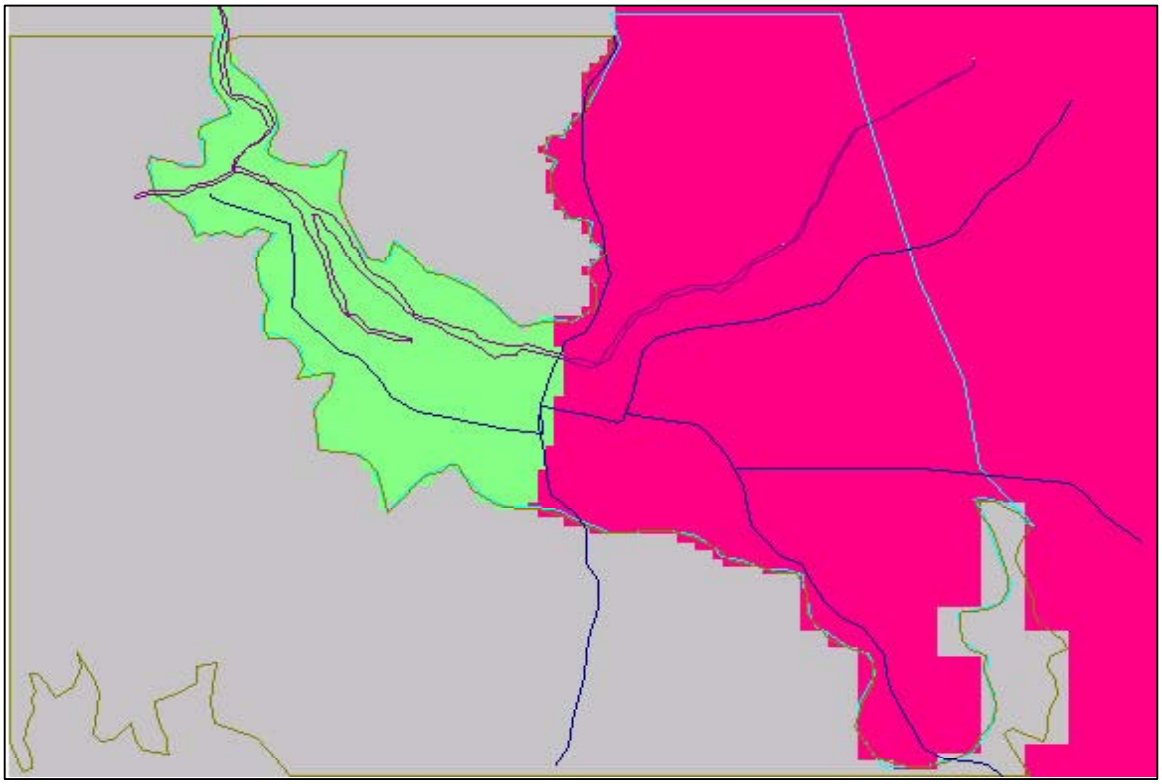

Inactive Model Cells

Recharge = 0.00025 m/day

Recharge = 0.003 m/day

North

*Not to Scale

FIGURE C-10

AREAL RECHARGE IN LAYER 1

Choloma, Honduras

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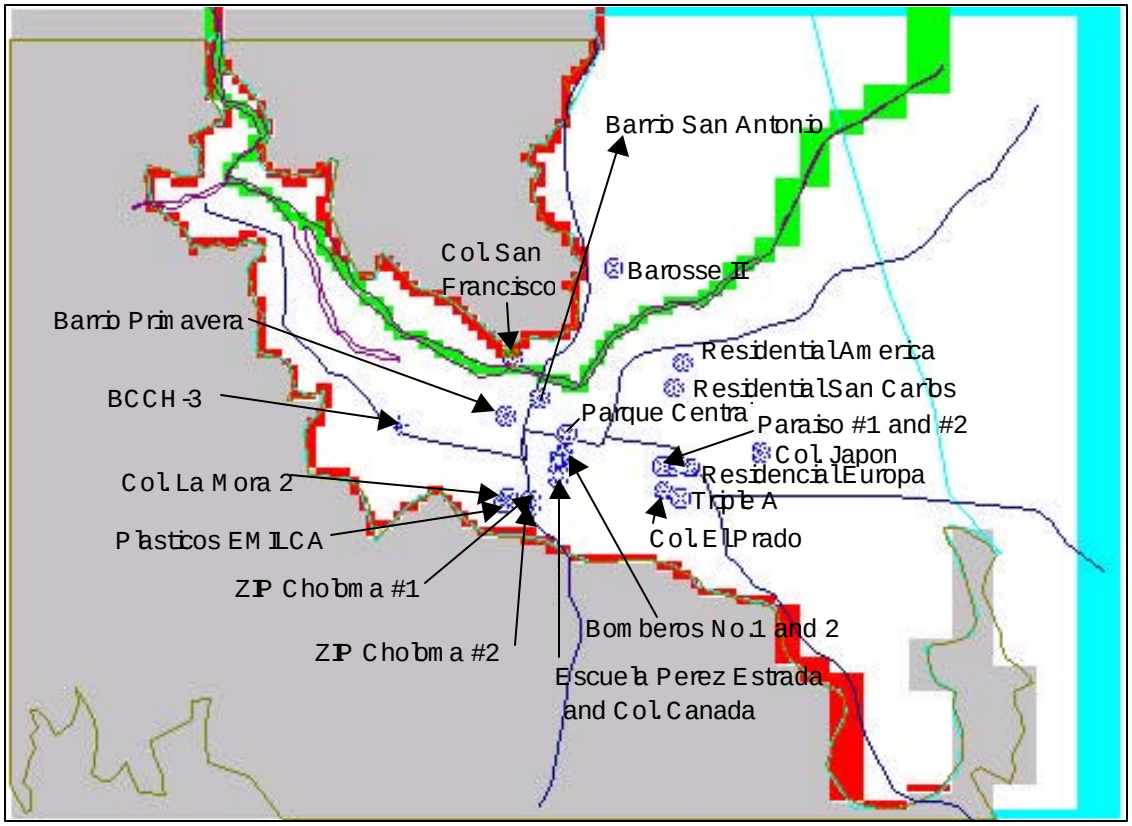

Inactive Model Cells

General Head Boundary

Flux Boundary

River Node

North

Note: BCCH-3 is NOT a pumping well

*Not to Scale

FIGURE C-11

LOCATION OF LAYER 1 PUMPING WELLS

Choloma, Honduras

USAID

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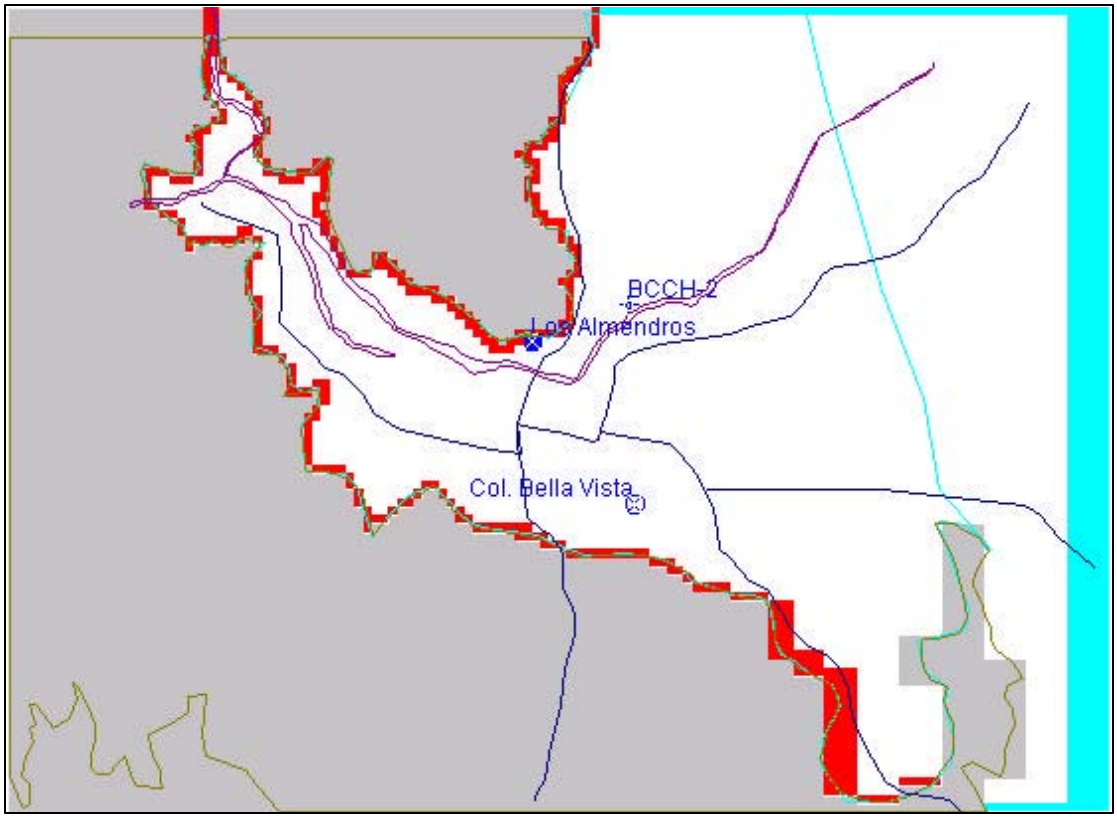


Inactive Model Cells

River Node

Flux Boundary

General Head Boundary

North

Note: BCCH-2 is NOT a pumping well

*Not to Scale

FIGURE C-12

LOCATION
OF LAYER 2 PUMPING WELLS

Choloma, Honduras

USAID

BROWN AND CALDWELL

4.4.2 General Head Boundaries. The northeast, east, and southeast perimeters are simulated using "general head" boundary (GHB) cells. These boundary cells simulate the extension of the aquifer beyond the model boundary by allowing water to enter or exit the model domain as a function of the local gradient, transmissivity, and cell dimensions. Head values used for the general head boundaries were estimated by projection of groundwater elevation data and topographical information. The general head boundaries are presented in Figure C-9.

4.4.3 Constant Flux Boundaries. Constant flux boundaries are used to represent mountain front recharge to the alluvial aquifer system from the surrounding highlands. The assignment of flux values to these boundaries is discussed in Section 4.3. The constant flux boundaries are presented in Figure C-9.

4.4.4 River Boundaries. River nodes are utilized in the model to represent flux to and from the Choloma River. The assignment of head values to the river nodes is discussed in Section 4.3. The river boundaries are presented in Figure C-9.

4.5 Selection of Calibration Targets and Goals

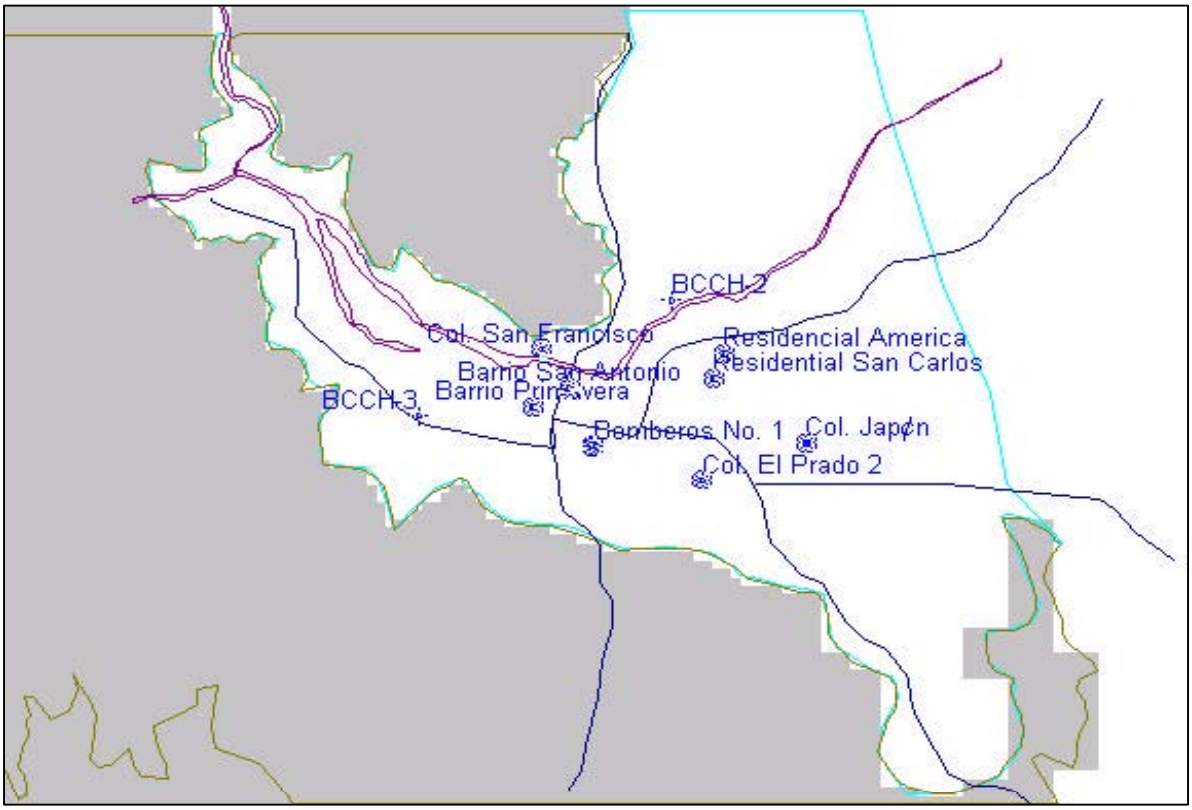
Ten wells with available static water level data were chosen within the model area as calibration targets. Water levels across the site have been measured sporadically since November 1999. BCCH-1 was not utilized because it was completed in the cemented sand below layer 4. Figure C-13 shows the location of the calibration target wells. Table C-4 presents the water level elevations of the ten calibration targets taken in December 2001.

Table C-4. Calibration Targets

Calibration target name	Water level elevation (m above sea level)
BCCH-2	21.70
BCCH-3	40.00
Barrio Primavera	30.69
Barrio San Antonio	28.71
Bomberos No.1	22.52
Col. El Prado 2	19.85
Col. Japon	17.15
Col. San Francisco	31.35
Residential America	22.94
Residential San Carlos	21.30

5.0 CALIBRATION

For this report, the term calibration refers to the standard approach of matching measured heads to model heads at steady-state conditions and adjusting input parameters within reasonable limits until an acceptable match is achieved.



North

Inactive Model Cells

Note: BCCH-2 is located in Layer 2

*Not to Scale

FIGURE C-13

LOCATION OF CALIBRATION TARGETS IN LAYER 1

Choloma, Honduras

USAID

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5.1 Qualitative and Quantitative Analyses

The first step in the calibration process is the selection of initial input parameters. The values used for the initial run were obtained from previous and ongoing investigations. Once the initial input parameters were selected, the initial base case simulations were conducted and results were evaluated using a head residual analysis. A head residual is the difference between the measured head in a well and the model-predicted head in the cell that represents the location and depth of the well. Positive residuals indicate the predicted head is lower than the measured value, whereas negative residuals indicate that the predicted head is higher than the measured value. The residual sum of squares is an indicator of an overall bias (heads generally too high or too low) in the prediction. If, for example, the predicted heads were quite close to the measured heads but most were slightly higher, this term would be elevated in the negative direction. The absolute residual mean is an indicator of the accuracy of the match and, as a general rule, should be less than 10 percent of the steady-state head change across the project area.

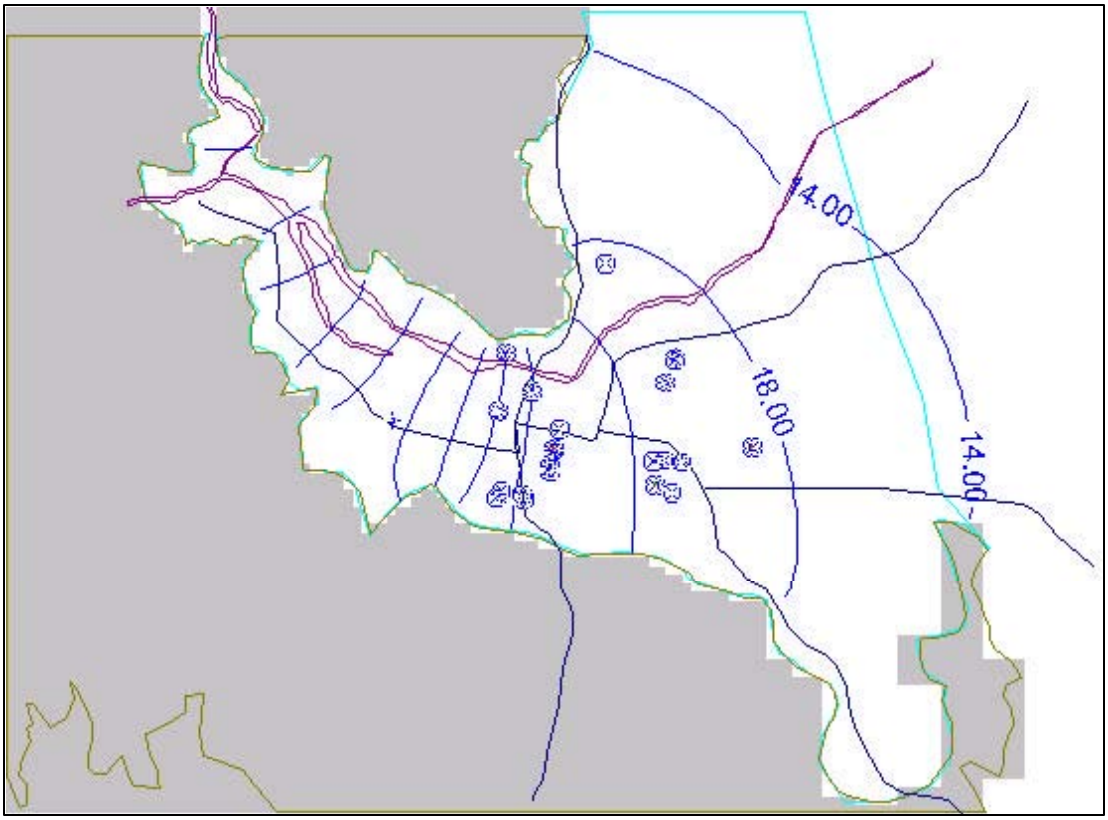
During the steady-state calibration process, the various input parameters were adjusted within reasonable limits and the results noted. This process was continued until an acceptable match was made with averaged head values. Table C-5 presents the results of the calibration simulation. The overall sum of residual is 37.6 m, with an absolute residual mean of 1.82 m. The residual sum of squares in layer 1 is 32.8 m, with an absolute residual mean of 1.78 m. The residual sum of squares in layer 2 is 4.89 m, with an absolute residual mean of 2.21 m. There were no calibration targets in layers 3 and 4. Considering the reliability of the water level data, these calibration results are reasonable matches to our understanding of the field conditions and the accuracy of the available data. The modeled groundwater elevation contours for layers 1 through 4 are presented in Figure C-14 through C-17, respectively.

Table C-5. Calibration Statistics

Calibration Statistics	(m)
Residual Mean	0.69
Residual Standard Deviation	1.81
Residual Sum of Squares	37.6
Absolute Residual Mean	1.82
Minimum Residual	-2.34
Maximum Residual	2.95
Observed Range in Head	22.86
Residual Std. Dev./Range	0.079

5.2 Sensitivity Analysis

A sensitivity analysis was performed to evaluate the sensitivity of the model output to uncertainties inherent in the input data. The first step in this process was to establish reasonable ranges within which to vary the input parameters. Where ranges of values were available based on field data, the upper and lower values were used. Otherwise, parameter values were increased and decreased to



North

Inactive Model Cells

Potentiometric Surface Lines

Contour Interval = 4 meters

*Not to Scale

FIGURE C-14

LAYER 1 STEADY-STATE POTENTIOMETRIC SURFACE

Choloma, Honduras

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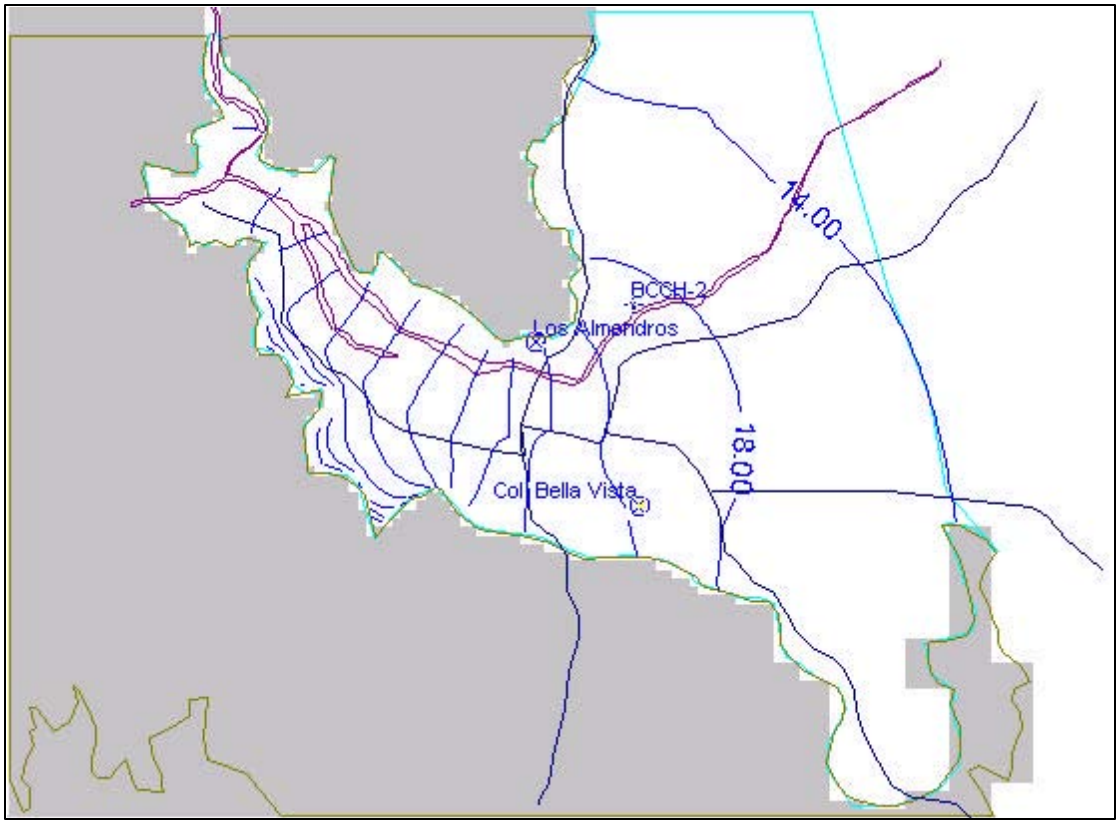


North

Inactive Model Cells

Potentiometric Surface Lines

Contour Interval = 4 meters

*Not to Scale

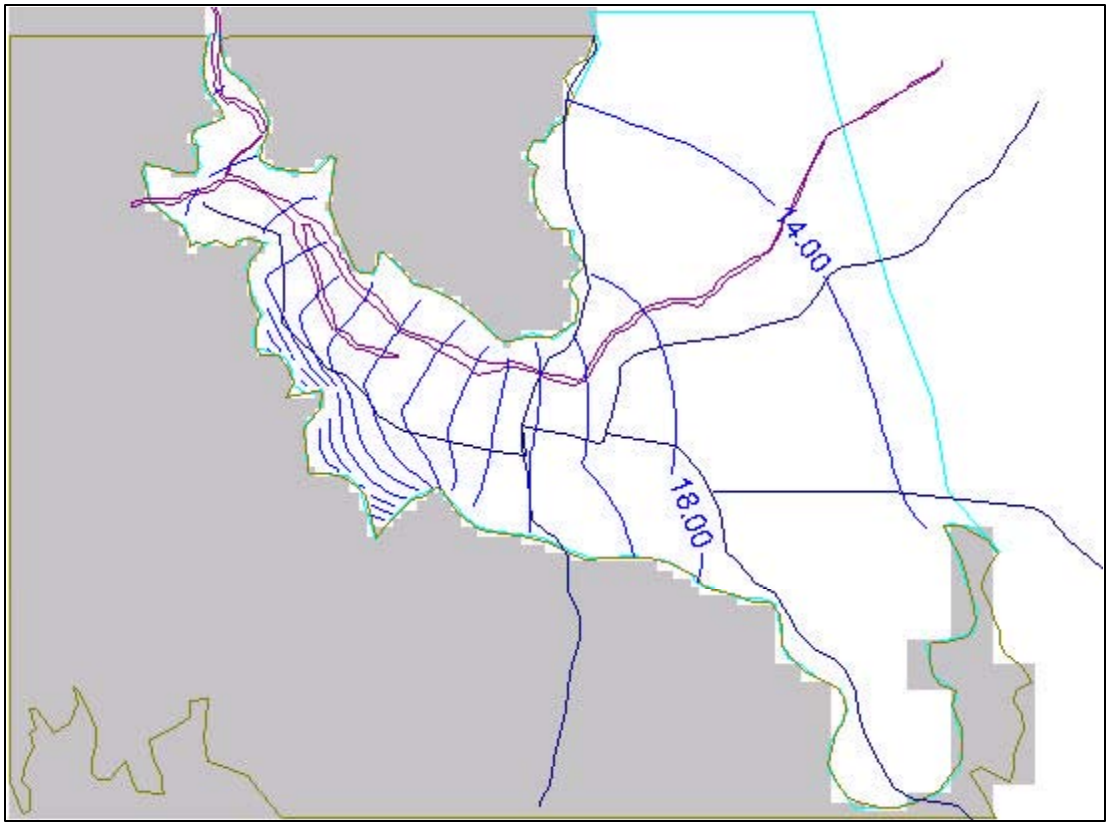
FIGURE C-15

LAYER 2 STEADY-STATE POTENTIOMETRIC SURFACE

Choloma, Honduras

USAID

BROWN AND CALDWELL



North

Inactive Model Cells

Potentiometric Surface Lines

Contour Interval = 4 meters

FIGURE C-16

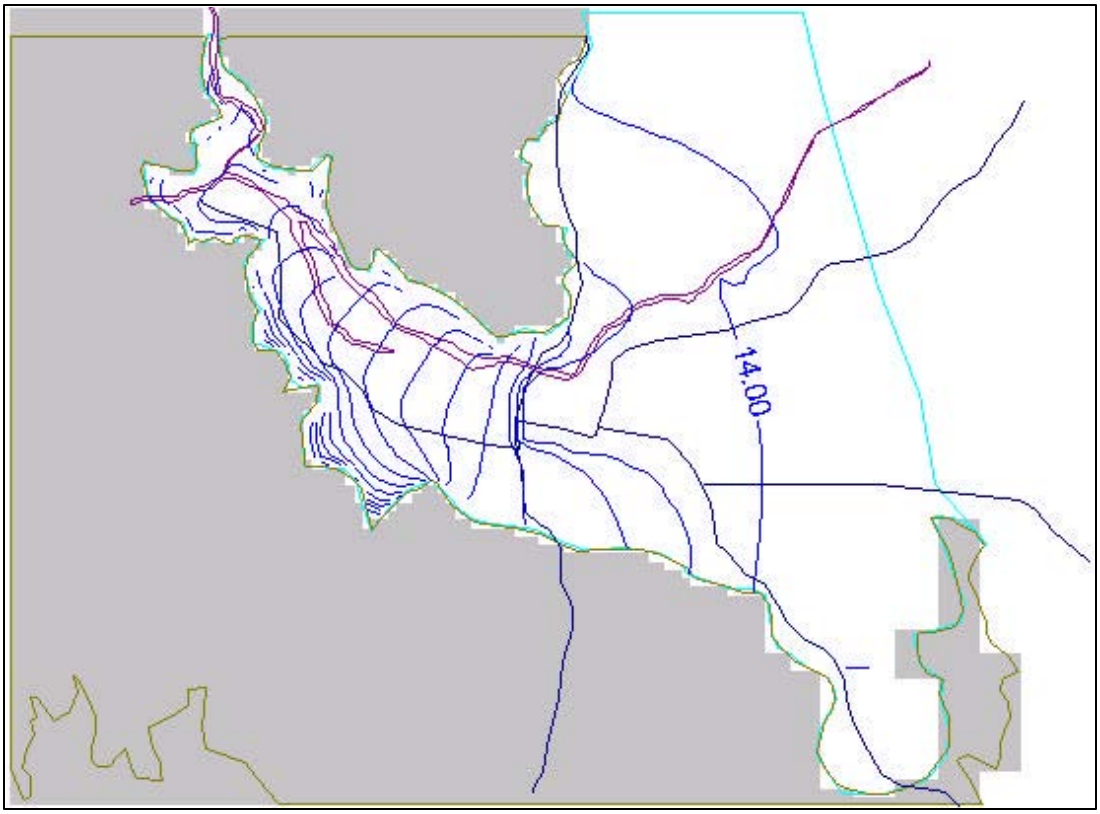
LAYER 3 STEADY-STATE POTENTIOMETRIC SURFACE

Choloma, Honduras

USAID

BROWN AND CALDWELL

*Not to Scale



North

Inactive Model Cells

Potentiometric Surface Lines

Contour Interval = 4 meters

*Not to Scale

FIGURE C-17

LAYER 4 STEADY-STATE POTENTIOMETRIC SURFACE

Choloma, Honduras

USAID

BROWN AND CALDWELL

represent upper and lower limits. The sensitivity analysis was conducted by varying one input parameter at a time and comparing the predicted steady-state match with that of the calibrated base case simulation.

