USAID
FROM THE AMERICAN PEOPLE

ENVIRONMENTAL SERVICES PROGRAM

POST-TSUNAMI WATER RESOURCE SCOPING STUDY IN NANGGROE ACEH DARUSSALAM, INDONESIA

SEPTEMBER 2005

This publication was produced by Development Alternatives, Inc. for the United States Agency for International Development under Contract No. 497-M-00-05-00005-00

Photo credit: Phillip E. Brown

Photo Caption: Salt water intrusion caused by the tsunami impacts coastal farm land and ground water resources in Nanggroe Aceh Darussalam.

POST-TSUNAMI WATER RESOURCE SCOPING STUDY IN NANGGROE ACEH DARUSSALAM, INDONESIA

Title:	**Post-Tsunami Water Resource Scoping Study in Nanggroe Aceh Darussalam, Indonesia**
Program, activity, or project number:	**Environmental Services Program, DAI Project Number: 5300201.**
Strategic objective number:	**SO No. 2, Higher Quality Basic Human Services Utilized (BHS).**
Sponsoring USAID office and contract number:	**USAID/Indonesia, Contract number: 497-M-00-05-00005-00.**
Contractor name:	**DAI.**
Date of publication:	**September 2005**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BAPEDALDA	Office of the Environment
BGR	*Bundesanstalt für Geowissenschaften und Rohstoffe* (German Federal Institute for Geosciences and Natural Resources)
BMG	*Badan Meteorologi & Geofisika* (Meteorogical and Geophysical Agency)
ESP	Environmental Services Program
FAO	Food and Agricultural Organization of the United Nations
FDEM.	Frequency Domain Electromagnetics
GIS	Geographical Information System
GOI	Government of Indonesia
GTZ.	*Deutsche Gesellschaft für Technische Zusammenarbeit* (German Development Agency)
IRC	International Relief Committee
IRD	International Relief and Development
LOE	Level of Effort
NGO	Non-Governmental Organization
OXFAM	Oxfam International
PDAM	*Perusahaan Daerah Air Minum* (Local Government-Owned Drinking Water Company)
SDC	Swiss Agency for Development and Cooperation
USAID	United States Agency for International Development
UN HIC	United Nations Humanitarian Information Centre (HIC)
UNICEF	United Nations Children's Fund
USTDA	United States Trade Development Agency
WATSAN	Water and Sanitation
WHO	World Health Organization
WRDA	Water Resource Development Areas

EXECUTIVE SUMMARY

To determine how best ESP could further support on-going work in Aceh, a Scoping Study on Water Resource Development and Protection was performed by Phillip Brown and Gatot Sudradjat with the support of John Pontius and the ESP staff. The objective of the study was to develop concepts that:

- Was consistent with USAID-ESP's on-going programs in Aceh for watershed management, for service provision, and for alternative financing supporting cross cutting themes of water authority capacity building, information system development, training, and the environment;
- Complimented existing programs in the Aceh region including the USAID funded West Coast road;
- Was doable on a small scale which can be rolled out to the entire region.

In the aftermath of the tsunami which struck the northern and western coasts of Aceh Province in December 2004, there have been serious concerns regarding the quality and quantity of groundwater supplies in the tsunami-affected areas. The direct affect of the tsunami as well as over pumping of shallow wells for water supply in that region has caused saltwater intrusion. After a thorough review of climate, geologic, hydrologic, and hydrogeologic information as well as an evaluation of the potential long-term impacts of the tsunami on water resources, it was found that in terms of long-term water resource development in the region emphasis should be placed on the development and protection of springs and surface water resources with the drilling and completion of wells being of secondary importance. This is largely due to the relative abundance of surface water (with the region receiving between 1.6 to over 3 meters of rainfall a year) and the complications of drilling wells in areas which have not been affected by the tsunami or past practices which may have contaminated the groundwater.

Towards this end, six basic concepts have been defined for Water Resources Development and Protection in the Aceh region which could be supported by ESP. These include:

1. **Hydromet Monitoring** – Meteorological and hydrologic data for water management is lacking in the region and data collection needs to be improved;
2. **Hydrochemical Evaluation** – Understanding the impact of the tsunami and land use on water chemistry of rivers in the region is important toward decision making;
3. **Water Balance/Water Supply Evaluation** - Lack of data and information on water balances in watersheds makes it difficult to develop and forecast long term water supplies;
4. **Water Resource Protection** - After the tsunami, water supply systems were disrupted. Numerous wells were drilled and springs were developed for water supply. Understanding and protecting these supplies is imperative to meet long-term water supply demands;
5. **Groundwater Management Model** - Currently groundwater is a primary source of water for the Kr. Aceh basin. Understanding the flow characteristics of aquifers supplying water is an important aspect for long-term water supply planning;
6. **Spring Development and WATSAN Planning** - Springs are a major source of water supply in the region. Communities depend on these springs,

however, development of springs and distribution is often haphazard and needs improvement.

The next of program will be develop and implement program designs.

1. INTRODUCTION

1.1. GENERAL

This report presents the findings of a hydrogeologic scoping study performed by Phillip E. Brown for the USAID funded Environmental Service Program[1]. The study took place in the tsunami ravaged Indonesian province of Aceh during the later part of August and early September, 2005. It consisted of a two-week evaluation of the water resources in the Province. During this study, a combination of Government of Indonesia (GOI) agencies, donors, non-governmental organization (NGOs), and others were interviewed and numerous reports were reviewed. Detailed daily activities for the time period spent in Aceh Province are presented in Attachment C to this report.

1.2. OBJECTIVE

In the aftermath of the tsunami which struck the northern and western coasts of Aceh Province in December 2004, there have been serious concerns regarding the quality and quantity of groundwater supplies in the tsunami-affected areas. The direct affect of the tsunami as well as over pumping of shallow wells for water supply in that region has caused saltwater intrusion. This in turn has created an increased demand for both unaffected shallow and deep wells, penetrating aquifers on which we have very little information as to location, extent, quantities or recharge rates. The purpose of this short term technical assistance was to perform a Scoping Study to evaluate the current situation, to define the current knowledge base, to examine how existing and projected activities are going to impact groundwaters in the region, and to determine needs to be done to perform a complete hydrological/ hydrogeological study for the affected watersheds in the region. This report presents the results this assessment and presents draft scope(s) of work for continuing efforts of ESP in water resource management in Aceh Province.

1.3. APPROACH

The general approach to study was to develop a general overview of the hydrology (both surface and groundwater) in the Aceh Province. This was completed by:

- Working with Gatot M. Sudradjat, an Indonesian Hydrogeologist, other ESP

---

[1] The Environmental Services Program (ESP) is a fifty-eight month program funded by the United States Agency for International Development (USAID) and implemented under the leadership of Development Alternatives, Inc. (DAI). ESP works with government, private sector, NGOs, community groups and other stakeholders to improve the management of water resources and broaden the distribution of safe water to urban dwellers by strengthening watershed management and delivery of key environmental services, including clean water, sanitation and solid waste management in Indonesia. The period of the project is from December 2004 through September 2009. ESP activities are focused on six High Priority Provinces: Aceh, North Sumatra, West Sumatra, East Java, West Java and DKI Jakarta. ESP also supports a limited set of activities in four Special Concern Imperative Areas: Balikpapan, Manado, Manokwari and Jayapura.

staff including John Pontius, ESP's regional director, to review current literature, reports, and previous subsurface studies of the area;
- Meeting with appropriate government agencies involved with surface and subsurface water resources in Aceh Province;
- Meeting with relief agencies, NGOs, local government and others working in the region, particularly those building communities and restoring urban environmental services such as water supply;
- Visiting field locations along upper and lower watersheds to gain understanding of the physical geography and geology of the region.
- Obtaining information as available concerning existing wells and deep borings, field data including well drilling data;
- Identifying data requirements, information gaps, analyses required and methodologies for assessing, mapping and reporting on groundwater conditions now and in future in area of concern.

Information gathered during the site visit was used to prepare the following observational report which provides:
- Background hydrologic and meteorological information;
- An understanding on what is currently being done by organizations in the area in terms of water resource development, and;
- An assessment on what needs to be done to collect, analyze and prepare information required for adequate decision-making with regard to current and future water resource development in Aceh.

Finally, this evaluation was used to define future programs which, if implemented, would enhance the development and protection of water resources in the region. The concepts for these programs were developed to:

- Be consistent with ESP's on-going programs in Aceh for watershed management, for service provision, and for alternative financing supporting cross cutting themes of water authority capacity building, information system development, training, and the environment;
- Compliment existing programs in the Aceh region including the USAID-funded West Coast road;
- Design a program that is doable on a small scale, and which can then be rolled out to the entire region;

These concepts are presented in terms of scopes of work which could be completed over the next four years .

2. BACKGROUND

The following presents a brief overview of the climate, land use, physiography, geology, and hydrology of the Aceh Province. This information acts as a basis for defining historic development of water resources and provides insight as to how water resources could be developed in the future.

2.1. CLIMATE

2.1.1. GENERAL

Climate observations in the Aceh Province are currently being taken in Banda Aceh/ Blangbintang, Indonesia. The station is currently located at the airport, which has an elevation of 21 meters above mean sea level. In the region, basic data for precipitation, temperature, wind speed, and relative humidity have been taken since 1894. Spatially, data are somewhat limited. At one time, there were over 15 recording stations in the region. Now there are only 3 WMO accredited stations, the nearest being at the airport.

The climate of the region can be described as tropical with high humidity. Seasonal variations are related to rainfall pattern. As illustrated in Figure 2-1, average daily temperatures (2004 – 2005) at the airport vary between 23 and 33o. Mean monthly relative humidity ranges between 70% and 85%. In general, temperature decreases with increasing altitude, with an average temperature lapse rate of 0.6o C per 100 meters. Wind speed is generally low, ranging between 1.5 to 2.5 m/sec. Higher wind speeds have been observed in coastal areas (IWACO, 1993).

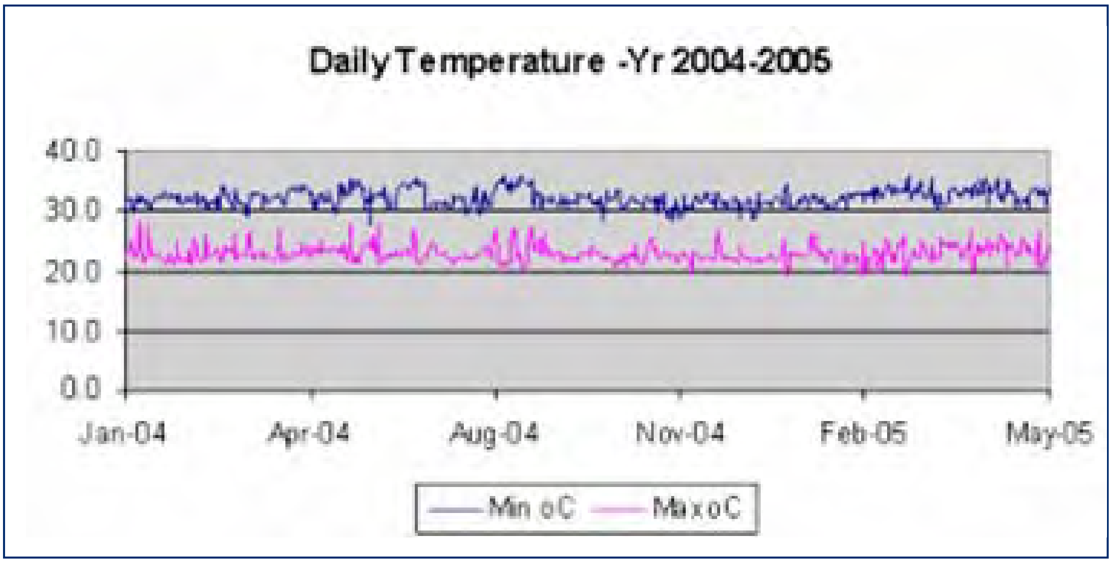

Figure 2-1 Daily Temperature Variation - Banda Aceh Airport

2.1.2. PRECIPITATION – EVAPORATION

Mean average annual rainfall is 1.607 meters (based on the 95 year record between 1879 and 1984). As presented in Figure 2-2, the wet season is between October and January with the highest precipitation occurring during December. The wet season is related to the west monsoon whereas the dry season is directly related to the east monsoon. Precipitation, like temperature, also varies with elevation. Figure 2-3 is an isohyetal map of the Aceh Province based on the work done by Binnie and Partners (1986). This map was based on historical rainfall records and rainfall-altitude relationships and shows variation between 1.5 and 5.0 meters/year.

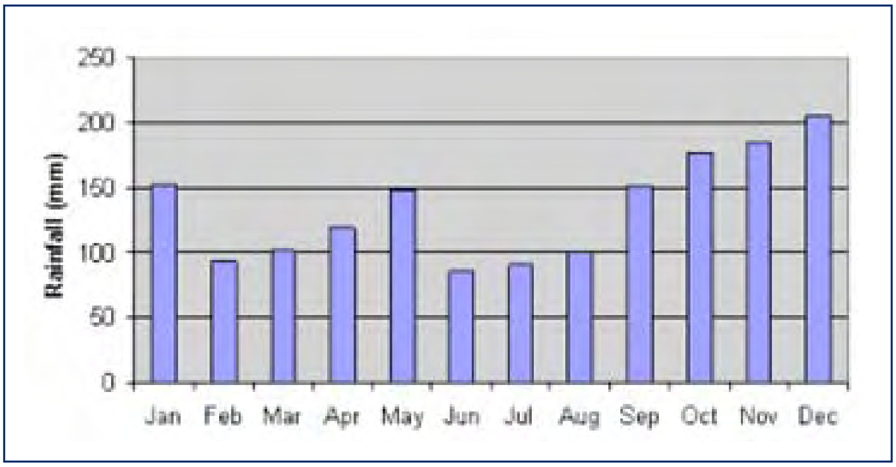

Figure 2-2 Average Monthly Precipitation - Banda Aceh (1879-1984).

Figure 2-3 Aceh Province Isohyetal Map - Yearly mm of Rainfall (Binnie and Partners, 1986).

2.2. LAND USE

Land use in Aceh Province includes urbanized land, savanna, agriculture, forest, as well as others. Figure 2-4 is a pie chart illustrating percentages of various of land uses for Aceh Province. About 68% of the landuse is considered jungle and forest, with the next highest land uses being for rice cultivation and for plantations.

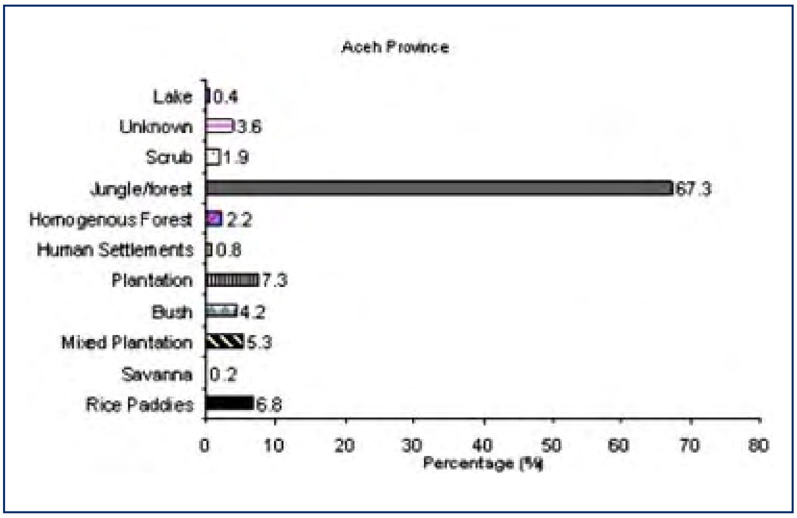

Figure 2-4 Aceh Province Land Use (IWACO, 1993).

2.3. PHYSIOGRAPHY

As illustrated in Figure 2-5, the Aceh Province is characterized by the Barisan mountain ridge running from southeast to northwest. On the northeast side is a wide sedimentary plain which gradually slopes towards the sea. These plains are bounded on the south by the Eastern Foothills and the Seulawah and Geureudong Volcanos. West of the mountain range large coastal plains have developed. These include the Meulaboh and Singkil embayments further south. Western Coastal Plains lie on the northwestern shore line of the province. Draining the province to the extreme northwest is the Krueng Aceh, or Aceh River, which lies in a structural basin on the extreme central northwest portion of the province.

