1. Title:
Developing a sustainable water resources management plan for San Cristóbal de las Casas, Chiapas

2. Name and contact info of proposers:
Brice Loose\(^1\), Jordan Clark\(^2\), Arturo Keller\(^3\)
\(^1\)Waterscience Research Community
\(^2\)Geology Dept., UCSB, Waterscience Research Community
\(^3\)Bren School, UCSB

3. Bren School Faculty sponsor:
Arturo Keller

4. Proposed project:
4.1 Problem statement:
The colonial city of San Cristóbal de las Casas, in the central highlands of Chiapas, Mexico is the cultural and economic center for a predominantly, rural population of descendents of the Mayan culture. The city has experienced major population expansion, caused in part by the sociopolitical upheaval of the last two decades that has brought into the city many peasants. The future of San Cristóbal’s water supply is being compromised by changes in population, land use and insufficient understanding of the limits of sustainable utilization. Even today, the water supply in San Cristóbal is insufficient to meet the needs of the growing population. There is evidence that the basin storage and recharge have diminished from their previous abundance, and will further decline if no action is taken.

4.2 Project objectives:
The objectives are to:
- develop a functional understanding of the hydrologic cycle in the San Cristóbal drainage;
- understand the point and non-point source loads in the watershed that influence water quality;
- use this understanding to develop a sustainable watershed management plan in collaboration with the stakeholders.
4.3 Project significance:

Apart from the educational value to Bren School MESM students, the project is the first step in addressing a major problem for a community of about 130,000 people in Mexico. The approach can serve as a blueprint for other communities with similar problems.

The project also provides an international scope for MESM students, as well as international exposure for the Bren School. In addition, the project promotes collaboration with the Geology Department at UCSB.

4.4 Background information:

The Mexican state of Chiapas is home to one of the highest concentrations of indigenous populations in the Americas. According to the 2000 census, 25% percent of the population in Chiapas speaks an indigenous tongue as their primary language. In comparison, the national average of indigenous speakers is 5% (Instituto Nacional de Estadística Geografía e Informática [INEGI], 2005). Chiapas is one of the poorest states in Mexico, despite its apparent wealth in industrial and agricultural resources, particularly oil, hydropower and coffee.

In the last decade, a large number of indigenous people from the highlands of Chiapas have concentrated along the periphery of the urban center, San Cristóbal, and exert a strain on the city’s tenuous infrastructure. It is estimated that more than 40,000 of the current 132,000 inhabitants of the city were displaced from their rural communities and are currently residing along the periphery in neighborhoods that are collectively referred to as “the belt of misery.” Although many of these people were displaced by the civil unrest, they will probably stay in San Cristóbal, since they also seek employment to have a more stable income.

The San Cristóbal drainage basin is situated in the central highlands of Chiapas, with a mean elevation of 2,100 m (Figure 1). The climate is that of mountainous subtropical rainforest; the mean temperature is 18 °C (65 °F) and the mean annual rainfall is ca. 1,600 mm. The basin is topographically concave, like a volcano crater; however, the subsoil is home to karst geology, which provides natural outlets from the basin. The primary watercourses transect the northern portion of the drainage; the Río Amarillo originates at the base of the Tzontehuitz volcano and runs 12 km before its confluence with Río Fogotico, which enters the catchment from the northeast and exits to the west, 22 km later (Figure 1) (SAPAM, 2003). Both rivers are heavily contaminated with raw sewage and sediments. Below the city, these waters are used for agriculture, fruits and berries, which are sold in San Cristóbal and other parts of Mexico.
Within the past two decades, the characteristics of the hydrologic cycle in the San Cristóbal basin have been undergoing dramatic change. Historically, the city has shared the valley floor with a lake, Lago Maria Eugenia. Today the lake is diminished in size and is only present as an ephemeral lagoon during particularly wet years. The primary source of water supply has been derived from some 25 artesian wells distributed along the north and eastern slopes. However, in the past decade 7 of these 25 springs have dried up completely, while another 12 function intermittently throughout the year, leaving only 6 springs to supply the potable water for the city (SAPAM, 2003).

In the low-lying areas of the basin, water is found less than 50 cm below the ground level; however, there is anecdotal evidence that an extensive clay layer separates this water from the deeper aquifer and is not an indicator of actual water table. Furthermore, the proximity of this water to the surface has caused widespread contamination with pathogens, among other contaminants. It is common knowledge in the city that this water will make you sick, and it is not considered potable by the residents.

The combination of a diminished spring water and population growth has caused extreme inadequacies in the potable water supply to the city of San Cristóbal. Currently, the city's water supply is so overtaxed that the operators are forced to alternate flow to different neighborhoods throughout the course of the day. In the poorest neighborhoods, the public spigot is left
wide open, with buckets stacked nearby. When the water starts gushing from the spigot the call is raised and everyone races to fill their buckets. It’s not uncommon that this occurs in the late night and early morning.

4.5 Stakeholders:

In 2004 several organizations recognized a common concern for sustainable water resources management in the city of San Cristóbal and rural periphery. The organizations formed a partnership, the San Cristóbal Hydro-Resources Partnership (SHRP) with the collective goal of investigating the water cycle in San Cristóbal and developing a plan for sustainable use and urban growth within the basin. By combining the resources and capacities of the member institutions, the Partnership is in the best possible position to rigorously study the system, define needs of the population, and affect policy change that is rooted upon a scientific understanding of system and focused ideal of sustainability. The participating entities include research universities, community-based nonprofit organizations, and a government-chartered citizen advisory board. Below are descriptions of each organization.