The results of the sensitivity analysis indicate that for the site as a whole, the most sensitive parameters in the model are hydraulic conductivity, the flux boundary, and river stage and conductance. Recharge was also slightly sensitive.

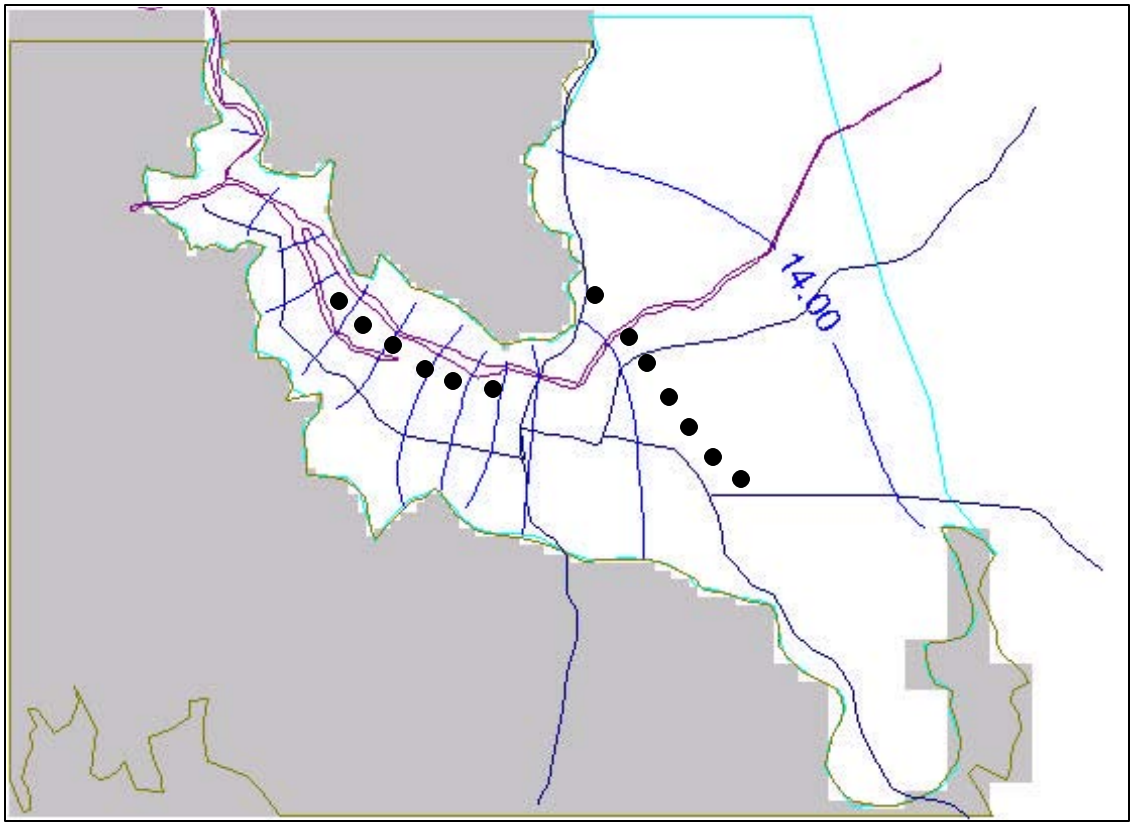
6.0 PREDICTIVE SIMULATIONS

A predictive model simulation was performed to evaluate the potential effects of increased groundwater production on the Choloma Valley aquifer system. The transient simulation incorporates an increase in groundwater demands for Choloma by the year 2020. Pumping rates were increased over the duration of the simulations to a maximum groundwater production rate of 12,000 gpm. The simulation was run for a predictive period of 20 years. The simulations uses hypothetical production wells located to the east and west of the current population growth (Figure C-18). Because of a lack of appropriate data, the transient model was not calibrated.

To accomplish the predictive simulations, the groundwater model was first converted to run in transient mode, with the calibrated steady-state water levels used for initial water level conditions. Transient model simulations are used to analyze time-dependent problems, and produce a set of hydraulic heads for each pre-determined time step (Anderson and Woessner, 1992). A steady state model simulation produces a set of hydraulic heads that are in equilibrium with stresses on the model, whereas a transient simulation produces a set of hydraulic heads that may not have yet reached equilibrium. Therefore, the hydraulic heads (or water levels) presented in the results of transient simulations may continue to change with time after the end of the simulation period.

For the simulation, a total of 13 hypothetical production wells were included in the model. Seven wells were located to the east (down-gradient) of Choloma and 6 wells were located to the west (up-gradient) of Choloma (Figure C-18). Each well was assigned a pumping rate of approximately 750 gpm, with all production from model Layer 2. As a conservative approach, all the hypothetical wells were turned on during year 1 of the simulation. Model-predicted water level elevations are presented for year 20 of the simulation in Figure C-18.

The performance of the existing wells and newly installed BC wells indicates that new wells located in this area would likely produce at the rate assigned in the predictive simulation. The simulation results (Figure C-19) indicate that the aquifer drawdown would be approximately 5 meters in the well field located to the west of Choloma and approximately 4 meters in the well field located to the east of Choloma at the end of the simulation period. Greater drawdown in the up-gradient production wells (west) is expected due to narrow width of the valley in this area, which limits the aquifer storage. These predicted drawdowns may have an impact to existing shallow wells in the Choloma Valley by reducing the saturated thickness within screened intervals of wells or dropping water levels below the screened intervals.



North

Pumping Well

Inactive Model Cells

Potentiometric Surface Contour Lines

Contour Interval = 4 meters

*Not to Scale

FIGURE C-18

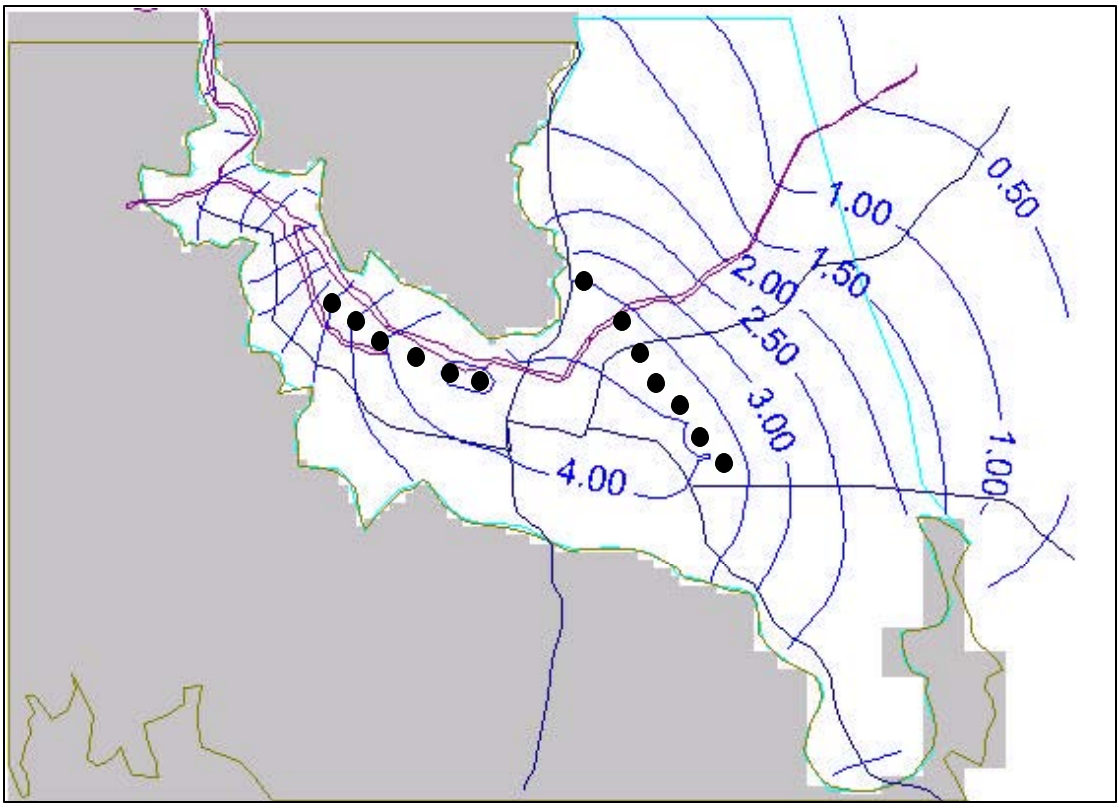
LAYER 1 PREDICTIVE SIMULATION POTENTIOMETRIC SURFACE

SIMULATION YEAR 20

Choloma, Honduras

USAID

BROWN AND CALDWELL



Pumping Well

Inactive Model Cells

Drawdown Contours

Contour Interval = 1 meter

North

*Not to Scale

FIGURE C-19

LAYER 1 PREDICTIVE SIMULATION
DRAWDOWN CONTOURS
SIMULATION YEAR 20
Choloma, Honduras
USAID

BROWN AND CALDWELL

The predictive simulation indicated that the aquifer system could support the projected groundwater needs through the year 2020. The majority of the groundwater demand can be obtained from pumping groundwater from the current well field area located to the east of the municipality of Choloma. However, this area has the potential for continued population growth and development, which may have impacts on groundwater quality. A portion of the projected groundwater demands (approximately 60 percent) can be met by developing a well field to the west and up-gradient of the municipality. Although the Choloma Valley aquifer can support the water needs into the future, it is very important that a well head protection program be developed to protect the community's groundwater resources.

7.0 SUMMARY AND CONCLUSIONS

Based on the available data and the data collected by BC, BC feels that the conceptual and numerical hydrogeologic models can reasonably represent the Choloma Valley aquifer system, and therefore can be used in the planning and development of future resources. The most viable groundwater resources are in the following areas: the lower sand unit, above the cemented sand unit, northeast and east of the municipality of Choloma; and the upper sand unit of the aquifer located upgradient of the municipality of Choloma. These two areas are least likely to be impacted by coliform bacteria and are highly productive areas of storage.

The conceptual groundwater budget indicates that of the estimated 21,831 gpm that enters the Choloma Valley aquifers through mountain front, aerial recharge and recharge from the Choloma River, approximately 4,167 gpm is currently extracted by production wells, approximately 4,953 gpm flows to the Choloma River and approximately 9,961 gpm flows out of the Choloma Valley aquifer into the Sula Valley aquifer system. This result suggests that the current estimated extraction rate could be increased to 6,876 gpm on a long-term, continuous basis before groundwater discharge from the Choloma Valley aquifer system is taken from storage.

Transient model simulations indicate that it is possible to increase groundwater production in the Choloma Valley to 12,000 gpm although this magnitude of production increase will cause significant changes in the groundwater flow system underlying the valley. The majority of the groundwater need can be obtained from pumping groundwater from the current well field area located to the east of the municipality of Choloma. However, this area has the potential for continued population growth and development, which may have impacts on groundwater quality. A portion of the groundwater projected needs (approximately 60 percent) can be met by developing a well field to the west and up-gradient of the municipality. Although the Choloma Valley aquifer can support the water needs into the future, it is very important that a wellhead protection program be developed to protect the community's groundwater resources. Drawdowns produced by the additional pumping may impact shallow wells screened within the upper portion of the aquifer.

8.0 REFERENCES

Anderson and Woessner, 1992. *Applied Groundwater Modeling, Simulation of Flow and Advective Transport*, Academic Press.

Environmental Simulations, Inc., 1997. *Groundwater Vistas*.

McDonald, M.G. and Harbaugh, A.W., 1988. *A Modular Three-dimensional Finite-Difference Groundwater Flow Model*, United States Geological Survey Techniques of Water-Resources Investigations, Book 6, Chapter A1.

APPENDIX D

Water Resources Management System Users Guide

WATER RESOURCES MANAGEMENT SYSTEM USER'S GUIDE

Choloma, Honduras

June 2002

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1.0 INTRODUCTION

The Water Resources Management System (WRMS) is a desktop computer application developed to store, manage, and analyze technical information gathered and generated for this project. The application is a management tool that can be used by the municipalities and other decision-makers to sustain and manage their groundwater resources. The system is composed of both a data management system and a geographic information system linked together as one application. Through the WRMS, users can:

- Manage and generate reports for wells, storage tanks, and springs
- View well logs and well completion diagrams
- Analyze water quality and water level data
- Track statistics on water use
- View wells, water quality information, and aquifer characteristics on maps of the study area
- Identify and prioritize future well sites

The application consists of two primary components; a data management system and a geographic information system (GIS). The application is written so that the two components work together and function as one system. Data are shared back and fourth between the data management system and the GIS.

1.1 Overview

The WRMS consolidates the most critical water resource information for a municipality. It provides a central place to manage, analyze, and display water resource information in both map and tabular form. The WRMS accommodates all major types of information needed for sound water resource management including data on wells and other water sources, future demand and growth, infrastructure and organizational boundaries, and water quality and aquifer characteristics.

Because the system is designed to accommodate additional data as more information is collected and wells are created or modified in the future, it can be used to facilitate sound water resource decision-making in the future. Is easy to use and requires minimal training, which will facilitate continued system use. It uses a standard methodology for identifying and prioritizing future well sites, which will allow municipalities to continue to apply a consistent planning approach.

The WRMS is designed to work in conjunction with the findings of the Water Resources Management Report. Most of the data collected or developed for the report are contained in this system, and are available for further analysis, display, and incorporation with new data as it is collected. The system can be used to view and explore additional details of the existing water system, as well as explore in detail the conceptual model of the aquifer system and the groundwater modeling results.

The WRMS should be used to provide a common environment for communication among stakeholder agencies for water resource planning. The system provides a consistent view and methodology for analyzing water resource data. Consistently using it as a communication tool among stake-holders will make the sometimes confusing and complex technical information easier to understand. New data, such as new wells, additional sampling results, or new water level measurements should be entered into the system in order to have the most up-to-date information available for decision-making.

1.2 How to Use the Manual

This manual is divided into two parts:

- **Users Guide** – This section describes the application and use of the system from the users perspective. It explains the functionality of the system, presents step-by-step instructions for adding and managing data, creating reports, generating maps, and using the analysis tools. Anyone who needs to use the system should read this section to find the proper procedures for adding, managing, and analyzing data.

- **Administrators Guide** – This section describes the operation of the system and covers the procedures necessary to keep the system functioning properly. It is written for the person who is responsible for making sure the system is configured and operating properly.

2.0 USER GUIDE

This section explains how the system can be used to manage, analyze, and report on water resource data. First the organization of the data will be discussed, and then an overview of the functionality of the interface will be explained. Finally, the user will be walked through a series of common tasks that are typically performed using the system.

2.1 Data Organization

Figure 2-1 shows how the data are organized in the WRMS. The data organization is presented in a hierarchy shown on the left. The types of data collected at each level are shown on the right. The highest level of data is at the Municipality level. All other data entered into the system will be associated with a Municipality. Information collected at this level includes map data in the GIS system and pre capita growth/water consumption statistics for each municipality.

Within each municipality, there will be one or more service areas. A service area is a self-contained portion of the distribution system. It is comprised of wells, storage tanks, piping, and other infrastructure designed to supply a specific portion of the municipality. Typically, it is self-contained, with its own operating characteristics[1]. The user can store water usage information for each storage area (e.g. population served, pressure, and water usage).

Within each service area, there may be one or more wells and storage tanks. Most of the information stored in the WRMS is related to wells. For each well, its construction, location, and operational specifications can be stored. Water sample records and water level records can be entered, and scanned images can be loaded (e.g. well completion diagrams, photographs, and well logs). For storage tanks, operational and construction specifications can be entered.

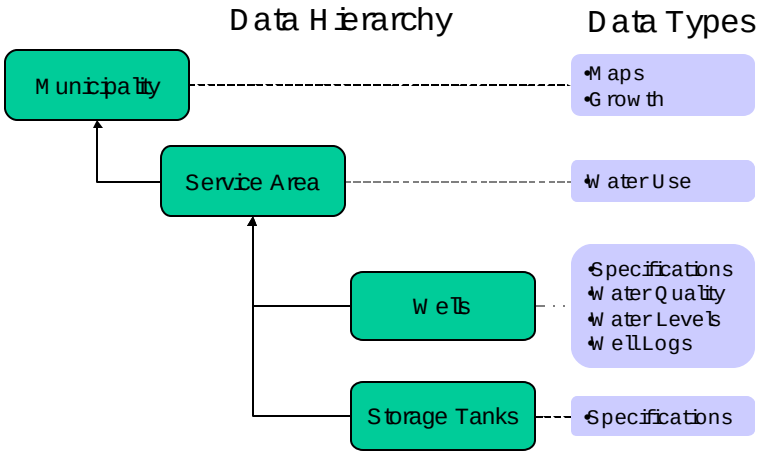

Figure 2-1. Data Organization

[1] This system is delivered with one service area defined for each municipality, which may or may not reflect the actual service area configuration for each municipality. The WRMS will work fine without changing this, however, the capability of redefining the service areas to more accurately reflect the conditions of each municipality is available. See Entering Infrastructure Data for more details.

2.2 User Interface

Once the application is started, the user is presented with a variety of options via the Main Menu at the top left-hand corner of the screen.

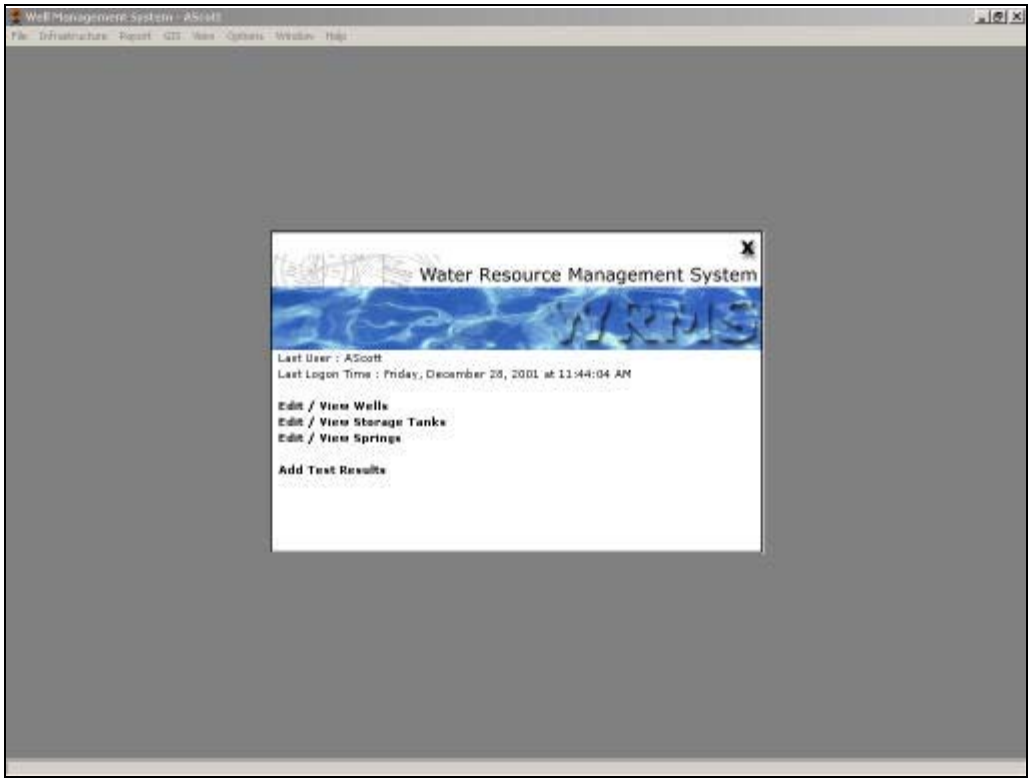

Figure 2-2. Startup Screen

The options available are:

- **FILE** – Exit the application.
- **INFRASTRUCTURE** – Used to manage data for the municipality, service areas, wells, and storage tanks.
- **REPORT** – Used to run reports and graphs for selected infrastructure data.
- **GIS** – Opens ArcView® to create maps or run the Well Site Prioritization tool.
- **VIEW** – Opens the USGS Database or the Water Resources Management Plan report.
- **OPTIONS** – Mostly an administrative area, it is where the user can change the language or to manage system configuration.
- **WINDOW** – Used to manage different application windows that are opened.
- **HELP** – Opens the help file for the WRMS.

2.3 Interface Terms

The following figure shows a typical interface screen and its components. The system functionality is selected via the **MAIN MENU** shown at the upper left-hand portion of the screen. Infrastructure components are navigated via the **DATA TREE** on the left. The **DATA TREE** allows the user to navigate through the infrastructure hierarchy. For example, each **MUNICIPALITY** contains a

SERVICE AREA, and each **SERVICE AREA** contains **WELLS** and **STORAGE TANKS**. Each element in the tree has a '+' box associated with it. Clicking on the '+' expands that branch of the tree. For example, clicking on the '+' next to **WELLS** opens a list of all wells within the selected **SERVICE AREA**. When the branch is expanded, the '+' symbol turns into a '-' symbol. Close the branch by clicking on the '-'. By expanding and contracting each branch, the user can quickly navigate to the desired information.

The area on the right is used to present information about the selected infrastructure element. In this example, the data entry screen for Well LC-1 is shown. This screen is composed of the following kinds of elements:

- **TEXT BOX**: Used for entering free-form text.
- **PICK LIST**: Used to make a select from a list. The lists are managed under **VALID VALUES** in the **OPTIONS** menu selection. See the Administrators Guide for more information.
- **CHECK BOX**: Represents a Yes (if checked) or No (if unchecked).
- **BUTTON**: Click on the button to initiate an action (e.g. Close the window, save data, etc.).

This terminology will be used throughout this Users Guide.

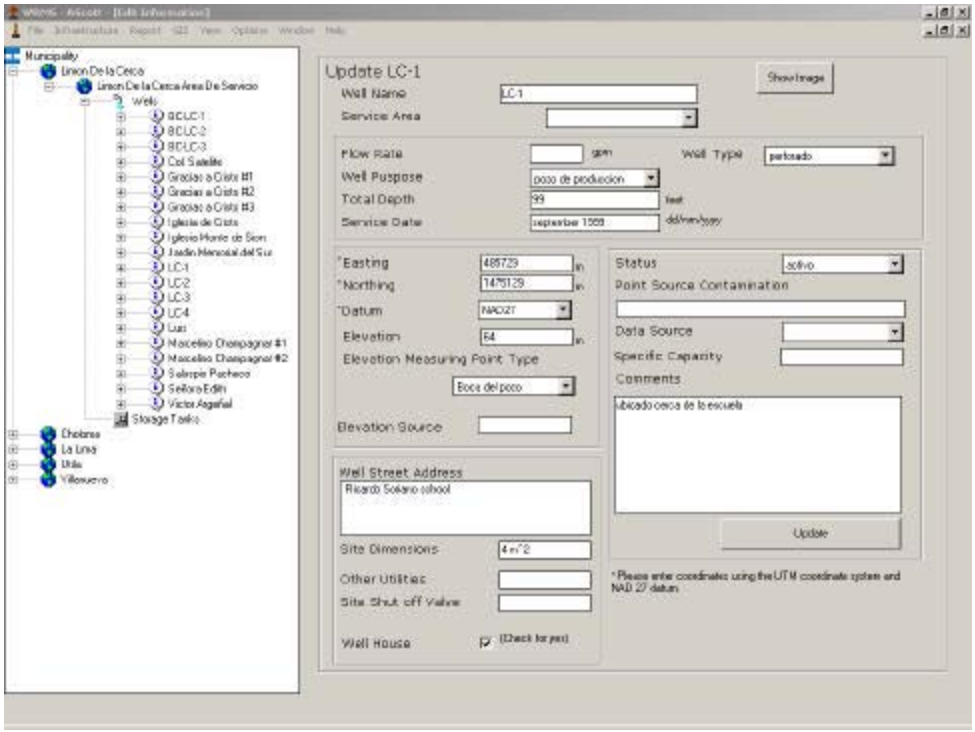

Figure 2-3. Interface Terms

Two additional terms are needed associated with the mouse-pointing device:

- **CLICK** – When instructed to click on something, point the arrow on the screen over the object and click the *left* mouse button.

- **RIGHT-CLICK** – When instructed to right-click, point the arrow on the screen over the object and click the *right* mouse button.