The topography of the province is characterized by:

- Mountains that range in elevation between 1810 m amsl for Gunung Seulawah and Gunung having an elevation of 2324 m amsl. Other high points include Gunung Hulumasen (2316 m amsl) and Gunung Meundon (1951 m amsl);
- The coastal zones which vary in width to a maximum of about 10 kilometers inland with areas near sea level generally extending to about 1 to 2 kilometers inland;
- The Krueng Aceh catchment area is about 10 km wide and 30 km long and extends southward to the base of the Central Barison Mountain Range. To the north, it is bounded by Gunung Seulawah.

Finally, to the north of Sumatra Island, is Weh Island which has an area of 153 km2. This island has a maximum elevation of 306 meters amsl.

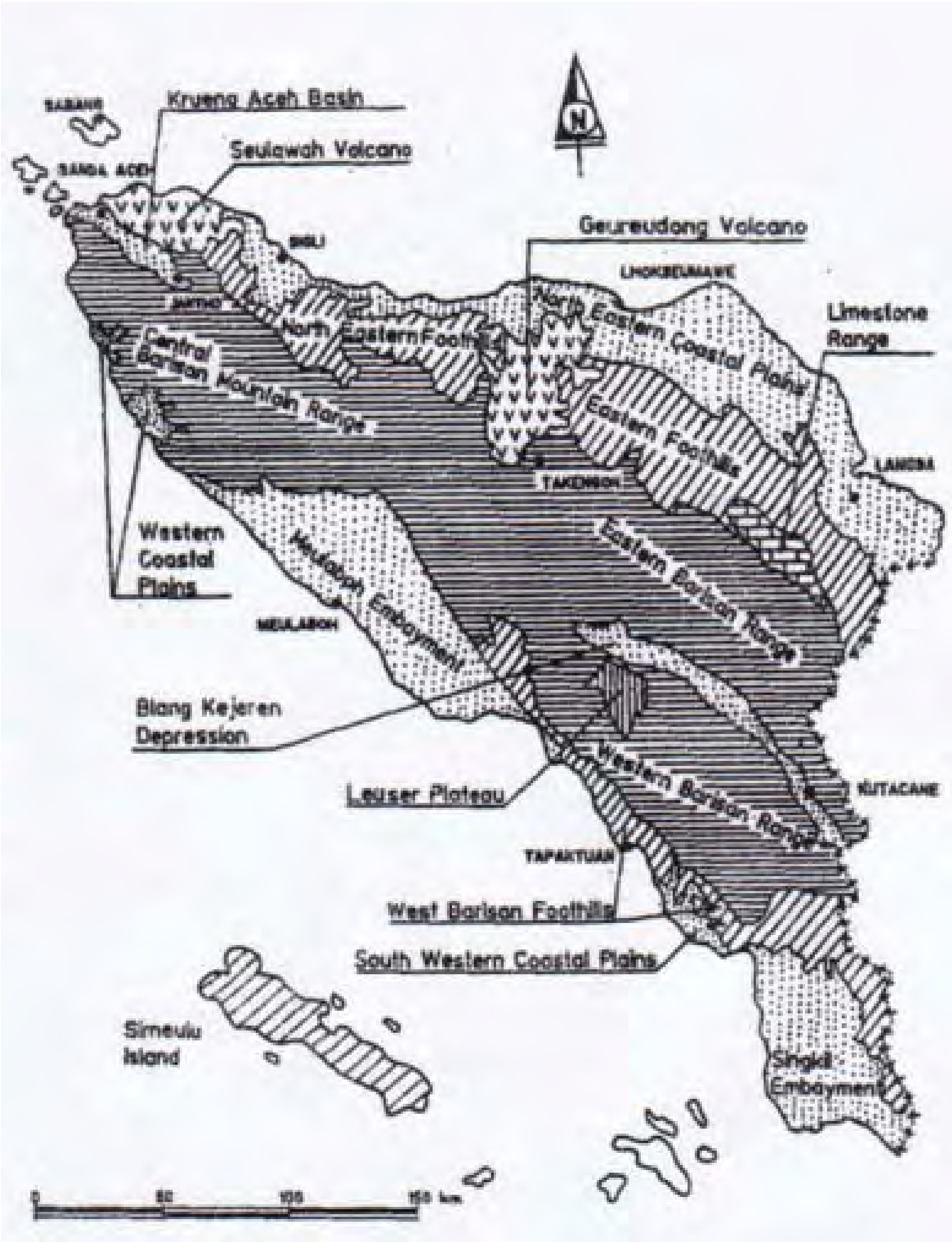

Figure 2-5 Aceh Province Physiography (IWACO, 1993).

2.4. GEOLOGY

The following section is based on a variety of sources including IWACO (1993), geologic maps (scale 1:250,000) from the Geological Research Centre (1982) and others.

2.4.1. REGIONAL SETTING

GEOLOGIC OVERVIEW

The low-lying coastal zones of Aceh consist of mainly clayey un-consolidated to semi-consolidated sediments intersected by coarser sediments along river valleys.
Beach deposits along the shore have formed sandy ridges.
Banda Aceh is situated in a depression formed by two parallel NW-SE trending faults filled with clayey to sandy un-consolidated to semi-consolidated sediments.
Sigli in the Pidi Plain is built on clayey coastal mud-flats.
Meulaboh is situated on the remnants of a limestone reef.
The islands Simeulue and Nias are composed of limestone.
Volcanic form the northeastern part of the province and Weh Island.

Sumatra lies on the Sundaland continental plate, which includes most of Southeast Asia. To the west, the oceanic crust underlying the Indian Ocean belongs to the India-Australia Plate. This plate is being subducted along the western margin of the Sundaland plate. Here lies the Sunda Trench just off the west coast of Sumatra. Magma generation associated with this subduction zone has given rise to the northwest-southeast trending Sumatran vocanic arc. Stresses resulting form the oblique approach and subduction of the incoming oceanic crust have been released periodically by dextral faults movements parallel to the plate margin. This includes the December 2004 earthquake generated when along a 341 kilometer fault line an average drop of about 7.4 meters occurred which in turn generated the destructive tsunami.

2.4.2. LITHOLOGY

Lithology of the province consists mostly of sedimentary and metamorphic rocks of Late Paleozoic, Mesozoic, Tertiary, and Quaternary age, periodically interrupted by volcanic activity. Various aged lithologies in the province can be described as follows:

Quaternary-Recent deposits in the area consist of valley and shoreline deposits, including river terraces. The alluvial deposits consist of sands and clays with minor thicknesses of gravel. These sediments commonly contain mafic minerals and this suggest a volcanic source. An extensive cover of Pleistocene strata and young shoreline deposits in some coastal areas have resulted from short-lived shoreline advance followed by regressions.

Tertiary lithologies consist of volcanic–andesitic lavas and pyroclastic, tuffaceous sandstones, conglomerate. The volcanics are andesitic lavas and pyroclastics and form the hilly country to the east of the Krueng Aceh valley. This tuff and`ash deposits were probably deposited under water.

Mesozoic sediments are mainly shales, slate and limestones which form the Barisan Mountains. These were formed by transgressive and regressive seas which were uplifted to there present position by Cenozoic folding, faulting and uplift followed by the eruption of coastal volcanics. The limestone consists of fairly massive but moderately weathered limestone. Slate and phyllites occur in small areas between the Ujungpanca and Ujungraja peninsulas and just south of the Banda Aceh to Lhonga road, east of Lhonga

2.4.3. BANDA ACEH, WEST COAST, AND WEH ISLAND

During this Scoping Study, particular attention was paid to areas near Banda Aceh, Calang, and the Weh Island.

Lithology of Banda Aceh, Lhonga, and the surrounding area consist of limestone, slates and phyllittes that outcrop on the west side in the valley. Limestone form generally steep mountains and mark the northernmost limit of the Barisan Mountain range. The limestone consists of fairly massive but moderately weathered limestone. Slate and phyllites occur in small areas between the Ujungpanca and Ujungraja peninsulas and just south of the Banda Aceh to Lhonga road, east of Lhonga.

The east side of the plain is flanked by extensive deposits of andesitic, tuffs and subsidiary flows which are probably water lain. Mesozoic limestone which consists of massive, pale and dark limestone is well jointed and forms the steep hills on the western margin on the basin. The conglomerate and tuffaceous sandstone are of limited extent. The volcanics are andesitic lavas and pyroclastics form the hills east of the Krueng Aceh valley.

The Krueng Aceh valley is underlain by a considerable thickness of recent sediments. The western and eastern margins of the Krueng Aceh are structurally controlled by major faults. The west and east Semangko Faults are important structural features for a considerable distance along the spine of North Sumatra. These form a major rift graben orientated northwest/southwest. The west Semangko Faults are fairly clearly defined by steep scrap of the Mesozoic Limestone. On the eastern side however the original margin of the rift depression formed by the East Semangko Faults has been obscured by the development of a major volcanic centre along the line of the fault.

The Calang area and surrounding dominant is lithology consists of volcanic breccia and sandstone. Soils consist of sandy clay – clayey sand with thickness of around 2 – 3 meters. The hills near the beach are composed of fluvial deposits which form a river terrace consisting of sand and gravel.

The Pulau Weh (Weh Island) and Sabang sub-district is underlain predominately by volcanic tuff, breccia, agglomerate and lahars. The soil is moderately weathered to a thickness of 2 to 3 meters below ground surface. Beach deposits are predominately sand and gravel.

2.5. HYDROLOGY

2.5.1. SURFACE WATER

As illustrated in Figure 2-7, the Aceh Province has been divided into Water Resource Development Areas (WRDAs). These areas generally are comprised of one or more river catchment areas. Discharge and runoff data for varying periods of record are available for major rivers. The latest set of data available to us was developed by Binnie and Partners (1988) and is summarized in Table 2-1. Average runoff data has been correlated to average annual rainfall for Indonesia by Delft Hydraulics (1993). This relationship is presented in Figure 2-8 and is based on water balance data of selected catchements, for which accurate runoff as well as rainfall data were available (IWACO, 1993). The standard error of estimate is about 100 mm. In general, it has also been shown that lower runoff values are associated with forested watersheds.

Figure 2-6 Typical River (Krueng Geupu) Draining the West Coast Highlands.

Table 2-1 Aceh Province River Discharge Data (Binnie and Partners,1988 and IWACO, 1993)

River	Gauging Station	Years of Record	Area (km2)	Mean Flow (m3/sec)	Mean Daily Max Flow (m3/sec)	Mean Daily Min Flow (m3/sec)
Kr. Aceh	Kr Jreue	7	165	7.58	56.40	0.79
	Seulimeum	9	392	18.54	150.00	1.96
	Lampisang/Tunong	4	675	21.30	177.00	
	Kp. Darang	9	1078	35.33	397.00	
	Pasie	3	1576	47.14	326.00	
Kr Lambesoi	Kp Sango	5	479	33.92	603.00	3.95
Kr. Teumarom	Panga Pucuk	3	24	4.04	108.07	0.35
Kr. Seuanagan	Ujung Blang	5	352	38.02	187.10	28.30
Kr. Kluet	Gunung Puckung	4	2326	140.07	545.00	44.40
Kr. Tripa	Gunung Kong	3	2707	200.49	598.00	29.00
Lawe Bulan	Kutacane	5	17	3.75	23.70	0.16
Lawe Alas	Gumpang	6	708	30.14	149.00	5.20
	Sukarimbun	5	1384	54.13	240.00	16.00
Kr. Baro	Keumala Dalam	4	232	14.35	90.40	2.09
	Klibeut	9	270	8.03	74.40	0.01
Kr. Peusangan	Takengon	6	252	7.96	22.40	2.40
	Remesan	5	373	13.27	77.00	1.00
	Beukah	3	2272	103.9	463.00	19.00
Kr. Mane	Lhok Gajah	1	520	21.90	75.20	6.82
	Lhok Juek	1	95	6.60	43.30	1.39
Jambo Aye	Rampah	4	4125	131.25	768.00	26.10
	Lhok Nibong	12	4500	153.31	874.00	31.70
	Seureuke	1	4131	147.00	794.00	25.00
Kr. Tamiang	Kuala Simapang	6	4598	284.31	1318.00	23.00

Figure 2-7 Aceh Province Water Resource Development Areas (IWACO, 1993)

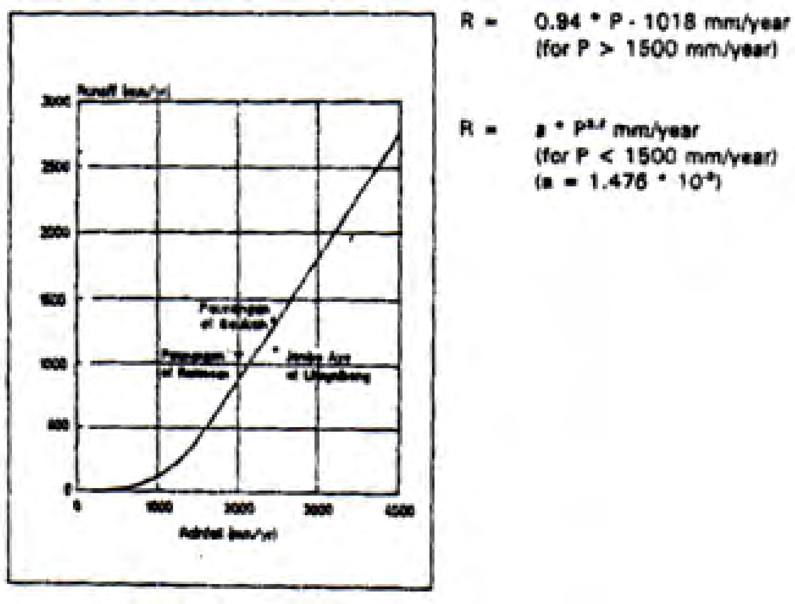

Figure 2-8 Indonesia Runoff Relationships (Delft Hydraulics, 1993)

2.5.2. GROUNDWATER

Groundwater resources in the Aceh Province can be generally described as follows:

- The groundwater in coastal zone is brackish to saline in many places;
- Fresh groundwater is sometimes found near the coast in the sandy beach deposits and more inland, in alluvial sediments along the rivers;
- Deeper groundwater is under artesian conditions but often contains methane gas due to the decomposing of organic material;
- Groundwater flow in volcanic rocks and limestone is controlled by fracture flow;
- Springs originate in highland areas along limestone and possibly volcanic ridges discharging along fault lines.

More specifically, groundwater with varying development potential can be found in alluvial sediments, limestone, and volcanic rocks. Each type of rock has varying development potential. Figure 2-9 is a generalized hydrogeologic column describing the hydrogeologic characteristics of the various units. These units are divided into recent alluvial deposits (including beach deposits), Tertiary and Quaternary volcanic aquifers, pre-Tertiary to Quaternary limestone, Tertiary and pre-Tertiary consolidated aquifers, and intrusive and metamorphic rocks of various ages. Figure 2-10 shows the distribution of the systems in the Kr Aceh basin as well as on the West and North Coasts.

Of the units described, even though alluvial sediments have high potential for development, water quality is a major issue in many areas due to saltwater intrusion and pollution from septic tanks, agricultural practices, leaky underground storage tanks, and other sources. The tsunami impact as described below has compounded these problems. The highest potential for groundwater is from springs that originate from fractured limestone and to some extent from volcanic rocks. Historically these have been used, but systems used to capture and to distribute spring water are in disrepair not only due to the tsunami but years of poor maintenance practices prior to the tsunami.

Table 2-2 Generalized Hydrogeologic Column (IWACO, 1993)

Graphic	Rock Type	Hydrogeologic Unit	Hydrogeologic Characteristics
	Alluvium	Unconsolidated	These sediments consist of unconsolidated and semi-consolidated gravels, sands, clays, and modes. The aquifers are often confined with piezometric heads at or below the land surface. In the coastal zone, artesian heads are known to be present. Quality of these waters is questionable with a high potential for salty and brackish water near shore. Away from shore there is a high potential for development.
		Semi-consolidated	
	Volcanic	Quaternary volcanics	These aquifers consist of both porous and fractured volcanic rocks including lava, lahar, tuff, and breccea. In higher terrains, these rocks have little groundwater potential. Down slope potential production increases. Young volcanics are usually tight and act as groundwater flow boundaries. Springs discharges vary throughout the year. Water quality is good but sometimes high in iron.
		Tertiary volcanics	

Graphic	Rock Type	Hydrogeologic Unit	Hydrogeologic Characteristics
	Limestones	Quaternary and Tertiary	Significant groundwater resources are present in limestone formations. Main outcrops are restricted to the region Southwest of Banda Aceh and the region east of Calang. These formations are composed of reef limestones and dolomites. Groundwater flow is governed by secondary porosity including solution cavities and fractures. Springs often have significant quantities of water of good quality.
		Tertiary	
		pre-Tertiary	
	Consolidated sediments	Tertiary	Consisting of consolidated sandstones, shales, and siltstone, these aquifer units are located for the most part north of the Sumatra Fault System. Groundwater flow is controlled by fractures which discharge via small springs. Water quality and potentiometric heads show wide variation. These units have in general what is considered a low potential for groundwater development.
		pre-Tertiary	
	ntrusive and metamorphic rocks	Intrusive rocks	No important groundwater resources are present. Groundwater is resisted to local fractured zones.