SAPAM Advisory Board – SAPAM (Servicio de Agua Potable y Alcantarillado Municipal) or Municipal Potable and Waste Water Utility, is responsible for “implementing potable and waste water services, and conducting studies and improvements for the operation, administration and conservation of the water supply in the municipality of San Cristóbal.” The Advisory Board is a citizen-staffed, citizen-elected board in charge of administrating the actions of SAPAM and ensuring public participation and consensus with the activities of the organism. Francisco Toledo is the current president of the SAPAM Board and is the coalition’s principal contact at SAPAM. Jesus Carmona is vice-president of SAPAM and a researcher at ECOSUR; he also participates in SHR Partnership.

ECOSUR, Chiapas – ECOSUR (El Colegio de la Frontera Sur) is a publicly chartered research institution providing research and post-graduate education focused primarily on the development and linkage of Mexico's southern-most states. ECOSUR maintains five campuses, including a campus in San Cristóbal. Two hydrologists, Duncan Goliche and Jesus Carmona participate as contacts and members in the SHR Partnership. URL: http://www.ecosur.mx

Waterscience Research Community – WRC is member-based 501(c)(3) nonprofit based in California whose members are professionals in many areas of earth and environmental science. As an organization of scientists and engineers, WRC seeks to support projects and organizations that work in the preservation of the environment and public welfare by providing scientific resources and expertise. WRC has extensive contacts and working relationships with institutions in Chiapas. The primary participants
from WRC are Brice Loose, an environmental engineer, and Al Leydecker a biogeochemist. URL: http://www.watersci.org

**University of California at Santa Barbara** – Two researchers from UC Santa Barbara will be participating in the Partnership. Jordan Clark is a hydrogeologist from the Geology Department, who specializes in the use of artificial and naturally occurring tracers to quantify the dynamics of superficial and subterranean aqueous transport. Arturo Keller is an environmental engineer whose research interests include the predictive modeling of the fate and transport of pollutants in the environment, and the development of contaminant remediation for organic pollutants. URL: http://www.geol.ucsb.edu/, http://www.bren.ucsb.edu

**SYJAC** – Skolta'el Yu'un Jlumaltic, A.C. is a nonprofit organization based in Mexico, whose objective is to support community building and improved life quality in the indigenous communities around San Cristóbal. SYJAC regularly participates in the execution of sustainable works projects in indigenous communities, including potable water supply and auto-digesting latrines. The director, Sabas Cruz Garcia participates in SHRP. URL: http://www.syjac.org

**4.6 Possible approach:**

Since the project is a partnership between several organizations, the students are expected to interact closely with Brice Loose (WRC), who is the point of contact with the SHRP, as well as be advised by Jordan Clark and Arturo Keller.

Although the MESM students are expected to develop their own approach, a logical sequence will be to first identify and assemble the existing information regarding the hydrologic cycle and then embark on a preliminary field program, to be focused on characterization of groundwater supply and the parameters governing aquifer storage.

Thanks to the participation of Duncan Goliche and ECOSUR, the project will have access to a database of precipitation extending back 79 years from 2001. The data set is derived from 278 stations throughout the territory of Chiapas, with an average of 7 precipitation readings per month. The data density and frequency of this data set should be sufficient to generate robust estimates of the monthly, seasonal, and annual mean rainfall within the San Cristóbal drainage, as well as within the rest of the state.

The GIS laboratory at ECOSUR has made available to SHRP a digital elevation model (DEM) of the entire state of Chiapas at 50 m resolution, which is available for this project. This tool will be essential in performing spatial geostatistics and modeling meteorology effects within the basin.

Through SAPAM, the Partnership has access to the public archives of well data and a database of potential monitoring sites throughout the city. The SHRP will develop an estimate of the location of the water table and the hydraulic conductivity of the soil, as derived from pump tests, and/or tracer experiments. The Partnership will assemble historic well records, and will
complement the existing data archive with contemporary well monitoring routine to be conducted within the drainage basin. This information will be available for the students as the project progresses.

The students will interact with other researchers in the SHRP to obtain other data sets (e.g. land use, agricultural and industrial practices, etc.) needed for developing the management plan.

4.7 **Deliverables:**

A document in English AND Spanish describing the watershed management plan.

4.8 **References:**


Consejo Consultivo de SAPAM, (September, 2003). El Tachilguil. [Newsletter], San Cristobal de las Casas, Chiapas, Mexico.


5. **Client:**

The ultimate client is SAPAM. The direct client is the SHRP.

6. **Anticipated financial needs and sources of support:**

The project requires only data collection, analysis, interpretation and the development of the management plan, which does not require additional funding than typical MESM projects are allocated. It will be highly desirable that the MESM students visit the site during the summer of 2005, to have a closer collaboration with SHRP and understand better the needs and capabilities of the stakeholders. At this stage, funding for travel has not been secured, but the students can work on fund-raising projects to achieve this objective. One possibility is to obtain a UC-MEXUS grant.