2.4 Common Tasks

This section describes the common tasks that can be performed using the WRMS. These are:

- Opening the application – How to start the WRMS.
- Changing the Interface Language – The WRMS interface can be translated between Spanish and English.
- Managing Infrastructure Data – Entering and managing data related to Municipalities, Service Areas, Wells, and Storage Tanks.
- Creating Reports – Generating standard reports for infrastructure data.
- Map Analysis – Using ArcView® to generate maps.
- Well Site Prioritization – Using the well site prioritization decision-support tool.
- Assessing Related Information – Opening up other applications.
- Getting Help – Accessing this manual on-line.

2.4.1 Opening the Application. This application comes already installed on the computers provided. To start the WRMS, do the following:

1. Click on the **START** button in the bottom left-hand corner of the screen to open the system menu.
2. Click on **PROGRAMS**. This will open a sub-menu of available programs and program folders
3. Click on on **WRMS**. The application will open when WRMS is clicked.

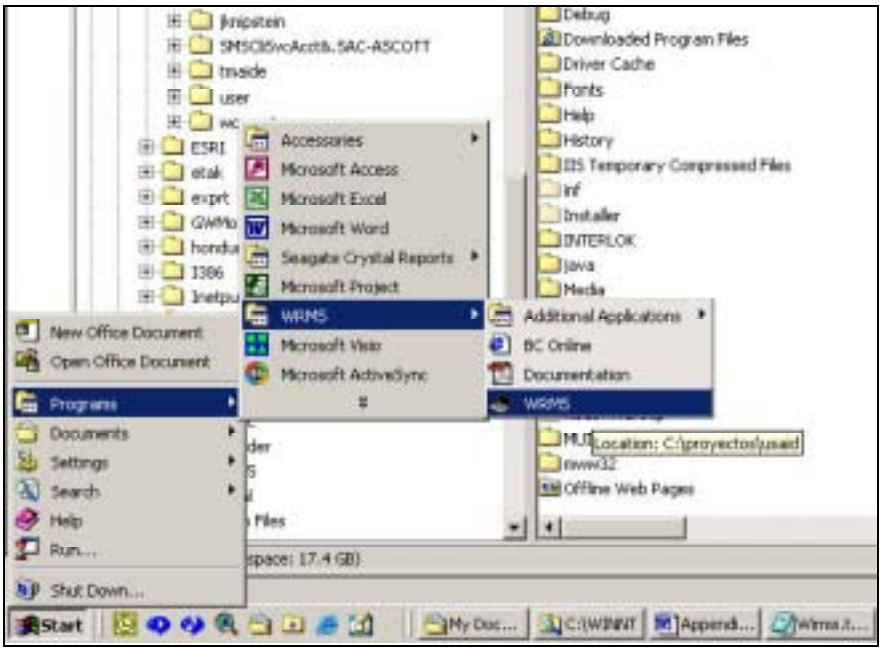

Figure 2-4. Starting the WRMS

2.4.2 Changing the Interface Language. The user may change the language used in the WRMS interface. To do this:

1. Click on **OPTIONS** from the menu. A sub-menu will appear.
2. Click on language from the sub-menu.
3. A pop window will appear with a list of available languages. Select the language desired and click **OK**.

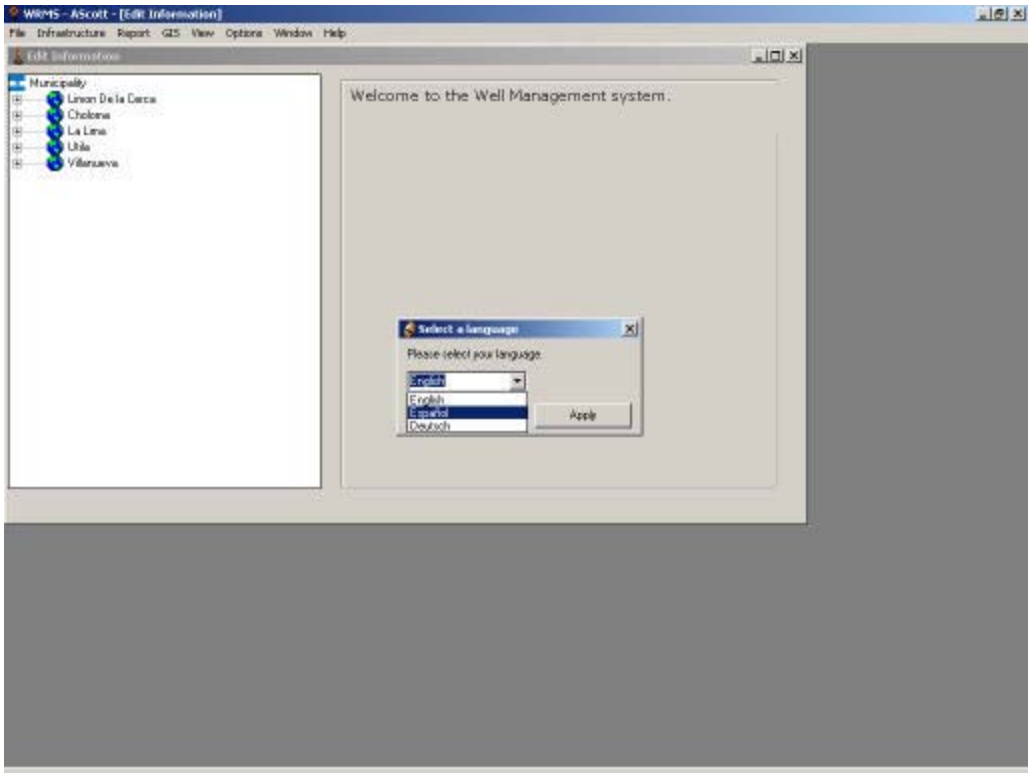

Figure 2-5. Changing the Language

The interface will be translated into the selected language.

Note: It may be necessary to close a window and re-open it for the translation to take effect. Also, if a phrase is not translated, it means that the translation has not been entered into the translation database. Please see the Administrators Guide for the steps to add a new translation.

2.4.3 Managing Infrastructure Data. Infrastructure data includes information on municipalities, service areas, wells, and storage tanks. These data are organized in a hierarchy in the database (see Data Organization, above) and are presented the same way in the user interface. To access the data entry and management screens:

1. Click on **INFRASTRUCTURE** from the **MAIN MENU**. A sub-menu for **WELLS** and **STORAGE TANKS** will appear.
2. Click on **WELLS** or **STORAGE TANKS**.

Selecting **WELLS** or **STORAGE TANKS** will open the **DATA TREE** and expand the desired branch of information. The first element of the desired type (either the first well or first storage tank) will be shown, presenting the general information for that particular record on the right. The user may then change or review any of the information associated. If data are changed, click on the **UPDATE** button to save the changes.

To navigate through the data, click on the desired branch. The branch will expand to the next level, allowing the user to view its contents. Depending upon the level selected, a data form will appear on the right. The table below shows the information provided at each level.

Table 2-1. Data Screens for Each Level

Level	Data Shown
Municipality	Growth and Water Consumption
Service Area	Service Area Characteristics
Wells	Well Depth Graph
Individual Wells	Well General Information
Individual Storage Tanks	Storage Tank General Information

2.4.3.1 Municipalities. Municipalities are the study areas defined for this project. Typically, they incorporate the urban and developed areas of a community, but may not include the entire municipal boundary. When a **MUNICIPALITY** is selected from the **DATA TREE**, water consumption data will be shown on the right. This is a simple table showing per-capita consumption per year. To enter a new record, click on the empty row on the bottom of the table. Enter the year, estimated population, and the average per-capita water consumption in gallons per day per person. The table can accommodate historical data as well as predicted growth. This information enables the user to view expected water consumption patterns over time.

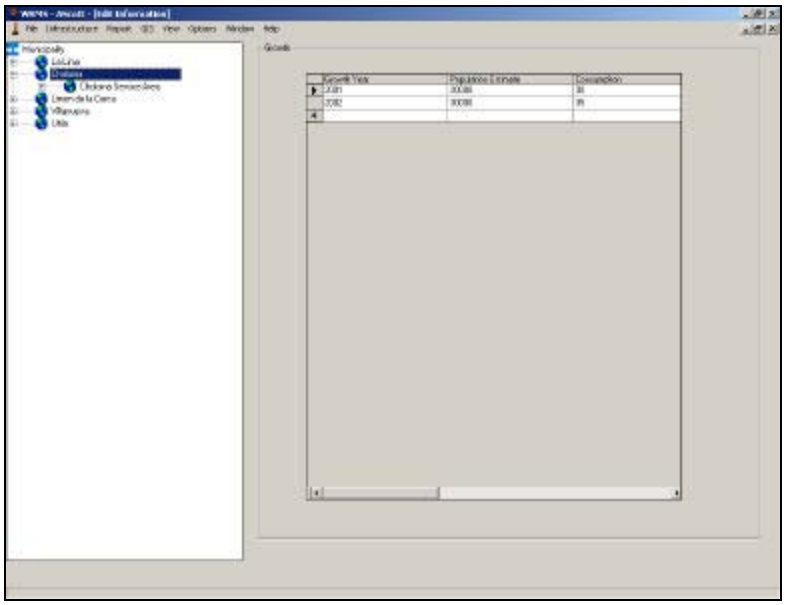

Figure 2-6. Predicted Growth Data Screen

2.4.3.2 Service Areas. To create a new **SERVICE AREA** for a **MUNICIPALITY**:

1. Click on the **MUNICIPALITY** desired, then right-click to bring up a popup menu.
2. Select **ADD SERVICE AREA**. A blank service area form will appear.

Enter the service area name and other data as desired, then click **UPDATE**. The **DATA TREE** will insert the new **SERVICE AREA**.

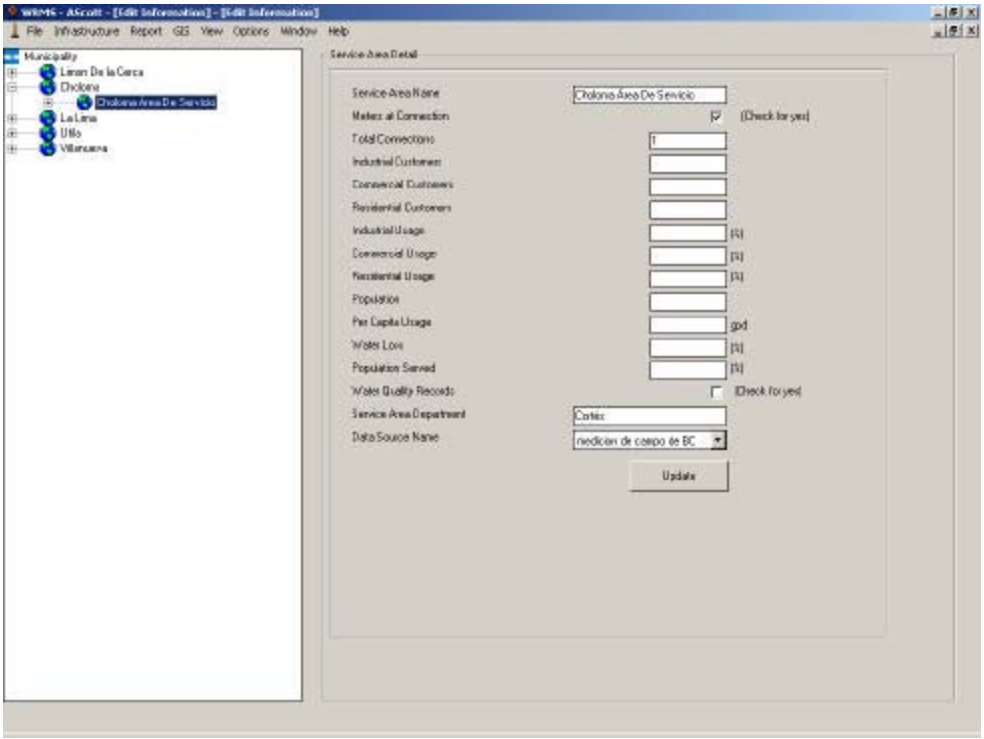

Figure 2-7. Service Area Data Screen

Clicking on an existing **SERVICE AREA** brings up a form displaying water consumption information for the area selected. This information can be entered for each service area for quick reference when evaluating service area needs. The following table describes the service area information:

Table 2-2. Service Area Data

Data Field	Description
Service Area Name	Enter the name of the Service Area
Meters at Connection (yes/no)	Check **YES** if present
Total Connections	Enter number
Industrial Customers (number)	Enter number
Commercial Customers (number)	Enter number
Residential Customers (number)	Enter number
Industrial Usage	Percent of total usage
Commercial Usage	Percent of total usage
Residential Usage	Percent of total usage

Data Field	Description
Per Capita Usage	Gallons per person per day
Percent Water Loss	Percent of total production
Percent Population Served	Percent of total service area population
Water Quality Records?	Check if water quality records are available
Service Area Municipality	Pick municipality name from pick list
Service Area Department	Pick department name from pick list
Data Source	Select data source. If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.

2.4.3.3 Wells. To add a new well to a service area:

Click on the desired **SERVICE AREA** and right-click the mouse. A pop-up menu will appear.

Select **ADD WELL TO SERVICE AREA**. A blank entry form will appear. Enter the new well name and it will be added.

Click on the desired data field and enter the desired information. Click on the **UPDATE** button to save. The new well will be added to the database.

2.4.3.4 General Information. Clicking on a **SERVICE AREA** opens up two additional branches: **WELLS** and **STORAGE TANKS**. Clicking on **WELLS** will expand that branch to show all the wells associated with the service area. Clicking on an individual **WELL** opens the general information form for the well.

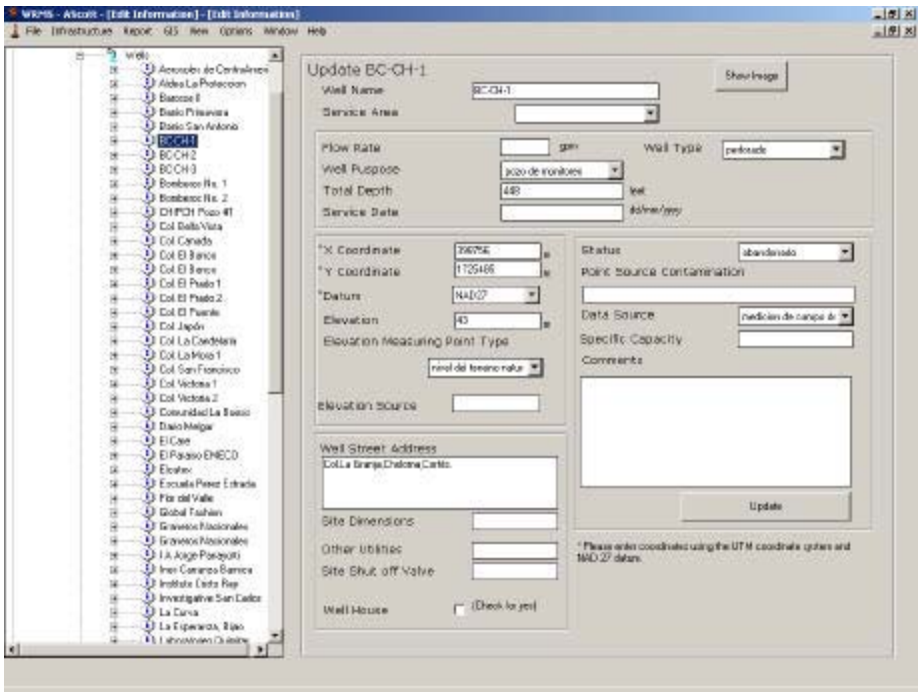

Figure 2-8. Well General Information

The table below describes the data fields available in the **WELL GENERAL INFORMATION** screen.

Table 2-3. Well General Information Data Fields

Data Field	Description
Well Name	Name of the well
Assign a New Service Area	Use the pick list to assign the well to a new service area
Flow Rate	Enter the flow rate in gallons per minute
Well Purpose	Select the purpose of the well from the list
Total Depth	Enter the total well depth in feet
Service Date	Enter the date the well went into service
Well Type	Select the type of well from the list. . If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.
Easting	Enter the easting coordinate in UTM meters, NAD27
Northing	Enter the northing coordinate in UTM meters, NAD 27
Datum	Select the datum used. If not known select unknown.
Elevation	Enter the well elevation in meters
Elevation Measuring Point Type	Select the type from the list
Elevation Source	Enter source (GPS, survey, map coordinates, etc.)
Well Street Address	Enter address, if known
Site Dimensions	Enter dimensions of site
Other Utilities	Enter other utilities present on site
Site Shut off valve	If present, describe location
Well House	Check if present
Status	Select current status of well from list
Point Source Contamination	List any potential contamination sources present
Data Source	Select data source of this information
Specific Capacity	Enter specific capacity of the well
Comments	Any additional information can go here.

Once data edits are complete, click on the **UPDATE** button to save changes.

Note: Coordinate must be entered in UTM meters using the NAD27 datum in order for the location to be properly placed on the GIS map. The user has the option of storing the coordinates using other datum, but these will not show up properly on the GIS map. It is important that these data be recorded accurately and correctly to avoid confusion about their physical location when display with other data.

2.4.3.5 Adding Images. Images and other electronic files, such as .jpg files of well completion diagrams, boring logs, spreadsheets of technical data, and site photographs can be loaded into the database for each well. To load a new image:

1. Click on the **SHOW IMAGES** button. This will open a pop-up window.
2. Click on **ADD**. A file navigation window will appear.

3. Navigate to the desired image or file.
4. Click on the image file and click the **SAVE** button.

If images are already present, they will be shown in the list. Double-click on an image to view it.

2.4.3.6 Construction. Clicking on an individual **WELL** opens these additional options:

- **CONSTRUCTION** – View/edit the well construction details
- **OPERATIONS** – View/edit the well operation details
- **SAMPLES** – View/edit the water quality samples for the well
- **WATER LEVELS** – View/edit the water level data for the well

An empty well construction record is automatically created when a new well is created. To update a construction record for a well:

1. Click on the desired **WELL** so that the **GENERAL INFORMATION** screen is showing,
2. Click **ON WELL CONSTRUCTION** in **THE DATA TREE**. The well construction data screen will appear.

Enter the desired construction data and click the **UPDATE** button. Construction details will be added for the well.

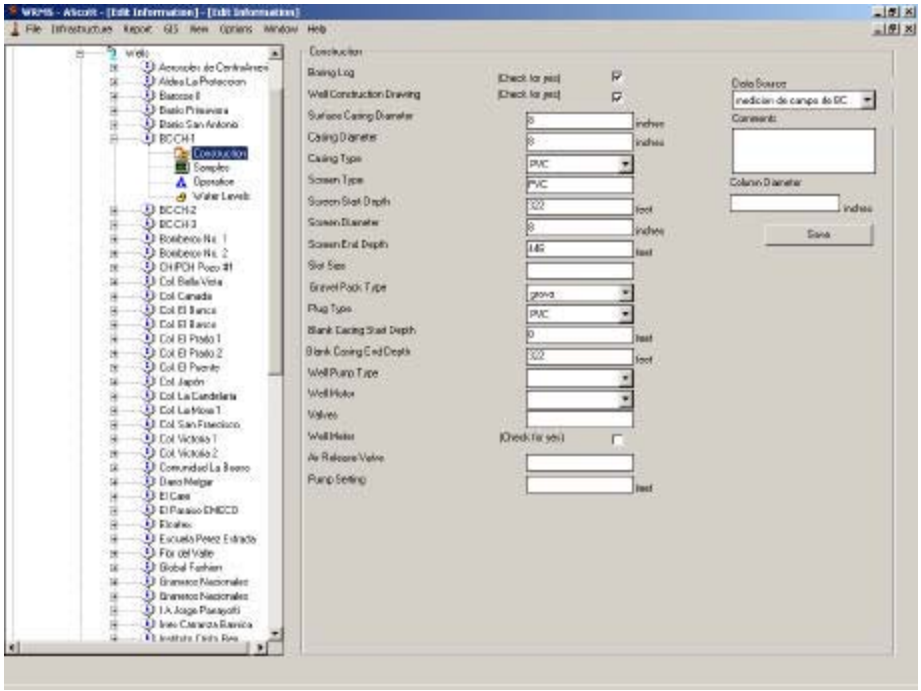

Figure 2-9. Well Construction Details Screen

The table below describes the data fields available in the **WELL CONSTRUCTION** screen.

Table 2-4. Well Construction Data Fields

Data Field	Description
Boring Log	Check (**YES**) if a boring log is available.
Well Construction Drawing	Check (**YES**) if a well construction drawing is available
Surface Casing Diameter	Enter the surface casing diameter if different from the casing diameter, in inches
Casing Diameter	Enter the casing diameter for the well, in inches
Screen Diameter	Enter the screen diameter for the well, in inches
Casing Type	Pick the casing type from the list. If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.
Screen Type	Pick the screen type from the list
Screen Start Depth	Enter the start depth, in feet from the ground surface, for the first screen
Screen End Depth	Enter the end depth, in feet from the ground surface, for the last screen
Slot Size	Enter the slot size for the screen
Gravel Pack Type	Pick the gravel pack type from the list
Plug Type	Pick the plug type from the list
Start Casing Depth	Enter the start depth, in feet from the ground surface, for the beginning of the casing
End Casing Depth	Enter the end depth, in feet from the ground surface, for the end of the casing.
Well Pump Type	Pick the type of well pump from the list
Motor	Enter the rating of the motor, in horsepower (hp)
Valves	Enter the types of valves present
Well Meter	Check if the well flow is metered
Air Release Valve	If an air release valve is present, describe
Pump Setting	Enter the depth of the pump setting from the ground surface, in feet
Data Source	Pick the data source for the construction information from the list
Comments	Enter any comments about the well construction
Column Diameter	Enter the column diameter in inches

2.4.3.7 Operation. When a new well is created, an operation record is automatically created for it. To update the data for a well:

1. Click on the desired **WELL** so that the **GENERAL INFORMATION** screen is showing,
2. Click on **OPERATION** in the **DATA TREE**. The well operation data screen will appear.

Enter the desired construction data and click the **UPDATE** button. Operational information will be added for the well.

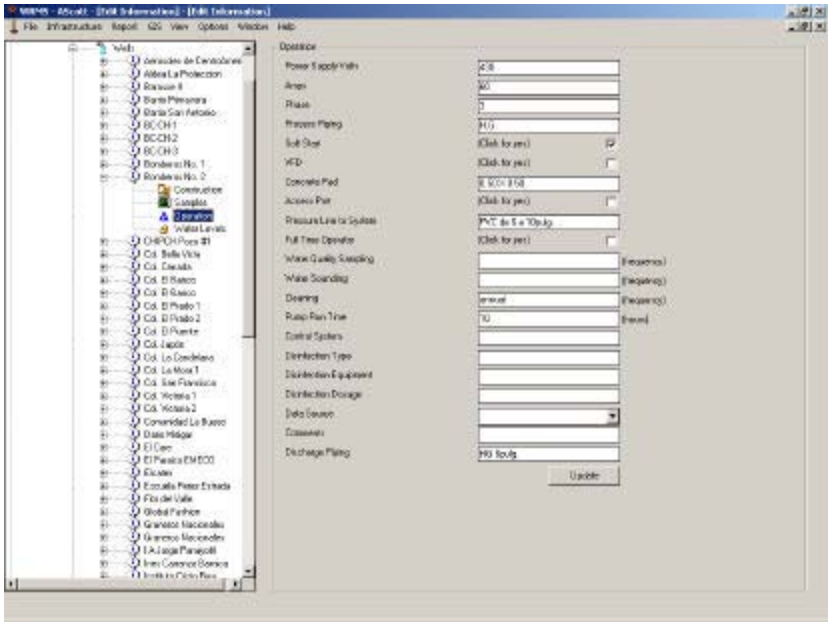

Figure 2-10. Well Operation Data Screen

The table below describes the data fields available in the **WELL OPERATION** screen.

Table 2-5. Well Operation Data Fields

Data Field	Description
Power Supply Volts	Enter the voltage of the power supply
Amps	Enter the amperage of the power supply
Phase	Enter the number of phases for the power supply
Soft Start	Check if a soft start device is present
VFD	Check in a variable flow device is present
Concrete Pad	Describe the concrete pad
Access Port	Check if an access port is present
Pressure Line to System	Describe the line to the system
Full-time Operator (yes/no)	Check (**YES**) if there is a full-time operator at the well
Frequency of Water Quality Sampling	Enter the frequency of water quality sampling (e.g. monthly, semi-annually, etc)
Frequency of Water Sounding	Enter the frequency of water level measurements
Frequency of Cleaning	Enter the frequency of cleaning
Pump Run Time	Enter the number of hours a day the pump is set to run
Control System	Describe the control system, if any
Disinfection (yes/no)	Check (**YES**) if there are any disinfection practices
Disinfection Type	Pick the type of disinfection from the list. If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.

Data Field	Description
Disinfection Equipment	Describe disinfection equipment
Disinfection Dosage	Enter the amount, including units (e.g. 10 mg/l)
Data Source	Pick the data source for the construction information from the list
Comments	Enter any additional operation comments
Discharge Piping	Describe the discharge piping

2.4.3.8 Water Quality. Water quality sample results can be stored and viewed for each well. The data are organized by sampling event. Each sampling event must be entered into the system in order to record the resulting water quality. Three types of information are needed to enter water quality information:

- **CHAIN-OF-CUSTODY (COC)** – Information about the form used to describe the sample for the analyzing laboratory.
- **SAMPLE** – The type of sample taken. A COC can contain more than one sample. Multiple samples can be entered for one COC.
- **RESULTS** – The analytical results from the tests performed at the laboratory. Each sample will have one or more test results.

Please see the Sample Manual Reference for more details on water quality sampling procedures.

To enter new water quality sampling results, navigate to the desired well in the **DATA TREE** and click the '+' to open well options. Click on the **SAMPLES** option. An empty grid will be shown on the right like the one below.

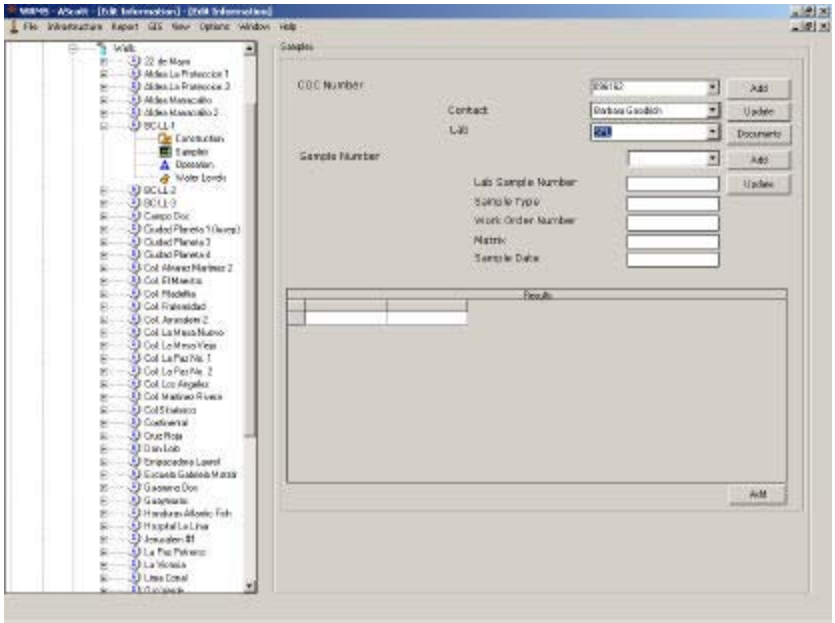

Figure 2-11. Initial Form for Water Quality Samples

Start by entering a new chain-of-custody number. Click on the upper-most **ADD** button. A popup form will appear prompting the user to enter the COC number, sampler, and analytical laboratory. Enter the data and click the **UPDATE** button.