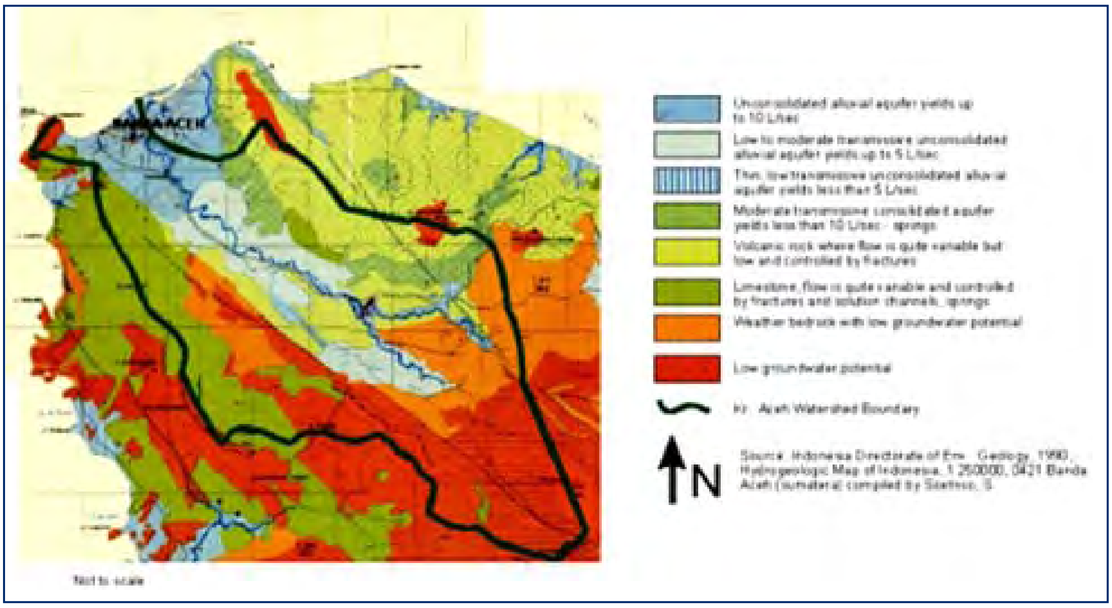

Figure 2-9 Hydrogeologic Map of Northern Aceh.

3. IMPACT OF THE TSUNAMI

3.1. MAGNITUDE AND EXTENT

The impact of the December tsunami has had considerable impact not only on water resources in terms of quality and quantity but also the infrastructure which was used to distribute the water to users. Given the magnitude with the highest being over 30 meters high and extent of the inundation by the tsunami, the impact was devastating. All low lying areas along the shore of Aceh were hit by the tsunami.

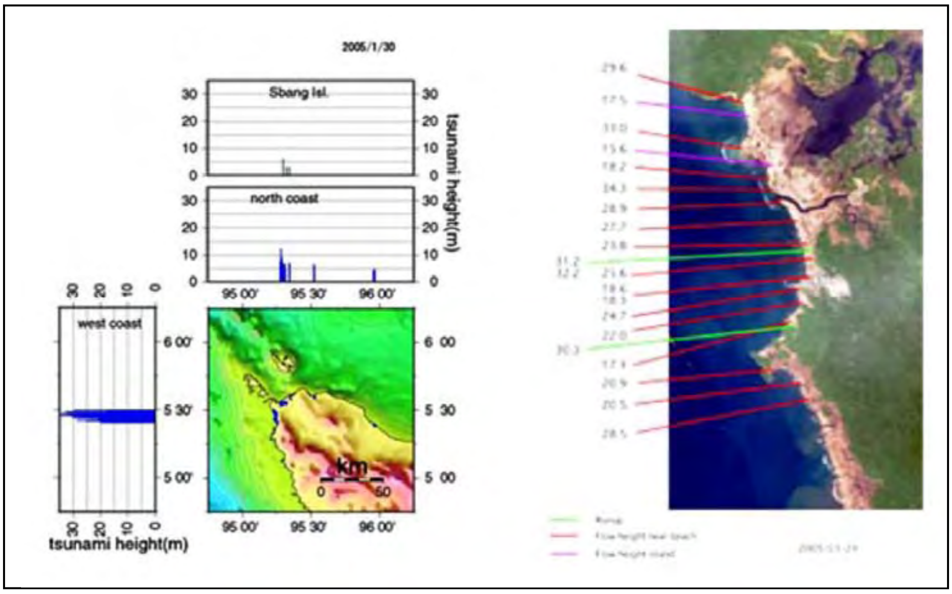

Figure 3-1 Magnitude of the Dec. 2004 Tsunami - Aceh Province (Lubis, 2005).

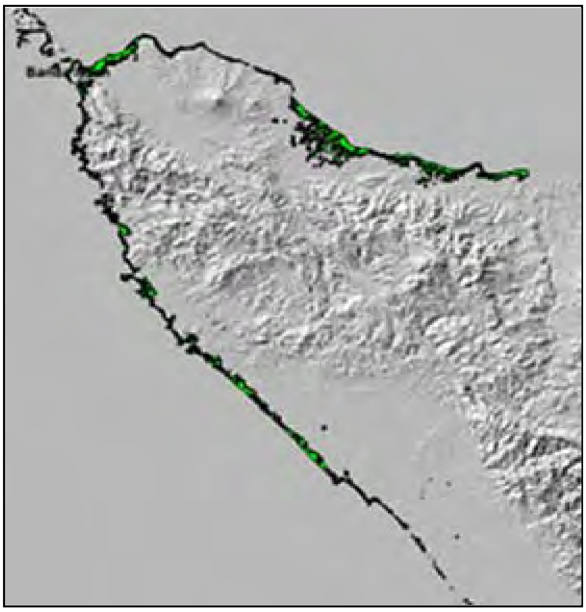

Figure 3-2 Extent of Inundation of the Dec. 2004 Tsunami in Aceh.

3.2. WATER RESOURCES

3.2.1. GROUNDWATER

Impact of the tsunami on groundwater and surface water can be summarized as follows:

- Intrusion of saline water during the tsunami flood most likely occurred especially along the south coast in areas with sandy sediments;
- Remaining stagnant brackish water may have increased the period of intrusion;
- Retreat of coastline may have caused inland movement of salt water interface;
- Areas with shallow groundwater suffered from groundwater pollution caused by seawater and by contamination from waste disposals and pit latrines:
- Dug wells and hand pumps were destroyed in many villages and towns; and
- Other wells were heavily contaminated with salt water, mud and debris.

Figure 3-3 Well Installation in Calang – 2005.

In addition, there is also a potential for indirect impacts of the tsunami to groundwater due to the poor construction of wells and sanitary facilities by relief organizations. These could cause pollution of the shallow groundwater system.

3.2.2. DISTRIBUTION SYSTEM

Along the west coast and northern coasts, the water distribution systems have been virtually destroyed. In Banda Aceh town, water supply wells were reported undamaged, however, its distribution system was damaged. Water supply, on an emergency basis, has been a major concern for the GOI as well as relief NGOs and donors. Shallow wells have been drilled and spring boxes have been developed. In addition, latrines and other sanitary facilities have been constructed.

Figure 3-4 Spring Box in Calang – 2005

For the most part in constructing water supply and sanitation facilities, organizations worked independently. For instance in Calang according to International Relief Committee (2005), at least 5 organizations were drilling wells and developing spring resources. Each was using different types of pumps and different sizes of pipe. Each one was planning to turn the system over to the local PDAM once it was established.

4. WHO IS DOING WHAT, WHERE

After the tsunami, there has been an outpouring of support from donors, NGOs and others. In terms of water resources development, numerous organizations are currently working on various projects, these can be summarized as follows:

- NGO's such as OXFAM, IRC, the American Red Cross, and other are drilling wells and developing springs in tsunami affected areas;
- BMG with the German BGR are doing an FDEM aerial survey to find fresh groundwater in Kr Aceh river basin;
- The Germans have just let out a request for proposal for the drilling of 120 small diameter wells for water supply on the north central coast of Aceh Province;
- UNICEF is working on database and resource development throughout the province;
- Swiss Agency for Development and Cooperation (SDC) is working on water treatment and distribution specifically for Banda Aceh and West Coast Villages;
- GTZ is performing a Solid Waste Landfill siting study using GIS in the Banda Aceh region;
- UN HIC is developing a clearing house for information for the entire affected area;
- FAO and numerous others are working on water supply, agriculture and GIS;
- USTDA is looking at the development of Jantho Springs southwest of Banda Aceh.

As an organizing identity, a WATSAN committee has been established. This committee is chaired by UNICEF, which has taken the lead in many areas of water resources development. This group was meeting weekly but now is meeting bi-weekly. UNICEF has also developed a GIS which has built a database containing information on who is doing what and where. They also have GIS layers which contain data on settlements, volcanoes, UNICEF waterholes, wells, health facilities, fault lines, basins, rivers, roads, 50,000 kilometer grid, district boundaries, sub-district boundaries, villages, and tsunami affected areas.

For the most part, water resources have been developed on an emergency basis since the tsunami. Now focus of the WATSAN committee is on reconstruction, the meaning of which varies depending on whom you talk to.
Discussion with Ramon Scoble of UNICEF indicated that he felt strongly that the number one data gap is the general lack of hydromet data in the region. He told us that current data on precipitation and river gauging is lacking. However, in the mid 70' through the 90's all river's were gauged at least once and that somewhere there are records for 28 precipitation gauges with varying periods of record. He also said that there were only 3 WMO recording stations in the entire region. The main reason for this lack of continuous data is that money is not available to maintain and operate them. He feels that a strong part of a program should be related to establishing low-maintenance stations, and educating people to maintain and calibrate them. Such a program would be necessary for design of drains and water supply forecasting.

In terms of groundwater, Ramon felt that there is plenty of water from springs and surface water sources for water supply in the region. The main problem is along the northeast coast where due to conflict in the coastal mountains collecting and diverting surface water has been problematic. He said that the Germans are drilling 120 – 10cm diameter boreholes in this area to supply local villages. In Banda Aceh, he told us that there is a major problem in the reporting of new wells drilled for tsunami relief. At this time, numerous NGOs are drilling wells and very few record anything about them. He has designed a database and constantly asks people to fill in basic information about these wells. However, he has not had much luck and there is a need to get this information up to date. The problem relates to the fact the BMG has waived the requirements for well permitting during the disaster and UNICEF has no authority to interfere.

Locating fresh groundwater supplies has also been the concern of many. BMG with the German BGR are doing an FDEM aerial survey to find fresh groundwater in Kr Aceh river basin. They have set up a fly over grid and are in the process of the initial fly over. Data from this survey when reduced will not only provide valuable information of the alluvial aquifer in the Kr Aceh valley but also boundary conditions for the aquifer and the extent of saline intrusion and to some extent pollution.

One of the major concerns of the WATSAN committee is getting the district level PDAMs up and running as well as identifying what needs to be done in terms of WATSAN facilities. They are in the process of developing a district level needs assessment. For this study, they are contracting an Indonesian based firm with capabilities in engineering and finance. Donors such as USAID and NGOs are being asked to assist them.

Water treatment facility upgrades for Banda Aceh are currently being done by the Swiss Agency for Development and Cooperation (SDC) and IRD, an NGO. The main water treatment facility is being up graded by IRD, and SDC is in the process of revamping a treatment plant that had been constructed but never used. UNICEF and SDC are also looking into spring development and pipeline rehabilitation for water supply to West Coast. They are looking toward using a Coca Cola grant and support from LaForge, the owner of the severely damage cement plant.

SCD is also looking at reconstructing a small water treatment plant on the Kr Geupu. This plant was constructed before the tsunami, but never operated. The structure was damaged by the tsunami but can be repaired. Also in the basin was the water supply intake for the LaForge cement plant. They are considering reconstructing this and using the USAID-funded road right away for their pipeline. Their main concern is working with the local PDAM. To avoid any delays, they are considering a desalination plant.

PDAM's records in Banda Aceh were in the lower level of their building and for the most part were destroyed by the tsunami. The GIS being put into service by the HIC will go along way in filling the void. In addition, there are several other organizations using GIS. A user group has been formed and it is hope the HIC will be the clearing house for the regional GIS. However, the use of GIS as a tool is also of concern to many. In the past, PDAM and the provincial BAPEDALDA did not have access to such systems and ability to use GIS as a planning tool could be questioned. GTZ is in the process of using GIS to help locate a solid waste landfill site. This study will go a long way toward showing various agencies the usefulness of GIS in planning.

In out lying communities such as Calang on the west coast, much of the work is being done by IRC, OXFAM, the Red Cross, and others. In Calang, they have organized a WATSAN committee and meet on a weekly basis. The main concern of the committee is where and what different organizations are doing, not so much how they are doing it. IRC is in the process of developing a database of who is doing what, where. No effort is being done to develop uniform water supply systems in the villages.

Finally, details on other activities in the region by NGOs and donors are presented in the Trip Report presented in Attachment C.

5. TOWARDS WATERS RESOURCE DEVELOPMENT

5.1. CONCEPT DEVELOPMENT

After a thorough review of climate, geologic, hydrologic, and hydrogeologic information as well as an evaluation of the potential long-term impacts of the tsunami on water resources as presented above, it was found that in terms of long-term water resource development in the region emphasis should be placed on the development and protection of springs and surface water resources with the drilling and completion of wells being of secondary importance. This is largely due to the relative abundance of surface water (with the region receiving between 1.6 to over 3 meters of rainfall a year) and the complications of drilling wells in areas which have not been affected by the tsunami or past practices which may have contaminated the groundwater.

Towards this end, six concepts have been defined for Water Resources Development and Protection in the Aceh region which could be supported by ESP. The development of these concepts was based on the following:

- Help meet water resources development requirements in the region on a long-term and sustainable basis (Needs);
- Be consistent with ESP's on-going programs in Aceh for watershed management, for service provision, and for alternative financing supporting cross cutting themes of water authority capacity building, information system development, training, and the environment;
- Compliment existing programs in the Aceh region including the USAID funded West Coast road;
- Design a program that is doable on a small scale which can then be rolled out and scaled up to the entire region.

Based on interviews with various governmental agencies, NGOs, donors, and others, water resource development requirements span all aspects of water supply, water and waste water treatment, and distribution system design and rehabilitation. This includes everything from data collection to design of WATSAN systems. Now that the region is in reconstruction phase, long term development and capacity building to appropriate standards is especially important given the loss of personnel and information during the tsunami.

5.2. THE CONCEPTS

The following six concepts for water resource development and protection programs have been developed based on the above criteria:

CONCEPT 1: HYDROMET MONITORING PROGRAM.
This program would involve the development of a hydromet monitoring program for the Kr Geupu River Watershed. It would be intended to be a pilot program which would involve the establishment of an automated weather station and a gauging station. In addition, it would involve the reconstruction of a foot bridge which was destroyed by the tsunami, so that the river could be gauged during periods of high flows. It is anticipated that this program would initiate a region wide hydromet monitoring network. In addition, the program would assist in assessment of the environmental impacts of the USAID funded road, deforestation on the west coast and the foot bridge may divert foot traffic away from the highway.

CONCEPT 2: WATER QUALITY MANAGEMENT - HYDROCHEMICAL EVALUATION PROGRAM.
This concept would consist of a total chemical loading study for the main stem of Kr Aceh. The program would be designed to evaluate the water quality in the watershed from source to fresh water intake or further down stream to tsunami affected area. It would used to determine the effect of land use on water quality and would assist BAPEDALDA, PDAM, and others in making informed decisions on water quality based on loading (flow and quality) whether than just quality. By sampling wells, it would also serve for ground truthing of the BGR EM survey. Ultimately, it will develop a loading model for the watershed and provide input into a basin wide GIS.

CONCEPT 3: WATER BALANCE AND WATER SUPPLY.
This program would apply water management concepts to a defined water supply system for Sabang-Weh Island. In doing so, tools would be developed for long-term water supply forecasting. The study would involved the hydrogeologic evaluation of the island, the evaluation of PDAM's distribution system in terms unaccounted for water (UFW) and would work with local community leaders on spring protections and environmental programs

CONCEPT 4: WATER RESOURCE PROTECTION.
This concept would assist the PDAM and others in defining and locating wells drilled during the period when well permits were not required (shallow and deep)– post-tsunami. The program would also define areas around springs and wells which need to be protected from adverse impacts from development and determine the probable impacts of silvaculture, farming, mining (quarries) and other land uses on water supplies. It would develop protection zones for springs on the west coast and provide guidance to expand the spring protection program for the entire region. This concept would be designed to work with UNICEF, PDAM, BAPEDALDA, as well as NGOs who are currently working in spring development along the West Coast in areas such as Calang.

CONCEPT 5 – GROUNDWATER MANAGEMENT MODEL (Kr. Aceh)
This project would involve the development of a finite element or finite difference groundwater/surface water model (quantity and quality) for the Kr. Aceh watershed. Hydrogeology boundaries of this basin are well defined and a model could be easily designed. It is not expected at this time that the input into the model would involve the drilling and testing of wells to obtain hydraulic characteristics. However, recommendations may be given requiring the establishment of a monitoring program and a testing program for the

calibration of the model. Such a model could be used by PDAM, BAPEDALDA, and others to evaluate the impacts of pumping, irrigation, and land use changes to the aquifer. It would ultimately be part of the GIS for the basin.

CONCEPT 6 – SPRING DEVELOMENT AND WATSAN PLANNING (West Coast Communities)

Springs are a major source of water supply in the region. Communities depend on these springs, however, development of springs and distribution is often haphazard and needs improvement. This program would develop:

- WATSAN Planning for the development of springs in small communities;
- Working in the communities of Lhoknga, Leupung and Lamno on the West Coast, a template for a WATSAN Plan for the development and distribution of water from the Mata Ie and Glee Taron Springs would be developed;
- Work with community leaders, alternative financing of design and implementation of the water and sanitation systems.

This work would compliment work being done by UNICEF using a Coca Cola grant and SCD (the Swiss) and would be directly related to the USAID road development corridor.

5.3. SCOPE OF WORK, LOE, AND EQUIPMENT COSTS

Attachment B presents basic SOWs, estimated level of effort (LOE), and equipment for each of the concepts presented above. Each concept is addressed in terms of needs, overall objectives, and a brief description including details and benefits. Estimated LOE based on general program requirements, and equipment costs are summarized in Table 5-1. Equipment costs are estimated based on costs supplied by US suppliers plus 20% for shipping and handling. It is entirely possible that outside contractors, NGOs, universities, or others could supply personnel to reduce costs.

Table 5-1 Estimated LOE and Costs

CONCEPT	Professional LOE		Costs	
	Local	Expat	Sampling Equipment	Weather Station/ Gauging Stations**
CONCEPT 1: HYDROMET MONITORING	140	75		$255,310
CONCEPT 2: WATER QUALITY MONITORING	67	63	$12,553	
CONCEPT 3: WATER BALANCE/WATER SUPPLY	170	105		$ 90,000
CONCEPT 4: WATER RESOURCE PROTECTION	100	45		
CONCEPT 5: GROUNDWATER MGMT*	170	30	$ 2,000	
CONCEPT 6: SPRING DEV. AND WATSAN**	20	25		
TOTAL	667	343	$14,553	$345,310

* Sampling Equipment includes software costs
** Includes only Task 1: Program Design

5.4. IMPLEMENTATION RECOMMENDATIONS

5.4.1. IMPLEMENTATION

To meet these needs, as well as the criteria presented above, it is important to take a staged approach to meet existing demand in a systematic fashion.
These needs can be addressed in terms of phases. Table 5-2 present various tasks which would need to be performed for each concept based on these time intervals. The concepts presented above each meet at least one or more of these basic requirements. This allows for overlap of various program tasks allowing for specific programs such as a GIS database to be developed that meet each of the programs' requirements.

Table 5-2: Concept Implementation

Tasks		**Concept**					
		1	**2**	**3**	**4**	**5**	**6**
Phase 1							
Data Collection and Analysis	Literature Search	√	√	√	√	√	√
	Database/GIS	√	√	√	√	√	√
	Hydrochemical Mapping		√			√	
	Well and Spring Survey		√	√	√	√	√
	Water Budget Studies	√		√	√	√	
Equipment	Equipment/Software Procurement	√	√	√	√	√	√
Design	Monitoring Program Design	√	√	√			
	Other Program Support	√	√	√			
Construction	Instrumentation	√		√			
Phase 2							
Equipment						√	√
Design	Implementation of Monitoring Programs	√					
	Collection (Spring and wells) and Reticulation System Design and Financing						√
	Decision Support System Design and Implementation					√	
	Water Resource Management Modeling					√	
	Well Head and Spring Protection Program Design				√		
Construction	Model Development					√	
Capacity Building	Capacity Building	√	√	√	√	√	√
Phase 3							
Capacity Building	Institution Development	√	√	√	√	√	√
	Water Resource Management Program Implementation				√	√	
	Well Head and Spring Protection				√		√
Construction	Spring Development/Distribution.						√

5.4.2. STAGING

Assuming that each of the concepts presented above will be implemented in one form or another, and since there is an overlap in tasks, it is important that each program be staged in a manner that places emphasis not only on priorities of ESP, GOI, and others but also on availability of personnel and equipment procurement. Table 5-3 is a matrix which could be used to stage tasks of various programs.

Table 5-3: Program Staging

TASK DESCRIPTION	YEAR 1	YEAR 2	YEAR 3	YEAR 4
CONCEPT 1: HYDROMET MONITORING				
Task 1 – Network Design and Construction Planning				
Task 2 -3 – Weather Hardware Procurement, Bench Testing and Configuration - Shipping				
Task 4 – Weather Station and Perform Radio Path Testing				
Task 5 – Radio Telemetry System Design				
Task 6 -7 - Telemetry Hardware Procurement, Bench Testing and Configuration - Shipping				
Tasks 8 - 9 – Radio Repeater, Receiving Base Station, and Data Collection Software - Data Feed				
Task 9 – Install and Configure Data Feed				
Task 10 – Final Documentation				
Task 11 – Training and Calibration				
CONCEPT 2: WATER QUALITY MANAGEMENT				
Task 1 – Monitoring Program Design				
Task 2 – Team Building				
Task 3 – Laboratory Selection				
Task 4 – Equipment Procurement				
Task 5 - Training				
Task 6 - Sampling				
Task 7 – Report Writing				
Task 8 - Capacity Building and Institutional Development				
CONCEPT 3: WATER BALANCE AND WATER SUPPLY				
Task 1 – Literature Review and Project Design				
Task 2 – Installation of Hydromet Monitoring Network				
Task 3 – Hydrogeologic Investigation				
Task 4 – Supply and Demand Evaluation				
Task 5 – Report Writing				
Task 6 - Capacity Building and Institutional Development				

TASK DESCRIPTION	YEAR 1	YEAR 2	YEAR 3	YEAR 4
CONCEPT 4: WATER RESOURCE PROTECTION				
Task 1 – Data Review and Project Design				
Task 2 – Well and Spring Survey				
Task 3 – Data Review				
Task 4 – Report Writing				
Task 5 - Capacity Building and Institutional Development				
CONCEPT 5: GROUNDWATER MANAGEMENT MODEL				
Task 1 – Data Review				
Task 2 –Conceptual Model Development				
Task 3 – Model Selection, Design, Implementation and Calibration				
Task 4 – Report Writing				
Task 5 - Capacity Building and Institutional Development				
CONCEPT 6 SPRING DEVELOPMENT AND WATSAN PLANNING				
Task 1 - Program Design				
Other Tasks to be determined				

5.4.3. WHERE DO WE GO FROM HERE

As illustrated in Table 5-3, initial efforts for each of the concepts concentrate around program design, work plan development and the development of sampling and analysis plans as well as equipment selection. It is, therefore, recommended that the next level of effort concentrate on these tasks. In terms of priorities, it is felt that developing a program design for Concept 6: Spring Development and WATSAN planning, is a priority. Work plans need to be developed at a minimum for Concepts 1, 2, 3, and 4. Sampling and analysis plans (SAP) could be developed for Concept 2: Water Quality Management and Concept 3: Water Balance and Water Supply. These SAPs would define sampling procedures and sampling points. In addition, a detailed list of sampling equipment and specifications based on field conditions would be developed and the procurement process begun. It is also assumed that these SAPs could be modified for inclusion under Concept 4: Water Resource Protection. A draft TOR for this work is presented in Attachment C.

6. REFERENCES

Departeme Enegi Dah Sumberdaya Mineral, 2005, Informasi Geologiling Jungan Untuk Rencana Tata Ruang Regional (Intra Urban) Daerah Aceh Bara Provisi Naggroe Ach Darassalam. (Environmental Geologic Atlas of the Banda Aceh Region).

Binnie & Partners, 1986, ACEH DESIGN UNIT – Provincial Water Resources Development Plan Inventory of Water Resources Schemes – Volume 1 Summary, January 1986.

Binnie & Partners, 1986, ACEH DESIGN UNIT – Provincial Water Resources Development Plan Inventory of Water Resources Schemes – Volume 2 Existing Situation, January 1986.

Culshaw, M.G., Sutarto, N. R., Duncan, S. V., and Effendi, A., (not dated), An Engineering Geologic Survey of the Banda aceh Basin, D.I. Aceh, Sumatra Indonesia.

Departeme Enegi Dah Sumberdaya Mineral, 2005, Informasi Geologiling Jungan Untuk Rencana Tata Ruang Regional (Intra Urban) Daerah Aceh Bara Provisi Naggroe Ach Darassalam. (Environmental Geologic Atlas of the Banda Aceh Region).

Farr, J.L. and Djaeni, A., 1975, A Reconnaissance Hydrogeological Study of the Krueng Aceh Basin, North Sumatra – Geological survey of Indonesia Engineering Geology – Hydrogeology Division.

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Province – Report Aceh Barat – 9 Septerber 1993.

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Provice – Kabupaten Aceh Barat – September 1993

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Provice – Kotamadya Banda Aceh Planning of Water Supply Development and Raw Water Sources Allocation – September 1993

Libis, S, 2005, Banda Aceh Pasca Tsunami: Implikasinya Terhadap Mitigasi Bencana Geologic. PENGEMBANGAN MODEL PENDIDIKAN DAN PENYADARAN MASYARAKAT TERHADAP BAHAYA BENCANA GEMPA DAN TSUNAMISeminar Nasional, BEM KMJP Geografi, 20 April 2005
UNIVERSITAS PENDIDIKAN INDONESIA.

Lawrence, a. and Djaeni, 1977, Indonesia – Reconnaissance study of the Groundwater Resources of the Krueng Aceh Basin – N. Sumatra

UNICEF, 2005, Database.

BGR, 2005, Electrical Conductivity (EC) of Shallow Groundwater in Banda Aceh City and Aceh Besar District (Feb 2005 data for well 1.6 to 13 meters below ground surface).

7. ATTACCHMENTS

ATTACHMENT A
WATER RESOURCE DEVELOPMENT: SCOPES OF WORK

ATTACHMENT B
DRAFT TERMS OF REFERENCE
FOR HYDROGEOLOGIST
NOVEMBER 2005 THROUGH JANUARY 2006

ATTACHMENT C
TRIP REPORT-BANDA ACEH:
WATER RESOURCE DEVELOPMENT AND PROTECTION

ATTACHMENT A

WATER RESOURCE DEVELOPMENT: SCOPES OF WORK

1. CONCEPT 1: HYDROMET MONITORING

Need: Meteorological and hydrologic data for water supply and drainage design, water supply forecasting, and water management is lacking in the region.

Objective: To develop on a small scale, an automated Hydromet monitoring program which could be rolled out to the entire region using GIS methods.

Description: Develop a pilot project for the Kr. Geupu with one gauging station and two weather stations.

Figure 1: The Kr. Geupu Watershed

Details and Benefits:

- Aid in the assessment of the impacts of the USAID funded highway.
- Assess the impacts to water resources of logging and industrial development on the watershed – flow, water quality and sedimentation.
- Assist in the development of water balance for defining water supply alternatives for the southwest coast.
- Build capacity for developing surface water monitoring programs.
- Develop relationship between flow and sediment yield to forestry and agricultural practices.
- Compliment work being done by the Swiss Agency for Development and Cooperation (Water Treatment) and UNICEF for tsunami relief.
- Act as prototype for other watersheds in the basins.

Challenge: To design and install a monitoring network for the Kr Geupu watershed Aceh Province in Indonesia. The network would consist of at least two weather stations and one stream monitoring stations. It would be expandable to include additional weather stations, stream and water quality monitoring stations for other watersheds in the future. For the roll out program, GIS would play an important role in defining other watershed with similar characteristics as Kr Geupu's.

Solution: Using an architecture that has proven successful at other sites throughout the World, the Environmental Services Program with appropriate subcontractors will design and install an expandable monitoring network using local radio telemetry or satellite communication system in the watershed. Software will be installed to allow for near real-time dissemination of all data collected via the Internet.

Scope of Work: The following is a Scope of Work (SOW) and roughly estimated costs which could be provided to a subcontractor. It should be noted that ESP would have to provide some the initial design work including determination of site locations, negotiation with landowners, development of bid documents for construction activities, construction management, and calibration of surface water flow gauging stations. In general, this SOW provides for services and hardware to install:

- Two new, solar powered, full weather station with radio telemetry or satellite communications;
- One gauging and water quality monitoring site with radio telemetry;
- Two new, solar powered, radio repeater or satellite communication system; and
- One new, central receiving base station.

In is anticipated that the work would be conducted in the U.S. and in Indonesia. Two (2) trips to Banda Aceh would be required to complete the design, planning, construction and integration of the monitoring system.

The following Scope presents an initial trip to construct the weather stations, gauging station and to conduct site investigations for the radio repeater or a determination if a satellite system is more appropriate. A second trip would be used to install the radio repeater (if necessary), telemetry equipment and central receiving base station. The data collection and dissemination software would be installed during the second trip. If found necessary, each new weather station and the gauging station will be installed and equipped with line-of-sight radio telemetry equipment. This system will use modulated radio frequencies to communicate between the weather station and a central receiving/data collection base station. The frequency to be used will be 169.500 MHz which is limited in range by the curvature of the earth to approximately 40 miles. Local topography may further decrease the effective range. A frequency in the VHF range does not require a completely clear path between a transmitter and receiver, its use in the Kr Geupu watershed in Indonesia, however will most likely require an intermediate transceiver called a repeater which is included in this project. If satellite communication is found to be the best alternative, this system would be installed.

The Scope of Work will be divided into eleven (11) tasks described as follows:

1.1. TASK 1 – NETWORK DESIGN AND CONSTRUCTION PLANNING

During this task the following will be developed:

- Preliminary site designs and construction plans for the weather stations and gauging stations, radio repeater or satellite system and base station:
- A hardware list for the weather station;
- A preliminary hardware list for the base station and radio repeater as well as hardware specifications and installation plans for the meteorological tower(s);
- Construction plans will be developed for the concrete pads at the weather station necessary to support the evaporation pan and the rain gage; and
- Hardware specifications and construction plans for the security fencing for the weather stations.

1.2. TASK 2 – WEATHER HARDWARE PROCUREMENT, BENCH TESTING AND CONFIGURATION

Using the final hardware list generated in Task 1, purchase orders would be written to procure the necessary weather hardware from the various vendors. All hardware will be ordered would be bench tested and configured in the United States prior to shipping to Indonesia.

1.3. TASK 3 – SHIPMENT OF WEATHER HARDWARE TO INDONESIA

Once all the hardware has been integrated and bench tested, the equipment will be shipped to Indonesia to Banda Aceh to ESP office.