Note: As a best practice, a unique COC number should be present on every chain of custody in order to accurately track and identify the samples when communicating with the laboratory or identify the sample results. A COC number must be entered for each sampling event. If no number is available, create a number that will be unique within the database. A good system, for example, would be to use the following pattern:

UNK-{Well Name}-{DDMMYY}

For well LC1 sampled on October 28, 2001 the COC number would be:

UNK-LC1-281001

By concatenating the well name and the sample date, a unique identifier can be created.

Descriptions of all the COC fields are shown in the table below:

Table 2-6. Chain-of-Custody Data Fields

Data Field	Description
COC Number	Unique chain-of-custody number. See Note describing required COC numbering
Contact	Pick the name of the person in responsible for the sampling. If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.
Laboratory Name	Pick the name of the laboratory responsible for the analysis.

Once the COC is created a sample number must be entered. This sample number is the number for the sample identified on the COC. To enter a new sample, click on the second **ADD** button. A popup screen will appear prompting the user for sampling information.

When adding a new sample, make sure that the correct COC is selected. The sample number, sample name, laboratory sample number (enter UNKNOWN if not available) and sample date are required fields. The following table shows the sample data fields.

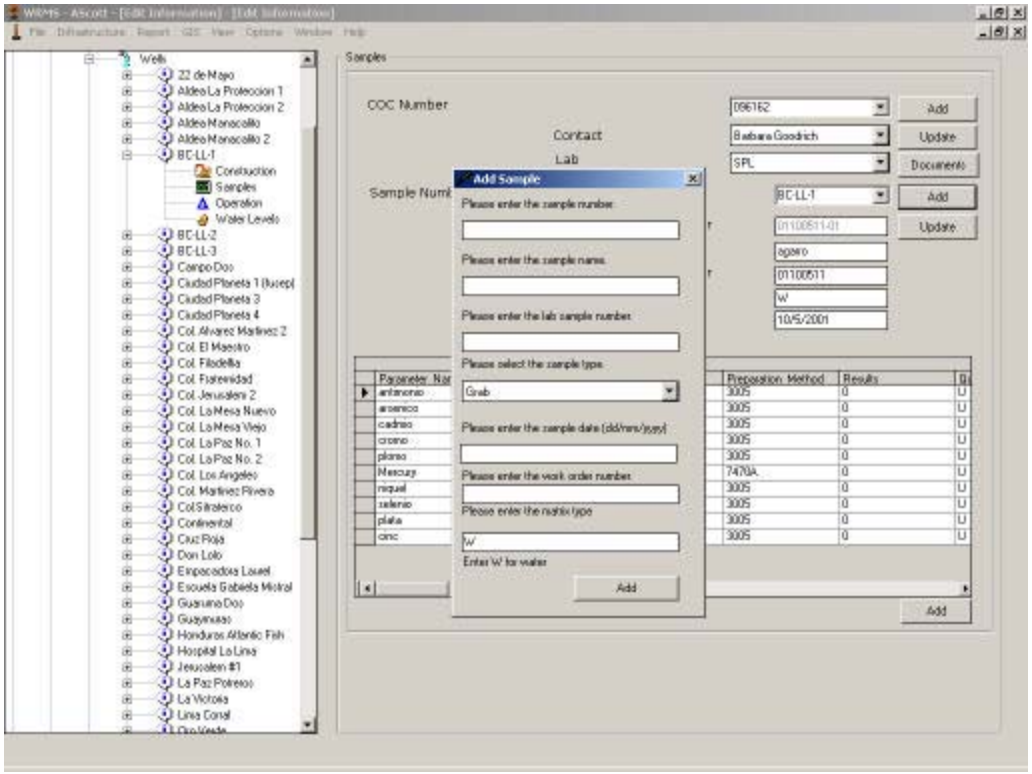

Figure 2-12. Sample Data Entry Screen

Table 2-7. Sample Information Data Fields

Data Field	Description
Sample Number	Designated sample number. This field is required
Sample Name	Name of sample, if used.
Laboratory Sample Number	Sample number designated by the laboratory. Enter UNKNOWN if not available.
Sample Type	Pick the sample type from the list. Grab sample is the most common type
Sample Date	Date sample was taken
Work Order Number	Number of the work order, if used
Matrix	Matrix of the sample. W, or Water, is most common

Once the sample is entered, analytical results can now be entered into the system. To start adding results click the third **ADD** button. A pop-up screen for sample results will be displayed.

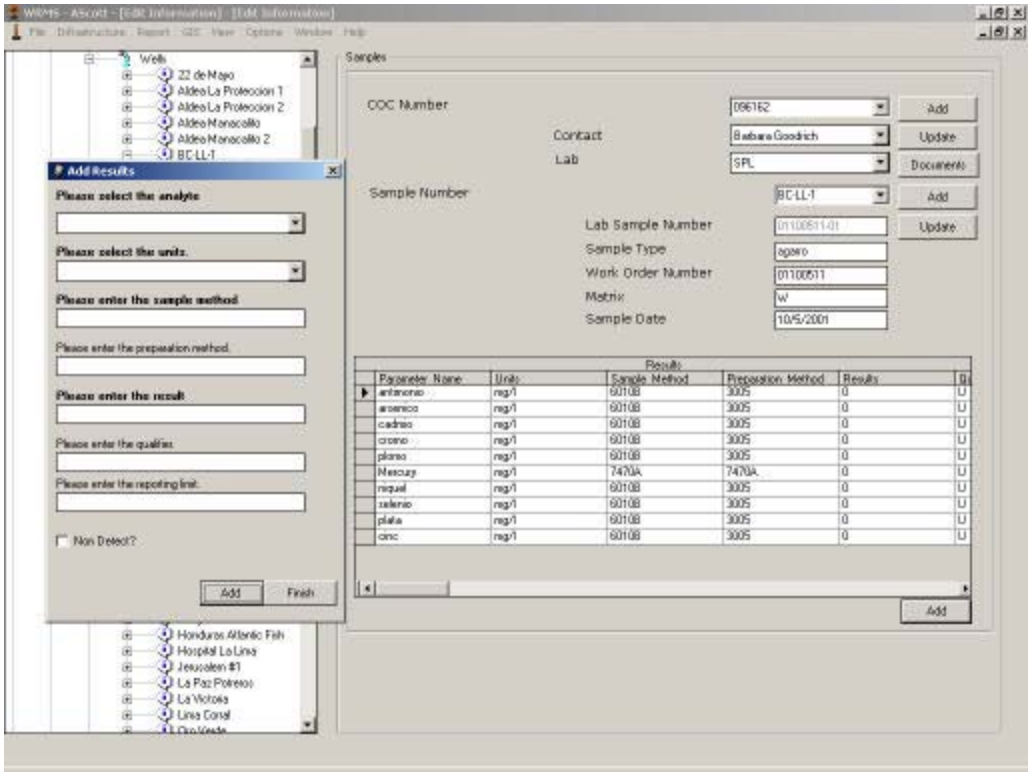

Figure 2-13. Analytical Results Data Entry Screen

The following table shows the results data fields.

Data Field	Description
Analyte Name	Pick the analyte name from the list
Units	Pick the analysis units from the list
Sample Method	Pick the analysis method from the list
Preparation Method	Pick the preparation method from the list, if known
Result	Enter the result. If it is a non-detect, enter 0, and check (YES) the ND checkbox. Otherwise, enter the value. See note below.
Qualifier	Enter any data qualifiers identified by the laboratory
Method Reporting Limit	Enter the reporting limit if known. Required for non-detects.
ND Flag	Check (YES) if the result is a non-detect.

Note: Typically a laboratory will report a non-detect as 'less than a specified reporting limit' as the result. For example, if a result of '< 5 mg/l' is reported by the laboratory, where '<' indicates that the nothing was detected and '5 mg/l' is the reporting or detection limit tested against. To report non-detects in the database:

- *Enter a zero (0) in the* **RESULTS** *field.*
- *Check (***YES***) the* **ND CHECKBOX**
- *Enter the reporting limit in the* **METHOD REPORTING LIMIT** *field.*

This procedure must be followed in order for the reports to properly format non-detect results.

To view water quality results for a well, navigate to the well in the **DATA TREE**, expand the options for the well, and click on **WATER QUALITY**. Select the desired **COC** and **SAMPLE** from the pick list. The analytical results will be displayed in the grid below.

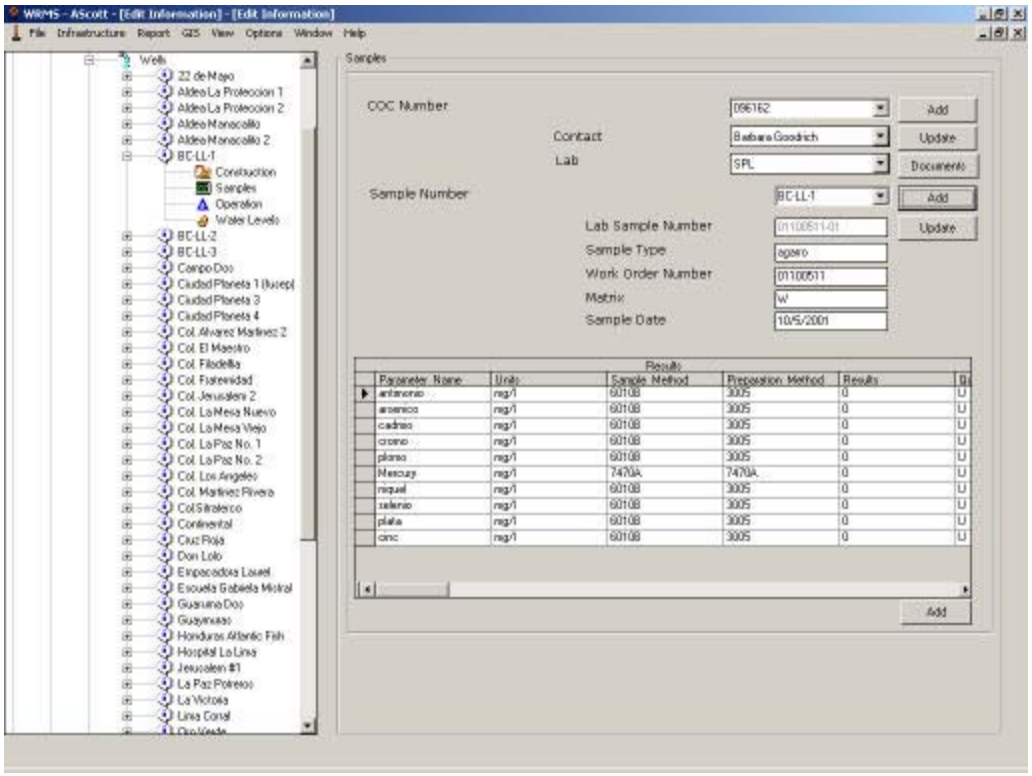

Figure 2-14. Analytical Results Table

To view an analytical summary for the well, go to the **REPORT** menu and select the **HITS REPORT**. See the Creating Reports section below for further details.

2.4.3.9 <u>Water Levels.</u> Water level measurements can be stored for each well by clicking on the **WATER LEVELS** option under the desired well in the **DATA TREE**. This will open a table of water levels for the well. To add one, click on the **ADD** button. A pop-up window will appear, prompting for entry of a new water level measurement. Enter the data and click on the **OK** button to save the entry. The following table shows the data elements associated with water levels.

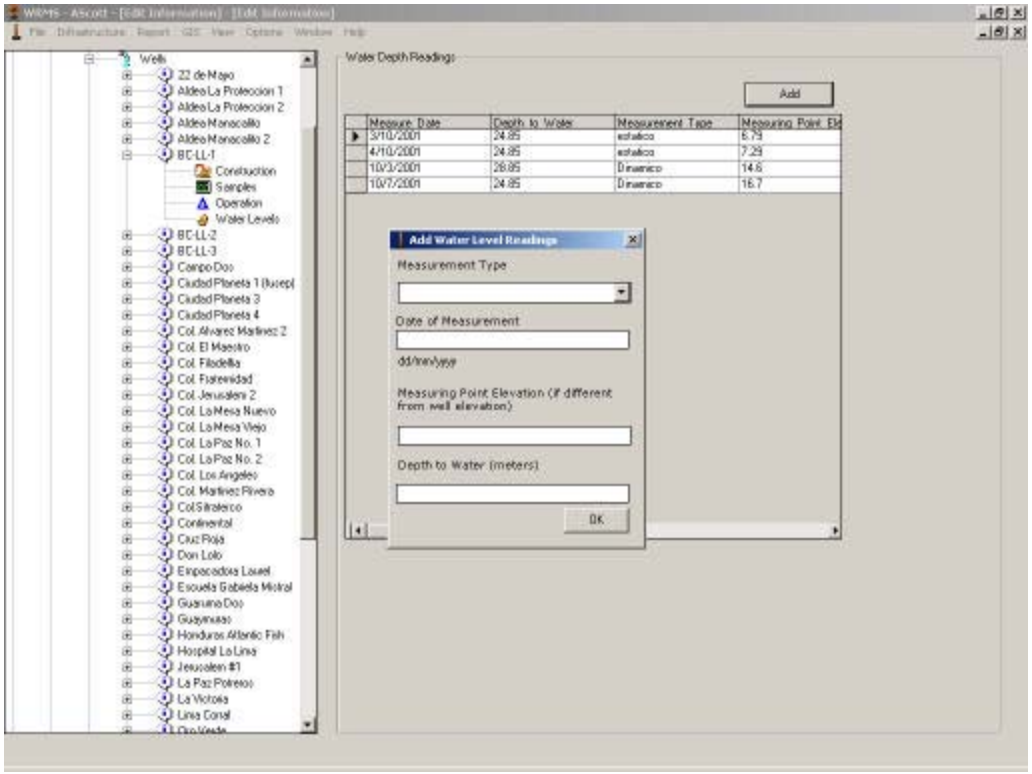

Figure 2-15. Water Level Measurement Data Entry Form

Data Field	Description
Measure Date	Enter the date the measurement was taken (DD/MM/YYYY)
Water Level	Enter the depth to water, in meters
Measurement Type	Pick the type of measurement (e.g. static or dynamic)
Measuring Point Elevation	Enter the elevation of the measuring point, in feet, if different from the well elevation. This is important in order to accurately identify the water table elevation at the well.

2.4.3.10 Storage Tanks. Storage tanks within a service area are also stored in the WRMS. To navigate to storage tanks, expand the **STORAGE TANKS** branch of a particular service area.

To enter a new storage tank, click on the **SERVICE AREA** and right-click the mouse. A popup menu will appear. Select **ENTER STORAGE TANK**. A blank storage tank form will appear, prompting for the name of the new storage tank. Enter the name and click **OK**. A new storage tank will be entered into the database.

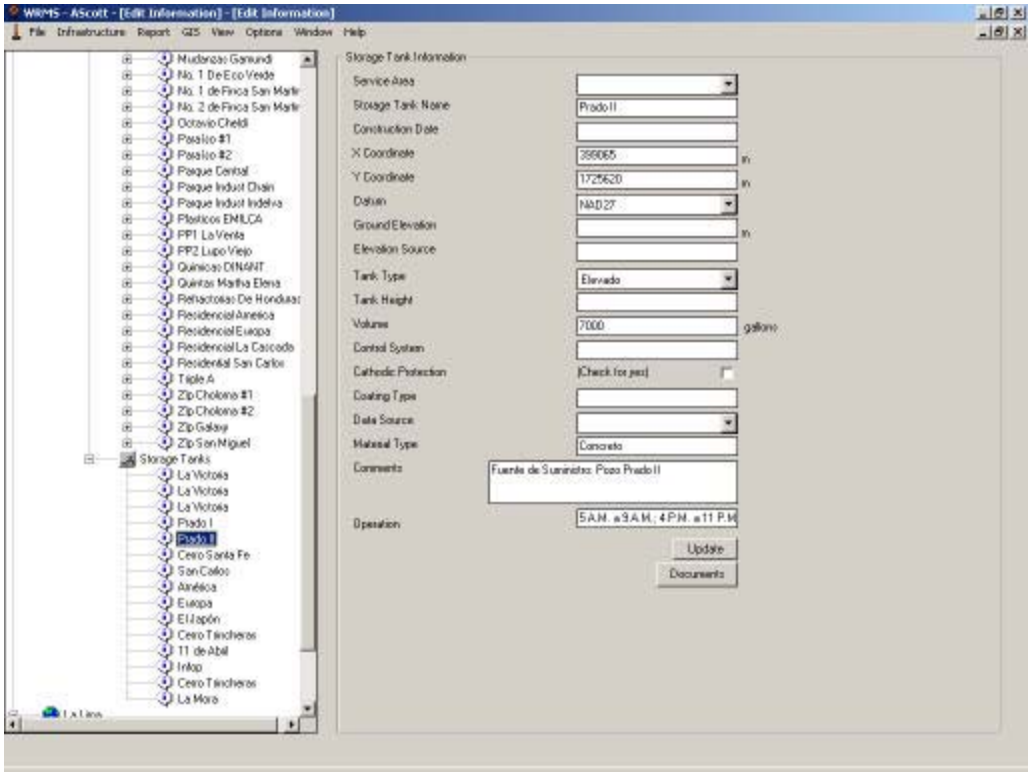

Figure 2-16. Storage Tank Data Entry Screen

The following table shows the data elements for storage tanks:

Data Field	Description
Service Area	Pick a service area from the list to change the designated service area
Storage Tank Name	Enter the name of the storage tank
Construction Date	Enter the construction date
Easting	Enter the Easting Coordinate in UTM meters., NAD27 Datum.
Northing	Enter the Northing Coordinate in UTM meters, NAD27 Datum.
Datum	Enter the Datum (e.g. NAD 27, WGS 84)
Elevation	Enter the elevation in meters
Elevation Source	Enter the source of elevation data (GPS, survey, map coordinates, etc)
Tank Type	Pick the type of tank from the list
Tank Height	Enter the height of the tank in meters
Volume	Enter the volume of the tank in gallons
Control System	Describe the Control System, if any
Cathodic Protection	Check (YES) if cathodic protection is available
Coating Type	Pick the type of coating from the list
Material Type	Pick the type of material from the list
Operation	Enter the hours of operation or enter continuous if operated 24 hours a day
Comments	Enter other descriptive information here

Data Field	Description
Data Source	Pick the source of the data. If selection is not available, it may be entered into the pick list. See the Administrators Guide for details on adding valid values.

Note: Coordinate must be entered in UTM meters using the NAD27 datum in order for the location to be properly placed on the GIS map. The user has the option of storing the coordinates using other datum, but these will not show up properly on the GIS map. It is important that these data be recorded accurately and correctly to avoid confusion about their physical location when display with other data.

2.4.4 Creating Reports. The WRMS allows the user to create standard reports from information in the database. These reports are tabular or graphical output that can be viewed on screen or printed to a standard printer.

The following reports are available:

- **HITS REPORT** – Lists all the positive analytical results for a selected well.
- **ANALYTE TREND** – Presents a linear graph showing concentration over time for a selected analyte for a well.
- **WELL CONSTRUCTION** – Print out well construction specifications for a set of wells.
- **WELL EQUIPMENT** – Lists equipment installed on selected wells.
- **WELL OPERATIONS** – Presents operational, maintenance, and cleaning information for wells.
- **STORAGE TANKS** – Lists storage tank specifications.
- **MUNICIPAL GROWTH** – Shows historical and projected growth and consumption information for municipalities.
- **SERVICE AREA STATISTICS** – Lists water consumption and use information for a service area.

Each report will be created using a similar process. To create a report:

1. Click on **REPORTS** on the main menu. The reports submenu will open up.
2. Click on the desired report from the submenu.
3. Once a report is selected, a series of popup windows will open prompting the user to make selections. For example, the **ANALYTE TREND REPORT** prompts the user to select one or more wells and then one or more analytes to display.
4. When selection is complete, the report will be generated for the wells identified.

2.4.5 Map Analysis. The WRMS can be used to create customized maps of water resource data. This is done using ESRI's ArcView® software. ArcView® is a geographic information system (GIS) used to view, analyze, and print customized maps and data.

ArcView® is integrated into the WRMS so that the user can launch a customized project from the WRMS user interface. This will open ArcView® showing all available GIS data for the municipality. The user will then turn on or off specific layers, change the map extent, interactively query the database for wells or storage tanks, and print out maps on a standard printer.

In order to the most flexibility and to leverage the existing capability of the ArcView® software, the standard ArcView® user interface has been used with minor enhancements. This users guide will present a brief overview of the inherent capabilities of ArcView®. For a detailed discussion using ArcView®, please see 'USING ARCVIEW GIS' users guide that comes with ArcView® or access the on-line help by clicking on **HELP; HELP TOPICS** from the menu bar.

The ArcView® system draws data from the WRMS database. For example, the coordinates for wells and storage tanks are derived directly from the database. Other information can be queried or viewed on the maps as well.

To open ArcView® from the WRMS, click on **GIS** from the main menu. A submenu will appear. Click on **BASE MAP**. This will open ArcView® and show all available data.

The figure below shows the main components of the ArcView® interface:

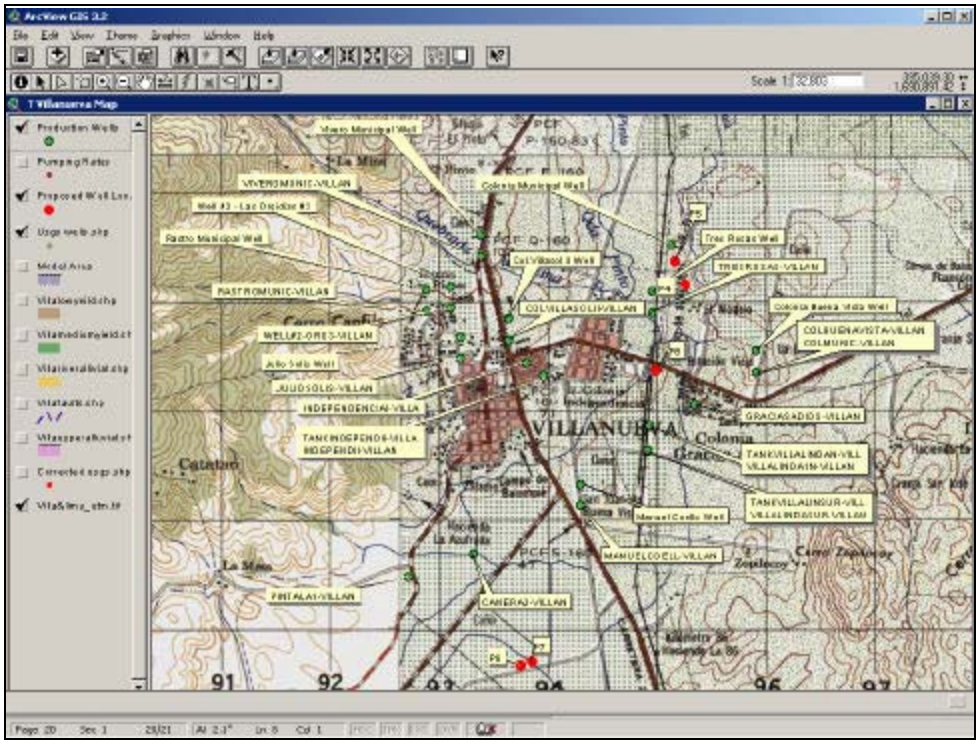

Figure 2-17. ArcView® Interface

The **MENU BAR**, **BUTTON BAR**, and **TOOL BAR** contain functions and controls for manipulating the map information, which is displayed in the map display area. The **LEGEND** is used to turn on and off data layers, and to change colors or symbols. The **MAP DISPLAY AREA** is where the map's elements are displayed.

Below, some of the most common ArcView® functionality is described, to enable the user to perform basic operations. Detailed description of ArcView® is beyond the scope of this document.

2.4.5.1 Close the ArcView® Interface. ArcView® is opened automatically when **BASE MAP** is selected from the **GIS** option on the WRMS main menu. This will open a separate ArcView® session every time the menu choice is selected. ArcView® and the WRMS window can both be open and operational simultaneously. To close the ArcView® session, select **FILE; EXIT** from the ArcView® Menu Bar. Alternatively, click on the 'X' in the upper right corner of the window. The user may be prompted to save changes before exiting. Saving changes will enable ArcView® to open to the same settings that were in place when the session was closed. Otherwise, ArcView® reverts to the previously saved settings.

2.4.5.2 Save Changes. The user can save changes made during the ArcView® session at any time. Either click on the **SAVE** button on the tool bar, or select **FILE; SAVE PROJECT** from the menu bar

2.4.5.3 Turn On or Off Layers. Each map layer that can be displayed is shown in the legend on the left side of the screen. Turn on each layer by clicking on the checkbox to check it. The map display area will be redrawn with the new layer shown. Uncheck the box to turn off the layer.

Each map layer (called a 'Theme' in ArcView®) corresponds to a source data file, called a Shapefile. Shapefiles each have an extension (file suffix) of 'shp' and are stored as regular files on the computer system. The shapefile contains the graphics and attribute data necessary to select and display information in the map display area. Please see the 'USING ARCVIEW GIS' users guide or access the on-line help (by clicking on **HELP; HELP TOPICS** from the menu bar) for more information on manipulating and adding shapefiles.

2.4.5.4 Change Symbol. The symbols for each of the map layers can also be changed. To do so, click on the layer so that it is highlighted by a box, then click on the **EDIT LEDGEND** button on the tool bar. This will open the legend editor pop-up window. Double click on the symbol (put the pointer on the symbol and click the left mouse button twice rapidly) to open the symbol window. Chose a new symbol, color, or line symbol and click the 'X' in the upper right hand corner of the symbol window. When the symbol window has closed, click on the **APPLY** button on the legend editor window to update the map with the new symbol. Close the legend editor window by clicking on the 'X' in the upper right hand corner.

2.4.5.5 Zoom In or Out. The geographical extent of the map view can be changed by zooming in or out. To zoom in (examine a smaller area in more detail), click on the **ZOOM IN** button on the tool bar. The cursor will change to a cross. Place the cursor on the new upper left-hand corner, press *and hold* the left mouse button. Drag down and to the right to define the new area for the map. When the button is released, the map will be redrawn to the new boundaries in the map display area. To return to the previous image, click on the **PREVIOUS EXTENT** button on the button bar.

To zoom out (see more area), click on the **ZOOM OUT** button on the tool bar. Place the pointer in the center of the map display area and click the mouse. The area will be enlarged by a power of two. Continue to zoom out until the appropriate display is shown.

To get out of zoom mode, click on the **POINTER** on the tool bar .

2.4.5.6 Pan. The user may want to move to a new area of the map without changing the scale of the display. This is called a pan. To pan, click on the **PAN** button on the tool bar . The pointer will turn into a hand.

Place the hand on the location on the map that will become the new center in the map display. Press *and hold* the left mouse button. Drag the location to the center of the display. The map will be dragged over to become the new center of the display.

To get out of zoom mode, click on the **POINTER** on the tool bar .

2.4.5.7 Identify Data. ArcView® allows the user to explore associated data for any of the data layers shown. To do so, click on the desired data layer in the **LEGEND** so that it is highlighted with a box. Then, click on the **IDENTIFY** button on the tool bar . The pointer will become an 'i' with cross-hairs. Put the pointer over the desired feature and click the mouse. A popup window will appear showing related data for the feature selected.

To get out of zoom mode, click on the **POINTER** on the tool bar .

2.4.5.8 Measure Length. To measure the distance between map features, click on the **MEASURE** button on the tool bar . The pointer will turn into a ruler. Click on a point to begin measurement. Click as many times as needed to define the line (the measurement does not have to be a straight line). The segment length and total length will be shown on the status bar on the bottom left-hand side of the screen. When finished double-click the last point.

To get out of zoom mode, click on the **POINTER** on the tool bar .

2.4.5.9 Print a Map. There are two ways to print a map. Either print the current view or create a layout for printing. Printing the current view is a quick way to produce a paper copy. Using a layout allows the user to produce a more formal map.

To print the current view, click on **FILE; PRINT** from the menu bar. A printer popup window will appear. Click **OK** to print

To create a default layout for printing, click on **VIEW; LAYOUT** from the menu bar. This will open the **LAYOUT MANAGER** popup window. Select the **LAYOUT TEMPLATE** and click **OK**. Select a new layout and click **OK**. A new layout will be created for printing. To print the layout, make sure the layout window is the active window (click on the layout once to make sure). Then print using the **FILE; PRINT** menu selection from the menu bar.

Close the layout by clicking the 'X' in the upper right-hand corner of the window.

For a detailed discussion on customizing layouts, please see 'USING ARCVIEW GIS' users guide that comes with ArcView® or access the on-line help by clicking on **HELP; HELP TOPICS** from the menu bar.

2.4.5.10 Well Classification. Well data can be displayed in the current view. The wells will be color coded by the type of data selected. The types of data that can be displayed for wells are:

- **TOTAL DEPTH** – Plots the wells by total well depth (in feet),
- **STATUS** – Plots the wells by their status (e.g. active, abandoned),
- **WELL TYPE** – Plots the wells by their construction type (e.g. bored, hand dug),
- **WATER LEVEL** – Plots the wells by their water level elevation,
- **WQ PARAMETER** – Plots the wells by the concentration of a selected analyte.

To plot well classifications, do the following:

1. Select **WELL ANALYSIS** from the menu bar. This will open a sub-menu.
2. Select **WELL CLASSIFICATION** from the submenu. A pop-up window will appear.
3. Select the desired well classification. Once selected, the well symbols will be color coded by the type of classification selected.
4. (For **WQ PARAMETER** only**)** An additional menu will appear listing the analytes that can be plotted. Select the desired analyte.
5. (For **WQ PARAMETER** only**)** Once an analyte is selected, a threshold value or reporting limit can be entered. Enter the limit or value and click ok. Wells with analytical data above the limit will be colored red.

2.4.6 Well Site Prioritization. The purpose of the well site prioritization tool is to identify and prioritize candidate locations for new wells based on a user-defined set of selection criteria. The typical process for evaluating well sites is to evaluate each site against a list of specified criteria. Each site gets a numerical score for each item in the list based on how well it meets the specification. The scores are then totaled for each site, and the site with the best score becomes the best candidate for new well facilities.

An example matrix of this prioritization approach is shown in the table below.

Criterion	Multiplier	Site 1		Site 2		Site 3		Site 4	
		Rank	Value	Rank	Value	Rank	Value	Rank	Value
Pumping Cost	1	2	2	2	2	2	2	1	1
Proximity to Existing Pipelines	1	3	3	3	3	2	2	2	2
Land Ownership	2	3	6	3	6	3	6	2	4
Groundwater Quality	3	4	12	4	12	4	12	3	9
Impacts on Existing Wells	4	1	4	1	4	1	4	0	0
Aquifer Characteristics	8	5	40	5	40	5	40	4	32
Aquifer Thickness	10	3	40	1	10	3	30	2	20
Total			**97**		**77**		**96**		**68**

The candidate sites are listed across the top of the matrix and the criteria to be scored are listed on the left. Each criterion is assigned a weighting factor shown in the multiplier column above. This multiplier enables the criterion that is most important to contribute the most to the final score, and thus have the most influence on the prioritization. Each site is assigned a rank, which is multiplied by the multiplier to get an overall value for each individual criterion. The values are then summarized to a final score for each site, which is used to determine the sites that best meet the criteria.

The well site prioritization tool performs this process on the entire region to be evaluated. Each criterion in the matrix table is represented by an ArcView® shapefile theme (Please see 'Turning on or off layers in the section above for a description of shapefiles[2]). In some cases, an item from the shapefile's attribute table will need to be identified. The tool will process each shapefile into a grid (Grids are discussed in the ArcView® 'USING SPATIAL ANALYST' users guide) is developed for the entire study area, and each cell in the grid is evaluated and scored against the criteria. The scores are then added together and the cells are categorized based on how well they meet the criterion. These categories are then displayed on the basemap. The areas with the highest total scores (green) are the best candidates for new well production, and the worst are shown in red.

2.4.6.1 Entering Criterion. The Well Site Prioritization Tool already contains an example set of pre-configured criteria for analysis and decision-making. The user may start with these and make changes to evaluate the study area. This section describes in detail the concepts and procedures involved in creating and manipulating new criteria. The last part of this section describes the user interface and how to change criterion parameters.

When entering criteria, there are three types of criteria evaluation methods used in the model. These are shown in the table below:

Table 2-8. Types of Analysis Methods Used in the Well Site Prioritization Tool

Method	Description	Example	Shapefile Type	Shapefile Item	Fields Used
Value	Areas that *EQUAL* a specific value are assigned a specific rank	Any area that falls within a municipal boundary.	Polygon	Any text item	Text Value

[2] Note: Adding and defining criteria in the Well Site Prioritization tool requires an understanding of ArcView® shapefile construction, which is beyond the scope of this manual. . For a detailed discussion, please see 'USING ARCVIEW GIS' users guide that comes with ArcView® or access the on-line help by clicking on HELP; HELP TOPICS from the menu bar.

Method	Description	Example	Shapefile Type	Shapefile Item	Fields Used
Range	If the value falls within a specific *RANGE*, it is assigned a specific rank	Aquifers greater than 150 feet thick are best; aquifers between 100 and 150 feet are good; anything less in unacceptable	Line	Any numeric item	Low Value and High Value
Buffer	Used to assign rankings based on *DISTANCE FROM* a map feature	New well sites should be within 500 meters of existing infrastructure	Line or Point	None required	Buffer, Text Value (optional)

The first step in defining criteria for the model is to complete a worksheet like the example shown below. Blank forms are located in the back of this manual. In the first column, list the criterion or theme name and the significance of the criterion by assigning a multiplier. Next, select the method to be used from the table above. Next, identify the shapefile to be used in the analysis (the type of shapefile is specified for each method in the table above). Identify an attribute item to be used in the evaluation, if required by the method. Then, identify the appropriate key word for the selected method from the description field in the table above (the *CAPITALIZED / ITALICIZED* words). Next, using as many lines as necessary, fill in the possible values and their corresponding rank. Remember, these values must be present with the exact spelling and case in the attribute field selected.

In the example, there are five criterion specified, but the user can enter as many sets of criteria required for the analysis. It is even permissible to enter multiple sets of criteria for the same type of information. For example, if there are multiple aquifers present, the user can enter a set of aquifer characteristics (e.g. specific capacity) and water quality parameters for each aquifer as separate criteria.

Table 2-9. Example Worksheet for Defining Criteria for Well Site Prioritization

Criterion/ Theme	Weight/ Multiplier	Method	Shape File Name	Item for evaluation	Key Words	Value	Rank
Municipal Boundary	9	Value	boundary.shp	ID	EQUALS		
						"IN"	10
Specific Capacity	7	Range	aquifer.shp	Value	RANGE		
						0 - 50	1
						50-100	5
						100-200	7
						200-10000	10
Infrastructure	4	Buffer	infrastructure.shp		DISTANCE FROM		
						< 500	10
						> 500	0
Water Quality	4	Value	quality.shp	Value	EQUALS		
						"EXCELLENT"	10
						"GOOD"	5
						"POOR"	0
Supply Wells	5	Range	wells.shp	Status	DISTANCE FROM		
						< 100	0
						> 100	10

Once the sheet has been completed and the multipliers and ranks have been satisfactorily assigned, the data can be input into the WRMS. To do so, click on **GIS** from the main menu and pick **WEIGHTED VALUES.** The data entry form shown below will open.

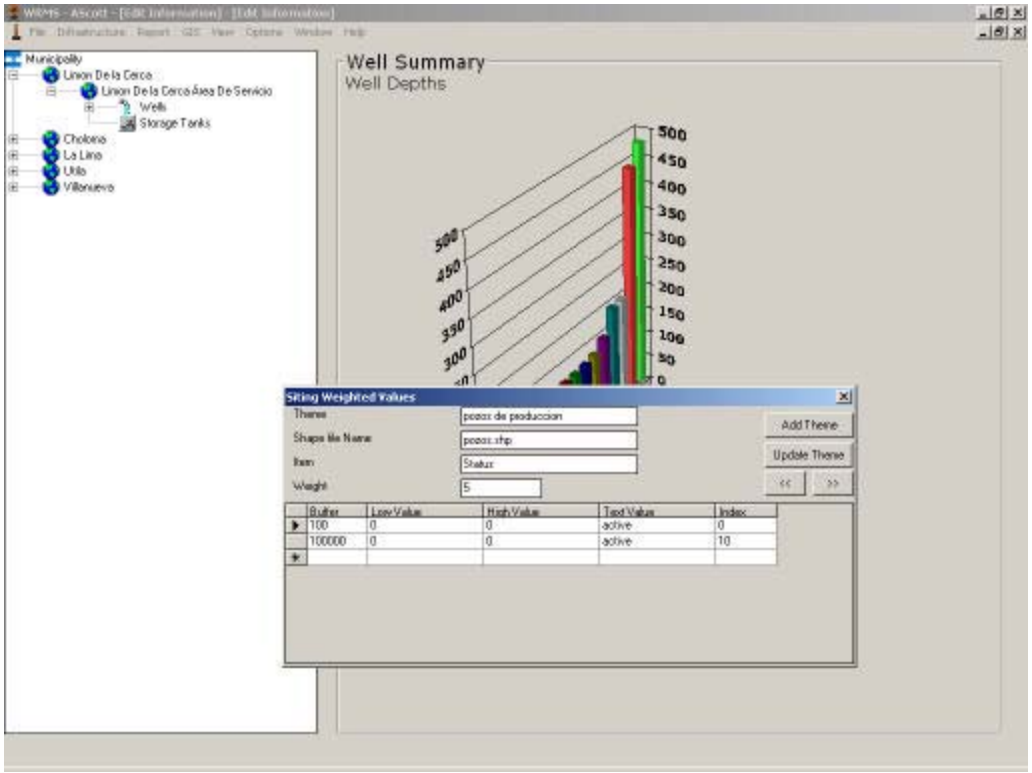

Figure 2-18. Well Siting Criterion Data Entry Screen

To enter a new criterion, do the following:

1. Click on the **ADD THEME** button. A pop-up window will appear.
2. Enter the theme name, shapefile name, field used (if any) and the weight value for the criterion.
3. Click on the **SAVE** button to store the new record.

To update a theme, enter the changes and click on the **UPDATE THEME** button.

To navigate between criteria records, click on the forward (>>) and back (<<) buttons.

1. To specify the parameters for the new criterion, click on the blank row and start entering data

Once the criteria are entered, use the same procedure to make updates and adjustments to the ranking and multiplier fields to calibrate or tune the model.

2.4.6.2 Performing the Analysis. Once the criteria are specified, the site prioritization process can be run. To start the process:

2. Click on **GIS** from the main menu and select **WELL SITE PRIORITIZATION**. An ArcView® GIS session will be initiated.
3. Select **WELL ANALYSIS** from the **MENU BAR**.
4. The analysis will begin. When completed, a new layer will be added to the map display area with its corresponding scores in the legend. The values are color-coded, based on the colors shown in the legend. The higher the values, the better the match to the specified criteria.

Typical results are shown in the figure below

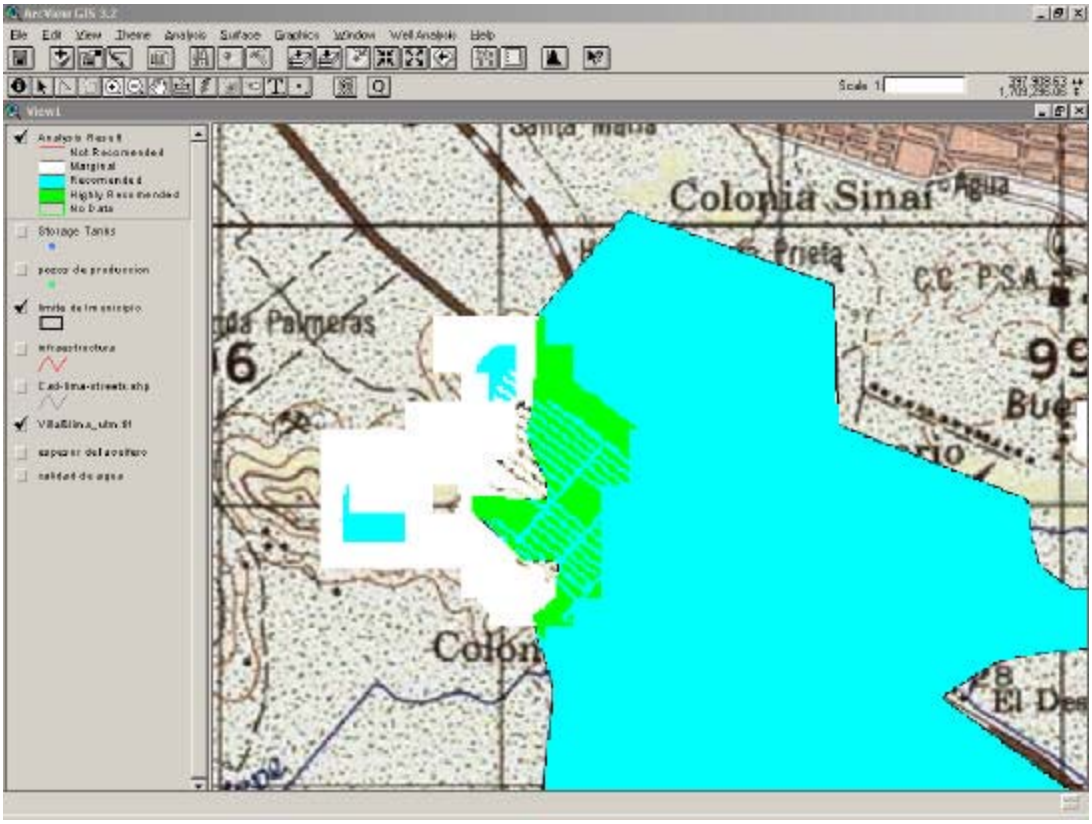

Figure 2-19. Well Site Prioritization Results

2.4.6.3 Querying the Results. The user may adjust the criteria and run the model as many times as necessary to identify reasonable ranking and multiplier values. In order to explore the results and identify the most significant contributing criteria for any location, a criteria query tool has been provided. To use the tool perform the following steps:

1. While in the ArcView® session, click on the criteria query tool button in the tool bar.

2. Locate the pointer over the location to be explored and click the mouse. A series of pop-up windows will appear displaying the criteria, the value, the weight, and total value for the point selected.

Typical results are shown in the figure below.

Figure 2-20. Using the Query Tool for Exploring the Siting Analysis

Using this tool, the user can evaluate the scoring characteristics for any location in the study area.

2.4.7 Assessing Related Information. The WRMS provides access to the GW Monitor – the USGS database of water supply wells – and the Water Resources Management Plan developed as part of this project. GW Monitor is an Access database that contains specifications on many of the water supply wells throughout Honduras. Many of the wells identified in WRMS are also present in GW Monitor, and it will be useful to compare the information between the two databases. To access GW Monitor, click on VIEW option from the WRMS main menu, then select USGS DATA. The GW Monitor application will open in a new window.

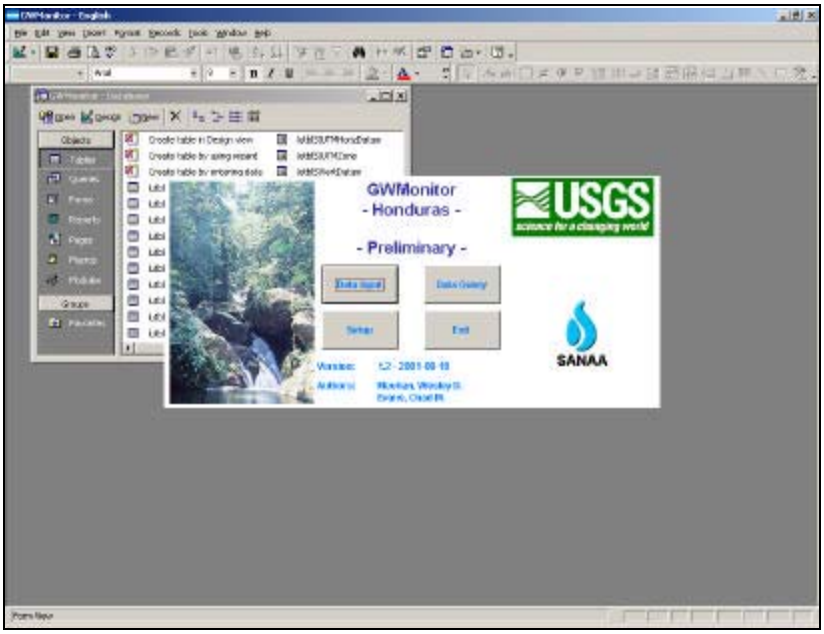

Figure 2-21. GW Monitor; the USGS Wells Database for Honduras

Once open, wells in the GW Monitor database can be queried through the functionality provided by the USGS. Please contact the USGS for information on how to use the GW Monitor database.

The Water Resources Management Plan is a report developed for each municipality containing a summary of water resource information, analysis of sustainable yield and aquifer characteristics, and recommendations for water resource management programs. The Water Resources Management Plan and WRMS are to be used in conjunction with each other. There are detailed data in the WRMS discussed and summarized in the plan, and recommendations from the plan can be explored using the WRMS. To access the Water Resources Management Plan, click on the **VIEW** button from the main menu, then select **WATER RESOURCES MANAGEMENT PLAN**. The plan will be opened in PDF format for viewing.

2.4.8 Getting Help

There are two type of user assistance available in the WRMS; assistance with the application and assistance with the ArcView® software.

2.4.8.1 WRMS Help. This users guide is available in PDF format from within the WRMS. To access help, click on **HELP** from the main menu, then select **USERS GUIDE**. The users guide will then open up in a new window. To access version information regarding the WRMS application, click on **HELP** from the main menu, then select **ABOUT**. This will open a popup screen showing the application version.

2.4.8.2 ArcView® Help. As mentioned previously, comprehensive discussions of ArcView® structure and functionality is available on-line from the ArcView® application. To access, click on **HELP** from the menu bar, then select **HELP TOPICS**. This will open a new window with help documentation.

3.0 ADMINISTRATORS GUIDE

3.1 Architecture

As mentioned previously, the data management system used in the WRMS is Microsoft Access, which is a relational database designed to efficiently manage complex data. The data are stored in a series of tables. Each table stores a different type of information, and each table is linked to others by a key field that defines the relationship. For example, one table contains a record of each well, while another table contains all the water level measurements. The table containing the water levels also contains the name of each well, so that it can be linked back to the appropriate well in the well table. This way, detailed information on each well and water level measurements can be stored most efficiently, without the need to maintain the same piece of information more than once, which would potentially introduce erroneous data into the system.

The GIS used is ArcView®, by Environmental Science Research Institute (ESRI). A GIS is an electronic mapping and analysis system. The power of GIS lies in its ability to manipulate, display, and analyze information on a map by linking map elements to attribute data in a database. For example, a well whose location is identified as a dot on the map, is connected to the construction data, sampling results, and water level information in the database. The user can post any of this information as text on the map, choose specific symbols or colors to represent these data, and overlay this layer of information on other map features. Because the data management system and GIS work together, it provides the user with a powerful set of management and analysis tools.

Both of these components are linked through a common interface developed in Microsoft Visual Basic. The interface is a series of screens that guide the user through various application functions. Through the interface the user can enter or update data, view reports, generate graphs, display scanned images, and create customized maps. The interface can be displayed in English or Spanish, uses water resource terminology, and is designed to be easy to use. Through this interface, municipalities will be able to continue to update their water resource data and use it for decision-making into the future.

3.2 Installation

The WRMS Application requires the following components to be fully installed on the system.

3.2.1 Hardware Requirements:

Minimum (Untested) configuration:

- Intel Pentium 200 MHz
- 64Mb RAM
- EIDE Drive (at least 100Mb free).

Recommended (Tested) configuration:

- Intel Pentium III 733+ MHz
- 128+Mb RAM
- EIDE RAM (at least 100Mb free)

3.2.2 Software Requirements:

The WRMS is designed to function on Microsoft Windows ME, NT4, 2000 or XP.

Additional Required Software:

- ESRI ArcView® 3.1
- ESRI Spatial Analyst
- Seagate Crystal Reports for ESRI
- Adobe Acrobat Reader (http://www.adobe.com/products/acrobat/)

3.3 Operations

This section explains how to back-up and restore the WRMS data and what to do if a system error occurs.

3.3.1 Backups and Recovery. WRMS features a basic backup and recovery system. The system allows the data stored in the system to be backed up whenever necessary. It is recommended that you set this system to backup your data at least once a week. This will enable you to recover your data if something goes wrong.

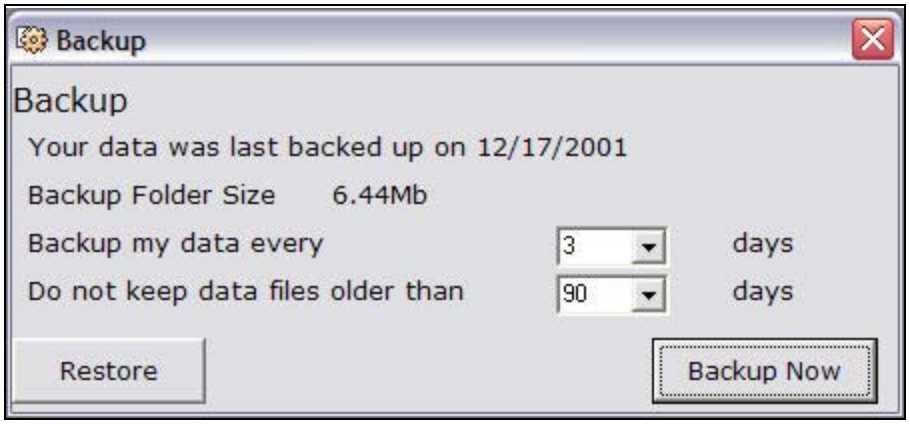

Figure 3-1. Backup and Restore Information

3.3.1.1 How to Backup Your Data. Backups are automated so there is no need to manually backup anything.

However, if you are planning on making major changes to your data or would just like to force a backup, you can force the backup by clicking the **BACKUP NOW** button.

3.3.1.2 How to Restore Your Data.

Click the **RESTORE** button on the **BACKUP** screen.

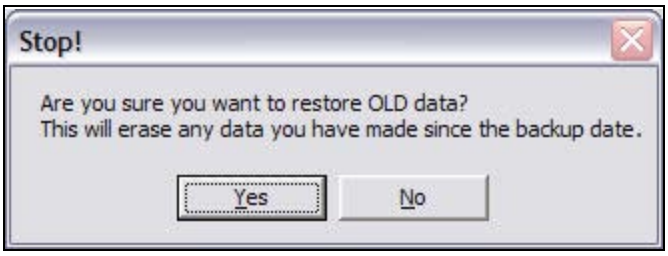

Figure 3-2. Restore Warning

Read the warning and make sure you understand the consequences of restoring OLD data.

Press **YES**.

You will then be presented by the following screen.

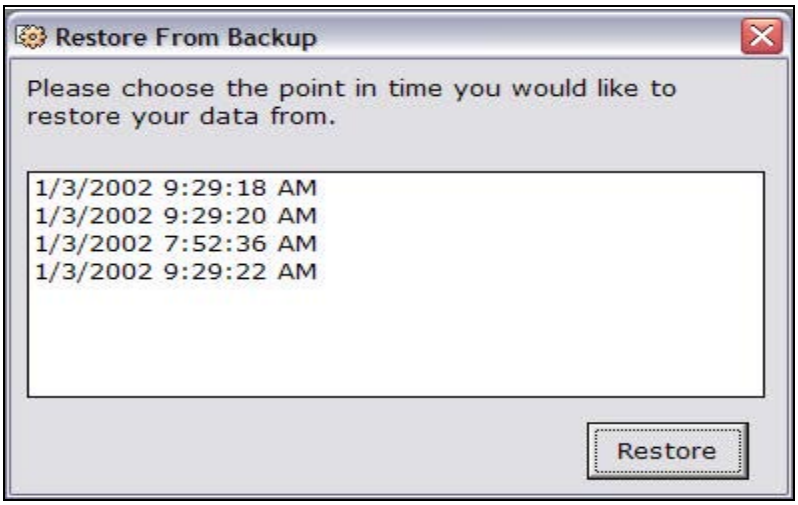

Figure 3-3. Restore from Selection of Backups

Select one of the items from the backup list. Then click **RESTORE**.

Your data will be backed up and then restored from the old data. It is recommended that you exit the application before using it again.

3.3.2 What to do if Error Occurs. We do not anticipate you encountering any errors. However, if you do encounter any errors make sure you write down the error number and what you were trying to do at the time that the error occurred. Send the details to the following email address: sac-support@brwncald.com.

3.3.3 Options

This section describes how to manage valid values, data paths, and interface translations.

3.3.3.1 Valid Values. Valid values allow you to alter and add to the contents of the drop-down menus. The illustration below shows part of the WRMS application. It includes a drop-down menu to change the well purpose of a well. The menu is populated using valid values.