1.4. TASK 4 – TRIP 1 TO INDONESIA TO INSTALL WEATHER/GAUGING STATIONS AND PERFORM RADIO PATH TESTING

Two engineers would be required for a three to four-week trip to Indonesia to install the weather/gauging stations, determine which telemetry method is most appropriate, and investigate potential repeater locations. The completion of this task assumes that:

- ESP personnel will procure and install the met tower using the specifications in Task 1;
- ESP will have contracted and constructed the necessary concrete supporting pads for the evaporation pan and rain gage using the specifications provided in Task 1;
- ESP will procure and install the security fencing around the weather station site;
- ESP will provide field laborers to support the installation;
- ESP will also supervise the construction of the calibration bridge and gauging station;
- Basic construction materials will be available in Banda Aceh.

If radio telemetry is selected as the best alternative, a physical radio path study will be performed at the mine site to evaluate potential repeater locations. It is assumed that a repeater will be required to facilitate the reception of data from the new weather station (and future monitoring sites) to the base station. Trip preparation would include assembly of electronic instrumentation, spare parts, tools, and other items needed to install the weather station and to perform the radio testing. Preparation will be conducted the week immediately preceding travel to Indonesia.

1.5. TASK 5 – FINALIZE TELEMETRY SYSTEM DESIGN

Upon returning to the U.S., the engineers would finalize the site designs including construction plans and hardware lists for the new radio repeater or satellite system stations and base stations. A final telemetry hardware list will be developed for the repeater and base station equipment.

1.6. TASK 6 – TELEMETRY HARDWARE PROCUREMENT, BENCH TESTING AND CONFIGURATION

Using the final telemetry hardware list generated in Task 5, the engineers would prepare the purchase order to procure the necessary hardware from the various vendors. All hardware will be ordered and received by the testing company where it would be bench tested and configured prior to shipping to Indonesia.

1.7. TASK 7 – SHIPMENT OF TELEMETRY HARDWARE TO INDONESIA

Once all the telemetry hardware has been received, configured, and bench tested, the engineers will coordinate with ESP to ship all hardware components to Banda Aceh. ESP would notify the engineers when all hardware so that trip plans can be made for the next trip.

1.8. TASK 8 – TRIP 2 TO INSTALL RADIO REPEATER, RECEIVING BASE STATION, AND DATA COLLECTION SOFTWARE

A second trip to Indonesia would be required to install the radio repeater, receiving base station equipment and data collection software. One engineer would be sent for a second three week TDY. The DIADvisor base station software will be installed to receive, display and store the data being transmitted from the newly installed weather station. All data will be stored in a Microsoft Access 2000 relational database. Training regarding the use of this software will be provided during the trip. A second piece of software will be installed called an FTP Uploader which will be used to automatically transfer data from the base station to a data server maintained in the USA. The data transferwill occur using file transfer protocol (FTP) via the Internet. From the server, data will be made available to authorized USAID-ESP users. The completion of this task assumes
that:

7. ESP personnel will procure and install the radio tower using the specifications provided by WET in Task 1; ESP will provide a personal computer running Windows 2000 or XP to function as the base station computer;
8. The base station computer will have constant, dedicated Internet access (dial-up is not sufficient);
9. The computer will be configured by ESP to allow for ftp transfers out through any firewalls;

10. A radio frequency of 169.500 MHz will be have been procured by GRC for the sole purpose of transmitting hydrometeorological data.

Trip preparation would include assembly of electronic instrumentation, spare parts, tools, and other items needed to install the radio repeater and base station. The DIADvisor software and ftp server will be configured in the U.S. and written to a CD for installation in Venezuela. Preparation will be conducted the week immediately preceding travel to Indonesia.

1.9. TASK 9 – INSTALL AND CONFIGURE DATA FEED AT THE ESP OFFICES IN BANDA ACEH AND JAKARTA AS WELL AS THE LOCAL PDAM

During the second trip trip, the engineer would install and configure the software necessary to query data from the data server. The engineer would provide a brief tutorial on the use of the software to the ESP and PDAM engineering staff.

1.10. TASK 10 – FINAL DOCUMENTATION

Upon completion of the project, the engineer would provide a report including:

1. A summary of installation activities;
2. An itemized list of all installed hardware;
3. Final data logger/transmitter programs;
4. Standard operating procedures for all installed equipment;
5. Factory supplied users manuals for all instrumentation and equipment;
6. An itemized list of all installed software including registration codes;
7. Users manual for the DIADvisor software.

1.11. TASK 11 – TRAINING AND CALIBRATION

Once the gauging station and the calibration bridge are constructed, interested authorities will be trained by ESP on flow measurement techniques. Calibration of the station will then begin on a periodic basis.

COSTS: Table presents a rough estimation of costs for the installation of the hydromet network should a contractor be hired. Table 2 is an estimate of ESP LOE.

Table 1: Estimated Contractor Costs for Installation of the Hydromet Network

Description	LOE (days)	Unit Cost	Total Cost
Task 1 – Network Design and Construction Planning			
Labor	5	$ 1,200	$ 6,000
Task 2 – Weather Hardware Procurement, Bench Testing and Configuration			
Labor	8	$ 1,200	$ 9,600
Full weather station hardware	2	$ 10,500	$ 21,000
Water Quality/transducer/gauging station	1	$ 19,000	$ 19,000
Task 3 – Shipment to Indonesia			
Labor	1	$ 800	$ 800
Task 4 – Trip 1 to Indonesia to Insall Weather Station and Perform Radio Path Testing			
Trip Preparation	5	$ 1,200	$ 6,000
Labor in Indonesia	36	$ 1,200	$ 43,200
Travel	2	$ 3,500	$ 7,000
Task 5 – Radio Telemetry System Design			
Labor	5	$ 1,200	$ 6,000
Task 6 - Telemetry Hardware Procurement, Bench Testing and Configuration			
Labor	8	$ 1,200	$ 9,600
Radio repeater, base hardware	1	$ 9,000	$ 9,000
Task 7 – Shipment of Telemetry Hardware to Indonesia			
Labor	1	$ 800	$ 800
Task 8 – Trip 2 to Indonesia to Install Radio Repeater, Receiving Base Station, and Data Collection Software			
Trip Preparation			
Labor in Indonesia	12	$ 1,200	$ 14,400
DIAvisor base station software, FTP Uploader	1	$ 10,000	$ 10,000
Travel	1	$ 3,500	$ 3,500
Task 9 – Install and Configure Data Feed			
Labor	6	$ 1,200	$ 7,200
Task 10 – Final Documentation			
Labor	10	$ 1,200	$ 12,000
Material, copies, binding	2	$ 500	$ 1,000
Task 11 – Training and Calibration (see LOE allocations below)			
Site Construction, Bridge, Roads and Fencing	3	$ 15,000	$ 45,000
Calibration Equipment (pygmy meter, cable, bridge stand, and weights)	1	$ 15,000	$ 15,000
TOTAL			
Labor (+15%)			$ 125,810
Hardware and Software			$ 94,000
Travel			$ 10,500
Total			**$ 255,310**

Table 2: Estimated LOE Allocation for ESP

Description	LOE (days)
Task 1 – Network Design and Construction Planning	
Hydromet Monitoring Expert (Expat)	5
Hydromet Monitoring Expert (local)	20
Task 2 – Weather Hardware Procurement, Bench Testing and Configuration	
Hydromet Monitoring Expert (Expat)	5
Task 3 – Shipment to Indonesia	
Hydromet Monitoring Expert (local)	3
Task 4 – Trip 1 to Indonesia to Insall Weather Station and Perform Radio Path Testing	
Hydromet Monitoring Expert (Expat)	10
Hydromet Monitoring Expert (local)	36
Task 5 – Radio Telemetry System Design	
Hydromet Monitoring Expert (Expat)	3
Task 6 - Telemetry Hardware Procurement, Bench Testing and Configuration	
Hydromet Monitoring Expert (Expat)	3
Task 7 – Shipment of Telemetry Hardware to Indonesia	
Hydromet Monitoring Expert (local)	3
Task 8 – Trip 2 to Indonesia to Install Radio Repeater, Receiving Base Station, and Data Collection Software	
Hydromet Monitoring Expert (Expat)	10
Hydromet Monitoring Expert (local)	36
Task 9 – Install and Configure Data Feed	
Hydromet Monitoring Expert (Expat)	6
Hydromet Monitoring Expert (local)	6
Task 10 – Final Documentation	
Hydromet Monitoring Expert (Expat)	10
Hydromet Monitoring Expert (local)	2
Task 11 – Training and Calibration	
Hydromet Monitoring Expert (Expat)	10
Hydromet Monitoring Expert (local)	10
Site Construction, Roads, Calibration Bridge, Gauging Station and Fencing	
Construction Supervisor (Expat)	10
Construction Supervisor (Local)	30
TOTAL	
Hydromet Monitoring/Construction Expert (Expat)	75
Hydromet Monitoring/Construction Expert (local)	140

2. CONCEPT 2: HYDROCHEMICAL EVALUATION

Need: Little is understood about the impacts of irrigation and pollution sources in the Aceh Region.

Objective: To initiate a program to evaluate the hydrogeochemical loading (flow and quantity) in the Kr. Aceh and use this information to promote land use and regulatory reforms.

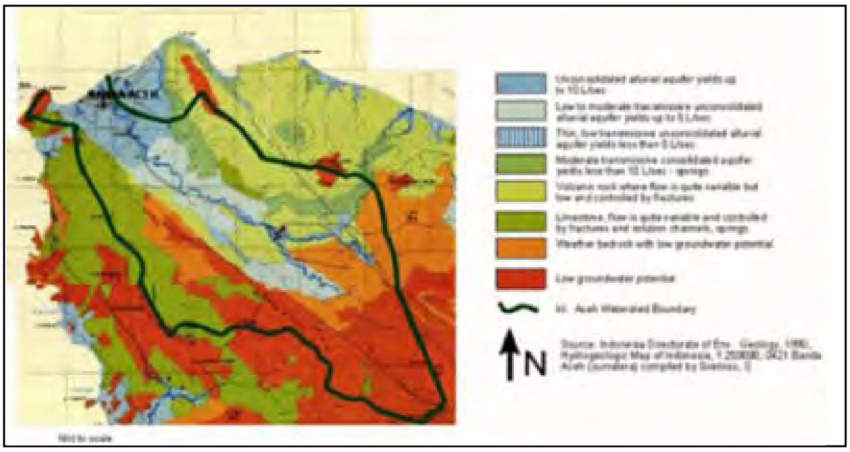

Figure 2: Hydrogeology of the Krueng Aceh.

Description: On a one-time basis, measure surface water flows, water levels in wells, analyze water quality samples, and conduct a visual survey of the main stem of the Kr. Aceh

Details and Benefits:

- Evaluate water quality in the watershed from source to fresh water intake or further down stream to tsunami affected area.
- Hydrochemical mapping could be used for ground truthing BGR EM survey.
- Determine the effect of land use on water quality.
- Identify and assess the impacts of discharges from municipalities and agricultural lands.
- Identify reaches along the stream that have high loading from groundwater
- Capacity building for the Health Dept. and BMG in terms of training on water quality sampling, loading, and monitoring.
- Assist in the development of stream specific water quality standards.
- Define ways to reduce loading through outreach programs and public participation.
- Develop a loading model for the watershed and provide input into a basin wide GIS.

Challenge: To develop a comprehensive hydrochemical loading model program for the Kr Aceh and define the impacts of not only the tsunami but also of various land uses on water quality. Base on experiences of other projects in Sumatra, understanding water quality and flow monitoring techniques is generally a new concept to local authorities. The challenge will be to develop a team potentially consisting of Universities, NGOs, and other interesting parties to assist in a one time sampling program. The team would be trained using proper field techniques including QA/QC. In addition, it will be important to determine the capacity of local and national laboratories to analyze samples.

Solution: ESP will provide expertise in water sampling (both groundwater and surface water) and analysis as well as equipment to meet the requirements of the program as well as ensure that international acceptable methods are used throughout the program.

Scope of Work:
The scope of work would consist of six (6) tasks defined as follows:

2.1. TASK 1 – MONITORING PROGRAM DESIGN

The task would consist of developing sampling and analysis plans for both surface water and groundwater for the Kr. Aceh. These plans would include:

1. Program justification
2. Sampling point locations
3. Proper sampling techniques
4. Instructions for equipment to be used in the field (velocity, pH, conductivity, and temperature meters as well as field test kits)
5. Field Sheets
6. Instruction on labeling of samples and shipment of samples
7. Sampling Quality Control and Quality Assurance (QA/QC)
8. Laboratory analysis (QA/QC)

These plans would be incorporated into field manuals.

2.2. TASK 2 – TEAM BUILDING

This task would consist of building a sampling team. Universities, NGOs, regulators and other organizations interested in water quality sampling and flow measurement would be contacted. It is anticipated that from these organization at least 10 engineers or scientist will be selected to participate in the program.

2.3. TASK 3 – LABORATORY EVALUATION

During this tasks, laboratories (both local and national) will be visited to determine there capacity in analyzing water samples. At least five (5) laboratories would be visited. For those laboratories interested in participating in the program, standard samples will be given to them for analyses. The results of these analyses will determine which laboratory would be chosen to do the work. The chose laboratory will be expected to provide sampling bottles and preservatives.

2.4. TASK 4 – EQUIPMENT PROCUREMENT

It is anticipated that at least five (5) sets of field water quality monitoriyg equipment would be procured for the sampling program. This would consist of pH meters, conductivity meters, and temperature probes. In addition, at least two flow meters with accessories would be purchased together with two (2) sampling pumps and 48 disposable bailers. The exact quantities and types of equipment will be determined during this task. A sampling boat may also be required.

2.5. TASK 5 – TRAINING

Once the team has been assembled and field equipment procured, a week long training program will be held. This program will be both classroom and field oriented. It would provide instruction on developing Sampling and Analysis Plans as well as proper sampling techniques.

2.6. TASK 6 – SAMPLING

Over a period of not more than two (2) weeks during a period of low flow, the team will assembled and sent to the field. The team will be supervised by ESP personnel. Samples and flow measurements will be taken along the entire reach of the Kr. Aceh. Between ten (10) and twenty (20) locations will be selected. In addition, between 20 and 40 wells will be sampled. The samples will be collected stored on ice and shipped as quickly as possible to the chosen laboratory.

2.7. TASK 7 – REPORT WRITING

With the completion of the sampling and analysis program, a detail report will be written by ESP on the methodologies and the results of the program. Conclusions and recommendations will be drawn from the results towards the expansion of the program towards other watersheds and the effects on the tsunami and land use on water quality. This information will then be used to develop a water quality management program for the Kr. Aceh basin.

Costs: Tables1 and 2 present estimated LOE and equipment costs for this concept:

Table 1: Estimated LOE for Concept 2: Hydrochemical Evaluation

Description	LOE (days)	Costs
Task 1 – Monitoring Program Design		
Water Quality Sampling Expert (Expat)	10	
Water Quality Sampling Expert (Local)	20	
Task 2 – Team Building		
Water Quality Sampling Expert (Local)	10	
Task 3 – Laboratory Selection		
Water Quality Sampling Expert (Expat)	10	
Water Quality Sampling Expert (Local)	10	
Standards		$500
Task 4 – Equipment Procurement		
Water Quality Sampling Expert (Expat)	3	
Equipment (see below)		$12,053
Task 5 - Training		
Water Quality Sampling Expert (Expat)	10	
Water Quality Sampling Expert (Local)	7	
Task 6 - Sampling		
Water Quality Sampling Expert (Expat)	20	
Water Quality Sampling Expert (Local)	20	
Task 7 – Report Writing		
Water Quality Sampling Expert (Expat)	10	
Water Quality Sampling Expert (Local)	10	
TOTAL		
Expat	**63**	
Local	**67**	
Equipment		**$12,553**

Table 2: Estimated Equipment Costs for Concept 2: Hydrochemical Evaluation

Description	Qty	Unit Cost	Cost
pH/conductivity/salinity/ temperature meter	4	$864	$3,456
Water Level Meter	2	$749	$1,498
Flow meter and accessories	2	$1,008	$2,016
100 m tape	4	$173	$691
Sampling Pump with Accessories	2	$1,354	$2,707
Downhole Multiprobe YSI 30	1	$1,123	$1,123
Disposable Bailer (24 to case)	3	$187	$562
Total			**$12,053**

* Includes 20% for shipping and handling

3. CONCEPT 3: WATER BALANCE/ WATER SUPPLY EVALUATION

Need: Lack of data and information on water balances in watersheds makes it difficult to develop and forecast long term water supplies.