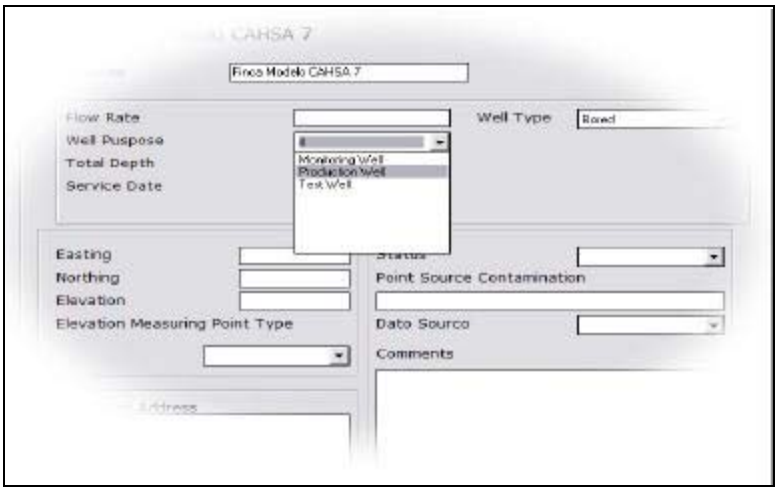

Figure 3-4. Well Purpose Drop-Down Menu Populated with Valid Values

You can easily change the valid values for this drop-down menu by pointing to **OPTIONS; VALID VALUES** then clicking on **WELL PURPOSE**.

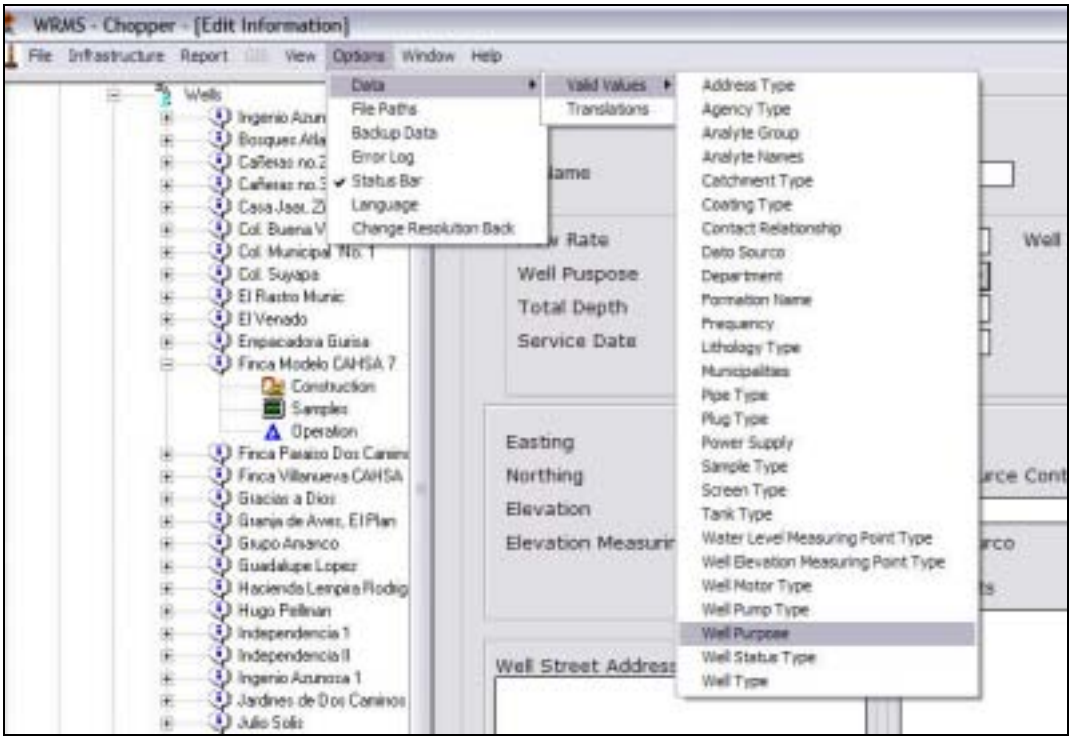

Figure 3-5. Valid Values Menu

You should follow the same process for any other drop-down menu in the application. This way the values can be easily managed.

3.3.3.2 Data Paths. WRMS requires some additional files to run with the full functionality. The following files should be setup in the **FILE PATHS** menu under **OPTIONS**.

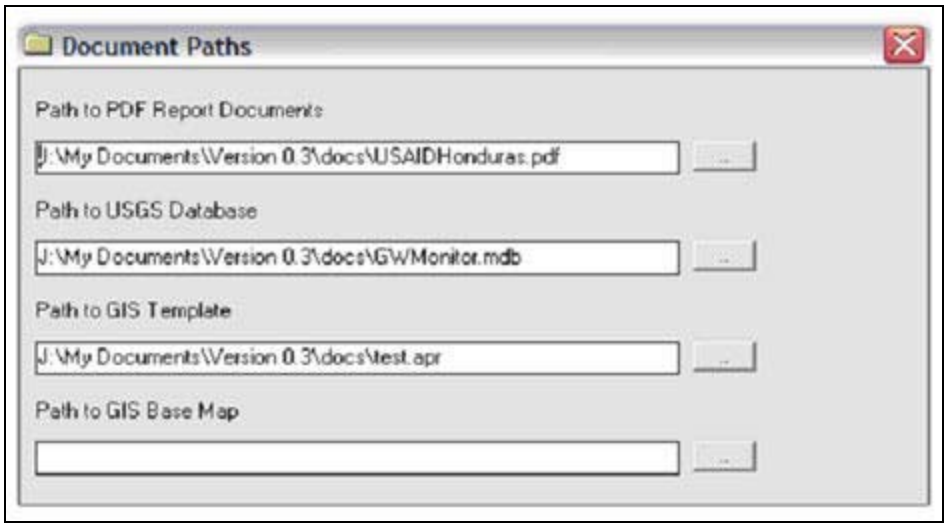

Figure 3-6. File Paths

Unless you are sure what you are doing, we strongly suggest you stay away from these options.

3.3.3.3 Translations. WRMS supports both English & Spanish. Because WRMS was developed in English, some of the translations may be incorrect. You may change these at any time by pointing to **OPTIONS; DATA** and then clicking on **TRANSLATIONS**. Here you will be presented with the English version of all the phrases that the application uses. You can update the Spanish by typing in the cell to the right of the English.

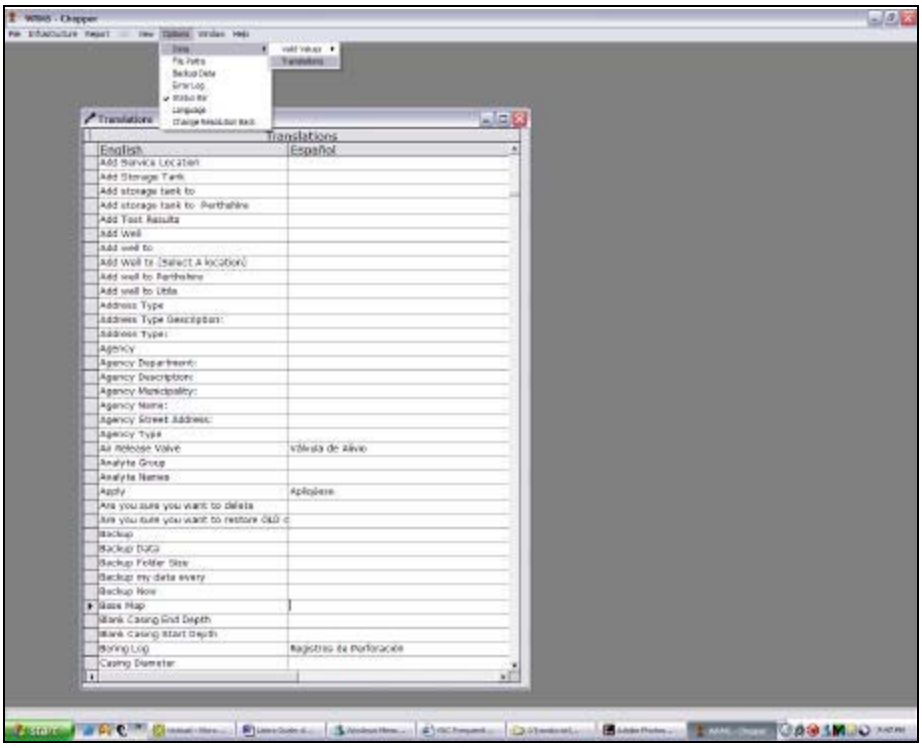

Figure 3-7. Translations Screen

ATTACHMENT

Criteria Worksheet

CRITERIA WORKSHEET

Criterion/Theme	Weight/ Multiplier	Method	Shape File Name	Item for Evaluation	Key Words	Value	Rank

Key Words: Equals
Range
Distance From

APPENDIX E

Groundwater Level and Monitoring Program
(Field Manual)

GROUNDWATER LEVEL AND MONITORING PROGRAM

FIELD MANUAL

BROWN AND CALDWELL

DECEMBER 2001

USAID

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1.0 PURPOSE AND OBJECTIVES

The purpose of this Sampling and Analysis Plan (SAP) is to outline the essential elements for establishing an effective groundwater level and monitoring program at various municipalities in Honduras, Central America. This report and guidance document is written in support of the Groundwater Monitoring Study conducted by Brown and Caldwell under USAID contract number 522-C-00-01-00287-00. This report covers the technical approach for the groundwater level and monitoring program, the rational for established procedures and step-by-step guidance for the continuation of the monitoring program into the future.

2.0 OVERVIEW

The groundwater level and monitoring program is being established to provide a tool that will be used in support of the current groundwater modeling effort. In addition, the monitoring program will provide a tool for future data collection that will be useful for growth planning.

The groundwater level and monitoring program has several components that are all equally important. These components include groundwater level data collection, water sample collection, analysis of water samples and review, compilation and understanding of water chemistry results. Each of these components is necessary in order to maintain a successful groundwater monitoring program. Each of these components is used to support and enhance the groundwater modeling effort and is discussed in more detail in later sections of this report.

3.0 TECHNICAL APPROACH

3.1 Well Selection

For this study, two types of wells were selected for monitoring: existing municipal or private wells, and new test and observation wells recently installed by Brown and Caldwell. All of the newly test and observation wells will be sampled for this study. Only a selected group of existing municipal and private wells were selected from each municipality for use in this monitoring program. The rational for choosing the existing wells included the following criteria:

- Geographic location—no more than one well per square kilometer was chosen to provide enhanced spatial distribution over the study areas.
- Proximity to Contamination—priority was given to wells located in areas that are assumed to be beyond the extent of agricultural or industrial contamination.
- Depth of the Screen—priority was given to wells screened in deeper aquifers with less chance of contamination from outside sources.
- Daily Use of Well—a representative number of wells that are heavily used and wells that are not pumped often were selected for the monitoring program.
- Use of Water—a representative number of wells used for residential, industrial and agricultural purposes were selected for this monitoring program.

In total, it is proposed to monitor and sample 52 wells for the survey. These wells consist of:

- 14 wells in Villanueva (nine existing wells and five newly installed wells)
- 17 wells in Choloma (14 existing wells and three newly installed wells)
- 12 wells in La Lima (nine existing wells and three newly installed wells), and
- 9 wells in Limon de la Cerca (six existing wells and three newly installed wells)

These wells are listed individually in Tables 1 through 4, and located on the figures in Chapter 3 of the report. It is important to note that the same wells will be sampled during each monitoring event to provide consistency in data and allow for ease of tracking trends in data over time.

3.2 General Groundwater Level and Sampling Procedures

The groundwater level and monitoring program has several components that are essential to support and enhance the groundwater modeling effort as well as provide a base of historical data that can be tracked over time. These components include groundwater level data collection, water sample collection, analysis of water samples, and review, compilation and understanding of water chemistry results. Each of these components is descried separately below.

3.2.1 Groundwater Level Data Collection. Groundwater levels will be measured so that changes in groundwater elevations can be documented and analyzed over time. For example, analysis of groundwater elevations over time can reveal seasonal trends. To collect groundwater levels, field personnel lower an electronic water level indicator down the well until groundwater is encountered (indicated by a beeping noise from the equipment). This depth to groundwater is then recorded in the log book. The water level measurement will be converted into an elevation by subtracting the depth to water from the well surface elevation. A more detailed description of the procedure for collecting groundwater level data is provided later in this text.

3.2.2 Groundwater Sampling. Following collection of the groundwater level measurement, a water sample will be collected. At a minimum, all wells included in this program will be sampled and analyzed for general chemical parameters, pH, electrical conductivity, bateriology and heavy metals. All wells in the monitoring program will also be analyzed for gross alpha and gross beta to establish the presence or absence of radiological compounds. Any of these minimum analytical parameters that are not detected in large quantities in the initial sampling event will be considered for elimination from future monitoring events.

In addition to analyzing for the minimum parameters described above, other important water quality parameters, including pesticides/herbicides and volatile organic compounds (VOCs), should be considered on a well-by-well basis. Sampling and analysis for these parameters will be based on information such as local land use and proximity to industrial activities. For example, the Caneras well fields in Villanueva will likely be sampled and analyzed for the presence of pesticides and herbicides because they are located within a sugar cane plantation. In Choloma, Well Colonial Canada is located near industrial runoff sources, and will likely be sampled and analyzed for VOCs.

Tables 2 through 5 provide a list of suggested monitoring parameters for each well included in this monitoring program.

3.2.3 Groundwater Chemical Analysis. After collecting groundwater samples from each well, the samples will be transported to the laboratory for analysis. For the initial sampling, conducted by Brown and Caldwell, some of the samples will be shipped to Southern Petroleum Laboratory in Houston, Texas, United States of America and some will remain locally in Honduras at Jordanlab located in San Pedro Sula.

3.2.4 Laboratory Data Review and Compilation. When the laboratory has completed the analysis of the samples, the data must be reviewed and compiled. For the initial sampling conducted by Brown and Caldwell, a chemist in the Sacramento, California office will evaluate the data and the data will be input into a project database. For subsequent sampling efforts, each municipality must assess the analytical data separately — look for trends with historical data, be aware of constituents that exceed health based guidelines, and perform quality assurance measures to verify the accuracy of the laboratory data. Once the data have been reviewed for accuracy and consistency, the data should be input into the database provided by Brown and Caldwell and the original copies from the laboratory filed for future reference.

3.3 Quality Assurance/Quality Control

Specific Quality Assurance/Quality Control (QA/QC) steps will be taken in the field and by the laboratory in order to document and ensure that the analytical data have the maximum amount of integrity. The QA/QC program for the groundwater monitoring will include collecting Quality Control samples, use of qualified laboratories, a specific laboratory reporting format, review of laboratory data packages, and consistency in sample identification. These QA/QC items are reviewed below:

- Samples will be carefully labeled with sample designation, the initials of the sampler, and the analysis to be performed. Date and time of sample collection will be added s the sample is collected.
- Field personnel involved in sample collection will wear disposable gloved to prevent potential contamination of samples. Gloves will be discarded after sampling each well.
- Groundwater samples collected from wells with dedicated pump systems will be collected with minimal potential agitation of the sample between the adductor pipe outlet and sample containers. All samples should be collected as closely as possible to the well head.
- Sampling heads should be constructed of non-metallic material, preferably polyethylene or Teflon®. Before collection of samples at all stations, the sampling heads will be cleaned in a non-phosphatic detergent and rinsed with tap water. This will be followed with a distilled-deionized water rinse.
- Groundwater samples collected from monitoring wells without dedicated pump systems will be collected with disposable Teflon or polyethylene bailers and nylon cord. The bailer and cord will be disposed of after the sample has been collected.
- Sample bottle guides for all parameters (bottle type, volume of sample needed, and type of preservatives used) are given in Table 3.

- Samples collected for dissolved metals will be filtered and preserved in the field.
- Immediately after collection of the sample is completed, the sample will be placed in a cooler at 4 degrees C.
- All pertinent information generated during the groundwater sampling event will be recorded on the Field Data Form and in the field log book.
- Duplicate samples will be collected as needed and are intended to be identical to the original sample. A field duplicate sample will originate from the project site and be in a separate sample container. Duplicates will be taken for approximately every 10 percent of samples collected during the sampling event, or a minimum of one per municipality per monitoring event. The location for duplicate sample collection will be determined prior to the sampling round.
- Equipment blanks will not be required because samples will be collected using dedicated pumps and disposable filters and bailers.
- Trip blanks will be provided by the laboratory whenever analysis of volatile compounds occurs.

3.3.1 Quality Control Samples. During each monitoring event, one blind duplicate sample will be collected from each municipality. A blind duplicate sample is a second sample collected from a predetermined well that is given a new (false) name so the laboratory does not know which well the sample is from. This method is commonly used to verify the accuracy of laboratory reports. In addition, a trip blank will be included in every cooler that is used to transport samples to be analyzed for VOCs. It is strongly recommended that this practice continue for all subsequent sampling events completed by the municipalities. A list of the wells that have been selected for duplicate sampling is illustrated in Tables 5 through 8.

3.3.2 Laboratory Qualifications. All chemical analyses will be performed by a laboratory certified by the USEPA or the Government of Honduras. Analytical methods and SOPs that are acceptable, in accordance with EPA recommendations, will be consistently maintained by the laboratory to satisfy the required QA/AC protocol.

3.3.3 Laboratory Data Packages. All results from USAID groundwater samples will be reported in modified Level 3+ QC data packages that provide the following documentation: sample chain-of-custody, method blank results, matrix spike/spike duplicate summary results, and detection limits listed on all reports. Data packages including all surrogate recoveries, laboratory control samples, initial and continuing calibrations, run logs, extraction logs, and correction action reports will be obtained from the laboratories as needed for individual samples.

3.3.4 Sample Naming Convention. For this groundwater level and monitoring program, the naming system will consist of three components: well name, month of the sampling event, year of the sampling event. For example, for the well named Cañeras 2 in Villanueva that will be sampled in October 2001 the sample name will be Cañeras 2 102001. It is important to follow this naming protocol so all samples have a unique identifier when they are entered into the database.

3.4 Schedule

The initial round of monitoring and sampling is scheduled for late October 2001. Sampling activities will be completed for one municipality prior to beginning sampling at the next municipality. This practice will be maintained in future monitoring events to reduce data analysis issues that may arise from weekly, monthly and seasonal changes in the water system. For the initial round of sampling, field work is anticipated to begin in Choloma and then move to Villanueva and La Lima. Finally, the samples will be collected in Limon de la Cerca.

4.0 DETAILED PROCEDURES

The following narrative provides a step-by-step outline of the activities necessary to complete the groundwater level and monitoring program. These steps should be followed each time groundwater samples are collected to ensure accuracy, consistency, and representativeness of data collected during this program.

4.1 Sampling Team and Responsibilities

The sampling team will consist of both field and office personnel. Each person on the team will have specific duties and responsibilities as described below.

- **Sampling Coordinator.** The sampling coordinator will have the overall responsibility for the sampling program and will be responsible for timing and scheduling of the sampling events, oversight of the sampling crew, and liaison with the laboratories. In order to respond to the changing requirements of the project, the sampling coordinator may, after consultation with the project manager, adjust the number and locations of samples to be collected, and the analytes for each sample.
- **Field Sampling Crew.** The field crew may consist of either two or three persons depending on the number of samples to be collected, and the time span allowed for that sampling. The field sampling crew will report directly to the sampling coordinator, and will be responsible for the physical collection of the samples according to the protocol described in this SAP.
- **Quality Assurance (QA) Reviewer.** This person will perform a detailed review of all data generated by this sampling program. The person will chart and document the water quality and will compare the analytical results to acceptable standards as they are available. After the results of each sampling event are reviewed, they will be compiled and a short data report will be prepared for each municipality for use by the project manager to document the results, any deviations from standards, and trends that may occur.

To ensure valid water chemistry determinations, the procedures outlined herein are based on guidelines established by the United States Environmental Protection Agency (USEPA, 1986) in the Code of Federal Regulations (40 CFR 100-149) and the U.S. Geological Survey (USGS, 1984).

4.2 Water Level Measurements

The following steps will be used to obtain water level measurements:

- On arrival at the wellhead, condition of the surface seal and protector or well cover will be checked and observations will be recorded in the field book.
- The area around the well will be cleared prior to unlocking the protector or well cover and removing the cap from the top of the well.
- Before taking any measurements, any previous data of water levels for the well will be reviewed.
- Measuring points will be established based on historical information. If no information is available, a notch on the north side of the well casing or the top of the sounding tube will be used.
- Each well will be sounded three times for depth to water with an electronic water sounder. Water level measurements will be continued until a difference of less than 0.02 feet between consecutive measurement is obtained.
- Depth to water and date of measurement will be recorded on the Field Data Form.
- The previous measured water level will be reviewed. If the difference between the current water level and historical water level measurement is greater than 1 foot, the current measurement will be rechecked.

Smoking, eating, or drinking in the vicinity of the well head, pump output, or field analytical setups will be forbidden in order to eliminate the potential for induced contamination.

Water level data will be collected and documented on the field sheet provided as Appendix A to this sampling manual.

4.3 Well Purging

Well purging activities include the following items:

- A minimal volume of water will be purged, taking into consideration the local hydrologic factors together with the stabilization of pH, temperature, and electrical conductance (EC) over at least two to three borehole volumes. The wells are expected to have very low-flow rates. Purging will possibly draw the water level down to a point that the pump will shut off due to lack of water. When this occurs, the well will be allowed to recover 80 percent of the original static water level, or for 24 hours. Sampling will proceed when these recovery conditions have been met.
- Readings of pH, temperature, and EC, will be recorded, and the cumulative volume pumped will be measured and recorded.
- Purge water will not be containerized but will be discharged directly to the surrounding ground surface.

4.4 Field Tests

During groundwater and surface water sampling activities, the following field tests will be conducted:

- Measurement of pH, temperature, EC, and depth to water in the well to be sampled will be taken and recorded immediately before and after collection of each groundwater sample.
- Conductivity, pH, and temperature meter probes will be thoroughly rinsed with distilled water prior to each use.
- The pH meter will be calibrated in pH 4 and pH 10 buffer solutions at the beginning and end of each sampling day. Calibration data will be recorded on the Field Data Form and in the field log book.
- The conductivity meter will be calibrated using manufacturer specified solutions before and after the sampling. Calibration data will be recorded on the Field Data Form and in the field log book.
- All field parameters will be collected and documented on the field data sheet provided as Appendix A to this sampling manual.

4.5 Groundwater Sample Collection

In order to ensure that proper groundwater samples are collected, the following items are required:

- The laboratory will be contacted at least two working days before receipt of the samples to establish a schedule for sample analysis. The following information will be provided for the laboratory:
  --approximate number of samples the laboratory will be receiving;
  --parameters to be tested;
  --holding time; and
  --number and types of sample bottles to be provided to the laboratory.
- All sample containers obtained from the laboratory shall be factory new. The exception to this is the jars received from JordanLabs in San Pedro Sula, Honduras for fecal and total coliform. These jars will be sterilized by way of an autoclave.
- An adequate number of forms will be obtained for documentation of field activities.
- Groundwater sample collection will be scheduled and performed to accommodate the required laboratory holding times, and to ensure that a maximum representation of the aquifer condition.

4.6 Sample Containers and Preservatives

Sample containers and appropriate sample preservatives will be provided by the laboratories performing analytical services. All container preparation by the laboratory will be done in a designated area. Containers will be labeled to indicate the added preservative. A full list of sample containers and preservatives for this project can be reviewed in Tables 2 through 5. Preparation is accomplished using the following SOPs for bottle preservation:

- Bottles for organic analyses will be provided by the laboratory. These will be purchased from suppliers who certify the containers to have been cleaned by protocols as prescribed in the Environmental Protection Agency (EPA) methods for organic analyses.
- Coolers, and applicable chain-of-custody forms will also be provided by the laboratories. Brown and Caldwell will be responsible for the purchase of bulk block ice that is appropriate for overseas shipping. Blue ice will not be used for cooling samples on this project.
- All sample containers with appropriate preservatives and coolers will be delivered at lease one week prior to sample collection.
- After a sample is collected, preserved, and labeled, it will be stored on ice at 4 degrees C in a plastic ice chest. No ice chest will be allowed to stay in the field beyond its ability to keep the temperature at 4 degrees C.
- All samples will be wrapped in plastic packing when necessary to avoid breakage, and will be clearly labeled and sealed to prevent tampering.
- All samples will have a label containing (at a minimum) the following information:
  --Sample designation;
  --Project name and number;
  --Date and time of collection; and
  --Comments – These may include parameters to be analyzed, whether the sample is filtered or unfiltered water, and any preservatives added to the sample.

4.7 Chain-of-Custody

Chain-of-Custody procedures will include:

- Samples collected by field personnel will be accompanied by a Chain-of-Custody Record Form, which will include date and time of collection, container type, preservatives used, number of samples, sample descriptions, and others.
- Sample identification labels and chain-of-custody records will be completed with waterproof ink, and placed in a waterproof bag for shipment.
- Chain-of-Custody documentation will be completed at each sample location prior to sampling at the next well.
- Samples will be hand delivered to JordanLabs in San Pedro Sula the day of the sampling. Samples that are being analyzed by Southern Petroleum Laboratory (SPL) in Houston, Texas will be delivered via DHL overnight shipment service. It should be noted that coliform samples have a short holding time of only 24 hours. It is imperative that field crew communicate with JordanLabs prior to sampling to verify that the analysis can be run in the appropriate time frame.
- The integrity of the samples will be examined, and the final signature of the Chain-of-Custody form will be completed by a receiving agent of the selected laboratory.
- A sample chain-of-custody is provided as Appendix B to this sampling manual.

5.0 DATA MANAGEMENT

Field and laboratory data management, data review, and reduction are given below to create a centralized working system, and to maintain data quality.

- Field Data. Water quality records for each sampling location will be produced, copied, and filed under the appropriate category for each groundwater quality well. Records completed in the field will include physio-chemical (pH, temperature, EC) parameters of groundwater and chain-of-custody records. These forms will be forwarded by the field manager to the project manager at the conclusion of the sampling effort.
- The following field documentation will be completed by the field personnel:
  --Complete entry in dedicated field notebook;
  --Complete the Field Data Form, and one Chain-Of-Custody Form.
- Laboratory Data. Analytical results and QC data relating to analytical precision and accuracy will be obtained from the laboratory. Laboratory analytical result data sheets will be specific to sampling location and method of analysis. The original Chain-Of-Custody Forms will be filed with the analytical results. Data will be organized with respect to date, original water quality results, and QA/QC results.
- Data Review. Field data will be reviewed for measurements collected during sampling, order of sample collection , and the observations and notes recorded during he course of the sampling day. Laboratory data forms will be reviewed for the completion of required measurements, including parameter results, limits of detection, and dilution factor. Validity of both the field and laboratory data will be determined by evaluating the completeness of the data for the required parameters as documented on the chain-of-custody form.
- The following data will also be reviewed:
  --Use of EPA methods with detection limits below water standards, where applicable;
  --Chemical data of control matrix blanks, control matrix spikes, standards, control matrix duplicates; and
  --Confirmation of sample analyses within specific holding times.

6.0 REPORTING

A general assessment of the groundwater and surface water quality for the fall of 2001 will be submitted to USAID in the final report presented at the termination of the project. It will be the responsibility of each municipality to report the water quality results to the appropriate individuals after each sampling event in the future.

7.0 GLOSSARY OF TERMS

Aquifer: The geological stratum that can produce enough water to support consumption. It is the section of the well where screening in a well is installed.

Bailer: a PVC tube one meter long used to collect water samples from wells that do not have a pump installed.

Casing: PVC or steel tubing installed into a borehole with perforated sections and non-perforated sections used to capture the water from an aquifer.

Chain-of-Custody: a legal document used to track groundwater samples. A chain-of-custody includes information such as the name of the sample, the date of collection, the time of collection, the name of the technician and the analysis requested by the laboratory. A chain-of-custody should remain with the samples at all times.

Database: A computer system used to archive historical data.

Drawdown: the difference, measured in feet or meters, between the water table or static water level and the level of the water after pumping.

Electrical Conductivity: a chemical parameter that quantifies the potential for water to conduct or carry electricity. Electrical conductivity is a function of the the quantity of dissolved minerals (particularly salt) in the water.

General Bacteriology: water quality analysis performed to determine the presence of bacteria and sometimes to determine the amount of fecal material present in a sample.

Holding Time: the amount of time between sample collection and when a laboratory needs to analyze the sample. For example, for fecal coliform samples, less that 24 hours can pass between sampling activities and analysis or the data will be invalid.

JORDANLAB: analytical laboratory in San Pedro Sula used to analyze samples for the USAID project.

Preservatives: chemicals—typically acids—added to sample bottles collected in the field to increase the time allowable between sampling and analysis. Preservatives are also used to retain potential contaminants in the sample so the laboratory can get a true understanding of what is in the water.

Radiological Chemicals (Gross a, Gross ß): chemical parameters used to demonstrate the amount of radiological chemicals in a sample.

Screening: the portion of PCV or steel casing that is perforated to allow the passage of aquifer water into the well.

Sounder: a device used to determine the level of water in the well. It measures feet or meters below ground surface.

SPL: Southern Petroleum Laboratories, laboratory used for the USAID Groundwater Resources Study for metals, radiological chemicals, pesticides and herbicides and VOCs.

Static Water Level: the level at which water stands in a well or unconfined aquifer when no water is being removed from the aquifer etiher by pumping or free flow.

QA/QC: Quality Assurance/Quality Control, a method of checking data to be sure it is valid.

Volatile Organic Chemicals: man-made organic chemicals that are widely used for industrial and domestic purposes including solvents for cleaning and pesticides/herbicides.

Tabla No.1 Pozos seleccionados para muestreo en los municipios de Villanueva, La Lima, Cholomma

Nombre del Pozo	Municipio	UTM	Q GPM	Fuente de contaminación	Profundidad del Pozo (Pies)	Profundidad Rejilla (pies)	Llave para muestreo	Elevación Terreno natural	Sector abastecido No. de Viviendas Abastecidas	Producción Diaria (Gal)
La Victoria	Villanueva	16P 0394395 1693962	120	Ninguna	195		SI	67.3278	Col. La Victoria 543	172,800
Pintala I	Villanueva	16P 0392752 1691490	400	Ninguna	240	41	SI	53.3728	Col. 1 de Mayo y San Antonio 96	48,000
Manuel Coello	Villanueva	16P 0394328 1692334	202	Ninguna	270	49	SI	50.1758	A tanque Col. Victoria y Col. Siriahmacs 543	115,140
Villa Linda Norte	Villanueva	16P 0394962 1695873	105	Letrinas a 10 metros	300	25	SI	54.1698	Col. Villa Linda Norte 144	25,200
Villa Sol	Villanueva	16P 0393671 1693850	27.24	Ninguna	184		SI	78.8138	Parte de la Col. Villa Sol 40	37,591
Cañeras II	Villanueva	16P 0393345 1691699	600	Ninguna	250	100	SI	47.2048	Conectado al Plan Maestro (Red baja y alta) 3369	864,000
Guadalupe Lopez	Villanueva	16P 0396098 1693853	150	Letrinas a 10 metros	260	70	SI	70.7248	Tanque 21 de Abril 315	216,000
22 de Mayo	La Lima	16P 0391650 1709438	90	Letrinas a 5 metros	180		SI	29.238	Tanque Col. 22 de Mayo 105	97,200
Villa Esther	La Lima	16P 0402604 17006467	200	Canal de aguas negras a 100 metros	260	154	SI	26.83	Residencial Villa Esther 9	252,000
Oro Verde	La Lima	16P 0403573 1705732	298	canal de aguas negras a 100 metros			SI	25.43	Residencial Oro Verde y Zip Continental	
Guaymuras	La Lima	16P 0397437 1708534	100	Letrinas a 30 metros	362		SI	28.937	A Tanque Guaymuras 155	108,000
Planeta #1 (Fusep)	La Lima	16P 0398234 1709076		Ninguna	200	40	SI	28.091	Red de la Col. Planeta 2312	
La Mesa (Nuevo)	La Lima	16P 0401055 1708035	400	Ninguna	200	63		27.755	Col. La Mesa NO HAY BOMBA	
Cruz Roja	La Lima	16P 0400429 1707065	150	Ninguna	200	150	SI	27.87	A la red del Centro de Lima Vieja	162,000
Martinez Rivera	La Lima	16P 0400140 1705694	150	Ninguna	180		SI	28.993	Tanque de la Col. Martinez Rivera 101	162,000
San Carlos	Choloma	16P 0399179 1726619	296	Ninguna	176	41	SI	26.223	Tanque de la Col. San Carlos 885	337,400

Nombre del Pozo	Municipio	UTM	Q GPM	Fuente de contaminación	Profundidad del Pozo (Pies)	Profundidad Rejilla (pies)	Llave para muestreo	Elevación Terreno natural	Sector abastecido No. de Viviendas Abastecidas	Producción Diaria (Gal)
Prado I	Chobma	16P 0399065 1728223	60	Quebrada con aguas negras a 75 metros	100		SI	26.298	Tanque de la Col. Prado I 161	14,400
Residencial Europa	Chobma	16P 0399366 1725680	225	Ninguna	117		SI	24.423	Tanque de la Col. Europa 389	283,500
San Antonio	Chobma	16P 0397599 17267087	450	Contaminación por infiltración de heces fecales	120	60	SI	33.852	A la red del centro de Chobma	648,000
Bella Vista	Chobma	16P 0398794 1725376	196.2	Quebrada contaminada por aguas negras 400 metros	200		SI	27.282	Sector Sur (Sector López Arellano) 2751	282,528
Bomberos I	Chobma	16P 0397867 1726032	257.2	Ninguna	200	40	SI	32.422	Sector SE, SO, NE de Chobma	370,368
San Francisco	Chobma	16P 0397287 1726970	100	Quebrada contaminada por aguas negras a 1 metro	80		SI	37.315	Col. Los Almendros y Col. Care 439	108,000
Barrosse II	Chobma	16P 0398472 1728223	587	Ninguna	200	60	SI	25.813	Sector N.O. de Chobma	845,280
Victoria (Gas. Depesa)	Chobma	16P 0397645 1721746	68	Ninguna	329	40	SI	52.523	A tanque Col. La Victoria 90	24,480
Canada	Chobma	16P 0397831 1725769	400	Canal de aguas negras a 30 metros y quebrada contaminada con aguas negras y desechos de fabricas a 150 metros	200		SI	31.992	A la red de la Col. Canadá 127	576,000.00
Parque Central	Chobma	16P 0397918 1726067	350	Ninguna	200		SI	32.077	A la red del centro de Chobma	420,000
Primavera	Chobma	16P 0397194 1726282	180	Ninguna	200		SI	36.434	Col. La Primavera 312	259,200

Tabla No.2 Método Analítico, Envase, y Especificaciones de Control de Calidad para Villanueva, Cortés, Honduras.

Nombre de la Muestra	Matriz	Analitos/Análisis	Tipo de Envase	No. de Envases	Preservantes	Duplicado	MS	MSD
Cañeras 2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
	A.S.	Pesticidas/Herbicidas	32 oz. Ámbar	2	Ninguno			
Pintala 1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Pintala 2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Plástico	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Guadalupe Lopez 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno	X	X	X
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno	X	X	X
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio	X	X	X
Manuel Coello 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Colonia Victoria 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Plástico	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Villa Linda Norte	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
BC-VI-1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
BC-VI-2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Plástico	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
BC-VI-3 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
BC-VI-4 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
	A.S.	Total a, Total ß	32 oz. Plástico	2	Ácido Nítrico			
BC-VI-5 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			

Tabla No.3 Método Analítico, Envase, y Especificaciones de Control de Calidad para Choloma, Cortés, Honduras.

Nombre de la Muestra	Matriz	Analitos/Análisis	Tipo de Envase	Número de Envases	Preservantes	Duplicado	MS	MSD
Parque Central 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Bomberos 1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Bella Vista 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Perez Estrada 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
San Carlos 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Res. Europa 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Col El Prado II 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Barrosse 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno	X	X	X
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno	X	X	X
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio	X	X	X
San Antonio 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
San Francisco 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
La Primavera 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
Victoria 1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
Inez Carranza Barrica 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
Res. América 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
BC-CH-1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
BC-CH-2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
	A.S.	Total a, Total ß	32 oz. Plástico	2	Acido Nítrico			
BC-CH-3 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			

Tabla No.4 Método Analítico, Envase, y Especificaciones de Control de Calidad para La Lima, Cortés, Honduras

Nombre de la Muestra	Matriz	Analitos/Análisis	Tipo de Envase	Número de Envases	Preservantes	Duplicado	MS	MSD
Don Lobo 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Oro Verde 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Martínez Rivera 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
22 de Mayo 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Guaymuras 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Villa Esther 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Planeta Fusep 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno	X	X	X
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno	X	X	X
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio	X	X	X
Cruz Roja 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Vivero Municipal 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
BC-LL-1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	32 oz. Plástico	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
BC-LL-2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			
	A.S.	Total a, Total ß	32 oz. Plástico	2	Ácido Nítrico			
BC-LL-3 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml Vidrio	2	Ninguno			
	A.S.	Metales	40 ml Plástico	2	Filtrado en el laboratorio			

Tabla No.5 Método Analítico, Envase, y Especificaciones de Control de Calidad para Limón de la Cerca, Choluteca, Honduras.

Nombre de la Muestra	Matriz	Analitos/Análisis	Tipo de Envase	Número de Envases	Preservantes	Duplicado	MS	MSD
Panamerica LC4 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Bolsa Samaritana LC3 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Ricardo Soriano LC1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Iglesia Cristo Rey 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Atlas LC2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
Luis 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	32 oz. Plástico	2	Filtrado en el laboratorio			
BC-LC-1 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
BC-LC-2 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			
	A.S.	Total a, Total ß	32 oz. Plástico	2	Ácido Nítrico			
BC-LC-3 102001	A.S.	Química General	32 oz. Plástico	1	Ninguno			
	A.S.	Bacteriológico	100 ml. Vidrio	2	Ninguno			
	A.S.	Metales	40 ml. Plástico	2	Filtrado en el laboratorio			

Tabla No. 6 Red de Monitoreo de Pozos
La Lima, Honduras

No	Nombre del pozo	Coordenadas UTM	Tipo de pozo	Elevación terreno Natural (m snm)	Elevación Nivel de Referencia (m snm)	Nivel Estático anterior (m)	Fecha lectura	Nuevo Nivel Estatico (m)	Fecha lectura	Observaciones
1	Colonia Fraternidad	16P 0399855 1707090	Observación	28.06	28.38	15.00	04-Oct-01			
2	Los Maestros	16P 0400224 1707203	Monitoreo	27.19	27.62	6.79	06-Sept-01			
3	El Mixto	16P 0400700 1706883	Procucción	28.51	29.42	6.67	04-Jan-02			
4	Cruz roja	16P 0400469 1707065	Procucción	27.87	28.37	12.88	04-Jan-02			
5	Sitraterco	16P 0400587 1707306	Procucción	27.57	28.01	8.56	04-Jan-02			
6	Martínez Rivera	16P 0400135 1705691	Procucción	28.99	29.05	4.54	04-Jan-02			
7	Gabriela Mistral	16P 0400294 1706908	Procucción	28.45	29.11	5.64	06-Jan-01			
8	Zapote No.1	16P 0398158 1706728	Procucción	31.09	31.75	4.95	04-Jan-02			
9	Zapote No.2	16P 0397798 1706836	Procucción	30.57	31.17	3.35	04-Jan-02			
10	Planeta No.1 (Fusep)	16P 0398803 1708994	Procucción	28.09	28.39	5.97	04-Jan-02			
11	Planeta No.3	16P 0398284 1709356	Procucción	27.89	28.16	6.46	04-Jan-02			
12	FHA No.1 (Fuerza Aérea Hondureña)	16P 0399594 1707531	Monitoreo	27.41	27.98	5.50	04-Jan-02			
13	FHA No.2 (Fuerza Aérea Hondureña)	16P 0399624 1707517	Monitoreo	27.31	27.61	4.10	04-Jan-02			
14	Aeropuerto	16P 0399349 1707864	Monitoreo	26.51	26.67	6.67	04-Jan-02			
15	Jerusalem No.1	16P 0397548 1709059	Procucción	28.48	28.76	5.50	04-Jan-02			

No	Nombre del pozo	Coordenadas UTM	Tipo de pozo	Elevación terreno Natural (msnm)	Elevación Nivel de Referencia (msnm)	Nivel Estático anterior (m)	Fecha lectura	Nuevo Nivel Estatico (m)	Fecha lectura	Observaciones
16	Jerusalem No 2 (Kinder)	16P 0397368 1708923	Procucción	28.42	28.60	7.10	04-Jan-02			
17	Guaymuras	16P 0397437 1708534	Procucción	28.94	29.99	8.85	04-Jan-02			
18	San Cristobal	16P 0397715 1708758	Procucción	29.37	31.45	13.60	04-Jan-02			
19	La Paz No 2 (Luis Thiebaud)	16P 0400263 1706706	Procucción	25.90	26.41	7.21	04-Jan-02			
20	Oro Verde	16P 0403573 1705732	Procucción	25.43	25.72	4.02	04-Jan-02			
21	Villa Esther	16P 0402604 1706467	Procucción	26.83	27.11	9.25	04-Jan-02			

Tabla No. 7 Red de Monitoreo de Pozos
Choloma, Honduras

No.	Nombre del pozo	Coordenadas UTM	Tipo de pozo	Elevación terreno Natural (m snm)	Elevación terreno Referencia (m snm)	Nivel Estático anterior (m)	Fecha lectura	Nuevo Nivel Estático (m)	Fecha lectura	Observaciones
1	San Francisco	16P 0397287 1726970	Producción	37.32	37.66	5.97	17-Dec-01			
2	San Antonio	16P 0397599 1726708	Producción	33.85	34.39	5.14	17-Dec-01			
3	Primavera	16P 0397194 1726282	Producción	36.43	36.68	5.74	17-Dec-01			
4	Prado I	16P 0399065 1728223	Producción	26.30	26.49	5.92	05-Dec-01			
5	Prado II	16P 0399065 1725620	Producción	25.61	26.21	5.76	05-Dec-01			
6	Residencial El Japón	16P 0400206 1725865	Producción	21.42	21.77	4.27	05-Dec-01			
7	Inés carranza Barnica	16P 0398277 1720762	Producción	42.23	42.74	13.86	18-Dec-01			
8	Bomberos I	16P 0397867 1726032	Producción	32.42	33.61	9.90	17-Dec-01			
9	Residencial San Carlos	16P 0399179 1726619	Producción	26.22	26.30	4.92	05-Dec-01			
10	Residencial América	16P 0399292 1726913	Producción	26.92	27.26	3.98	05-Dec-01			
11	Victoria #1 (gasolinera)	16P 0397645 1721746	Producción	52.52	52.94	21.32	18-Dec-01			
12	Residencial Europa	16P 0399366 1725680	Producción	24.42	24.92	4.10	05-Dec-01			
13	Canadá	16P 0397831 1725769	Producción	31.99	33.87	9.61	17-Dec-01			
14	La Mora No.1	16P 0396909 1725541	Producción	35.78	35.96	10.77	18-Dec-01			

Tabla No. 8 Red de Monitoreo de Pozos
Villanueva, Honduras

No.	Nombre del pozo	Coordenadas UTM	Tipo de pozo	Elevación terreno Natural (m snm)	Elevación terreno Referencia (m snm)	Nivel Estático anterior (m)	Fecha lectura	Nuevo Nivel Estático (m)	Fecha lectura	Observaciones
1	Orquidea II	16P 0393142 1694141	Producción	92.66	92.82	33.80	29-Nov-01			
2	Orquidea III	16P 0393034 1694095	Producción	94.51	94.95	43.56	29-Nov-01			
3	Col Municipal	16P 0395157 1694522	Producción	64.93	65.50	10.60	29-Nov-01			
4	Buena Vista	16P 0395939 1693554	Producción	71.48	72.09	34.43	29-Nov-01			
5	Villa Linda Norte	16P 0394962 1692873	Producción	54.51	54.96	13.50	29-Nov-01			
6	Guadalupe Lopéz	16P 0396098 1693853	Producción	71.10	71.40	30.17	29-Nov-01			
7	La Victoria	16P 0394395 1693962	Producción	67.98	68.76	32.66	29-Nov-01			
8	Cañeras II	16P 0393445 1691699	Producción	47.51	47.91	10.94	06-Julio-01			
9	Pintala I	16P 0392752 1691490	Producción	53.37	53.78	8.77	29-Nov-01			
10	Villasol	16P 0393671 1363850	Producción	71.81	72.04	28.17	30-Nov-01			
11	Independencia I	16P 0393832 1693445	Producción	72.52	73.02	23.00	30-Nov-01			
12	Manuel Coelb	16P 0394328 1692334	Producción	50.18	50.56	14.57	20-Nov-01			
13	Vivero Municipal	16P 0393415 1694607	Producción	97.28	97.48	32.64	29-Nov-01			
14	Llanos de Canadá	16P 0395814 1692807	Producción	52.00	52.84	6.49	19-Julio-01			
15	Zip Villanueva #6	16P 0394991 1694016	Producción	61.73	63.93	18.32	18-Julio-01			

APPENDIX A

Field Form

WATER SAMPLE DATA LOG

Project No.:	Project:
Well No.:	Date:
Location:	Weather:
Purpose of Sampling Event:	

WELL DATA

Total Depth of Well (ft bls):	Depth to Water (ft bls):
Screened Interval (ft bls):	Date/Time:
Casing Diameter (in):	Pt. of Measurement:

FIELD SAMPLING DATA

Time	Discharge Rate (gpm)	Total Discharge (gallons)	pH	Temp. °F	Specific Conduct. (µmhos/cm)	Sand Content (ml/l)	Comments

Time Pumping Started: _____ Time of Sample Collection: _____

Type of Samples Collected: _____

Total Discharge (gpm): _____ Type of EC-T-pH Meter: _____

Sample Collected by: _____

How Sample Collected: _____

Comments: _____

APPENDIX B

Chain of Custody

SPL, Inc.

Analysis Request & Chain of Custody Record

SPL Workorder No: 104520

page 1 of 1

Client Name: Brown & Caldwell
Address/Phone: Barbara Goodrich
Client Contact: 925-937-9010
Project Name: USAID Groundwater Monitoring
Project Number: 213605
Project Location: Villanueva, Cortés, Honduras
Invoice To: Brown & Caldwell, Walnut Creek

SAMPLE ID	DATE	TIME	comp	grab	matrix (W=water S=soil SL=sludge O=other:)	bottle (P=plastic A=amber glass G=glass V=vial)	size (1=1 liter 4=4oz 40=vial 8=8oz 16=16oz)	pres. (1=HCl 2=HNO3 3=H2SO4 O=other:)	Number of Containers	metales	coliformes	VOCs						
nombre de muestra	11/30/2001	1420		X	W	P	1	–	1	X								
nombre de muestra	11/30/2001	1425		X	W	G	16	1	1		X							
nombre de muestra	11/30/2001	1425		X	W	G	40	3				X						

Barbara Goodrich

Client/Consultant Remarks:

Laboratory remarks:

Intact? ☐ Y ☐ N

Temp:

Requested TAT

24hr ☐ 72hr ☐

48hr ☐ Standard ☒

Other ☐

Special Reporting Requirements: Fax Results ☒ Raw Data ☐ Standard QC ☒ Level 3 QC ☐ Level 4 QC ☐

Special Detection Limits (specify):

PM review (initial):

1. Relinquished by Sampler: Barbara Goodrich to DHL	date 11/30/2001	time 1750	2. Received by:
3. Relinquished by:	date	time	4. Received by:
5. Relinquished by:	date	time	6. Received by Laboratory:

☒ 8880 Interchange Drive, Houston, TX 77054 (713) 660-0901

☐ 459 Hughes Drive, Traverse City, MI 49684 (616) 947-5777

☐ 500 Ambassador Caffery Parkway, Scott, LA 70583 (318) 237-4775

APPENDIX C

Groundwater Sampling Event Checklist

CHECKLIST FOR GROUNDWATER SAMPLING EVENT

Before leaving for the field:

1. Contact the laboratory responsible for bacteriological analysis before sampling event.
2. Arrangements made for international transport of water samples.
3. Access to well and proper pump function have been verified before water sample.
4. The following materials and equipment are available:
   Electronic water level meter
   Field meter for conductivity, pH, and temperature
   Field meter calibration solutions
   Water sample containers (supplied by laboratory)
   Ice chests
   Ice
   Water sample labels
   Disposable gloves
   Zipper-lock plastic bags
   Water sampling field forms
   Chain of custody form
   Camera and film
   Sample packing material
   Water sample field filtering equipment
   Flame disinfection equipment
5. Confirm proper function of the electronic water level meter

In the field:

1. Observation and proper documentation of conditions at the well site prior to sampling.
2. Locate elevation reference point for water level measurement.
3. Conduct three consecutive measurements of groundwater level and record results on the field data form.
4. Disinfection of the sampling port using flame.
5. Proper purging of three well volumes before water sampling.
6. Calibration of the field conductivity, pH, and temperature meter.
7. Measurement of conductivity, pH, and temperature and documentation in field form.
8. Water sampling personnel use disposable gloves during water sampling.
9. Collection of the necessary quantity of groundwater for each analysis.
10. Samples for iron and magnesium analysis were filtered in the field.
11. Sample containers for volatiles analysis were free of bubbles.
12. Sample date and time are recorded and documented on field form.
13. All samples are properly labeled.
14. Chain of custody documentation is filled out prior to sampling of next well.
15. Periodic confirmation that water sample ice chest contains sufficient ice to maintain a temperature not greater than 40 C.

After water sampling:

1. Water samples for bacteriological analysis were delivered to the laboratory within the appropriate holding time.
2. The laboratory signed the chain of custody for receipt of water samples.
3. Water samples for shipment were carefully packed in protective material, preferably bubble-wrap.
4. Ice for the ice chest is placed in zipper-lock plastic bags to avoid spilling.
5. Water samples and ice are placed in a large plastic bag within the ice chest.
6. The signed and dated chain of custody is placed in the ice chest for shipping.
7. The ice chest was carefully sealed prior to shipping.
8. An international air bill and a commercial invoice are filled out to accompany the ice chest during shipping and transport.
9. The laboratory in Houston was contacted to notify of the shipment, the number of samples in the shipment, the requested analyses, and the estimated time of arrival of the shipment.

APPENDIX D

Photographs

Containers for water samples

Water level sounder

Temperature, pH and conductivity meter

Flame cleaning of sampling port prior to sample collection

Field filtering of water samples to be analyzed for dissolved iron and manganese

Cleaning of sampling port

APPENDIX F

Wellhead Protection Plan

WELLHEAD PROTECTION PLAN

Choloma, Honduras

June 2002

INTRODUCTION

The most effective means in protecting the groundwater quality used for public water supply in Choloma is establishing a wellhead protection program. Wellhead protection is the practice of managing the land area around a well to prevent groundwater contamination. Prevention of groundwater contamination is essential to maintain a safe drinking water supply.

The control measures included in this section should be incorporated into municipal regulations to ensure control on water use and to protect the area covered with dense vegetation that represents potential groundwater recharge areas through rainfall infiltration.

Groundwater may become contaminated through natural sources or numerous types of human activities. One of the main causes of groundwater contamination induced by human activity is the effluent from septic tanks, cesspools, and latrines. Although each disposal system releases a relatively small amount of waste into the ground, the large number and widespread use of these systems results in a significant contamination source. Similarly, improper disposal of gray water, hazardous wastes, leaking fuel storage tanks, and chemical storage and spill sites are sources of contamination to groundwater.

KEY STEPS

Development of a wellhead protection plan for Choloma consists of five key steps that are described in detail below:

Step 1: Planning. The municipality should assemble a team to arrive at a cooperative effort for wellhead protection objectives. The team may include municipal officials, representatives from the public works departments, environmental managers, and members from the local health department.

Team objectives should focus on delineation of a wellhead protection area to protect the water wells from unexpected contaminant releases, as well the development of a plan for controlling high-risk activities within the well recharge area.

Step 2: Delineate the Wellhead Protection Area. The geographic limits most critical to the protection of a well water supply must be delineated. Based on this information, a base map should be developed that shows detailed information on the natural features of the area, both surface and subsurface, land use including roadways and utilities, and location of all public supply wells and water recharge areas. Clear acetate overlays can be added that illustrate the radius of influence (even if estimated) for every pumping residential and municipal water supply well, location of aquifers and aquifer recharge zones, watershed in which the aquifers are located, wetlands, lakes and flood zones that may affect recharge, and potentiometric surface information that illustrates groundwater flow direction.

The actual delineation of a wellhead protection area ranges in complexity from drawing a circle of specified radius around each well, to more sophisticated techniques involving analytical methods and groundwater modeling. Using an arbitrary fixed radius - calculating a fixed radius measured from the well to the wellhead protection area boundary - is an inexpensive, easily implemented method of wellhead delineation. Choosing a large fixed radii will increase the protective effectiveness, but alternatively, could lead to overcompensation and unnecessary wellhead protection costs. However, a disadvantage of the fixed radius approach is that it is not based on hydrogeologic principles and could lead to inadequate protection of recharge areas. Given the limited aerial extent of the freshwater aquifer at Choloma, the entire area may be included inside the protection zone.

Step 3: Identify and Locate Potential Sources of Contamination. The objective of this step is to prepare a master wellhead protection area map that shows all existing contaminant sources and identifies potential threats. First, a comprehensive inventory of potential and known contaminant sources should be developed within each wellhead protection area. Sources should include past and present waste sites such as sewage treatment and disposal areas, landfills, and chemical storage and disposal areas, including small commercial and any future industrial waste areas. The inventory should also include agricultural sources such as crops where pesticides and insecticides may have been used, animal feedlots, livestock waste disposal areas, and agricultural drainage ditches and canals. In addition, residential areas with septic systems, latrines, cesspools, and buried waste disposal areas should be inventoried. Once all of the potential sources of contamination have been identified, each source should be plotted on an overlay of the wellhead protection area.