Objective: To develop an information data base and provide technical assistance that will assist a local PDAM develop initiate a program to develop a viable water supply.

Description: The water supply on Weh Island and the city of Sabang was adversely affected by the 2004 earthquake. Working with the PDAM a program would be developed to assist with the development of a long-term water supply.

Figure 3: Water Supply Lake for Sabang.

Details and Benefits:

- Apply water management concepts to a defined water supply system.
- Develop a tool for long term water supply forecasting.
- Install hydromet monitoring equipment.
- Determine origination of springs and evaluate the impact of the 2004 earthquake on water supply.
- Compliment work in water supply and sanitation being done by NGOs.
- Build capacity of PDAM in terms of water supply analysis.

Challenge: The 2004 Boxing Day Earthquake and the tsunami drastically affected the water supply situation on Weh Island. The last study on water supply studies was completed by IWACO (1993) and needs to be update given the current situation. This report was based on very little information with spring flow, precipitation, and surface flow being based on very little hard data. Understanding the water balance as well as the post-tsunami hydrogeology is imperative for long term water supply forEcasting.

Solution: By completing a comprehensive hydrogeologic evaluation of the island and install hydromet equipment similar to that proposed in Concept 1, a detailed picture can be drawn as to long-term water supply options for the island.

Scope of Work: The SOW can be divided into five (5) tasks. These are delineated as follows:

3.1. TASK 1: LITERATURE REVIEW AND PROJECT DESIGN

During this task, a detail literature search will be completed. This will build on the work done by IWACO (1993). Hydromet and geologic data would be updated. Based on the results of this review, a detail project design would be completed.

3.2. TASK 2: INSTALLATION OF HYDROMET MONITORING NETWORK

Using the same procedures outlined under Concept 1: Hydromet Monitoring, a hydromet monitoring program will be designed and install on Weh Island. At this time it is anticipated that at least one weather station would be installed at the airport. In addition a river gauging station and a lake level monitoring station would also be installed. Local PDAM or other personnel will be trained to operate equipment.

3.3. TASK 3: HYDROGEOLOGIC INVESTIGATION

Using the same equipment as recommended in Concept 2: Water Quality Management, a detailed well and spring survey would take place. A Sampling and Analysis plan will be written and samples taken to be sent to the acceptable laboratory. In addition, flow, water levels, and field water quality measurements will be made. To the extent possible, the hydrogeology of the island will be mapped in detail. All information will be placed in a database which could be accessed by GIS.

3.4. TASK 4: SUPPLY AND DEMAND EVALUATION

With the completion of the hydrogeologic study, a supply and demand evaluation will be completed. For demand, historic and recent records of population and consumption will be used. UFW will also be evaluated and current revenues will be analyzed. Suggestions will be made as too ways to improve revenues and ensure a long term water supply for the island.

3.5. TASK 5: REPORT WRITING

With the completion of the hydrogeologic and supply/demand studies, a detail report will be written which will act as a long-term planning document for the PDAM for the City of Sabang and Weh Island. Recommendations will be made as to how ESP can improve revenues and water supply systems for the island. In

Costs: Table 1 is an estimate of LOE and equipment costs. It should be noted that equipment cost included installation based on Table 1 Concept 1: Hydromet Monitoring.

Table 1: Estimated LOE and Costs for Concept 3: Water Balance Evaluation

Description	LOE (days)	Costs
Task 1 – Literature Review and Project Design		
Hydrogeologist (Expat)	10	
Hydrogeologist (Local)	20	
Task 2 – Installation of Hydromet Monitoring Network		
Engineer (Expat)	10	
Engineer (Local)	30	
Equipment		$90,000*
Task 3 –Hydrogeologic Investigation		
Hydrogeologist (Expat)	30	
Hydrogeologist (Local)	50	
Equipment		NA**
Task 4 – Supply and Demand Evaluation		
Economist/Demand Specialist (Expat)	15	
Financial Specialist (Local)	30	
Task 5 – Report Writing		
Hydrogeologist (Expat)	20	
Hydrogeologist (Local)	20	
Economist/Demand Specialist (Expat)	20	
Financial Specialist (Local)	20	
TOTAL		
Expat	**105**	
Local	**170**	
Equipment		**$90,000**

*Equipment costs are based on one-third of the costs presented in Concept 1: Hydromet Monitoring plus $10,000 for the lake level monitoring station.
** It is assumed that the same equipment would be used as presented in Concept 2: Water Quality Management

4. CONCEPT 4: WATER RESOURCE PROTECTION

Need: After the tsunami, water supply systems were disrupted. On emergency basis, numerous wells were drilled and springs were developed for water supply. Understanding and protecting these supplies is imperative to meet long-term water supply demands

Figure 4: Spring Water.

Objective: To define aquifer characteristics and abstraction areas and develop a program for spring and well head protection.

Description: To continue the work being done by UNICEF in the development of a database for wells and springs (quality and quantity) in the Aceh Region and write guidelines for Aquifer Protection Zone development.

Details and Benefits:

- Assist the PDAM in defining and locating wells drilled - post-tsunami.
- Define areas around springs and wells which need to be protected from adverse impacts from development.
- Develop protection zones for springs on the west coast.
- Provide guidance for developing and maintaining protected areas.
- Utilize the database system developed by UNICEF.
- Assist in developing inventory of equipment that will left by NGOs with detailed specifications so that an inventory can be built up.
- Develop layers for a GIS system showing well locations, field parameters (pH, temperature, EC).
- Incorporate the work being done by the Germans based of the results of there EM survey.
- Build capacity of the PDAM in GIS and mapping.

Challenge: During the reconstruction of water supply systems, it is imperative that there is a thorough understanding of the systems that were installed for emergency water supply as well as those pre-tsunami. It is also important to have a thorough understanding of the impacts of the tsunami as well as man has had on the water resources of the region. It is also important to protect groundwater and springs from further degradation.

Solution: It is felt that by continuing the work implement by UNICEF and others in the development of water quality, well, and spring database. It is felt that a detailed well and spring survey which not only collects data on water levels, spring flow, field water quality parameters, and other information about the wells will go a long way in meeting this goal. This information could then be used to develop a comprehensive well head and spring protection program.

Scope of Work: The SOW can be divided into four (4) tasks. These are delineated as follows:

4.1. TASK 1: DATA REVIEW AND PROJECT DESIGN

During this task, all data collected to date by UNICEF and others will be reviewed. This information would then be used to design a detailed well and spring survey. It is anticipated that this survey will concentrate on the West Coast and in limestone and volcanic areas defined in the text of this Scoping Study. It is assumed that Concept 2: Water Quality Management will provide information for the Kr. Aceh.

4.2. TASK 2: WELL AND SPRING SURVEY

Using the same equipment as recommended in Concept 2: Water Quality Management, a detailed well and spring survey would take place. A Sampling and Analysis plan will be written and samples taken to be sent to the acceptable laboratory. In addition, flow, water levels, and field water quality measurements will be made. To the extent possible, the hydrogeology of the island will be mapped in detail. All information will be placed in a database which could be accessed by GIS.

4.3. TASK 3: DATA ANALYSES

With the completion of the well and spring survey, data will be reviewed and QA/QC. These data would shared with HIC and others through the GIS. Data would be evaluated in terms of potential for water supply and the extent of groundwater/spring/surface water contamination either through salt water intrusion or man made pollution. Catchment areas of springs will be defined and land used evaluated (current and future). For wells which have a high probability of continuing to supplying communities, analytical groundwater models will be run to determine recharge areas which need protection.

4.4. TASK 4: REPORT WRITING

With the completion of the Well and Spring Survey and the Data Analyses, a detailed report will be written which will act as a long-term planning document for the PDAM and the Aceh Province.. Recommendations will be made towards the development of well head and spring protection zones.

Costs: Table 1 is an estimate of LOE and equipment costs. It should be noted that equipment cost included installation based on Table 1 Concept 1: Hydromet Monitoring.

Table 1: Estimated LOE and Costs for Concept 3: Water Balance Evaluation

Description	LOE (days)	Costs
Task 1 – Data Review and Project Design		
Hydrogeologist (Expat)	10	
Hydrogeologist (Local)	20	
Task 2 –Well and Spring Survey		
Hydrogeologist (Expat)	10	
Hydrogeologist (Local)	30	
Equipment		NA*
Task 3 – Data Review		
Hydrogeologist (Expat)	15	
Hydrogeologist (Local)	30	
Task 4 – Report Writing		
Hydrogeologist (Expat)	20	
Hydrogeologist (Local)	20	
TOTAL		
Expat	**45**	
Local	**100**	

* It is assumed that the same equipment would be used as presented in Concept 2: Water Quality Management

5. CONCEPT 5: GROUNDWATER MANAGEMENT MODEL

Need: Currently groundwater is a primary source of water for the Kr. Aceh river basin. Understanding the flow characterics of aquifers supplying water is an important aspect for long-term water supply planning.

Figure 5: Well Drilling in Aceh.

Objective: To develop a groundwater model for the Kr. Aceh valley which would be used to manage deep and shallow aquifers.

Description: Using numerical and GIS modeling techniques, a program would be developed to evaluate impacts on the aquifers of current and future pumping schemes as well as the impacts of saltwater intrusion, and pollution sources.

Details and Benefits:

- Evaluate saltwater intrusion of shallow and deep aquifer systems;
- Define water supply implications of current and potential extraction wells on the aquifer.
- Evaluate the impact of irrigation of shallow aquifers as well as known pollution sources.
- Assess the potential for artificial recharge to reduce salt water intrusion.
- Compliment on-going work by BGR and UNICEF.
- Develop an understanding of the hydraulics of the aquifer system by performing pump tests with observation wells.
- Develop a long-term water level and quality monitoring network for yearly model calibration.

Challenge: Historically, considerable information has been developed on the groundwater in the Kr Aceh basin. This information together with data collected during Concepts 2 and 4as well as the on-going work by BGR will paint an interesting picture of the aquifer system. However, at this time there is no mechanism available to develop these data into a long-term groundwater management strategy for the basin.

Solution: It is felt that by developing a state-of-art groundwater flow and quality model for the basin will assist Aceh Province in managing this resource. At this time there are several off-the-shelf model which would be applicable and could be used effectively as a management tool.

Scope of Work: The SOW can be divided into four (4) tasks. These are delineated as follows:

5.1. TASK 1: DATA REVIEW

During this task, all data collected to date by BGR and historically by the British and the IWACO will be reviewed and place where appropriate into a database.. This information would then be used to design a conceptual model of the groundwater system. Data from Concepts 2 and 4 will also be evaluated and incorporated into the database

5.2. TASK 2: CONCEPTUAL MODEL DEVELOPMENT

Based on the results of Task 1, a conceptual model will be developed for the groundwater flow and quality within the Aceh Basin. Current potentiometric surface maps will be developed and data gaps will be determined. Initially, it is not planned to drill test wells or to perform pump tests, however, these actions may be recommended for further model calibration.

5.3. TASK 3: MODEL SELECTION, DESIGN, IMPLEMENTATION AND CALIBRATION

Task 2 results will be evaluated and the most appropriate model or models will be selected. The model may be either finite element or finite difference. It is anticipated that model will be developed by either a local or national university or local contractor under the supervision of ESP and an expat hydrogeologist. Familiarity of the selected contractor with a particular will also be a factor in the model selection process. Based on the results of Task 2, the appropriate model would be selected, designed, and implemented. A monitoring program will be design for calibration of the model. The results would be placed as a layer in the regional GIS system.

5.4. TASK 4: REPORT WRITING

Upon completion of each Task, a report would be written detailing the results to date, Information for these reports will allow the ESP and the expat hydrogeologist a mechanism to ensure that the program is on the right track. In addition, as mentioned earlier, following the completion of Task 3, recommendations may be made for the drilling and testing of wells to further calibrate the model(s).

Costs: Table 1 is an estimate of LOE and Software costs.

Table 1: Estimated LOE and Costs

Description	LOE (days)	Costs
Task 1 – Data Review		
Hydrogeologist (Expat)	5	
Hydrogeologist (Local)	30	
Task 2 –Conceptual Model Development		
Hydrogeologist (Expat)	10	
Hydrogeologist (Local)	30	
Task 3 – Model Selection, Design, Implementation and Calibration		
Hydrogeologist (Expat)	15	
Hydrogeologist (Local)	90	
Software		$2000
Task 4 – Report Writing		
Hydrogeologist (Expat)	10	
Hydrogeologist (Local)	30	
TOTAL		
Expat	**30**	
Local	**170**	
Software		**$2000**

6. CONCEPT 6: SPRING DEVELOPMENT AND WATSAN PLANNING

Need: Springs are a major source of water supply in the region. Communities depend on these springs, however, development of springs and distribution is often haphazard and needs improvement.

Objective: To develop a program for WATSAN Planning and for the development of springs in small communities.

Description: Working in the communities of Lhoknga, Leupung, Lamno, and Celang on the West Coast, develop a template for a WATSAN Plan for development and distribution of water from the Mata Ie and Glee Taron Springs. In addition, work with community leaders for alternative financing of design and implementation of the water and sanitation systems.

Details and Benefits:

- Provide WATSAN Planning for small communities;
- Work with PDAMs on developing formats and methodologies for bankable studies so that loans could be acquired for construction of water supply and sanitary systems;
- Compliment work being done by UNICEF under a Coca Cola Grant and the Swiss which is developing a pipeline;
- Provide an opportunity to work with LaForge the owners of the main employer in the area in their development work and in seeking alternative financing;
- Compliment other USAID –ESP program in capacity building in water and sanitation;
- Support USAID programs along the West Coast which will soon be constructed.

Challenge: With the advent of the US AID funded road, much attention will be focused on development of infrastructure in small communities along the right away. Visits to various communities indicate that spring water is and will continue to be the primary source of drinking water. The challenge is to assist these communities in developing plan which could be funded by the World Bank, Asian Development Bank or other alternative financing schemes.

Solution: By developing a program that allows communities to develop their own plans for water and sanitation will assist greatly for them to obtain long-term financing. By working with selected communities, a template can be developed for requesting financing for WATSAN plans.

Scope of Work: At this time, not enough information is available to develop this concept fully. With the completion of UNICEF efforts to define individual district WATSAN needs, a full program can be defined for individual communities. It is, therefore, believed that the initial effort for this task should be spent on program design. Towards this end, lending institutions should be contacted to determine there requirements for loans and plan with specific tasks should be developed. These tasks could include but not be limited to:

1. Community Selection
2. Spring Development Evaluation
3. Water Resource Alternative
4. Basic Design Standard Development
5. Basic reticulation system design
6. Future demand
7. Cost Benefit
8. Quality Control and Quality Assurance
9. Environmental Impact
10. Others

Costs: For the project design, it is anticipated that LOE requirements would be:

Expat WATSAN Engineer – 10 days
Expat Hydrogeologist – 5 days
Expat Financial Expert – 10 days
Local Engineer – 20 days

ATTACHMENT B

DRAFT TERMS OF REFERENCE FOR HYDROGEOLOGIST

NOVEMBER 2005 THROUGH JANUARY 2006

DRAFT
TERMS OF REFERENCE
HYDROGEOLOGIST

Consultant Name: (Last, First)	**Brown, Phillip E.**	**Position Title:**	Hydrogeologist
Contract Name:	Environmental Services Program (ESP)		
Billing Code:	5300-200	**Contract No:**	497-M-00-05-00005-00
Period of Performance:	10 November – January 15		
Travel Days	4		
Work Days Overseas:	20 (12 November – 20 December, 2005)		
Remaining Work Days: (Research, Report Writing)	6		
Total Level of Effort:	30 days		
Evaluator:	William J. Parente, Chief of Party		

BACKGROUND

The Environmental Services Program (ESP) is a fifty-eight month program funded by the United States Agency for International Development (USAID) and implemented under the leadership of Development Alternatives, Inc. (DAI). ESP works with government, private sector, NGOs, community groups and other stakeholders to improve the management of water resources and broaden the distribution of safe water to urban dwellers by strengthening watershed management and delivery of key environmental services, including clean water, sanitation and solid waste management in Indonesia. The period of the project is from December 2004 through November 2009. ESP activities are focused on six High Priority Provinces: Aceh, North Sumatra, West Sumatra, East Java, West Java and DKI Jakarta. ESP also supports a limited set of activities in four Special Concern Imperative Areas: Balikpapan, Manado, Manokwari and Jayapura.

OBJECTIVES

With the completion of the Scoping Study, six concepts were developed towards improved water resources management in Aceh Province after the 2004 tsunami which devastated water supply and distribution systems. These concepts are defined as follows:

CONCEPT 1: HYDROMET MONITORING PROGRAM.

This program would involve the development of a hydromet monitoring program for the Kr Geupu River Watershed which we had visited the other day. It would be intended to be a pilot program which would involve the establishment of two automated weather station and a gauging station. In addition, it would involve the reconstruction of a foot bridge which was destroyed by the tsunami so that the river could be gauged during periods of high flows. It is anticipated that this program would initiate a region wide hydromet monitoring network. In addition, the program would assist in assessment of the environmental impacts of the USAID funded highway, deforestation on the West Coast and the foot bridge may divert foot traffic away from the highway.

CONCEPT 2: WATER QUALITY MANAGEMENT-HYDROCHEMICAL EVALUATION PROGRAM.

This concept would consist of a total chemical loading study for the main stem of Kr Aceh. The program would be designed to evaluate the water quality in the watershed from source to fresh water intake or further down stream to tsunami affected area. It would used to determine the effect of land use on water quality and would assist BAPEDALDA, PDAM, BPDAS, and others in making informed decisions on water quality based on loading (flow and quality) whether than just quality. By sampling wells, it would also serve for ground truthing of the BGR EM survey. Ultimately, it will develop a loading model for the watershed and provide input into a basin wide GIS.

CONCEPT 3: WATER BALANCE AND WATER SUPPLY.

This program would apply water management concepts to a defined water supply system of Sabang-Weh Island. In doing so, tools would be developed for long-term water supply forecasting. The study would involved the hydrogeologic evaluation of the island, the evaluation of PDAM's distribution system in terms unaccounted for water (UFW) and would work with local community leaders on spring protections and environmental programs.

CONCEPT 4: WATER RESOURCE PROTECTION.

This concept would assist the PDAM and others in defining and locating wells drilled during the period when well permits were not required (shallow and deep)– post-tsunami. The program would also define areas around springs and wells which need to be protected from adverse impacts from development and determine to extent possible the probable impacts of silvaculture, farming, mining (quarries) and other land uses on water supplies. It would develop protection zones for springs on the west coast and provide guidance to expand the spring protection program for the entire region. The would be designed to work with UNICEF, PDAM, BAPEDALDA, as well as NGOs who are currently working in spring development along the West Coast in areas such as Calang.

CONCEPT 5: GROUNDWATER MANAGEMENT MODEL (KR. ACEH)

This project would involve the development of a finite element or finite difference groundwater/surface water model (quantity and quality) for the Kr. Aceh watershed. Hydrogeology the boundaries of this basin are well defined and a model could be easily designed. It is not expected at this time that the input into the model would involve the drilling and testing of wells to obtain hydraulic characteristics. However, recommendations may be given requiring the establishment of a monitoring program and a testing program for the calibration of the model. Such a model could be used by PDAM, BAPEDALDA, and others to evaluate the impacts of pumping, irrigation, and land use changes to the aquifer. It would ultimately be part of the GIS for the basin.

CONCEPT 6: SPRING DEVELOMENT AND WATSAN PLANNING (WEST COAST COMMUNITIES)

Springs are a major source of water supply in the region. Communities depend on these springs, however, development of springs and distribution is often haphazard and needs improvement. This program would develop:

- WATSAN Planning for the development of springs in small communities;
- Working in the communities of Lhoknga, Leupung and Lamno on the West Coast, a template for a WATSAN Plan for the development and distribution of water from the Mata Ie and Glee Taron Springs would be developed;
- Work with community leaders for alternative financing of design and implementation of the water and sanitation systems.

This work would compliment work being done by UNICEF using a Coca Cola grant and SCD (the Swiss) and would be directly related to the USAID road development corridor.

The objective of this TDY would to initiate the development and implementation of programs recommended by these concepts. This work would include the development of program designs, work plans, sampling and analysis plans, and to develop specifications for equipment which would purchased and procured by the project.

TASKS

- Work with Indonesian Engineer/Hydrogeologist and other ESP staff to develop a program design for Concept 6: Spring Development and WATSAN Planning;
- Develop work plans for Concept 1: Hydromet Monitoring, Concept 2: Water Quality Management, Concept 3: Water Balance/Water Supply, and Concept 4: Water Resource Protection;
- Develop Sampling and Analysis Plans for Concepts 2 and 3. This would include field trips to potential sampling sites;
- Visit local and national laboratories determine capabilities;
- Define problem areas which may be associated with implementing these programs;

- Meet with relief agencies, NGOs, local government and others working in the region, to obtain buy-in to the water resource management programs and seek their help in fielding sampling teams;
- Obtain addition information as available concerning springs, groundwater, and surface water resources;
- Obtain and review any further data available on water resources in the region which was not collected during the Scoping Study;
- Based on information obtain, make changes as appropriate to the Scoping Study and the Concepts develop.

DELIVERABLES

Consultant will prepare or provide the following:

- A preliminary program design for Concept 6: Spring Development and WATSAN Planning;
- Work plans for Concepts 1 through 4 with attention paid to scheduling activities;
- Sampling and Analysis Plans for groundwater, surface water, and spring sampling which will take place under Concepts 2, 3, and 4;
- A trip report together with a report that presents the findings of the Concept 6 design and laboratory visits as well as work plans and Sampling and Analysis Plans. In addition, the report will identify problem areas for meeting the objectives of the program.

ILLUSTRATIVE FIELD SCHEDULE

(to be finalized upon arrival in Jakarta)

November 12: Arrival in Indonesia;
November 13: Meetings with ESP Jakarta, USAID EA staff;
November 14: Travel to Banda Aceh, meet with ESP staff there;
November 15 – 23: Visit with USAID/Banda Aceh, concerned NGOs (e.g CARE, UNICEF, IRD, etc.), local government officials (city, public works, etc), and the local Universities to obtain pay into the program and team building. Complete preliminary design for Spring Development and WATSAN program;
November 24: Leave Banda Aceh to Jakarta and meet with the ESP and set up laboratory visits for Jakarta;
December 10: Return to Jakarta;
December 11: Visit laboratory(s);
December 12: Return to Banda Aceh;
December 13 – 15: Visit potential sampling sites;
December 15 – 20: Finalize Work Plans and SAPs;
December 20: Return to Jakarta;
December 21 – 22: Return to USA.

ATTACHMENT C

TRIP REPORT-BANDA ACEH

WATER RESOURCE DEVELOPMENT AND PROTECTION

ENVIRONMENTAL SERVICES PROGRAM

22 – 30 AUGUST 2005
by Phillip E. Brown, Consultant in Hydrogeology

The following presents a day to day summary of activities for Phillip Brown during his short term assignment in Banda Aceh.

Figure 1: USAID in Calang (IRD Office).

21-August – Left Jakarta at 06:20 to Banda Aceh. Arrived at 10:00 AM. Met with John Pontius who gave me a tour of the tsunami affected area in the immediate vicinity of Banda Aceh. John gave an overview of the project and showed me aerial photographs, maps, and reports that he had collected regarding the hydrology of the Banda Aceh region.
I completed a very preliminary outline of the report.

22-August – In the morning, I reduced climatic data and evaluated hydrogeologic and geologic maps of the Banda Aceh region. Went with John on a tour the water intake facilities and water treatment plants.

The first stop was a bladder dam on the *Krueng Aceh* (Aceh River). This dam is inflated occasionally during the year to prevent the salt water wedge from progressing up river and affecting the fresh water intake. Located at N 5 ° 31'11.4", E095 ° 21'33.5", the dam site was adversely affected by the Dec 2004 earthquake and earthworks have been completed to improve the channel where the dam is located. At the fresh water intake, there is a General Electric Rapid Sand Filter and Nano filtration plant which treats water directly from the river and provides drinking water to individuals and tankers. The UN has provided tanks and the distribution system. Besides tanker trucks filling up at this point that were individuals with jugs and pick up trucks with bladders. Across the street is the main water treatment plant that is currently being renovated by International Relief and Development (IRD). Pumping systems and electrical systems are being improved, sand filters are being replaced, and a system of backwashing and clean-up has been implemented. The plant is capable of treating about 450 L/sec. Its location is N 5° 30' 53.7",E 095° 21' 18.8".

The next stop was newer treatment plant across the river. This was originally built by the Banda Aceh PDAM but was not put into operation. The Swiss Agency for Development and Cooperation has updated two sand filter units and a chlorination system. One unit is capable of treating 20 L/sec and the other 40 L/sec. It is located at N 5 ° 30' 51.2", E095° 21' 30.5". The last stop was a series of springs and a reservoir site on the eastern flank of the mountains in Aceh Basar. These springs which emanate from limestone have been developed for over 400 year and were originally used by the Sultan for recreation. The Dutch further developed the springs and put in a distribution system. Flow from the springs currently is around 40??? L/sec. They supply water to west side of Banda Aceh and Aceh Basar. The approximate location of the reservoir for the main water supply spring is N 5 ° 29' 45.9", E 095 ° 17' 37.5".

Later John and I went to the HIC (Humanitarian Information Center) and signed up for a helicopter trip to the south to Calang. Also went through the map atlas, maps that we do not have include:

UNICEF, 2005, Database.

BGR, 2005, Electrical Conductivity (EC) of Shallow Groundwater in Banda Aceh City and Aceh Besar District (Feb 2005 data for well 1.6 to 13 meters below ground surface).

BGR, 2005, Temperature of Shallow Groundwater in Banda Aceh City and Aceh Besar District (Feb 2005 data for well 1.6 to 13 meters below ground surface).

BGR, 2005, pH of Shallow Groundwater in Banda Aceh City and Aceh Besar District (Feb 2005 data for well 1.6 to 13 meters below ground surface).

24 August – Today we left early in the morning and took a trip to the West side of the Island. The purpose of the trip was to take a look at the devastation caused by the tsunami to water supplies and villages and to take a first look at the Kr Geopu watershed. During this trip, John pointed out how PDAM's operation were disrupted with distribution pipes being stolen and the water treatment plant at Geupu being virtually destroyed by the tsunami (note: this plant never did operate). We saw tankers hauling water to village tanks and saw where springs from the limestone being tapped by villages for water.

Figure 2: Krueng Geupu Watershed.

The focus of the trip was to visit the Kr Geupu watershed. This watershed is approximately 12,500 hectares in size and originates in the mountains to the north and west. The upper portion of the watershed has been disturbed by illegal logging and some plantations within a 2 hour walk from the main road. The cement factory also had its fresh water intake on the river and PDAM had constructed a water treatment plant which had not be functional due to lack of funding. At this point, the height of the tsunami was approximately 23 meters high. In the lower part of the watershed trees and some structures were destroyed. A foot bridge was also flattened and the water treatment plant suffer sever structural damage. In addition, the USAID funded highway will cross this river at some point.

One concept that we are currently evaluating is developing hydrometeorological monitoring program in this watershed. The reason for this is that it is relatively pristine and could serve as a baseline watershed in terms of water quality and runoff characteristics for other watersheds along the west and south coast. At the same time, it has been disturbed by man to some extent with by logging and for water supply operations. Such a program would have many benefits and would:

- Aid in the assessment of the impacts of the USAID funded highway;
- Help to assess the impacts to water resources of logging and industrial development on the watershed – flow, water quality and sedimentation;
- Assist in the development of water balance for developing water supply alternatives for the southwest coast;

SUM14-003 and -004 – Salinity in wells in Aceh Barat
SUM14-010,-011, and -014 - Hydrologic maps

These are available for download on the web.

After the HIC, John and I attended the WATSAN (Water and Sanitation Coordination) meeting. The meeting was well attended but not very well organized. A presentation was given on projects that were still seeking donor funding. Most involved drainage and consisted of both technical and non-technical projects. In other words, a wish list was provided hoping that NGOs or donors would bite. It was also stated that 500 km of galvanized steel pipe was available at UNICEF for distribution system. This pipe was originally ordered over 4 months ago. Finally, Ramon Scoble of UNICEF had just returned from Sabang where he was evaluating the groundwater situation there. There the principal water supply for the city is a natural lake in a caldera. Before the December '04 earthquake, springs near the lake produced 5 to 10 L/sec now they produced over 40 L/sec. At this time, it is not certain as to why.

Later Gatot Sudradjat, our Indonesian hydrogeologist, arrived. John, Gatot, and myself met Ramon Sabang (UNICEF), Christof Mor (Swiss Agency for Development and Cooperation) for dinner. At dinner, we set out plans for meeting on the next day. Also we were invited to hear a presentation from the Germans on the siting of landfill.

23 August - In the morning, John Pontius, Gatot Sudrajat, and myself attended a presentation by Alfred Eberhardt and Jan Peter Schemmel of GTZ on "Environmental Assessment in scope the reconstruction efforts in Aceh". We were led to believe that this was going to be presentation of the landfill siting effort of GTZ and did not stay around for the presentation. However, we did briefly meet with Holger Treidler – an environmental geologist – in charge of their GIS work for the landfill and set up a meeting with him for 15:00 Monday.

After we left the GTZ meeting, we went to UNICEF and met with Ramon Scoble. In our discussion, it was apparent that he feels strongly that the number one data gap is the general lack of hydromet data in the region. He said that current data on precipitation and river gauging is lacking. However, in the mid 70' through the 90's all river's were gauged at least once and that somewhere there are records for 28 precipitation gauges with varying periods of record. He also said that there only 3 WMO recording stations in the whole region. The main reason for this lack of continuous data is that money is not available to maintain and operate them. He feels that a strong part of program should be related to establishing low maintenance stations and educating people to maintain and calibrate them.

In terms of groundwater, he feels that there is plenty of water from springs and surface water sources for water supply in the region. The main problem is along the northeast coast where due to guerilla activity in the coastal mountains collecting and diverting surface water is problematic. He said that the Germans are drilling 120 – 4" diameter boreholes in this area to supply local villages. In Banda Aceh, he told us that there is a major problem is the reporting of new wells drilled for tsunami relief. At this time, numerous NGOs are drilling wells and very few record anything about them. He has designed a database and constantly asks people to fill in basic information about these wells. However, he has not had much luck. There is a need to get this information up to date. The problem relates to the fact the BMG has waived the requirements for well permitting during the disaster and UNICEF has not authority to interfere. Finally, we discussed the possibility of instrumenting a pilot watershed on the West coast. He believes this is a good idea and could serve a role model for other watersheds.

In the afternoon, Gatot and I met with Dr. Dieter Ploethner and Bernd Roettger of who are in charge of the “HELicopter Project ACEH” which is a joint project between the German federal Institute for Geosciences and Natural Resources (BGR) and the Indonesian Directorate General fro Geology and Mineral Resources. This meeting was extremely helpful and beneficial. Through their research, they have compiled considerable amount of information and were more than willing to share it with us. A complete list of reports that they gave to us for our review is list below. Essentially, their project is involved with performing an airborne electric magnetic resistivity survey over the Aceh River basin. This survey with proper ground truthing is capable of evaluating shallow groundwater salinity down to 60 meters below the ground surface using a method know as FDEM (Frequency domain Electric Magnetics). Ground truthing involves sampling wells or doing ground surveys to verify the results. He also explained to me in more detail the work the Germans were doing on the northeast coast. He gave us an overview of the hydrogeology as he understands for the region and supplied us several maps and a newly published Environmental Atlas (Post tsunami) of the Banda Aceh. Finally, he suggested that we talk NGOs including IRC – Melody Munz – 62-0-811-904 686 (mobile) and OxFam – Sarah Dryhurst.

List of Publications received for BGR:

Farr, J.L. and Djaeni, A., 1975, A Reconnaissance Hydrogeological Study of the Krueng Aceh Basin, North Sumatra – Geological survey of Indonesia Engineering Geology – Hydrogeology Division.

Lawrence, a. and Djaeni, 1977, Indonesia – Reconnaissance study of the Groundwater Resources of the Krueng Aceh Basin – N. Sumatra

Culshaw, M.G., Sutarto, N. R., Duncan, S. V., and Effendi, A., (not dated), An Engineering Geologic Survey of the Banda aceh Basin, D.I. Aceh, Sumatra Indonesia.

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Province – Report Aceh Barat – 9 Septerber 1993.

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Provice – Kabupaten Aceh Barat – September 1993

IWACO, 1993, Study of Water Sources Allocation for Water Supply for D.I. Aceh Provice – Kotamadya Banda Aceh Planning of Water Supply Development and Raw Water Sources Allocation – September 1993

Binnie & Partners, 1986, ACEH DESIGN UNIT – Provincial Water Resources Development Plan Inventory of Water Resources Schemes – Volume 1 Summary, January 1986.