Following identification of source areas, an evaluation of the immediacy and degree of risk associated with each potential source of contamination should be conducted. Values of risk can be assigned and ranked based on their proximity to groundwater supply, the nature of the contaminant, and the intended use of groundwater. By assigning risk values, it is possible to prepare a map illustrating the location and magnitude of potential threats to the groundwater supply, as well as aid in determining which areas require immediate attention to prevent contamination to the water supply.

Step 4: Manage the Wellhead Protection Area. A long term, low cost management wellhead protection plan can be tailored for the municipality. It may be initiated by addressing identified immediate threats to the groundwater supplies followed by a program of prevention and protection of future supplies. One easily achieved component of the plan is to institute a public education program to increase awareness of the threats of groundwater contamination and encourage groundwater protection and conservation measures. Other programs may include the municipality acquiring sensitive recharge areas and converting them to park land, recreational facilities, or other community-based land uses.

Another component of wellhead protection is groundwater monitoring. Regular groundwater monitoring around municipal and residential water supply wells can detect potential sources of contamination before they infiltrate the municipal water supply. A good groundwater monitoring program consists of collecting numerous groundwater samples on a regular basis and performing laboratory tests to detect various contaminants, which will identify problems quickly. The further

the monitoring wells are located from the pumping well, the sooner problems can be identified and more time will be available to rectify the situation or provide adequate substitute water supplies.

Step 5: Plan for the Future. A critical component of a successful wellhead protection plan is regular annual review and update of the plan. This will allow for improvement of management strategies and provide time to act on new information regarding sources of contamination. A critical aspect of the plan is the identification of future hazards that could threaten the wellhead protection areas. Early identification will allow time to develop solutions or contingency plans for alternate water supplies.

APPENDIX G

Training and Workshops

TRAINING AND WORKSHOPS

Choloma, Honduras

June 2002

INTRODUCTION

Brown and Caldwell conducted a series of workshops and training sessions throughout the project. These sessions consisted of project kick-off, status meetings, training sessions, and project wrap-up meetings, as described below.

Project Kick-off and Status Meetings

Initially, Brown and Caldwell held two project kick-off meetings to introduce the project to interested stakeholders and build consensus regarding project objectives. The kick-off meetings were held in Tegucigalpa on 3 May 2001 and in San Pedro Sula on 22 May 2001. Kick-off meeting agendas and lists of attendees are included at the end of this section.

On 11 July 2001, Brown and Caldwell held a workshop to present the conceptual hydrogeologic models we developed for each of the study areas and update interested parties on the status of the project. This meeting was held in San Pedro Sula. A workshop agenda and list of attendees is also included at the end of this section.

Training Sessions

To help ensure project sustainability, Brown and Caldwell held seminars to train local municipal personnel in groundwater monitoring techniques and in operating the water resource database developed for each project municipality. Groundwater monitoring training sessions were held on December 4th, 6th, and 10th, 2001 at Limon de la Cerca, the Sula Valley, and Utila, respectively. A training session agenda and list of municipal personnel who participated in the training is included at the end of this section. The training sessions on how to use and update the project databases developed by Brown and Caldwell were held in San Pero Sula and Tegucigalpa on February 12th and 14th, respectively. These training sessions were held at the local UNITEC campuses. Again, a training session agenda and list of attendees is included at the end of this section.

Project Wrap-Up Meetings

The project also calls for project wrap-up meetings to be held with mayors and other representatives of each municipality. These meetings are intended to help ensure project sustainability by introducing the project to the new municipal governments, discussing project results, and making recommendations for implementing components of the water resource management plans developed for each municipality. Although these meetings were not completed at the time of the writing of this report, the meetings were scheduled as follows:

Limon de la Cerca/Choluteca – 20 June 2002
Isla de Utila – 22 June 2002
Choloma – 24 June 2002
La Lima – 25 June 2002
Villanueva – 26 June 2002.

A copy of the agenda for the wrap-up meetings is included at the end of this section.

PROJECT KICK-OFF AND STATUS MEETINGS

AGENDA
May 3, 2001 Kickoff Meeting – Tegucigalpa
USAID Groundwater Monitoring (Water Resource Management) Studies
Choloma, La Lima, Limón de la Cerca, Utila, Villanueva

I. Introduction
   A. USAID Project Background (audience introductions)
   B. Brown and Caldwell Project Team

II. Project Goals and Objectives – Jeff Nelson
   A. Background
   B. Meeting Objectives (consensus)
   C. Project Objectives (sustainability)
   D. Scope of Work/5 Phases
   E. Municipality Needs

III. Program Implementation – Horacio Juarez
   A. Development of Partnerships
   B. Sustainability
   C. Project Schedule

10:30 – 10:45 Coffee Break

IV. Project Overview – Jim Oliver
   A. Conceptual Model
   B. Hydrogeology
   C. Modeling
   D. Matrix Prioritization

V. Water Resource Management Plans – Paul Selsky
   A. Water Needs
   B. Water Supply and Delivery
   C. Recommendations
   D. Management Plan Development

12:00 – 1:30 Lunch Break

VI. Municipality Input – Audience

VII. Technical Approach – Jay Lucas/Milton Sagustume
   A. Phases (update)
   B. Drilling
   C. Project Schedule

3:00 – 3:15 Coffee Break

VIII. Data Base – Allan Scott
   A. USGS Data Base
   B. Project GIS
   C. Technology Transfer and Training

IX. ReCap and Open Discussion
   A. Consensus

5/3/2001

Name	Organization	Phone Numbe
ALLAN SCOTT	BROWN & CALDWELL	916 853-5380 [redacted]
Barbara Goodrich	Brown & Caldwell	925-210-2345
Francisco CASCO	Municipalidad Villanueva	504-670-[illegible]
Ramón Jiménez Flores	Municipalidad Villanueva	670-04-05
Rodolfo Ochoa	SANAA.	2206506
Carlos M. Flores	USAID	236-9320-X-44[illegible]
Paul Selsky	Brown & Caldwell	
Alicia Villar Landa	PRIMHOR	239-41-14 / 41-8[illegible]
Maurice James	US. Army Corps of Engineers	911-9189
Mauricio Cruz	USAID	236-9320 (479
Carlos Verdin	USAID	236-9320 (40[illegible]
Juan Benito Guevara	Alcaldia Chol.	882-7171
John Walker	USGS	992-8312
Olman E. Rivera	USACE-USAID	995-74-79
Susan Grant	Brown and Caldwell	925-210-2253
Mario A Flores	Fundemun	
César H. Monzón	Fundemun	882-4298
Ricardo Valle L	FUNDEMUN	985 4930
James Oliver	Brown & Caldwell	602-222-4463
Alfredo Stein	Embajada de Suecia	221-1736
DAVID BOURAN	USAID (dbouran@usaid.gov)	236-9320 (466
ARCELIA SALGADO	USAID (a.salgado@usaid.gov)	236-9320 (4663
Jeff Nelson	Brown & Caldwell JNelson@broncall.com	988-5927 (cell)
Francisco Juan	Gerente DIMUSEE	552 5211
Jorge Flores	FHIS	234 8619 / 99 633
Isidro Alberto Mondragon	Fundemun	882-429[illegible]
Horacio Juarez	Brown & Caldwell	(915) 545-44[illegible] 188-593

Name	Organization	Phone Number
LOURDES RETES	CHF	2396815/31/2325
Lisa Pacholek	CHF	LPacholek_CHF@cablecolor.hn
Karen Perez	Brown & Caldwell	983-1607

AGENDA
22 de Mayo 2001
Estudio y Monitoreo de Aguas Subterráneas (Manejo de Recursos de Agua)
Los Municipios de Choloma, La Lima, Limón de la Cerca, Utila, Villanueva
Financiado por USAID

I. Introducción – Ing. Carlos Flores
   A. Antecedentes del Proyecto USAID (Presentación de los Participantes)
   B. Presentación de Brown and Caldwell y el equipo técnico del Proyecto

II. Metas y Propósitos del Proyecto – Ing. Jeff Nelson
   A. Antecedentes
   B. Propósitos de la Reunión (consenso)
   C. Propósitos del Proyecto (sostenibilidad)
   D. Alcance del Trabajo (cinco fases)

III. Implementación del Programa – Ing. Horacio Juarez
   A. Desarrollo de Asociaciones entre Agencias Participantes
   B. Sostenibilidad
   C. Programa del Proyecto

IV. FUNDEMUN – Ing. Jenny Chávez
   Aplicación de Tasas de Cobre por Explitación de Aguas Subterráneas según Plan de Arbitrios

   DESCANSO (Quince minutos)

V. Resumen de Actividades del Proyecto
   A. Evaluación de Sistemas Existentes y Recopilación de Datos – Ing. Dean Wolcott
   B. Base de Datos Hidrogeológicos – Lic. Dean Wolcott
   C. Modelación Hidrogeológica – Ing. Milton Sagastume
   D. Manejo de Recuros Hídricos – Ing. Milton Sagastume
   E. Programa de Perforación de Pozos – Ing. Milton Sagastume

VI. Comentarios por parte de Alcaldes, Gerentes o Jefes de Servicios

US AGENCY FOR INTERNATIONAL DEVELOPMENT
USAID/Honduras

Tegucigalpa, M.D.C.
21 de mayo de 2001

A QUIEN INTERESE

De todos es conocido, que cada vez es más frecuente y significativa la utilización y explotación de acuíferos subterráneos para satisfacer las demandas de agua de las poblaciones de varias comunidades y ciudades alrededor del país. Por lo que es fácilmente previsible que el uso de las aguas subterráneas para el abastecimiento de agua potable en estas localidades, se incrementará en la misma medida que haya un crecimiento de la población futura y por lo tanto los rendimientos de estos acuíferos se verán disminuidos en una mayor proporción.

Los sistemas de abastecimiento de agua de las ciudades de La Lima, Choloma y Villanueva en el valle de sula, de la Isla de Utila y de Choluteca, que utilizan las aguas subterráneas como principal fuente de abastecimiento, fueron severamente dañados durante el paso del Huracán Mitch. Actualmente, la Agencia Internacional para el Desarrollo de los Estados Unidos (USAID) realiza fuertes inversiones en estas regiones para construir nuevos centros habitacionales y para rehabilitar y a su vez expandir los sistemas de abastecimiento de agua respectivos.

Recientemente, la USAID ha contratado los servicios de la Firma Consultora Brown and Caldwell para elaborar un estudio de monitoreo de aguas subterráneas en las ciudades arriba mencionadas. El desarrollo de dicho proyecto conlleva el realizar estudios hidrogeológicos, recopilar una base de datos que provea información suficiente para implementar planes prácticos y efectivos en la administración del recurso agua subterránea en cada localidad y determinar si este recurso cumple y satisface adecuadamente las expectativas y requerimientos de demanda actual y futura. Así mismo, el Estudio contempla realizar una evaluación preliminar de la infraestructura de abastecimiento de agua subterránea existente en cada municipalidad y desarrollar costos estimados preliminares para el mejoramiento de esta infraestructura.

El éxito de este proyecto será medido al asegurar la sostenibilidad de los objetivos planteados en el mismo, una vez que éste finalice. Por lo tanto, un componente fundamental para asegurar dicha sostenibilidad será el de crear relaciones de trabajo permanentes entre el Consultor y cada una de las municipalidades involucradas, así como con otros organismos y/o instituciones relacionadas con el tema de aguas subterráneas, como ser SANAA, FUNDEMUN, Acción Contra el Hambre, UNITEC y la Comisión Ejecutiva del Valle de Sula. Dentro de este contexto, cabe mencionar que es menester de la Municipalidad designar el recurso humano necesario para que sea debidamente

Mailing Addresses: From USA: USAID/Honduras, UNIT 2927, APO AA 34022. Tel. 011-504-236-9320
In Honduras: Apartado Postal 3453, Tegucigalpa, M. D. C. Tel. 236-9320, Fax (504) 236-7778

capacitado por la Firma Consultora en el manejo, seguimiento y monitoreo del modelo y de la base de datos que será proporcionada a la Municipalidad.

En base a lo anterior, solicitamos su gentil cooperación para proporcionar toda aquella información que usted estime conveniente a la Firma Brown & Caldwell, la cual ha sido contratada para elabora este estudio. Su cooperación y asistencia son vitales para alcanzar el éxito y garantizar los futuros recursos de agua subterránea en Honduras.

Atentamente,

Todd Sloan
Director
Oficina de Desarrollo Municipal
e iniciativas Democráticas

Lista de Invitados

22 de Mayo 2001

No.	Nombre	Empresa/Corporación	Teléfono	E-mail
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3	Ruben C. Rosales	COE	334-990-3143	ruben.c.rosales@usarmy.mil
4	Antonio Morales Flores	FHIS/USAID	980-2090	
5	José Francisco Casco	Municipalidad Villanueva	226-7269	670-04-47
6	Ramón Tinoco Flores	Municip. de Villanueva	670-04-47	
7	Heclon A Cabrera	MUNIC de VILLANUEVA	6704084	
8	JAVIER REYES	MUNIC de VILLANUEVA	670-4445	
9	Rigoberto Rivera C	Municip de Villanueva	670-58-80	
10	RUBEN - SARAVIA	MUNICIP - DE - LIMA	668-24-00	
11	Silvia Fernandez	Alcaldesa La Lima	991-6547	SIFzelaya@
12	MONTERRY CÁRDENAS	MUNICIPALIDAD de LIMA	425-3293	—
13	Juan Ramón Melín A.	Municipalidad Choloma	669-39-22	— " —
14	Reid Orellana O	Municipalidad choloma	669-55-22	
15	Osman O. Alvarenga M.	MUNICIPALIDAD DE CHOLOMA	669-3223	odvarengam@hotmail.com
16	Alilio Benavides Alvarez	Municipalidad de Choluteca	983-4055	— " —
17	María Alejandrina Meza	Municipalidad. La Lima	668-0656	
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34	NELY R. Lemus	ATICA	558-1751	— " —
35	Aurora Rodríguez	Municipalidad La Lima	668-2400	Ediolima@hotmail.com.
36	José EVARISTO ESCALA F.	Municipalidad La Lima	668-26-01	
37	Doris Marlene Pérez Lazo	Municipalidad La Lima	668-26-01	
38	Mario Ramón Ramírez Soto		651-27-35	

USAID

BROWN AND CALDWELL

Resend 6- 6-02; 6:26PM;Brown and Caldwell; SACRAMENTO ;925 210 2487 # 2/ 17

Lista de Invitados

22 de Mayo 2001

No.	Nombre	Empresa/Corporación	Teléfono	E-mail
	Germán Wilfredo Henríquez	Municipalidad Choloma	668 2488	

USAID

BROWN AND CALDWELL

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AGENDA
USAID Monitorio y Estudios de Aguas Subterráneas
Presentación del Modelo Conceptual Hidrogeológico Preliminar
Utila, Valle de Sula y Limón de la Cerca

11 de Julio 2001
9:30 a.m.
Hotel Princess
San Pedro Sula

I. INTRODUCCION

II. RECURSOS DE AGUA EXISTENTES
- A. Fuentes de Agua
- B. Localización de Pozos

III. MODELOS CONCEPTUALES HIDROGEOLOGICS PRELIMINARES
- A. Geología
- B. Hidrogeología

IV. DATOS
- A. Geología
- B. Hidrogeología
- C. Calidad de Agua
- D. Modelación
- E. Información del Sistema de Agua

V. FASE II INVESTIGACION DE CAMPO
- A. PERFORACION
  1. Pozos de Prueba
  2. Aquíferos de Prueba
  3. Muestreo y Análisis de Agua
- B. ESTUDIOS GEOFISICOS
  1. Estudios EM
  2. Estudios Sísmicos y Reflexión

VI. EVALUACION DE LA INFRAESTRUCTURA DEL SISTEMA DE AGUA
- F. Población
- G. Uso de Agua
- H. Facilidades de Sistema de Agua

VII. DISCUSION

11 de Julio 2001
Invitee List

VILLANUEVA MUNICIPALITY 670-4788/670-4445

1. Lic. José Felipe Borjas (Alcalde Municipal)
2. Lic. Francisco Casco (Jefe de Obras y Servicios Públicos)
3. Lic. Rigoberto Rivera (Jefe de Servicios Públicos)
4. Juan Pago Avila (Jefe de Departamento de Agua)
5. Alfredo Cabrera (Jefe de Operación de Mantenimiento)
6. Ramón Jímenez Flores
7. Hector Cabrera

LA LIMA MUNICIPALITY 668-2400/668-2601

1. Lic. Evaristo Euceda (Alcalde Municipal)
2. Ing. Doris Pérez (Directora de Servicios Públicos)
3. Ruben Saravia (Jefe de Servicios Públicos)
4. Ing. Aurora Rodríguez (Asistente)
5. Jorge Nery López (Asistente Departamento de Catastro)
6. Dilcia Fernandez
7. Lic. José Luis Caballero-- ASITENCIA SOLICITADA POR ALCADE
8. Ing. German Henríquez-- ASITENCIA SOLICITADA POR ALCADE

CHOLOMA MUNICIPALITY 669-3322/6693223

1. Lic. Armando Gale (Alcalde Municipal) (no)
2. Ing. Osman Alvarenga (Director de Servicios Públicos)
3. Ing. Julio César Hernández (Jefe de Servicios Públicos)
4. Ing. Edy Martínez (Asistente de Ingeniería)
5. Juan Ramón Mejía
6. Dario Perdomo

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1. Actilio Alvarez (Técnico DIMUSED)
2. Manuel Mejía (Técnico DIMUSED) (no)
3. Juan Benito Guevara (Alcalde Municipal) (no)

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2. Ing. Jenny Chávez (Choloma, Villanueva) 984-1577
3. Ing. Jose Tulio Gómez (La Lima) 647-3136

COE

1. Rueben Rosales

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1. Monterrey Cárdenas (Alcalde Municipal)

UNITEC

11 de Julio 2001
Invitee List (Continued)

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1. Ing. Claudia Enamorado

SANAA

1. Rodolfo Ochoa (Arturo Trochez en representación) (220-6506)

USAID (236-9320)

1. Carlos Verdial
2. Mauricio Cruz
3. Frank Almaguer (Embajador)
4. John Jones (Consul)
5. Timothy M. Mahoney (Director de la Misión)
6. Glenn Berce-Oroz (Director Interino de la oficna de Desarrollo Municipal e Iniciativa Democrática)
7. Charles Oberbeck

PRIMHOR (239-4114)

1. Alicia Villar Landa (Ing. Victor Manuel Leva Coordinador unidad SPS)

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1. John Walkey
2. Olman O. Rivera
3. Jeff Phillips

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1. Jorge Flores (992-6334)
2. Antonio Morales (980-2090)
3. Gunther Von-Weise
4. Ing. Samuel Alvarado

USAGE

1. Carlos Selva

CHF

1. Lourdes Retes (Asistirá *Nohemy Carrasco* de parte de HOGAR)
2. Lisa Pacholek (no asistirá)

LISTA ASISTENTES

11 de Julio 2001

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LISTA ASISTENTES

11 de Julio 2001

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Jorge Nery Lopez	Municipalidad La Lima	Asist. Dept. Catastro	668-24-00	668-26-01		
Ruben Samayoa	Municipalidad Lima	Jefe Serv. Pub.	668-24.00	668-26-01		
Julio César Hernández	Municipalidad Choloma	Asesor Técnico	669-32-23	669-17-74	—	
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Resend 6- 6-01 6:30PM;Brown and Caldwell SACRAMENTO 1925 210 2487 # 13/ 17

TRAINING SESSIONS

GROUNDWATER MONITORING STUDIES/HONDURAS
GROUNDWATER MONITORING TRAINING
December 4, 6, and 10, 2001

INTRODUCTION

Brown and Caldwell performed three groundwater monitoring training events in early December, 2001, covering the five project municipalities. Similar training was conducted throughout Phase II of the project and the purpose of the recent training was to reinforce knowledge and practices learned by the participants during earlier fieldwork and training. Attached is the outline that was presented for the training session.

The training of Honduran personnel is essential to one of the project's main goals: project sustainability. The purpose of the training program is to ensure that each municipality will continue the Groundwater Level and Monitoring Program after the current project is completed.

These training sessions were conducted by Dean Wolcott, P.G., with the assistance of Barbara Goodrich and Fabiola Andrade (Sula Valley and Utila). Mr. Atilio Alvarez, technician for the municipality of Choluteca, assisted the BC staff in the Limon de la Cerca/Choluteca training session.

TRAINING PARTICIPANTS

The following lists describe the individuals who participated in the groundwater monitoring training. While the majority of participants are municipal engineers and technicians, personnel from non-governmental organizations were also invited and participated.

Site: Limon de la Cerca / Choluteca
Conducted by: Dean Wolcott, P.G., and Atilio Alvarez
Training date: December 4, 2001

PARTICIPANT	ORGANIZATION
Romulo Vivas	DIMUSEB/Choluteca
Guillermo Ordonez	DIMUSEB/Choluteca
Atilio B. Alvarez	DIMUSEB/Choluteca
Rosa Fiallos	PNUD/DIMUSEB
Cesar H. Mondragon	FUNDEMUN
Jorge Flores	FHIS

Site: La Lima, Villanueva, and Choloma
Conducted by: Dean Wolcott, P.G., Barbara Goodrich, and Fabiola Andrade
Training date: December 6, 2001

PARTICIPANT	ORGANIZATION
Jorge Nery Lopez Vasquez	La Lima Municipality
Jose Ruben Saravia	La Lima Municipality
Doris Marlenee Perez Lazo	La Lima Municipality
Alexis Orellana Martinez	La Lima Municipality
Jenny Mariela Chavez	FUNDEMUN
Jose Rigobero Rivera	Villanueva Municipality
Julio Cesar Hernandez	Choloma Municipality
Osman O. Alvarenga. M.	Choloma Municipality
Carlos R. Castillo L.	Choloma Municipality
Jose Francisco Casco P.	Villanueva Municipality
Hector A. Cabrera	Villanueva Municipality
Olga Lara de Hubin	Choloma Municipality
Antonio Morales Flores	FHIS

Site: Island of Utila
Conducted by: Dean Wolcott, P.G., Barbara Goodrich, and Fabiola Andrade
Training Date: December 10, 2001

PARTICIPANT	ORGANIZATION
Jonell Jackson	
Joslyn J. Ponce	
Alton Cooper	Utila (Mayor Elect)
Glenn Gabourel	Island Spring
Jorge Flores	FHIS
Gilda Ordonez	Utila
Carolina Escobar	Utila

TRAINING TOPICS

The subject matter of the training sessions consisted of all relevant technical material associated with the Groundwater Level and Monitoring Program. Topics included monitoring system well selection criteria, groundwater level measuring methodology, groundwater sampling methodology, field analysis of groundwater samples, laboratory analysis of groundwater samples, quality assurance/quality control, and data interpretation.

Each training session consisted of a classroom lecture and discussion followed by a hands-on field practice session where monitoring and data collection activities were conducted at a monitoring well.

A special emphasis was placed on proper documentation of field activities and the use of designated data collection forms developed for the Program.

TRAINING MATERIALS

Training participants were provided with a copy of the Groundwater Level and Monitoring Program Field Manual. This field manual contains detailed descriptions of the activities contained in the monitoring program, copies of field data forms, pictures of specific field activities, and a list of wells in the monitoring well network for each municipality.

Materials provided in the training sessions included an electronic water level meter, Oakton field water quality kit, groundwater sample kit, water filter apparatus, and other monitoring equipment.

Water Resources Management System
Training Summary
February 12 and 14, 2002

Introduction

Brown and Caldwell conducted two training workshops in February to train representatives from each municipality on the use of the Water Resources Management System (WRMS). The WRMS is a custom database and geographic information system application that has been custom developed to use as a water resource planning tool to support the goals of this project.

Integration of the use of the WRMS with the other recommendations and programs established in this project are essential to the main project goal of providing for sustainable water resource management in the future. The WRMS has been designed to support other project programs such as the Groundwater Level and Monitoring Program (training conducted in December, 2001). The purpose of this training was to provide hands-on training and experience with the WRMS application so that the municipalities can use it to maintain and manage data and to use the tool for future decision-making.

The main goals of the training were to gain an understanding of the capabilities of the WRMS, learn how to enter and manage data, and create maps and reports from data in the database. Each workshop consisted of a one-day hands-on course and covered a system overview, how to start using the system, entering infrastructure data, accessing other resources, system administration, creating GIS basemaps, and using well prioritization tools. The following workshops were conducted:

- UNITEC Campus, San Pedro Sula, February 12, 2002;
- UNITEC Campus, Tegucigalpa, February 14, 2002.

Training Topics

Each workshop was conducted at the UNITEC computer laboratory and each participant had their own computer and a training copy of the database. The participants used a 114 page training manual that contained a detailed discussion of each function in the WRMS, theory and recommendations for best practices, and 20 individual exercises designed to provide hands-on training and practice. During the training, the following objectives were successfully accomplished by the participants:

- Learn the components of the WRMS
- Enter and edit service areas data
- Enter well information
- Store images and other electronic files
- Enter water quality samples and water levels
- Enter storage tank information
- Create reports from the database

- Learn how to access other resources (the USGS Groundwater Well Database, Municipal Water Resources Reports, etc.)
- View wells and storage tanks on a map
- Use the basic functionality of ArcView to create a map
- Display well information on a map (water level, water quality, depth, etc.)
- Overview of the well site prioritization tool

Training Participants

Training was conducted by Allan Scott of Brown and Caldwell, with assistance from Fanny Letona (ATICA), David Esponiza (ATICA), and Fabiola Andrade (Brown and Caldwell).

The following are lists of the individuals that participated in the workshops.

San Pedro Sula, February 12, 2002 participants:

Participant	Organization
Ramón Jimenéz Florez	Villanueva Municipality
José Rigobero Rivera	Villanueva Municipality
Francisco Casco	Villanueva Municipality
Marvin Pinador	Villanueva Municipality
Jackeline Reyes	La Lima Municipality
Jose Ruben Saravia	La Lima Municipality
Carlos H. Ochoa	La Lima Municipality
Doris Perez	La Lima Municipality
Julio Cesar Hernández	Choloma Municipality
Ruglio Diaz	UNITEC

Tegucigalpa, February 14, 2002 participants:

Participant	Organization
Mauricio Cruz	USAID
Carlos Verdial	USAID
Jorge Flores	FHIS
Glenn Gabourel	Utila Municipality
John Walkey	USGS

PROJECT WRAP-UP MEETINGS

USAID Groundwater Water Resources Management Project
Project Wrap-up Workshop Agenda

Introductions (All)

Project Purpose (USAID)
- History
- Objectives

Project Sequence (BC/Atica)
- Initial data gathering
- Conceptual model development
- Field Investigation
- Groundwater flow model
- Evaluation

Results and Findings (BC/Atica)
- Water requirements/demand
- Aquifer characteristics
- Groundwater quality
- Future wells
- Well head protection

Data base (BC/Atica)

Training (BC/Atica)

Computers & Equipment (USAID)

Recommendations/Summary

Break

Field visit to wells