Binnie & Partners, 1986, ACEH DESIGN UNIT – Provincial Water Resources Development Plan Inventory of Water Resources Schemes – Volume 2 Existing Situation, January 1986.

Departeme Enegi Dah Sumberdaya Mineral, 2005, Informasi Geologiling Jungan Untuk Rencana Tata Ruang Regional (Intra Urban) Daerah Aceh Bara Provisi Naggroe Ach Darassalam. (Environmental Geologic Atlas of the Banda Aceh Region).

- Build capacity for developing a surface water and groundwater monitoring programs.
- Compliment work being done by the Swiss Agency for Development and Cooperation (Water Treatment) and UNICEF for tsunami relief;
- Act as prototype for other watersheds in the basins;
- The old foot bridge could be replaced with a bridge designed for high water gauging and foot traffic keeping people off the new highway.

In the afternoon, we returned to the office and began setting up appointments and finalizing our helicopter tour of the Aceh Area. Gatot began writing an overall review of the hydrology and hydrogeology of the Aceh region.

25 August – Today Gatot and I flew via the UN Air Service to Calang on the West Coast. The flight gave us an opportunity to view the tsunami impacts from the air. When we arrived we started contacting locals to determine who we should talk to about reconstruction efforts particularly in water and sanitation. We were told to go visit the International Relief Committee (IRC). We went to their office and we were welcomed with open arms. They gave us a complete briefing on what they are doing. There work has included rehabilitation of springs and spring water collection systems, the drilling of six shallow groundwater wells with two additional well currently being drilled, surface water treatment system and health services throughout the region. They are also in the process of developing a map of all the current villages, wells, sanitation facilities, and areas where the other NGOs were working. They also gave us photographs of their activities in the WATSAN

Figure 3: IRC Water Distribution Equipment.

IRC together with OxFam and others are dealing with water and sanitation systems for thirty to forty villages in the Calang region. Water for drinking comes mainly from springs although there are some wells with saline free water. Well water is generally used for toilets and some washing. OXFam has put in septic tanks and has drilled more wells than IRC. Other NGOs have also installed wells and spring collection systems. We were told that each planned to turn these systems over to the PDAM once they are finished. Even though they coordinate activities at a weekly WATSAN meeting, each organization uses different types of pipe, pump equipment, tanks, etc. This non-conformity will most likely be a night mare for the PDAM when they take over these systems. Maintaining a parts supply will be difficult. It will be important for the PDAM to get a complete list of the kinds equipment installed, specifications of pipes for the distribution systems, as well as other components to the now installed WATSAN systems so they can either build an inventory of spare equipment parts once the NGOs supply runs out or start a program for a uniform code. Finally, the one thing I noticed is that most new dwelling and buildings have corrugated galvanized steel roofs. None had rooftop collection systems. With water being at such a shortage and over 1.5 meters of rain a year, I think such system would be a viable method for household water supply.

Figure 4: Drilling of Well at Lhok Buya near Calang (IRC photograph).

Figure 5: Well and Pump System at Lhok Buya near Calang.

Figure 6: Final Water Supply System at Lhok Buya (IRC photo).

Figure 7: Spring Box at Batee Tutong (IRC photo).

26 August – In the morning, I met with Christoph Mor of the Swiss Agency for Development and Cooperation. During this meeting he explained to me that the SDC is Banda Aceh to support water projects. They were currently involved mainly with the rehabilitation of the water treatment plant which John and I had visited on the 22 July. He also told me that because estimation of the rehabilitation project was $2 M higher than actual cost, he is tasked to look for projects in water supply development that they could support. He said that they were looking at spring development, improvement of reticulation systems, and any number of other projects.

Figure 8: SDC Supported Water Treatment Plant.

I showed him the database of maps and reports that our team has developed and gave him digital copies of reports and maps that we had in our files. I also went through the 5 Concepts that I had been thinking about for our project. These concepts include:

CONCEPT 1: HYDROMET MONITORING PROGRAM. This program would involve the development of a hydromet monitoring program for the Kr Geupu River Watershed which we had visited the other day. It would be intended to be a pilot program which would involve the establishment of two automated weather station and a gauging station. In addition, it would involve the reconstruction of a foot bridge which was destroyed by the tsunami so that the river could be gauged during periods of high flows. It is anticipated that this program would initiate a region wide hydromet monitoring network. In addition, the program would assist in assessment of the environmental impacts of the USAID funded highway, deforestation on the West Coast and the foot bridge may divert foot traffic away from the highway.

CONCEPT 2: WATER MANAGEMENT - HYDROCHEMICAL EVALUATION PROGRAM. This concept would consist of a total chemical loading study for the main stem of Kr Aceh. The program would be designed to evaluate the water quality in the watershed from source to fresh water intake or further down stream to tsunami affected area. I would used to determine the effect of land use on water quality and would assist BAPEDALDA, PDAM, BPDAS, and others in making informed decisions on water quality based on loading (flow and quality) whether than just quality. By sampling wells, it would also serve for ground truthing of the BGR EM survey. Ultimately, it will develop a loading model for the watershed and provide input into a basin wide GIS.

CONCEPT 3: WATER BALANCE AND WATER SUPPLY. This program would apply water management concepts to a defined water supply system of Sabang-Weh Island. In doing so, tools would be developed for long-term water supply forecasting. The study would involved the hydrogeologic evaluation of the island, the evaluation of PDAM's distribution system in terms unaccounted for water (UFW) and would work with local community leaders on spring protections and environmental programs

CONCEPT 4: GROUNDWATER PROTECTION/DATABASE MANAGEMENT/GIS. Assist the PDAM in defining and locating wells drilled during the period when well permits were not required (shallow and deep)– post-tsunami. The program would also define areas around springs and wells which need to be protected from adverse impacts from development and determine to extent possible the probable impacts of silvaculture, farming, mining (quarries) and other land uses on water supplies. It would develop protection zones for springs on the west coast and provide guidance to expand the spring protection program for the entire region. The would be designed to work with UNICEF, PDAM, BAPEDALDA, as well as NGOs who are currently working in spring development along the West Coast in areas such as Calang.

CONCEPT 5 – GROUNDWATER MANAGEMENT MODEL (Kr. Aceh)
This project would involve the development of a finite element or finite difference groundwater/surface water model (quantity and quality) for the Kr. Aceh watershed. Hydrogeology the boundaries of this basin are well defined and a model could be easily designed. However, input into the model would involve the drilling and testing of wells to obtain hydraulic characteristics and the establishment of a monitoring program for calibration of the model. Such a model could be used by PDAM, BAPEDALDA, and others to evaluate the impacts of pumping, irrigation, and land use changes to the aquifer. It would ultimately be part of the GIS for the basin.

After discussing these concepts with Christoph, he could see how his program could compliment each of the concepts. For Concept 1, SDC is seriously thinking about upgrading the water treatment plant in the Kr Geupu Basin. For Concept 2, during the our survey, we could help identify and prioritized water collection systems in disrepair which they could perhaps find funding for. For Concept 3, there would be numerous small civil projects which they may be interested in. For Concept 4, spring protection is very much a concern of the SDC and as mentioned earlier they are currently evaluating on what they can do and we could support these activities. Finally, he was not very keen of the Model (Concept 5) because he like others feel that there is plenty of spring and surface water available and given the correct reticulation system amble water is here.

Figure 9: A Lake that supplies Sabang water.

27 August – Jefry, Gatot, and I traveled to Sabang. Also along on the trip was Christoph Mor of the Swiss Agency for Development and Cooperation. The objective of the trip was to evaluate how ESP and the Swiss could work together on help with water supply and environmental issues on the Island. After getting off the boat, we went to the PDAM office where they briefed us on the water supply issues of the Island.

Essentially, they are under a mandate from the Mayor to quit using water from their current source which is a natural lake in a caldera on the hill between the City of Sabang and the Airport. This lake has historically been the main water supply for the city. Concerns started to arise between 2000 and 2004 during which the water level dropped 2 meters. After the Boxing Day earthquake in 2004, the lake started dropping at a rate of 1 centimeter per day. A spring which before the earthquake was flowing at less than 5 L/sec was now flowing at a rate between 20 and 25 L/sec. They basically say that a crack open up and increase the flow of spring and they believe that this is the reason that the lake is dropping so rapidly. However, there really is no data available to quantitatively evaluate this phenomenon.

The water supply system currently feeds 3300 households. The water is pumped from the lake at 50 L/sec – 24 hours a day. In addition, water supply trucks with 4 m^3 capacity feed water to communities not connected to system. These trucks make 15 trips a day. Water is sand filtered and not chlorinated. In addition, the PDAM has two wells which are used for communal toilets and owns two springs (*Reuteu* and *Aneuk Itam*) which produce about 25 L/sec. They would like to further develop these springs for about 500 household out side the city. There is a perennial spring fed stream that they believe has the potential of supplying 100 L/sec. Finally, a dam is being constructed – the person from PDAM that we were with did not know the purpose of the dam but a community leader we met earlier said that the dam was build for water supply for the city. The design and construction of the dam is very unconventional and may or may not be viable. On looking at the dam, both Christoph and myself felt that the dam needs further evaluation both from a design and water supply perspective. Understanding the water balance and hydrology of the Island would go a long way towards the development of a long-term supply.

Figure 10: Spring Flow from a "crack" caused by the earthquake on December 24.

The PDAM on the Island is struggling. Only 60% of the household serve pay their water bill. The remaining 40% are either too poor or don't bother. 50% of the household connections are not metered and pay the minimum. In addition, UFW is about 50% of the delivered water. The tariff structure and reducing UFW needs to be evaluated.

Figure 11: Sabang Water Distribution System.

That evening Christoph and I met with David T. Van De Carr, an American working on community development issues and Daml, a community lead on Weh Island (Tel: 081534612189). Both gave us interesting aspects on what was going on the community level on the Island. Essentially, with local leadership, communities have been able to fairly rapidly clean up after the tsunami and get basic services working. Daml has fought successfully to keep a cement plant off the Island because of its potential environmental impacts and local labor and materials are used to make concrete. A serious effort is being made to put septic tanks is some of the communities instead of discharging to the sea and mangroves destroyed by the tsunami are being replanted. Gapang which is famous for diving is being promoted to some extent for ecotourism. However, the small communities feel that the PDAM is insensitive to their needs and after eight months water supply from a nearby spring has not been restored.

In many ways, Weh Island and Sepang are ideal program sites. Understanding the hydrogeology/hydrology of this confined area is doable and helping meet the Mayor's demand for alternative water supplies through springs and surface water can be achieved. Support for the PDAM is also something that could be accomplished. Having a small enough population base, the tariff structure and UFW could be evaluated and recommendations made. Finally, ecotourism could easily become a major industry on the Island. Protecting the watersheds should be of major importance.

28 August – Returned to Banda Aceh from Sabang – Began putting together Power Point Presentation for the report.

29 August – In the morning, I met with Alois Ndambuki (0812 104 6876)– GIS Officer and Rodd McGibbon (0811 840-0758) – Manager of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) – Humanitarian Information Center. The Center is acting as a Clearing House for Information. It is mandate to promote the use of common datasets and the sharing and distribution of information to support humanitarian and recovery effort. The HIC has developed relationships with donors, NGOs and others to form a GIS user forum. This forum is to begin having regular meetings in the near future. According to Alois, the have developed a GIS digital atlas for the Banda Aceh province which will be available soon. Layers included are settlements, volcanos, UNICEF waterholes, health facilities, fault line, basin, rivers, road, 50,000 kilometer grid, district boundaries, sub-district boundaries, villages, and tsunami affected areas. The HIC also handles maps of various scales in a relational database.

In the afternoon, John, Jefry and myself attended the WATSAN coordination meeting. Of note at the meeting, were the plans to hire a Jakarta based firm to do a Water and Sanitation needs assessment for each of the Districts. The concept was to have a team of four professional consisting of engineers, planners and financial analysts to conduct a two-week study at each District. The program would begin with one and then expanded. It is hoped that eventually that more than one team would be working so that all the Districts could be covered in a short time period. John told the group that ESP would be happy to work with the teams on capacity building. My thoughts on this concept are as follows:

1. Based on my visits to various communities, I truly believe that the needs of the people are fairly obvious and perhaps these assessments should lean more toward a pre-feasibility and development of a Master Plan for each District. Such a program would not only address needs but also take a giant step toward a bankable document;
2. During the studies, efforts should be made to eliminate systems that did work in the past. It will be far cheaper to replace systems than to repair old ones which may or may not work;
3. Guidelines should be set that future demand is at least addressed for time period of at least twenty years;
4. I suggest that the use of standardized water treatment plants, waste water treatment plants, pumping stations, and storage facilities be mandatory. This would allow for quick and responsive training program for operators, the ability for the development of part warehouses on a regional level, and ensure the long-term viability of the programs;

5. Community involvement is also essential in the planning process. Such former urban communities such as Calang were totally wiped out. It is important that during the planning process that the planners listen to the community leaders and understand what the people want. This will give the citizens a feeling of ownership;
6. Look toward the development of regional water authorities which go beyond district borders. This in the long run will save costs;
7. Eliminate individual or neighbor water supply wells. These keep people wanting to be connected to the reticulation system;
8. Care must be taken in looking at sanitation facilities. The use of individual household systems should be eliminated in urban areas. Managed community systems are okay for the near term but should be eliminated once sewerage and wastewater treatment plants are operating;
9. Add cost of meters and household connections to the total cost of each project. This will assist PDAMs in cost recovery in the future. Also as seen in other parts of Indonesia, people have a hard time accepting the fact that water and waste disposal are not free. However, I believe that they are willing to pay for delivery of such services. By placing meters and connections at no cost, the people will pay for the delivery of the water;
10. Develop protection plans for springs, wells, and other water supply sources. This will save treatment costs.

That evening John and I together with Christoph Mor (SCD) and Ramon Scoble (UNICEF) met with La Forge and later with the World Bank representative. Ramon and Christoph presented to them their concept on developing springs on the West coast.

The result of the meetings became a 6th Concept dealing with Spring Development and WATSAN planning for small communities. Working with the Swiss, UNICEF and LaForge, USAID ESP would work with communities such as Lhoknga, Leupung and Lamno on the West Coast to develop a template for a WATSAN Plan for the development and distribution of water from the Mata Ie and Glee Taron Springs. In addition, we would work with community leaders for alternative financing of design and implementation of the water and sanitation systems. Benefits of such a program would be:

1. Provide WATSAN Planning for small communities;
2. Work with PDAMs on developing formats and methodologies for bankable studies so that loans could be acquired for construction of water supply and sanitary systems;
3. Compliment work being done by UNICEF under a Coca Cola Grant and the Swiss which is developing a pipeline;
4. Provide an opportunity to work with LaForge the owners of the main employer in the area in their development work and in seeking alternative financing;
5. Compliment other USAID –ESP program in capacity building in water and sanitation;
6. Support USAID programs along the West Coast which will soon be constructed.

30 August – Nofaldi and I met with Holger Treidler – an environmental geologist – in charge of their GIS work for the GTZ landfill study. On the way to GTZ, I briefed Nofaldi on what I was doing and ideas that I had which could be supported by GIS. As mentioned earlier, each concept could be supported by GIS. One of the key components to this is to develop a base map. To do this we have to get the topographic data and shape files for the region. I also made suggestions on people and organizations to whom he should speak to while in Aceh.

The meeting with Holger went well. He briefed us on the GTZ landfill siting project. Essentially working the Provincial BAPEDALDA , they selected around 20 to 30 potential sites for a landfill site. To do this, they compiled geologic, hydrologic, land use, soils, and other data into a GIS database. They then narrowed the list down to 2 sites that would be considered acceptable in term of environmental protection. They gave to us pdf files giving the results of their study and invited Nofaldi back to share how they developed their GIS.

After a final debrief with John, I flew to Bali for "The Second Southeast Asia Water Forum."

31 August – Worked on my PowerPoint presentation for USAID and attended an afternoon session on watershed management and impacts of the Tsunami at the Forum.

ENVIRONMENTAL SERVICES PROGRAM
Ratu Plaza Building, 17th. Fl.
Jl. Jend. Sudirman No. 9
Jakarta 10270
Indonesia

Tel. +62-21-720-9594
Fax. +62-21-720-4546

www.esp.or.id